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IBM z/OS V2R1 Communications Server TCP/IP Implementation Volume 3: High Availability, Scalability, and Performance

Describes z/OS Communications Server TCP/IP high availability capabilities

Includes TCP/IP high availability implementation examples

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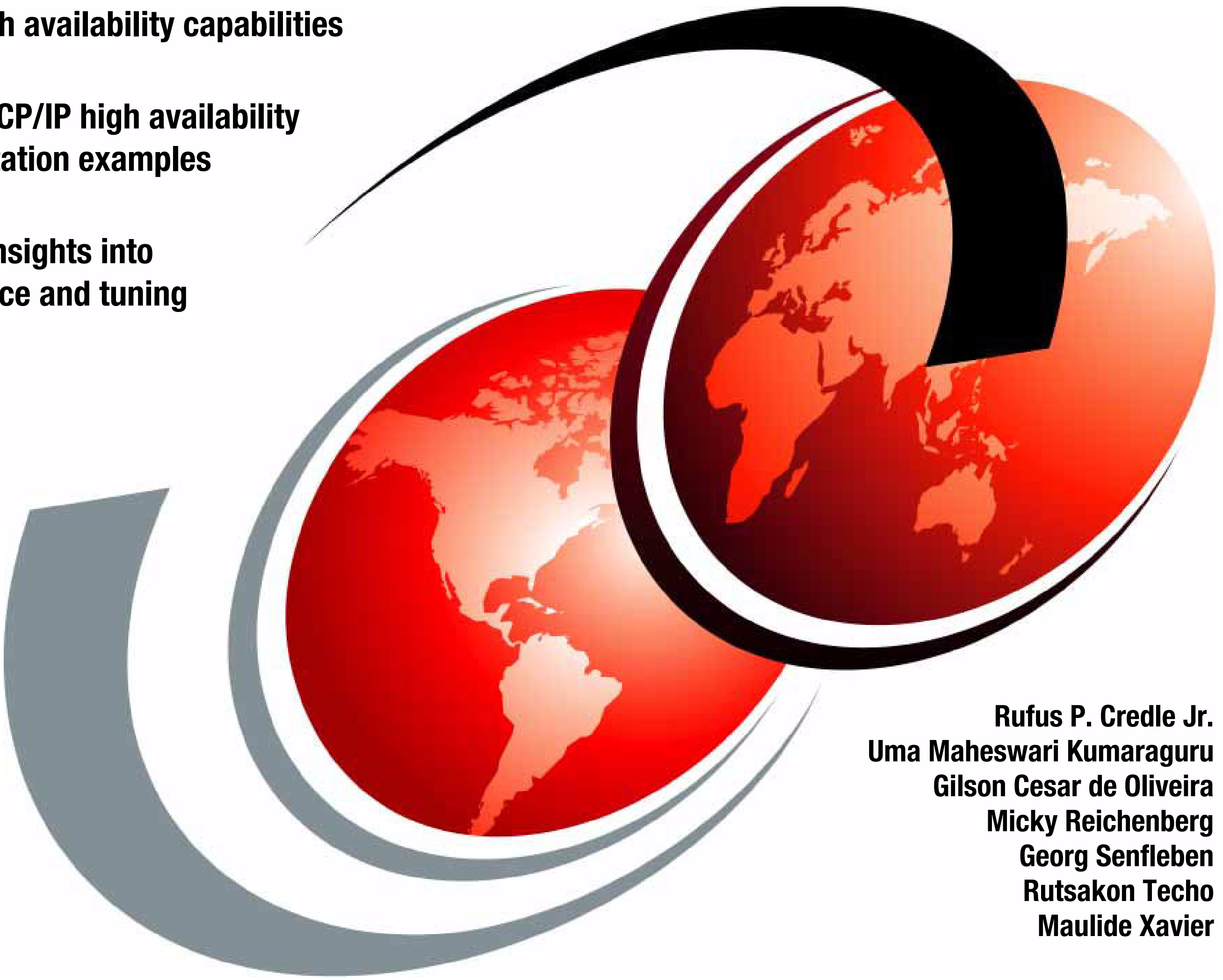

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Note: Before using this information and the product it supports, read the information in “Notices” on page vii.

First Edition (December 2013)

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Contents

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Preface

For more than 40 years, IBM® mainframes have supported an extraordinary portion of the world's computing work, providing centralized corporate databases and mission-critical enterprise-wide applications. IBM System z®, the latest generation of the IBM distinguished family of mainframe systems, has come a long way from its IBM System/360 heritage. Likewise, its IBM z/OS® operating system is far superior to its predecessors in providing, among many other capabilities, world-class and state-of-the-art support for the TCP/IP Internet protocol suite.

TCP/IP is a large and evolving collection of communication protocols managed by the Internet Engineering Task Force (IETF), an open, volunteer organization. Because of its openness, the TCP/IP protocol suite has become the foundation for the set of technologies that form the basis of the Internet. The convergence of IBM mainframe capabilities with Internet technology, connectivity, and standards (particularly TCP/IP) is dramatically changing the face of information technology and driving requirements for even more secure, scalable, and highly available mainframe TCP/IP implementations.

The *IBM z/OS Communications Server TCP/IP Implementation* series provides understandable, step-by-step guidance for enabling the most commonly used and important functions of z/OS Communications Server TCP/IP.

This IBM Redbooks® publication is for people who install and support z/OS Communications Server. It starts with a discussion of virtual IP addressing (VIPA) for high-availability, with and without a dynamic routing protocol. It describes several workload balancing approaches with the z/OS Communications Server. It also explains optimized sysplex distributor intra-sysplex load balancing. This function represents improved application support using optimized local connections together with weight values from extended Workload Manager (WLM) interfaces. Finally, this book highlights important tuning parameters and suggests parameter values to maximize performance in many client installations.

Note: In this book, we use the terms *internal* and *external* application workload balancing. They refer to approaches where the decision about which application instance should receive a given connection request is made within the sysplex environment (such as by sysplex distributor) or outside of it (using a separate, external, workload balancing solution), respectively.

For more specific information about z/OS Communications Server base functions, standard applications, and security, see the other volumes in the series:

- *IBM z/OS V2R1 Communications Server TCP/IP Implementation Volume 1: Base Functions, Connectivity, and Routing*, SG24-8096
- *IBM z/OS V2R1 Communications Server TCP/IP Implementation Volume 2: Standard Applications*, SG24-8097
- *IBM z/OS V2R1 Communications Server TCP/IP Implementation Volume 4: Security and Policy-Based Networking*, SG24-8099

For comprehensive descriptions of the individual parameters for setting up and using the functions described in this book, along with step-by-step checklists and supporting examples, see the following publications:

- *z/OS Communications Server: IP Configuration Guide*, SC27-3650
- *z/OS Communications Server: IP Configuration Reference*, SC27-3651
- *z/OS Communications Server: IP System Administrator's Commands*, SC27-3661
- *z/OS Communications Server: IP User's Guide and Commands*, SC27-3662

This book does not duplicate the information in those publications. Instead, it complements them with practical implementation scenarios that can be useful in your environment. To determine at what level a specific function was introduced, see *z/OS Communications Server: New Function Summary*, GC31-8771. For complete details, we encourage you to review the documents referred to in "Related publications" on page 339.

New in this book, Volume 3, is the information about Sysplex-Wide Security Associations for IPv6, described in Chapter 4, "VIPA with dynamic routing" on page 85.

Note: The scope of work provided to update the four volumes in this series, allowed for the writing and demonstration of only the latest V2R1features. Therefore, you see scenarios and demonstrations of V2R1 and V1R13 within the volumes.

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An introduction to IBM z/OS Communications Server high availability technologies

Organizations invest in information systems because the value they receive (through automation of business processes) is greater than the cost. Depending upon the business processes supported, certain availability, response times, and throughput must be provided for an application for it to be useful. For example, an unreliable credit card authorization system would be useless. Meeting the service levels required for each application, however, comes at a potentially significant cost in terms of additional redundancy, capacity, and complexity. By consolidating services onto IBM System z mainframe hosts, critical mass can be achieved wherein investments to provide higher availability for all applications are more easily justified.

This book provides guidance for implementing the most important high-availability capabilities of z/OS Communications Server for TCP/IP applications. Because scalability and performance concerns often manifest themselves as availability issues (such as when application response times degrade to the point where the application is unusable), this book addresses those topics too.

In the case of scalability, the same architectural solutions that are used for high availability (running multiple instances of an application and balancing load across them) are extended to scale application services to serve larger numbers of users and higher transaction volumes than can be supported by a single application instance.

This chapter contains the following topics.

Section	Topic
1.1, “Overview of high availability” on page 2	An overview of high availability
1.2, “Fundamental technologies for z/OS TCP/IP availability” on page 2	Technologies that are important for z/OS TCP/IP availability
1.3, “Quick-start table” on page 11	Cross-reference to technologies that we discuss in this book

1.1 Overview of high availability

For the purposes of this book, *high availability* is the ability of an application to continue to provide its services regardless of component failures. High availability is achieved by choosing highly reliable system components (such as System z mainframes), and by understanding and avoiding *single points of failure*, which are places in the underlying infrastructure where the failure of a single component can impact the availability of an entire application (or set of applications).

Note: In some cases, the cost of eliminating a single point of failure exceeds the expected cost of outages (estimated as the cost of a single outage multiplied by the probability of occurrence). For example, justifying either of the following items might be too expensive:

- Providing redundant high-speed wide area network (WAN) connectivity for certain small locations
- Rewriting an application so that it can be distributed across multiple hosts (to prevent a host failure from impacting application availability)

In such cases, the organization chooses to *assume* the risk of an outage.

Redundancy, by itself, does not necessarily provide higher availability. It is also necessary to design and implement the system using technologies that can take advantage of the redundancy, as listed in the following examples:

- Dynamic routing protocols (such as OSPF) enable networks to take advantage of redundant connectivity to route traffic around failed links or nodes.
- Virtual IP addressing (VIPA) technology (described in Chapter 2, “Virtual IP addressing” on page 13) can be used to support multiple instances of an application in a z/OS environment to provide continuing application services in spite of the failure of individual instances (or mainframe systems).

1.2 Fundamental technologies for z/OS TCP/IP availability

This section introduces several important technologies for z/OS TCP/IP availability. Several of these technologies, along with implementation examples, are discussed in more detail in subsequent chapters.

1.2.1 Single z/OS system availability

Based on the remarkable reliability of System z mainframe technology, many organizations have found that they can cost-effectively achieve higher application availability and scalability with a single mainframe system than would be possible with many smaller *distributed* systems. Although most technology solutions discussed in this book take advantage of clusters of z/OS systems, some also apply in single-system environments:

- Virtual IP addressing (VIPA)

  VIPA provides physical interface independence for the TCP/IP stack (the part of a z/OS Communications Server software that provides TCP/IP protocol support) and applications so that interface failures will not impact application availability. See 1.2.3, “Virtual IP addressing” on page 4, and Chapter 2, “Virtual IP addressing” on page 13 for more information about this topic.

- Address Resolution Protocol (ARP) takeover

  ARP enables your system to transparently exploit redundant physical interfaces without implementing a dynamic routing protocol in your mainframe. See Chapter 3, “VIPA without dynamic routing” on page 61 for more information about this topic.

- Dynamic routing

  Dynamic routing uses network-based routing protocols (such as OSPF) in the mainframe environment to use redundant network connectivity for higher availability (when used in conjunction with VIPA). See Chapter 4, “VIPA with dynamic routing” on page 85 for more information about this topic.

- Port sharing

  Port sharing enables you to run multiple instances of an application for higher availability and scalability (to the extent possible in a single system). See 5.2.4, “Workload distribution methods” on page 133 for more information about this topic.

1.2.2 z/OS Parallel Sysplex availability

z/OS IBM Parallel Sysplex® combines parallel processing with data sharing across multiple systems to enable you to harness the power of plural z/OS mainframe systems, yet make these systems behave like a single, logical computing facility. This combination gives the z/OS Parallel Sysplex unique availability and scalability capabilities.

The overall objective of designing a Parallel Sysplex environment for high availability is to create an environment where the loss of any single component does not affect the availability of the application. This objective is achieved by designing a fault-tolerant systems environment in the following situations:

- Hardware and software failures are masked by redundant design.
- Hardware and software systems are configured such that all systems have access to all devices, thereby enabling workloads to run anywhere in the sysplex.
- Sysplex distributor, the strategic IBM solution for connection workload balancing within a sysplex, balances workloads and logons among systems that implement multiple concurrent application instances, each sharing access to data.
- Recovery events are automated so that when a failure does occur, user impact is minimized by fast-restart mechanisms.

Note: For applications that cannot support multiple concurrent instances, the best approach you can take (without reengineering the application) is to minimize the duration of outages by using automation, such as the following examples:

- Automatic Restart Manager (ARM) for quick application server restart
- Dynamic VIPA takeover for transferring application services to a standby server

Nodes in a sysplex use XCF Communication Services (XCF) to perform coordination among Sysplex TCP/IP stacks, to discover when new TCP/IP stacks are started, and to learn when a TCP/IP stack is stopped or leaves the XCF group (such as resulting from some sort of failure). That information is essential for automating the movement of applications and for enabling sysplex distributor to make intelligent workload balancing decisions. XCF communication messages can be transported either through a coupling facility or directly through IBM ESCON® or IBM FICON® CTCs.

Note: Dynamic VIPA and sysplex distributor capabilities do not rely on data stored in structures in the coupling facility. Therefore, they can be implemented using XCF communication without a coupling facility (also called *Basic Sysplex connectivity*).

1.2.3 Virtual IP addressing

In TCP/IP networking, Internet Protocol (IP) addresses are typically assigned to physical network interfaces. If a server has two physical interfaces, a separate IP address is assigned to each of them. IBM introduced the concept of virtual IP addressing (VIPA) for its z/OS environment to support the use of IP addresses, representing TCP/IP stacks, applications, or clusters of applications, that are not tied to any specific physical interface. The association between a VIPA and an actual physical interface is subsequently accomplished using either the Address Resolution Protocol (ARP) or dynamic routing protocols (such as OSPF).

We discuss VIPA technology in Chapter 2, “Virtual IP addressing” on page 13. Consequently, we introduce only the basic concepts here.

Static VIPA

A *static VIPA* is an IP address that is associated with a particular TCP/IP stack. Using either ARP takeover or a dynamic routing protocol (such as OSPF), static VIPAs can enable mainframe application communications to continue unaffected by network interface failures. As long as a single network interface is operational on a host, communication with applications on the host will persist.

Note: Static VIPA does not require sysplex (XCF communications) because it does not require coordination between TCP/IP stacks.

Dynamic VIPA (DVIPA)

*Dynamic VIPA*s (DVIPAs) can be defined on multiple stacks and moved from one TCP/IP stack in the sysplex to another automatically. One stack is defined as the primary or owning stack, and the others are defined as backup stacks. Only the primary stack is made known to the IP network.

TCP/IP stacks in a sysplex exchange information about DVIPAs and their existence and current location, and the stacks are continuously aware of whether the partner stacks are still functioning. If the owning stack leaves the XCF group (such as resulting from some sort of failure), then one of the backup stacks automatically takes its place and assumes ownership of the DVIPA. The network simply sees a change in the routing tables (or in the adapter that responds to ARP requests).

In this case, applications associated with these DVIPAs are active on the backup systems, thereby providing a hot standby and high availability for the services. DVIPA addresses identify applications independently of which images in the sysplex the server applications execute on and allow an application to retain its identity when moved between images in a sysplex.

When used with a sysplex distributor *routing* stack, DVIPAs (in such cases referred to as *distributed* DVIPAs) allow a cluster of hosts, running the same application service, to be perceived as a single large server node.

1.2.4 z/OS network connectivity and dynamic routing

Ever since the earliest support of TCP/IP in mainframe environments, if you wanted high availability, we recommended that you use a dynamic routing protocol in your mainframes. Recently, however, innovative designs have used z/OS support of ARP takeover to achieve comparable availability without using a dynamic routing protocol. The basic concepts of each of these approaches is discussed in the following section. For more detailed information and implementation examples, see Chapter 3, “VIPA without dynamic routing” on page 61.

z/OS availability without dynamic routing

Why bear the cost and complexity of implementing a dynamic routing protocol in a mainframe environment while not doing so in other server environments? Why not simply leave dynamic routing to the network people, and keep servers out of it? These are important questions.

But without dynamic routing, how can your mainframe environment take advantage of redundant network connectivity and reroute around a network interface failure? The answer is by using z/OS ARP takeover support.

To understand how ARP takeover works, you need to understand something about how the z/OS Communications Server and the OSA-Express adapter (in QDIO mode) work together to support TCP/IP communication:

- The OSA adapter depends on the z/OS Communications Server TCP/IP stacks to maintain IP-layer routing tables and handle IP routing issues.
- The z/OS TCP/IP stacks pass IP address location information to the OSAs, allowing them to maintain dynamically OSA Address Tables (OATs) containing information such as that shown in Table 1-1.

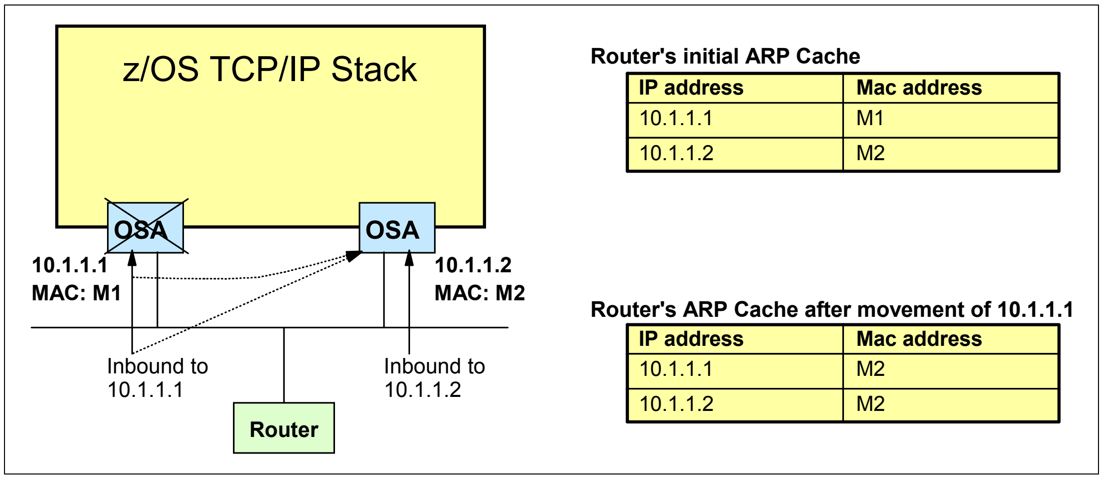
Table 1-1 Example of OSA address table information

IP-Dest=	Give to...
10.0.1.1	LPAR-1
10.0.1.4	LPAR-2
10.0.1.5	LPAR-2
10.0.1.6	LPAR-2

Note: The OAT is maintained and updated automatically when using OSA-Express in QDIO mode.

- When an OSA adapter is shared by multiple logical partitions (LPARs), all IP packets to those LPARs are sent to the same local area network (Ethernet) MAC address and the OSA adapter looks into the IP header to determine to which LPAR an IP packet should be sent.
- Whenever a QDIO device is activated or the home list is modified (through `OBEYFILE` command processing or through dynamic changes, such as VIPA takeover), the TCP/IP stack updates the OAT configuration dynamically with the HOME list IP addresses of the stack.

Consider the example of ARP takeover illustrated in Figure 1-1.



Router's initial ARP Cache

IP address	Mac address
10.1.1.1	M1
10.1.1.2	M2

Router's ARP Cache after movement of 10.1.1.1

IP address	Mac address
10.1.1.1	M2
10.1.1.2	M2

Figure 1-1 Example of ARP takeover

Figure 1-1 shows a z/OS TCP/IP stack with two OSA interfaces to the same Ethernet subnet. Initially, the stack assigns address 10.1.1.1 to one of the interfaces and 10.1.1.2 to the other.

However, when the 10.1.1.1 interface fails, the stack *automatically* moves that address over to the second interface. Furthermore, when the second OSA interface is assigned address 10.1.1.1, it broadcasts its newly-added address to the subnetwork (using a protocol known as *gratuitous* ARP) so that every host on that subnet (the router, in this example) is informed of the change and can update its ARP cache appropriately. ARP takeover thereby allows TCP/IP traffic to be rerouted, in most cases nondisruptively, around a failed OSA interface.

The ARP takeover function shown in Figure 1-1 is an important availability tool in and of itself because it provides for high availability in the event of an interface failure. However, that is really just the beginning. Using the same underlying ARP takeover function in conjunction with Sysplex XCF communications, the z/OS Communications Server can also move DVIPAs from one TCP/IP stack to another (including on a completely separate system), providing high availability even for application failures. An implementation example of ARP takeover is shown in 3.2, “High availability using ARP takeover in one TCP/IP stack” on page 63.

Using ARP takeover, you can achieve comparable high availability to what can be provided using dynamic routing, with the following *limitations*:

- Given a well-designed OSA connectivity environment, it is extremely unlikely that one of your systems could lose all OSA connectivity. However, should such a loss of connectivity occur, you cannot configure your other mainframe-to-mainframe connectivity (such as IBM HiperSockets™, CTCs, or XCF communications) to be dynamically used for alternative connectivity out of the system without a dynamic routing protocol (though you can still use such back-end connectivity, with static routing and separate subnets, for host-to-host traffic).
- All of your systems must be attached to the same layer-2 subnetwork infrastructure (such as an Ethernet LAN), and you must be satisfied with the availability that can be achieved by your router or switch vendors' technology within a subnet:
  - Redundant switches, trunked together, and using their VLAN technology to create highly available subnetworks
  - Gateway router redundancy capabilities (such as VRRP or HSRP)

- *All* of your IP addresses (interfaces, static VIPAs, and DVIPAs) should be allocated out of the same subnet to which all of the sysplex hosts are attached to be reachable from the network (though you could use a separate and isolated subnet for your HiperSockets connectivity for high-speed connectivity between LPARs).
- Although it is possible to configure and use multiple parallel paths to increase available bandwidth (called *multipathing*) without a dynamic routing protocol, if there is a failure in the network beyond a point where the OSA adapter is able to detect it, TCP connection setups that are directed across the failed path will time out and UDP and RAW traffic is lost.

z/OS availability using dynamic routing

With all of the functions available without implementing a dynamic routing protocol in the z/OS Communications Server, why ever consider implementing one? One reason is because a sysplex (a cluster of System z mainframes coupled together with dynamic XCF connectivity) is a network in itself. So, when you connect a sysplex to a network, you are really connecting two networks together, which is a situation in which one would normally want to use a dynamic routing protocol. (Specifically, you should use OSPF and configure the sysplex as a *totally stubby area* to give the sysplex and the network full awareness of each other while minimizes the amount of routing information that has to be shared.)

If you do not use a dynamic routing protocol, you are essentially bridging together two dynamic TCP/IP networks with static, layer-2 based, network connectivity. To summarize the advantages of using a dynamic routing protocol, we need only take the limitations inherent in not using one and turn them around:

- If a system should lose all OSA connectivity, dynamic routing provides the ability to automatically use back-end connectivity (such as HiperSockets, CTCs, or XCF) as alternative pathing for your OSA-based network connectivity. And you can use OSPF link weights to ensure that traffic is routed across the optimal links (HiperSockets first, then OSAs, and then XCF).
- You can design your layer-2 connectivity for higher availability, using isolated and redundant Ethernet switches (each its own subnet and not interconnected) and dynamic routing to recover from any subnetwork failure. You also do not need router redundancy technologies (such as Virtual Router Redundancy Protocol (VRRP) or Hot-Standby Router Protocol (HSRP)) because, through dynamic routing protocols, your sysplex understands which routing paths are (or are not) available.
- You have much greater flexibility in terms of allocation of IP addresses. Indeed, your VIPA addresses should come from unique (and easily identifiable) subnets.
- Multipathing for bandwidth scalability is a built-in and fully supported capability of OSPF.

1.2.5 Single-instance and multiple-instance applications

The basic approach to availability is avoiding single points of failure. For server applications, that means executing multiple instances of the same application on separate operating system images and systems. However, some clients might care about which server they reach, although others might not.

Single-instance applications

The relationship of a client to a particular server instance might require that only a single-instance of an application be available at a time. In other cases, it might be that the server application needs exclusive access to certain resources, which prevents the use of multiple-concurrent instances of an application. Such application environments, then, are necessarily single-instance applications, meaning that only one instance of an application is available at a time.

As mentioned in 1.2.2, “z/OS Parallel Sysplex availability” on page 3, the best that can be done in terms of availability for such applications is to use automation to either quickly restart them, or to redirect requests to another instance that is standing by. One example of a necessarily single-instance application is a TN3270 server that must support mapping to specific LU names (because the same LU names cannot be active on more than one IBM VTAM at a time).

Multiple-instance applications

For multiple-instance applications (also sometimes called *application clusters*), the server instance that a particular connection gets directed to does not matter, as long as some server is there to field the connection request. These applications are characterized by doing all their work over a single connection, and either not saving state between connections (possibly including state information with the work request), or having the server applications share saved state among the instances. Such applications include the following examples:

- Web servers (IBM WebSphere), either for simple web requests that do not create persistent client state, or where the web servers share state in a database (such as can be done with WebSphere and IBM DB2)
- LDAP and MQ, which share their state among the application instances through their own means (shared files or structures in the coupling facility)

1.2.6 Balancing workload across multiple application instances

In general, application workload balancing refers to the ability to use separate systems within the cluster simultaneously, thereby taking advantage of the additional computational function of each one. The next sections describe the following approaches for workload balancing:

- Internal application
- External application
- Hybrid

Internal application workload balancing

Using internal workload balancing in a z/OS environment, when a TCP connection request is received for a given *distributed* DVIPA address, the decision as to which instance of the application serves that particular request is made by the sysplex distributor running in the TCP/IP stack that is configured to be the *routing* stack.

The sysplex distributor has real-time capacity information available (from the sysplex workload manager) and can use QoS information from the Service Policy Agent. Consequently, internal workload balancing requires no special external hardware. However, all inbound messages to the distributed DVIPA must first transit the routing stack before being forwarded along to the appropriate application instance.

Note: With the VIPARoute function, you can use any available interface for DVIPA traffic forwarding. Using alternative interfaces (such as HiperSockets or OSA-Express connectivity) can improve performance while reducing the usage of XCF interfaces.

Sysplex distributor supports only the balancing of TCP (not UDP) traffic.

Internal application workload balancing is discussed in detail (including implementation examples) in Chapter 5, “Internal application workload balancing” on page 127.

External application workload balancing

External workload balancing uses switching hardware outside of the mainframe environment to distribute connection requests across available z/OS servers. Such hardware usually supports both UDP and TCP traffic, and can be shared with other (non-mainframe) servers, thus making external workload balancing a potentially more cost-effective alternative.

An external load balancer represents multi-instance servers as one application to the outside world. Application users know the application cluster only as an IP address within the external load balancer. How many application instances are available, the relationship between the IP address of the application cluster and the application instances, and port assignments are configured and managed in the external load balancer. This relationship is illustrated in Figure 1-2.

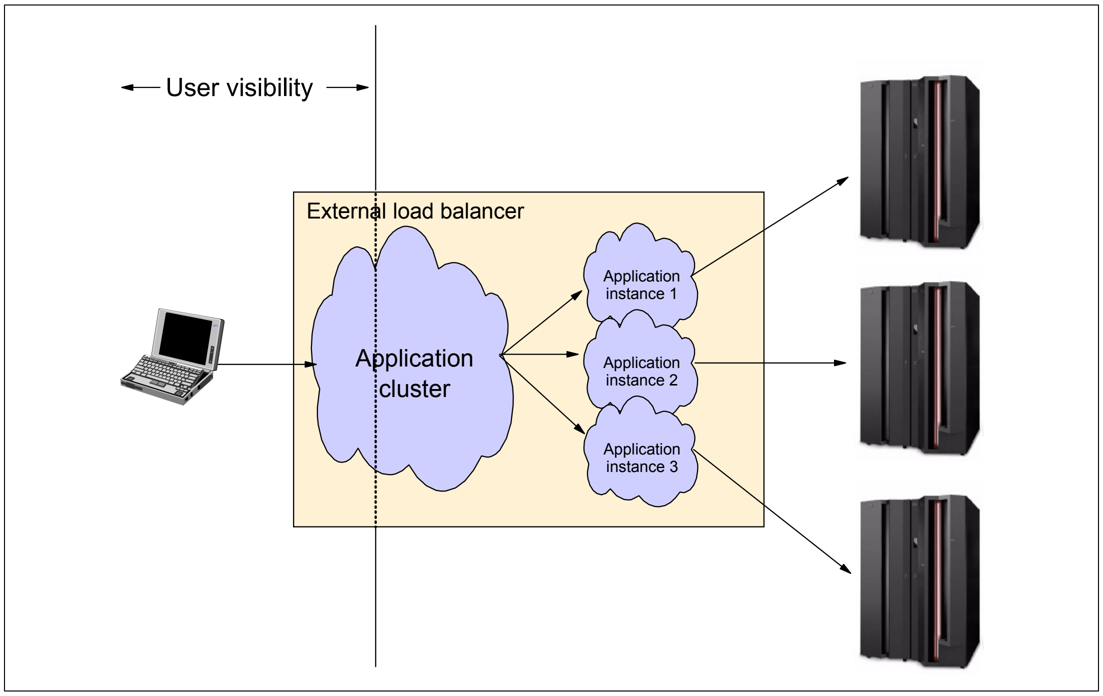


Figure 1-2 Relationship between application cluster and application instances

The external load balancer receives datagrams destined for the IP address representing the application cluster and then forwards the datagrams to application instances belonging to the application cluster.

One challenge for external load balancers involves a lack of awareness about the status of the target application instances. The environment includes three levels that affect the usability of the application instances:

- The networking infrastructure
- The operating environment
- The application instance and any multi-instance locking that might exist

External load balancers have developed various techniques to sense the environmental status. The most common techniques include polling of the application, pinging the IP address used by the application, measurement of turnaround times for datagrams, execution of a predefined dummy transaction, or analysis of transaction behavior. These techniques provide only part of the information needed to make the best decision for server assignment.

A disadvantage of these techniques is that there can be some delay between the time an environmental problem occurs and when the load balancer detects it. In a highly loaded application environment, this can result in many connections being forwarded to an unhealthy application instance.

The reverse problem arises when the application instance becomes fully operational again. Hybrid internal or external workload balancing approaches (described in “Hybrid internal or external approaches” on page 10) can give external load balancers (such as CSS) real-time awareness of the status of the sysplex environment and applications.

The strength of external load balancers is that they are dedicated devices performing a fixed set of tasks. They typically have significant processing capacity, giving them the ability to find and make decisions using higher-layer information buried deep inside datagrams rather than just using IP addresses, including application-specific information such as HTTP (or FTP) Uniform Resource Locators (URLs). External load balancers can also be implemented in redundant modes for availability, and more devices can usually be added in parallel to increase capacity. External load balancers are especially attractive (as compared to internal workload balancing) when the workload includes large amounts of inbound data traffic, because of their more-efficient inbound data path.

External application workload balancing is described in detail (including implementation examples) in Chapter 6, “External application workload balancing” on page 191.

Hybrid internal or external approaches

In many cases, your application load balancing requirements might be such that purely internal or external workload balancing is satisfactory. However, in some situations, you might need elements of both approaches.

For example, you might need the UDP workload balancing capability of an external load balancer but want to make z/OS application load balancing decisions based upon real-time awareness of current application workloads and performance. Two technology solutions address this requirement:

- Sysplex distributor’s Multi-Node Load Balancing (MNLB) Service Manager support
- z/OS Load Balancing Advisor (LBA), which uses the Server Application State Protocol (SASP)

In the MNLB architecture, the entity that decides which target server receives a given connections is called the Service Manager. The entity that forwards data to target servers is called the *Forwarding Agent*. In a hybrid environment, the sysplex distributor acts as the Service Manager and switches perform the Forwarding Agent role.

Note that the sysplex distributor makes the actual workload distribution decision. Then, acting as a Service Manager, sysplex distributor relays that decision to the Forwarding Agents, which thereafter directly send traffic for that connection to the target server, bypassing the distribution stack (thereby saving the mainframe CPU cycles associated with routing messages through the distribution stack).

The z/OS Load Balancing Advisor is a z/OS Communications Server component that allows any external load balancing solution to become *sysplex-aware*. The external load balancer must support the Server Application State Protocol (SASP) to obtain sysplex information through this function. Sysplex awareness information is collected by the Load Balancing Advisor, a weight metric is calculated (based upon Workload Manager (WLM) and z/OS Communications Server information), and then the weight is sent to the external load balancer. Ultimately, however, the external load balancer decides which application instance is best for the next request, which makes the LBA/SASP approach slightly different from the MNLB Service Manager approach.

Note: Because the external load balancer makes the actual workload distribution decision, we chose to include the detailed discussion of the LBA/SASP approach (including implementation examples) in Chapter 6, “External application workload balancing” on page 191.

Hybrid solutions, though more complex, combine the information advantages of internal workload balancing with the routing efficiency and functionality of external load balancing. This book contains an example of z/OS Load Balancing Advisor in Chapter 6, “External application workload balancing” on page 191.

For more information to decide which load balancing solution to use, see “Choosing a load balancing solution” section in *z/OS Communications Server: IP Configuration Guide*, SC27-3650.

1.3 Quick-start table

The information in Table 1-2 on page 12 can help you quickly find your way to the parts of this book that are of interest to you. Start by finding the row in the table that most closely corresponds to your environment: single z/OS system or z/OS Parallel Sysplex, and with or without the use of dynamic routing in your z/OS environment. Then find the column with availability, scalability, or performance functionality that interests you. In the table cells, we have identified technologies that might be helpful for you and where we discuss these technologies in this book.

Table 1-2 Quick start for high availability, scalability, and performance

Description	High availability		Scalability	Performance
	Network connectivity	Application	Workload balancing	
Single z/OS system without dynamic routing	Static VIPA and ARP takeover (Chapter 2, “Virtual IP addressing” on page 13, and Chapter 3, “VIPA without dynamic routing” on page 61)		► SHAREPORT and SHAREPORTWLM (Chapter 5, “Internal application workload balancing” on page 127) ► External WLB (Chapter 6, “External application workload balancing” on page 191) ► LBA/SASP (Chapter 6, “External application workload balancing” on page 191)	► General ► TCP/IP ► z/OS UNIX ► Storage ► Applications (Chapter 8, “Performance and tuning” on page 289)
Single z/OS system with dynamic routing	Static VIPA and OSPF (Chapter 2, “Virtual IP addressing” on page 13, and Chapter 4, “VIPA with dynamic routing” on page 85)			
z/OS Parallel Sysplex without dynamic routing	Static VIPA and ARP takeover (Chapter 2, “Virtual IP addressing” on page 13, and Chapter 3, “VIPA without dynamic routing” on page 61)	DVIPA and ARP takeover (Chapter 2, “Virtual IP addressing” on page 13, and Chapter 3, “VIPA without dynamic routing” on page 61	► Distributed DVIPA and sysplex distributor (Chapter 2, “Virtual IP addressing” on page 13 and Chapter 6, “External application workload balancing” on page 191) ► External WLB (Chapter 6, “External application workload balancing” on page 191) ► LBA/SASP (Chapter 6, “External application workload balancing” on page 191) ► Sysplex distributor (Chapter 5, “Internal application workload balancing” on page 127 and Chapter 7, “Intra-sysplex workload balancing” on page 239)	
z/OS Parallel Sysplex with dynamic routing	Static VIPA and OSPF (Chapter 2, “Virtual IP addressing” on page 13, and Chapter 4, “VIPA with dynamic routing” on page 85)	DVIPA and OSPF (Chapter 2, “Virtual IP addressing” on page 13, and Chapter 4, “VIPA with dynamic routing” on page 85)		
OEM other than z/OS IBM DataPower®		DVIPA and OSPF (Chapter 2, “Virtual IP addressing” on page 13, and Chapter 4, “VIPA with dynamic routing” on page 85)	► Sysplex distributor (Chapter 7, “Intra-sysplex workload balancing” on page 239)	

2 Virtual IP addressing

In TCP/IP networking, Internet Protocol (IP) addresses are typically assigned to physical network interfaces. If a server has two physical interfaces, a separate IP address is assigned to each of them.

IBM introduced the concept of virtual IP addressing (VIPA) for its z/OS environment to support the use of IP addresses, representing TCP/IP stacks, applications, or clusters of applications, that are not tied to any specific physical interface. The association between a VIPA and an actual physical interface is subsequently accomplished using either the Address Resolution Protocol (ARP) or dynamic routing protocols (such as OSPF).

This chapter contains the following topics.

Section	**Topic**
2.1, "Basic concepts of virtual IP addressing" on page 14	Basic concepts, commands, and functions associated with a VIPA.
2.2, "Importance of VIPA" on page 16	Why VIPA is important.
2.3, "Types of DVIPA" on page 17	Understand the characteristics of a several types of DVIPA.
2.4, "Static VIPA example" on page 26	Implementation of a basic static VIPA environment.
2.5, "Dynamic VIPA example" on page 29	Implementation of a basic dynamic VIPA (DVIPA) environment.
2.6, "Sysplex problem detection and recovery" on page 38	Controlling the timing of when a stack activates the DVIPA.

2.1 Basic concepts of virtual IP addressing

The IBM z/OS Communications Server supports two types of virtual IP addressing (VIPA):

- Static
- Dynamic

2.1.1 Static VIPA

A *static VIPA* is an IP address that is associated with a particular TCP/IP stack. Using either ARP takeover or a dynamic routing protocol (such as OSPF), static VIPAs can enable mainframe application communications to continue unaffected by network interface failures. As long as a single network interface is operational on a host, communication with applications on the host persist.

Static VIPAs have the following characteristics:

- They can be activated during TCP/IP initialization or **`VARY TCPIP`**, **`OBEYFILE`** command processing, and are configured using an appropriate set of DEVICE, LINK, HOME, or INTERFACE statements and, optionally, OMPROUTE configuration statements or BSDROUTINGPARMS statements for IPv4 and IPv6 Static VIPAs.
- Using the SOURCEVIPA configuration option, or SOURCEVIPA parameter on the INTERFACE configuration statement, static VIPAs can be used as the source IP address for outbound datagrams for TCP, RAW, UDP (except routing protocols), and ICMP requests.
- They can be specified as the source IP address for outbound TCP connection requests for *all* applications using this stack with TCPSTACKSOURCEVIPA, or just a specific *job* and a specific *destination* through the use of the SRCIP profile statement block.
- The number of static VIPAs on a stack is limited only by the range of host IP addresses that are available for that host.
- They can be moved to a backup stack after the original owning stack has left the XCF group (such as resulting from some sort of failure), by using **`VARY TCPIP,,OBEYFILE`** command processing to configure the VIPA on the backup stack.

Note: Static VIPA does not require sysplex (XCF communications) because it does not require coordination between TCP/IP stacks.

2.1.2 Dynamic VIPA

A *dynamic VIPA* (DVIPA) can be defined on multiple stacks and moved from one TCP/IP stack in the sysplex to another automatically. One stack is defined as the primary or owning stack, and the others are defined as backup stacks. Only the primary stack is made known to the IP network.

TCP/IP stacks in a sysplex exchange information about DVIPAs, their existence, and their current location, and the stacks are continuously aware of whether the partner stacks are still functioning. If the owning stack leaves the XCF group (such as resulting from some sort of failure), then one of the backup stacks automatically takes its place and assumes ownership of the DVIPA. The network simply sees a change in the routing tables (or in the adapter that responds to ARP requests).

In this case, applications associated with these DVIPAs are active on the backup systems, thereby providing a hot standby and high availability for the services. DVIPA addresses identify applications independently of which images in the sysplex the server applications execute on and allow an application to retain its identity when moved between images in a sysplex.

DVIPAs can be moved between TCP/IP stacks by any of the following methods:

- Automatic movement of a VIPA from a failing TCP/IP stack to a backup stack, known as *automatic takeover* and *takeback*
- Dynamic allocation of a VIPA by an application program application programming interface (API) call, using any of the following methods:
  - The application issues a `bind()` to that particular (specific) IP address.
  - The application binds to INADDR_ANY instead of a specific IP address, but the server BIND control function changes the generic `bind()` to a specific one.
  - An authorized application issues a **`SIOCSVIPA IOCTL`** command. An example of such an application is the **`MODDVIPA`** utility.
- Manual movement of a VIPA by deactivating or reactivating it with the **`VARY TCPIP,,SYSPLEX`** command

Figure 2-1 shows a simple DVIPA case of a failed TCP/IP stack (and associated applications).

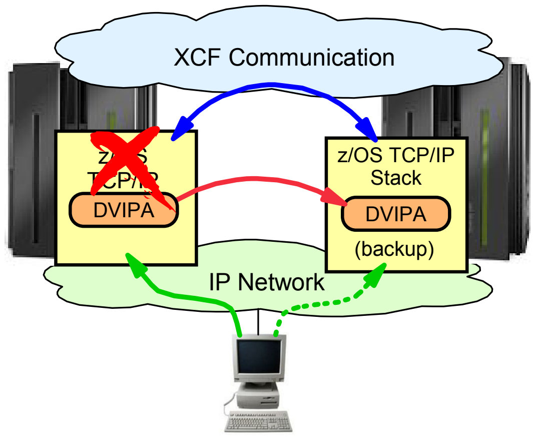


Figure 2-1 DVIPA address movement

DVIPA automatically moves operation of the failed IP address to another z/OS image. With proper planning, the same application is available on the second z/OS image and it immediately picks up the workload that is directed to the IP address. External users see only workload directed to an IP address; the shift of this IP address from the first z/OS to the second z/OS is largely transparent.

Dynamic VIPAs are defined with the VIPADynamic statement and have the following characteristics:

- They can be configured to be moved dynamically from a failing stack to a backup stack within the same sysplex without operator intervention or external automation. This is a *stack-managed* configuration and is defined using the VIPADefine and VIPABackup parameters.

- They can be activated dynamically by an application program (using **IOCTL**) or by a supplied utility (**MODDVIPA**). This is *event activation* or *command activation* and is managed using the VIPARange parameter.
- They can be specified on a TCPSTACKSOURCEVIPA statement. This allows a user to specify one dynamic VIPA to be used as the source IP address for outbound datagrams for TCP-only requests.
- When used with sysplex distributor, DVIPAs (in such cases referred to as *distributed* DVIPAs) allow a cluster of hosts, running the same application service, to be perceived as a single large server node. Distributed DVIPAs are defined using the VIPADistribute parameter with the VIPADynamic statement and have the following characteristics:
- They have all the characteristics of DVIPAs, but cannot be dynamically activated by an application program.
- One stack (called the *routing stack*) defines a DVIPA and advertises its existence to the network. Stacks in the target distribution list activate the DVIPA and accept connection requests.
- Connection workload can be spread across several stacks.

See 2.3.3, "Distributed DVIPA (sysplex distributor)" on page 19 for a more detailed description of this function.

2.2 Importance of VIPA

VIPA provides a foundation technology solution for enhancing the availability and scalability of a z/OS system by providing the following capabilities:

- Automatic and transparent recovery from device and adapter failures.

  When a device (for example, a channel-attached router) or an adapter (for example, an OSA-Express adapter) fails, another device or link can automatically provide alternate paths to the destination.
- Recovery from a z/OS TCP/IP stack failure.

  Assuming that an alternate stack is installed to serve as a backup, the use of VIPAs enables the backup stack to activate the VIPA address of the failed stack. Connections on the failed primary stack will be disrupted, but they can be reestablished on the backup using the same IP address as the destination. In addition, the temporarily reassigned VIPA address can be restored to the primary stack after the cause of failure has been removed. When the DVIPA is used, the VIPA takeover can be automatic, while the static VIPA must be taken over with an operation (using **OBEYFILE** command).
- Limited scope of a stack or application failure.

  If a DVIPA is distributed among several stacks, the failure of only one stack affects only the subset of clients connected to that stack. If the distributing stack experiences the failure, a backup assumes control of the distribution and maintains all existing connections.
- Enhanced workload management through distribution of connection requests.

  With a single DVIPA being serviced by multiple stacks, connection requests and associated workloads can be spread across multiple z/OS images according to Workload Manager (WLM) and Service Level Agreement policies (for example, QOS).
- With the use of a DVIPA, nondisruptive movement of an application server to another stack is allowed so that workload can be drained from a system in preparation for a planned outage.

2.3 Types of DVIPA

This section describes stack-managed, event-activated, and distributed DVIPAs. Examples are in subsequent sections.

2.3.1 Stack-managed DVIPA

Stack-managed DVIPAs are defined by VIPADefine and VIPABackup, and are moved between stacks. The switch can be automatic or manual:

- Automatic

  If the owning stack leaves the XCF group (for example, resulting from some sort of failure), the stack with an already-configured VIPABACKUP definition for that DVIPA activates and advertises the DVIPA, and this is the TAKEOVER operation. Multiple stacks can back up a DVIPA. The stack with the highest configured rank will take over.

- Manual (planned)

  This method uses **`VARY TCPIP,,SYSPLEX deact`** or **`react`** operator commands:

  - The **`deactivate`** command:
    - If the DVIPA is active, **`deactivate`** deletes the DVIPA allowing a backup stack to take over the DVIPA.
    - If the DVIPA is a backup, **`deactivate`** removes this stack as a backup, preventing this stack from taking over if the current owner leaves the XCF group (for example, resulting from some sort of failure).
  - The **`reactivate`** command:
    - Causes takeback for a VIPADEFINE DVIPA.
    - Re-enables VIPABACKUP DVIPA to take over if a stack leaves the XCF group.

2.3.2 Event-activated DVIPA

Event-activated DVIPA functions are indicated by the VIPARANGE parameter in the TCP/IP profile. Activation of an application-specific DVIPA IP address associated with a specific application instance occurs only using an application program's API call, in any of the following ways:

- When the application instance issues a `bind()` function call and specifies an IP address that is not active on the stack. The stack activates the address as a DVIPA, if it meets certain criteria. When the application instance closes the socket, the DVIPA is deleted.
- Some applications cannot be configured to issue `bind()` for a specific IP address, but are unique application-instances. For such applications, a utility is provided (**`MODDVIPA`**), which issues SIOCSVIPA or SIOCSVIPA6 `ioctl()` to activate or deactivate the DVIPA.

  This utility can be included in a JCL procedure or OMVS script to activate the DVIPA before initiating the application. As long as the same JCL package or script is used to restart the application instance on another LPAR in the event of a failure, the same DVIPA will be activated on the new stack.
- An alternative for unique application-instance applications that do not contain the logic to bind to a unique IP address is to use the BIND parameter on the PORT reservation statement. Usually, a good practice is to reserve a port for the listening socket of a server application.

If the BIND parameter *and* an IP address are specified on the PORT reservation statement for a server application, and the application binds a socket to that port and specifies INADDR_ANY, then z/OS TCP/IP converts the bind to be specific to the IP address specified on the PORT reservation statement.

From that point on, it appears as though the application itself had issued the `bind()` specifying the designated IP address, including having the IP address deleted when the server application closes the socket.

Because the VIPA is specified by the application, it does not need to be uniquely defined in the TCP/IP profile. However, we must ensure that the addresses being used by the application correspond to our IP addressing scheme. We use the VIPARange statement in the TCP/IP profile to indicate the range of VIPAs that we are willing to activate dynamically.

The VIPARange statement defines an IP subnetwork using a network address (prefix) and a subnet mask. Because the same VIPA address cannot be activated by IOCTL or `bind()` while also participating in automatic takeover as defined by VIPADEFine/VIPABackup, we suggest that subnets for VIPADEFine be different from subnets for VIPARange.

VIPARange in itself does not create, activate, or reserve any dynamic VIPAs. It merely defines an allocated range within which program action (or the BIND parameter or a PORT statement) can cause a dynamic VIPA to be created and activated for a specific IP address. The same range can have DVIPAs defined through VIPADEFINE or VIPABACKUP, provided that no attempt is made to use the same IP address for both VIPADEFINE and activations using a BIND or IOCTL.

After it is activated on a stack using `bind()` or IOCTL, a Dynamic VIPA IP address remains active until the VIPA IP address is moved to another stack or is deleted. The system operator might delete an active application-specific Dynamic VIPA IP address by using the **`MODDVIPA`** utility or by stopping the application that issued the `bind()` to activate the VIPA. To remove an active VIPARange statement, the VIPARange DELETE statement can be used.

Deleting a VIPARANGE does not affect existing DVIPAs that are already activated within the range, but it does prevent new ones from being activated within the deleted range until the VIPARANGE is reinstated.

Applications that bind to INADDR_ANY

An application can issue a `bind()` to INADDR_ANY to accept connection requests from any IP address associated with the stack. This is insufficient if the application must be associated with a specific VIPA address. There are three ways to manage this situation:

- Cause the application to `bind()` to a specific address (instead of INADDR_ANY) by using the Server Bind Control function that is implemented by the BIND keyword on a PORT statement.
- Modify the application to `bind()` to a specific address.
- Use the **`MODDVIPA`** utility or modify the application to send the appropriate IOCTL.

The most attractive solution is to use the Server Bind Control function because it does not require changing the application. Using this function, a generic server (such as the TN3270 server) can be directed to bind to a specific address instead of INADDR_ANY. When the application attempts binds to INADDR_ANY, the `bind()` is intercepted and converted to the specified IP address. The process then continues as though the server had issued a `bind()` to that specific address. To use this function, however, the port used by the application must be known in advance so that it can be added to the PORT statement in the TCP/IP profile.

In situations where the application cannot take advantage of the server bind control function and cannot be otherwise modified, the **`MODDVIPA`** utility can be used to create a Dynamic VIPA IP address using the IOCTL call. The utility can be initiated through JCL, from the **`OMVS`** command line, or from a shell script. This utility is in `EZB.MODDVIPA.sysname.tcpname`. For more detailed information about the **`MODDVIPA`** utility, see *z/OS Communications Server: IP Configuration Guide*, SC27-3650. For **`MODDVIPA`** utility example, see Chapter 3, “VIPA without dynamic routing” on page 61.

Activation of the Dynamic VIPA IP address succeeds as long as the desired IP address is not claimed by any other stack, is not an IP address of a physical interface or a static VIPA, and is not defined using VIPADEFine or VIPABackup in a VIPADynamic block.

MODDVIPA must run with APF authorization. For more information about APF authorization, see *IBM z/OS V2R1 Communications Server TCP/IP Implementation Volume 4: Security and Policy-Based Networking*, SG24-8099.

2.3.3 Distributed DVIPA (sysplex distributor)

Sysplex distributor is a function that allows an IP workload to be distributed to multiple server instances within the sysplex without requiring changes to clients or networking hardware and without delays in connection setup. It allows you to implement a dynamic VIPA as a single network-visible IP address that is used for a set of hosts belonging to the same sysplex cluster. A client on the IP network sees the sysplex cluster as one IP address, regardless of the number of hosts in the cluster.

With sysplex distributor, clients receive the benefits of workload distribution provided by both the Workload Manager (WLM) and the Quality of Service (QoS) Policy Agent. In addition, sysplex distributor ensures high availability of the IP applications running on the sysplex cluster by providing continued operation if a LAN fails, or an entire IP stack leaves the XCF group=, or a z/OS image is lost.

Important: Sysplex distributor works only for TCP applications, not UDP applications.

How sysplex distributor works

Consider the environment shown in Figure 2-2. It includes four TCP/IP stacks (in four z/OS images) running in the same sysplex cluster in WLM GOAL. All stacks have SYSPLEXROUTING and DYNAMICXCF configured. Assume the following configuration:

- H1 is configured as the distributing IP stack with V1 as the Dynamic VIPA (DVIPA) assigned to the sysplex cluster.
- H2 is configured as backup for V1.
- H3 and H4 are configured as secondary backups for V1.
- APPL1 is running in all the hosts that are members of the same sysplex cluster.

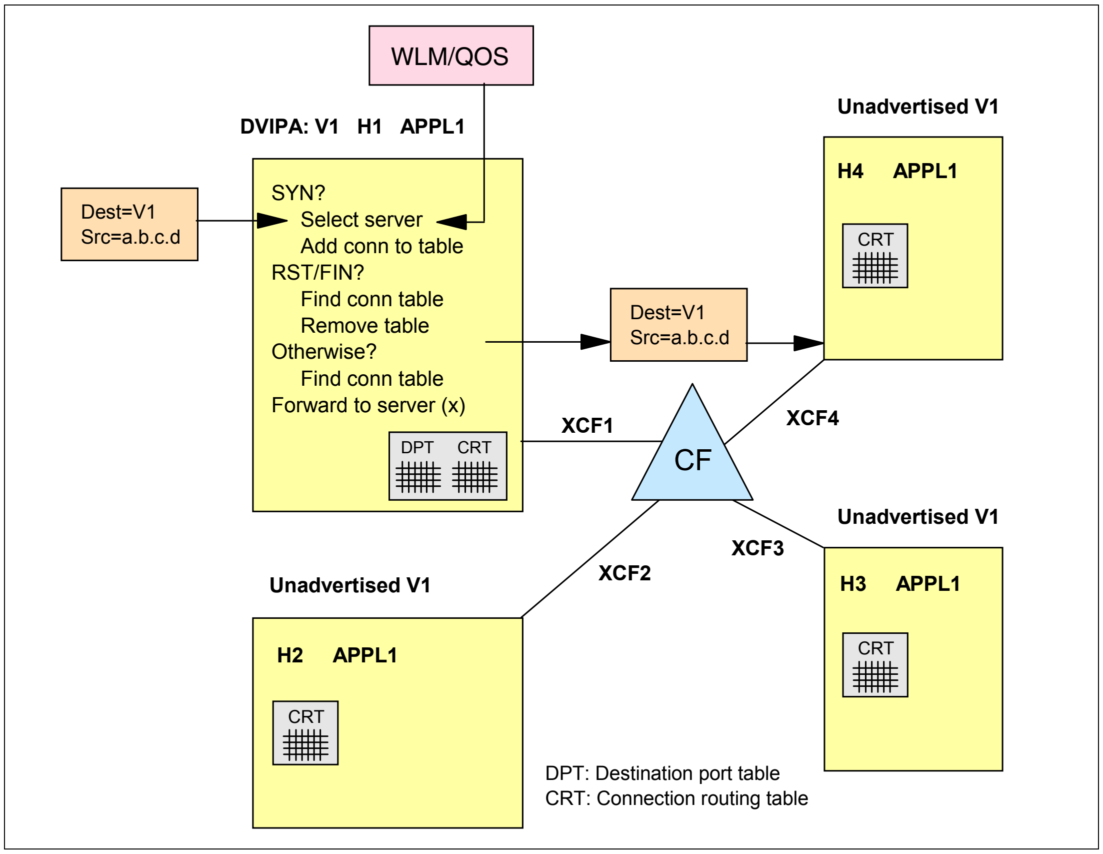


Figure 2-2 Sysplex distributor functionality

Sysplex distributor works as follows:

1. When IP stack H1 is activated, the definitions for the local XCF1 link are created dynamically because of DYNAMICXCF being coded in the H1 profile. Through this link, H1 recognizes the other IP stacks that belong to the same sysplex cluster and their XCF associated links: XCF2, XCF3, and XCF4.
2. The DVIPA assigned to the sysplex cluster and the application ports that this DVIPA serves are read from the VIPADISTRIBUTE statement in the profile data set. An entry in the home list for all stacks is added for the distributed IP address. The home list entry on the target stacks is done with a message that H1 sends to all the stacks read from the VIPADISTRIBUTE statement. Only one stack (H1, in this example) advertises the DVIPA through the RIP or OSPF routing protocol.

3. H1 monitors whether there is at least one application (APPL1 in Figure 2-2 on page 20) with a listening socket for the designated port and DVIPA. H2, H3, and H4 send a message to H1 when a server (APPL1) is bound to either INADDR_ANY or specifically to the DVIPA (and, of course, the designated port). With that information, H1 builds a table with the name of the application and the IP stacks that could serve a connection request for it. The table matches the application server listening port with the target XCF IP address.
4. When a network client requests a service from APPL1, DNS resolves the IP address for the application with the DVIPA address. (This DNS could be any DNS in the IP network and does not need to register with WLM.)
5. When H1 receives the connection request (a TCP segment with the SYN flag), it queries WLM or QoS (or both) to select the best target stack for APPL1 and forwards the SYN segment to the chosen target stack. In our example, it is APPL1 in H4 that best fits the request.
6. An entry is created in the connection routing table (CRT) in H1 for this new connection, with XCF4 as the target IP address. H4 also adds the connection to its connection routing table.

   If a program binds to DVIPA on H4 and initiates a connection, H4 needs to send a message to H1 so that H1 can update its connection routing table accordingly. As an example, this is used when the FTP server on H4 would initiate a data connection (port 20) to a client.
7. The H1 IP stack forwards subsequent incoming data for this connection to the correct target stack.
8. When the H4 IP stack decides that the connection no longer exists, it informs the H1 IP stack with a message so H1 can remove the connection from its connection routing table.

Backup capability

The VIPA takeover functionality supports sysplex distributor. The following example illustrates its usage, as shown in Figure 2-3 on page 22.

Consider the situation where our example has been running for some time without problems. APPL1 connections have been distributed (according to WLM directions) to H1, H2, H3, and H4. Many connections are currently established between several APPL1 server images and clients in the IP network.

Assume we now have a major failure in our distributing IP stack (H1). Automatic dynamic VIPA takeover occurs. This function allows a VIPA address to automatically move from one IP stack where it was defined to another one in the event of the failure of the first. The VIPA address remains active in the IP network, allowing clients to access the services associated with it.

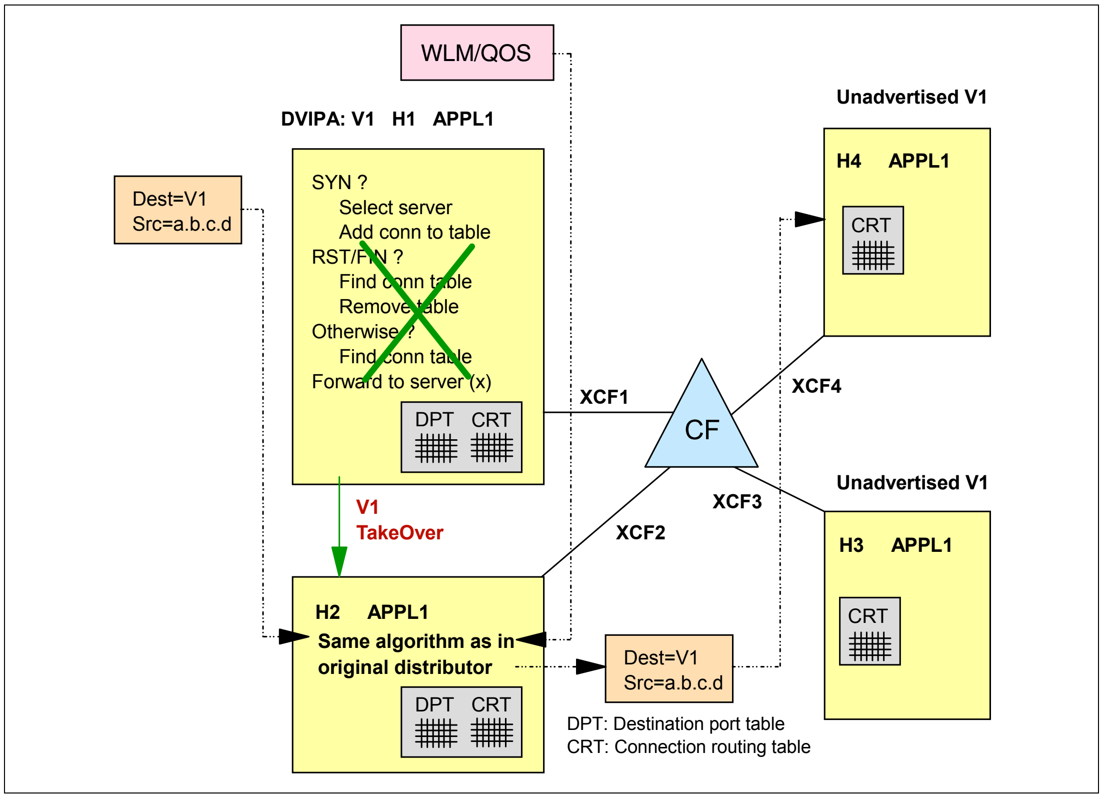


Figure 2-3 DVIPA backup capability

In our example, H1 is the distributing IP stack and H2 is the primary VIPABACKUP IP stack. When H1 fails, the following actions occur:

1. All the IP connections terminating at H1 are lost. The sysplex distributor connection routing table (CRT) is also lost.
2. H2 detects that H1 is down (because it has left the XCF group) and defines itself as the distributing IP stack for the VIPA.
3. Because H2 saved information about H1, it informs the other target stacks that it knows V1 is distributable.
4. H3 and H4 are informed that H2 is the chosen backup for V1 and they immediately send connection information regarding V1 to IP stack H2.
5. H2 advertises V1 (DVIPA) through the dynamic routing protocol (RIP or OSPF). Retransmitted TCP segments for already existing connections or SYN segments for new connections are hereafter processed by IP stack H2 and routed by H2 to the appropriate target stacks.

Notice that only the IP connections with the failing IP stack are lost. All other connections remain allocated and function properly.

Recovery

After the H1 IP stack is activated again, the process of taking back V1 to H1 is started automatically. This process is nondisruptive for the IP connections already established with V1, regardless of which host is the owner at that time (in our example, H2). In our example, connection information is maintained by H2. When H1 is reactivated, H2 sends its connection information to H1. This gives H1 the information it needs to distribute packets again for existing connections to the correct stacks in the sysplex.

Connections with the backup host are not broken when the V1 address is taken back to H1, and takeback is not delayed until all connections with the backup host have terminated. Figure 2-4 illustrates this situation.

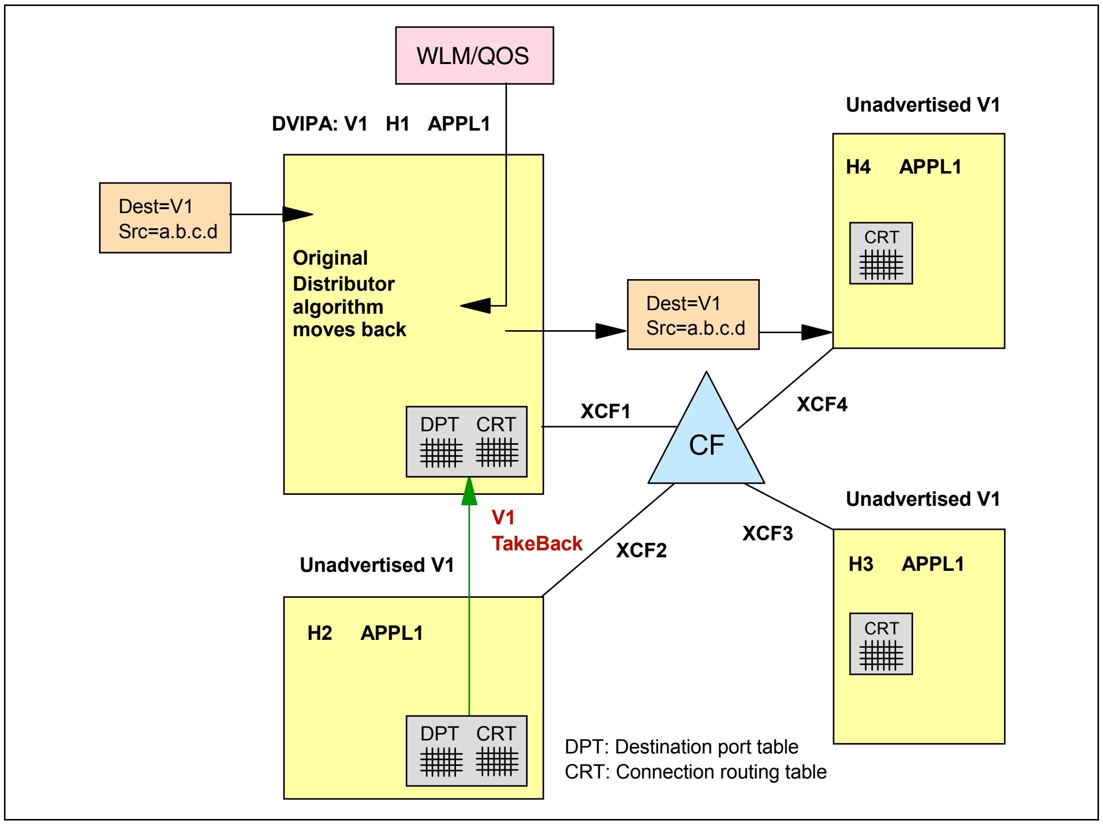


Figure 2-4 Sysplex distributor and VIPA takeback

Dynamic routing with sysplex distributor

Routing IP packets for sysplex distributor can be divided into two cases:

- Routing inside the sysplex cluster
- Routing through the IP network

Routing *inside* the sysplex cluster is accomplished by the distributing host. All incoming traffic (new connection requests and connection data) arrives at the distributing stack. This stack forwards the traffic to the target applications in the sysplex cluster, using XCF links or using the VIPARoute function. (See “VIPARoute function” on page 24 for more information.) OSA-Express connections can be used also.

Routing *outside* the sysplex is done by the downstream routers. Those routers learn about the DVIPA assigned to the sysplex dynamically using OSPF or RIP routing protocols. It is usually necessary to implement either one of these routing protocols in all the IP stacks of the sysplex cluster.

The distributing VIPA address is dynamically added to the home list of each IP stack participating in the sysplex distributor, but only one IP stack advertises the sysplex VIPA address to the routers: the one defined as the distributing IP stack. The other stacks do not advertise it and only the backup IP stack does so if the distributing IP stack leaves the XCF group (for example, resulting from some sort of failure).

When using OMPROUTE, consider the following information:

- Names of Dynamic VIPA interfaces are assigned dynamically by the stack when they are created. Therefore, the name coded for the OSPF_Interface statement in the Name field is ignored by OMPROUTE.
- As a suggestion, be sure each OMPROUTE server has an OSPF_Interface defined for each Dynamic VIPA address that the IP stack might own or, if the number of DVIPAs addresses is large, use a wildcard character.

Another possibility is to define ranges of dynamic VIPA interfaces using the subnet mask and the IP address on the OSPF_Interface statement. The range defined includes all the IP addresses that fall within the subnet defined by the mask and the IP address.

For consistency with the VIPARANGE statement in the TCPIP.PROFILE, any value that can fall within this range can be used to define a range of dynamic VIPAs.

VIPARoute function

The VIPARoute function was introduced with z/OS V1R7 Communications Server. Previously, all DVIPA IP traffic was forwarded to target stacks only by using Dynamic XCF interfaces. The VIPARoute function can use any available interface for this traffic forwarding. Using alternative interfaces can improve performance while reducing the usage of Sysplex XCF interfaces.

Figure 2-5 illustrates this function where a mixture of XCF, an external Ethernet LAN, and HiperSockets can be used to forward traffic. WLM and QoS weights are factors considered in target selection for new requests. However, *outgoing* traffic generated by the applications is routed according to the routing table in each stack.

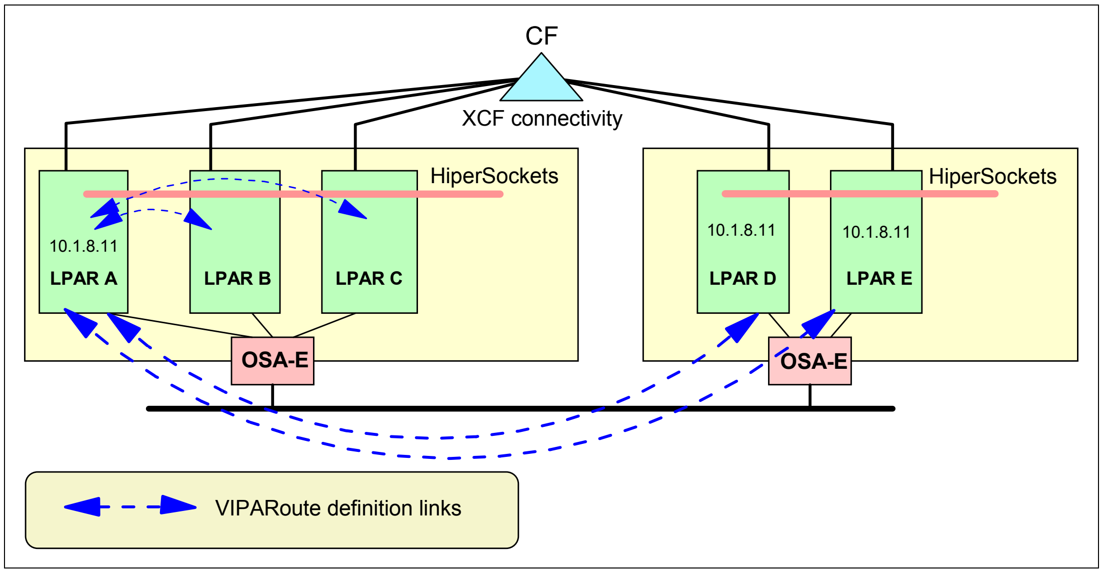


Figure 2-5 VIPARoute function

Because z/OS releases prior to V1R7 cannot process a VIPAROUTE statement, they must send distributed traffic using Dynamic XCF interfaces.

For more information, see 5.2.6, “Optimized routing” on page 145.

Application availability modes

Consider the following *availability modes* for an application (arranged in order from least available to most highly available) to determine which type of DVIPA is appropriate:

- Single-instance

  Running only one instance of an application

- Single-instance with automated restart

  Running only one instance of an application, but leveraging automation utilities such as Automatic Restart Manager (ARM) in the case of an application failure to either immediately restart the application in the same place or start it on another stack

- Single-instance with hot standby

  Running only one instance of an application, but having standby instances of the same application running and ready to take over in the event of a failure (or termination) of the first instance (this is still essentially single-instance because there is only one copy of the application that is available at any given time)

- Multiple-instance

  Running multiple, concurrently available instances of the same application and balancing workload across them

Multiple application instances provide the highest availability (and higher scalability), but not all applications can support multiple concurrent instances, as in the following examples:

- An FTP server might require exclusive access to certain data sets.
- A TN3270 server might require use of specific LU names.
- Software license limitations might exist.
- Specific requirements might exist for application implementation that limit the application to a single instance, such as lack of locking or data sharing in the basic program design, need for exclusive access to certain resources, architecturally-related dependencies, or other issues.
- Possible client dependencies upon a particular server instance might exist.

For the purposes of this chapter, we assume that such single-instance characteristics are fixed and cannot be changed. Depending on your applications, you might need to implement several of these application availability modes.

Ultimately, the availability modes that you need to support (based upon your specific set of applications) dictate how you set up and use DVIPAs and distributed DVIPAs. Table 2-1 summarizes the choices for providing availability that is higher than just running a single instance of an application.

Table 2-1 Matching DVIPA support with application requirements

Availability mode	Type of DVIPA to use	How to define it
Single-instance with automated restart (same stack or different stack)	Event-activated DVIPA (driven by application bind, `IOCTL`, or `MODDVIPA` command)	VIPARANGE
Single-instance with hot standby	Stack-managed DVIPA	VIPADEFINE (primary owner), VIPABACKUP (backup stacks)
Multiple-instance	Distributed DVIPA	VIPADEFINE (primary owner) VIPABACKUP (backup stacks) VIPADISTRIBUTE

2.4 Static VIPA example

In this section, we implement a static VIPA configuration. Also, we show you how to delete a VIPA on a stack and redefine the same VIPA on another stack. This information is useful when there is a requirement to move an IP address to a system that is not in the same sysplex, or to a system not in a sysplex.

We define a static VIPA for TCPIPA on SC30, and use two OSA interfaces for actual packet forwarding. Example 2-1 shows the configuration we used. You may use either static routing or dynamic routing. We used static routing for this example.

Example 2-1 Configuration for static VIPA with static routing

```
IPCONFIG SOURCEVIPA

DEVICE VIPA1      VIRTUAL 0         1
LINK   VIPA1L     VIRTUAL 0   VIPA1 1

INTERFACE OSA2080I     2
DEFINE IPAQENET
PORTNAME OSA2080
SOURCEVIPAINT VIPA1L
IPADDR 10.1.2.11/24    3
MTU 1492
VLANID 10
VMAC ROUTELCL
;
INTERFACE OSA20A0I     2
DEFINE IPAQENET
PORTNAME OSA20A0
SOURCEVIPAINT VIPA1L
IPADDR 10.1.2.12/24    3
MTU 1492
VLANID 10
VMAC ROUTEALL

HOME
   10.1.1.10     VIPA1L 4

BEGINRoutes  5
ROUTE 10.1.2.0/24         =        OSA2080I    MTU 1492
ROUTE 10.1.2.0/24         =        OSA20A0I    MTU 1492
ROUTE DEFAULT        10.1.2.230    OSA2080I    MTU 1492
ROUTE DEFAULT        10.1.2.230    OSA20A0I    MTU 1492
ENDRoutes

START OSA2080I
START OSA20A0I
```

The highlighted numbers have the following meaning:

1. Define the static VIPA DEVICE and LINK.
2. Define the OSA interfaces.
3. Set the IP address for the OSA interfaces.
4. Set the IP address for the static VIPA.
5. Define the static routes.

If the static VIPA does not reside on the same IP subnet as OSA, the external router needs to know the static VIPA can be reached through OSA. For static routing, we must define the static routes on the external router, as shown in Example 2-2. The router might need to advertise (redistribute) this static route using dynamic routing protocol to make this VIPA known throughout the network.

Example 2-2 Static route configuration for external router

```
ip route 10.1.1.10 255.255.255.255 10.1.2.12 1
```

The highlighted number 1 means the static VIPA address, 10.1.1.10, can be reached through OSA address, 10.1.2.12.

Example 2-3 shows that the static routes on the external router is correctly set, and it has connectivity to the static VIPA on z/OS.

Example 2-3 Static route configuration showing connectivity

```
show ip route 10.1.1.10
Routing entry for 10.1.1.10/32
  Known via "static", distance 1, metric 0 1
  Routing Descriptor Blocks:
  * 10.1.2.12 2
      Route metric is 0, traffic share count is 1

ping 10.1.1.10
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.1.10, timeout is 2 seconds:
!!!!! 3
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
```

The highlighted numbers have the following meaning:

1. This is a static route.

2. The VIPA address can be accessed through 10.1.2.12.

3. The `ping` command to the VIPA is successful.

Now we demonstrate how to remove the static VIPA from TCPIPA on SC30, and redefine them for TCPIPB on SC31. Example 2-4 shows the OBEYFILE to be issued on SC30 to delete the static VIPA. Example 2-5 on page 28 shows the OBEYFILE to be issued on SC31 to add the static VIPA.

Example 2-4 Definition for OBEYFILE on SC30

```
HOME
;  10.1.1.10     VIPA1L       1
   10.1.4.11     IUTIQDF4L
   10.1.5.11     IUTIQDF5L
   10.1.6.11     IUTIQDF6L
DELETE LINK   VIPA1L          2
DELETE DEVICE VIPA1           2
```

Example 2-5 Definitions for OBEYFILE on SC31

```
DEVICE VIPA1A VIRTUAL 0       3
LINK VIPA1LA VIRTUAL 0 VIPA1A  3
;
HOME
   10.1.1.20     VIPA1L
   10.1.4.21     IUTIQDF4L
   10.1.5.21     IUTIQDF5L
   10.1.6.21     IUTIQDF6L
   10.1.1.10     VIPA1LA       4
```

The highlighted numbers in the two examples have the following meaning:

1. Remove the IP address from the HOME list. Include the IP address of the devices that you do not want to modify.
2. These statements delete the static VIPA DEVICE and LINK.
3. These statements define the static VIPA DEVICE and LINK.
4. Set the IP address for the newly defined static VIPA (which is taken over from TCPIPA stack). Include the IP address of the devices that you do not want to modify.

Note: When OBEYFILE is issued against the definition containing the HOME statements, it replaces the entire HOME statement list. Make sure you include the IP address of the devices you do not want to modify in the HOME statement list.

Issue OBEYFILE first on TCPIPA, and then TCPIPB. Example 2-6 shows the NETSTAT,HOME display. It includes the newly defined static VIPA for TCPIPB on SC31.

Example 2-6 NETSTAT HOME display with new static VIPA

```
D TCPIP,TCPIPB,N,HOME
EZD0101I NETSTAT CS V1R13 TCPIPB 895
HOME ADDRESS LIST:
LINKNAME:   VIPA1L
  ADDRESS:  10.1.1.20
    FLAGS:  PRIMARY
LINKNAME:   IUTIQDF4L
  ADDRESS:  10.1.4.21
    FLAGS:
LINKNAME:   IUTIQDF5L
  ADDRESS:  10.1.5.21
    FLAGS:
LINKNAME:   IUTIQDF6L
  ADDRESS:  10.1.6.21
    FLAGS:
LINKNAME:   VIPA1LA                    5
  ADDRESS:  10.1.1.10                  5
    FLAGS:
INTFNAME:   OSA2080I
  ADDRESS:  10.1.2.21
    FLAGS:
INTFNAME:   OSA20A0I
  ADDRESS:  10.1.2.22
    FLAGS:
```

The highlighted number 5 indicates the newly defined static VIPA that has the IP address taken over from TCPIPA stack.

Because this is a static routing configuration, the external router still has a routing information that static VIPA, 10.1.1.10, can be accessed through OSA on TCPIPA (10.1.2.12). So, we change the configuration on the external router, as shown in Example 2-7, to delete the old static route and add a new static route that routes the packets to VIPA through OSA on TCPIPB (10.1.2.22).

Example 2-7 Adding a new static route

```
no ip route 10.1.1.10 255.255.255.255 10.1.2.12
ip route 10.1.1.10 255.255.255.255 10.1.2.22
```

Example 2-8 shows that the new routing information and the ping to the static VIPA on TCPIPB is now successful.

Example 2-8 NETSTAT HOME display of new route

```
show ip route 10.1.1.10
Routing entry for 10.1.1.10/32
  Known via "static", distance 1, metric 0
  Routing Descriptor Blocks:
  * 10.1.2.22
      Route metric is 0, traffic share count is 1

ping 10.1.1.10
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.1.10, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
```

Tip: If you do not want to change the router configuration when moving the static VIPA, consider moving the IP address of the OSA also. (In our case, we would move OSA IP address10.1.2.12 to the TCPIPB stack). In this case, the external router does not need the routing changes.

2.5 Dynamic VIPA example

This section has examples of the three types of DVIPAs:

- Stack-managed
- Event-activated
- Distributed

2.5.1 Stack-managed DVIPA

In this section, we implement a stack-based (VIPADEFINE and BACKUP) configuration. It relates the design, implementation, and operational techniques we use. We work in two LPARs named SC30 and SC31, and we use TCP/IP stacks named TCPIPA and TCPIPB. Our goal is to implement and exercise a failover situation (both automatic and operator-directed), as illustrated in Figure 2-6 on page 30. To keep the example simple, we use FTP as the application.

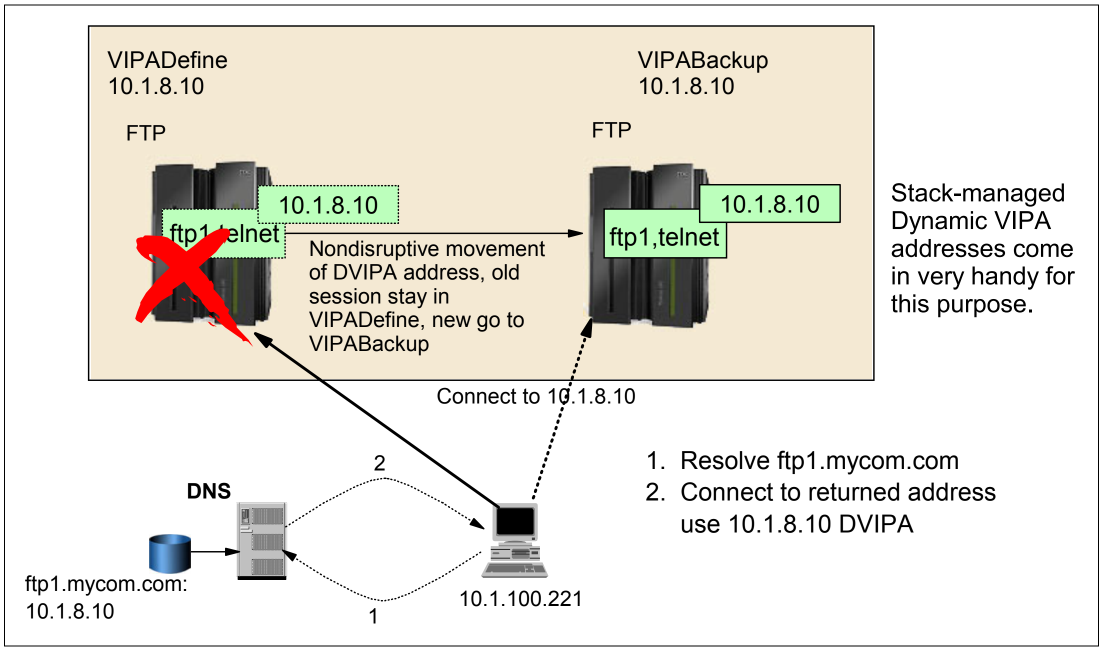

VIPADefine
10.1.8.10
FTP
10.1.8.10
ftp1,telnet
VIPABackup
10.1.8.10
FTP
10.1.8.10
ftp1,telnet
Nondisruptive movement of DVIPA address, old session stay in VIPADefine, new go to VIPABackup
Stack-managed Dynamic VIPA addresses come in very handy for this purpose.
Connect to 10.1.8.10
DNS
2
1
ftp1.mycom.com:
10.1.8.10
10.1.100.221
1. Resolve ftp1.mycom.com
2. Connect to returned address use 10.1.8.10 DVIPA

Figure 2-6 Stack-managed DVIPA with nondisruptive movement in TAKEBACK

Advantages

When a stack or its underlying z/OS fails, it is not necessary to restart the stack with the same configuration profile on a separate z/OS image. After the stack leaves the XCF group, the VIPA address is moved automatically to another stack without the need for human intervention. The new stack receives information regarding the connections from the original stack and accepts new connections for the DVIPA. The routers are informed automatically about the change. This method increases availability because multiple server instances can be started in separate stacks.

VIPA takeover allows complete flexibility in the placement of servers within sysplex nodes, and is not limited to traditional LAN interconnection with MAC addresses. Building on the VIPA concept means that spare adapters do not have to be provided, as long as the remaining adapters have enough capacity to handle the increased load. Spare processing capacity can be distributed across the sysplex rather than on a single node.

Dependencies

External access to our TCP/IP is through DNS and we need OMPROUTE active to inform DNS about any changes to the DVIPA location. We also need our TCP/IP stacks configured to support DYNAMICXCF, which is needed for nondisruptive movement of DVIPAs. Finally, we decide to use SYSPLEXROUTING, although this is optional.

Implementation

The goal is to do the following tasks:

- Provide the necessary definitions to use VIPA Define and VIPA Backup.
- Use various commands to display the results of our definitions.
- Exercise the takeover and takeback function in both automatic and manual operation.

Figure 2-7 shows the base network configuration that we use.

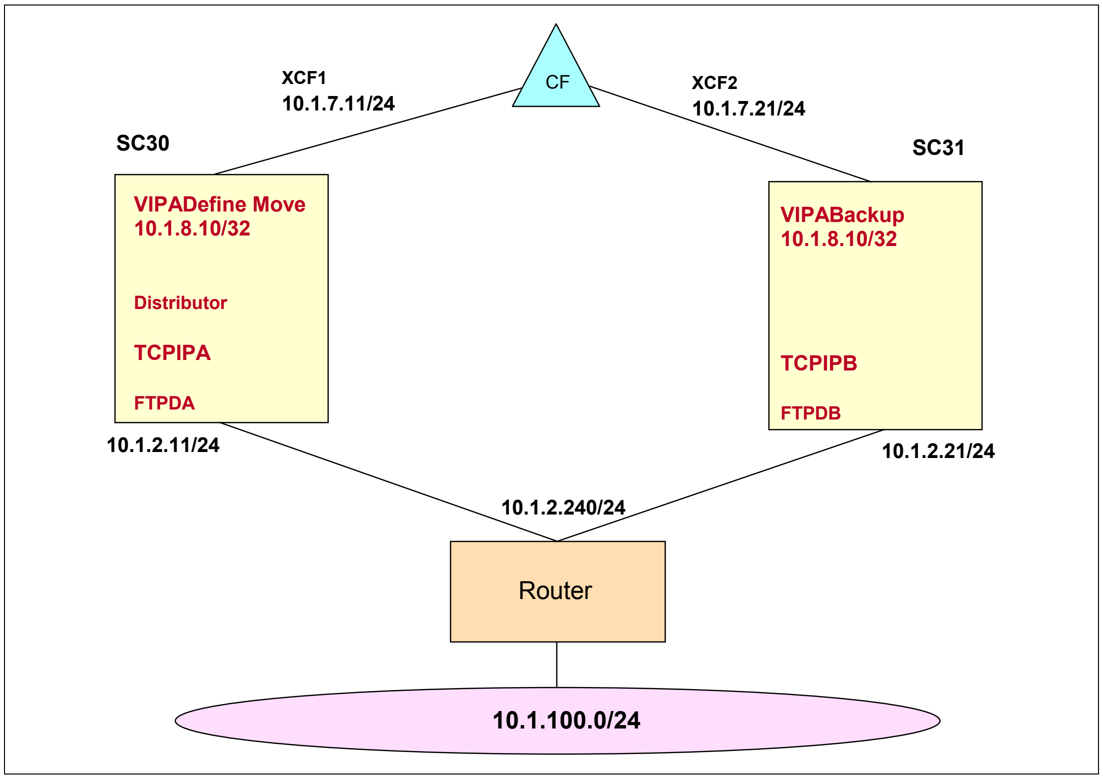


Figure 2-7 Base network diagram used for stack-managed implementation

Definitions

Remember that we are using LPARs SC30 and SC31, and our TCP/IP stack names are TCPIPA and TCPIPB. The following material illustrates only the statements in the PROFILEs (and OMPRoute configuration) that are relevant to our specific task.

Our PROFILE for TCPIPA on SC30 includes the statements shown in Example 2-9.

Example 2-9 Our PROFILE for TCPIPA on SC30

```
IPCONFIG DATAGRAMFWD SYSPLEXROUTING
DYNAMICXCF 10.1.7.11 255.255.255.0 8
...
VIPADynamic
VIPADEFine     MOVEable IMMEDiate 255.255.255.255 10.1.8.10
VIPABACKUP 100 MOVEable IMMEDiate 255.255.255.255 10.1.8.20
ENDVIPADynamic
```

Example 2-10 shows the statements in our PROFILE for TCPIPB on SC31.

Example 2-10 Our PROFILE for TCPIPB on SC31

```
IPCONFIG DATAGRAMFWD SYSPLEXROUTING
DYNAMICXCF 10.1.7.21 255.255.255.0 8
...
VIPADynamic
VIPADEFine     MOVEable IMMEDiate 255.255.255.255 10.1.8.20
VIPABACKUP 100 MOVEable IMMEDiate 255.255.255.255 10.1.8.10
ENDVIPADynamic
```

Example 2-11 shows the statements in our OMPRoute definitions.

Example 2-11 Our OMPRoute definitions for TCPIPA on SC30 and TCPIPB on SC31

```
; VIPADefine/VIPABackup vipa
OSPF_Interface ip_address=10.1.8.*
           subnet_mask=255.255.255.0
           Advertise_VIPA_Routes=HOST_ONLY
           attaches_to_area=0.0.0.2
           cost0=10
           mtu=65535;
```

Verification

After activating the TCP/IP stacks with these definitions, we use operator commands to display VIPADCFG and VIPADYN status. Example 2-12 shows the commands and results from the two LPARs.

Example 2-12 Display results VIPA definition for TCPIPA and TCPIPB(SC30 and 31)

```
D TCPIP,TCPIPA,N,VIPADCFG
EZD0101I NETSTAT CS V1R13 TCPIPA 553
DYNAMIC VIPA INFORMATION:
  VIPA BACKUP:
    IPADDR/PREFIXLEN: 10.1.8.20
      RANK: 100  MOVEABLE:            SRVMGR:     FLG:
  VIPA DEFINE:
    IPADDR/PREFIXLEN: 10.1.8.10/24
      MOVEABLE: IMMEDIATE  SRVMGR: NO  FLG:
END OF THE REPORT

D TCPIP,TCPIPB,N,VIPADCFG
EZD0101I NETSTAT CS V1R13 TCPIPB 714
DYNAMIC VIPA INFORMATION:
  VIPA BACKUP:
    IPADDR/PREFIXLEN: 10.1.8.10
      RANK: 100  MOVEABLE:            SRVMGR:
  VIPA DEFINE:
    IPADDR/PREFIXLEN: 10.1.8.20/24
      MOVEABLE: IMMEDIATE  SRVMGR: NO  FLG:
END OF THE REPORT

D TCPIP,TCPIPA,SYSPLEX,VIPADYN
EZZ8260I SYSPLEX CS V1R13 555
VIPA DYNAMIC DISPLAY FROM TCPIPA   AT SC30
LINKNAME: VIPL0A01080A
IPADDR/PREFIXLEN: 10.1.8.10/24
  ORIGIN: VIPADEFINE
  TCPNAME  MVSNAME  STATUS RANK DIST
  -------- -------- ------ ---- ----
  TCPIPA   SC30     ACTIVE
  TCPIPB   SC31     BACKUP 100
IPADDR: 10.1.8.20
  ORIGIN: VIPABACKUP
  TCPNAME  MVSNAME  STATUS RANK DIST
  -------- -------- ------ ---- ----
  TCPIPB   SC31     ACTIVE
  TCPIPA   SC30     BACKUP 100

D TCPIP,TCPIPB,SYSPLEX,VIPADYN
EZZ8260I SYSPLEX CS V1R13 711
VIPA DYNAMIC DISPLAY FROM TCPIPB   AT SC31
IPADDR: 10.1.8.10
  ORIGIN: VIPABACKUP
  TCPNAME  MVSNAME  STATUS RANK DIST
  -------- -------- ------ ---- ----
  TCPIPA   SC30     ACTIVE
  TCPIPB   SC31     BACKUP 100
LINKNAME: VIPL0A010814
IPADDR/PREFIXLEN: 10.1.8.20/24
  ORIGIN: VIPADEFINE
  TCPNAME  MVSNAME  STATUS RANK DIST
  -------- -------- ------ ---- ----
  TCPIPB   SC31     ACTIVE
  TCPIPA   SC30     BACKUP 100
```

We also display the OSPF routing table on TCPIPA, as shown in Example 2-13. Note the presence of the local dynamic VIPA with its stack-generated link name.

Example 2-13 Display OMPRoute after DVIPA activation

```
D TCPIP,TCPIPA,OMPR,RTTABLE
EZZ7847I ROUTING TABLE 560
TYPE   DEST NET         MASK      COST    AGE     NEXT HOP(S)

SPIA   0.0.0.0                 0  101     2538    10.1.2.240       (4)
 DIR*  10.1.1.0         FFFFFF00  1       2549    10.1.1.10
 DIR*  10.1.1.10        FFFFFFFF  1       2549    VIPA1L
 SPF   10.1.1.20        FFFFFFFF  100     2253    10.1.4.21        (2)
 SPF*  10.1.2.0         FFFFFF00  100     2538    OSA2080I         (2)
 DIR*  10.1.2.10        FFFFFFFF  1       2549    VIPA2L
 SPF*  10.1.3.0         FFFFFF00  100     2538    OSA20C0I         (2)
STAT*  10.1.7.0         FFFFFF00  0       2550    10.1.7.11
STAT*  10.1.7.21        FFFFFFFF  0       2257    10.1.7.11
 DIR*  10.1.8.0         FFFFFF00  1       2257    10.1.8.10
 DIR*  10.1.8.10        FFFFFFFF  1       2549    VIPL0A01080A
 SPF   10.1.8.20        FFFFFFFF  100     2253    10.1.4.21        (2)
 SPF   10.1.100.0       FFFFFF00  101     2538    10.1.2.240       (4)
```

We start the FTP service in the client workstation to use this DVIPA address. We then check the new status of the session, as shown in Example 2-14.

Example 2-14 Display sessions using DVIPA address

```
D TCPIP,TCPIPA,N,CONN
EZD0101I NETSTAT CS V1R13 TCPIPA 564
USER ID  CONN     STATE
FTPDA1   000000E1 ESTBLSH
  LOCAL SOCKET:   ::FFFF:10.1.8.10..21
  FOREIGN SOCKET: ::FFFF:10.1.100.222..1163
FTPDA1   00000029 LISTEN
  LOCAL SOCKET:   ::..21
  FOREIGN SOCKET: ::..0
```

MOVE IMMED and WHENIDLE

We try two separate options for this exercise, based on MOVE IMMED and MOVE WHENIDLE parameters. When a stack leaves the XCF group (such as resulting from a failure), it causes immediate movement of a DVIPA to its backup stack. These two parameters determine how the original stack takes back the DVIPA from the backup stack when the problem is resolved.

The MOVE IMMED causes the DVIPA to be moved back to the primary stack immediately after the primary stack is available.The existing TCP connections are preserved, however, new TCP connections are now routed to primary stack.

The MOVE WHENIDLE parameter causes the takeback to be delayed. The existing TCP connections are preserved, and new TCP connections are still routed to the backup stack until all TCP connections are closed on the backup stack.

Examples of MOVE IMMED and WHENIDLE

This section shows examples of MOVE IMMED (movable and immediate) and WHENIDLE.

MOVE IMMED

In this example, we use the definitions from Example 2-9 on page 31 and Example 2-10 on page 31.

We define the primary VIPA IP addresses of 10.1.8.10 on TCPIPA in SC30, and we define the same VIPA address in TCPIPB on SC31 as the backup, with MOVE IMMED specified. We start our server application (FTP) on both stacks and establish connections from a client to the server on TCPIPA in SC30 10.1.8.10.

We stop the TCPIPA to verify that the automatic takeover function works. Example 2-15 and Example 2-16 shows the result of this operation. The network is informed, using dynamic routing of OSPF, that the VIPA has moved and all connection requests are routed to the new stack owning the VIPA now. All other sysplex stacks are informed of the failure through XCF (because the stack left the XCF group) and take steps to recover the failed VIPA. The stack with the highest rank (the only stack) on the backup list for 10.1.8.10 is TCPIPB on SC31.

Example 2-15 TCPIPA termination in SC30

```
P TCPIPA
EZZ3205I SNMP SUBAGENT: SHUTDOWN IN PROGRESS
EZZ0673I AUTOLOG TASK: SHUTDOWN IN PROGRESS
...
EZZ4201I TCP/IP TERMINATION COMPLETE FOR TCPIPA
IEF352I ADDRESS SPACE UNAVAILABLE
```

Example 2-16 Display on SC31 after TCPIPA termination in SC30

```
EZZ8301I VIPA 10.1.8.10 TAKEN OVER FROM TCPIPA ON SC30

D TCPIP,TCPIPB,SYSPLEX,VIPAD
EZZ8260I SYSPLEX CS V1R13 725
VIPA DYNAMIC DISPLAY FROM TCPIPB   AT SC31
LINKNAME: VIPL0A01080A
IPADDR/PREFIXLEN: 10.1.8.10/24
  ORIGIN: VIPABACKUP
  TCPNAME  MVSNAME  STATUS RANK DIST
  -------- -------- ------ ---- ----
  TCPIPB   SC31     ACTIVE
LINKNAME: VIPL0A010814
IPADDR/PREFIXLEN: 10.1.8.20/24
```

```
  ORIGIN: VIPADEFINE
  TCPNAME  MVSNAME  STATUS RANK DIST
  -------- -------- ------ ---- ----
  TCPIPB   SC31     ACTIVE

D TCPIP,TCPIPB,N,VIPADYN
EZD0101I NETSTAT CS V1R13 TCPIPB 723
DYNAMIC VIPA:
  IPADDR/PREFIXLEN: 10.1.8.10/24
    STATUS:  ACTIVE     ORIGIN: VIPABACKUP       DISTSTAT:
    ACTTIME: 07/15/2011 18:22:52
  IPADDR/PREFIXLEN: 10.1.8.20/24
    STATUS:  ACTIVE     ORIGIN: VIPADEFINE       DISTSTAT:
    ACTTIME: 07/15/2011 17:33:11
2 OF 2 RECORDS DISPLAYED
END OF THE REPORT

(Display of new ftp session using 10.1.8.10 in VIPABACKUP)
D TCPIP,TCPIPB,N,CONN
EZD0101I NETSTAT CS V1R13 TCPIPB 729
USER ID  CONN     STATE
...
FTPDB1   00000036 LISTEN
  LOCAL SOCKET:   ::..21
  FOREIGN SOCKET: ::..0
FTPDB1   000000CA ESTBLSH
  LOCAL SOCKET:   ::FFFF:10.1.8.10..21
  FOREIGN SOCKET: ::FFFF:10.1.100.222..1166
```

Disruptive failure: This type of “failure” is disruptive to connections that are active when the takeover occurs. However, most TCP/IP applications recover from this automatically. Movements during takeback are nondisruptive.

We then restart the original TCPIPA stack on SC30, including the FTP application. The VIPA address 10.1.8.10 is returned automatically from SC31 to SC30. Example 2-17 and Example 2-18 show the console messages associated with this action.

Example 2-17   Console message on SC31 after recovery of TCPIPA on SC30

```
EZZ8303I VIPA 10.1.8.10 GIVEN TO TCPIPA ON SC30
```

Example 2-18   Console messages on SC30 after recovery of TCPIPA

```
EZD1176I TCPIPA HAS SUCCESSFULLY JOINED THE TCP/IP SYSPLEX GROUP
EZBTCPCS
EZZ8302I VIPA 10.1.8.10 TAKEN FROM TCPIPB ON SC31
EZD1214I INITIAL DYNAMIC VIPA PROCESSING HAS COMPLETED FOR TCPIPA
```

TCPIPB in SC31 has the VIPA 10.1.8.10 active and has several active connections when the address is taken back by SC30. These active connections are not broken. Example 2-19 on page 36 shows the existing connections to SC31. However, TCPIPA in SC30 now receives all new connections. Example 2-19 on page 36 also shows the creation of a new FTP connection. It shows the VIPA connection routing table (VCRT) in both stacks, which include the old and new connections.

Example 2-19 Display of the older session in SC31 and new session in SC30 after the takeback

```
D TCPIP,TCPIPA,N,VCRT
EZD0101I NETSTAT CS V1R13 TCPIPA 726
DYNAMIC VIPA CONNECTION ROUTING TABLE:
DEST:      10.1.8.10..21
  SOURCE:  10.1.100.222..1167         2
  DESTXCF: 10.1.7.11
DEST:      10.1.8.10..21
  SOURCE:  10.1.100.222..1166         1
  DESTXCF: 10.1.7.21
2 OF 2 RECORDS DISPLAYED
END OF THE REPORT

D TCPIP,TCPIPA,N,CONN
EZD0101I NETSTAT CS V1R13 TCPIPA 728
USER ID  CONN     STATE
FTPDA1   0000003E ESTBLSH
  LOCAL SOCKET:   ::FFFF:10.1.8.10..21
  FOREIGN SOCKET: ::FFFF:10.1.100.222..1167 2
FTPDA1   00000028 LISTEN
  LOCAL SOCKET:   ::..21
  FOREIGN SOCKET: ::..0

D TCPIP,TCPIPB,N,CONN
EZD0101I NETSTAT CS V1R13 TCPIPB 734
USER ID  CONN     STATE
FTPDB1   00000036 LISTEN
  LOCAL SOCKET:   ::..21
  FOREIGN SOCKET: ::..0
FTPDB1   000000CA ESTBLSH
  LOCAL SOCKET:   ::FFFF:10.1.8.10..21
  FOREIGN SOCKET: ::FFFF:10.1.100.222..1166 1
```

In this example, the numbers correspond to the following information:

1. This is a connection that is preserved (still active) on SC31. Notice Netstat VCRT display shows it is routed to DESTXCF of 10.1.7.21 (SC31).
2. This is a new connection that is established on SC30 after the takeback. Notice Netstat VCRT display shows it is routed to DESTXCF of 10.1.7.11 (SC30).

As long as the session exists in SC31, backup stack TCPIPB is in the MOVING state. Example 2-20 shows this result.

Example 2-20 Display results VIPADYN command during the MOVING state

```
D TCPIP,TCPIPA,SYSPLEX,VIPADYN
EZZ8260I SYSPLEX CS V1R13 730
VIPA DYNAMIC DISPLAY FROM TCPIPA   AT SC30
LINKNAME: VIPL0A01080A
IPADDR/PREFIXLEN: 10.1.8.10/24
  ORIGIN: VIPADEFINE
  TCPNAME  MVSNAME  STATUS RANK DIST
  -------- -------- ------ ---- ----
  TCPIPA   SC30     ACTIVE
  TCPIPB   SC31     MOVING
```

```
IPADDR: 10.1.8.20
  ORIGIN: VIPABACKUP
  TCPNAME  MVSNAME  STATUS RANK DIST
  -------- -------- ------ ---- ----
  TCPIPB   SC31     ACTIVE
  TCPIPA   SC30     BACKUP 100
```

MOVE WHENIDLE

In this case, we use the same definitions and processes as for the last example, except that we change the parameter MOVE IMMED to MOVE WHENIDLE in VIPA DEFINE statements.

After activating the TCP/IP stacks with this definition, we use the **VIPADCFG** operator command to display moveable status. Example 2-21 shows this command's result.

Example 2-21 Display results of MOVE WHENIDLE definition

```
D TCPIP,TCPIPA,N,VIPADCFG
EZD0101I NETSTAT CS V1R13 TCPIPA 657
DYNAMIC VIPA INFORMATION:
  VIPA BACKUP:
    IPADDR/PREFIXLEN: 10.1.8.20
      RANK: 100  MOVEABLE:            SRVMGR:     FLG:
  VIPA DEFINE:
    IPADDR/PREFIXLEN: 10.1.8.10/24
      MOVEABLE: WHENIDLE   SRVMGR: NO  FLG:
  VIPA ROUTE:
    DESTXCF:     10.1.7.21
      TARGETIP:  10.1.1.20
END OF THE REPORT
```

The behavior is exactly the same as in the previous scenario. TCPIPA is informed of the failure through XCF and takes steps to recover the failed DVIPA. TCPIPB on SC31 dynamically defines and activates this DVIPA address.

We then restart TCPIPA in SC30 and start a new connection to DVIPA address 10.1.8.10. Because we define this DVIPA as MOVE WHENIDLE, the DVIPA is not taken back to SC30 because there were active connections to 10.1.8.10 on SC31.

Example 2-22 shows a new FTP connection to DVIPA address 10.1.8.10 and shows that this connection is established with TCPIPB in SC31, because the DVIPA has not yet been taken back.

Example 2-22 New connection still going to SC31

```
D TCPIP,TCPIPB,N,CONN
EZD0101I NETSTAT CS V1R13 TCPIPB 594
USER ID  CONN     STATE
FTPDB1   00000059 ESTBLSH
  LOCAL SOCKET:   ::FFFF:10.1.8.10..21
  FOREIGN SOCKET: ::FFFF:10.1.100.222..1487
FTPDB1   00000053 ESTBLSH
  LOCAL SOCKET:   ::FFFF:10.1.8.10..21
  FOREIGN SOCKET: ::FFFF:10.1.100.222..1486
```

While the sessions exist on SC31, the active DVIPA stays on the stack in SC31. Example 2-23 shows this result.

Example 2-23 VIPA active in SC31

```
D TCPIP,TCPIPB,N,VIPADYN
EZD0101I NETSTAT CS V1R13 TCPIPB 588
DYNAMIC VIPA:
  IPADDR/PREFIXLEN: 10.1.8.10/24
    STATUS:  ACTIVE     ORIGIN: VIPABACKUP       DISTSTAT:
    ACTTIME: 07/20/2011 15:01:17

D TCPIP,TCPIPB,SYSPLEX,VIPAD
EZZ8260I SYSPLEX CS V1R13 603
VIPA DYNAMIC DISPLAY FROM TCPIPB   AT SC31
LINKNAME: VIPL0A01080A
IPADDR/PREFIXLEN: 10.1.8.10/24
  ORIGIN: VIPABACKUP
  TCPNAME  MVSNAME  STATUS RANK DIST
  -------- -------- ------ ---- ----
  TCPIPB   SC31     ACTIVE
  TCPIPA   SC30     BACKUP 255
```

After all the FTP sessions are closed, the takeback operation is performed, and the active DVIPA returns to SC30. Example 2-24 shows the result of this operation.

Example 2-24 Take back DVIPA after close sessions

```
SC31 console message
EZD1298I DYNAMIC VIPA 10.1.8.10 DELETED FROM TCPIPB
EZZ8303I VIPA 10.1.8.10 GIVEN TO TCPIPA ON SC30

SC30 console message
EZZ8301I VIPA 10.1.8.10 TAKEN OVER FROM TCPIPB ON SC31
```

2.5.2 Event-activated DVIPA example

See Chapter 3, “VIPA without dynamic routing” on page 61 for detailed descriptions about distributed DVIPA.

2.5.3 Distributed DVIPA (sysplex distributor) example

See Chapter 5, “Internal application workload balancing” on page 127 for detailed descriptions about distributed DVIPA.

2.6 Sysplex problem detection and recovery

z/OS Communications Server provides for the monitoring of TCPIP stacks. If a stack detects a problem, a sysplex member removes itself from a sysplex group automatically and lets other stacks take over the DVIPAs (if a VIPABACKUP statement is defined on other stacks).

2.6.1 Problem detection

A variety of methods are available to detect a problem in the stack. When a problem is detected and GLOBALCONFIG SYSPLEXMONITOR RECOVERY is specified, the stack automatically leaves the sysplex group and deactivates all DVIPAs. Problems can include the following items:

- The TCP/IP stack suffers five or more abends within one minute.
- The VTAM address space is not currently active.
- There are no routes available to any partners, given the configured method chosen for forwarding data (VIPAROUTE statement or dynamic XCF interfaces).
- All critical interfaces are inactive (monitoring enabled by MONINTERFACE option).
- Absence of dynamic routes available over any of the critical interfaces (monitoring enabled by DYNROUTE option).
- OMPROUTE heartbeats are no longer being received.
- CSM storage is continuously critical.
- TCP/IP ECSA storage is continuously critical.
- TCP/IP private storage is continuously critical.
- XCF status is not being updated.

2.6.2 Automatic control of leaving/joining the sysplex group

There are several options you may specify on GLOBALCONFIG SYSPLEXMONITOR for automatic control of the TCP/IP stack leaving or joining the sysplex group when a problem is detected and relieved.

RECOVERY option

RECOVERY option causes the stack to leave the sysplex automatically. If a problem is detected and this stack is not the only member of the TCP/IP sysplex group, the stack leaves the sysplex group. The stack actually leaves when the time specified on TIMERSECS option has elapsed after the problem detection. The default value for TIMERSECS is 60 seconds.

AUTOREJOIN option

AUTOREJOIN option is used to let stack rejoin the sysplex when the problem that caused it to leave the sysplex is relieved. The stack automatically rejoins the sysplex group and reprocesses the saved VIPADYNAMIC block. AUTOREJOIN is supported only in combination with the SYSPLEXMONITOR RECOVERY option.

Tips: Restart of the stack also causes it to join the sysplex group.

NOJOIN option

NOJOIN option prevents a TCP/IP stack from automatically joining the sysplex group at startup. At a later time, this stack can join or leave the sysplex group manually when you use the manual operator commands. This option was introduced in z/OS V1R12.

You can use the `NETSTAT CONFIG /-f` command to display these options, as illustrated in Example 2-25.

Example 2-25 NETSTAT CONFIG/-f result for NOJOIN

```
Global Configuration Information:
TcpIpStats: Yes  ECSALimit: 0000000M  PoolLimit: 0000000M
MlsChkTerm: No   XCFGRPID:  21        IQDVLANID: 21
SegOffLoad: No   SysplexWLMPoll: 060  MaxRecs:   100
ExplicitBindPortRange:  00000-00000   IQDMultiWrite: No
WLMPriorityQ: No
Sysplex Monitor:
  TimerSecs: 0060  Recovery: No   DelayJoin: No   AutoRejoin: No
  MonIntf:   No    DynRoute: No   Join:      No
```

2.6.3 Automatic control of the DVIPA activation timing

By default, as soon as TCP/IP stack starts and the basic stack function's initialization completes, the stack joins the TCP/IP sysplex group and processes its dynamic VIPA configuration within TCP/IP profile statements. It is possible to control the timing of when a stack joins the TCP/IP sysplex group or when it activates dynamic VIPAs by TCP/IP profile definitions.

DELAYJOIN

DELAYJOIN specifies that joining the sysplex group and creating dynamic VIPAs is to be delayed until OMPROUTE is active.

When DELAYJOIN is specified, TCP/IP does not join the sysplex group until OMPROUTE is active. Because the stack's dynamic VIPA configuration is not processed until after the stack has joined the sysplex group, this delay in joining the sysplex group ensures that OMPROUTE is active and ready to advertise dynamic VIPAs when they are created on this stack.

Using AUTOLOG with DELAYJOIN

Procedures specified in the AUTOLOG statement automatically start as soon as TCP/IP initialization is completed.

If DELAYJOIN is configured, TCP/IP does not join the sysplex group and create dynamic VIPAs until OMPROUTE is ready to advertise them. However, procedures specified in the AUTOLOG statement can be started before OMPROUTE is active. Binds to dynamic VIPAs will fail until OMPROUTE is initialized and the stack has joined the sysplex group and created the dynamic VIPAs.

When the TCP/IP stack is started with DELAYJOIN configured, the following steps occur:

1. The stack completes basic initialization, but it is not in the sysplex group yet.
2. AUTOLOG then starts the specified procedures.
3. When OMPROUTE has completed its initialization and is active, it notifies the stack.
4. The stack joins the sysplex group and processes its dynamic configuration, which includes creating its dynamic VIPAs.

Until the stack has completed its dynamic configuration processing, any bind request to a dynamic VIPA fails because of the delay in creating these DVIPAs.

AUTOLOG DELAYSTART

z/OS Communications Server provides an optional keyword, DELAYSTART, for procedures specified on the AUTOLOG profile statement. DELAYSTART is used to identify procedures that should not be automatically started until after the stack has joined the sysplex group and its dynamic sysplex configuration is completed. After that occurs, bind requests to dynamic VIPAs can follow.

Important: Do not specify the DELAYSTART parameter for your OMPROUTE procedure if you specify the DELAYJOIN parameter on the GLOBALCONFIG profile statement. Otherwise, the stack completes its basic initialization, but OMPROUTE is never be started because AUTOLOG is waiting for the stack to join the sysplex group. The stack does not join the group and create its dynamic VIPAs because the stack is waiting for OMPROUTE to be active.

Figure 2-8 illustrates a timeline showing the process of sysplex-related definitions and autologged server binding to a dynamic VIPA when the TCP/IP stack starts. The first row shows default processing without DELAYJOIN and DELAYSTART parameters. The second row shows the process with DELAYJOIN. The third row shows the one with both DELAYJOIN and DELAYSTART.

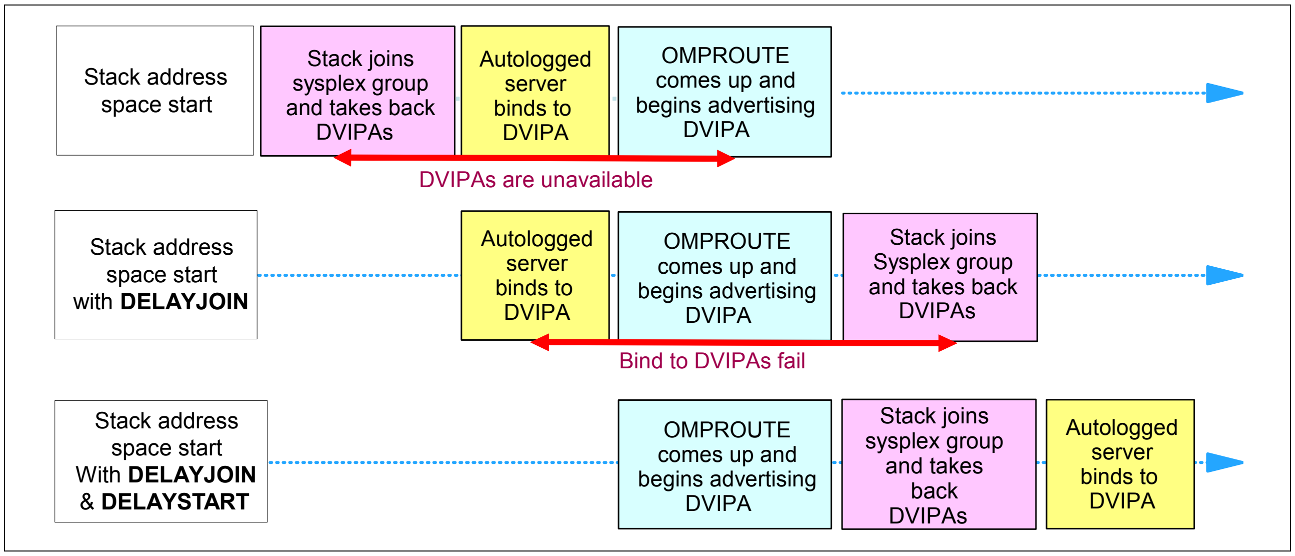

Stack address space start
Stack joins sysplex group and takes back DVIPAs
Autologged server binds to DVIPA
OMPROUTE comes up and begins advertising DVIPA
DVIPAs are unavailable
Stack address space start with **DELAYJOIN**
Autologged server binds to DVIPA
OMPROUTE comes up and begins advertising DVIPA
Stack joins Sysplex group and takes back DVIPAs
Bind to DVIPAs fail
Stack address space start With **DELAYJOIN** & **DELAYSTART**
OMPROUTE comes up and begins advertising DVIPA
Stack joins sysplex group and takes back DVIPAs
Autologged server binds to DVIPA

Figure 2-8 Startup sequence of TCP/IP stack

Example of using DELAYJOIN and AUTOLOG without DELAYSTART

In Example 2-26, we use the FTP server FTPDA in the AUTOLOG statement, and add a BIND option on the PORT statement to make FTP bind to a specific DVIPA.

Example 2-26 Sample AUTOLOG definition

```
GLOBALCONFIG SYSPLEXMONITOR DELAYJOIN
...
AUTOLOG 5
   FTPDA JOBNAME FTPDA1            ; FTP server
   OMPA                            ; OMPROUTE
ENDAUTOLOG

PORT
20 TCP OMVS    NOAUTOLOG      ; FTP Server
21 TCP FTPDA1  BIND 10.1.8.10 ; control port
```

Example 2-27 shows that the FTP server was started by AUTOLOG before the TCP/IP stack joins the sysplex group and activates DVIPA. FTP server initialization failed.

Example 2-27 Syslog: DELAYJOIN:YES and DELAYSTART:NO

```
S TCPIPA
 $HASP100 TCPIPA   ON STCINRDR
...
*EZD1166E TCPIPA DELAYING SYSPLEX PROFILE PROCESSING - OMPROUTE IS NOT
 ACTIVE
...
 S FTPDA
 S OMPA
 $HASP100 FTPDA    ON STCINRDR
 $HASP100 OMPA     ON STCINRDR
 $HASP395 FTPDA    ENDED
 EZY2714I FTP server shutdown in progress
 EZYFT59I FTP shutdown complete.
...
 EZZ7898I OMPA INITIALIZATION COMPLETE
 EZD1176I TCPIPA HAS SUCCESSFULLY JOINED THE TCP/IP SYSPLEX GROUP
 EZBTCPCS
 EZD1214I INITIAL DYNAMIC VIPA PROCESSING HAS COMPLETED FOR TCPIPA
```

Example of using DELAYJOIN and AUTOLOG with DELAYSTART

Example 2-28 uses the FTP server FTPDA in the AUTOLOG statement again, but a DELAYJOIN option is added.

Example 2-28 Sample AUTOLOG definition

```
GLOBALCONFIG SYSPLEXMONITOR DELAYJOIN
...
AUTOLOG 5
   FTPDA JOBNAME FTPDA1 DELAYSTART ; FTP server
   OMPA                            ; OMPROUTE
ENDAUTOLOG

PORT
20 TCP OMVS    NOAUTOLOG      ; FTP Server
21 TCP FTPDA1  BIND 10.1.8.10 ; control port
```

You may use the **NETSTAT CONFIG /-f** command to display DELAYJOIN and DELAYSTART definitions, as illustrated in Example 2-29.

Example 2-29 NETSTAT CONFIG/-f result

```
D TCPIP,TCPIPA,N,CONFIG
EZD0101I NETSTAT CS V1R13 TCPIPA 760
GLOBAL CONFIGURATION INFORMATION:
...
SYSPLEX MONITOR:
  TIMERSECS: 0060  RECOVERY: NO   DELAYJOIN: YES  AUTOREJOIN: NO
  MONINTF:   NO    DYNROUTE: NO   JOIN:      YES
AUTOLOG CONFIGURATION INFORMATION: WAIT TIME: 0300
PROCNAME: FTPDA     JOBNAME: FTPDA1
  PARMSTRING:
  DELAYSTART: YES
    DVIPA
PROCNAME: OMPA      JOBNAME: OMPA
  PARMSTRING:
  DELAYSTART: NO
```

Example 2-30 shows the startup of TCPIPA. The FTP server starts after the TCP/IP stack joins the sysplex group and activates DVIPA, and therefore the FTP server initialization is successful.

Example 2-30 Syslog: DELAYJOIN:Yes and DELAYSTART:Yes

```
 S TCPIPA
 $HASP100 TCPIPA   ON STCINRDR
...
*EZD1166E TCPIPA DELAYING SYSPLEX PROFILE PROCESSING - OMPROUTE IS NOT
 ACTIVE
...
 S OMPA
...
 EZZ7898I OMPA INITIALIZATION COMPLETE
 EZD1176I TCPIPA HAS SUCCESSFULLY JOINED THE TCP/IP SYSPLEX GROUP
 EZBTCPCS
 EZD1214I INITIAL DYNAMIC VIPA PROCESSING HAS COMPLETED FOR TCPIPA
 S FTPDA
 $HASP100 FTPDA    ON STCINRDR
...
 EZY2702I Server-FTP: Initialization completed at 20:07:19 on
 07/15/11.
```

2.6.4 Monitoring the network reachability

Sysplex autonomics can be configured to specify key network interfaces that should be monitored by the TCP/IP stacks. You can monitor interfaces to ensure that they are functioning and that dynamic routes are known over these interfaces, as shown in Figure 2-9 on page 44. If these external interfaces fail, or the networks they are attached to experience a failure, the DVIPAs owned by the local stack might become isolated. To prevent the DVIPAs from becoming isolated, you can use the MONINTERFACE parameter on the GLOBALCONFIG statement and the MONSYSPLEX parameter on the LINK statement. If the MONINTERFACE parameter is defined, you can monitor the status of interfaces that are configured with the MONSYSPLEX keyword. When an inactive status is detected on all monitored interfaces, the stack will leave the sysplex group, allowing dynamic VIPAs to be taken over by other stacks. In the figure, SD is sysplex distributor.

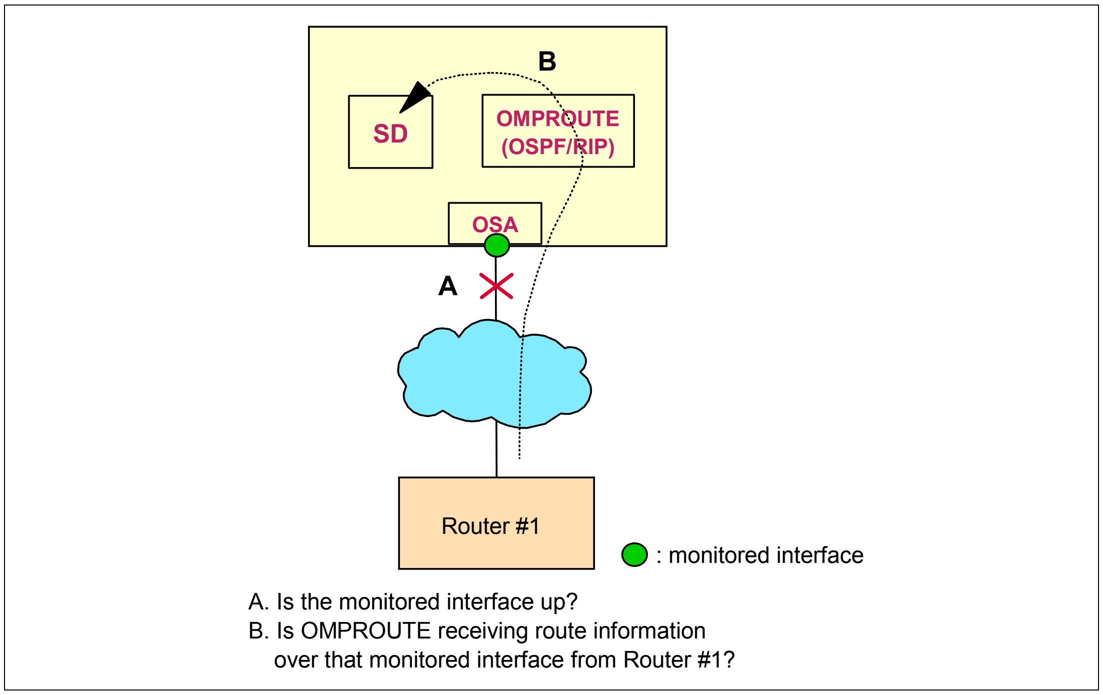

B
SD
OMPROUTE (OSPF/RIP)
OSA
A
Router #1
: monitored interface
A. Is the monitored interface up?
B. Is OMPROUTE receiving route information over that monitored interface from Router #1?

Figure 2-9 Sysplex autonomics detection of an unreachable DVIPA

MONINTERFACE

The MONINTERFACE option requests the TCP/IP stack to monitor whether the specified interfaces are active are not. The interfaces being monitored are those that are configured with the MONSYSPLEX parameter on the LINK or INTERFACE statement.

DYNROUTE

Optionally, you can monitor for the presence of dynamic routing over the interfaces if the DYNROUTE parameter is specified on the GLOBALCONFIG statement.

The DYNROUTE option requests the TCP/IP stack to monitor for the presence of dynamic routes over monitored interfaces. This level of monitoring is useful in detecting problems that OMPROUTE is having communicating with other routing daemons on the selected interfaces. If no dynamic routes are present in the TCP/IP stack, even though the monitored interface is active, this provides an indicator that client requests are not able to reach this TCP/IP stack over that interface. This is the default when MONINTERFACE is configured.

Most preferred: DYNROUTE monitors whether an indirect route is available through the monitored interface. Therefore, at least one of the monitored interfaces must be the most preferred device for an indirect route on the TCPIP/IP stack’s routing table.

MONSYSPLEX

The MONSYSPLEX option on the LINK or INTERFACE statement indicates that the status of this link is monitored by sysplex autonomics. This parameter is not in effect unless the MONINTERFACE parameter is coded on the GLOBALCONFIG SYSPLEXMONITOR profile statement. This parameter is dynamically modifiable.

Example of MONINTERFACE and DYNROUTE

Our example uses MONINTERFACE and DYNROUTE. In our environment, SC30 is defined as the owner of a DVIPA, 10.1.8.10. SC31 and SC32 are the backup stacks for the DVIPAs. Four shared OSA adapters on each TCP/IP stack are defined as the OSPF interface, and these interfaces are also defined as monitored.

Implementation tasks

The implementation tasks are as follows:

1. Specify the GLOBALCONFIG SYSPLEXMONITOR option for monitoring interfaces defined with the MONSYSPLEX option specified.
   - MONINTERFACE: The TCP/IP stack monitors the status of interfaces with the MONSYSPLEX option (assumed healthy if active).
   - DYNROUTE: The TCP/IP stack monitors for the presence of dynamic routes over interfaces with the MONSYSPLEX option (assumed healthy if routes are received).
   - RECOVERY: If both MONINTERFACE and DYNROUTES are configured and all monitored interfaces fail, the stack leaves the sysplex group. If no indirect routes are received over any of the monitored interfaces, the stack leaves the sysplex group.
   - DELAYJOIN: The stack waits to join the sysplex group until an indirect route is received over at least one monitored interface.
   - AUTOREJOIN: If at least one of the monitored interfaces recovers from an unhealthy condition, the stack automatically joins the sysplex group.
2. Specify the MONSYSPLEX parameter on the INTERFACE statement for the interfaces you want the stack to monitor.

Example 2-31 shows a part of our TCP/IP profile that is necessary to monitor the interfaces and to detect and recover any failures. We omit the configuration sample for SC31 and SC32. The basic configuration is the same as SC30 but VIPABACKUP for 10.1.8.10 is defined to take over the DVIPA when TCPIPA on SC30 leaves the sysplex group.

Example 2-31 Profile for TCPIPA on SC30

```
GLOBALCONFIG
SYSPLEXMONitor RECOVERY DYNROUTE MONINTERFACE DELAYJOIN AUTOREJOIN 1
IPCONFIG NODATAGRAMFWD SYSPLEXROUTING
IPCONFIG MULTIPATH PERCONNECTION
IPCONFIG SOURCEVIPA
IPCONFIG DYNAMICXCF 10.1.7.11 255.255.255.0 8
;
DEVICE VIPA1      VIRTUAL 0
LINK   VIPA1L     VIRTUAL 0   VIPA1
;
INTERFACE OSA2080I
DEFINE IPAQENET
PORTNAME OSA2080
SOURCEVIPAINT VIPA1L
IPADDR 10.1.2.11/24
MTU 1492
VLANID 10
VMAC ROUTEALL
MONSYSPLEX 2
;
INTERFACE OSA20A0I
DEFINE IPAQENET
```

```
PORTNAME OSA20A0
SOURCEVIPAINT VIPA1L
IPADDR 10.1.2.12/24
MTU 1492
VLANID 10
VMAC ROUTEALL
MONSYSPLEX 2
;
INTERFACE OSA20C0I
DEFINE IPAQENET
PORTNAME OSA20C0
SOURCEVIPAINT VIPA1L
IPADDR 10.1.3.11/24
MTU 1492
VLANID 11
VMAC
MONSYSPLEX 2
;
INTERFACE OSA20E0I
DEFINE IPAQENET
PORTNAME OSA20E0
SOURCEVIPAINT VIPA1L
IPADDR 10.1.3.12/24
MTU 1492
VLANID 11
VMAC
MONSYSPLEX 2
;
VIPADynamic
   VIPADEFine MOVEable IMMEDiate 255.255.255.255 10.1.8.10 3
ENDVIPADYNAMIC
;
HOME
   10.1.1.10   VIPA1L 4
```

The highlighted numbers indicate important considerations for this TCPIP profile:

1. Define the DYNROUTE and MONINTERFACE parameters. Moreover, we defined the RECOVERY parameter so that the recovery action is initiated when the stack detects an unreachable DVIPA.

   Note: The TIMERSECS value on the GLOBALCONFIG statement can be used to determine how quickly sysplex autonomics reacts when a failure is detected. The default value is 60 seconds.

2. Define both OSA adapters as monitored interfaces.
3. Use the IP address 10.1.8.10 as the Distributed DVIPA.
4. Define three VIPAROUTE statements, each pointing to the static VIPA of our target systems. The static VIPA target addresses also needs to be correctly defined in the HOME list of the target stack.

Verification

We use the following steps to verify our sysplex distributor implementation with the Unreachable DVIPA function:

1. Verify the sysplex group (EZBTCPCS) that the stacks should join.
2. Verify the general dynamic VIPA and sysplex distributor setup.
3. Verify that the VIPAROUTE definitions work.
4. Verify the monitored interfaces setup.
5. Verify that the Unreachable DVIPA detection and recovery function works.

We use a **`Display XCF,GROUP,`*`groupname`*** command to verify that all three stacks (1) are joined into the same XCF group, as shown in Example 2-32.

Example 2-32 Display of XCF Group on SC30

```
D XCF,GROUP,EZBTCPCS
IXC332I  13.45.47  DISPLAY XCF 641
 GROUP EZBTCPCS:
                SC30TCPIPA 1
                SC31TCPIPB 1
                SC32TCPIPC 1
```

To verify the general dynamic VIPA and sysplex distributor setup, issue several commands:

- `Display NETSTAT,VIPADYN`
- `Display SYSPLEX,VIPADYN`
- `Display NETSTAT,HOME`

Issuing a **`NETSTAT,VIPADCFG`** command on SC30, shown in Example 2-33, provides helpful information about the sysplex distributor configuration.

Example 2-33 Display result of the NETSTAT,VIPADYN command on SC30

```
D TCPIP,TCPIPA,NETSTAT,VIPADYN
EZD0101I NETSTAT CS V1R13 TCPIPA 643
DYNAMIC VIPA:
  IPADDR/PREFIXLEN: 10.1.8.10/24
    STATUS:  ACTIVE     ORIGIN: VIPADEFINE 1     DISTSTAT: DIST/DEST 3
    ACTTIME: 07/27/2011 15:53:14 2
```

The highlighted numbers indicate important information in this output:

1. `ORIGIN` represents the original definition of DVIPA.

2. This is the time stamp indicating when the DVIPA was activated on the local stack, specified as Coordinated Universal Time (UTC).

3. This stack is the distributor stack and the destination stack for the Distributed DVIPA 10.1.8.10. Note the following information about the target IP address specified:
   - It is on the local stack.
   - It is reachable from this stack, and it also means that the VIPAROUTE definition works.

Issuing a **SYSPLEX,VIPADYN** command, shown in Example 2-34, displays the relationship among the members of the sysplex group.

Example 2-34 Display result of the SYSPLEX,VIPADYN command on SC30

```
D TCPIP,TCPIPA,SYSPLEX,VIPADYN
EZZ8260I SYSPLEX CS V1R13 645
VIPA DYNAMIC DISPLAY FROM TCPIPA   AT SC30
LINKNAME: VIPL0A01080A
IPADDR/PREFIXLEN: 10.1.8.10/24
  ORIGIN: VIPADEFINE
  TCPNAME  MVSNAME  STATUS   RANK  DIST
  -------- -------- ------   ----  ----
  TCPIPA   SC30     ACTIVE 1
  TCPIPB   SC31     BACKUP 1 100 2
  TCPIPC   SC32     BACKUP 1 090 2
```

Several fields show important information about members in the sysplex group:

1. STATUS represents the actual status of the TCP/IP stacks.
2. RANK shows which backup stack takes over the distributor stack when the primary sysplex distributor is unreachable or goes down.

We issued a **NETSTAT,CONFIG** command and a **NETSTAT,DEVLINKS** command to verify that the Unreachable DVIPA Detection and Recovery function was correctly defined.

Example 2-35 shows the output from issuing a **NETSTAT,CONFIG** command.

Example 2-35 Display result of the NETSTAT,CONFIG command on SC30

```
D TCPIP,TCPIPA,NETSTAT,CONFIG
EZD0101I NETSTAT CS V1R13 TCPIPA 647
GLOBAL CONFIGURATION INFORMATION:
...
SYSPLEX MONITOR:
  TIMERSECS: 0060   RECOVERY: YES   DELAYJOIN: YES  AUTOREJOIN: YES
  MONINTF:   YES  1 DYNROUTE: YES 2 JOIN:      YES
```

In Example 2-36, which is the output of the **NETSTAT,DEVLINKS** command on SC30, MONSYSPLEX: YES (1) indicates that the status of this link is being monitored by Sysplex Autonomics (only the output for OSA20A0 is shown).

Example 2-36 Display result of the NETSTAT,DEvlinks on SC30

```
D TCPIP,TCPIPA,N,DEV,INTFNAME=OSA20A0I
EZD0101I NETSTAT CS V1R13 TCPIPA 636
INTFNAME: OSA20A0I          INTFTYPE: IPAQENET   INTFSTATUS: READY
    PORTNAME: OSA20A0   DATAPATH: 20A2     DATAPATHSTATUS: READY
    CHPIDTYPE: OSD
    SPEED: 0000001000
    IPBROADCASTCAPABILITY: NO
    VMACADDR: 02005377688D   VMACORIGIN: OSA    VMACROUTER: ALL
    SRCVIPAINTF: VIPA1L
    ARPOFFLOAD: YES                 ARPOFFLOADINFO: YES
    CFGMTU: 1492                    ACTMTU: 1492
    IPADDR: 10.1.2.12/24
    VLANID: 10                      VLANPRIORITY: DISABLED
    DYNVLANREGCFG: NO               DYNVLANREGCAP: YES
    READSTORAGE: GLOBAL (4096K)
    INBPERF: BALANCED
    CHECKSUMOFFLOAD: YES            SEGMENTATIONOFFLOAD: YES
    SECCLASS: 255                   MONSYSPLEX: YES 1
    ISOLATE: NO                     OPTLATENCYMODE: NO
...
```

Detection and recovery: Scenario 1

After we verify that all the stacks are joined, we stop all four monitored OSA interfaces (OSA20A0I and OSA20E0I on SC30), one at a time. If at least one of them is active and a dynamic route is received over that interface, the stack will not leave the sysplex group. If all monitored interfaces are down, the stack leaves the sysplex group about 60 seconds later (which is the default TIMERSECS value) and DVIPA takeover occurs. Several syslog messages are displayed, as shown in Example 2-37. In this example, DVIPA on TCPIPA on SC30 is taken over by TCPIPB, on SC31.

Example 2-37 Syslog message of SC30 and SC31 (Scenario 1)

```
V TCPIP,TCPIPA,STOP,OSA20C0I
V TCPIP,TCPIPA,STOP,OSA20E0I
V TCPIP,TCPIPA,STOP,OSA2080I
V TCPIP,TCPIPA,STOP,OSA20A0I
...
EZZ4341I DEACTIVATION COMPLETE FOR INTERFACE OSA20A0I
EZZ7921I OSPF ADJACENCY FAILURE, NEIGHBOR 10.1.2.240, OLD STATE 128,
NEW STATE 1, EVENT 11

console message on SC30
*EZD1209E TCPIPA DETERMINED THAT ALL MONITORED INTERFACES WERE NOT
 ACTIVE FOR AT LEAST       60 SECONDS                             1
*EZZ9676E SYSPLEX PROBLEM DETECTION CLEANUP HAS SUCCEEDED FOR TCPIPA 2

console message on SC31
 EZZ8301I VIPA 10.1.8.10 TAKEN OVER FROM TCPIPA ON SC30
```

The following detection and recovery messages are involved:

1. EZD1209E indicates that sysplex problem detection has determined that all monitored interfaces are inactive.
2. EZZ9676E indicates that sysplex problem detection caused the stack to leave the sysplex group and cleared up all DVIPAs.

We check the status of sysplex distributor, using several **NETSTAT** commands and a **SYSPLEX** command, as shown in Example 2-38, Example 2-39 on page 50, Example 2-40 on page 50, and Example 2-41 on page 50.

Example 2-38 Display of XCF group of SC30 (Scenario 1)

```
D XCF,GROUP,EZBTCPCS
IXC332I  14.09.08  DISPLAY XCF 724
 GROUP EZBTCPCS: 1
                SC31TCPIPB
                SC32TCPIPC
```

Example 2-39 Display result of the NETSTAT,VIPADCFG command on SC31 (Scenario 1)

```
D TCPIP,TCPIPB,NETSTAT,VIPADCFG
EZD0101I NETSTAT CS V1R13 TCPIPB 490
DYNAMIC VIPA INFORMATION:
  VIPA BACKUP:
    IPADDR/PREFIXLEN: 10.1.8.10
      RANK: 100  MOVEABLE:           SRVMGR:     FLG:
  VIPA DISTRIBUTE: 2
    DEST:      10.1.8.10..23
      DESTXCF: 10.1.7.31
      DISTMETHOD: SERVERWLM
      SYSPT:   NO   TIMAFF: NO    FLG:
    DEST:      10.1.8.10..23
      DESTXCF: 10.1.7.21
      DISTMETHOD: SERVERWLM
      SYSPT:   NO   TIMAFF: NO    FLG:
    DEST:      10.1.8.10..23
      DESTXCF: 10.1.7.11
      DISTMETHOD: SERVERWLM
      SYSPT:   NO   TIMAFF: NO    FLG:
END OF THE REPORT
```

Example 2-40 Display result of the SYSPLEX,VIPADYN command on SC31 (Scenario 1)

```
D TCPIP,TCPIPB,SYSPLEX,VIPADYN
EZZ8260I SYSPLEX CS V1R13 488
VIPA DYNAMIC DISPLAY FROM TCPIPB   AT SC31
LINKNAME: VIPL0A01080A
IPADDR/PREFIXLEN: 10.1.8.10/24
  ORIGIN: VIPABACKUP
  TCPNAME  MVSNAME  STATUS RANK DIST
  -------- -------- ------ ---- ----
  TCPIPB   SC31     ACTIVE      BOTH  3
  TCPIPC   SC32     BACKUP 090  DEST
  TCPIPD   SC33     BACKUP 080
```

Example 2-41 Display result of the NETSTAT,HOME command on SC31 (Scenario 1)

```
D TCPIP,TCPIPB,N,HOME
EZD0101I NETSTAT CS V1R13 TCPIPB 492
HOME ADDRESS LIST:
LINKNAME:   VIPL0A01080A
  ADDRESS:  10.1.8.10
    FLAGS: 4
```

Those examples show the following information:

1. SC30 TCPIPA leaves the XCF group of EZBTCPCS.
2. SC31 takes the VIPA DISTRIBUTE configuration from SC30.
3. SC31 shifts the BOTH status from the DEST status.
4. SC31 FLAGS is not INTERNAL any longer.

Next, we start an OSA interface OSA20A0I of SC30 again. A few seconds later, the takeback process occurs and syslog messages are displayed, as shown in Example 2-42.

Example 2-42 Syslog messages of SC30 and SC31 (Scenario 1)

```
console message on SC30
V TCPIP,TCPIPA,START,OSA20A0I
...
 EZZ4340I INITIALIZATION COMPLETE FOR INTERFACE OSA20A0I
*EZD1212E TCPIPA DELAYING SYSPLEX PROFILE PROCESSING - NO DYNAMIC
 ROUTES OVER MONITORED INTERFACES WERE FOUND 1

EZD1176I TCPIPA HAS SUCCESSFULLY JOINED THE TCP/IP SYSPLEX GROUP
EZBTCPCS
EZZ8302I VIPA 10.1.8.10 TAKEN FROM TCPIPB ON SC31
EZD1192I THE VIPADYNAMIC CONFIGURATION WAS SUCCESSFULLY RESTORED FOR
TCPIPA
EZD1214I INITIAL DYNAMIC VIPA PROCESSING HAS COMPLETED FOR TCPIPA

console message on SC31
EZZ8303I VIPA 10.1.8.10 GIVEN TO TCPIPA ON SC30
```

In this example, `EZD1212E` (**1**) indicates that TCP/IP joined a sysplex group and finished processing the sysplex definitions when at least one dynamic route over monitored interfaces is found.

Detection and recovery: Scenario 2

We stop the OMPROUTE of SC30. The takeover occurs about 60 seconds later. However, we receive a message that differs from Scenario 1, as shown in Example 2-43.

Example 2-43 Syslog messages of SC30 and SC31 (Scenario 2)

```
console message on SC30
*EZD1210E TCPIPA DETERMINED THAT NO DYNAMIC ROUTES OVER MONITORED
      INTERFACES WERE FOUND FOR AT LEAST       60 SECONDS              1
*EZZ9676E SYSPLEX PROBLEM DETECTION CLEANUP HAS SUCCEEDED FOR TCPIPA

console message on SC31
EZZ8301I VIPA 10.1.8.10 TAKEN OVER FROM TCPIPA ON SC30
```

In this example, `EZD1210E` (**1**) indicates that sysplex problem detection has determined that no dynamic routes over monitored interfaces were found.

2.7 Controlling DVIPA with commands

TCP/IP commands are provided to manually control the DVIPA for management, problem detection, and recovery.

The **`VARY TCPIP`** command parameters are as follows:

- `LEAVEGROUP` and `JOINGROUP`
- `DEACTIVATE` and `REACTIVATE`
- `QUIESCE` and `RESUME`

You may also control DVIPAs by changing the VIPADYNAMIC definitions by the **`OBEYFILE`** command.

2.7.1 LEAVEGROUP and JOINGROUP

The **LEAVEGROUP** and **JOINGROUP** command parameters are used to connect or disconnect a whole TCP/IP stack from a Parallel Sysplex environment.

Many reasons exist for removing a TCP/IP stack from sysplex operation. For more information, see 2.6, “Sysplex problem detection and recovery” on page 38.

LEAVEGROUP

This parameter requests the TCP/IP stack to leave the sysplex group, delete all dynamic DVIPAs, and inactivate all its configured VIPADYNAMIC definitions. The VIPADYNAMIC configuration information is retained for possible future use by the **SYSPLEX,JOINGROUP** command.

Because the stack leaves the sysplex group, the TCP connections established with this stack are disrupted. The connections established with other stacks are retained.

The following dynamic stack configuration definitions are not saved when a stack leaves a sysplex:

- Target DVIPAs

  These definitions are re-created automatically when the stack rejoins the group if this stack is still a target for another (distributing) stack.

- BIND-created or IOCTL-created DVIPAs

  These definitions must be re-created by the applications or by the **MODDVIPA** utility after the stack rejoins the group.

JOINGROUP

This parameter requests the TCP/IP stack to join the sysplex group. If the DELAYJOIN parameter is configured for GLOBALCONFIG SYSPLEXMONITOR, the join does not take place until OMPROUTE is available. This command parameter can be used after the TCP/IP stack detected a problem and left the sysplex group, or the stack is initialized with NOJOIN option.

Examples of LEAVEGROUP and JOINGROUP

This section shows examples of **LEAVEGROUP** and **JOINGROUP** command parameters.

LEAVEGROUP

TCPIPA is the distributor stack. The three target stacks including the TCPIP stack have TCP connections established. This example issues the **LEAVEGROUP** command parameter on our TCPIPA stack.

Example 2-44 shows the messages displayed after issuing the command and the status of the DVIPA. All connections established with DVIPA on the stack that left the sysplex group are disrupted **1**. Connections distributed to other stacks are retained. The TCPIPA stack left the sysplex group **2**.

Example 2-44 LEAVEGROUP command parameter issued

```
On SC30
D TCPIP,TCPIPA,SYSPLEX,VIPADYN
EZZ8260I SYSPLEX CS V1R13 993
VIPA DYNAMIC DISPLAY FROM TCPIPA   AT SC30
LINKNAME: VIPL0A01080A
```

```
IPADDR/PREFIXLEN: 10.1.8.10/24
  ORIGIN: VIPADEFINE
  TCPNAME  MVSNAME  STATUS RANK DIST
  -------- -------- ------ ---- ----
  TCPIPA   SC30     ACTIVE      BOTH
  TCPIPB   SC31     BACKUP 100  DEST
  TCPIPC   SC32     BACKUP 090  DEST

V TCPIP,TCPIPA,SYSPLEX,LEAVEGROUP
 EZZ0060I PROCESSING COMMAND: VARY TCPIP,TCPIPA,SYSPLEX,LEAVEGROUP
*EZZ9676E SYSPLEX PROBLEM DETECTION CLEANUP HAS SUCCEEDED FOR TCPIPA
 EZZ0053I COMMAND SYSPLEX,LEAVEGROUP COMPLETED SUCCESSFULLY
 IKT100I USERID          CANCELED DUE TO UNCONDITIONAL LOGOFF 1
 IKT122I IPADDR..PORT 10.1.100.222..2754
 IKT100I USERID          CANCELED DUE TO UNCONDITIONAL LOGOFF 1
 IKT122I IPADDR..PORT 10.1.100.222..2755

D TCPIP,TCPIPA,SYSPLEX,VIPADYN
EZZ8269I TCPIPA   IS NOT A MEMBER OF A SYSPLEX GROUP 2

On SC31
EZZ8301I VIPA 10.1.8.10 TAKEN OVER FROM TCPIPA ON SC30

D TCPIP,TCPIPB,SYSPLEX,VIPADYN
EZZ8260I SYSPLEX CS V1R13 605
VIPA DYNAMIC DISPLAY FROM TCPIPB   AT SC31
LINKNAME: VIPL0A01080A
IPADDR/PREFIXLEN: 10.1.8.10/24
  ORIGIN: VIPABACKUP
  TCPNAME  MVSNAME  STATUS RANK DIST
  -------- -------- ------ ---- ----
  TCPIPB   SC31     ACTIVE      BOTH
  TCPIPC   SC32     BACKUP 090  DEST
```

JOINGROUP

Next example issues a **JOINGROUP** command parameter on TCPIPA stack.

Example 2-45 shows the messages displayed after issuing the command and the status of DVIPA. The TCPIPA stack is now back to ACTIVE again (1) and TCPIPB stack is in MOVING status (2). All connections established on other stacks are retained.

Example 2-45 JOINGROUP command parameter issued

```
V TCPIP,TCPIPA,SYSPLEX,JOINGROUP
EZZ0060I PROCESSING COMMAND: VARY TCPIP,TCPIPA,SYSPLEX,JOINGROUP
EZD1178I THE VARY TCPIP,,SYSPLEX,JOINGROUP COMMAND WAS ACCEPTED
EZD1176I TCPIPA HAS SUCCESSFULLY JOINED THE TCP/IP SYSPLEX GROUP
EZBTCPCS
EZZ8302I VIPA 10.1.8.10 TAKEN FROM TCPIPB ON SC31
EZD1192I THE VIPADYNAMIC CONFIGURATION WAS SUCCESSFULLY RESTORED FOR
TCPIPA
EZD1214I INITIAL DYNAMIC VIPA PROCESSING HAS COMPLETED FOR TCPIPA
EZZ8303I VIPA 10.1.8.10 GIVEN TO TCPIPA ON SC30

D TCPIP,TCPIPA,SYSPLEX,VIPADYN
```

```
EZZ8260I SYSPLEX CS V1R13 061
VIPA DYNAMIC DISPLAY FROM TCPIPA   AT SC30
LINKNAME: VIPL0A01080A
IPADDR/PREFIXLEN: 10.1.8.10/24
  ORIGIN: VIPADEFINE
  TCPNAME  MVSNAME  STATUS RANK DIST
  -------- -------- ------ ---- ----
  TCPIPA   SC30     ACTIVE      BOTH 1
  TCPIPB   SC31     MOVING      DEST 2
  TCPIPC   SC32     BACKUP 090  DEST
```

2.7.2 DEACTIVATE and REACTIVATE

Commands to manually move individual stack-managed DVIPA are provided, as Figure 2-10 shows.

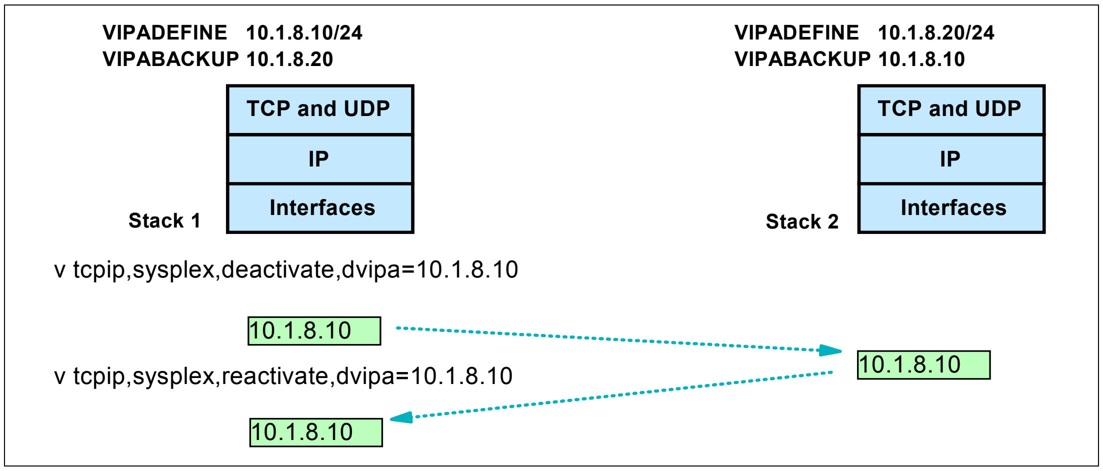


Figure 2-10 VIPA command parameters DEACTIVATE and REACTIVATE

DEACTIVATE

The **DEACTIVATE** command parameter requests the TCP/IP stack to deactivate a dynamic VIPA. A configured backup stack (if one exists) takes over the DVIPA. A backup DVIPA can be deactivated, which removes its eligibility as a backup. When you deactivate a dynamic VIPA, it appears as though the DVIPA has been deleted, but the DVIPA's configuration is saved.

REACTIVATE

The **REACTIVATE** command parameter requests the original stack to regain ownership of the DVIPA. A backup DVIPA can be reactivated, making it eligible to function as a backup.

Restriction: You cannot use these commands on a DVIPA that was created from VIPARANGE with `bind()`, `ioctl()`, or the **MODDVIPA** utility.

Examples of DEACTIVATE and REACTIVATE

This section shows examples of **DEACTIVATE** and **REACTIVATE** command parameters.

DEACTIVATE

Using the same configuration, issue a **DEACTIVATE** command parameter to force a takeover process. This way moves the active DVIPA address from SC30 to SC31 in the same way a failure in SC30 causes the move. Example 2-46 and Example 2-47 show the results of this manual operation.

Example 2-46 Console message on SC30 as the result of the DEACTIVATE parameter

```
V TCPIP,TCPIPA,SYSPLEX,DEACTIVATE,DVIPA=10.1.8.10
EZZ0060I PROCESSING COMMAND: VARY TCPIP,TCPIPA,SYSPLEX,DEACTIVATE,
DVIPA=10.1.8.10
EZD1197I THE VARY TCPIP,,SYSPLEX,DEACTIVATE,DVIPA COMMAND COMPLETED
SUCCESSFULLY
```

Example 2-47 Console message on SC31 as a result of DEACTIVATE parameter on SC30

```
EZZ8301I VIPA 10.1.8.10 TAKEN OVER FROM TCPIPA ON SC30
```

Example 2-48 shows that SC31 now has the DVIPA active.

Example 2-48 TCPIPB on SC31 took over the DVIPA after the DEACTIVATE operation on TCPIPA

```
D TCPIP,TCPIPB,N,VIPADYN
EZD0101I NETSTAT CS V1R13 TCPIPB 744
DYNAMIC VIPA:
  IPADDR/PREFIXLEN: 10.1.8.10/24
    STATUS:  ACTIVE     ORIGIN: VIPABACKUP       DISTSTAT:
    ACTTIME: 07/15/2011 18:47:52
  IPADDR/PREFIXLEN: 10.1.8.20/24
    STATUS:  ACTIVE     ORIGIN: VIPADEFINE       DISTSTAT:
    ACTTIME: 07/15/2011 17:33:11
2 OF 2 RECORDS DISPLAYED
END OF THE REPORT
```

REACTIVATE

Use **REACTIVATE** parameter to start the takeback function, moving the DVIPA address from SC31 to SC30. We issue this command for SC30. Example 2-49 and Example 2-50 show the results of this manual operation.

Example 2-49 Result of takeback operation using the REACTIVATE parameter in SC30

```
V TCPIP,TCPIPA,SYSPLEX,REACTIVATE,DVIPA=10.1.8.10
EZZ0060I PROCESSING COMMAND: VARY TCPIP,TCPIPA,SYSPLEX,REACTIVATE,
DVIPA=10.1.8.10
EZZ8302I VIPA 10.1.8.10 TAKEN FROM TCPIPB ON SC31
EZD1189I THE VARY TCPIP,,SYSPLEX,REACTIVATE,DVIPA COMMAND COMPLETED
SUCCESSFULLY
```

Example 2-50 Console message on SC31 as a result of takeback operation in SC30

```
EZD1298I DYNAMIC VIPA 10.1.8.10 DELETED FROM TCPIPB
EZZ8303I VIPA 10.1.8.10 GIVEN TO TCPIPA ON SC30
```

Note: The existing connections during takeback remain active. They are not disrupted.

After all sessions to the backup are closed, the new connections go to the primary DVIPA system. The *moving status* continues until the last connections end, then the status changes to backup.

2.7.3 QUIESCE and RESUME

Commands are provided to quiesce and resume the individual server applications or full target systems. The ability to quiesce a target system stack or an application instance, without a full system shutdown, is useful for many reasons, including the following situations:

- When the system or application is planned for maintenance
- When you must drain the work queue from existing systems or applications prior to shutdown
- When you must relieve temporary constraints of resources on target system
- When the quiesce is temporary and does not affect the sysplex distributor's permanent configuration
- When the commands are issued on the target system that is affected
- When you need to control individual server applications in a SHAREPORT group

Notes about QUIESCE and RESUME:

- These commands must be issued on the system and TCP/IP stack where the application instance is running.
- The commands apply to a single TCP/IP stack's application instance.
- Any sysplex distributor timed affinities with the application instance being quiesced are terminated.
- Existing connections are not affected.
- The QUIESCE state for a TARGET persists for all application instances (existing and new) running on this TCP/IP stack, until the TCP/IP stack is recycled or the following command is issued:

  ```
  V TCPIP,,RESUME,TARGET
  ```
- RESUME with the TARGET option is the only valid command following a QUIESCE with the TARGET option command.
- When a TCP/IP stack is quiesced, the "ready count" (Rdy) field that appears on the **`netstat VDPT`** display (issued on the sysplex distributor routing stack) is zero (0) for all entries associated with this target TCP/IP stack.

QUIESCE

The **`QUIESCE`** command parameter requests that the specified application, or all applications on a particular TCP/IP stack, be quiesced from DVIPA sysplex distributor workload balancing. After the command is issued, sysplex distributor will no longer route new TCP connection requests to the specified applications, however, the existing connections are not affected. This command must be issued on the local system where the applications are to be quiesced. After the **`QUIESCE`**, no new TCP connections are sent to the quiesced target (stack or application). Existing TCP connections are maintained (that is, the process is nondisruptive).

RESUME

The **RESUME** command parameter requests that the specified application or all applications associated with a TCP/IP stack be resumed for DVIPA sysplex distributor workload balancing, and become eligible for new TCP connection requests.

Examples of QUIESCE and RESUME

This section shows examples of **QUIESCE** and **RESUME** command parameters.

QUIESCE

TCPIPA stack is the distributor stack. TCPIPA, TCPIPB, and TCPIPC are the target stacks and each target has TCP connections established. In this example, the command is issued on the TCPIPC stack. The existing connections on TCPIPC stack are retained, but it does not accept any new connections.

Use the **NETSTAT ALL /-A** command to display application status and the quiescing state, as illustrated in Example 2-51.

Example 2-51 NETSTAT ALL/-A result

```
On SC32
V TCPIP,TCPIPC,SYSPLEX,QUIESCE,PORT=23
EZZ0060I PROCESSING COMMAND: VARY TCPIP,TCPIPC,SYSPLEX,QUIESCE,PORT=23
EZD1198I THE VARY TCPIP,,SYSPLEX,QUIESCE COMMAND COMPLETED SUCCESSFULL
Y

D TCPIP,TCPIPC,N,ALL,PORT=23
EZD0101I NETSTAT CS V1R13 TCPIPA 647
CLIENT NAME: TN3270C                 CLIENT ID: 00000030
  LOCAL SOCKET: ::..23
  FOREIGN SOCKET: ::..0
    QUIESCED:           DEST 1

On SC30
D TCPIP,TCPIPA,N,VDPT,DETAIL
EZD0101I NETSTAT CS V1R13 TCPIPA 100
DYNAMIC VIPA DESTINATION PORT TABLE FOR TCP/IP STACKS:
DEST:        10.1.8.10..23
  DESTXCF:   10.1.7.11
  TOTALCONN: 0000000000  RDY: 001  WLM: 16  TSR: 100
  DISTMETHOD: SERVERWLM
  FLG:
    TCSR: 100  CER: 100 SEF: 100
    WEIGHT: 64
      RAW          CP: 48 ZAAP: 64 ZIIP: 64
      PROPORTIONAL CP: 64 ZAAP: 00 ZIIP: 00
    ABNORM: 0000        HEALTH: 100
    ACTCONN:   0000000000
    QOSPLCACT: *DEFAULT*
      W/Q: 16
DEST:        10.1.8.10..23
  DESTXCF:   10.1.7.21
  TOTALCONN: 0000000000  RDY: 001  WLM: 16  TSR: 100
  DISTMETHOD: SERVERWLM
  FLG:
    TCSR: 100  CER: 100 SEF: 100
    WEIGHT: 64
      RAW         CP: 48 ZAAP: 64 ZIIP: 64
      PROPORTIONAL CP: 64 ZAAP: 00 ZIIP: 00
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000016
    QOSPLCACT: *DEFAULT*
      W/Q: 16
DEST:       10.1.8.10..23
  DESTXCF:   10.1.7.31
  TOTALCONN: 0000000003  RDY: 000 2 WLM: 16  TSR: 100
  DISTMETHOD: SERVERWLM
  FLG:
    TCSR: 100  CER: 100 SEF: 100
    WEIGHT: 64
      RAW         CP: 48 ZAAP: 64 ZIIP: 64
      PROPORTIONAL CP: 64 ZAAP: 00 ZIIP: 00
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000016
    QOSPLCACT: *DEFAULT*
      W/Q: 16
```

In the example, the number 1 indicates whether this server application has been quiesced for DVIPA sysplex distributor workload balancing. A `Dest` value indicates that this server will receive no new DVIPA sysplex distributor workload connections until the server application has been resumed. The **NETSTAT VDPT,DETAIL** command display shows that the TCPIPC port 23 is not ready (2).

RESUME

Issue the **RESUME** command parameter on TCPIPC so that the stack becomes eligible to accept new TN3270 connections again.

Example 2-52 shows that the TCPIPC is not quiesced 1, and is in ready status 2.

Example 2-52 TCPIPC ready and not quiesced

```
On SC32
V TCPIP,TCPIPC,SYSPLEX,RESUME,PORT=23
EZZ0060I PROCESSING COMMAND: VARY TCPIP,TCPIPC,SYSPLEX,RESUME,PORT=23
EZD1198I THE VARY TCPIP,,SYSPLEX,RESUME COMMAND COMPLETED SUCCESSFULLY

D TCPIP,TCPIPC,N,ALL,PORT=23
EZD0101I NETSTAT CS V1R13 TCPIPC 311
CLIENT NAME: TN3270C                  CLIENT ID: 00000030
  LOCAL SOCKET: ::..23
  FOREIGN SOCKET: ::..0
    QUIESCED:          NO      1

On SC30
D TCPIP,TCPIPA,N,VDPT,DETAIL
EZD0101I NETSTAT CS V1R13 TCPIPA 107
DYNAMIC VIPA DESTINATION PORT TABLE FOR TCP/IP STACKS:
DEST:       10.1.8.10..23
  DESTXCF:   10.1.7.11
  TOTALCONN: 0000000000  RDY: 001  WLM: 16  TSR: 100
  DISTMETHOD: SERVERWLM
  FLG:
    TCSR: 100  CER: 100 SEF: 100
    WEIGHT: 64
      RAW         CP: 48 ZAAP: 64 ZIIP: 64
      PROPORTIONAL CP: 64 ZAAP: 00 ZIIP: 00
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000000
    QOSPLCACT: *DEFAULT*
      W/Q: 16
DEST:        10.1.8.10..23
  DESTXCF:   10.1.7.21
  TOTALCONN: 0000000001  RDY: 001  WLM: 16  TSR: 100
  DISTMETHOD: SERVERWLM
  FLG:
    TCSR: 100  CER: 100 SEF: 100
    WEIGHT: 64
      RAW         CP: 47 ZAAP: 64 ZIIP: 64
      PROPORTIONAL CP: 64 ZAAP: 00 ZIIP: 00
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000017
    QOSPLCACT: *DEFAULT*
      W/Q: 16
DEST:        10.1.8.10..23
  DESTXCF:   10.1.7.31
  TOTALCONN: 0000000003  RDY: 001 2 WLM: 16  TSR: 100
  DISTMETHOD: SERVERWLM
  FLG:
    TCSR: 100  CER: 100 SEF: 100
    WEIGHT: 64
      RAW         CP: 48 ZAAP: 64 ZIIP: 64
      PROPORTIONAL CP: 64 ZAAP: 00 ZIIP: 00
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000017
    QOSPLCACT: *DEFAULT*
      W/Q: 16
3 OF 3 RECORDS DISPLAYED
END OF THE REPORT
```

When the server application is resumed, the quiesced value changes to `No`.

For additional information about these commands, see *z/OS Communications Server: IP System Administrator’s Commands*, SC27-3661.

3 VIPA without dynamic routing

As previously mentioned, you should use a dynamic routing protocol in your mainframes for high availability. Now, innovative designs take advantage of z/OS support of Address Resolution Protocol (ARP) takeover to achieve comparable availability without using a dynamic routing protocol. In this chapter, we explain how to design and implement high availability for your IBM z/OS Communications Server environment without dynamic routing.

This chapter contains the following topics.

Section	Topic
3.1, “Basic concepts” on page 62”	Background information and an explanation of why this solution can be important in typical environments
3.2, “High availability using ARP takeover in one TCP/IP stack” on page 63	Implementation and test scenarios for high availability across within a TCP/IP stack using ARP Takeover.
3.3, “High availability across multiple TCP/IP stacks using DVIPA” on page 69	Implementation and test scenarios for high availability across multiple TCP/IP stacks using DVIPA.
3.4, “Debugging tips” on page 84	Summary of debugging approaches useful when working with layer two definitions

3.1 Basic concepts

High availability designs that do not use dynamic routing protocols (which are part of TCP/IP) achieve availability based on local area networking (LAN) capabilities instead (such LAN capabilities are also often referred to as layer 2 functions, because LANs constitute layers 1 and 2 of the seven-layer OSI networking model).

The most fundamental of those capabilities is the ability to transfer an IP address from a failing (or failed) physical interface or stack to a separate physical interface or stack. In an z/OS Communications Server environment, *dynamic* movement of an IP address (without the use of dynamic routing) is called ARP takeover, and it requires OSA-Express adapters.

In addition, if you want to move an IP address from one *adapter* to another within a system, you can optionally set up Static Virtual IP Addresses (VIPAs). If you want to implement dynamic movement of an IP address from one TCP/IP *stack* to another (including a stack on a completely separate system), you must set up Dynamic Virtual IP Addresses (DVIPAs), which, in turn, requires Sysplex XCF communications.

Note: Virtual IP addressing is introduced, along with implementation scenarios, in Chapter 2, “Virtual IP addressing” on page 13.

ARP takeover uses LAN broadcast protocols. Therefore, to use ARP takeover, all of the systems in your sysplex must be connected to the same LAN (or virtual LAN (VLAN)) and thus, in the same TCP/IP subnet (also called *flat* network connectivity). Also, ARP takeover does not provide protection from failures in routers or switches in the network. Backup and recovery for these elements must be considered separately.

A *flat* network is one in which all stacks can reach each other without going through intermediate bridges or routers that transform IP addresses. Expressed another way, a flat network is contained in one network segment or subnet. It is one *broadcast domain*.

Stacks within a flat network communicate with each other at layer 2 of the OSI model. Layer 2 frames are switched based on MAC addresses. (Layer 3 frames are switched based on IP addresses.) A flat network does not preclude the incorporation of transparent switches or bridges, and it might support up to a few hundred stations.

No external routing changes are needed as a result of the move from the primary stack to the backup stack. Therefore, a dynamic routing protocol is not required.

3.2 High availability using ARP takeover in one TCP/IP stack

ARP takeover is a function that allows traffic to be redirected from a failing OSA connection to another OSA connection. This function is supported with IPv4 and IPv6 OSA interfaces.

When an OSA DEVICE or INTERFACE defined in a TCP/IP stack is started, all IP addresses associated with that OSA port in QDIO mode (which is device type MPCIPA in the TCP/IP profile) are dynamically downloaded to the OSA card.

Note: If you want to use the ARP takeover function, use your OSA-Express ports in QDIO mode. If the port is defined in non-QDIO mode (device type LCS in the TCP/IP profile), then you must use OSA/SF to build and activate a configuration that identifies the multiple IP addresses that *might* be used with the adapter. In a DVIPA environment (or a simple OSA takeover environment), the use of QDIO mode simplifies setup and management.

If an OSA port fails while there is a backup OSA port available on the same subnetwork, then TCP/IP informs the backup adapter as to which IP addresses (real and VIPA) to take over and network connections are maintained. After it is set up correctly, the fault tolerance provided by the ARP takeover function is automatic.

3.2.1 Implementation

This section shows an ARP takeover example. We define two OSA interfaces named OSA2080I and OSA20A0I by INTERFACE statement with VMAC ROUTEALL option. You may also use DEVICE/LINK statement instead for defining OSA interfaces. In this example, we define a static VIPA interface, VIPA2L, but it is not a requirement for an ARP takeover configuration. Two OSAs and a static VIPA have the IP address from same IP subnet.

Note: Although we do not show it in this section, you may also define the static VIPA with an IP address not belonging to the subnet that OSAs belong to. In this case, the external router requires the routing information to VIPA, using the OSA IP address as the next hop address. Suppose VIPA is 10.1.1.10, OSA1 is 10.1.2.11, and OSA2 is 10.1.2.12. In such a case, the external router needs routing information:

```
ip route 10.1.1.10 255.255.255.255 10.1.2.11
```

Using the next hop IP address 10.1.2.11, the packets destined to VIPA are routed to OSA1. If OSA1 fails, 10.1.2.11 is moved over to OSA2 and the packets are routed to OSA2.

Figure 3-1 shows our environment.

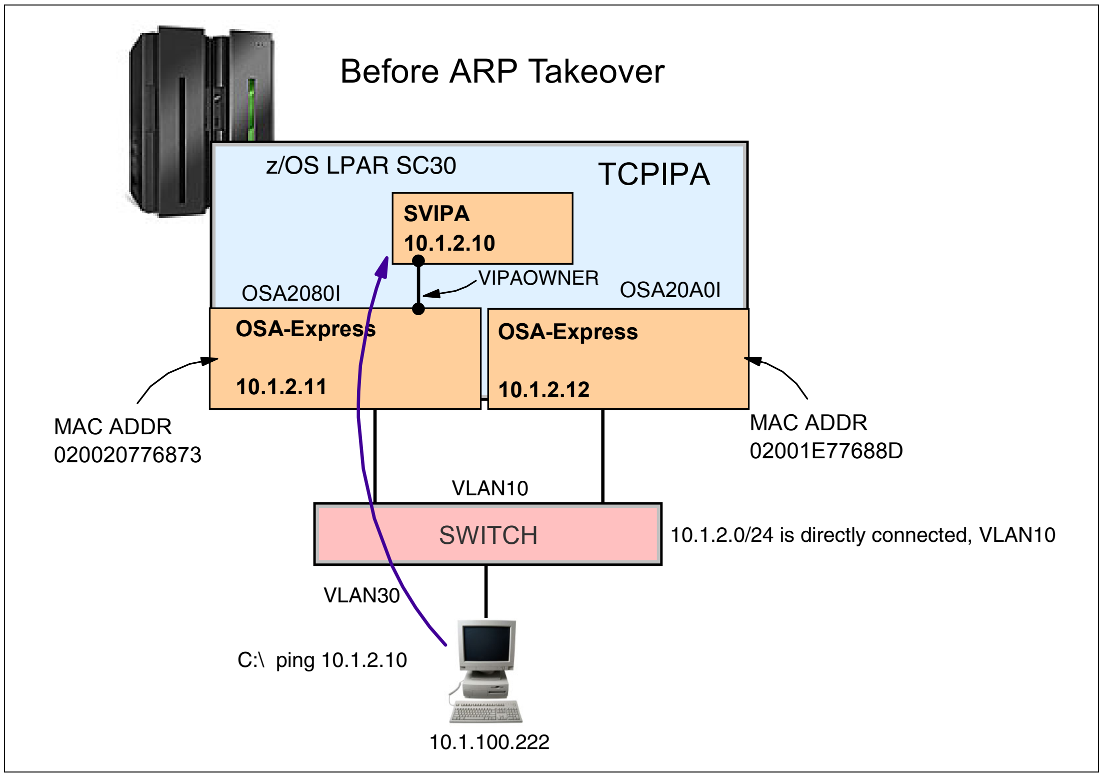


Figure 3-1 ARP takeover environment

Single versus multiple switches: For demonstration purposes, these example show a single-switch environment. However, to avoid single points of failure, always separate your OSA connections across multiple switches.

Example 3-1 shows the definition sample we use.

Example 3-1 ARP Takeover definition

```
DEVICE VIPA2      VIRTUAL 0
LINK   VIPA2L     VIRTUAL 0   VIPA2

INTERFACE OSA2080I
DEFINE IPAQENET
PORTNAME OSA2080
SOURCEVIPAINT VIPA2L
IPADDR 10.1.2.11/24
MTU 1492
VLANID 10
VMAC ROUTEALL
;
INTERFACE OSA20A0I
DEFINE IPAQENET
PORTNAME OSA20A0
SOURCEVIPAINT VIPA2L
IPADDR 10.1.2.12/24
MTU 1492
```

```
VLANID 10
VMAC ROUTEALL

HOME
   10.1.2.10     VIPA2L

BEGINRoutes
ROUTE 10.1.2.0/24         =          OSA2080I    MTU 1492
ROUTE 10.1.2.0/24         =          OSA20A0I    MTU 1492
ROUTE DEFAULT         10.1.2.230     OSA2080I    MTU 1492
ROUTE DEFAULT         10.1.2.230     OSA20A0I    MTU 1492
ENDRoutes

START OSA2080I
START OSA20A0I
```

3.2.2 Verification

This section describes how we verified the ARP takeover function.

Normal Status

Example 3-2 shows the status of LANGROUP and VIPAOWNER before a failure.

Example 3-2 Display result of a NETSTAT, DEV command before takeover

```
D TCPIP,TCPIPA,N,DEV
LANGROUP: 00002 1
LANGROUP: 00002
  NAME              STATUS      ARPOWNER          VIPAOWNER
  ----              ------      --------          ---------
  OSA2080I          ACTIVE      OSA2080I          YES        2
  OSA20A0I          ACTIVE      OSA20A0I          NO
```

In this example, the numbers correspond to the following information:

1. OSA2080I and OSA20A0I belong to the LANGROUP: 00002.

2. The OSA2080I is the VIPAOWNER and has ARP processing responsibility for the VIPA.

Example 3-3 shows the IP address and MAC address relationship for each active OSA interface using the **DISPLAY NETSTAT,ARP** command. This information is only for reference. You should verify an ARP table on neighboring switching hubs or systems to obtain correct information, because ARP takeover is a layer 2 function.

Example 3-3 Display result of a NETSTAT, ARP command before a failure

```
D TCPIP,TCPIPA,N,ARP
EZD0101I NETSTAT CS V1R13 TCPIPA 851
QUERYING ARP CACHE FOR ADDRESS 10.1.2.11
INTERFACE: OSA2080I          ETHERNET: 020020776873
QUERYING ARP CACHE FOR ADDRESS 10.1.2.12
INTERFACE: OSA20A0I          ETHERNET: 02001E77688D
```

Example 3-4 shows an ARP table on our switching hub using the **`show arp`** command. Notice the MAC address used to reach static VIPA 10.1.2.10 is OSA2080I's MAC address **3**.

Example 3-4 Display result of a show arp command before a failure

```
Router1#show arp | inc 10.1.2
Internet  10.1.2.10             9   0200.2077.6873  ARPA   Vlan10 3
Internet  10.1.2.11            43   0200.2077.6873  ARPA   Vlan10
Internet  10.1.2.12             9   0200.1e77.688d  ARPA   Vlan10
```

ARP takeover

Figure 3-2 shows our environment as we simulate an error condition by stopping the interface OSA2080I in the TCP/IP stack.

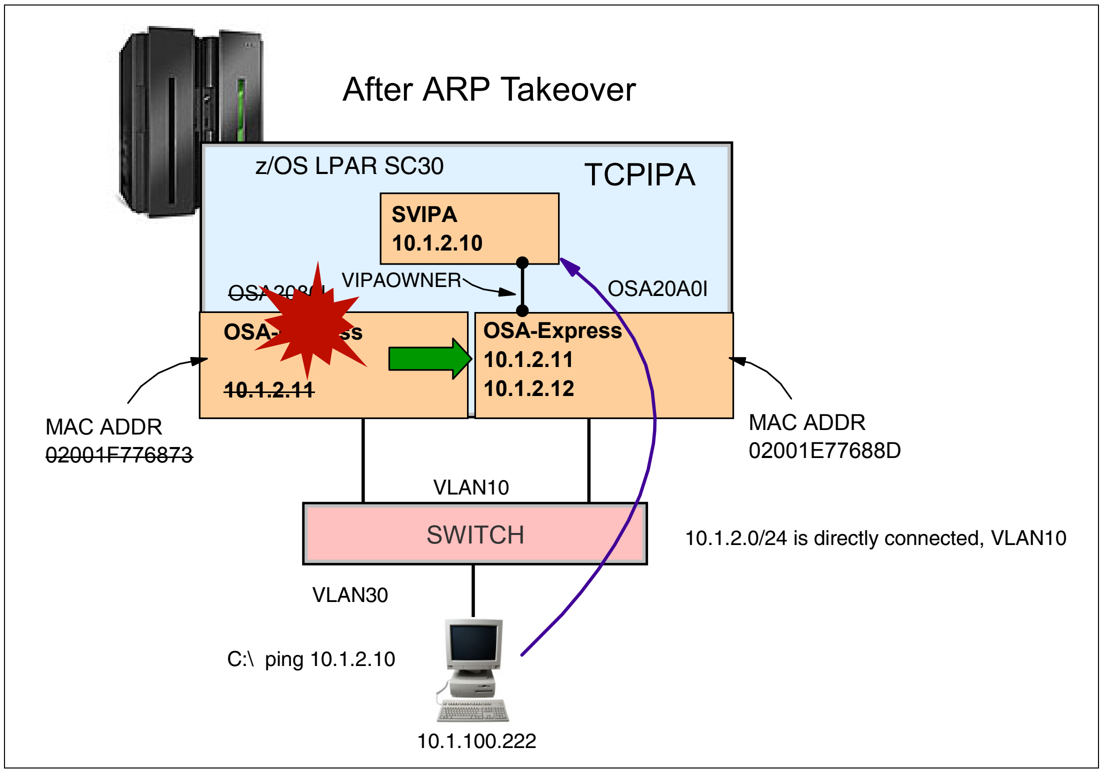


Figure 3-2 ARP takeover after OSA2080I failed

This simulated failure produces messages on the z/OS console, as shown in Example 3-5. The EZD0040I message marked as **1** shows that OSA20A0I has taken over ARP responsibility for OSA2080I. OSA20A0I responds to all ARP requests for IP addresses formerly owned by OSA2080I. If you configured DEVICE and LINK statements for OSA ports, you see the EZZ4329I message instead of EZD0040I.

Example 3-5 ARP takeover message after stopping OSA2080I

```
V TCPIP,TCPIPA,STOP,OSA2080I
EZZ0060I PROCESSING COMMAND: VARY TCPIP,TCPIPA,STOP,OSA2080I
EZZ0053I COMMAND VARY STOP COMPLETED SUCCESSFULLY
EZD0040I INTERFACE OSA20A0I HAS TAKEN OVER ARP RESPONSIBILITY FOR
INACTIVE INTERFACE OSA2080I 1
EZZ4341I DEACTIVATION COMPLETE FOR INTERFACE OSA2080I
```

Example 3-6 and Example 3-7 show the ARP cache tables of TCPIPA and our switching hub.

Example 3-6 Display results of a NETSTAT, ARP command after takeover

```
D TCPIP,TCPIPA,N,ARP
EZD0101I NETSTAT CS V1R13 TCPIPA 872
QUERYING ARP CACHE FOR ADDRESS 10.1.2.12
INTERFACE: OSA20A0I         ETHERNET: 02001E77688D 1
QUERYING ARP CACHE FOR ADDRESS 10.1.2.11
INTERFACE: OSA20A0I         ETHERNET: 02001E77688D 1
```

Example 3-7 Display results of a show arp command after takeover

```
Router1#sh arp | inc 10.1.2
Internet  10.1.2.11             2   0200.1e77.688d  ARPA   Vlan10 1
Internet  10.1.2.10             2   0200.1e77.688d  ARPA   Vlan10 1
Internet  10.1.2.12            23   0200.1e77.688d  ARPA   Vlan10 1
```

Both IP addresses point to the same MAC address, marked as **1**, which is associated with the interface OSA20A0I. TCPIPA notifies all hosts on the LAN by broadcasting gratuitous ARPs when the interface (OSA2080I) stops.

Example 3-8 shows the status of VIPAOWNER after taking over.

Example 3-8 Display result of a NETSTAT, DEV command after takeover

```
D TCPIP,TCPIPA,NETSTAT,DEV
LANGROUP: 00002
  NAME              STATUS      ARPOWNER          VIPAOWNER
  ----              ------      --------          ---------
  OSA20A0I          ACTIVE      OSA20A0I          YES 1
  OSA2080I          NOT ACTIVE  OSA20A0I          NO  2
```

In this example, the numbers correspond to the following information:

1. The VIPAOWNER is switched to the OSA20A0I interface.

2. The interface OSA2080I is inactive, and is no longer ARPOWNER.

ARP takeback

We start OSA2080I using a **VARY TCPIP,,START** command. Figure 3-3 shows our environment after the interface OSA2080I starts.

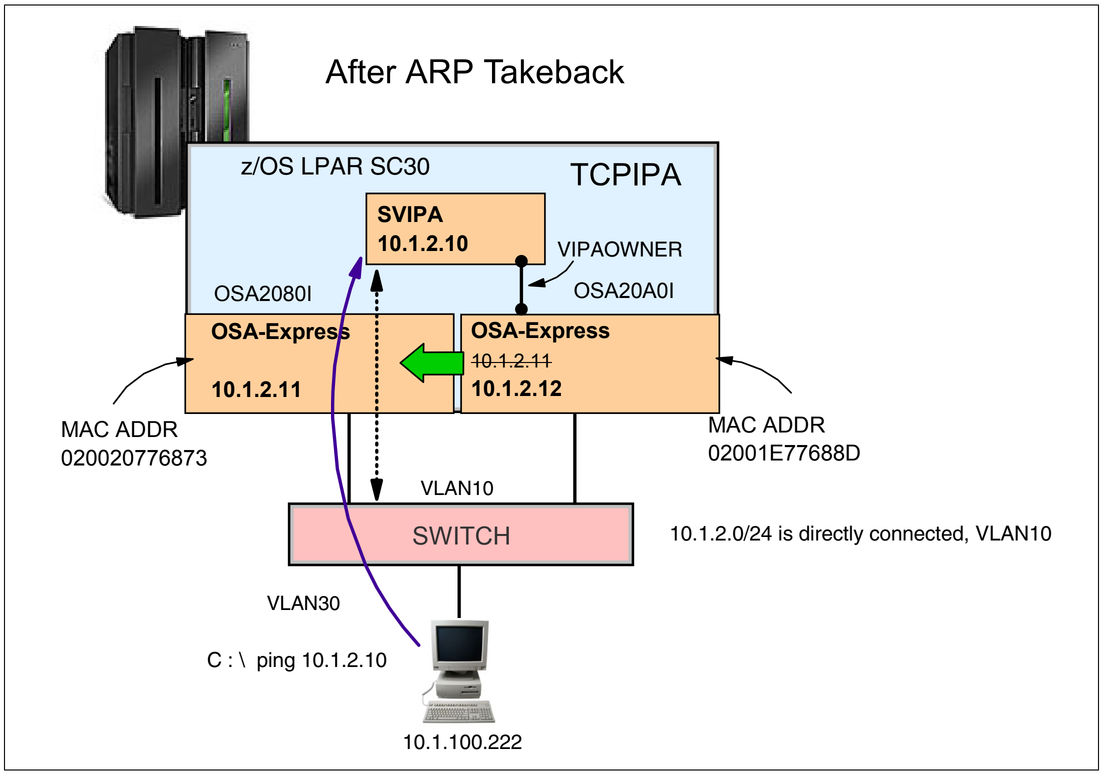


Figure 3-3   ARP takeback after OSA20A0I recovers

When the OSA2080I interface starts using a **VARY TCPIP,,START** command, the messages in Example 3-9 are displayed.

Example 3-9   ARP takeback message after starting OSA2080I

```
V TCPIP,TCPIPA,START,OSA2080I
EZZ0060I PROCESSING COMMAND: VARY TCPIP,TCPIPA,START,OSA2080I
EZZ0053I COMMAND VARY START COMPLETED SUCCESSFULLY
EZD0041I INTERFACE OSA2080I HAS TAKEN BACK ARP RESPONSIBILITY FROM
INTERFACE OSA20A0I
EZZ4340I INITIALIZATION COMPLETE FOR INTERFACE OSA2080I
```

The EZD0041I message marked as 1 shows that the interface OSA2080I takes back the ARP responsibility from the OSA20A0I interface. With DEVICE and LINK statements, you see EZD0013I instead of EZD0041I.

After the interface OSA2080I is taken back, we verify that the ARP cache tables are correctly modified by using the DISPLAY NETSTAT ARP, DISPLAY NETSTAT DEV, and **show arp** commands, as shown in Example 3-10 on page 69, Example 3-11 on page 69, and Example 3-12 on page 69.

Example 3-10 Display result of a NETSTAT, ARP command after takeback

```
D TCPIP,TCPIPA,N,ARP
EZD0101I NETSTAT CS V1R13 TCPIPA 884
QUERYING ARP CACHE FOR ADDRESS 10.1.2.11
INTERFACE: OSA2080I          ETHERNET: 020020776873 1
QUERYING ARP CACHE FOR ADDRESS 10.1.2.12
INTERFACE: OSA20A0I          ETHERNET: 02001E77688D
```

In the example, the number 1 indicates that the ARP cache now references the original MAC address for 10.1.2.11.

Example 3-11 Display result of a show arp command after takeback

```
Router1#sh arp | inc 10.1.2
Internet  10.1.2.11            8   0200.2077.6873  ARPA   Vlan10 2
Internet  10.1.2.10           14   0200.1e77.688d  ARPA   Vlan10
Internet  10.1.2.12           35   0200.1e77.688d  ARPA   Vlan10
```

In the example, the number 2 indicates that gratuitous ARPs are broadcasted on the LAN by the TCPIP stack, and the ARP cache in the switching hub is updated with the original MAC address.

Example 3-12 Display result of a NETSTAT, DEV command after takeback

```
D TCPIP,TCPIPA,NETSTAT,DEV
LANGROUP: 00002
  NAME              STATUS      ARPOWNER          VIPAOWNER
  ----              ------      --------          ---------
  OSA20A0I          ACTIVE      OSA20A0I          YES 3
  OSA2080I          ACTIVE      OSA2080I          NO
```

In the example, the number 3 indicates that the OSA2080I interface is now active and has its own ARPOWNER status back. However, the OSA20A0I interface keeps the VIPAOWNER. This is because a VIPA belongs to a stack and not to a particular interface; therefore, it does not matter which OSA is the VIPAOWNER.

Spanning Tree Protocol: If a spanning tree is used in the bridge or switch that is connected to an OSA QDIO port, the Spanning Tree Protocol portfast must be enabled on switching hub port for OSA to allow the routing protocol packets that advertise a VIPA to flow correctly. Without the Spanning Tree Protocol portfast enabled, there is a transition through the Listening and Learning stages (30 seconds in total) of Spanning Tree before the port can actually pass valid traffic.

3.3 High availability across multiple TCP/IP stacks using DVIPA

In our environment, we use two OSA adapters in QDIO mode, connected to two switches. We use a unique VLAN (VLAN 10), spanning our switches, and connect our hosts to that VLAN.

We work in two LPARs, SC30 and SC31, using static routing between them. Our DVIPA fail-over implementation moves the active IP address from one LPAR to the other when needed.

Our design has the following dependencies:

- We need separate LAN adapters for each stack. We use OSA-Express3 adapters in QDIO mode. QDIO mode is recommended because the OSA internal IP tables (OATs) are updated dynamically. Other LAN interfaces, such as channel-attached routers, cannot be used in the high availability configuration described in this chapter.
- All z/OS images must be connected to the same LAN segment, so that all adapters receive broadcast frames.
- This scenario is suitable for a subnet with a small number of hosts. If the subnet has more hosts, then we must consider the potential effects of LAN broadcast (sometimes called *broadcast storms*). This exposure is not directly related to the DVIPA operation we are describing, but should be considered when designing high availability network environments.
- To show a flat network scenario, all resources in VLAN 10, including the DVIPA addresses, belong to the same subnet.

This design has the following advantages:

- It is simple and easy to configure, and it avoids the complexities of implementing dynamic routing.
- No additional routers or router paths are required.
- This design supports DVIPA takeover and takeback functions, and distributed DVIPA.

3.3.1 Implementation

Figure 3-4 illustrates our working environment. The OSA-Express3 ports are defined as OSD types, causing them to work in QDIO mode.

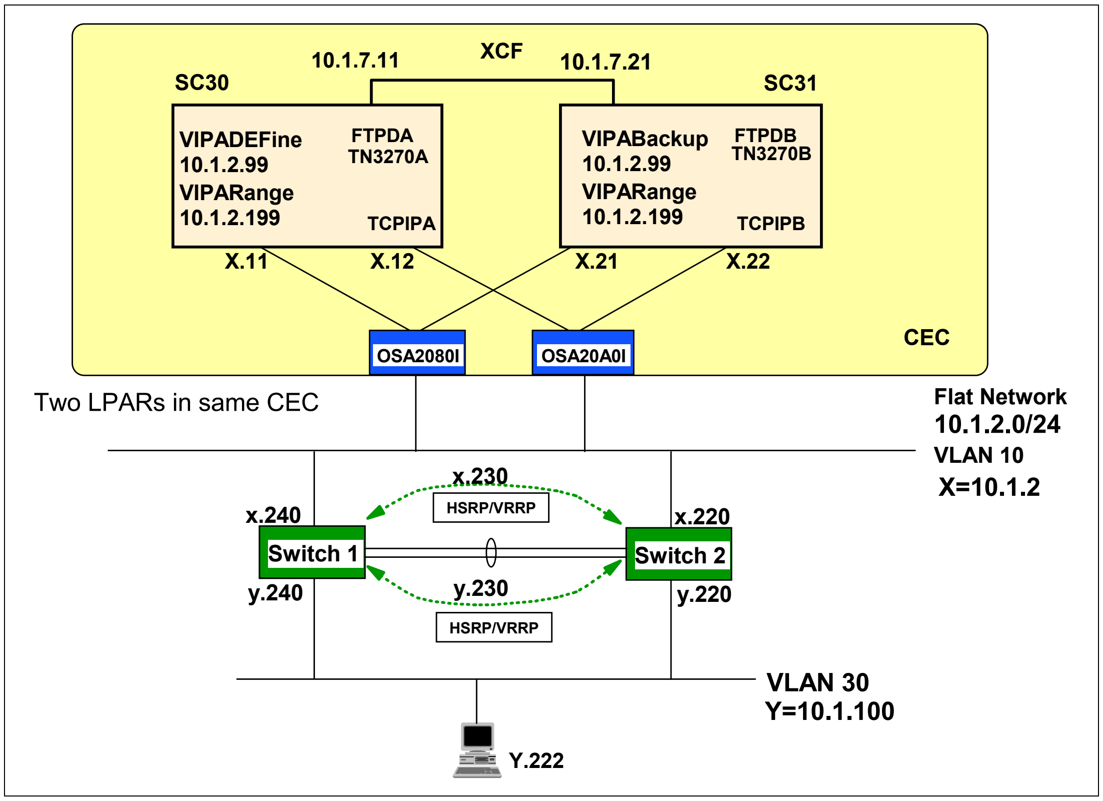


Figure 3-4 Diagram of our working environment

Example 3-13 and Example 3-14 on page 72 list the relevant statements in our TCP/IP profiles for the two LPARs. Consider the following key items in the examples:

1. The two OSA ports are configured to use the same VLAN (VLAN 10).
2. Static route and default route definitions to both OSA ports that belong to the VLANID are created. By doing this, have high availability exists at the interface level (one is a backup of the other).
3. One DVIPA address is defined using VIPADEFine/VIPABackup.
4. VIPARange is also defined for event-activated DVIPAs.
5. The FTP application to `bind()` to a specific address (DVIPA) is defined instead of INADDR_ANY by using the server bind control that is implemented through the BIND keyword on the PORT statement.

Example 3-13 TCP/IP profile in SC30

```
IPCONFIG SYSPLEXROUTING MULTIPATH PERCONNECTION
DYNAMICXCF 10.1.7.11 255.255.255.0 1
;
INTERFACE OSA2080I
DEFINE IPAQENET
PORTNAME OSA2080
IPADDR 10.1.2.11/24
MTU 1492
VLANID 10 1
VMAC   ROUTEALL
;
INTERFACE OSA20A0I
DEFINE IPAQENET
PORTNAME OSA20A0
IPADDR 10.1.2.12/24
MTU 1492
VLANID 10 1
VMAC   ROUTEALL
;
VIPADYNAMIC
   VIPADEFINE MOVEable IMMEDiate 255.255.255.0 10.1.2.99 3
   VIPARANGE DEFINE MOVEable NONDISRUPTive 255.255.255.0 10.1.2.0 4
ENDVIPADYNAMIC
;
BEGINRoutes 2
ROUTE 10.1.2.0/24       =           OSA2080I    MTU 1492
ROUTE 10.1.2.0/24       =           OSA20A0I    MTU 1492
ROUTE DEFAULT         10.1.2.230    OSA2080I    MTU 1492
ROUTE DEFAULT         10.1.2.230    OSA20A0I    MTU 1492
ENDRoutes
;
PORT
    20 TCP OMVS    NOAUTOLOG      ; FTP Server
    21 TCP OMVS    BIND 10.1.2.199 ; control port 5
;
SACONFIG ENABLED COMMUNITY public AGENT 161
;
START OSA2080I
START OSA20A0I
```

Example 3-14 shows our TCP/IP profile in SC31.

Example 3-14 TCP/IP profile in SC31

```
IPCONFIG SYSPLEXROUTING MULTIPATH PERCONNECTION
DYNAMICXCF 10.1.7.21 255.255.255.0 1
;
INTERFACE OSA2080I
DEFINE IPAQENET
PORTNAME OSA2080
IPADDR 10.1.2.33/24
MTU 1492
VLANID 10 1
VMAC   ROUTEALL
;
INTERFACE OSA20A0I
DEFINE IPAQENET
PORTNAME OSA20A0
IPADDR 10.1.2.34/24
MTU 1492
VLANID 10 1
VMAC   ROUTEALL
;
VIPADYNAMIC
   VIPABACKUP 100 MOVEable IMMEDiate 255.255.255.0 10.1.2.99 3
   VIPARANGE DEFINE MOVEable NONDISRUPTive 255.255.255.0 10.1.2.0 4
ENDVIPADYNAMIC
;
BEGINRoutes 2
   ROUTE 10.1.2.0/24       =           OSA2080I    MTU 1492
   ROUTE 10.1.2.0/24       =           OSA20A0I    MTU 1492
   ROUTE DEFAULT         10.1.2.230    OSA2080I    MTU 1492
   ROUTE DEFAULT         10.1.2.230    OSA20A0I    MTU 1492
ENDRoutes
;
PORT
    20 TCP OMVS    NOAUTOLOG      ; FTP Server
    21 TCP OMVS    BIND 10.1.2.199; control port 5
;
SACONFIG ENABLED COMMUNITY public AGENT 161
;
START OSA2080I
START OSA20A0I
```

3.3.2 Verification

This sections shows the normal status and the following high availability scenarios:

- Adapter interface failure
- Application movement
- Stack failure

Normal status

We start TCPIPA and TCPIPB now. FTPDA is started also on SC30. FTPDB on SC31 is inactive.

To verify that our network is operational, we first use NETSTAT to check the routing configuration, as shown in Example 3-15.

Example 3-15 Flat network result display routes in normal operation of SC30 and SC31

```
On SC30
D TCPIP,TCPIPA,N,ROUTE
EZD0101I NETSTAT CS V1R13 TCPIPA 008
IPV4 DESTINATIONS
DESTINATION       GATEWAY         FLAGS    REFCNT     INTERFACE
DEFAULT           10.1.2.230 1    UGS      0000000002 OSA2080I
DEFAULT           10.1.2.230 1    UGS      0000000000 OSA20A0I
10.1.2.0/24       0.0.0.0         US       0000000000 OSA2080I
10.1.2.0/24       0.0.0.0         US       0000000000 OSA20A0I
10.1.2.11/32      0.0.0.0         UH       0000000000 OSA2080I
10.1.2.12/32      0.0.0.0         UH       0000000000 OSA20A0I
10.1.7.0/24       0.0.0.0         US       0000000000 IQDIOLNK0A01070B
10.1.7.11/32      0.0.0.0         H        0000000000 EZASAMEMVS
10.1.7.11/32      0.0.0.0         UH       0000000000 IQDIOLNK0A01070B
10.1.7.21/32      0.0.0.0         UHS      0000000000 IQDIOLNK0A01070B
10.1.2.99/32      0.0.0.0         UH       0000000000 VIPL0A010263
10.1.2.199/32     0.0.0.0         UH       0000000000 VIPL0A0102C7

On SC31
D TCPIP,TCPIPB,N,ROUTE
EZD0101I NETSTAT CS V1R13 TCPIPB 066
IPV4 DESTINATIONS
DESTINATION       GATEWAY         FLAGS    REFCNT     INTERFACE
DEFAULT           10.1.2.230      UGS      0000000001 OSA2080I
DEFAULT           10.1.2.230      UGS      0000000000 OSA20A0I
10.1.2.0/24       0.0.0.0         US       0000000000 OSA2080I
10.1.2.0/24       0.0.0.0         US       0000000000 OSA20A0I
10.1.2.21/32      0.0.0.0         UH       0000000000 OSA2080I
10.1.2.22/32      0.0.0.0         UH       0000000000 OSA20A0I
```

Note the two default route entries to a virtual IP address 10.1.2.230 (1) on routers in Example 3-15. This virtual IP address can be either a Hot Stand-by Router Protocol (HSRP) or Virtual Router Redundancy Protocol (VRRP) IP address.

A NETSTAT with a VIPADCFG operand provides information about the DVIPA configuration in each stack where the command is issued. The results are illustrated in Example 3-16.

Example 3-16 Display NETSTAT DVIPA config in SC30 and SC31

```
On SC30
D TCPIP,TCPIPA,N,VIPADCFG
EZD0101I NETSTAT CS V1R13 TCPIPA 010
DYNAMIC VIPA INFORMATION:
VIPA DEFINE:
    IPADDR/PREFIXLEN: 10.1.2.99/24
      MOVEABLE: IMMEDIATE  SRVMGR: NO  FLG:
VIPA RANGE:
    IPADDR/PREFIXLEN: 10.1.2.0/24
      MOVEABLE: NONDISR

On SC31
D TCPIP,TCPIPB,N,VIPADCFG
EZD0101I NETSTAT CS V1R13 TCPIPB 219
DYNAMIC VIPA INFORMATION:
  VIPA BACKUP:
    IPADDR/PREFIXLEN: 10.1.2.99
      RANK: 100  MOVEABLE:            SRVMGR:     FLG:
  VIPA RANGE:
    IPADDR/PREFIXLEN: 10.1.2.0/24
      MOVEABLE: NONDISR
```

We use two TCP/IP applications, TN3270E server and FTP. Both are used from a client workstation at address 10.1.100.222. The TN3270E client is configured to access the VIPADEFine 10.1.2.99,which is (**1**) in Example 3-17. The FTP client is started to access the 10.1.2.199, which is within the VIPARange (**2**). The DVIPA address 10.1.2.199 appears in the home list after the application FTP server is started.

A NETSTAT with a VIPADYN operand provides information about DVIPA status in each stack where the command is issued. The results are illustrated in Example 3-17.

Example 3-17 Display SYSPLEX DVIPA status in SC30 and SC31

```
On SC30
D TCPIP,TCPIPA,N,VIPADYN
EZD0101I NETSTAT CS V1R13 TCPIPA 012
DYNAMIC VIPA:
  IPADDR/PREFIXLEN: 10.1.2.99/24 1
    STATUS:  ACTIVE     ORIGIN: VIPADEFINE       DISTSTAT:
    ACTTIME: 07/20/2011 17:31:55
after we start the FTP the VIPARange address appears
  IPADDR/PREFIXLEN: 10.1.2.199/24 2
    STATUS:  ACTIVE     ORIGIN: VIPARANGE BIND   DISTSTAT:
    ACTTIME: 07/20/2011 17:32:42                 JOBNAME: FTPDA1

On SC31
D TCPIP,TCPIPB,N,VIPADYN
EZD0101I NETSTAT CS V1R13 TCPIPB 217
DYNAMIC VIPA:
  IPADDR/PREFIXLEN: 10.1.2.99/24
    STATUS:  BACKUP     ORIGIN: VIPABACKUP       DISTSTAT:
    ACTTIME: N/A
```

A NETSTAT with a CONN operand, shown in Example 3-18, provides connection information.

Example 3-18 TN3270E and FTP to DVIPA address in use

```
On SC30
D TCPIP,TCPIPA,N,CONN
EZD0101I NETSTAT CS V1R13 TCPIPA 069
USER ID  CONN     STATE
FTPDA1   0000002A LISTEN
  LOCAL SOCKET:   ::FFFF:10.1.2.199..21
  FOREIGN SOCKET: ::FFFF:0.0.0.0..0
FTPDA1   00000073 ESTBLSH
  LOCAL SOCKET:   ::FFFF:10.1.2.199..21
  FOREIGN SOCKET: ::FFFF:10.1.100.222..1496
TN3270A  00000067 LISTEN
  LOCAL SOCKET:   ::..23
  FOREIGN SOCKET: ::..0
TN3270A  00000082 ESTBLSH
  LOCAL SOCKET:   ::FFFF:10.1.2.99..23
  FOREIGN SOCKET: ::FFFF:10.1.100.222..1497
```

Adapter interface failure

We stop the OSA adapter (OSA2080I) to simulate the adapter interface failure on SC30 TCPIPA to verify that the connection from the client workstation continues to function during the takeover by the backup system. The failure scenario is illustrated in Figure 3-5.

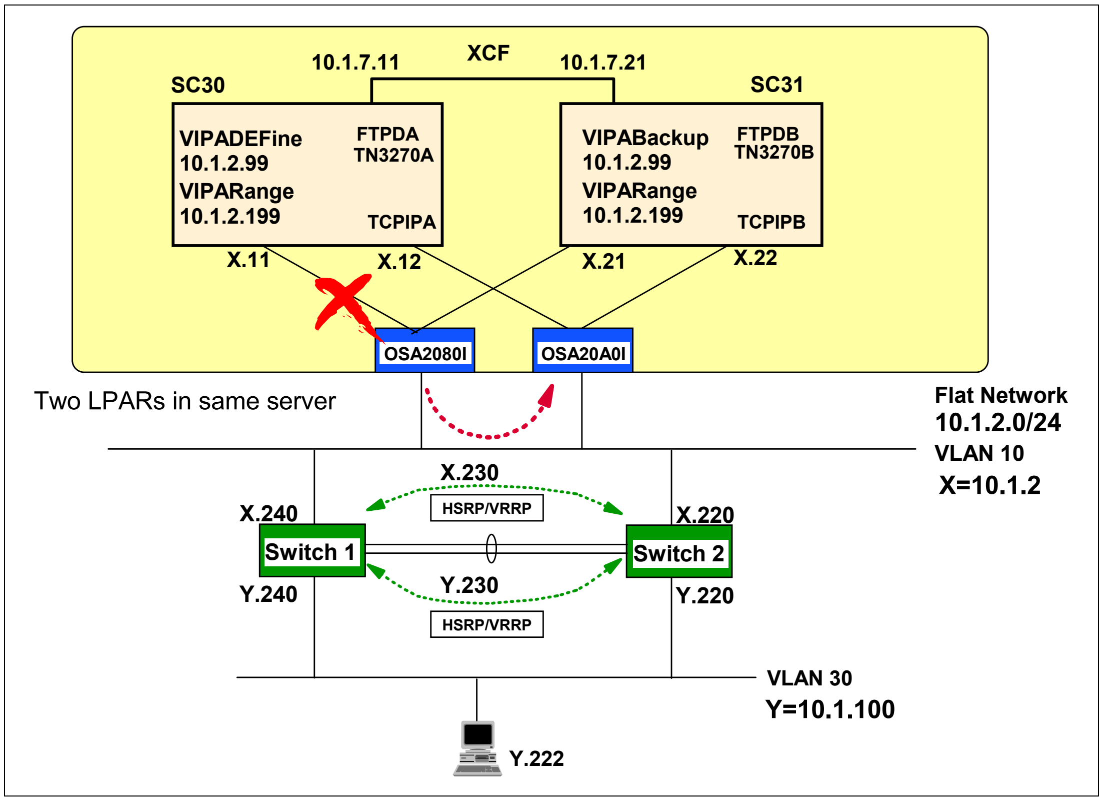


Figure 3-5 High availability for an adapter failure

The command to stop the primary interface and the resulting messages are shown in Example 3-19.

Example 3-19 High availability in the case of a failure of an interface

```
V TCPIP,TCPIPA,STOP,OSA2080I
EZZ0060I PROCESSING COMMAND: VARY TCPIP,TCPIPA,STOP,OSA2080I
EZZ0053I COMMAND VARY STOP COMPLETED SUCCESSFULLY
EZD0040I INTERFACE OSA20A0I HAS TAKEN OVER ARP RESPONSIBILITY FOR
INACTIVE INTERFACE OSA2080I
EZZ4341I DEACTIVATION COMPLETE FOR INTERFACE OSA2080I
```

We observe that the traffic is automatically redirected from the failing interface connection (OSA2080I) to the backup interface connection (OSA20A0I). This is the ARP takeover function. The takeover operation is described in more detail in 3.2, “High availability using ARP takeover in one TCP/IP stack” on page 63.

Note that this function requires that both LAN adapters involved be accessible to the LPAR running the stack and applications. The FTP and TN3270E connections continued to operate in SC30, the primary system. In this scenario, the operational TCP/IP stack and application remain in their original LPAR.

Example 3-20 shows that the TCP connections, TN3270E and FTP, are preserved. The adapter takeover is transparent to the client.

Example 3-20 FTP and TN3270 services keep running after the interface fails

```
D TCPIP,TCPIPA,N,CONN
EZD0101I NETSTAT CS V1R13 TCPIPA 083
USER ID  CONN     STATE
FTPDA1   0000002A LISTEN
  LOCAL SOCKET:   ::FFFF:10.1.2.199..21
  FOREIGN SOCKET: ::FFFF:0.0.0.0..0
FTPDA1   00000073 ESTBLSH
  LOCAL SOCKET:   ::FFFF:10.1.2.199..21
  FOREIGN SOCKET: ::FFFF:10.1.100.222..1496
TN3270A  00000067 LISTEN
  LOCAL SOCKET:   ::..23
  FOREIGN SOCKET: ::..0
TN3270A  00000082 ESTBLSH
  LOCAL SOCKET:   ::FFFF:10.1.2.99..23
  FOREIGN SOCKET: ::FFFF:10.1.100.222..1497
```

After observing these results, we restart the OSA (OSA2080I) interface. The result is a takeback function that was transparent to the client.

Application movement

This example illustrates how you can benefit from nondisruptive movement of an application by simply starting another instance of the application in another LPAR that takes over new connections. We define the FTP services in SC30 and SC31 to be manually started, that is, we do not use *autolog* in the port definition profile. First, we start the FTP server in SC30 and this step activates the DVIPA address 10.1.2.199. We then connect to the FTP server from the workstation.

When the new instance of the application becomes active, the TCP/IP stack can immediately take over the ownership of the DVIPA while existing connections continue to the original

TCP/IP stack (until the connections end or the original application or TCP/IP stack is taken down). This approach can be useful for planned outage situations (such as software maintenance). In failure situations, if the application supports Automatic Restart Manager (ARM), you can have ARM restart the application automatically. If your application cannot bind to a DVIPA, you can use the `BIND` on the port statement or the **`MODDVIPA`** utility. The situation is illustrated in Figure 3-6.

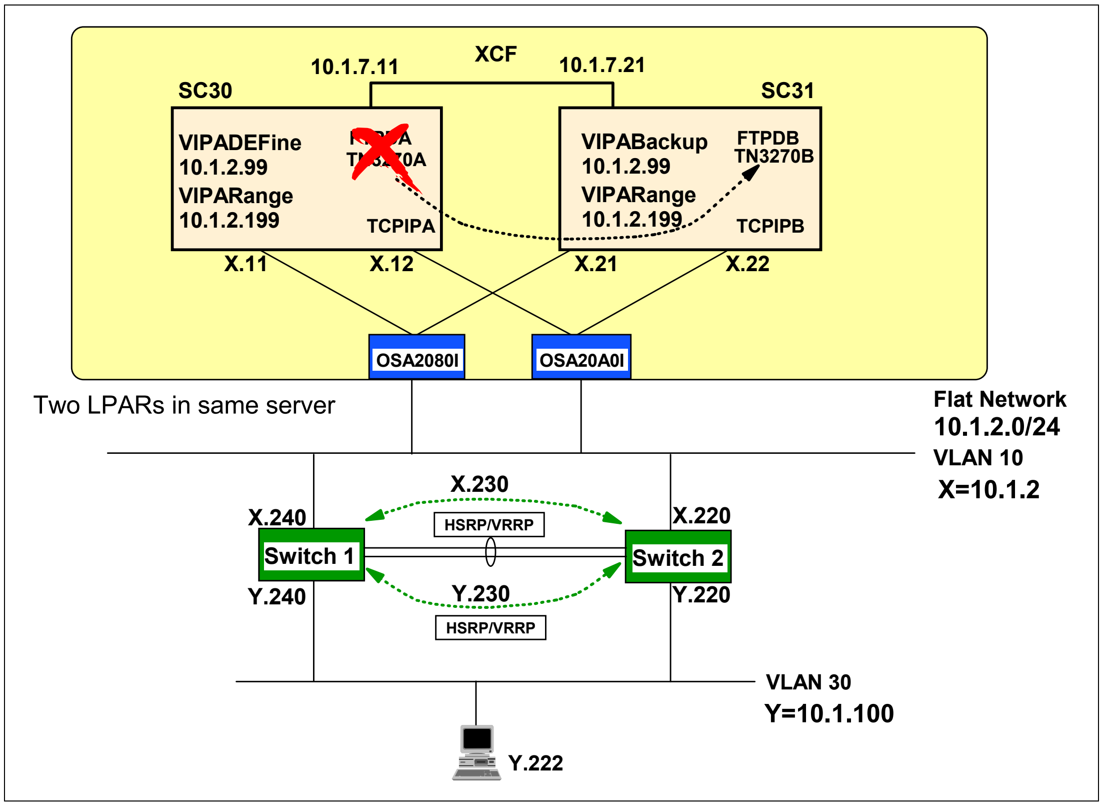


Figure 3-6 High availability for an application failure

We can observe that the DVIPA address defined by VIPARange is redirected from stack SC30 to another stack, SC31. This is the DVIPA movement. We can see it in the following examples.

Before starting FTP in SC31, the DVIPA address is active in SC30. We can verify this by using SYSPLEX with a VIPADYN operand. The results are shown in Example 3-21.

Example 3-21 DVIPA active in SC30

```
LINKNAME: VIPL0A0102C7
IPADDR/PREFIXLEN: 10.1.2.199/24
  ORIGIN: VIPARANGE BIND
  TCPNAME  MVSNAME  STATUS RANK DIST
  -------- -------- ------ ---- ----
  TCPIPA   SC30     ACTIVE
```

We then start an FTP application in SC31 and observe this stack take over the VIPA address, as shown in Example 3-22.

Example 3-22 The DVIPA address moves to SC31

```
SC31 console message
S FTPDB
$HASP100 FTPDB    ON STCINRDR
IEF695I START FTPDB    WITH JOBNAME FTPDB    IS ASSIGNED TO USER
TCPIP   , GROUP TCPGRP
$HASP373 FTPDB    STARTED
$HASP395 FTPDB    ENDED
EZZ8302I VIPA 10.1.2.199 TAKEN FROM TCPIPA ON SC30
EZD1205I DYNAMIC VIPA 10.1.2.199 WAS CREATED USING BIND BY FTPDB1 ON
TCPIPB
EZY2702I Server-FTP: Initialization completed at 18:14:15 on
07/20/11.

SC30 console message
EZZ8303I VIPA 10.1.2.199 GIVEN TO TCPIPB ON SC31
```

After starting FTP in SC31, the DVIPA status automatically changes, and the DVIPA address is now active in SC31. Example 3-23 illustrates this new status.

Example 3-23 DVIPA active in SC31

```
On SC30
D TCPIP,TCPIPA,SYSPLEX,VIPADYN
LINKNAME: VIPL0A010263
IPADDR/PREFIXLEN: 10.1.2.99/24
  ORIGIN: VIPADEFINE
  TCPNAME  MVSNAME  STATUS RANK DIST
  -------- -------- ------ ---- ----
  TCPIPA   SC30     ACTIVE
  TCPIPB   SC31     BACKUP 100
IPADDR: 10.1.2.199
  ORIGIN: VIPARANGE BIND
  TCPNAME  MVSNAME  STATUS RANK DIST
  -------- -------- ------ ---- ----
  TCPIPB   SC31     ACTIVE
  TCPIPA   SC30     MOVING

D TCPIP,TCPIPA,N,VIPADYN
EZD0101I NETSTAT CS V1R13 TCPIPA 102
DYNAMIC VIPA:
  IPADDR/PREFIXLEN: 10.1.2.99/24
    STATUS:  ACTIVE     ORIGIN: VIPADEFINE       DISTSTAT:
    ACTTIME: 07/20/2011 17:31:55
  IPADDR/PREFIXLEN: 10.1.2.199/24
    STATUS:  MOVING     ORIGIN: VIPARANGE BIND   DISTSTAT:
    ACTTIME: N/A                                 JOBNAME:

On SC31
D TCPIP,TCPIPB,N,VIPADYN
EZD0101I NETSTAT CS V1R13 TCPIPB 423
DYNAMIC VIPA:
  IPADDR/PREFIXLEN: 10.1.2.99/24
    STATUS:  BACKUP     ORIGIN: VIPABACKUP       DISTSTAT:
    ACTTIME: N/A
  IPADDR/PREFIXLEN: 10.1.2.199/24
    STATUS:  ACTIVE     ORIGIN: VIPARANGE BIND   DISTSTAT:
    ACTTIME: 07/20/2011 18:14:15                 JOBNAME: FTPDB1
```

Now, when a new FTP client connects, it connects to SC31. Existing FTP sessions remain with SC30 until they end.

Stack failure

In this example, we lose the entire TCP/IP stack. (We simulate this loss by simply stopping the stack.) The failure situation is illustrated in Figure 3-7.

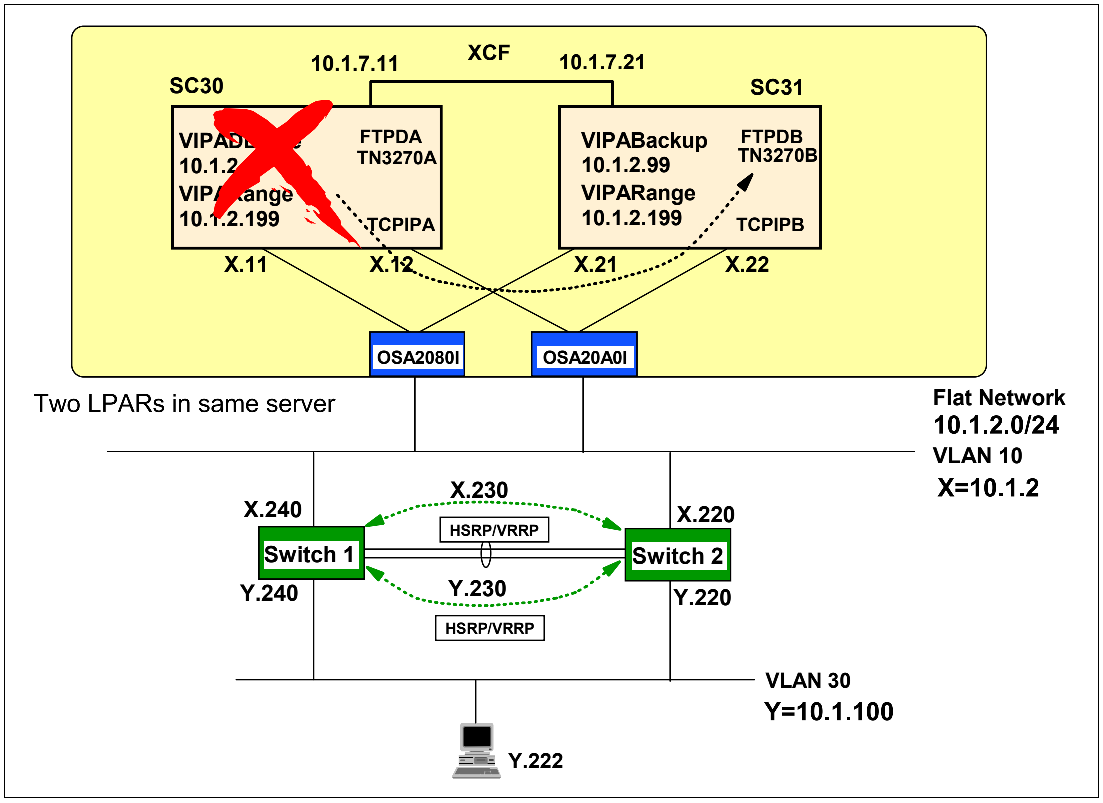


Figure 3-7 High availability for a stack failure

We use VIPADEFINE and VIPABACKUP definitions for the DVIPA to create a takeover and takeback environment. For the purpose of demonstration, we activated FTPDA on SC30 and FTPDB on SC31, using same DVIPA 10.1.2.199. Example 3-24 shows the status before the stack failure.

Example 3-24 Status before TCPIPA stack failure

```
D TCPIP,TCPIPA,SYSPLEX,VIPADYN
EZZ8260I SYSPLEX CS V1R13 135
VIPA DYNAMIC DISPLAY FROM TCPIPA   AT SC30
LINKNAME: VIPL0A010263
IPADDR/PREFIXLEN: 10.1.2.99/24
  ORIGIN: VIPADEFINE
  TCPNAME  MVSNAME  STATUS RANK DIST
  -------- -------- ------ ---- ----
  TCPIPA   SC30     ACTIVE
  TCPIPB   SC31     BACKUP 100
LINKNAME: VIPL0A0102C7
IPADDR/PREFIXLEN: 10.1.2.199/25
  ORIGIN: VIPARANGE BIND
  TCPNAME  MVSNAME  STATUS RANK DIST
  -------- -------- ------ ---- ----
  TCPIPA   SC30     ACTIVE
  TCPIPB   SC31     MOVING
```

We stop the primary TCP/IP (in SC30) and observe the results, as shown in Example 3-25.

Example 3-25 High availability for a stack failure

```
SC30 console message
P TCPIPA
EZZ3205I SNMP SUBAGENT: SHUTDOWN IN PROGRESS
EZZ0673I AUTOLOG TASK: SHUTDOWN IN PROGRESS
...
IUT5002I TASK FOR ULPID TCPIPA USING TRLE IUTSAMEH TERMINATING
IUT5002I TASK FOR ULPID TCPIPA USING TRLE OSA2080 TERMINATING
IUT5002I TASK FOR ULPID TCPIPA USING TRLE OSA20A0 TERMINATING
EZZ4201I TCP/IP TERMINATION COMPLETE FOR TCPIPA
IEF352I ADDRESS SPACE UNAVAILABLE
$HASP395 TCPIPA   ENDED

SC31 console message
EZZ8301I VIPA 10.1.2.99 TAKEN OVER FROM TCPIPA ON SC30
D TCPIP,TCPIPB,SYSPLEX,VIPADYN
EZZ8260I SYSPLEX CS V1R13 478
VIPA DYNAMIC DISPLAY FROM TCPIPB   AT SC31
LINKNAME: VIPL0A010263
IPADDR/PREFIXLEN: 10.1.2.99/24
  ORIGIN: VIPABACKUP
  TCPNAME  MVSNAME  STATUS RANK DIST
  -------- -------- ------ ---- ----
  TCPIPB   SC31     ACTIVE 1
IPADDR: 10.1.2.199
  ORIGIN: VIPARANGE BIND
  TCPNAME  MVSNAME  STATUS RANK DIST
  -------- -------- ------ ---- ----
  TCPIPB   SC31     MOVING 2
```

This failure is disruptive. The TCP connections established to SC30 TCPIPA stack are disrupted. When system SC31 discovers that SC30 has gone down (when SC30 leaves the XCF group), SC31 takes over the DVIPA address 10.1.2.99 (**1**, in the example) by advertising the DVIPA address with a gratuitous ARP, as discussed in 3.2, “High availability using ARP takeover in one TCP/IP stack” on page 63.

Note that DVIPA defined with VIPARANGE, 10.1.2.199, is not moved to SC31 automatically. It remains in MOVING state (**2**). It requires the application request to gain DVIPA as shown in Application movement example, or creation of DVIPA with `MODDVIPA` utility.

Example 3-26 and Example 3-27 show how to move the DVIPA using the **MODDVIPA** utility.

Example 3-26 MODDVIPA utility example

```
//MODDIPA  PROC
//MODDIPA  EXEC PGM=MODDVIPA,REGION=0K,TIME=1440,
//   PARM='-p TCPIPB -c 10.1.2.199' 1
//SYSPRINT DD SYSOUT=A,DCB=(RECFM=FB,LRECL=132,BLKSIZE=132)
//SYSERR   DD SYSOUT=A
//SYSERROR DD SYSOUT=A
//SYSDEBUG DD SYSOUT=A
//SYSUDUMP DD SYSOUT=A
//SYSABEND DD SYSOUT=A
```

Example 3-27 DVIPA creation with MODDVIPA utility

```
On SC31
S MODDVIPA
IRR812I PROFILE ** (G) IN THE STARTED CLASS WAS USED 644
        TO START MODDVIPA WITH JOBNAME MODDVIPA.
$HASP100 MODDVIPA ON STCINRDR
IEF695I START MODDVIPA WITH JOBNAME MODDVIPA IS ASSIGNED TO USER
IBMUSER , GROUP SYS1
$HASP373 MODDVIPA STARTED
EZD1204I DYNAMIC VIPA 10.1.2.199 WAS CREATED USING IOCTL BY MODDVIPA
ON TCPIPB
$HASP395 MODDVIPA ENDED

D TCPIP,TCPIPB,SYSPLEX,VIPADYN
EZZ8260I SYSPLEX CS V1R13 653
VIPA DYNAMIC DISPLAY FROM TCPIPB   AT SC31
LINKNAME: VIPL0A010263
IPADDR/PREFIXLEN: 10.1.2.99/24
  ORIGIN: VIPABACKUP
  TCPNAME  MVSNAME  STATUS RANK DIST
  -------- -------- ------ ---- ----
  TCPIPB   SC31     ACTIVE
LINKNAME: VIPL0A0102C7
IPADDR/PREFIXLEN: 10.1.2.199/25
  ORIGIN: VIPARANGE BIND
  TCPNAME  MVSNAME  STATUS RANK DIST
  -------- -------- ------ ---- ----
  TCPIPB   SC31     ACTIVE
```

Delete a VIPA address: In addition to creating a DVIPA, the **MODDVIPA** utility can also be used to delete a VIPA address as an alternative to using a **VARY OBEY** operator command. The parameter option field can be **-c** for create or **-d** for delete.

Example 3-28 shows the destination MAC address for DVIPA 10.1.2.99, and 10.1.2.199 is now changed to the one that SC31 TCPIPB owns (3).

Example 3-28 Changed destination MAC address

```
On SC31
D TCPIP,TCPIPB,N,ARP
EZD0101I NETSTAT CS V1R13 TCPIPB 512
QUERYING ARP CACHE FOR ADDRESS 10.1.2.21
INTERFACE: OSA2080I          ETHERNET: 020021776873 3
QUERYING ARP CACHE FOR ADDRESS 10.1.2.22
INTERFACE: OSA20A0I          ETHERNET: 02001F77688D

On router
Router1#sh arp | inc 10.1.2
Internet  10.1.2.21             99   0200.2177.6873  ARPA   Vlan10 3
Internet  10.1.2.22              0   0200.1f77.688d  ARPA   Vlan10
Internet  10.1.2.99              6   0200.2177.6873  ARPA   Vlan10 3
Internet  10.1.2.199             2   0200.2177.6873  ARPA   Vlan10 3
```

We then start new TN3270 connections to the DVIPA address 10.1.2.99, which is now running in SC31. We can use NETSTAT operand N,VCRT to verify that these connections are going to DESTXCF 10.1.7.21 (4, the Dynamic XCF address of the SC31 stack). Example 3-29 illustrates this situation.

Example 3-29 New connections go to SC31

```
On SC31
D TCPIP,TCPIPB,N,CONN
EZD0101I NETSTAT CS V1R13 TCPIPB 530
USER ID  CONN     STATE
TN3270B  00000181 ESTBLSH
  LOCAL SOCKET:   ::FFFF:10.1.2.99..23
  FOREIGN SOCKET: ::FFFF:10.1.100.222..1509
TN3270B  0000017E ESTBLSH
  LOCAL SOCKET:   ::FFFF:10.1.2.99..23
  FOREIGN SOCKET: ::FFFF:10.1.100.222..1508

D TCPIP,TCPIPB,N,VCRT
EZD0101I NETSTAT CS V1R13 TCPIPB 543
DYNAMIC VIPA CONNECTION ROUTING TABLE:
DEST:      10.1.2.99..23
  SOURCE:  10.1.100.222..1508
  DESTXCF: 10.1.7.21                 4
DEST:      10.1.2.99..23
  SOURCE:  10.1.100.222..1509
  DESTXCF: 10.1.7.21                 4
```

We finally restart the TCP/IP stack in SC30 and observe the takeback operation, shown in Example 3-30 on page 83. DVIPA defined with VIPADEFine statement is automatically taken back to TCPIPA on SC30, but the DVIPA within VIPARange (created by application or MODDIPA) is not automatically taken back. By starting FTPDA on SC30, which binds to 10.1.2.199, this DVIPA is taken back to TCPIPA.

Example 3-30 Start TCPIPA in SC30 takeback function

```
On SC30
S TCPIPA
$HASP100 TCPIPA   ON STCINRDR
IEF695I START TCPIPA   WITH JOBNAME TCPIPA   IS ASSIGNED TO USER
TCPIP   , GROUP TCPGRP
$HASP373 TCPIPA   STARTED
EZB6473I TCP/IP STACK FUNCTIONS INITIALIZATION COMPLETE.
EZAIN11I ALL TCPIP SERVICES FOR PROC TCPIPA ARE AVAILABLE.
EZD1176I TCPIPA HAS SUCCESSFULLY JOINED THE TCP/IP SYSPLEX GROUP
EZBTCPCS
EZZ8302I VIPA 10.1.2.99 TAKEN FROM TCPIPB ON SC31
EZD1214I INITIAL DYNAMIC VIPA PROCESSING HAS COMPLETED FOR TCPIPA

S FTPDA
$HASP100 FTPDA    ON STCINRDR
IEF695I START FTPDA    WITH JOBNAME FTPDA    IS ASSIGNED TO USER
TCPIP   , GROUP TCPGRP
$HASP373 FTPDA    STARTED
$HASP395 FTPDA    ENDED
EZZ8302I VIPA 10.1.2.199 TAKEN FROM TCPIPB ON SC31
EZD1205I DYNAMIC VIPA 10.1.2.199 WAS CREATED USING BIND BY FTPDA1 ON
TCPIPA
EZY2702I Server-FTP: Initialization completed at 20:08:48 on
07/20/11.

SC31 console message
EZZ8303I VIPA 10.1.2.99 GIVEN TO TCPIPA ON SC30
EZZ8303I VIPA 10.1.2.199 GIVEN TO TCPIPA ON SC30

On SC30
D TCPIP,TCPIPA,SYSPLEX,VIPADYN
EZZ8260I SYSPLEX CS V1R13 400
VIPA DYNAMIC DISPLAY FROM TCPIPA   AT SC30
LINKNAME: VIPL0A010263
IPADDR/PREFIXLEN: 10.1.2.99/24
  ORIGIN: VIPADEFINE
  TCPNAME  MVSNAME  STATUS RANK DIST
  -------- -------- ------ ---- ----
  TCPIPA   SC30     ACTIVE
  TCPIPB   SC31     MOVING
LINKNAME: VIPL0A0102C7
IPADDR/PREFIXLEN: 10.1.2.199/24
  ORIGIN: VIPARANGE BIND
  TCPNAME  MVSNAME  STATUS RANK DIST
  -------- -------- ------ ---- ----
  TCPIPA   SC30     ACTIVE
  TCPIPB   SC31     MOVING
```

3.4 Debugging tips

When you are analyzing problems in a flat network, the first step is to verify that the static and default routes are correct. After trying **PING** and **TRACERT** commands from a remote host, use **NETSTAT ROUTE**, **NETSTAT GATE**, and **NETSTAT ARP** commands in the z/OS system to verify that the routing parameters are correct. (You can also use UNIX System Services commands, such as **onetstat -r**.)

Routing is almost always a two-way function. That is, packets from remote systems must find their way back to z/OS. Problems with *return routing* (back to z/OS) are possibly the most common errors found when implementing TCP/IP in a new host. This return routing is usually under the control of external systems and routers, and there is no easy way to check it from the z/OS end. DVIPA configurations might involve multiple IP addresses for z/OS stacks, and *all* these addresses must be handled correctly by the external network.

If the routing appears correct, then a PKTTRACE in z/OS can be useful. This trace consists of IP packets flowing to and from a TCP/IP stack, and the trace provides a detailed view of local routing and packet flow.

The following additional steps might be helpful:

- Use a **netstat** command with the vipadcfg operand to verify the DVIPA definition.
- Use a **netstat** command with the vipadyn operand to verify that the DVIPA status is ACTIVE.
- As a last resort, collect a CTRACE with options XCF, INTERNET, TCP, and VTAMDATA. These can be used to do the following tasks:
  - Identify the connection being received by the stack.
  - Determine the stack to which the connection will be forwarded.
  - Verify that the connection is being forwarded.
  - Verify that the expected target stack is receiving and processing the connection.

More debugging information is in the *z/OS Communications Server: IP Configuration Guide*, SC27-3650.

4

VIPA with dynamic routing

This chapter introduces and provides implementation examples for using dynamic routing in a IBM z/OS Communications Server environment. The dynamic routing protocols supported in z/OS Communications Server are Open Shortest Path First (OSPF) and Routing Information Protocol (RIP), which are implemented in OMPROUTE.

This chapter focuses on OSPF as the suggested dynamic routing protocol for z/OS Communications Server.

For more details about implementation and concepts of OMPROUTE, see *IBM z/OS V2R1 Communications Server TCP/IP Implementation Volume 1: Base Functions, Connectivity, and Routing*, SG24-8096.

This chapter contains the following topics.

Section	**Topic**
4.1, “Basic concepts of high availability using dynamic routing” on page 86	Basic concepts of high availability using dynamic routing
4.2, “Design example of DVIPA with dynamic routing” on page 95	Selected implementation scenario tasks, configuration examples, and verification steps, and problem determination suggestions
4.3, “High availability scenarios” on page 105	Examples of failing scenarios and how they are recovered in a dynamic routing environment
4.4, “Sysplex-Wide Security Associations” on page 119	Explanation and selected implementation of Sysplex-Wide Security Associations

4.1 Basic concepts of high availability using dynamic routing

In its most basic sense, dynamic routing is a process used in an IP network to ensure that the routing tables always reflect the current network topology. Using those routing tables, the routing process is then able to deliver datagrams to the correct destinations. Dynamic routing is implemented in a *routing daemon* in each router. The daemon is responsible for maintaining local routing information, propagating changes to neighbors, and updating its routing table according to changes received from neighbors.

The main goal of designing for high availability is to ensure that users can reach their applications as close to 100% of the time as can be achieved most cost-effectively. An important benefit of using a dynamic routing protocol in z/OS Communications Server is being able to use a consistent, TCP/IP-based, end-to-end approach for dynamically recognizing and responding to changes in the network and z/OS environment.

4.1.1 Dynamic routing and OMPROUTE

OMPROUTE supports both OSPF and RIP as dynamic routing protocols. The main function of both protocols is to exchange routing information with routers in the network.

OSPF is a link-state routing protocol. Every router has a full map of the entire network topology. Changes to the network topology (because of link-state changes or outages) is propagated throughout the network. Every router that receives updates must then recompute its shortest path to all destinations. The convergence time for OSPF is low and there is virtually no limit to the network design.

RIP (RIPv1 and RIPv2) is a distance vector routing protocol. Every 30 seconds, each router sends its full set of distance vectors to neighboring routers. When each router receives a set of distance vectors, it must recalculate the shortest path to each destination. The convergence time for RIP can be up to 180 seconds and the longest path that can be managed by RIP is 15 hops, which means that a distance of 16 or more hops constitutes an invalid or unreachable destination.

For further details regarding dynamic routing protocols, see *IBM z/OS V2R1 Communications Server TCP/IP Implementation Volume 1: Base Functions, Connectivity, and Routing*, SG24-8096.

4.1.2 Advertisement of VIPA addresses

VIPA addresses must be known or recognized by the routing protocol to propagate them throughout the network. This means that VIPA addresses (and associated subnet masks) must be defined in all OMPROUTE instances in the sysplex that might own the addresses. Normally, VIPA addresses are defined by the OSPF_Interface statement so that the OSPF protocol sends out Link State Advertisements (LSAs) about them.

When a VIPA address is created in the TCP/IP stack, OMPROUTE receives that information and searches for the OSPF_Interface statement that best matches the VIPA address. OSPF then propagates by default both the VIPA host address and the VIPA IP subnet that belongs to the VIPA address.

Figure 4-1 shows how VIPA addresses are propagated throughout the network. Each VIPA address is represented both by the VIPA address (/32) and by the VIPA subnet (/24). The VIPA address (/32) is more specific than the VIPA subnet (/24), so at first sight the VIPA subnet is never to be used.

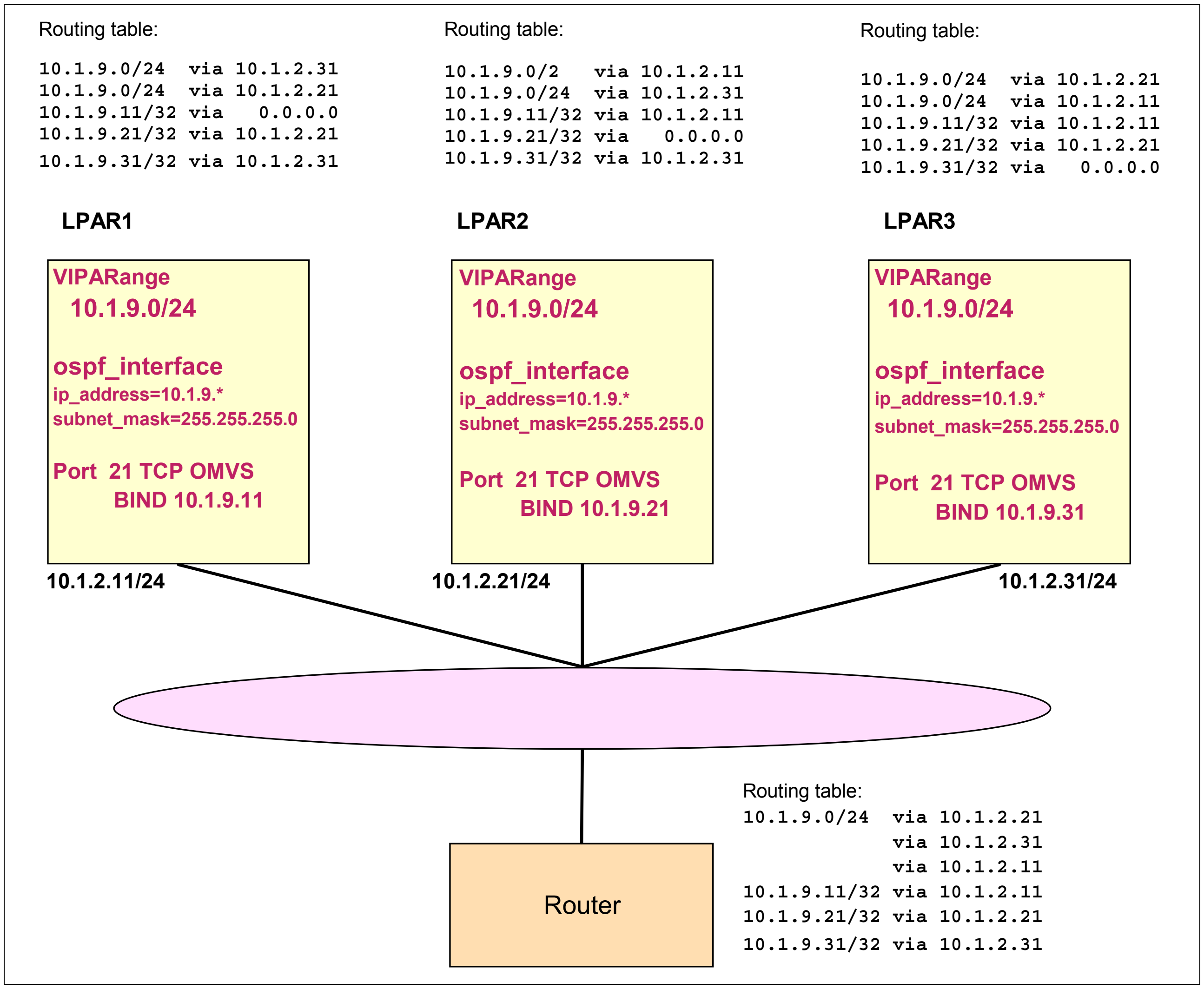

Routing table:
10.1.9.0/24 via 10.1.2.31
10.1.9.0/24 via 10.1.2.21
10.1.9.11/32 via   0.0.0.0
10.1.9.21/32 via 10.1.2.21
10.1.9.31/32 via 10.1.2.31
Routing table:
10.1.9.0/2   via 10.1.2.11
10.1.9.0/24 via 10.1.2.31
10.1.9.11/32 via 10.1.2.11
10.1.9.21/32 via   0.0.0.0
10.1.9.31/32 via 10.1.2.31
Routing table:
10.1.9.0/24 via 10.1.2.21
10.1.9.0/24 via 10.1.2.11
10.1.9.11/32 via 10.1.2.11
10.1.9.21/32 via 10.1.2.21
10.1.9.31/32 via   0.0.0.0
LPAR1
LPAR2
LPAR3
VIPARange 10.1.9.0/24
ospf_interface ip_address=10.1.9.* subnet_mask=255.255.255.0
Port 21 TCP OMVS BIND 10.1.9.11
VIPARange 10.1.9.0/24
ospf_interface ip_address=10.1.9.* subnet_mask=255.255.255.0
Port 21 TCP OMVS BIND 10.1.9.21
VIPARange 10.1.9.0/24
ospf_interface ip_address=10.1.9.* subnet_mask=255.255.255.0
Port 21 TCP OMVS BIND 10.1.9.31
10.1.2.11/24
10.1.2.21/24
10.1.2.31/24
Router
Routing table:
10.1.9.0/24 via 10.1.2.21
             via 10.1.2.31
             via 10.1.2.11
10.1.9.11/32 via 10.1.2.11
10.1.9.21/32 via 10.1.2.21
10.1.9.31/32 via 10.1.2.31

Figure 4-1 VIPA subnet across LPARs

Figure 4-2 shows what happens if one of the FTP servers in this setup is taken down and the VIPA address is deleted.

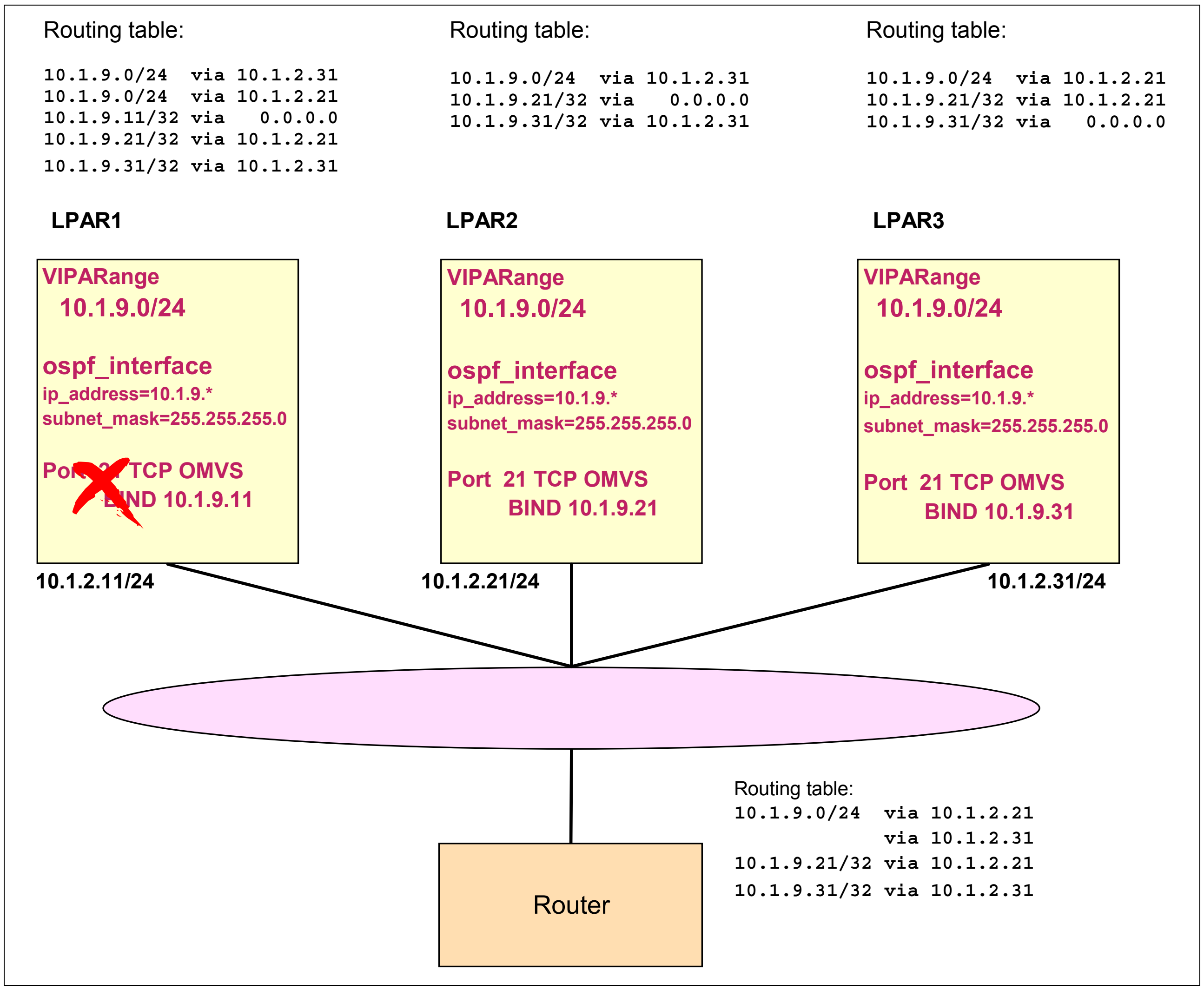

Routing table:
10.1.9.0/24 via 10.1.2.31
10.1.9.0/24 via 10.1.2.21
10.1.9.11/32 via 0.0.0.0
10.1.9.21/32 via 10.1.2.21
10.1.9.31/32 via 10.1.2.31
Routing table:
10.1.9.0/24 via 10.1.2.31
10.1.9.21/32 via 0.0.0.0
10.1.9.31/32 via 10.1.2.31
Routing table:
10.1.9.0/24 via 10.1.2.21
10.1.9.21/32 via 10.1.2.21
10.1.9.31/32 via 0.0.0.0
LPAR1
LPAR2
LPAR3
VIPARange 10.1.9.0/24
ospf_interface
ip_address=10.1.9.*
subnet_mask=255.255.255.0
Port 21 TCP OMVS BIND 10.1.9.11
VIPARange 10.1.9.0/24
ospf_interface
ip_address=10.1.9.*
subnet_mask=255.255.255.0
Port 21 TCP OMVS BIND 10.1.9.21
VIPARange 10.1.9.0/24
ospf_interface
ip_address=10.1.9.*
subnet_mask=255.255.255.0
Port 21 TCP OMVS BIND 10.1.9.31
10.1.2.11/24
10.1.2.21/24
10.1.2.31/24
Routing table:
10.1.9.0/24 via 10.1.2.21
via 10.1.2.31
10.1.9.21/32 via 10.1.2.21
10.1.9.31/32 via 10.1.2.31
Router

Figure 4-2 VIPA subnet across LPARs after FTP server is taken down in LPAR1

The routing tables now reflect the deletion of VIPA address 10.1.9.11. Both the IP address and the subnet entry have been deleted from all routing tables. The interesting point is that the VIPA subnet entries now come into play.

Consider what happens if an FTP client requests a connection to the FTP server in LPAR 1 (10.1.9.11). The request arrives at the router, but the router does not have a route to 10.1.9.11. The next best match in the router is an equal cost entry (10.1.9.0/24) pointing to LPAR2 and LPAR3. The routing tables in LPAR2 and LPAR3 do not have a route to 10.1.9.11 either. The next best match in LPAR 2 is a route pointing to LPAR3, and the next best match in LPAR 3 is a route pointing to LPAR 2. This looks like a routing loop. The FTP client request continues searching for the IP address until the time-to-live count goes to zero (0) and the packet is discarded.

From an availability point of view, two ways exist to circumvent this situation:

- Avoid using IPCONFig DATAGRamfwd. This circumvention prevents datagrams from being forwarded between TCP/IP stacks, but it does not prevent the router from sending the first request to the first LPAR.
- Avoid advertising the VIPA subnet throughout the network. This circumvention prevents the router from sending the request to any TCP/IP stack not owning the exact VIPA address. You can control this action by using the Advertise_VIPA_Routes parameter on the OSPF_Interface statement. Our OSPF_Interface statement is shown in the following example:

```
ospf_interface ip_address=10.1.9.*
           subnet_mask=255.255.255.0
           attaches_to_area=0.0.0.2
           Advertise_VIPA_Routes=HOST_ONLY
           cost0=10
           mtu=65535 ;
```

By not advertising the VIPA subnet, the routing tables now display as shown in Figure 4-3.

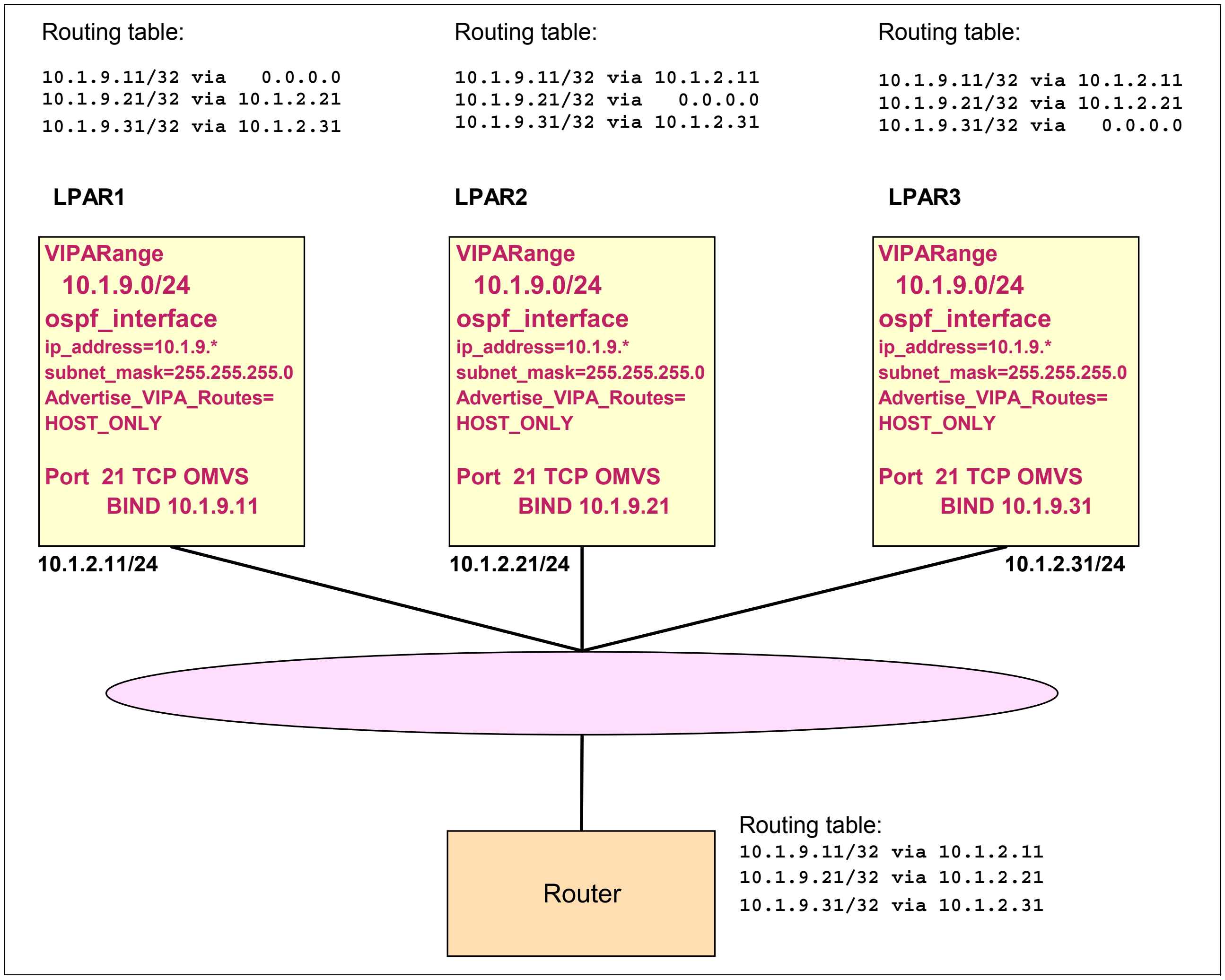


Figure 4-3   VIPA addresses without VIPA subnet

The routing tables are simplified and there is no searching for VIPA addresses not available. Datagrams are forwarded to VIPA addresses in the LPARs only if the specific VIPA address is active and advertised as an IP host address.

4.1.3 Multiple links between IP nodes and LPARs

A system that is designed for high availability should have more than one link between the various TCP/IP stacks in the system. It should also have more than one router for connections to the external network.

In our test environment, we designed a network with four OSA ports. Two ports connected to one Layer 3 switch (router), VLANs 10 and 11, and the other two ports connected to the second Layer 3 switch (router), also VLANs 10 and 11, thus achieving the physical and logical redundancy shown in Figure 4-4.

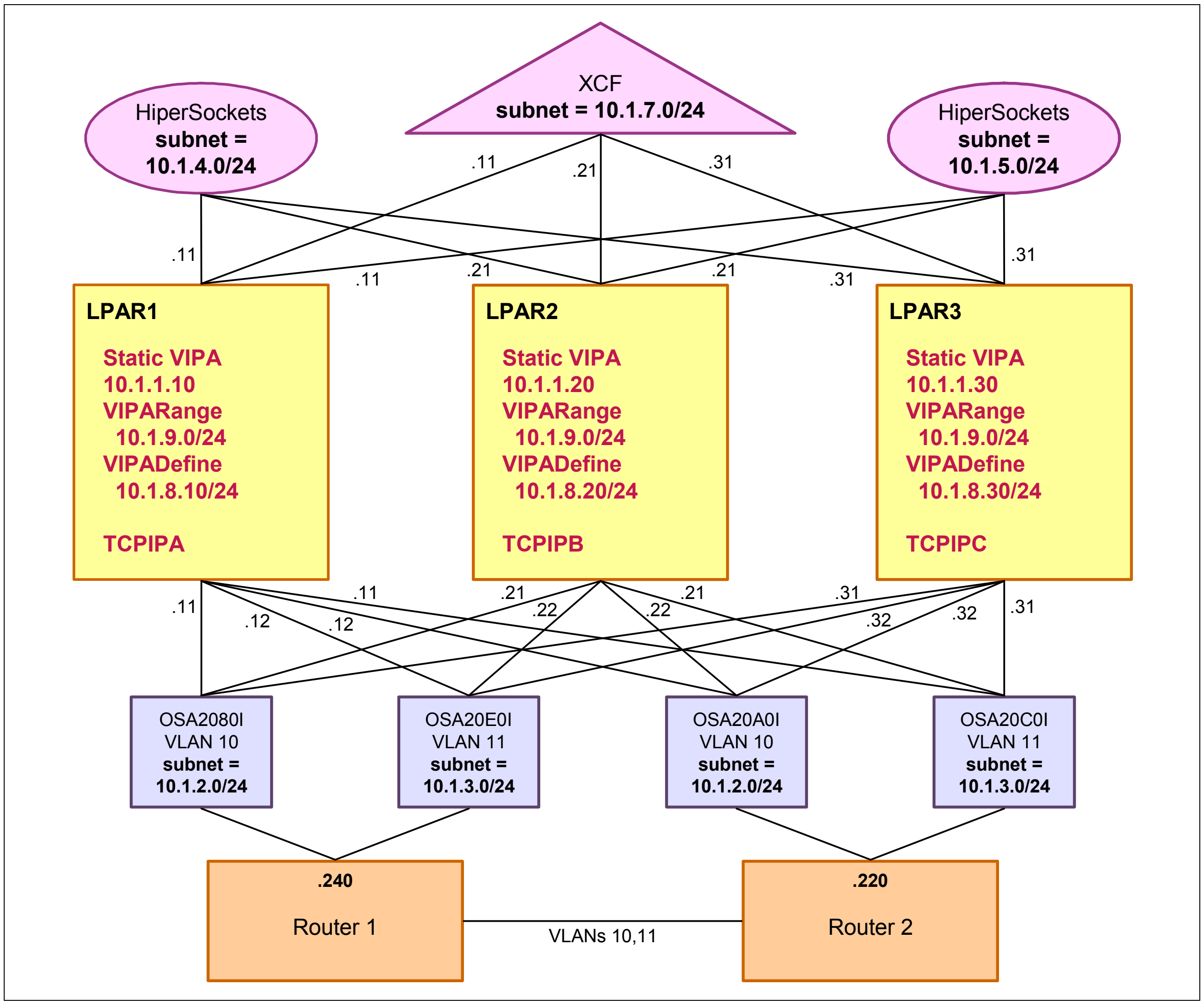


Figure 4-4 Sample network with multiple paths between LPARs

From a routing perspective, by default, all links in this scenario that have the same distance and the same cost are considered equal-cost links, and datagrams are forwarded in a round-robin fashion according to the IPCONFIG MULTIPATH implementation. In our example, datagrams between LPARs are equally distributed across the XCF, HiperSocket, and OSA links. We can use the **`netstat at TCPIPA`** command to display the routing information shown in Example 4-1.

Example 4-1 Routing information displayed using netstat

```
D TCPIP,TCPIPA,N,ROUTE,IPA=10.1.9.*
IPV4 DESTINATIONS
DESTINATION        GATEWAY         FLAGS     REFCNT  INTERFACE
10.1.9.21/32       10.1.4.21       UGHO      000000  IUTIQDF4L
10.1.9.21/32       10.1.5.21       UGHO      000000  IUTIQDF5L
10.1.9.21/32       10.1.7.21       UGHO      000000  IQDIOLNK0A01070B
10.1.9.21/32       10.1.2.22       UGHO      000000  OSA2080L
10.1.9.21/32       10.1.2.21       UGHO      000000  OSA2080L
10.1.9.21/32       10.1.2.22       UGHO      000000  OSA20A0L
10.1.9.21/32       10.1.2.21       UGHO      000000  OSA20A0L
10.1.9.21/32       10.1.3.22       UGHO      000000  OSA20C0L
10.1.9.21/32       10.1.3.21       UGHO      000000  OSA20C0L
10.1.9.21/32       10.1.3.22       UGHO      000000  OSA20E0L
10.1.9.21/32       10.1.3.21       UGHO      000000  OSA20E0L
10.1.9.31/32       10.1.2.32       UGHO      000000  OSA2080L
10.1.9.31/32       10.1.2.31       UGHO      000000  OSA2080L
10.1.9.31/32       10.1.2.32       UGHO      000000  OSA20A0L
10.1.9.31/32       10.1.2.31       UGHO      000000  OSA20A0L
10.1.9.31/32       10.1.3.32       UGHO      000000  OSA20C0L
10.1.9.31/32       10.1.3.31       UGHO      000000  OSA20C0L
10.1.9.31/32       10.1.3.32       UGHO      000000  OSA20E0L
10.1.9.31/32       10.1.3.31       UGHO      000000  OSA20E0L
10.1.9.31/32       10.1.4.31       UGHO      000000  IUTIQDF4L
10.1.9.31/32       10.1.5.31       UGHO      000000  IUTIQDF5L
10.1.9.31/32       10.1.7.31       UGHO      000000  IQDIOLNK0A01070B
10.1.9.11/32       0.0.0.0         UH        000000  VIPL0A01090B
```

Note that OSPF used all available links with the same cost value, and created routes to destination hosts 10.1.9.21 and 10.1.9.31 using all the equal cost links. As a result, there are eleven equivalent ways to reach destination 10.1.9.21; there are also eleven equal cost routes to reach destination 10.1.9.31. There might be situations where we require more control over which links are used. After all, are all these paths truly equivalent routes? Should they really be assigned the same routing cost? Probably not. The links might have different capacities, or might be dedicated for specific traffic, for example. A way to control this situation is by specifying different OSPF cost values on the OMPROUTE definitions of the OSPF interfaces.

As an example, we want to use the following values:

- OSA as the primary path for traffic between LPARs in separate servers and external connections.
- HiperSockets for the primary path between LPARs in the same server
- XCF as the backup and last path available

For the external connections, we also want, as an example, to define the OSA connections with a separate cost to provide a preferable path. We achieve this goal by giving XCF the highest cost, OSA a medium cost, and HiperSockets the lowest cost, as shown in Table 4-1 on page 92.

Table 4-1 Overview of the prioritization of available paths

Path used for communication between TCP/IP stacks	First	Second	Third
Same LPAR	HiperSockets	OSA	XCF
Same server	HiperSockets	OSA	XCF
Across servers	OSA (using VLAN11)	OSA (using VLAN10)	XCF
External connections	OSA (using VLAN11)	OSA (using VLAN10)	

Installation requirements differ, of course, and this example is intended only to illustrate a general technique. We define the cost0 parameter of each `ospf_interface` statement in our OSPF configuration, as shown in Example 4-2.

Example 4-2 Sample of OSPF_Interface configuration

```
; OSA Qdio 10.1.2.x
ospf_interface ip_address=10.1.2.*  1
           subnet_mask=255.255.255.0
           ROUTER_PRIORITY=0
           attaches_to_area=0.0.0.2
           cost0=100
           mtu=1492
;
; OSA Qdio 10.1.3.x
ospf_interface ip_address=10.1.3.*  2
           subnet_mask=255.255.255.0
           ROUTER_PRIORITY=0
           attaches_to_area=0.0.0.2
           cost0=90
           mtu=1492
;
; Hipersockets 10.1.4.x
ospf_interface ip_address=10.1.4.*  3
           subnet_mask=255.255.255.0
           ROUTER_PRIORITY=1
           attaches_to_area=0.0.0.2
           cost0=80
           mtu=8192
;
; Hipersockets 10.1.5.x
ospf_interface ip_address=10.1.5.*  3
           subnet_mask=255.255.255.0
           ROUTER_PRIORITY=1
           attaches_to_area=0.0.0.2
           cost0=80
           mtu=8192
;
; Dynamic XCF
ospf_interface ip_address=10.1.7.11 4
           name=IQDIOLNK0A01070B
           subnet_mask=255.255.255.0
           ROUTER_PRIORITY=1
           attaches_to_area=0.0.0.2
           cost0=110
           mtu=8192;
```

In this example, the numbers correspond to the following information:

1. The OSA links in VLAN 10 (10.1.2.0/24) with a cost of 100

2. The OSA links in VLAN 11 (10.1.3.0/24) with a cost of 90

3. The HiperSockets links (10.1.4.0/24 and 10.1.5.0/24) with a cost of 80

4. The XCF link (10.1.7.0/24) with a cost of 110

The lowest cost interfaces in this configuration are now reduced to the HiperSockets interfaces with their cost of 80. After the cost changes are in effect, OSPF sends only the lowest cost routes to the TCP/IP stack's routing table. We verify this setup by using the **NETSTAT ROUTE** command, as shown in Example 4-3.

Example 4-3 SC30 NETSTAT Route display command

```
D TCPIP,TCPIPA,N,ROUTE,IPA=10.1.9.*
EZD0101I NETSTAT CS V2R1 TCPIPA 966
IPV4 DESTINATIONS
DESTINATION        GATEWAY          FLAGS    REFCNT     INTERFACE
10.1.9.11/32       0.0.0.0          UH       0000000000 VIPL0A01090B
10.1.9.21/32       10.1.4.21        UGHO     0000000000 IUTIQDF4L 1
10.1.9.21/32       10.1.5.21        UGHO     0000000000 IUTIQDF5L 1
10.1.9.31/32       10.1.4.31        UGHO     0000000000 IUTIQDF4L 1
10.1.9.31/32       10.1.5.31        UGHO     0000000000 IUTIQDF5L 1
```

In this example, the number corresponds to the following information:

1. HiperSockets is the preferred path towards VIPA 10.1.9.21 and VIPA 10.1.9.31.

If the HiperSockets path becomes unavailable, this situation affects the network topology and causes OSPF to recalculate the routing table. We disabled the HiperSockets paths, IUTQID4 and IUTIQD5 (Example 4-4).

Example 4-4 Stopping HiperSockets devices (only IUTIQDF4 shown)

```
V TCPIP,TCPIPA,STOP,IUTIQDF4
EZZ0060I PROCESSING COMMAND: VARY TCPIP,TCPIPA,STOP,IUTIQDF4
EZZ0053I COMMAND VARY STOP COMPLETED SUCCESSFULLY
EZZ4315I DEACTIVATION COMPLETE FOR DEVICE IUTIQDF4
EZZ7921I OSPF ADJACENCY FAILURE, NEIGHBOR 10.1.4.21, OLD STATE 128,
NEW STATE 1, EVENT 11
EZZ7921I OSPF ADJACENCY FAILURE, NEIGHBOR 10.1.4.41, OLD STATE 128,
NEW STATE 1, EVENT 11
```

We expect the routes to be recomputed and to favor the next lowest cost interfaces, which are the OSA interfaces that are attached to VLAN 11. These interfaces are assigned a cost of 90. The routing table now looks like Example 4-5.

Example 4-5 D TCPIP,TCPIPA,ROUTE,IPA=10.1.9. command*

```
D TCPIP,TCPIPA,N,ROUTE,IPA=10.1.9.*
EZD0101I NETSTAT CS V1R13 TCPIPA 993
IPV4 DESTINATIONS
DESTINATION        GATEWAY          FLAGS     REFCNT  INTERFACE
10.1.9.11/32       0.0.0.0          UH        000000  VIPL0A01090B
10.1.9.21/32       10.1.3.22        UGHO      000000  OSA20C0L 1
10.1.9.21/32       10.1.3.21        UGHO      000000  OSA20C0L 1
10.1.9.21/32       10.1.3.22        UGHO      000000  OSA20E0L 1
10.1.9.21/32       10.1.3.21        UGHO      000000  OSA20E0L 1
10.1.9.31/32       10.1.3.32        UGHO      000000  OSA20C0L 1
10.1.9.31/32       10.1.3.31        UGHO      000000  OSA20C0L 1
10.1.9.31/32       10.1.3.32        UGHO      000000  OSA20E0L 1
10.1.9.31/32       10.1.3.31        UGHO      000000  OSA20E0L 1
9 OF 9 RECORDS DISPLAYED
END OF THE REPORT
```

Now the routing paths (1) converge on the OSA links with less cost in our configuration, that is, OSA20C0L and OSA20E0L. These interfaces are now the preferred interfaces to VIPA addresses 10.1.9.21 and 10.1.9.31. There are two OSA adapters available, and datagrams are forwarded in a round-robin fashion because we assigned each one with the same cost.

The examples shown in this section show how to use dynamic routing to provide several levels of backup automatically for IP traffic within a single server. The only significant cost involved is the time to plan and to test the required definitions.

Availability: To ensure availability of your environment, your OSPF definitions *must* match the intention of your IP infrastructure; otherwise, you can experience unpredictable results.

4.2 Design example of DVIPA with dynamic routing

This section shows an example of the dynamic routing that we previously introduced.

4.2.1 Overview

The best way to use dynamic routing in the z/OS environment is through OSPF, with the z/OS Communications Server environment defined as an OSPF *stub area* or (even better) a *totally stubby area*.

Stub areas minimize storage and CPU utilization at the nodes that are part of the stub area because less knowledge is maintained about the topology of the Autonomous System (AS) compared to being a full node in an OSPF area or OSPF backbone.

Note the following points:

- A stub area system maintains knowledge only about intra-area destinations, summaries of inter-area destinations, and the default routes needed to reach external destinations.
- A totally stubby area system receives even less routing information than a stub area. It maintains knowledge only about intra-area destinations and default routes to reach external destinations.

z/OS Communications Server typically connects to the IP network through routers that act as gateways. A totally stubby area is a good solution because all it needs is a default route pointing to the gateways.

In this section, we show the steps to implement an OSPF totally stubby area using OMPROUTE. For more information about the implementation of OMPROUTE, see *IBM z/OS V2R1 Communications Server TCP/IP Implementation Volume 1: Base Functions, Connectivity, and Routing*, SG24-8096.

Figure 4-5 illustrates a totally stubby area setup.

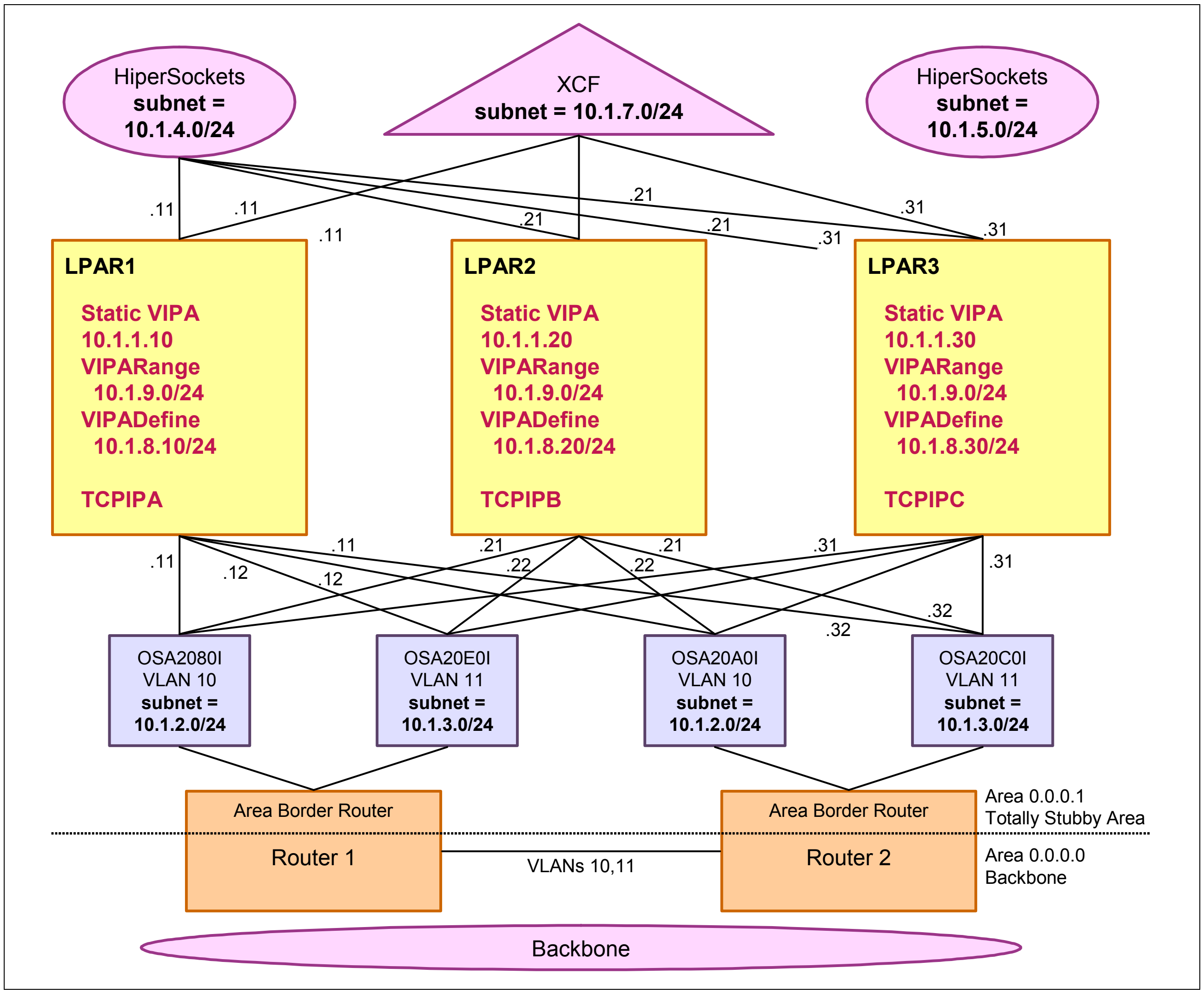


Figure 4-5 Sample network with z/OS being defined as a totally stubby area

In this example, XCF is part of the OSPF design. We could omit XCF as an alternate path for our IP traffic by not configuring XCF links as an OSPF_Interface and by using interface statements instead.

The tasks are described in 4.2.2, “Implementation tasks” on page 96.

4.2.2 Implementation tasks

This section describes the four implementation tasks for our design.

1. Defining TCPIP PROFILE statements for the stacks
2. Defining OMPROUTE configuration files
3. Defining router configuration
4. Verifying that the configuration works as planned

Defining TCPIP PROFILE statements for the stacks

Example 4-6 lists the relevant TCPIP PROFILE statements for the SC30 system.

Example 4-6 TCP/IP profile for SC30

```
ARPAGE 20
;
GLOBALCONFIG NOTCPIPSTATISTICS
;
IPCONFIG DATAGRAMFWD SYSPLEXROUTING
DYNAMICXCF 10.1.7.11 255.255.255.0 1
...
;
;OSA DEFINITIONS
INTERFACE OSA2080I
DEFINE IPAQENET
PORTNAME OSA2080
SOURCEVIPAINT VIPA1L
IPADDR 10.1.2.11/24
MTU 1492
VLANID 10
VMAC ROUTELCL
;
INTERFACE OSA20A0I
DEFINE IPAQENET
PORTNAME OSA20A0
SOURCEVIPAINT VIPA1L
IPADDR 10.1.2.12/24
MTU 1492
VLANID 10
VMAC ROUTEALL
;
INTERFACE OSA20C0I
DEFINE IPAQENET
PORTNAME OSA20C0
SOURCEVIPAINT VIPA1L
IPADDR 10.1.3.11/24
MTU 1492
VLANID 11
VMAC  ROUTEALL
;
INTERFACE OSA20E0I
DEFINE IPAQENET
PORTNAME OSA20E0
SOURCEVIPAINT VIPA1L
IPADDR 10.1.3.12/24
MTU 1492
VLANID 11
VMAC
;
;HIPERSOCKETS DEFINITIONS
DEVICE IUTIQDF4   MPCIPA
LINK   IUTIQDF4L  IPAQIDIO    IUTIQDF4
DEVICE IUTIQDF5   MPCIPA
LINK   IUTIQDF5L  IPAQIDIO    IUTIQDF5
;
;STATIC VIPA DEFINITIONS
DEVICE VIPA1      VIRTUAL 0
LINK   VIPA1L     VIRTUAL 0   VIPA1
;
```

```
;DYNAMIC VIPA DEFINITIONS
VIPADYNAMIC
VIPADEFINE MOVEABLE IMMEDIATE 255.255.255.0 10.1.8.10
;
VIPARANGE 255.255.255.0 10.1.9.0
ENDVIPADYNAMIC
;
HOME
   10.1.1.10     VIPA1L
   10.1.4.11     IUTIQDF4L
   10.1.5.11     IUTIQDF5L
;
 PRIMARYINTERFACE VIPA1L
AUTOLOG 5
   FTPDA JOBNAME FTPDA1
   OMPA
ENDAUTOLOG
;
PORT
    20 TCP *  NOAUTOLOG          ; FTP Server
    21 TCP OMVS BIND 10.1.9.11 ; control port
;
SACONFIG ENABLED COMMUNITY public AGENT 161
;
START OSA2080I
START OSA20C0I
START OSA20E0I
START OSA20A0I
START IUTIQDF4
START IUTIQDF5
```

Table 4-2 summarizes the differences between the TCPIP PROFILE for SC30 (shown in Example 4-6 on page 97) and the profiles for SC31 and SC32.

Table 4-2 Summary of TCPIP PROFILE differences between SC30, SC31, and SC32

Statement	SC30 - TCPIPA	SC31 - TCPIPB	SC32 - TCPIPC
DYNAMICXCF	10.1.7.11	10.1.7.21	10.1.7.31
VIPARANGE	10.1.9.0/24	10.1.9.0/24	10.1.9.0/24
VIPADEFine	10.1.8.10	10.1.8.20	10.1.8.30
INTERFace			
OSA2080I	10.1.2.11	10.1.2.21	10.1.2.31
OSA20A0I	10.1.2.12	10.1.2.22	10.1.2.32
OSA20C0I	10.1.3.11	10.1.3.21	10.1.3.31
OSA20E0I	10.1.3.12	10.1.3.22	10.1.3.32
HOME			
VIPA1L	10.1.1.10	10.1.1.20	10.1.1.30
IUTIQDF4L	10.1.4.11	10.1.4.21	10.1.4.31
IUTIQDF5L	10.1.5.11	10.1.5.21	10.1.5.31
PORT			
21 TCP OMVS	BIND 10.1.9.11	BIND 10.1.9.21	BIND 10.1.9.31

Defining OMPROUTE configuration files

Example 4-7 shows the OMPROUTE configuration file for SC30.

Example 4-7 OMPROUTE configuration file for SC30

```
Area Area_Number=0.0.0.2
   Stub_Area=YES 1
   Authentication_type=None
   Import_Summaries=No ; 2
;
OSPF
 RouterID=10.1.1.10 A
 Comparison=Type2
 Demand_Circuit=YES;
Global_Options
 Ignore_Undefined_Interfaces=YES
;
; Static vipa
ospf_interface ip_address=10.1.1.10 3a
           name=VIPA1L 3b
           subnet_mask=255.255.255.0
           Advertise_VIPA_Routes=HOST_ONLY
           attaches_to_area=0.0.0.2
           cost0=10
           mtu=65535
; OSA Qdio 10.1.2.x
ospf_interface ip_address=10.1.2.*  4
           subnet_mask=255.255.255.0
           ROUTER_PRIORITY=0
           attaches_to_area=0.0.0.2
           cost0=100
           mtu=1492
; OSA Qdio 10.1.3.x
ospf_interface ip_address=10.1.3.*  5
           subnet_mask=255.255.255.0
           ROUTER_PRIORITY=0
           attaches_to_area=0.0.0.2
           cost0=90
           mtu=1492
; Hipersockets 10.1.4.x
ospf_interface ip_address=10.1.4.*  6
           subnet_mask=255.255.255.0
           ROUTER_PRIORITY=1
           attaches_to_area=0.0.0.2
           cost0=80
           mtu=8192
; Hipersockets 10.1.5.x
ospf_interface ip_address=10.1.5.*  6
           subnet_mask=255.255.255.0
           ROUTER_PRIORITY=1
           attaches_to_area=0.0.0.2
           cost0=80
           mtu=8192
; Dynamic XCF
ospf_interface ip_address=10.1.7.11 7a
           name=IQDIOLNK0A01070B 7b
           subnet_mask=255.255.255.0
           ROUTER_PRIORITY=1
           attaches_to_area=0.0.0.2
           cost0=110
           mtu=8192;
; Dynamic vipa VIPADEFINE
ospf_interface ip_address=10.1.8.*  8
           subnet_mask=255.255.255.0
           Advertise_VIPA_Routes=HOST_ONLY
           attaches_to_area=0.0.0.2
           cost0=10
           mtu=65535
; Dynamic vipa VIPARANGE
ospf_interface ip_address=10.1.9.*  9
           subnet_mask=255.255.255.0
           attaches_to_area=0.0.0.2
           Advertise_VIPA_Routes=HOST_ONLY
           cost0=10
           mtu=65535
```

These definitions include the following key elements:

A Note how we followed best practices and assigned a static VIPA as the OSPF router ID.

1. Indicates an OSPF Stub Area.

2. No summaries indicates a totally stubby area.

The entry here on z/OS is in our scenario for documentation purposes only. In fact, the Area Border Router (ABR) decides whether an area is totally stubby. Therefore, the definition in the Area Border Router enforces the totally stubby nature of the connections to z/OS. See "Defining router configuration" on page 101 for an example of the router coding.

3. Indicates a static VIPA.

a. We assigned the full IP address, all four octets, in this definition, which requires us to code the link name of the interface.

b. We specify the full link name as it is known to the IP stack; this name is found in the stack's HOME list.

4. Indicates an OSA adapter in VLAN 10.

5. Indicates an OSA adapter in VLAN 11.

6. Indicates a HiperSockets link.

7. Indicates an XCF link using HiperSockets.

a. We assigned the full IP address, all four octets, in this definition, which requires us to code the link name of the interface.

b. We specify the full link name as it is known to the IP stack; this name is found in the stack's HOME list.

8. Indicates DVIPA - VIPADefine/VIPABackup.

9. Indicates DVIPA - VIPARange.

Table 4-3 summarizes the differences between the OMPROUTE configurations for SC30 (shown previously) and those of SC31 and SC32.

Table 4-3 Summary of OMPROUTE configuration differences between SC30, SC31, & SC32

Statement	**SC30**	**SC31**	**SC32**
OSPF RouterID	10.1.1.10	10.1.1.20	10.1.1.30
OSPF_Interface IP_address (Static VIPA)	10.1.1.10	10.1.1.20	10.1.1.30
OSPF_Interface IP_address (XCF)	10.1.7.11	10.1.7.21	10.1.7.31

Defining router configuration

The router configurations are critical. This section describes the relevant definitions for Router 1. We create an interface for VLAN 10 to include it in the OSPF service configuration, as shown in Example 4-8.

Example 4-8 Configuration of VLAN10 in Router 1

```
interface Vlan10
 ip address 10.1.2.240 255.255.255.0
 ip policy route-map pbr-to-csm
 ip ospf cost 100
 ip ospf priority 100
```

We create an interface for VLAN 11 to include it also in the OSPF service configuration, as shown in Example 4-9.

Example 4-9 Configuration of VLAN11 in Router 1

```
interface Vlan11
 ip address 10.1.3.240 255.255.255.0
 ip policy route-map pbr-to-csm
 ip ospf cost 100
 ip ospf priority 100
```

The physical interfaces that are related to the OSA connections are configured as *Trunk*, so they are not seen as part of this routing configuration.

After we define the interfaces that participate in the OSPF environment, we define the OSPF service, as shown in Example 4-10.

Example 4-10 OSPF configuration in Router 1

```
router ospf 100
router-id 10.1.3.240
log-adjacency-changes
area 2 stub no-summary 1
network 10.1.2.0 0.0.0.255 area 2
network 10.1.3.0 0.0.0.255 area 2
network 10.1.0.0 0.0.255.255 area 0
network 10.200.1.0 0.0.0.255 area 0
default-information originate always metric-type 1
```

In this example, the no-summary parameter (**1**) indicates that this is a totally stubby area. As shown in Example 4-7 on page 99, the z/OS coding of `Import_Summaries=No` does not influence the behavior of the connections to this router, because z/OS is not acting as an Area Border Router.

The definitions are the same for Router 2.

4.2.3 Verifying that the configuration works as planned

To verify that the configuration works as planned, we execute the following steps:

1. Listing the OSPF configuration in use.
2. Listing the OSPF neighbors.
3. Listing the routing tables.
4. Listing the OSPF neighbors on the router.
5. Listing the routing table on the router.

For details about other commands that you can use to obtain more information about the routing environment, see *z/OS Communications Server: IP Diagnosis Guide*, GC31-8782.

Note: The route table shown here is related only to the Dynamic VIPA subnet, as an example. All other VIPA subnets have the same routes.

Listing the OSPF configuration in use

To verify that the correct configuration is implemented, use the **`Display OMPR,OSPF,LIST,ALL`** command. We execute the command on SC30. The resulting output is shown in Example 4-11.

Example 4-11 OSPF global configuration in SC30

```
D TCPIP,TCPIPA,OMPR,OSPF,LIST,ALL
EZZ7831I GLOBAL CONFIGURATION 087
    TRACE: 2, DEBUG: 1, SADEBUG LEVEL: 0
    STACK AFFINITY:          TCPIPA
    OSPF PROTOCOL:           ENABLED
    EXTERNAL COMPARISON:     TYPE 2
    AS BOUNDARY CAPABILITY:  DISABLED
    DEMAND CIRCUITS:         ENABLED
    DR MAX ADJ. ATTEMPT:     10

EZZ7832I AREA CONFIGURATION 1
AREA ID          AUTYPE          STUB? DEFAULT-COST IMPORT-SUMMARIES?
0.0.0.2          0=NONE           YES         1             YES
0.0.0.0          0=NONE           NO          N/A           N/A

EZZ7833I INTERFACE CONFIGURATION 2
IP ADDRESS      AREA             COST RTRNS TRDLY PRI HELLO  DEAD
DB_E*
10.1.9.11       0.0.0.2            10   N/A   N/A N/A   N/A   N/A
N/A
10.1.8.20       0.0.0.2            10     5     1   0    10    40
40
10.1.8.10       0.0.0.2            10   N/A   N/A N/A   N/A   N/A
N/A
10.1.5.11       0.0.0.2            80     5     1   1    10    40
```

```
40
10.1.4.11       0.0.0.2           80     5     1   1    10    40
40
10.1.3.12       0.0.0.2           90     5     1   0    10    40
40
10.1.3.11       0.0.0.2           90     5     1   0    10    40
40
10.1.2.12       0.0.0.2          100     5     1   0    10    40
40
10.1.2.14       0.0.0.2          100     5     1   0    10    40
40
10.1.2.11       0.0.0.2          100     5     1   0    10    40
40
10.1.7.11       0.0.0.2          110     5     1   1    10    40
40
10.1.2.10       0.0.0.2           10   N/A   N/A N/A   N/A   N/A
N/A
10.1.1.10       0.0.0.2           10   N/A   N/A N/A   N/A   N/A
N/A

             ADVERTISED VIPA ROUTES  3
10.1.9.11         /255.255.255.255   10.1.8.10      /255.255.255.255
10.1.2.10         /255.255.255.255   10.1.1.10      /255.255.255.255
```

The following numbers indicate the key elements of the OSPF definitions:

1. The OSPF stub area with no summaries (totally stubby area).

2. The OSPF cost values reflect the configuration (wildcards).

3. The VIPA routes being advertised.

Listing the OSPF neighbors

To verify that SC30 is part of the implemented OSPF Area, use the **Display OMPR,OSPF,NBRS** command. The resulting output is shown in Example 4-12.

Example 4-12 OSPF neighbors as seen from SC30

```
D TCPIP,TCPIPA,OMPR,OSPF,NBRS
EZZ7851I NEIGHBOR SUMMARY 085
NEIGHBOR ADDR   NEIGHBOR ID     STATE  LSRXL DBSUM LSREQ HSUP IFC
10.1.5.31       10.1.1.30           8      0     0     0  OFF IUTIQDF5L
10.1.5.21       10.1.1.20         128      0     0     0  OFF IUTIQDF5L
10.1.4.31       10.1.1.30           8      0     0     0  OFF IUTIQDF4L
10.1.4.21       10.1.1.20         128      0     0     0  OFF IUTIQDF4L
10.1.3.32       10.1.1.30           8      0     0     0  OFF OSA20E0I
10.1.3.22       10.1.1.20           8      0     0     0  OFF OSA20E0I
10.1.3.240      10.1.3.240        128      0     0     0  OFF OSA20E0I
10.1.3.42       10.1.1.40           8      0     0     0  OFF OSA20E0I
10.1.2.240      10.1.3.240        128      0     0     0  OFF OSA20A0I
10.1.2.32       10.1.1.30           8      0     0     0  OFF OSA20A0I
10.1.2.22       10.1.1.20           8      0     0     0  OFF OSA20A0I
10.1.7.31       10.1.1.30           8      0     0     0  OFF IQDIOLNK*
10.1.7.21       10.1.1.20         128      0     0     0  OFF IQDIOLNK*
* -- LINK NAME TRUNCATED
```

Listing the routing tables

To verify that the expected routing table has been created, use the **NETSTAT,ROUTE** command to list the generated routes for subnet 10.1.9.0. The resulting output for SC30 is shown in Example 4-13.

Example 4-13 IP route table for subnet 10.1.9. in SC30*

```
D TCPIP,TCPIPA,N,ROUTE,IPA=10.1.9.*
EZD0101I NETSTAT CS V1R13 TCPIPA 083
IPV4 DESTINATIONS
DESTINATION        GATEWAY          FLAGS    REFCNT     INTERFACE
10.1.9.11/32       0.0.0.0          UH       0000000000 VIPL0A01090B
10.1.9.21/32       10.1.4.21        UGHO     0000000000 IUTIQDF4L
10.1.9.21/32       10.1.5.21        UGHO     0000000000 IUTIQDF5L
10.1.9.31/32       10.1.4.31        UGHO     0000000000 IUTIQDF4L
10.1.9.31/32       10.1.5.31        UGHO     0000000000 IUTIQDF5L
5 OF 5 RECORDS DISPLAYED
END OF THE REPORT
```

Notice the VIPA addresses are advertised only as host address (/32) because of the `Advertise_VIPA_Routes=HOST_ONLY` parameter. It is also important to notice the routes are created using the links that we defined with the lowest cost (the HiperSockets links).

Listing the OSPF neighbors on the router

Example 4-14 lists the neighbors in Router 1.

Example 4-14 Display of OSPF neighbors in Router 1

```
Router1#sh ip ospf 100 neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
10.1.1.10         0   FULL/DROTHER    00:00:31    10.1.2.12       Vlan10 3
10.1.1.20         0   FULL/DROTHER    00:00:36    10.1.2.22       Vlan10 3
10.1.1.30         0   FULL/DROTHER    00:00:39    10.1.2.32       Vlan10 3
10.1.3.220      101   FULL/DR         00:00:31    10.1.2.220      Vlan10 1
10.1.1.10         0   FULL/DROTHER    00:00:30    10.1.3.12       Vlan11 4
10.1.1.20         0   FULL/DROTHER    00:00:35    10.1.3.22       Vlan11 4
10.1.1.30         0   FULL/DROTHER    00:00:38    10.1.3.32       Vlan11 4
10.1.3.220      101   FULL/DR         00:00:31    10.1.3.220      Vlan11 2
```

The numbers correspond to the following key points:

1. Router 2 is the Designated Router for Subnet 10.1.2.0.

2. Router 2 is the Designated Router for Subnet 10.1.3.0.

3. All other neighbors in subnet 10.1.2.0 cannot act as Designated Router (Pri=0).

4. All other neighbors in subnet 10.1.2.0 cannot act as Designated Router (Pri=0).

Listing the routing table on the router

Example 4-15 shows the routing tables in Router 1.

Example 4-15 Display of IP route table in Router 1

```
Router1#sh ip route ospf 100
     10.0.0.0/8 is variably subnetted, 21 subnets, 2 masks
O   1   10.1.9.11/32 [110/110] via 10.1.2.12, 00:00:29, Vlan10
                     [110/110] via 10.1.2.11, 00:00:29, Vlan10
                     [110/110] via 10.1.3.12, 00:00:29, Vlan11
                     [110/110] via 10.1.3.11, 00:00:29, Vlan11
O   1   10.1.9.21/32 [110/110] via 10.1.2.22, 00:00:50, Vlan10
                     [110/110] via 10.1.2.21, 00:00:50, Vlan10
                     [110/110] via 10.1.3.22, 00:00:50, Vlan11
                     [110/110] via 10.1.3.21, 00:00:50, Vlan11
O   1   10.1.9.31/32 [110/110] via 10.1.2.32, 00:00:00, Vlan10
                     [110/110] via 10.1.2.31, 00:00:00, Vlan10
                     [110/110] via 10.1.3.32, 00:00:00, Vlan11
                     [110/110] via 10.1.3.31, 00:00:00, Vlan11
```

Note that 1 VIPA addresses are advertised as host address (/32) because of the Advertise_VIPA_Routes=HOST_ONLY parameter.

4.3 High availability scenarios

In this section, we describe how certain failing scenarios are recovered using a dynamic routing environment. The examples discussed here are the same ones used in Chapter 3, “VIPA without dynamic routing” on page 61 and are not designed to be indicative of typical failures. Instead, they help you to understand various recovery and transfer processes. Our scenarios cover the following situations:

- Adapter interface failure
- Application movement using VIPADEFINE
- Stack failure scenario using VIPADEFINE and VIPABACKUP

To simplify these scenarios, we use one OSA port for each subnet with separate costs and only one router.

4.3.1 Adapter interface failure

In this scenario, we use OSA2080I and OSA20E0I only to simplify the demonstration. We stop the OSA adapter (OSA2080I) on our primary system to verify that the connection from the client workstation continues to function through an alternate route during the takeover by the backup system.

The failure scenario is illustrated in Figure 4-6.

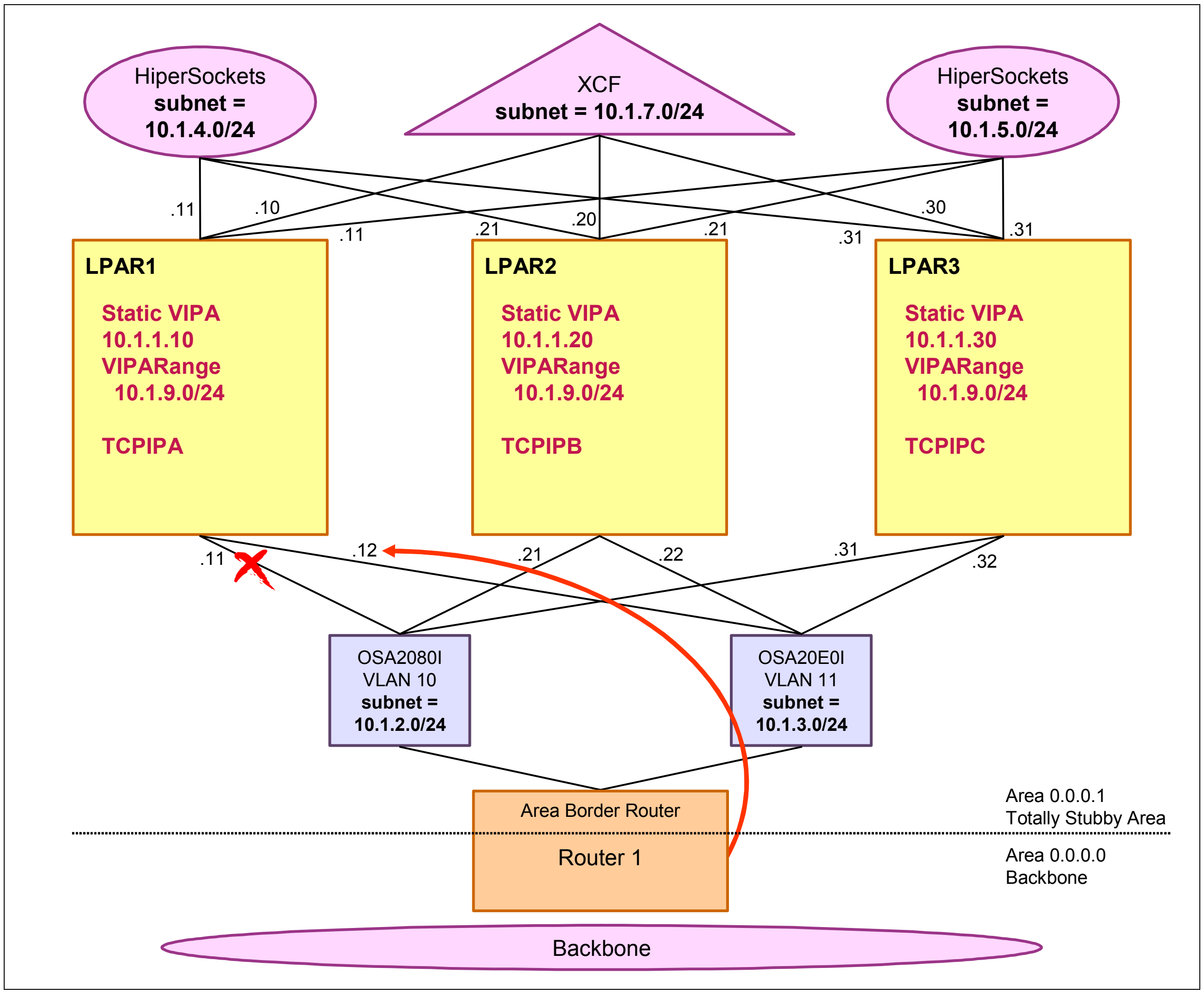


Figure 4-6 High availability for an adapter failure

Example 4-16 shows a display of the route table in Router 1 with the primary route to VIPA host 10.1.9.11 before we stop the OSA2080I device.

Example 4-16 Show IP route ospf 100 in Router 1 before we lose the OSA2080 device

```
O       10.1.9.11/32 [110/110] via 10.1.2.11, 00:01:28, Vlan10
                     [110/110] via 10.1.3.12, 00:01:28, Vlan11
```

We execute a **tracert** command in a workstation located in the backbone network to verify that we are able to reach host 10.1.9.11 on SC30, as shown in Example 4-17.

Example 4-17 TRACERT 10.1.9.11 command in the workstation

```
C:\Documents and Settings\RESIDENT>tracert 10.1.9.11
Tracing route to 10.1.9.11 over a maximum of 30 hops
  1    <1 ms    <1 ms    <1 ms  10.1.100.240
  2    <1 ms    <1 ms    <1 ms  10.1.9.11
```

Then, we stop OSA2080I, which causes OSPF to lose adjacency to the neighbor at 10.1.2.240, as shown in Example 4-18.

Example 4-18 Show IP route ospf 100 in Router 1 after we lose the OSA2080I device

```
V TCPIP,TCPIPA,STOP,OSA2080I
EZZ0060I PROCESSING COMMAND: VARY TCPIP,TCPIPA,STOP,OSA2080I
EZZ0053I COMMAND VARY STOP COMPLETED SUCCESSFULLY
EZZ4341I DEACTIVATION COMPLETE FOR INTERFACE OSA2080I
EZZ7921I OSPF ADJACENCY FAILURE, NEIGHBOR 10.1.2.240, OLD STATE 128,
NEW STATE 1, EVENT 11
```

Next, OSPF recovers through OSA20E0, which can be verified by using the OSPF neighbor summary, as shown in Example 4-19.

Example 4-19 Neighbor summary in SC30 showing OSPF has recovered its neighbors through OSA20E0

```
D TCPIP,TCPIPA,OMPR,OSPF,NBRS
EZZ7851I NEIGHBOR SUMMARY 077
NEIGHBOR ADDR   NEIGHBOR ID     STATE  LSRXL DBSUM LSREQ HSUP IFC
10.1.5.31       10.1.1.30           8      0     0     0  OFF IUTIQDF5L
10.1.5.21       10.1.1.20         128      0     0     0  OFF IUTIQDF5L
10.1.4.31       10.1.1.30           8      0     0     0  OFF IUTIQDF4L
10.1.4.21       10.1.1.20         128      0     0     0  OFF IUTIQDF4L
10.1.3.32       10.1.1.30           8      0     0     0  OFF OSA20E0I
10.1.3.22       10.1.1.20           8      0     0     0  OFF OSA20E0I
10.1.3.240      10.1.3.240        128      0     0     0  OFF OSA20E0I
10.1.3.42       10.1.1.40           8      0     0     0  OFF OSA20E0I
10.1.7.31       10.1.1.30           8      0     0     0  OFF IQDIOLNK*
10.1.7.21       10.1.1.20         128      0     0     0  OFF IQDIOLNK*
* -- LINK NAME TRUNCATED
```

Using the **`sh ip route ospf 100`** command, we can confirm that we still have a route to reach host 10.1.9.11, as shown in Example 4-20.

Example 4-20 Show ip route ospf 100 command (only host address 10.1.9.11 is shown here)

```
O       10.1.9.11/32 [110/110] via 10.1.3.12, 00:00:12, Vlan11
```

These displays confirm that we are still able to reach VIPA host 10.1.9.11 through the alternate OSA path.

Next, see what happens if we lose this OSA path (Figure 4-7 on page 108).

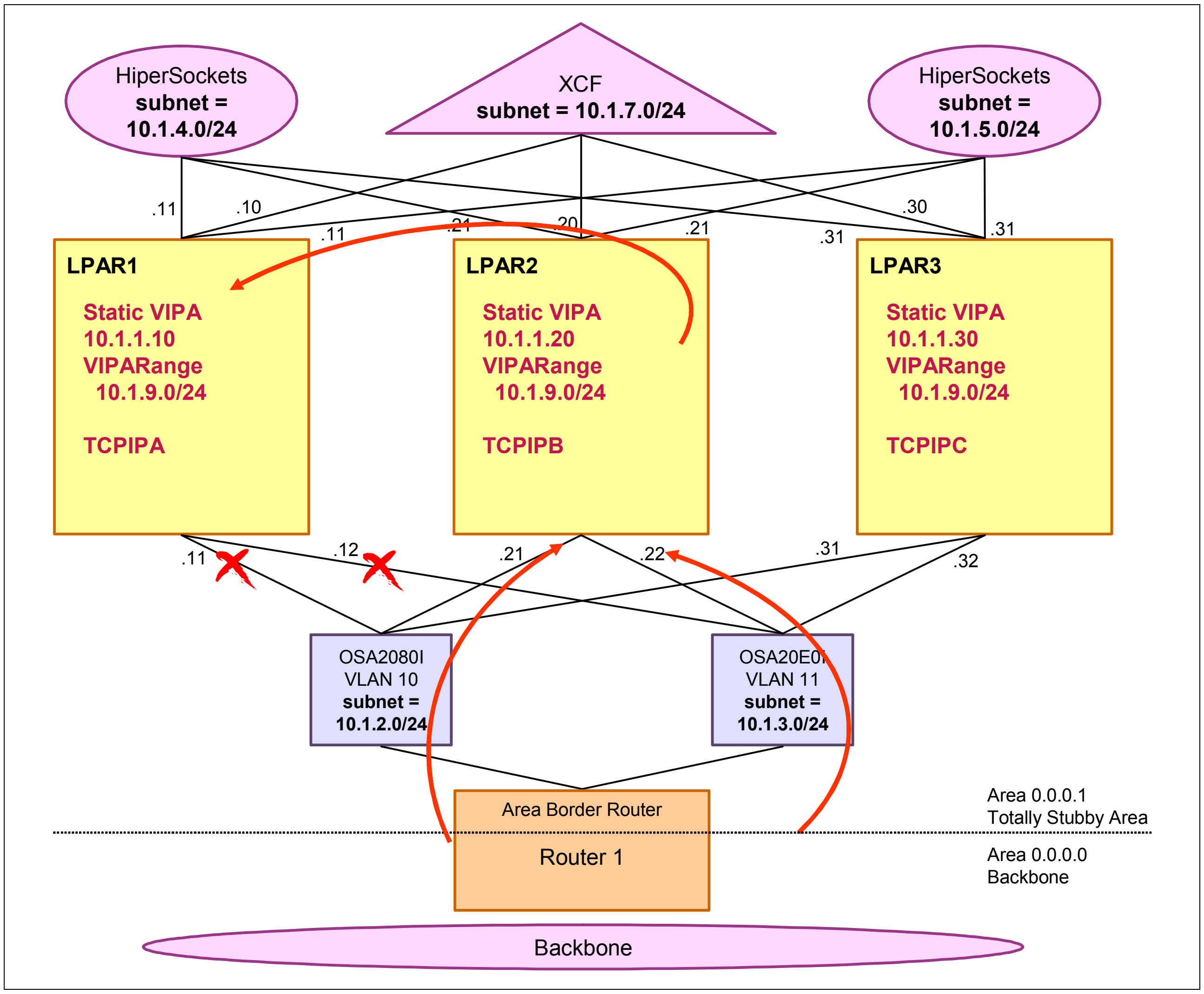


Figure 4-7 Losing contact with SC30 through OSA paths

We stop OSA20E0I device, and OSA2080I.

The OSPF in Router 1, as soon as it discovered that the route to VIPA 10.1.9.11 has been lost, calculates a new route, this time through links OSA2080I and OSA20E0I on stack TCPIPB. TCPIPB routes the traffic to VIPA 10.9.1.11 through HiperSockets. The new route can be verified by displaying the routing table to 10.1.9.11 in Router 1 (Example 4-21).

Note: To make TCPIPB route the packets to TCPIPA, IPCONFIG DATAGRAMFWD option must be turned on.

Example 4-21 The sh ip route ospf 100 command results

```
Router1#sh ip route ospf 100
     10.0.0.0/8 is variably subnetted, 22 subnets, 2 masks
O       10.1.9.11/32 [110/190] via 10.1.2.21, 00:00:35, Vlan10
                     [110/190] via 10.1.3.22, 00:00:35, Vlan11
                     [110/190] via 10.1.2.31, 00:00:35, Vlan10
                     [110/190] via 10.1.3.32, 00:00:35, Vlan11
```

Example 4-22 shows a user issuing an **ls** command through the FTP session, with the expected results. The route convergence is transparent to the client, and the existing TCP connections are preserved. The result of a **NETSTAT** command is also shown in Example 4-22.

Example 4-22 FTP to VIPA 10.9.1.11 is still running after losing the OSA interface connections

```
ftp> ls
200 Port request OK.
125 List started OK
BRODCAST
HFS
NTUSER.DAT
NTUSER.DAT.LOG
NTUSER.INI
SC30.ISPF42.ISPPROF
SC30.SPFLOG1.LIST
SC30.SPF1.LIST
TESTE.TXT
TESTE2.TXT
250 List completed successfully.
ftp: 134 bytes received in 0.00Seconds 134000.00Kbytes/sec.

C:\Documents and Settings\RESIDENT>tracert 10.1.9.11
Tracing route to 10.1.9.11 over a maximum of 30 hops
  1     1 ms    <1 ms    <1 ms  10.1.100.240
  2     1 ms    <1 ms    <1 ms  10.1.1.20
  3    <1 ms    <1 ms    <1 ms  10.1.9.11
Trace complete.
```

To recover the original route through OSA20A0, all we have to do is to restart the device. OSPF recalculates the best route based on cost definitions.

4.3.2 Application movement using VIPADEFINE

This example illustrates how we can benefit from nondisruptive movement of an application by simply starting another instance of the application in another LPAR that takes over new connections. We define the FTP services in SC30 and SC32 to be manually started, that is, we do not use *autolog* in the port definition profile. First, we start the FTP server in SC30, which activate the 10.1.9.11 DVIPA address. Next, we connect to the FTP server from the workstation.

When the new instance of the application becomes active, the TCP/IP stack can immediately take over the ownership of the DVIPA while existing connections continue to the original TCP/IP stack (until the connections end or the original application or TCP/IP stack is taken down). This approach can be useful for planned outage situations (such as software maintenance).

In failure situations, if the application supports Automatic Restart Manager (ARM), you might be able to have ARM restart the application automatically. If your application cannot bind to a DVIPA, you might be able to use the `bind()` on the port statement or the **`MODDVIPA`** utility. The situation is illustrated in Figure 4-8.

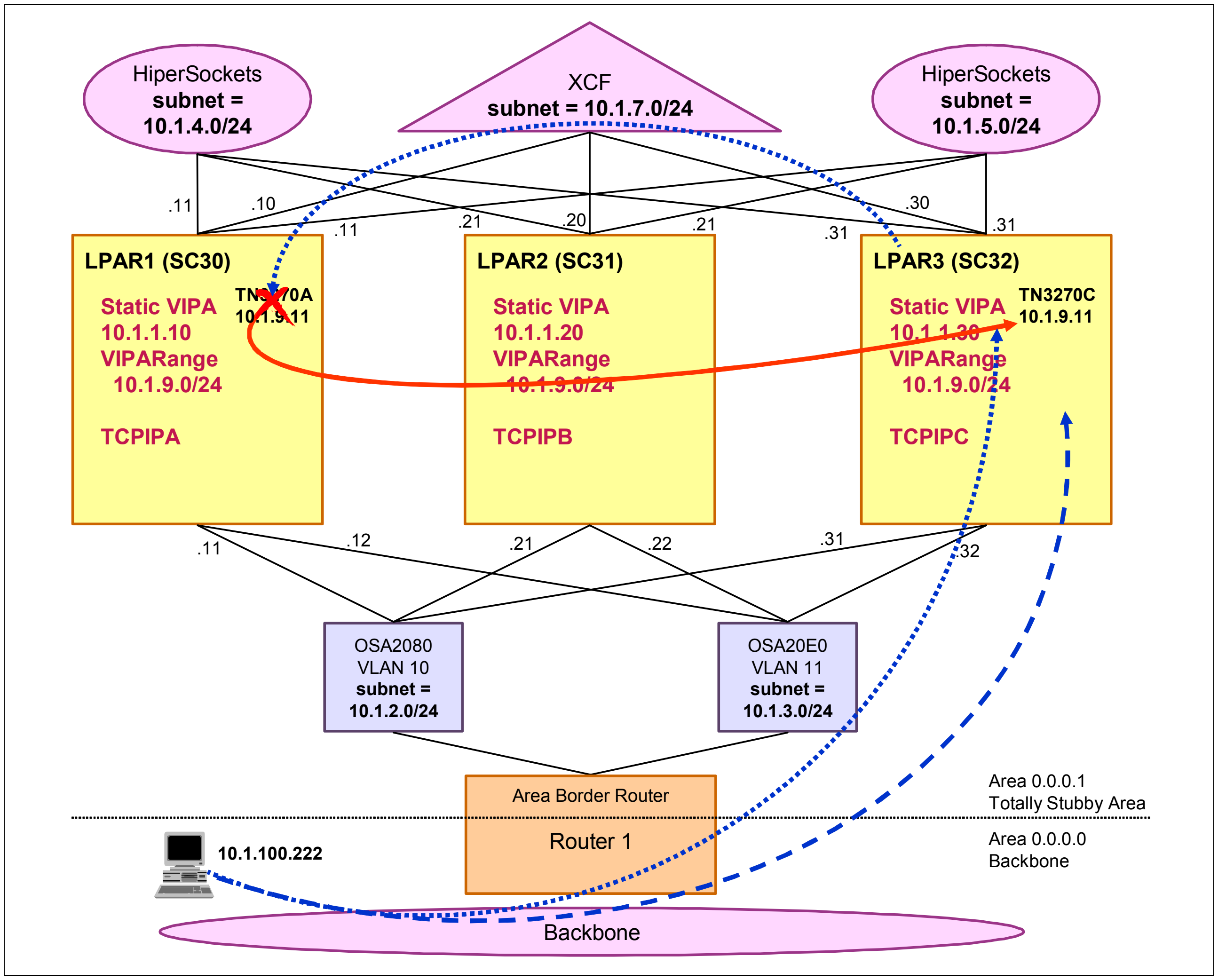


Figure 4-8 High availability for an application movement

We observe that the DVIPA address defined by VIPARange is redirected from stack TCPIPA in SC30 to stack TCPIPC in SC32. This is the DVIPA movement. We can verify that the application movement process is working as expected by performing the following steps.

We start the TN3270A server using the 10.1.9.11 VIPA address, which is in the VIPARANGE definition in our test environment. Verify this address by using the following display comment:

```
D TCPIP,TCPIPA,SYS,VIPADYN
```

The results are shown in Example 4-23.

Example 4-23 Verifying VIPA address 10.1.9.11 is active in SC30

```
D TCPIP,TCPIPA,SYSPLEX,VIPADYN,IPA=10.1.9.11
EZZ8260I SYSPLEX CS V2R1 133
VIPA DYNAMIC DISPLAY FROM TCPIPA   AT SC30
LINKNAME: VIPL0A01090B
IPADDR/PREFIXLEN: 10.1.9.11/24
  ORIGIN: VIPARANGE BIND
  TCPNAME  MVSNAME  STATUS RANK DIST
  -------- -------- ------ ---- ----
  TCPIPA   SC30     ACTIVE
1 OF 1 RECORDS DISPLAYED
```

The routing table in Router 1 shows that the route to VIPA address 10.1.9.11 is using SC30 OSA path, as shown in Example 4-24.

Example 4-24 The sh ip route 10.1.9.11 command results

```
Router1#sh ip route 10.1.9.11
Routing entry for 10.1.9.11/32
  Known via "ospf 100", distance 110, metric 110, type intra area
  Last update from 10.1.3.12 on Vlan11, 00:12:35 ago
  Routing Descriptor Blocks:
  * 10.1.2.11, from 10.1.1.10, 00:12:35 ago, via Vlan10
      Route metric is 110, traffic share count is 1
    10.1.3.12, from 10.1.1.10, 00:12:35 ago, via Vlan11
      Route metric is 110, traffic share count is 1
```

We start a new TN3270E Server in SC32 (TN3270C), which binds to a specific DVIPA (Example 4-25).

Example 4-25 Binding

```
PORT
23 TCP TN3270C BIND 10.1.9.11
```

We observe this stack takeover of the DVIPA from SC30, as shown in Example 4-26.

Example 4-26 The DVIPA address moves to SC32

```
S TN3270C
$HASP100 TN3270C  ON STCINRDR
IEF695I START TN3270C  WITH JOBNAME TN3270C  IS ASSIGNED TO USER
TCPIP   , GROUP TCPGRP
$HASP373 TN3270C  STARTED
IEE252I MEMBER CTIEZBTN FOUND IN SYS1.IBM.PARMLIB
EZZ6001I TN3270C SERVER STARTED
EZZ6044I TN3270C PROFILE PROCESSING BEGINNING FOR FILE 627
           TCPIPC.TCPPARMS(TN3270C)
EZZ6045I TN3270C PROFILE PROCESSING COMPLETE FOR FILE
           TCPIPC.TCPPARMS(TN3270C)
EZZ6003I TN3270C LISTENING ON PORT  4992
EZZ6003I TN3270C LISTENING ON PORT   992
EZZ6003I TN3270C LISTENING ON PORT  5023
EZZ8302I VIPA 10.1.9.11 TAKEN FROM TCPIPA ON SC30
EZD1205I DYNAMIC VIPA 10.1.9.11 WAS CREATED USING BIND BY TN3270C ON
```

```
TCPIPC
EZZ6003I TN3270C LISTENING ON PORT    23

SC30 console message
EZZ8303I VIPA 10.1.9.11 GIVEN TO TCPIPC ON SC32
```

The new VIPA location is advertised by OSPF changing the routes (Example 4-27).

Example 4-27 The sh ip route 10.9.1.11 command to verify the new route to VIPA 10.9.1.11

```
Router1#sh ip route 10.1.9.11
Routing entry for 10.1.9.11/32
  Known via "ospf 100", distance 110, metric 110, type intra area
  Last update from 10.1.2.31 on Vlan10, 00:00:02 ago
  Routing Descriptor Blocks:
  * 10.1.2.31, from 10.1.1.30, 00:00:02 ago, via Vlan10
      Route metric is 110, traffic share count is 1
    10.1.3.32, from 10.1.1.30, 00:00:02 ago, via Vlan11
      Route metric is 110, traffic share count is 1
```

We can now verify the DVIPA status, confirming it has moved to SC32. Example 4-28 illustrates this new status.

Example 4-28 DVIPA active in SC32

```
D TCPIP,TCPIPC,SYS,VIPADYN,IPA=10.1.9.11
EZZ8260I SYSPLEX CS V1R13 641
VIPA DYNAMIC DISPLAY FROM TCPIPC   AT SC32
LINKNAME: VIPL0A01090B
IPADDR/PREFIXLEN: 10.1.9.11/24
  ORIGIN: VIPARANGE BIND
  TCPNAME  MVSNAME  STATUS RANK DIST
  -------- -------- ------ ---- ----
  TCPIPC   SC32     ACTIVE
  TCPIPA   SC30     MOVING
2 OF 2 RECORDS DISPLAYED
```

The active connections with TN3270A server in SC30 continue to work and the traffic related to it is sent through the new route and redirected to SC30 using the XCF connection. When a new TN3270 client connects using address 10.1.9.11, it connects to TN3270C Server in SC32. This situation can be verified by using the **`Display TCPIP,TCPIPC,N,VCRT`** display command, as shown in Example 4-29.

Example 4-29 D TCPIP,TCPIPC,N,VCRT

```
D TCPIP,TCPIPC,N,VCRT
EZD0101I NETSTAT CS V1R13 TCPIPC 683
DYNAMIC VIPA CONNECTION ROUTING TABLE:
DEST:      10.1.9.11..23
  SOURCE:  10.1.100.222..1529
  DESTXCF: 10.1.7.31
DEST:      10.1.9.11..23
  SOURCE:  10.1.100.222..1530
  DESTXCF: 10.1.7.31
2 OF 2 RECORDS DISPLAYED
END OF THE REPORT
```

The existing sessions remain with SC30 until they end. At that time, the DVIPA address for SC30 disappears.

4.3.3 Stack failure scenario using VIPADEFINE and VIPABACKUP

In this example, we lose the entire TCP/IP stack. (We simulate this situation by simply stopping the stack.) The failure situation is illustrated in Figure 4-9.

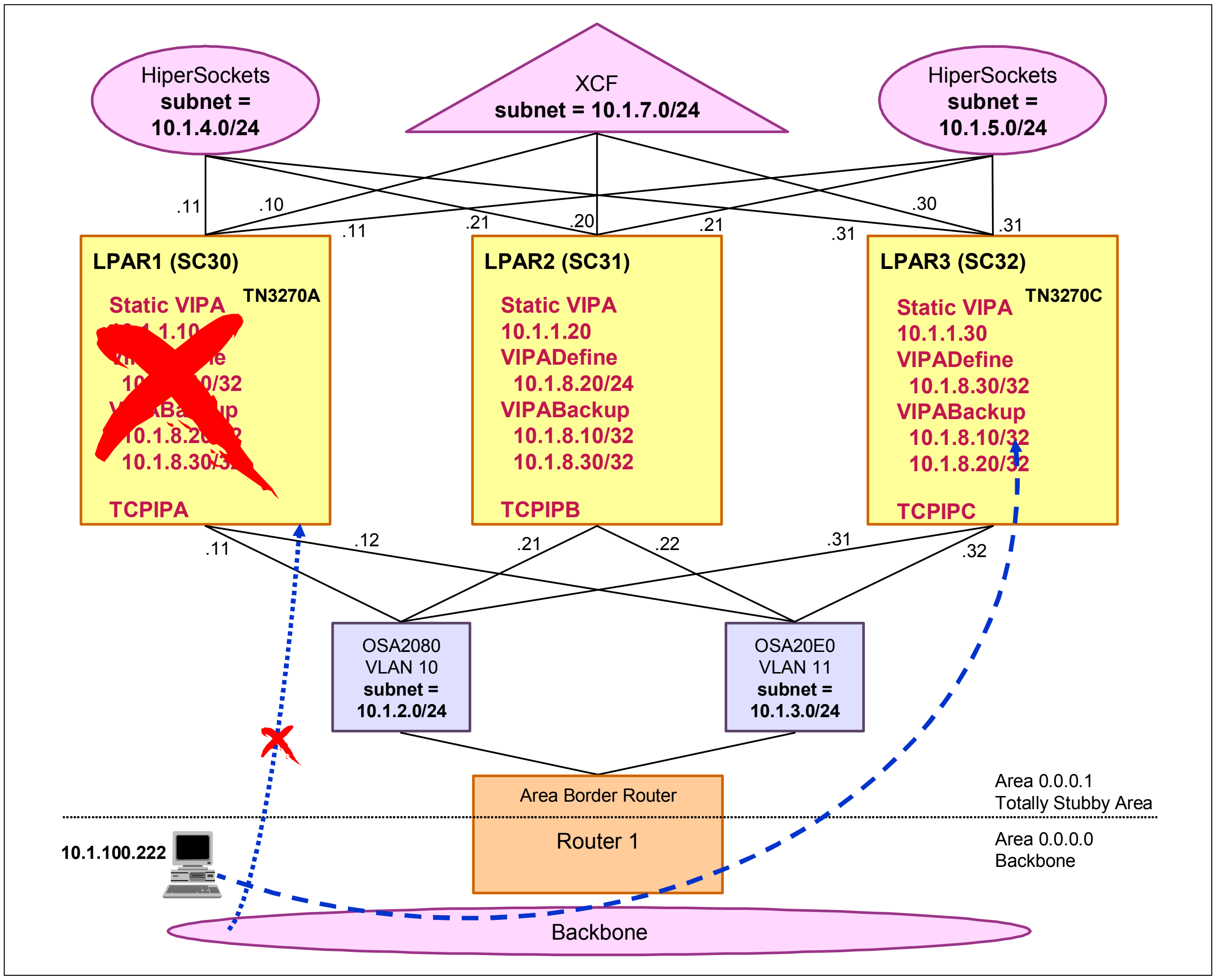


Figure 4-9 High availability for a stack failure

We use VIPADEFINE and VIPABACKUP definitions for the DVIPA to create a takeover and takeback environment. In our TCPIPA configuration, we create a VIPADEFINE with address 10.1.8.10, which is activated in SC30 as soon as the stack comes up. We also create, in the TCPIPC configuration, a VIPABACKUP for 10.1.8.10 with a rank of 4, stating that this stack is a candidate to take over this address if something happens with the TCPIPA stack. We can verify this configuration is in place using the **`Display TCPIP,TCPIPA,SYS,VIPADYN`** command, as shown in Example 4-30 on page 114.

Example 4-30 The d tcpip,tcpipa,vipadyn,ipa=10.1.8.10 command

```
D TCPIP,TCPIPA,SYSPLEX,VIPADYN,IPA=10.1.8.10
EZZ8260I SYSPLEX CS V1R13 152
VIPA DYNAMIC DISPLAY FROM TCPIPA   AT SC30
LINKNAME: VIPL0A01080A
IPADDR/PREFIXLEN: 10.1.8.10/24
  ORIGIN: VIPADEFINE
  TCPNAME  MVSNAME  STATUS RANK DIST
  -------- -------- ------ ---- ----
  TCPIPA   SC30     ACTIVE
  TCPIPB   SC31     BACKUP 100
  TCPIPC   SC32     BACKUP 090
4 OF 4 RECORDS DISPLAYED
```

We establish a Telnet session using address 10.1.8.10, then stop the primary TCP/IP (in SC30) and observe the results (Example 4-31).

Example 4-31 High availability in failure of the stack

```
P TCPIPA
EZZ3205I SNMP SUBAGENT: SHUTDOWN IN PROGRESS
EZZ0673I AUTOLOG TASK: SHUTDOWN IN PROGRESS
...
EZZ4201I TCP/IP TERMINATION COMPLETE FOR TCPIPA
IEF352I ADDRESS SPACE UNAVAILABLE
$HASP395 TCPIPA   ENDED

SC31 console message
EZZ8301I VIPA 10.1.8.10 TAKEN OVER FROM TCPIPA ON SC30


D TCPIP,TCPIPB,SYSPLEX,VIPAD,IPA=10.1.8.10
EZZ8260I SYSPLEX CS V1R13 875
VIPA DYNAMIC DISPLAY FROM TCPIPB   AT SC31
LINKNAME: VIPL0A01080A
IPADDR/PREFIXLEN: 10.1.8.10/24
  ORIGIN: VIPABACKUP
  TCPNAME  MVSNAME  STATUS RANK DIST
  -------- -------- ------ ---- ----
  TCPIPB   SC31     ACTIVE
  TCPIPC   SC32     BACKUP 090
3 OF 3 RECORDS DISPLAYED
```

This is a disruptive failure mode. Depending on the applications involved, clients might need to restart their sessions. (A subsequent takeback, when the TCP/IP stack in SC30 is restarted, is nondisruptive.)

When system SC32 discovers that SC30 has gone down (when SC30 leaves the XCF group), SC31 takes over the DVIPA address 10.1.8.10, advertising its new address through OSPF, as shown in Example 4-32.

Example 4-32 The sh ip route 10.1.8.10 in Router 1

```
Router1#sh ip route 10.1.8.10
Routing entry for 10.1.8.10/32
  Known via "ospf 100", distance 110, metric 110, type intra area
  Last update from 10.1.2.21 on Vlan10, 00:02:04 ago
  Routing Descriptor Blocks:
  * 10.1.2.21, from 10.1.1.20, 00:02:04 ago, via Vlan10
      Route metric is 110, traffic share count is 1
    10.1.3.22, from 10.1.1.20, 00:02:04 ago, via Vlan11
      Route metric is 110, traffic share count is 1
```

Next, we start new Telnet connections to the DVIPA address 10.1.8.10, which is now running on SC31. We use the NETSTAT operand N,VCRT to verify that these connections are going to DESTXCF 10.1.7.21 (the Dynamic XCF address of the SC31 stack), as shown in Example 4-33.

Example 4-33 New connections go to SC31

```
D TCPIP,TCPIPB,N,VCRT
EZD0101I NETSTAT CS V1R13 TCPIPB 881
DYNAMIC VIPA CONNECTION ROUTING TABLE:
DEST:      10.1.8.10..23
  SOURCE:  10.1.100.222..1531
  DESTXCF: 10.1.7.21                 1
1 OF 1 RECORDS DISPLAYED
END OF THE REPORT
```

In this example, number **1** indicates DESTXCF 10.1.7.21, which is the Dynamic XCF address of the SC31 stack.

We restart the TCPIPA stack in SC30 and observe the takeback operation (Example 4-34).

Example 4-34 Start TCPIPA in SC30 takeback function

```
S TCPIPA
...
$HASP373 TCPIPA   STARTED
...
EZB6473I TCP/IP STACK FUNCTIONS INITIALIZATION COMPLETE.
EZAIN11I ALL TCPIP SERVICES FOR PROC TCPIPA ARE AVAILABLE.
EZD1176I TCPIPA HAS SUCCESSFULLY JOINED THE TCP/IP SYSPLEX GROUP EZBTCPCS
EZZ8302I VIPA 10.1.8.10 TAKEN FROM TCPIPB ON SC31
EZD1214I INITIAL DYNAMIC VIPA PROCESSING HAS COMPLETED FOR TCPIPA

SC31 console message
EZZ8303I VIPA 10.1.8.10 GIVEN TO TCPIPA ON SC30
```

We verify that OSPF advertises the relocation of the VIPA address 10.1.8.10 to SC30 by displaying the route table in Router 1 (Example 4-35).

Example 4-35 The sh ip route 10.1.8.10

```
Router1#sh ip route 10.1.8.10
Routing entry for 10.1.8.10/32
  Known via "ospf 100", distance 110, metric 110, type intra area
  Last update from 10.1.3.11 on Vlan11, 00:00:38 ago
  Routing Descriptor Blocks:
  * 10.1.2.11, from 10.1.1.10, 00:00:38 ago, via Vlan10
      Route metric is 110, traffic share count is 1
    10.1.3.12, from 10.1.1.10, 00:00:38 ago, via Vlan11
      Route metric is 110, traffic share count is 1
```

Finally, we start a new TN3270 session using the same address, and confirm that we connect to the server located in SC30. We also confirm our TN3270 session is still up as expected by the using **`Display TCPIP,TCPIPA,N,VCRT`** command (Example 4-36).

Example 4-36 D TCPIP,TCPIPA,N,VCRT

```
D TCPIP,TCPIPA,N,VCRT
EZD0101I NETSTAT CS V1R13 TCPIPA 351
DYNAMIC VIPA CONNECTION ROUTING TABLE:
DEST:      10.1.8.10..23
  SOURCE:  10.1.100.222..1534
  DESTXCF: 10.1.7.11
DEST:      10.1.8.10..23
  SOURCE:  10.1.100.222..1531
  DESTXCF: 10.1.7.21
2 OF 2 RECORDS DISPLAYED
END OF THE REPORT
```

4.3.4 IPv6 stack failure scenario with VIPADEFINE and VIPABACKUP

To show how the same process can be done using IPv6, we created a simple scenario using TCPIPC from SC32, TCPIPD from SC32, and TCPIPB from SC31. The following network prefix is selected:

```
2001:400:2:1::
```

TCPIPC is a distributor of FTP traffic to itself and the other stacks. TCPIPB is a stack with no DVIPA, a typical target stack.

Implementation tasks

This section describes the implementation tasks for the design.

1. Defining TCPIP PROFILE statements for the stacks
2. Defining OMPROUTE configuration files
3. Verifying that the configuration works as planned.

Defining TCPIP PROFILE statements for the stacks

Example 4-37 has the configuration profile for TCPIPC.

Example 4-37 TCPIPC profile for IPv6

```
...
IPCONFIG6 1
 IPSECURITY DATAGRAMFWD DYNAMICXCF AOA::1E5
...
;-------------------------------------------------------
;IPv6 interfaces
;-------------------------------------------------------
INTERFACE IP6VIPAC 2
DEFINE VIRTUAL6
IPADDR 2001:400:2:1::30

INTERFACE OSA2080I DEFINE IPAQENET6 PORTNAME OSA2080
SOURCEVIPAINTERFACE IP6VIPAC
IPADDR 2001:400:2:1::/64
MTU 1492 INTFID 0:3:3:12
INBPERF DYNAMIC VMAC PRIROUTER
;-------------------------------------------------------
...
VIPADYNAMIC
; IPv6 DVIPA
VIPADEFINE  MOVE IMMED IP6DVIPA1 2001:400:2:1::31 3
VIPABACKUP  MOVE IMMED IP6BDVIP1 2001:400:2:1::41
...
; IPV6 4
   VIPADISTribute DISTMethod ROUNDROBIN IP6DVIPA1
   PORT 20 21
   DESTIP AOA::1E4 AOA::1E5 AOA::1E6
ENDVIPADYNAMIC
```

IPCONFIG6 1 is necessary to be able to have IPv6 configured. We defined a static VIPA and the physical interface associated to it 2. The use of INTFID ensures that the link local address gets created as we want. Next, create the DVIPA with VIPADEFINE 3, and finally, choose which stacks to distribute 4.

Few differences exist when creating a DVIPA using IPv6 instead of IPv4.

Note: if you do not specify the INTFID, the link local address is created based on the MAC address of the interface using a well known prefix.

Part of the profile of TCPIPD is depicted next. If you try to define `IP6BDVIP1` with other than the address previously specified and activated in the TCPIPC profile, you receive an error message.

Example 4-38 TCPIPD profile for IPv6

```
...
VIPADEFINE  MOVE IMMED IP6BDVIP1 2001:400:2:1::41
VIPABACKUP  MOVE IMMED IP6DVIPA1 2001:400:2:1::31
...
```

Defining OMPROUTE statements for the stacks

The configuration file of OMPROUTE for TCPIPC was created as shown in Example 4-39.

Example 4-39 OMPROUTE configuration statements for IPv6

```
...
IPV6_AREA
 Area_Number=0.0.0.3
 Stub_Area=YES
 Import_Prefixes=Yes;
...
; OSA Qdio for ipv6
IPV6_OSPF_INTERFACE
           name=OSA*
           prefix=2001:400:2:1::/64
           attaches_to_area=0.0.0.3;
IPV6_OSPF_INTERFACE
           name=IP6*
           attaches_to_area=0.0.0.3;
```

4.2.3, “Verifying that the configuration works as planned” on page 102

After creating the configuration files and activating them, we tested using FTP to TCPIPC, as shown in Example 4-40.

Example 4-40 FTP to TCPIPC

```
Connecting to:   2001:400:2:1::31 port: 21.
220-FTPDD1 IBM FTP CS V2R1 at wtsc33.itso.ibm.com, 16:40:51 on 2013-08-01.
220 Connection will close if idle for more than 5 minutes.
NAME (2001:400:2:1::31:CS04):
```

Next, the DYNAMIC VIPA (DVIPA) of TCPIPC is displayed, as in Example 4-41.

Example 4-41 D TCPIP,TCPIPC,N,VCRT

```
RESPONSE=SC32
  EZD0101I NETSTAT CS V2R1 TCPIPC 654
  DYNAMIC VIPA CONNECTION ROUTING TABLE:
  DEST:      2001:400:2:1::31..21
    SOURCE:  2001:500:2:1::40..1026
    DESTXCF: A0A::1E6
  1 OF 1 RECORDS DISPLAYED
  END OF THE REPORT
```

The commands of OMPROUTE with IPv6 are slightly different than with IPv4, and produce a different response, as in Example 4-42.

Example 4-42 D TCPIP;TCPIPC,OMP,IPV6OSPF,IFS

```
RESPONSE=SC32
 EZZ7958I IPV6 OSPF INTERFACES 656
 NAME            AREA           TYPE   STATE COST HELLO DEAD NBRS ADJS
 IP6DVIPA1       0.0.0.3        VIPA    N/A     1  N/A   N/A  N/A  N/A
 OSA2080I        0.0.0.3        BRDCST   64     1   10    40    3    3
 IP6VIPAC        0.0.0.3        VIPA    N/A     1  N/A   N/A  N/A  N/A
```

At failure of TCPIPC, the DVIPA is taken by TCPIPD, as shown in Example 4-43.

Example 4-43 /d TCPIP,TCPIPD,N,VDPT

```
EZD0101I NETSTAT CS V2R1 TCPIPD 223
DYNAMIC VIPA DESTINATION PORT TABLE FOR TCP/IP STACKS:
...
DDESTINTF:      IP6DVIPA1
  DEST:        2001:400:2:1::31..20
    DESTXCF:   A0A::1E6
    TOTALCONN: 0000000000 RDY: 000 WLM: 01 TSR: 100
    DISTMETHOD: ROUNDROBIN
    FLG:
DESTINTF:      IP6DVIPA1
  DEST:        2001:400:2:1::31..21
    DESTXCF:   A0A::1E4
    TOTALCONN: 0000000000 RDY: 000 WLM: 01 TSR: 100
    DISTMETHOD: ROUNDROBIN
    FLG:
```

For more information about IPv6, see *IBM z/OS V2R1 Communications Server TCP/IP Implementation Volume 1: Base Functions, Connectivity, and Routing*, SG24-8096.

4.4 Sysplex-Wide Security Associations

Sysplex-Wide Security Associations (SWSA) represent the joining of two Communications Server features, IP Security (IPSec), and sysplex distributor. The former, IPSec, protects network data using security associations (SAs). The latter, sysplex distributor, distributes application workload and provides backup and recovery mechanisms for Dynamic Virtual IP addresses (DVIPAs).

With SWSA in an IPv4 network, you can encrypt sysplex distributor workload. The distributor is responsible for negotiating a SA with a remote host. Copies of the SA, known as Shadow SAs, are sent to any target stacks that can potentially receive workload for the DVIPA. In addition to distribution, you can recover SAs associated with DVIPAs that are migrated to an alternate TCP/IP stack (DVIPA takeover). Any stacks that back up the DVIPA do not receive SA data from the distributor directly, but have access to the SA data in the coupling facility (CF), which is needed for SA recovery if a DVIPA move happens. To learn more about implementing Internet Key Exchange (IKE) and IPSec, see Volume 4 of this series (*IBM z/OS V2R1 Communications Server TCP/IP Implementation Volume 4: Security and Policy-Based Networking*, SG24-8099). Also see Figure 4-10 on page 120.

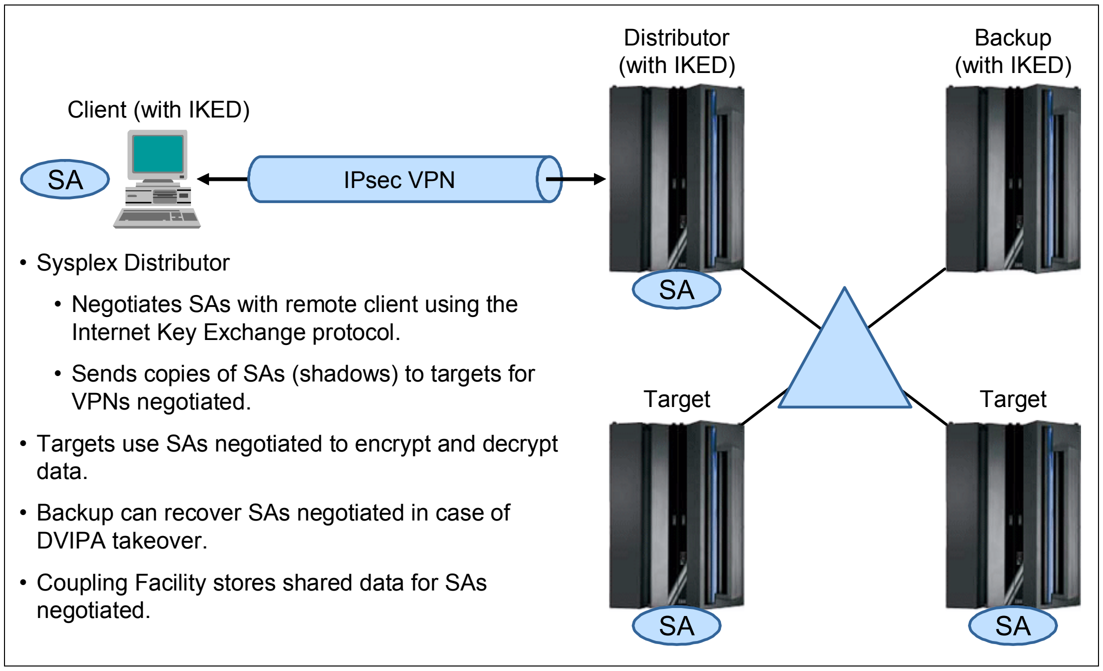

Distributor (with IKED)
Backup (with IKED)
Client (with IKED)
SA
IPsec VPN
• Sysplex Distributor
• Negotiates SAs with remote client using the Internet Key Exchange protocol.
• Sends copies of SAs (shadows) to targets for VPNs negotiated.
• Targets use SAs negotiated to encrypt and decrypt data.
• Backup can recover SAs negotiated in case of DVIPA takeover.
• Coupling Facility stores shared data for SAs negotiated.
SA
Target
Target
SA
SA

Figure 4-10 SWSA support of IKE

When you use SWSA, consider the two possible configurations: DVIPA takeover and sysplex distributor.

In DVIPA takeover, the IKE running on behalf of the TCP stack of the DVIPA owner is responsible for all IKE SA negotiations. The TCPIP stack that owns the DVIPA is responsible for keeping the coupling facility updated with information needed to reestablish the SAs in the event of a DVIPA takeover. When a takeover occurs, the IKE on the backup host assumes responsibility for renegotiating new SAs based on the stored information read from the coupling facility during the takeover by the TCP stack of the new DVIPA owner.

In sysplex distributor, TCP traffic protected by an IPSec SA with a sysplex-distributed DVIPA endpoint can be distributed to target hosts. IPSec cryptography for inbound traffic is performed on the target host when possible. If not possible, the distributor performs the cryptography before forwarding the packet to the target stack. IPSec cryptography for outbound traffic is performed on the target host, and then sent directly into the network *without being routed through the distributor*. For more information about either mode, see *z/OS Communications Server: IP Configuration Guide*, SC27-3650

4.4.1 Enabling the SWSA in a stack with IPSec defined

Our test scenario was created using LPARs SC31 for TCPIPB, SC32 for TCPIPC, and SC33 for TCPIPD and TCPIPE. We used sysplex distributor and defined a distributed VIPA 10.1.8.30 on TCPIPC of LPAR SC32 and a VIPA backup on TCPIPD in LPAR SC33. We accessed the distributed VIPA using TCPIPE (as would an external client). Our target applications were the TN3270 servers of TCPIPB,TCPIPC and TCPIPD.

To support IPSec in conjunction with DVIPA takeover and sysplex distributor, some amount of IKE and IPSec configuration is required. SWSA also requires the use of a CF structure with a name in the form `EZBDVIPA`*`vvtt`* where *`vv`* is the two-digit VTAM group ID suffix specified on the XCFGRPID start option, and *`tt`* is the TCP group ID suffix specified on the

GLOBALCONFIG statement in the TCP/IP profile. For more about this issue, see the *z/OS Communications Server: SNA Network Implementation*, SC31-8777.

In our test environment, we chose not to specify any group ID for VTAM or TCP/IP. See Example 4-44.

Example 4-44 Display of EZBDVIPA

```
D XCF,STR,STRNAME=EZBDVIPA
IXC360I  14.54.55  DISPLAY XCF 105
STRNAME: EZBDVIPA
 STATUS: ALLOCATED
 EVENT MANAGEMENT: POLICY-BASED
 TYPE: LIST
 POLICY INFORMATION:
  POLICY SIZE    : 40448 K
  POLICY INITSIZE: 34380 K
  POLICY MINSIZE : 25784 K
  FULLTHRESHOLD  : 85
  ALLOWAUTOALT   : YES
  REBUILD PERCENT: 1
  DUPLEX         : DISABLED
  ALLOWREALLOCATE: YES
  PREFERENCE LIST: CF39     CF38
  ENFORCEORDER   : NO
  EXCLUSION LIST IS EMPTY

 ACTIVE STRUCTURE
 ----------------
  ALLOCATION TIME: 11/09/2011 16:27:09
  CFNAME         : CF39
  COUPLING FACILITY: 002817.IBM.02.0000000B3BD5
                   PARTITION: 1F   CPCID: 00
  ACTUAL SIZE    : 34 M
  STORAGE INCREMENT SIZE: 1 M
  USAGE INFO      TOTAL     CHANGED    %
   ENTRIES:        7631           3    0
   ELEMENTS:      73027          16    0
  PHYSICAL VERSION: C8A643C1 1E21D1AB
  LOGICAL  VERSION: C8A643C1 1E21D1AB
  SYSTEM-MANAGED PROCESS LEVEL: 8
  DISPOSITION    : DELETE
  ACCESS TIME    : 1800
  MAX CONNECTIONS: 32
  # CONNECTIONS  : 3 1

 CONNECTION NAME  ID VERSION  SYSNAME  JOBNAME  ASID STATE
 ---------------- -- -------- -------- -------- ---- ---------
 USIBMSC_SC31M    03 00030001 SC31     NET      001F ACTIVE 2
 USIBMSC_SC32M    02 0002000A SC32     NET      001F ACTIVE
 USIBMSC_SC33M    01 00010009 SC33     NET      001F ACTIVE

 DIAGNOSTIC INFORMATION:  STRNUM: 00000031 STRSEQ: 00000007
                          MANAGER SYSTEM ID:  00000000

EVENT MANAGEMENT: POLICY-BASED
```

Notice the number of active connections (1) and the display of the LPARS using this structure (2)

Before advancing to step 2 we also set up the following three VPN tunnels with pre-shared keys, by using the instructions in Volume 4 of this series, (*IBM z/OS V2R1 Communications Server TCP/IP Implementation Volume 4: Security and Policy-Based Networking*, SG24-8099). In Volume 4, see the information about configuring IPSec between two z/OS systems: Pre-shared Key Mode using IKEv2.

- Between TCPIPE (192.168.1.40) and TCPIPC (10.1.8.30)
- Between TCPIPE (192.168.1.40) and TCPIPD (10.1.8.30)
- Between TCPIPE (192.168.1.40) and TCPIPB (10.1.8.30)

Step 2: Defining the DVIPSEC parameter

To take advantage of the functions described here, you must add the DVIPSEC parameter to your primary (including sysplex distributor hosts) and backup hosts (TCPIPC-SC32 and TCPIPD-SC33). It is not necessary to add DVIPSEC to hosts that serve only as targets for sysplex distributor (TCPIPB-SC31). See Example 4-45.

Example 4-45 Definition of DVIPASEC parameter in TCPIPC PROFILE

```
...
;--------------------------------------------------------------------
;  IPCONFIG
;--------------------------------------------------------------------
IPCONFIG
 NODATAGRAMFWD
 SYSPLEXROUTING
 SOURCEVIPA
 DYNAMICXCF 10.1.7.31 255.255.255.0 1
 IPSECURITY
...
;--------------------------------------------------------------------
;  IPSEC
;--------------------------------------------------------------------
  IPSEC DVIPSEC 1
IPSECRULE *  *  NOLOG  PROTOCOL *
;;  OSPF protocol used by Omproute
  IPSECRULE *  *  NOLOG  PROTOCOL OSPF
  ENDIPSEC
...
VIPADYNAMIC
VIPADEFINE     MOVEABLE IMMED 255.255.255.0   10.1.8.30
VIPABACKUP  90 MOVEABLE IMMED 255.255.255.0   10.1.8.40
VIPADISTribute DISTMethod ROUNDROBIN   10.1.8.30
PORT 23
DESTIP 10.1.7.31 10.1.7.41 10.1.7.21
ENDVIPADYNAMIC
```

Notice the parameter DVIPSEC (1). We coded this in both TCPIPC and TCPIPD profiles. If we had not coded this parameter, the only TN3270 server that would respond would be TN3270C (the server associated to the distributor stack), and the distribution would not occur as we had wanted. In TCPIPB there was no need to code this parameter as explained previously.

The profile is shown in Example 4-46.

Example 4-46 TCPIPB profile for IPSEC

```
IPSEC
IPSECRULE *  *  NOLOG  PROTOCOL *
;;  OSPF protocol used by Omproute
  IPSECRULE *  *  NOLOG  PROTOCOL OSPF
ENDIPSEC
```

4.4.2 Verifying the SWSA

In our scenario, we sometimes experienced a delay in the setting up of the tunnel between the TCPIPE and the TCPIPD at the time of failure of TCPIPC, which caused the first attempt to connect to fail by timeout. The subsequent attempts would work correctly.

The **`ipsec -y display -s`** command shows a shadow tunnel installed into a target Sysplex stack (Example 4-47).

Example 4-47 Command ipsec -p TCPIPD -y display -s

```
CS V1R13 ipsec  Stack Name: TCPIPD  Thu Nov 10 15:45:15 2011
Primary:  Dynamic tunnel  Function: display (shadows)  Format:   Detail
Source:   Stack           Scope:    Current            TotAvail: 1
TunnelID:                     Y35
Generation:                   1
IKEVersion:                   2.0
ParentIKETunnelID:            K33
VpnActionName:                IPSec__Silver:17
LocalDynVpnRule:              n/a
State:                        Active
HowToEncap:                   Transport
LocalEndPoint:                10.1.8.30
RemoteEndPoint:               192.168.1.40
LocalAddressBase:             10.1.8.30
LocalAddressPrefix:           n/a
LocalAddressRange:            n/a
RemoteAddressBase:            192.168.1.40
RemoteAddressPrefix:          n/a
RemoteAddressRange:           n/a
...
```

The **display net,stats** command (Example 4-48) shows a typical coupling facility entry for a tunnel.

Example 4-48 DISPLAY NET,STATS

```
D NET,STATS,TYPE=CFS,STRNAME=EZBDVIPA,LIST=ALL
IST097I DISPLAY ACCEPTED
IST350I DISPLAY TYPE = STATS,TYPE=CFS 220
IST1370I USIBMSC.SC33M IS CONNECTED TO STRUCTURE EZBDVIPA
IST1797I STRUCTURE TYPE = LIST
IST1517I LIST HEADERS = 2048 - LOCK HEADERS = 0
IST1373I STORAGE ELEMENT SIZE = 256
IST924I -------------------------------------------------------------
IST1374I                            CURRENT     MAXIMUM  PERCENT
IST1375I STRUCTURE SIZE              34816K      40960K    *NA*
IST1376I STORAGE ELEMENTS                16       73027       0
IST1377I LIST ENTRIES                     3        7631       0
IST924I -------------------------------------------------------------
IST1834I LIST DVIPA SYSNAME  TCPNAME    #ENTRIES    TGCOUNT SEQNUMBER
IST1835I    1 10.1.8.30
IST1837I           SC32     TCPIPC           1                    76
IST1835I    2 10.1.8.30
IST1836I           SC32     TCPIPC           1         6
IST314I END
```

The CF stores shared information about IKE and IPSec SAs whose endpoint is a Sysplex DVIPA. The information is maintained in the EZBDVIPA structure, which must be defined to use SWSA. In addition to the DVIPA endpoint, also included in the display output is a stack that currently owns the DVIPA, designated by `TCPNAME`. The IBM MVS™ system, on which the owning stack that is active is displayed, is designated by `SYSNAME`. Also included is the sequence number for the SA, which is designated by `SEQNUMBER`. Designation `TGCOUNT` shows the number of times that the DVIPA has moved.

Tip: To help debug SWSA problems, see “Steps for diagnosing Sysplex-Wide Security Association (SWSA) problems” in the *z/OS Communications Server: IP Diagnosis Guide*, GC31-8782. Several of those steps are listed here:

- Code the DVIPSEC option on the owning and backup stacks and use the **ipsec -f display** command to confirm DVIPSEC is enabled.
- Verify that VTAM connected to an EZBDVIPA structure. An IST1370I message is issued to the console when VTAM connects.
- Use the **ipsec -y display** command to display tunnels on the distributing stack.
- Use the **ipsec -y display -s** command to display shadow tunnels on the target stacks.
- Use the **D NET,STATS** command to view the tunnel entries in the CF.

4.4.3 Sysplex-Wide Security Associations for IPv6

Beginning with this release, the SWSA feature is enhanced to work with IPv6 DVIPA. This support is extended to both IKEv1 and IKEv2. The coupling facility (CF) stores the data for IPv6 tunnels. Shadow copies of IPv6 SAs are sent to target stacks that can process workloads for IPv6 IPsec protected connections. Then, backup stacks are able to recover IPv6 security association (SA) after a DVIPA takeover by using the IPv6 tunnel data stored in the CF.

For distribution, the distributor must be at release level V2R1and distribute IPv6 connections to target systems at release level V2R1. For takeover, the backup stack must be at V2R1 to take over IPv6 SAs.

In previous Communications Server releases, the DVIPSEC parameter enabled SWSA only for IPv4. With this current release, the combination of IPCONFIG6 IPSECURITY and IPSECURITY DVIPSEC enables SWSA for IPv6 also.

IPv6 TCP traffic that is protected by an IPSec SA with a sysplex-distributed DVIPA endpoint can be distributed to target hosts. The proper IP security policy must be active in target hosts. The CF keeps SAs with IPv6 DVIPA endpoints. When an IPv6 DVIPA is moved during a planned or unplanned DVIPA takeover, the new owner attempts to reestablish SAs with the same security service characteristics. The required IP security policies must be active in backup hosts too.

Restriction: NAT Traversal support is not supported for IPv6 security.

Considerations before enabling IPv6 SWSA

There is no new configuration required, that is, the syntax for the IPSEC and ENDIPSEC block in TCP/IP profile remains unchanged for this feature from the previous example shown for IPv4.

IPv6 SWSA is enabled when both of the following statements are true:

- IPSECURITY is specified on IPCONFIG6 statement.
- DVIPSEC is specified within the IPSEC and ENDIPSEC block.

DVIPSEC must be enabled for the distributor stacks and any backup stacks. It is not required to be enabled for target stacks.

To show this, we created a scenario for IPv6 SWSA. For information about IPv6 addressing, consult Appendix A, “IPv6 support” in *IBM z/OS V2R1 Communications Server TCP/IP Implementation Volume 1: Base Functions, Connectivity, and Routing*, SG24-8096.

Again, this test scenario was created using LPARs SC31 for TCPIPB, SC32 for TCPIPC, SC33 for TCPIPD, and TCPIPE as an external client. Furthermore, we used sysplex distributor and defined a distributed VIPA on TCPIPC of LPAR SC32 and a VIPA backup on TCPIPD in LPAR SC33. We accessed the distributed VIPA using TCPIPE (as would an external client). Our target applications were the FTP servers of TCPIPB, TCPIPC, and TCPIPD because Time Sharing Option (TSO) Telnet is not supported for IPv6.

In our environment we chose the network prefix of 2001:400:2:1::/64.

Adjust the TCP/IP profile of distributor and backup stacks in IPv6 environment

The next example for TCPIPC (distributor stack) shows the changes made to the profile. These changes are similar to what we would have done for any distributor stack in an IPv4 environment, except they are for IPv6. This was also done for TCPIPD (backup stack) profile.

Example 4-49 TCPIPC profile statements

```
IPCONFIG6
 IPSECURITY 1 DATAGRAMFWD DYNAMICXCF AOA::1E5
...
;  IPSEC
 ;----------------------------------------------------------------
   IPSEC DVIPSEC 2
 ; IPSEC
   IPSECRULE *  *  NOLOG  PROTOCOL *
 ;;  OSPF protocol used by Omproute
   IPSECRULE *  *  NOLOG  PROTOCOL OSPF
 ;  ;;  IPv6 Rules
   IPSEC6RULE *  *  NOLOG  PROTOCOL ICMPV6
 ; Permit local outbound IPv6 Neighbor Solicitations
 ; Permit local inbound IPv6 Neighbor Solicitations
         IPSEC6R * *  LOG PROTO          ICMPV6  TYPE 135
 ; Permit local outbound IPv6 Neighbor Advertisements
 ; Permit local inbound IPv6 Neighbor Advertisements
      IPSEC6R *  * LOG       PROTO   ICMPV6  TYPE  136
...
```

The combination of IPCONFIG6 IPSECURITY (1) and DVIPSEC (2) parameters enables the SWSA for IPv6 as it was previously explained.

The steps to determine the SWSA are the same as for IPv4 SWSA (described previously in this book).

5

Internal application workload balancing

With internal application workload distribution, decisions for load balancing are made within the z/OS environment. The application workload balancing decision maker provided with the Communications Server is the sysplex distributor. Another option, the use of Shareport, is a method of workload distribution performed by the stack itself within a single z/OS system. This chapter describes internal application workload balancing and focuses primarily on the sysplex distributor function and the benefits that it provides. We also explain the use of Shareport in this chapter.

This chapter contains the following topics.

Section	Topic
5.1, “Basic concepts of internal application workload balancing” on page 128	Basic concepts of internal application workload balancing
5.2, “Sysplex distributor” on page 129	Description and available options for sysplex distributor
5.3, “Sysplex distributor examples” on page 149	Commonly implemented internal application workload balancing design scenarios
5.4, “Port sharing” on page 181	Basic concepts of port sharing and its implementation
5.5, “Problem determination” on page 189	Summary of useful NETSTAT commands and debugging approaches

5.1 Basic concepts of internal application workload balancing

Internal workload balancing within the sysplex ensures that a group or cluster of application server instances can maintain optimum performance by serving client requests simultaneously. High availability considerations suggest at least two application server instances should exist, both providing the same services to their clients. If one application instance fails, the other carries on providing service. Multiple application instances minimize the number of users affected by the failure of a single application server instance. Thus, load balancing and availability are closely linked.

Sysplex distributor extends the notion of dynamic VIPA and automatic VIPA takeover to allow for load distribution among application instances within the sysplex. It extends the capabilities of dynamic VIPAs to enable distribution of incoming TCP connections to ensure high availability of a particular service within the sysplex. With z/OS Communications Server, you can implement a dynamic VIPA as a single network-visible IP address for a set of hosts that belong to the same sysplex cluster. A client, located anywhere in the IP network, can see the sysplex cluster as one IP address, regardless of the number of hosts that it includes.

Port sharing is another function for workload distribution. It enables the load balancing among application instances within a z/OS image. For a TCP server application to support a large number of client connections on a single system, while providing good performance for those connections, running more than one instance of the server application to service the connection requests might be necessary. For all instances of the server application to receive client connection requests without changing the client applications, the servers must all bind to the same server IP address and port.

Figure 5-1 depicts, at a high level, where the decision-maker for internal application workload balancing resides.

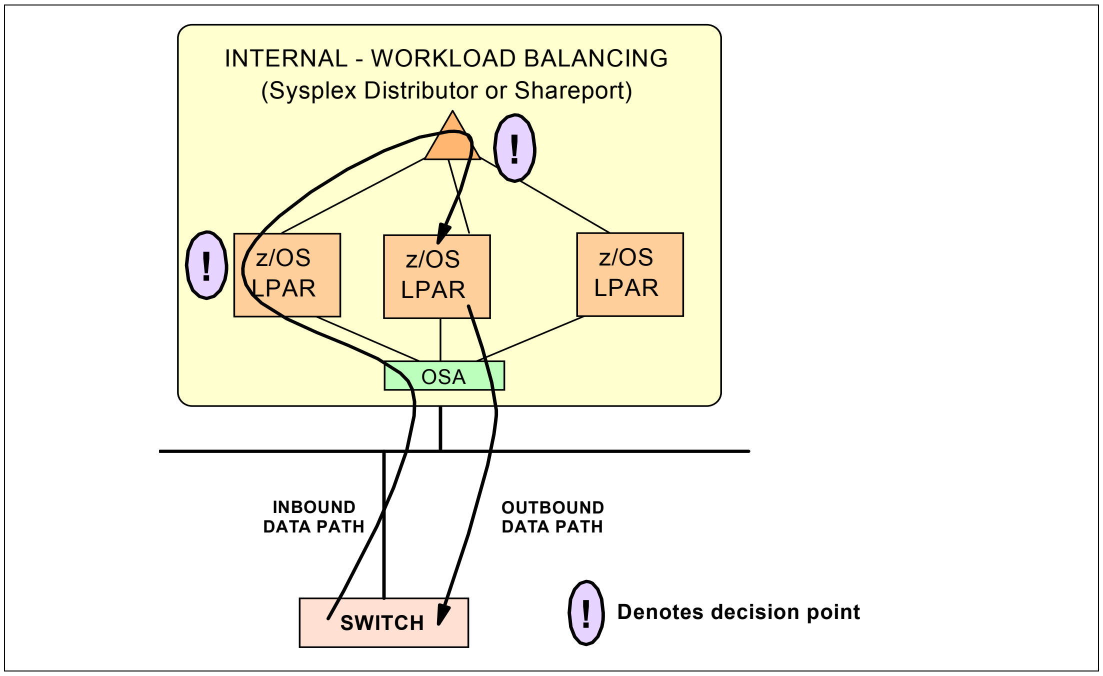


Figure 5-1 Decision point within the sysplex: Internal workload balancing

For more information about Distributed DVIPA in a sysplex distributor environment, see 2.3.3, “Distributed DVIPA (sysplex distributor)” on page 19.

5.2 Sysplex distributor

The sysplex distributor is the internal decision-maker for application workload balancing. The sysplex distributor, together with XCF dynamics and dynamic VIPA, creates an advanced level of availability and workload balancing in a sysplex. Workload can be distributed to multiple server application instances without requiring changes to clients or networking hardware, and without delays in connection setup.

5.2.1 Sysplex distributor: Principles of operation

The main target for sysplex distributor workload distribution is the applications on z/OS images, however, non-z/OS targets are supported also. The non-z/OS target that is currently supported is IBM DataPower. For more information about using DataPower as sysplex distributor targets and implementing multitier optimized intra-sysplex workload balancing, see Chapter 7, "Intra-sysplex workload balancing" on page 239.

The *distributor stack* is a network-connected stack that owns a specific VIPA address and acts as the distributor for connection requests to the VIPA address. The *target stack* is the owner of the application instances, to which the distributing stack forwards the requests. Together, they are called *participating stacks* for sysplex distributor.

All z/OS images that are involved communicate through XCF, which permits each TCP/IP stack to have full knowledge of IP addresses and server availability in all stacks. Sysplex distributor provides an advisory mechanism that checks the availability of applications running on separate z/OS servers in the same sysplex, and then selects the best-suited target server for a new connection request. The sysplex distributor bases its selections on real-time information from sources such as Workload Manager (WLM), QoS data from the Service Policy Agent, and weights received from non-z/OS targets servers (such as IBM DataPower). Sysplex distributor also measures the responsiveness of target servers in accepting new TCP connection setup requests, favoring those servers that are accepting new requests more successfully. There are a several methods provided to specify how this information is used to determine the target stack.

Supported distribution methods are as follows:

- SERVERWLM method, which uses weights that are received from z/OS servers
- BASEWLM method, which uses weights that are received from z/OS servers
- WEIGHTEDActive method, which is based on target weight and active connections.
- Round-Robin method, which is a simple round-robin mechanism.
- HotStandby method, where the preferred server receives all incoming connection and the other servers act as standby servers.

When the selection of the target stack is complete, the connection information is stored in the sysplex distributor stack to route future IP packets that belong to the same connection as the selected target stack. Routing is based on the connection (or session) to which IP packets belong, which is known as *connection-based routing*. The backup stack takes over the ownership of the VIPA address and the distributor function if the primary sysplex distributor stack leaves the XCF group because of a failure or a planned outage. This takeover is nondisruptive to all existing connections except the ones that are established on a failed node.

Figure 5-2 provides a conceptual overview of sysplex distributor operation.

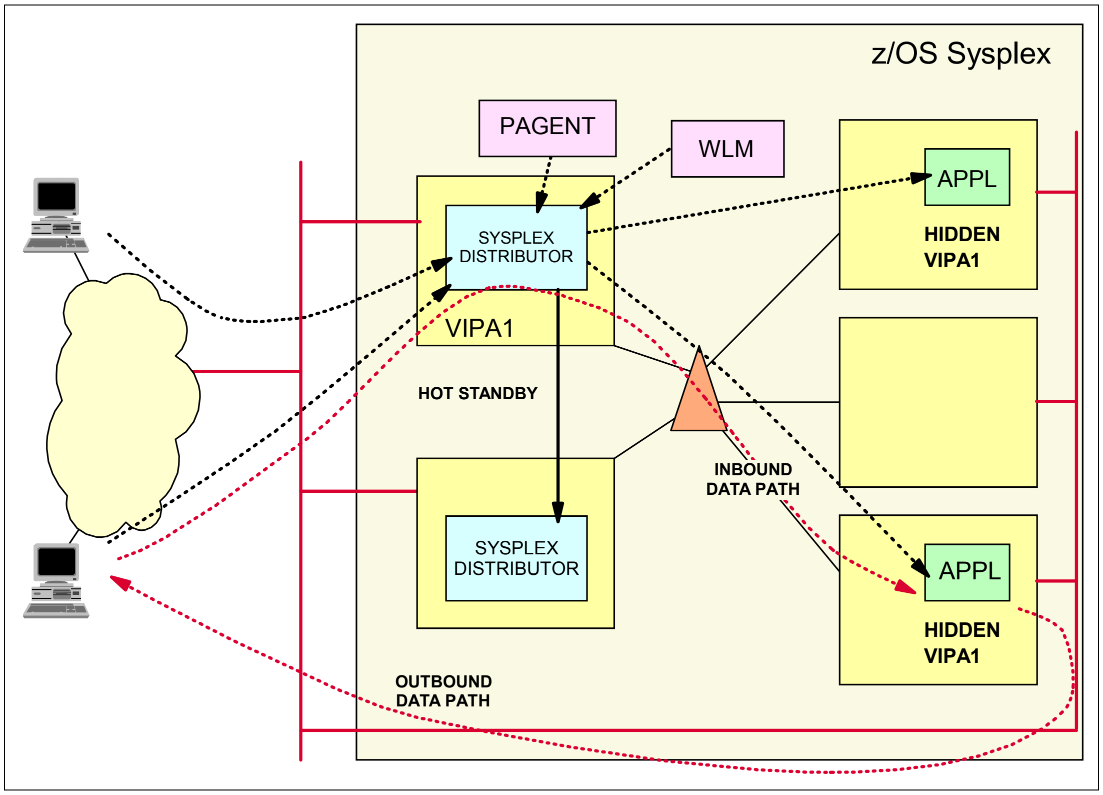


Figure 5-2 Sysplex distributor for z/OS-integrated intra-sysplex workload balancing

To configure the distributor stack, use the VIPADEFINE and VIPADISTRIBUTE statements in the VIPADYNAMIC/ENDVIPADYNAMIC block. To configure the backup stack, you only need a VIPABACKUP statement in the VIPADYNAMIC/ENDVIPADYNAMIC block, unless the backup stack has another responsibility for workload distribution. By taking over the DVIPA, the backup stack inherits the distributor role.

5.2.2 Sysplex distributor and quality of service policy

The use of internal application workload balancing and distribution is closely related to quality of service (QoS) objectives. The Policy Agent interacts with the sysplex distributor to assist with workload balancing. The ability to monitor server performance dynamically and affect sysplex workload distribution is an important part of the overall QoS mechanism.

The Policy Agent performs the following distinct functions to assist the sysplex distributor:

- Policies can be defined to control which stacks the sysplex distributor can select. The definition of the *outbound interface* on the PolicyAction statement can limit the potential target stacks to a subset of those defined on the VIPADISTRIBUTE statement in the TCPIP.PROFILE. The stacks to which work is distributed can vary, for example, based on time periods in the policy.

  Another possibility is to limit the number of the sysplex distributor target stacks for inbound traffic from a given subnet. In this way, the total set of target stacks can be partitioned among separate groups of users or applications requesting connections to distributed applications.

- The PolicyPerfMonitorForSDR statement in the `pagent.conf` file activates the Policy Agent QoS performance monitor function. When activated, the Policy Agent uses data about packet loss and timeouts that exceed defined thresholds and derives a QoS weight fraction for that target stack. This weight fraction is then used to reduce the WLM weight assigned to the target stacks, so that the sysplex distributor stack can use this information to better direct workload to where network traffic is best being handled. In this way, processor performance, server performance, and application network performance are taken into account when a decision is made for work distribution. This policy is activated on the sysplex distributor and the target stacks.
- The Policy Agent at each target now collects information with an additional level of granularity, and the QoS performance data is collected for each service level that a target's DVIPA port or application supports.
- The Policy Agent on the distributing stack drives the collection of this information by pulling it from the Policy Agents on the target stacks.

To exclude stale data from target stacks where the Policy Agent has terminated, the Policy Agent sends a *heartbeat* to the distributing stack at certain intervals. The distributing stack deletes QoS weight fraction data from a target stack when the heartbeat has not been received within a certain amount of time.

5.2.3 Monitoring the responsiveness of the target server

When the sysplex distributor distributes connections to servers on a set of target stacks, in certain cases, a server's ability to process new connections is slow because of external issues.

z/OS has a function that allows the sysplex distributor to monitor the target server's responsiveness at intervals of approximately one minute. If a target server experiences response problems, sysplex distributor diverts new connection requests away from that server. When the distribution method for a target server is BASEWLM or WeightedActive, the weights to the target server are modified to reflect its ability to handle new connection requests. Target servers whose weights are lowered because of this are less favored by the distribution algorithm.

Note: When the distribution method for a target server is ROUNDROBIN and the target server appears to have lost its ability to process new connection setup requests, it is not selected as part of the round-robin distribution.

Target server responsiveness (TSR)

TSR values are displayed as a percentage. A value of 100 indicates full responsiveness and a value of 0 (zero) indicates no responsiveness in setting up new TCP connections. A value of 0 (zero) for the TSR causes the removal of the server from distribution target list. The TSR values are applied only if all participating stacks are above z/OS V1R7.

The TSRs are calculated by combining the following two factors:

- Target Connectivity Success Rate (TCSR)

  TCSR is a measure of how many new TCP connection setup requests (SYNs) sent by the distributing stack to a target stack are received by the target stack. A low value could indicate a problem with the connectivity between the distributing stack and target stack.

  New route lookup: If the TCSR drops to 25 or lower, the optimized routing function is triggered to perform a new route lookup.

- Server accept Efficiency Fraction (SEF)

  SEF measures how well a target server is accepting new TCP connection setup requests and managing its backlog queue (for example, is the server accepting new work?).

Connection Establishment Rate (CER)

The CER value is shown only as a diagnostic aid, and its value has no affect on the WLM weight. CER measures how many TCP connection setup requests received by the target stack become established. The CER value is displayed as a percentage; 100 indicates that all of the connection setup requests that were received entered the established state. A lower value could indicate a routing problem in the network.

Figure 5-3 illustrates the use of the monitoring of the target server responsiveness.

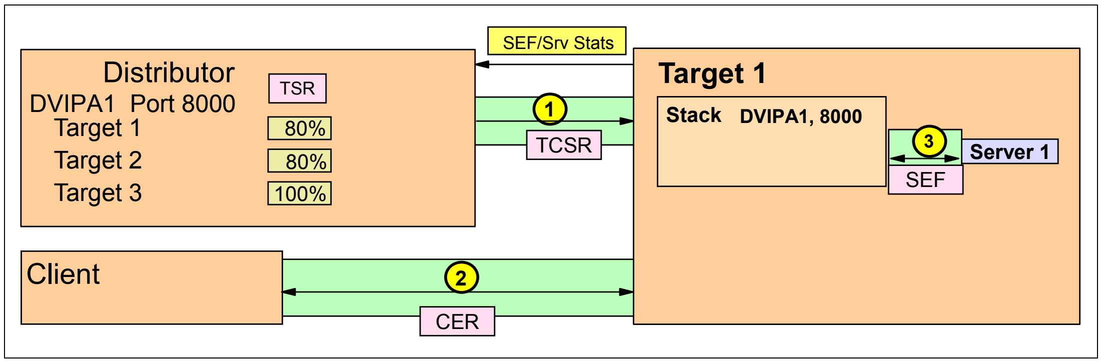


Figure 5-3 Possible weak points monitored automatically by the sysplex autonomics health monitor

All these values are sent to the distributor. The sysplex distributor then creates a Target Server Responsiveness fraction (TSR). This fraction, in turn, influences the decisions made by the sysplex distributor. The higher the value, the healthier the condition of the target server.

The Sysplex Autonomic Health indicators are shown in various display messages issued by TCP/IP. All have a value in the range of 0 - 100 (with 0 being the worst and 100 being the best, except for the QoS, which is the opposite).

We can check Sysplex Autonomic Health indicators in an extract of the output from the **D TCPIP,TCIPIP,VPD,DETAIL** command, as shown in Example 5-1. The fields are self-explanatory, except the QoS fraction, which is shown as W/Q in the message display.

Example 5-1 Part of the NETSTAT VDPT output

```
DEST:         10.1.8.30..23
  DESTXCF:    10.1.7.21
  TOTALCONN: 0000000000  RDY: 001  WLM: 16  TSR: 100
  FLG: SERVERWLM
    TCSR: 100  CER: 100  SEF: 100
    WEIGHT: 64
      RAW         CP: 64 ZAAP: 00 ZIIP: 00
      PROPORTIONAL CP: 64 ZAAP: 00 ZIIP: 00
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000000
    QOSPLCACT: *DEFAULT*
      W/Q: 16
```

5.2.4 Workload distribution methods

With z/OS, there is a sysplex distribution feature providing server-specific WLM recommendations for load balancing. The distribution of new connection requests can be based on the actual workload of a target server. This method (SERVERWLM) indicates how well a specific server on a stack is meeting the goals of the WLM service class for the transactions that it is servicing (server-specific weights). This additional granularity enables the distributor to balance the workload more effectively.

Server-specific WLM recommendations can also be used by a stack to more evenly balance workload across a group of servers sharing the same port in a single system by specifying SHAREPORTWLM (instead of just SHAREPORT) on the PORT statement in the TCP/IP profile. When using this option, connections are distributed in a weighted round-robin fashion based on the WLM server-specific recommendations for the server running on that system. The workload distribution methods are as follows:

- Server-specific WLM method
- BASEWLM method
- WEIGHTEDActive method
- ROUNDROBIN method
- HOTSTANDBY method

Server-specific WLM method

WLM can assign a weight based on how well the *server* (application) is meeting the goal of its service class and the displaceable capacity for the new work in relation to the actual used service. The displaceable capacity is based on the importance level of its service class for the work that is to be executed.

To use the server-specific WLM method, specify the SERVERWLM parameter on the VIPADISTRIBUTE statement. Also, the IPCONFIG SYSPLEXROUTING parameter is required.

Figure 5-4 on page 134 illustrates the server-specific WLM distribution method.

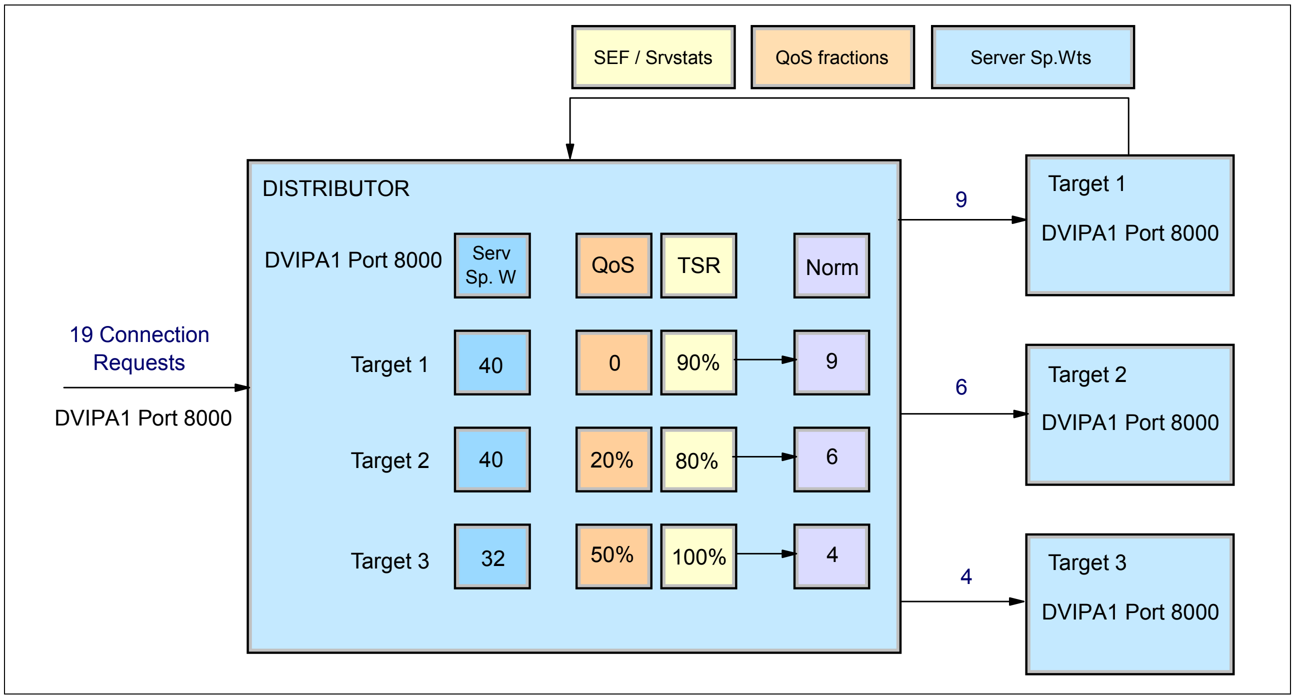


Figure 5-4 Server-specific WLM

In this example, a *server-specific* weight is received for each of the targets for DVIPA1, port 8000. The weights for target 1, target 2, and target 3 are calculated as shown in Table 5-1.

Table 5-1 Server-specific WLM weight calculation

Target	Server-specific weight * QOS * TSR	Normalized weight
Target 1	36 = (40 - (40 * 0%)) * 90%	9
Target 2	25 = (40 - (40 * 20%)) * 80%	6
Target 3	16 = (32 - (32 * 50%)) * 100%	4

WLM depends on the server receiving work to change server weights. Even if a server weight is zero (0), a connection request is forwarded infrequently to that server to generate new WLM values.

In our example, if 19 connections arrive for DVIPA1, port 8000 based on the QoS-modified WLM weights for this DVIPA, port, and service level, then nine connections are distributed to target 1, six connections are distributed to target 2, and four connections are distributed to target 3.

Note the following differences between the BASEWLM and SERVERWLM methods:

- BASEWLM uses the total available system capacity as the base for the weight, while SERVERWLM uses the capacity relative to the importance level of the specific workload that the server is running.
- SERVERWLM bases its calculation on the goal achievement of the work that the server is executing.
- SERVERWLM includes server health and abnormal termination information from WLM to mitigate the *storm drain issue* (see “Local connection (1)” on page 241 for more information about the storm drain issue).

Note the following characteristics of SERVERWLM:

- WLM server recommendations can be used only if the sysplex distributor and all target stacks for a distributed DVIPA port are V1R7 or later. The distributing stack relies on receiving the WLM server recommendations from each target stack. The WLM system weight recommendations in prior releases are not comparable to the latest WLM server recommendations; therefore, if one of the target stacks is *not* z/OS V1R7 or later, then the BASEWLM distribution method must be used.
- The backup stack must be V1R7 or later so that, after a takeover, distribution continues to use the latest WLM server recommendations.
- If the distributor and target systems are z/OS V1R9 or later, the WLM recommendation is a composite weight based on the available and displaceable capacity of each processor type (general, zIIP, and zAAP), and the current utilization of each processor type by this application.
- If the distributor and target systems are z/OS V1R11 or later, the WLM server-specific recommendation can be adjusted by using the PROCXCOST and ILWEIGHTING parameters. PROCXCOST parameter specifies how aggressively WLM favors servers on systems with available zIIP and zAAP capacity over the servers on systems where work targeted for the specialty processors has instead run on the conventional processor. For more information, see the following sections:
  - "Including zAAP and zIIP for WLM weight calculation" on page 141
  - "Sysplex distributor using the zIIP and zAAP specialty engines"

  The ILWEIGHTING parameter influences how aggressively WLM favors servers on systems with displaceable capacity at lower importance levels over servers on systems with displaceable capacity at higher importance levels. For more information, se the following sections:
  - "Considering importance level option" on page 143
  - "Sysplex distributor using the zIIP and zAAP specialty engines" on page 174

BASEWLM method

BASEWLM provides capacity recommendations in the form of weights for each *system*. WLM assigns a relative weight to each system in the sysplex, with the highest weight going to the system with the most available CPU capacity. The weights are in the range of 0 - 64.

To use the BASEWLM method, specify BASEWLM parameter on the VIPADISTRIBUTE statement. Also, the IPCONFIG SYSPLEXROUTING parameter is required.

In the example in Figure 5-5 on page 136, the BASEWLM system weights of 15, 25, and 5 are returned by WLM for the targets for DVIPA1 port 8000. Then, a QoS level fraction is received from the target for each group of connections that map to a DVIPA/PORT for that service level. The QoS fraction percentage represents the performance of this group of connections, and is used to reduce the WLM weight.

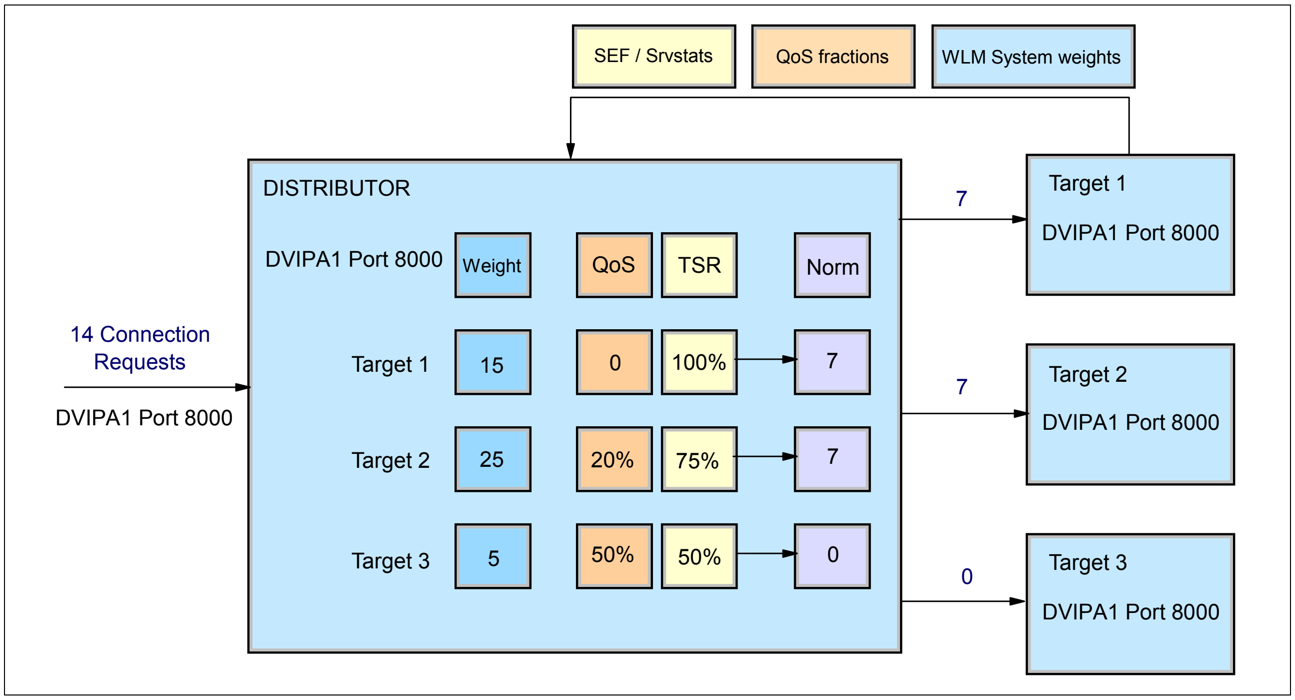


Figure 5-5 BASEWLM distribution method using QoS data

The weights are then *normalized* (reduced proportionally), if necessary, to keep the number of successive connections directed to any given target small. For example, the weights for target 1, target 2, and target 3 are calculated as shown in Table 5-2.

Table 5-2 BASEWLM weight calculations

	WLM weights	**QoS fractions**	**TSR fractions**	**QoS-modified weights**	**Normalized weights**
Target 1	15	0%	100	15 = (15 - (15 * 0%)) * 100%	7
Target 2	25	20%	75	15 = (25 - (25 * 20%)) * 75%	7
Target 3	5	50%	50	1.25 = (5 - (5 * 50%)) * 50%	0

Algorithm: The z/OS Communications Server uses the following normalization algorithm:

> If any system weight provided by WLM is greater than 16, then all weights are normalized by dividing by 4 (and ignoring any remainder) after applying QoS fractions.

However, this approach *might* be changed in future releases of z/OS Communications Server.

Continuing with our example, assume that 14 connection requests arrive for DVIPA1, port 8000. Based on the QoS-modified WLM weights for this DVIPA, port, and service level, seven connections are distributed to target 1, seven connections are distributed to target 2, and no connection is distributed to target 3.

Consider the following information for this process:

- The WLM weight is based on a comparison of the available capacity for new work on each system, not how well each server (application) is meeting the goals of its service class.
- If all systems are using close to 100% of capacity, the WLM weight is based on a comparison of displaceable capacity (the amount of lower importance work on each system). However, if the service class of the server is of low importance, it might not be able to displace this work.
- If a target stack or a server on the target stack is not responsive, new connection requests continue to be routed to the target. The stack might appear lightly loaded because applications are not processing any new work.
- QoS fractions monitor target or client performance but do not monitor the path to the target.
- WLM calculates the weight based on the general CPU availability. Optionally, you may include the zIIP and zAAP specialty engines for calculation, by specifying PROCTYPE parameter on the VIPADISTRIBUTE statement. To use this option, all the systems in the sysplex must be z/OS V1R9 or later. For details, see “Including zAAP and zIIP for WLM weight calculation” on page 141, and 5.3.6, “Sysplex distributor using the zIIP and zAAP specialty engines” on page 174.

Note: QoS fractions are available only if the Policy Agent is enabled on the sysplex distributor and all target systems and appropriate policies have been configured.

WEIGHTEDActive method

WEIGHTEDActive Distribution provides a more granular control over workload distribution based on predetermined active connection count proportions for each target (fixed weights). Weighted active connections provide granular control over workload distribution based on predetermined active connection count proportions for each target (fixed weights). Distribution of incoming TCP connection requests is balanced across the targets so that the number of active connections on each target is proportionally equivalent to a configured active connection weight for each target.

The configured weight is used with other indicators to achieve the real connection weight on each target. These indicators are the server-specific abnormal completion information, the general health indicator, and the TSR value. These values are used to reduce the active connection weight when these indicators are not optimal. If weighted active connections are used, study and determine the comparative workload that you want on each system so that you can configure appropriate connection weights.

If weighted active connections are configured with default proportions for each target, connections are evenly distributed across all target servers; the goal is to have an equal number of active connections on each server. This is similar to the round-robin distribution method; the difference is that round-robin distribution distributes connections evenly to all target servers without consideration for the active number of connections on each server. Round-robin distribution bypasses a target if the TSR value is 0. For weighted active forwarding, the TSR value and application health indicators are be used to reduce the active connection weight.

This distribution method is not influenced by the number of server instances that are active on a target TCP/IP stack instance and listening on the same port (SHAREPORT parameter specified on the PORT reservation statement). For example, when two target TCP/IP stacks are configured with the same active connection weight, if one of the targets has multiple active servers for that port and the other target has only one instance of that server active, both stacks initially receive the same number of connection requests.

To use WEIGHTEDActive method, specify WEIGHTEDACTIVE parameter on the VIPADISTRIBUTE statement. Also, IPCONFIG SYSPLEXROUTING parameter is required.

WEIGHTEDActive distribution provides more granular control over workload distribution, as shown in Figure 5-6.

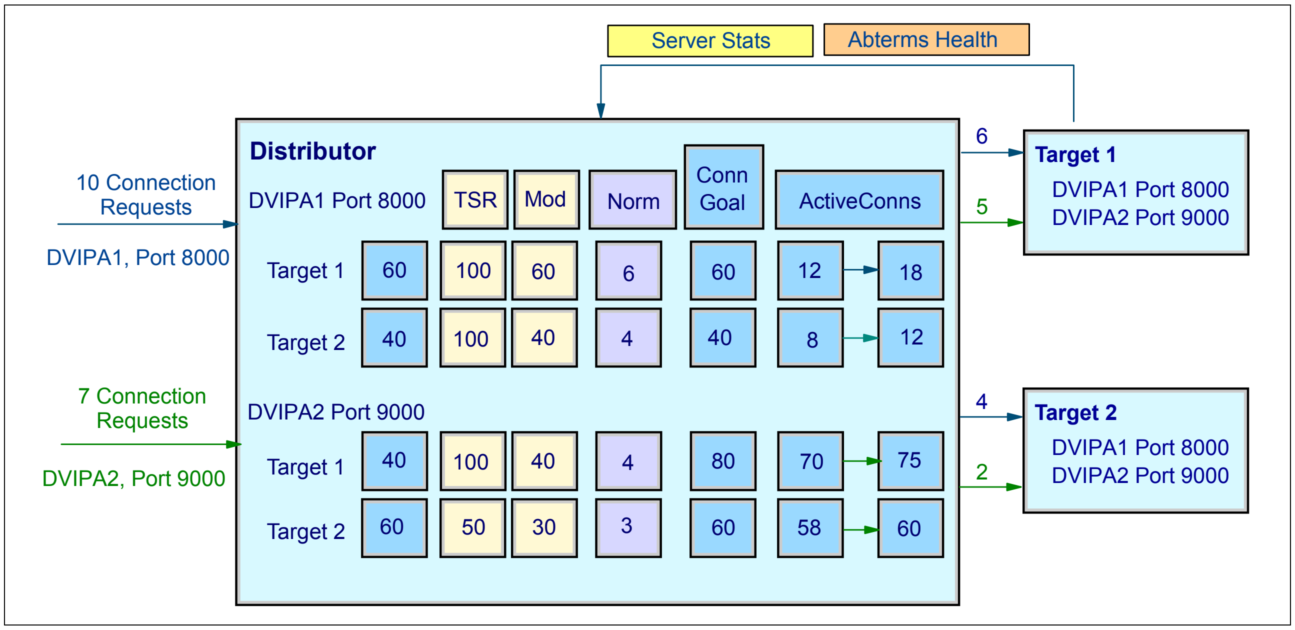


Figure 5-6 WEIGHTEDActive distribution

This distribution is as follows:

- The comparative workload that is desired on each system must be understood so that appropriate connection weights can be configured (fixed weights). Looking at DVIPA2 Port 9000:
  - 40% of the workload is configured to go to Target 1.
  - 60% of the workload is configured to go to Target 2.
- TSR values and Health metrics (Abterms, Health) are applied to create a modified weight.

  In the example, the TSR of 50% results in a modified weight of 30 for Target 2. (Health Metrics are not shown in this example.)
- Active connection count goals are determined based on the modified connection weights and the active connections on each target (multiple of modified weight > active connections).

  In the example, Target 2’s modified weight is 30. The connection goal is 60 (a multiple of 30 and greater than 58). Target 1’s weight must be 80 so that the proportions remain the same. New connection goals are determined when the active connection counts for all targets equals the connection goals
- The modified weights are normalized or reduced by dividing by 10.
- Distribution is still weighted round-robin based on the normalized weight, but a target is skipped if a connection goal is reached.

Because 10 connection requests are received for DVIPA 1 port 8000, six are routed to Target 1, and four are routed to Target 2.

Because seven connection requests are received for DVIPA 2 port 9000, only two requests (instead of three) are routed to Target 2 because the connection goal of 60 is reached. Thus, the other five connection requests are routed to Target 1.

Consider using weighted active connections (WEIGHTEDActive) in the following cases:

- Application scaling concerns

  Target systems vary significantly in terms of capacity (small systems and larger systems). WLM recommendations might favor the larger systems significantly. However, a target application might not scale well to larger systems; because of its design, it might not be able to take full advantage of the additional CPU capacity on the larger systems. This can result in these types of servers getting inflated WLM recommendations when running on larger systems, and getting overloaded with work.

- Unequal number of SHAREPORT servers

  If SHAREPORT is being used, but not all systems have the same number of SHAREPORT server instances (for example, one system has two instances and the other has three). The current round-robin or WLM recommendations do not change distribution based on the number of server instances on each target. The round-robin distribution distributes one connection per target stack regardless of the number of SHAREPORT server instances on that stack. WLM server-specific weights from a target stack with multiple server instances reflect the average weight.

- Controlling the amount of capacity that specific workloads can consume on each system

  For example, you might need to reserve some capacity on certain systems for batch workloads that are added into selected systems during specific time periods and have specific time window completion requirements. If those systems are also a target for long-running distributed DVIPA connections, WLM recommendations allow that available capacity to be consumed. This situation can potentially impact the completion times of the batch jobs when they begin to run, if they are not able to displace the existing non-batch workloads. Similarly, the existing connections on that system can experience performance problems if the batch jobs displace those workloads.

ROUNDROBIN method

The round-robin method distributes connections evenly across all target servers, without consideration for the capacity of each target system or the number of currently active connections on each server. Round-robin method does not use WLM recommendations.

To use the round-robin method, specify ROUNDROBIN on a VIPADISTRIBUTE statement.

HOTSTANDBY method

In certain situations, you might need to provide high availability, but do not want to distribute the incoming connections. There are cases where data sharing between multiple server applications and LPARs is required for availability, but it is more efficient if the work runs on one LPAR instead of interlocking access to the same data across multiple LPARs. For these situations, you can use the hot standby distribution method.

When this method of distribution is defined, the distributing stack does not perform load balancing of new connection requests across multiple targets. Instead, the defined preferred target server with an active listener receives all new incoming connection requests; hot standby target servers, which must also have a ready listener application, do not receive any new connection requests.

The hot standby servers act as backup servers if the designated server becomes unavailable or unhealthy. You can rank the hot standby servers to control which will become the active server.

We can also define whether the sysplex distributor automatically switches back to using the preferred server if it becomes available, and whether the distributor automatically switches servers if the active target is not healthy.

Restriction: The sysplex distributor must be V1R12 or later and the TCP/IP target stacks must be V1R10 or later.

A target is considered unavailable if any of the following situations is true:

- The target is not ready.
- The distributor does not have an active route to the target.
- The target is not healthy.

To use the hot standby method, specify HOTSTANDBY on a VIPADISTRIBUTE statement.

Figure 5-7 presents a sysplex distributed implementation where three Telnet servers are used. TN3270B is the preferred server and TN3270A and TN3270C are the backup servers.

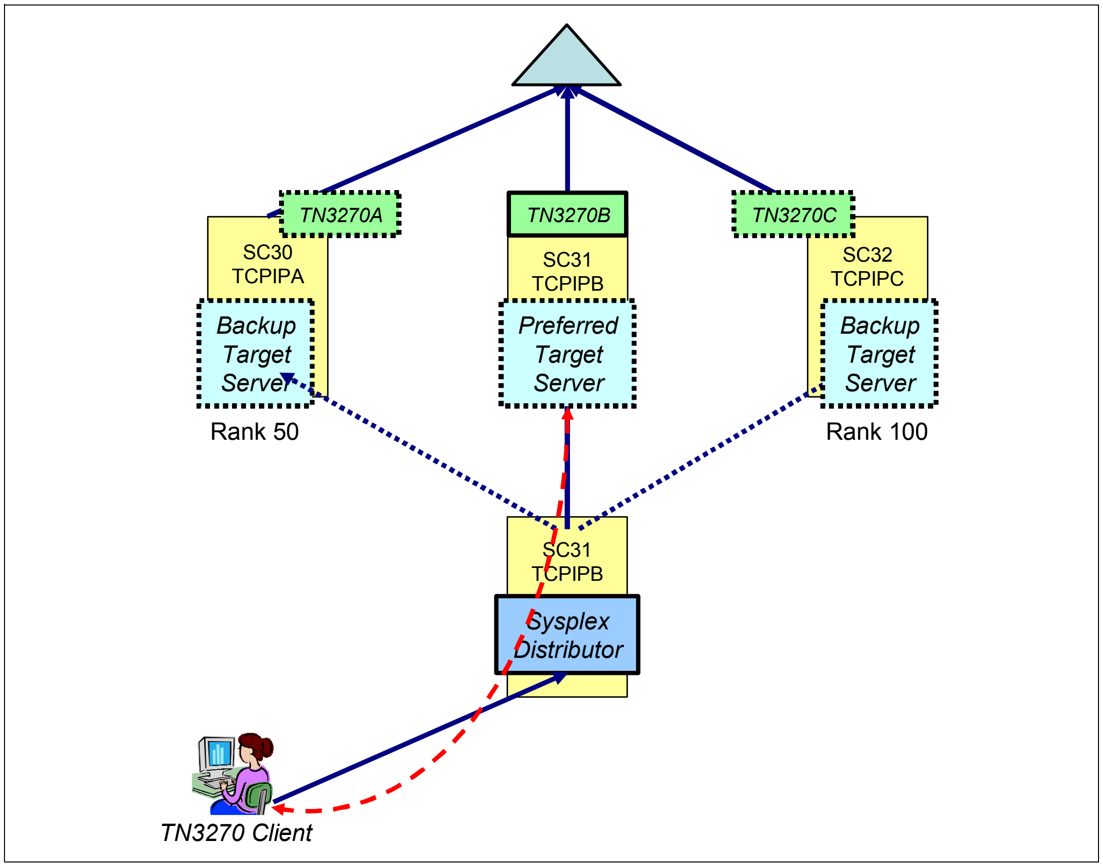


Figure 5-7 Sysplex distributor HOTSTANDBY method (Part 1)

In this scenario, all connections will be directed to TN3270B and the other active servers are not used.

If the preferred server has a problem or it becomes unhealthy, new connection requests are then redirected to one of the backup servers, based on rank definition. In our case, this server is TN3270C, as shown in Figure 5-8.

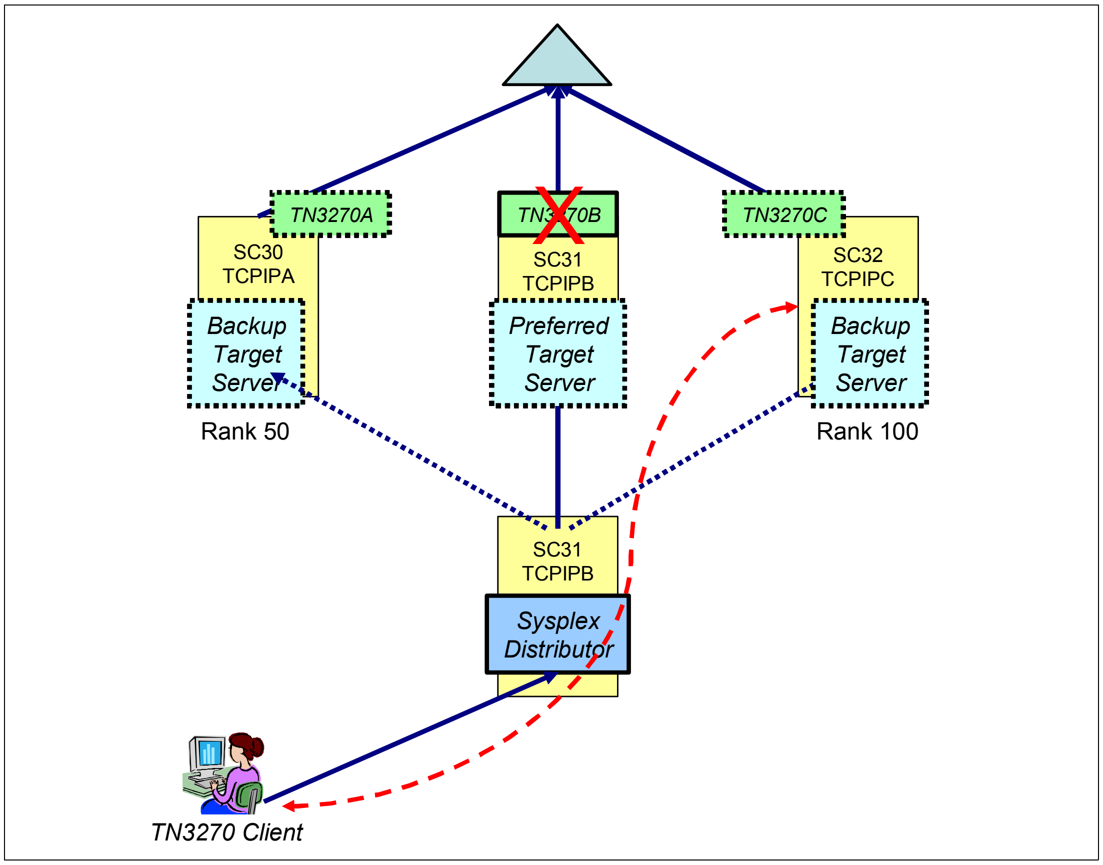


Figure 5-8 Sysplex distributor HOTSTANDBY method (Part 2)

For further information about how to implement sysplex distributor with the HOTSTANDBY method, see 5.3.6, “Sysplex distributor using the zIIP and zAAP specialty engines” on page 174.

5.2.5 Optimizing for sysplex distributor

There are a number of ways that you can affect how the sysplex distributor will route connections and balance the workload

Including zAAP and zIIP for WLM weight calculation

The IBM System z platform introduced specialty processors that can be deployed and used by qualified workloads on z/OS. Support is included for the following processors:

- System z Application Assist Processor (zAAP)

  These processors can be used for Java application workloads on z/OS (including workloads running under z/OS WebSphere Application Server).

- System z Integrated Information Processor (zIIP)

  These processors can be used by qualified z/OS DB2-related workloads and IPSec processing.

When the sysplex distributor routes incoming connections based on Workload Manager (WLM) system weights, it returns raw central processor (CP), zAAP, and zIIP weights, considering the available zAAP CPU capacity, the available zIIP CPU capacity, or both. In this case, sysplex distributor uses a composite WLM weight that is based on a comparison of displaceable capacity for each processor type, given the importance level and goals of the target servers' service class. WLM returns proportional weights based on the actual usage pattern of the targeted servers for each processor type.

If you need to consider zAAP and zIIP CPU capacity, evaluate whether you can use SERVERWLM distribution as an alternative to BASEWLM distribution for this application:

- SERVERWLM distribution has the advantage that processor proportions are automatically determined and dynamically updated by WLM based on the actual CPU usage of the application.
- BASEWLM distribution for the processor proportions is determined by studying the workload usage of the assist processors (zAAPs and zIIPs). This can be done by analyzing SMF records and using performance monitors reports such as IBM RMF™.

WLM recommendations consider the *cost* of specialty versus conventional processors or zAAp and zIIP processors versus general CPs. Server WLM uses server-specific weights that are based in part on a comparison of displaceable capacity that is available for each processor type, reduced by the actual percentage used of each processor. On previous releases, the *crossover cost*, that is, the cost of running zIIP or zAAP intended workloads on the general CP, is not considered.

The solution is to implement a crossover cost parameter, PROCXCOST, on the VIPADISTribute statement. The crossover cost is used to penalize service units that run on the CP instead of the specialty processor. The crossover cost range is between 1 (no crossover penalty) and 100 (heavy crossover penalty).

This configuration parameter can be used to cause WLM to direct more workload targeted for zIIP or zAAP specialty processors to systems that have these more affordable processor cycles available, reducing the overall cost of running those workloads. Similarly, the configuration parameter directs workload that does not require zIIP or zAAP specialty processors to systems with the least amount of zIIP or zAAP processing crossover.

To use zAAP and zIIP with the BASEWLM method, specify PROCTYPE on the VIPADISTRIBUTE statement. To use zAAP and zIIP with SERVERWLM method, specify PROCXCOST on VIPADISTRIBUTE statement.

Note: A high crossover cost can cause systems that have constrained specialty processor service units to receive a significantly lower percentage of the overall workload. This lower percentage can have an adverse effect on performance. Run the RMF Workload Activity Report before and after changing this parameter to understand how this change can affect performance.

This support is based on the METHOD=EQUICPU function in the IWM4SRSC WLM service.

Restriction: These composite weights are returned by WLM only if all systems in the sysplex are V1R11 or later, regardless of whether the systems participate in workload distribution or whether systems are members of separate subplexes.

In a mixed-release environment, CP weights are used only to determine the WLM System or server-specific weight because there is no information available about zAAP and zIIP capacity from older releases.

To make use of the solution that is implemented by the PROCXCOST parameter on the VIPADISTribute statement, all systems must be running on V1R11.

Load Balancing Advisor (LBA) considers zAAP and zIIP weight recommendations for server members but not system members. WLM recommendations for system members consider only CP capacity.

Considering importance level option

WLM supports a method to calculate relative weights of the target servers to which sysplex distributor distributes incoming connections. WLM considers the relative importance of existing work that is displaced on each target as new work is distributed. Target systems with more lower importance displaceable work are favored over systems with higher importance displaceable work. The ILWEIGHTING parameter is configured on a VIPADISTRIBUTE statement.

The ILWEIGHTING parameter value indicates how aggressively WLM should favor systems with displaceable capacity at low importance levels over systems with displaceable capacity at high importance levels. The higher the value specified for ILWEIGHTING, the more a stack with displaceable capacity at lower importance levels is favored.

The following importance level (IL) weighting factors are supported:

IL 0 Ignore importance levels when comparing system displaceable capacity, which is the default.

IL 1 Moderate. Specifies that WLM weigh displaceable capacity at each successively lower importance level slightly higher than the capacity at the preceding higher importance level. Adjusts the service units by the square root of the importance level difference of the new work and the Displaceable Service Units + 1.

IL 2 Aggressive. Specifies that WLM weigh displaceable capacity at each successively lower importance level significantly higher than the capacity at the preceding higher importance level. Adjusts the service units by the importance level difference of the new work and the Displaceable Service Units + 1.

IL 3 Exceptionally Aggressive. Adjusts the service units by the square of the importance level difference of the new work and the Displaceable Service Units + 1.

Consider the following notes:

- This parameter is available only for the SERVERWLM distribution method with METHOD=EQUICPU.
- It can be useful in environments where the target system workload mix varies significantly.
- The impact can be larger when LPARs differ significantly in their capacities.
- Some level of differentiation of the importance levels is generally desirable.
- The levels that can be specified are 0 (not used), 1 (moderate), 2 (aggressive), and 3 (very aggressive). Start with the moderate level of 1 and then increase gradually if you find that the result is beneficial.

Performance: Using an IL value of 2 or greater can cause systems with comparatively higher importance displaceable workloads to receive a significantly lower percentage of the new workload, which can have an adverse effect on performance. As a guideline, use a Moderate (IL 1) value initially. Run the RMF Workload Activity Report before and after a change to understand how this setting affects performance.

WLM polling interval

The timings used in TCP/IP and WLM can influence the behavior of workload balancing by the sysplex distributor. Using the default settings, the TCP/IP stacks poll WLM every 60 seconds for weight information as follows:

- For BASEWLM, the distributor polls WLM for *system* weights.
- For SERVERWLM, each target polls WLM for *server-specific* weights.

WLM calculates new weights as follows:

- Calculates based on a comparison of the last 10 seconds of CPU utilization on registered sysplex systems or servers.
- Maintains a 3-minute rolling average of these calculations. The 3-minute rolling average is used to smooth the result.
- The average is returned by WLM in response to the request from the TCP/IP stack.

The default TCP/IP polling interval assumes weights do not change significantly from minute to minute, which is not always true, especially with many short living connections or high CPU utilization. Therefore, you can change the WLM polling interval using the SYSPLEXWLMPOLL option on the GLOBALCONFIG parameter in the TCP/IP profile.

Keep in mind that WLM makes its policy adjustment calculations every 10 seconds. Therefore, you should not specify the value too small. In addition, because it is a global parameter, it influences all specified sysplex distributors that operate on the stack.

For detailed information about the WLM services used, see *z/OS MVS Programming: Workload management services*, SA22-7619.

Sysplex-wide source VIPA

Sysplex distributor provides a single image to the clients outside the sysplex, using a single IP address for inbound TCP connection requests. The applications within the sysplex might need to initiate an outbound TCP connection to the clients. If each application uses a separate source IP address for outbound connections, it might not appear as a single image to other hosts. The use of a distributed DVIPA as the source IP address for outbound TCP connections solves this problem, but it needs special caution.

Because all stacks in the sysplex distributor environment share the distributed DVIPA as the source IP address, they must collaborate with each other to avoid the use of the same ephemeral port numbers. This way ensures the connection 4-tuples (combination of source and destination IP addresses and ports) are not duplicated. This function is provided by SYSPLEXPORTS, in conjunction with either job-specific source IP addressing or sysplex-wide source VIPAs for TCP connections.

For more details, see *z/OS Communications Server: IP Configuration Guide*, SC27-3650.

Timed affinities

The Sysplex distributor normally distributes each connection request as it arrives at one of the candidate server instances, based on available capacity and policies in effect when the connection request arrives. In particular, each connection is assumed to be independent of all other existing and future connections, with respect to the server instance that will receive the incoming connection request.

Certain applications, however, establish an affinity between a client and a particular server instance that needs to span multiple connections. For example, web-based applications, such as shopping carts, might need to have all connections from a particular client come to the server instance that has the contents of the shopping cart stored as session state.

The TIMEDAFFINITY parameter on the VIPADISTRIBUTE statement indicates to sysplex distributor that connections to a particular distributed DVIPA need to take into account the client origin. Connections from the same client, as identified by IP address, must be routed to the same server instance, even when multiple server instances are hosted by a single target stack.

For more details, see *z/OS Communications Server: IP Configuration Guide*, SC27-3650.

5.2.6 Optimized routing

z/OS Communications Server provides several options for optimized routing in the sysplex distributor environment.

Using non-dynamic XCF link with VIPAROUTE option

To optimize the traffic forwarding with sysplex distributor, the following routes are selected automatically by z/OS Communications Server without any specific configuration.

What is used from the distributing stack's point of view:

- If the target server is within the same z/OS image, IUTSAMEH is used.
- If the target server is within the same CPC, HiperSockets is used (if available).

If the target server is not within the same CPC, then a dynamic XCF link is used (a dynamic XCF link definition is required). However, z/OS Communications Server V1R7 introduced the VIPAROUTE option, which enables traffic forwarding from the distributing stack to the target stack with any IP devices, such as OSA-Express, instead of dynamic XCF.

The advantages of this function are as follows:

- It improves performance by using fast, high-bandwidth connectivity such as OSA-Express.
- It helps to relieve the CPU constraints of the dynamic XCF and leaves room for other important sysplex data sharing traffic.

When a connection from the client is processed by sysplex distributor, it determines whether a matching VIPAROUTE statement has been specified. If it has, the best available route is determined by using the normal IP routing tables. If no matching VIPAROUTE statement exists for that target, the sysplex distributor uses Dynamic XCF interfaces.

When a VIPAROUTE statement is in effect, the packet is encapsulated using generic routing encapsulation (GRE) prior to being forwarded. This encapsulation enables the packet to be forwarded through the network to the target stack while preserving the original packet's destination IP address (that is, the DVIPA address).

The GRE encapsulation process increases the size of the forwarded packet by 28 bytes. As a result, if the size of the encapsulated GRE packets is larger than the maximum transmission unit (MTU) of the network interface that is used for forwarding the packet, the TCP/IP stack might have to perform fragmentation or send ICMP path-MTU messages, depending on whether the connection partner is performing path MTU discovery. The target stack then reassembles the fragmented packets.

The first parameter of the VIPAROUTE statement specifies the Dynamic XCF address of the target stack. The second parameter specifies any fully qualified IP address in the HOME list of the target server (preferably a static VIPA address so that interface failures do not affect the availability of the target stack). This usage is shown in the following example:

```
VIPADISTRIBUTE DEFINE 10.1.8.10 PORT 23 DESTIP ALL
VIPAROUTE DEFINE 10.1.7.21 10.1.1.20
```

Tip: Define the dynamic XCF network with a rather high routing cost so it is not used for normal IP routing unless it is the only available interface (or define it as a non-OSPF interface so that it is not used for distributed DVIPA routing at all).

Figure 5-9 illustrates the use of DVIPA IP forwarding using OSA-Express adapters.

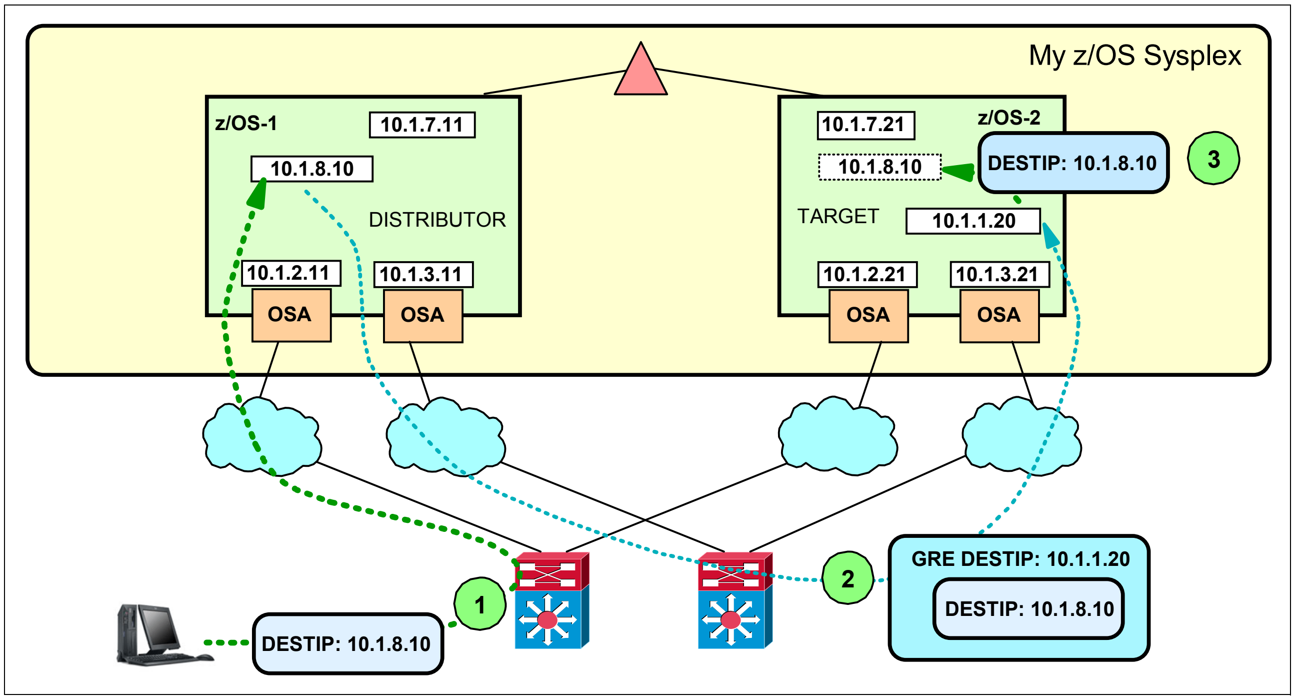


Figure 5-9 Intra-sysplex IP communication using OSA-Express instead of DynamicXCF

Restrictions

The following restrictions apply:

- Internal indicators, which are requested using the SO_CLUSTERCONNTYPE option of the GETSOCKOPT API and used to determine if the partner application is running in the same system or in the same sysplex, are no longer set if the destination IP address is a Dynamic VIPA or distributed Dynamic VIPA residing in the sysplex. The reason for this change is that traffic destined to these IP addresses can now be forwarded to the target TCP/IP stacks over links or interfaces that are external to the sysplex.
- You must still configure the dynamic XCF address when using VIPAROUTE support because the sysplex distributor still uses dynamic XCF addresses to identify target TCP/IP stacks in the sysplex. In addition, several functions continue to depend on dynamic XCF connectivity for intra-sysplex communications:
  - Sysplex-Wide Security Associations (SWSA)
  - Multi-level security (MLS) packets
  - Quality of service (QoS) performance data collection of Policy Agent

Sysplex distributor connection routing accelerator

With sysplex distributor, the distributor stack receives packets and forwards them to a target stack. QDIO Accelerator can provide accelerated forwarding of packets that sysplex distributor forwards to a target stack when the packets are flowing over one of the following inbound and outbound data link control (DLC) combinations:

- Inbound packets that are routed over HiperSockets and that are forwarded outbound over OSA-Express QDIO or HiperSockets
- Inbound packets that are routed over OSA-Express QDIO and that are being forwarded outbound over OSA-Express QDIO or HiperSockets

Figure 5-10 shows sysplex distributor forwarding with QDIO Accelerator.

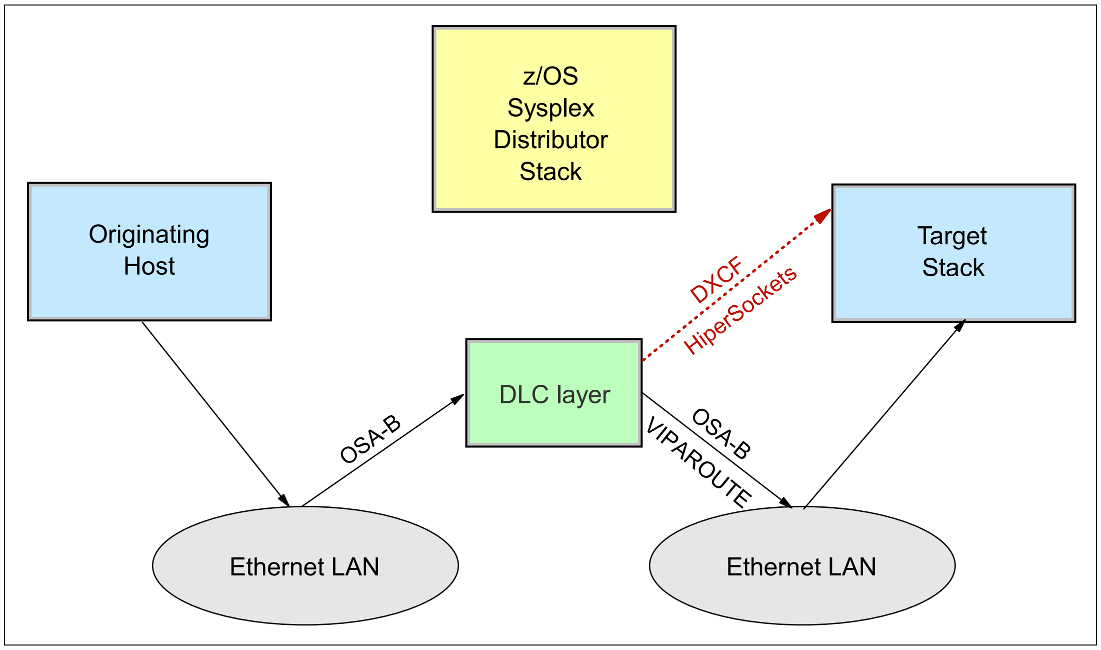


Figure 5-10 Sysplex distributor forwarding with QDIO Accelerator

In this figure, sysplex distributor is using a VIPAROUTE over an OSA-Express QDIO interface to get to the target stack (as shown by the solid arrows). Elements of the IP routing table are "pushed" into the DLC layer. This function enables the DLC layer to make routing decisions between the supported interfaces without passing IP packets up through the IP layer, thus consuming fewer processor resources and providing lower latency while routing the packets.

This function also provides sysplex distributor acceleration when the sysplex distributor reaches the target stack using the Dynamic XCF connectivity over HiperSockets (as shown by the dotted arrow). In addition, although the figure shows inbound OSA-Express QDIO, the sysplex distributor acceleration function also applies to data that is received inbound over HiperSockets.

To enable QDIO Accelerator, configure QDIOACCELERATOR on the IPCONFIG statement in the TCPIP profile, as shown in Example 5-2. This parameter is mutually exclusive with IQDIOROUTING. You can turn these accelerator functions off and on by using the **VARY TCPIP,,OBEYFILE** command, but you cannot enable either accelerator function unless one was configured in the initial profile.

Example 5-2 Routing accelerator option on TCPIP profile

```
IPCONFIG DATAGRAMFWD SYSPLEXROUTING QDIOACCELERATOR
```

When the QDIOACCELERATOR function is enabled, qualified traffic takes advantage of the improved path. The TCP/IP stack keeps track of the QDIO Accelerator routing information in a routing table that is a subset of the stack's own routing table. You can display this routing table using the **NETSTAT ROUTE QDIOACCEL** command. Note that this routing table does not include sysplex distributor routing information. You can display which sysplex distributor connections are using QDIO Accelerator using the NETSTAT VCRT report.

Table 5-3 shows the types of tasks and information that are available for operating with the QDIOACCELERATOR function.

Table 5-3 QDIOACCELERATOR tasks

Task	Procedure
Enable the QDIO Accelerator function to provide accelerated forwarding of packets.	Specify the QDIOACCELERATOR parameter on the IPCONFIG statement in the TCP/IP profile.
Display whether QDIO Accelerator is enabled.	Issue the **NETSTAT CONFIG/-f** command.
Display the routing table that has been pushed into the DLC layer.	Issue the **NETSTAT ROUTE QDIOACCEL** command.
Display whether a sysplex distributor connection is eligible for acceleration.	Issue the **NETSTAT VCRT/-V** command with the DETAIL parameter.
Display information about the number of packets and bytes that are accelerated after being received over a specific interface.	Initiate VTAM tuning statistics for the OSA-Express QDIO or HiperSockets interface.
View information similar to packet trace for packets that are accelerated either from or to an OSA-Express QDIO interface.	Use the OSAENTA function.

The following restrictions apply to this function:

- QDIOACCELERATOR is mutually exclusive with IPSECURITY; it cannot be enabled if IPSECURITY is enabled.
- The function applies only to IPv4.
- This function provides acceleration for VIPAROUTE over OSA, but not VIPAROUTE over HiperSockets, because of differences in how acceleration works over HiperSockets compared to OSA-Express QDIO.
- If the traffic that is forwarded requires fragmentation based on the MTU of the outbound route, then those packets are not accelerated but instead are forwarded by the stack.
- Incoming fragments for a sysplex distributor connection are not accelerated but instead sent to the stack, because the sysplex distributor requires the fragments to be reassembled before forwarding can occur. Similarly, the distributor stack needs to process SYN packets to select a target stack, so SYN packets for sysplex distributor are not accelerated.

Acceleration is not allowed to or from interfaces that use optimized latency mode (OLM). For more information, see *IBM z/OS V2R1 Communications Server TCP/IP Implementation Volume 1: Base Functions, Connectivity, and Routing*, SG24-8096.

Improved convergence for Sysplex Distribution routing

The VIPAROUTE optimized sysplex distributor routing function allowing the distribution of sysplex distributor traffic over other interfaces than dynamic XCF.

VIPAROUTE maintains a target cache for target routes, which is refreshed every 60 seconds. However, during a takeover situation, network traffic can be slowed or even disrupted until the target cache is refreshed.

To avoid slowdowns or disruptions, z/OS Communications Server changes the cache refresh interval when joining or rejoining the sysplex, and when OMPROUTE is restarted. During a takeover that occurs because the primary routing stack is restarted, a route is unavailable until its interface finishes activating. This function uses an interval pattern of 5, 5, 15, 35, and 60 seconds to allow for faster convergence of the target routes.

The VIPAROUTE target cache is now refreshed at smaller intervals after the following operations happen:

- Joining the sysplex group at TCP/IP initialization
- Rejoining the sysplex group
- Restarting of OMPROUTE

This function is automatically enabled with no need to configure anything else.

5.3 Sysplex distributor examples

This section contains the following scenarios, which demonstrate sysplex distributor usage:

- Sysplex distributor using the server-specific WLM method
- Sysplex distributor using the BASEWLM method
- Sysplex distributor using the WEIGHTEDActive method
- Sysplex distributor using the round-robin method
- Sysplex distributor using the hot standby method
- Sysplex distributor using the zIIP and zAAP specialty engines

5.3.1 Sysplex distributor using the server-specific WLM method

Server-specific Workload Manager (WLM) controls for load balancing is a Sysplex Distribution feature in z/OS.

Figure 5-11 illustrates how incoming TN3270 connections are load balanced using server-specific WLM weights.

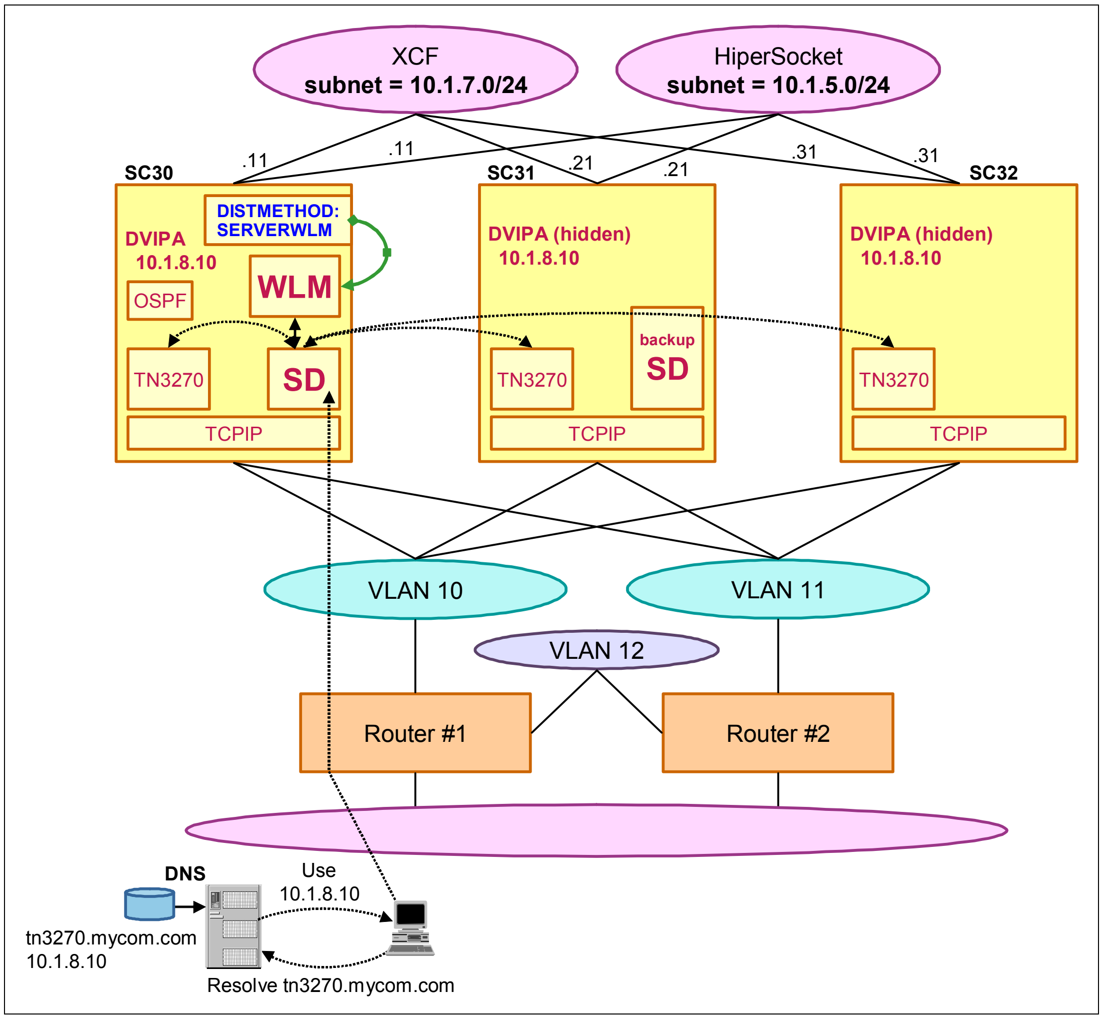


Figure 5-11 Server-specific WLM Workload balancing of TN3270 connections

Implementing the server-specific WLM method

To implement the sysplex distributor function, you must define a matching set of VIPADEFINE, VIPABACKUP, and VIPADISTRIBUTE statements. The TCP/IP configuration required is minimal compared to other dispatching mechanisms. For the most part, the standard sysplex environment enables the dynamic establishment of links and the dynamic coordination between stacks in the cluster.

The following specific implementation tasks are involved:

- Choose which IP stack executes the sysplex distributor distributing function. We chose LPAR SC30.
- Select which IP stack will be the backup stack for the sysplex distributor stack, and in which order. We selected SC31 to be the first backup and SC32 to be second backup.

- Ensure that the WLM GOAL mode is enabled in all the LPARs participating in the sysplex distributor. We use the **`D WLM,SYSTEMS`** command to ensure that all the LPARs participating in the sysplex distributor are running in GOAL mode.
- Enable sysplex routing in all the IP stacks participating in the sysplex distributor using the SYSPLEXROUTING statement.
- For IP stacks that are active under a multistack environment, the SAMEHOST links must be created dynamically. In general, code DYNAMICXCF in all the IP stacks participating in the sysplex distributor.

Note: For sysplex distributor, you cannot specify the XCF address using the IUTSAMEH DEVICE, LINK, and HOME statements. XCF addresses must be allowed to be dynamically created by coding the IPCONFIG DYNAMICXCF statement.

- Select, by port numbers, the applications that are to be managed by the sysplex distributor function. Note that if the application chosen requires data and control ports (like FTP), then both ports must be considered. We select port 23 to distribute TN3270 services.
- Code the VIPADYNAMIC/ENDVIPADYNAMIC block for the distributing IP stack.
- Define the dynamic VIPA for the distributing IP stack with the VIPADEFINE statement. We select 10.1.8.10 as the port address.
- Associate the sysplex Dynamic VIPA with the application's port number by using the VIPADISTRIBUTE statement.
- Code the VIPADYNAMIC/ENDVIPADYNAMIC block for the distributor's backup IP stack.
- Define the IP stack as backup for the sysplex DVIPA address with the VIPABACKUP statement. We define SC31 and SC32 to be the VIPABACKUP.

Configuring the server-specific WLM method

Example 5-3 shows the most important parameters of our TCP/IP profile that we need to define to enable the distribution of TN3270 connections.

Example 5-3 Profile TCPIPA SC30 sysplex distributor

```
IPCONFIG NODATAGRAMFWD SYSPLEXROUTING                  3
IPCONFIG SOURCEVIPA
IPCONFIG MULTIPATH PERCONNECTION
DYNAMICXCF 10.1.7.11 255.255.255.0 8
VIPADynamic
 VIPADEFine MOVEable IMMEDiate 255.255.255.0 10.1.8.10 1
 VIPADISTribute DISTMethod SERVERWLM 10.1.8.10 2
  PORT 23 DESTIP 10.1.7.11 10.1.7.21 10.1.7.31
 VIPAROUTE 10.1.7.11 10.1.1.10 4
 VIPAROUTE 10.1.7.21 10.1.1.20 4
 VIPAROUTE 10.1.7.31 10.1.1.30 4
ENDVIPADYNAMIC
```

This profile has the following important considerations:

1. We use the IP address 10.1.8.10 as DVIPA for the TN3270 servers.

2. We specify the VIPADIStribute parameter DISTMethod SERVERWLM.

3. We code IPCONFIG SYSPLEXROUTING to enable SERVERWLM method.

4. We define three VIPAROUTE statements, each pointing to one of our target systems.

> **Note:** VIPAROUTE allows us to relieve our XCF infrastructure by using any available IP interface for sysplex distributor-related forwarding traffic.

The relevant PROFILE statements for SC31 and SC32 are shown in Example 5-4 and Example 5-5. These statements define SC31 and SC32 to act as backup sysplex distributor in case the primary sysplex distributor on SC30 fails. Example 5-4 shows the SC31 target and backup.

Example 5-4 Profile TCPIPB SC31 target and backup

```
IPCONFIG NODATAGRAMFWD SYSPLEXROUTING
IPCONFIG SOURCEVIPA
DYNAMICXCF 10.1.7.21 255.255.255.0
VIPADynamic
 VIPABACKUP 100 MOVEABLE IMMEDIATE 255.255.255.0 10.1.8.10 1
ENDVIPADynamic
```

Example 5-5 shows the SC32 target and backup.

Example 5-5 Profile TCPIPC SC32 target and backup

```
IPCONFIG NODATAGRAMFWD SYSPLEXROUTING
IPCONFIG SOURCEVIPA
DYNAMICXCF 10.1.7.31 255.255.255.0
 VIPADynamic
 VIPABACKUP 90 MOVEABLE IMMEDIATE 255.255.255.0 10.1.8.10 2
 ENDVIPADynamic
```

The example has the following important points:

1. If the sysplex distributor on SC30 fails, SC31 takes over as the first backup distributor.

2. If the sysplex distributor on SC30 fails and SC31 is *not* active, SC32 takes over as the second backup distributor.

Verifying the server-specific WLM method implementation

We complete the following steps to verify that our implementation was correct:

1. Verification of the general Dynamic VIPA setup, including the backup sysplex distributor
2. Verification that server-specific WLM is set up correctly and is used
3. Verification that optimized routing using VIPAROUTE is set up correctly and is used

Step 1: Verification of general Dynamic VIPA setup

After of all IP stacks are active and running, we start our verification steps.

Issuing a **NETSTAT,VIPADCFG** command, as shown in Example 5-6, on our distribution stack (SC30) provides important information that helps us verify our sysplex distributor configuration.

Example 5-6 Display results of the VIPADCFG command issued on distribution stack SC30

```
D TCPIP,TCPIPA,N,VIPADCFG
EZD0101I NETSTAT CS V1R13 TCPIPA 363
DYNAMIC VIPA INFORMATION:
  VIPA DEFINE:
    IPADDR/PREFIXLEN: 10.1.8.10/24                        1
      MOVEABLE: IMMEDIATE  SRVMGR: NO  FLG:
  VIPA DISTRIBUTE:
    DEST:      10.1.8.10..23                            2 3
      DESTXCF: 10.1.7.11                                  4
      DISTMETHOD: SERVERWLM                               5
      SYSPT:   NO   TIMAFF: NO    FLG:
    DEST:      10.1.8.10..23
      DESTXCF: 10.1.7.21
      DISTMETHOD: SERVERWLM
      SYSPT:   NO   TIMAFF: NO    FLG:
    DEST:      10.1.8.10..23
      DESTXCF: 10.1.7.31
      DISTMETHOD: SERVERWLM
      SYSPT:   NO   TIMAFF: NO    FLG:
  VIPA ROUTE:                                             6
    DESTXCF:     10.1.7.11
      TARGETIP:  10.1.1.10
    DESTXCF:     10.1.7.21
      TARGETIP:  10.1.1.20
    DESTXCF:     10.1.7.31
      TARGETIP:  10.1.1.30
```

This example includes the following key information:

1. This is the DVIPA address representing the TN3270 servers.
2. TN3270 connections are being distributed by the sysplex distributor.
3. We use port number 23 for TN3270.
4. This is the XCF IP address assigned and used.
5. DISTMETHOD: SERVERWLM indicates that server-specific WLM is active and will be used.
6. VIPAROUTE indicates that we do not use XCF links, but use any available IP network interface for forwarding sysplex distributor-related packets. Three VIPAROUTE definitions point to the static VIPA in each of our stacks.

Example 5-7 shows the results of **VIPADCFG** commands for SC31 and SC32.

Example 5-7 Display results of the VIPADCFG command issued on SC31 and SC32

```
SC31
D TCPIP,TCPIPB,N,VIPADCFG
EZD0101I NETSTAT CS V1R13 TCPIPB 290
DYNAMIC VIPA INFORMATION:
  VIPA BACKUP:
    IPADDR/PREFIXLEN: 10.1.8.10
     1 RANK: 100  MOVEABLE:           SRVMGR:     FLG:

SC32
D TCPIP,TCPIPC,N,VIPADCFG
EZD0101I NETSTAT CS V1R13 TCPIPC 840
DYNAMIC VIPA INFORMATION:
  VIPA BACKUP:
    IPADDR/PREFIXLEN: 10.1.8.10
    2 RANK: 090  MOVEABLE:           SRVMGR:     FLG:
```

The output from our TCPIPB stack on SC31 shows that this stack is the primary backup (1) with rank 100. The output from the TCPIPC stack on SC32 shows that it is the secondary backup (2) with rank 90.

A **SYSPLEX,VIPADYN** command, as shown in Example 5-8, provides concise information about all stacks participating in the sysplex.

Example 5-8 Display of SYSPLEX,VIPADYN issued on distribution stack SC30

```
D TCPIP,TCPIPA,N,VIPADYN
EZD0101I NETSTAT CS V1R13 TCPIPA 431
DYNAMIC VIPA:
  IPADDR/PREFIXLEN: 10.1.8.10/24
    STATUS:  ACTIVE 1 ORIGIN: VIPADEFINE       DISTSTAT: DIST/DEST 3
    ACTTIME: 07/21/2011 00:55:03
VIPA ROUTE:
  DESTXCF: 10.1.7.11
    TARGETIP: 10.1.1.10
    RTSTATUS: DEFINED
  DESTXCF: 10.1.7.21
    TARGETIP: 10.1.1.20
    RTSTATUS: ACTIVE
  DESTXCF: 10.1.7.31
    TARGETIP: 10.1.1.30
    RTSTATUS: ACTIVE

D TCPIP,TCPIPA,SYSPLEX,VIPADYN
EZZ8260I SYSPLEX CS V1R13 433
VIPA DYNAMIC DISPLAY FROM TCPIPA   AT SC30
LINKNAME: VIPL0A01080A
IPADDR/PREFIXLEN: 10.1.8.10/24
  ORIGIN: VIPADEFINE
  TCPNAME  MVSNAME  STATUS  RANK DIST
  -------- -------- ------  ---- ----
  TCPIPA   SC30     ACTIVE1      BOTH3
  TCPIPB   SC31     BACKUP1 1002 DEST3
  TCPIPC   SC32     BACKUP1 0902 DEST3
```

This output shows the following important information:

1. Actual status of the TCP/IP stack.

2. The rank value, which determines the order on which a backup distributor will take over if the primary sysplex distributor fails.

3. This line indicates whether a stack is defined as the distributor, a destination, or both.

Issue **NETSTAT,HOME** commands on all stacks to obtain a list of all known IP addresses.

Example 5-9 contains the output of these commands and **1** marks the distributed DVIPA address. These addresses are owned and announced only by the TCPIPA stack on SC30, but TCPIPB on SC31 and TCPIPB on SC32 also define this DVIPA internally, shown as **2**, and are capable of handling the traffic using this DVIPA.

Example 5-9 Display results of NETSTAT,HOME in all stacks

```
SC30
D TCPIP,TCPIPA,N,HOME
EZD0101I NETSTAT CS V1R13 TCPIPA 435
HOME ADDRESS LIST:
LINKNAME:   VIPA1L
  ADDRESS:  10.1.1.10
    FLAGS:  PRIMARY
LINKNAME:   VIPL0A01080A
  ADDRESS:  10.1.8.10          1
    FLAGS:


SC31
D TCPIP,TCPIPB,N,HOME
EZD0101I NETSTAT CS V1R13 TCPIPB 292
HOME ADDRESS LIST:
LINKNAME:   VIPA1L
  ADDRESS:  10.1.1.20
    FLAGS:  PRIMARY
LINKNAME:   VIPL0A01080A
  ADDRESS:  10.1.8.10    1
    FLAGS:  INTERNAL     2

SC32
D TCPIP,TCPIPC,N,HOME
EZD0101I NETSTAT CS V1R13 TCPIPC 842
HOME ADDRESS LIST:
LINKNAME:   VIPA1L
  ADDRESS:  10.1.1.30
    FLAGS:  PRIMARY
LINKNAME:   VIPL0A01080A
  ADDRESS:  10.1.8.10     1
    FLAGS:  INTERNAL      2
```

Step 2: Verification that WLM is set up correctly and is used

We next must verify that the server-specific WLM function worked correctly. We start 35 TN3270 sessions and use a display command, shown in Example 5-10, to determine the distribution of these sessions.

Example 5-10 NETSTAT,VDPT,DETAIL command at our distribution stack SC30

```
D TCPIP,TCPIPA,N,VDPT,DETAIL
EZD0101I NETSTAT CS V1R13 TCPIPA 860
DYNAMIC VIPA DESTINATION PORT TABLE FOR TCP/IP STACKS:
DEST:        10.1.8.10..23  1 2
  DESTXCF:   10.1.7.11 3
  TOTALCONN: 0000000027 4 RDY: 001 5 WLM: 16 8 TSR: 100 9
  DISTMETHOD: SERVERWLM 6
  FLG:
    TCSR: 100 10 CER: 100 11 SEF: 100 12
    WEIGHT: 64
      RAW          CP: 47 ZAAP: 64 ZIIP: 64
      PROPORTIONAL CP: 64 ZAAP: 00 ZIIP: 00
    ABNORM: 0000        HEALTH: 100
    ACTCONN:   0000000003 7
    QOSPLCACT: *DEFAULT*
      W/Q: 16 13
DEST:        10.1.8.10..23
  DESTXCF:   10.1.7.21
  TOTALCONN: 0000000043  RDY: 001  WLM: 16  TSR: 100
  DISTMETHOD: SERVERWLM
  FLG:
    TCSR: 100  CER: 100 SEF: 100
    WEIGHT: 64
      RAW          CP: 48 ZAAP: 64 ZIIP: 64
      PROPORTIONAL CP: 64 ZAAP: 00 ZIIP: 00
    ABNORM: 0000        HEALTH: 100
    ACTCONN:   0000000016
    QOSPLCACT: *DEFAULT*
      W/Q: 16
DEST:        10.1.8.10..23
  DESTXCF:   10.1.7.31
  TOTALCONN: 0000000019  RDY: 001  WLM: 16  TSR: 100
  DISTMETHOD: SERVERWLM
  FLG:
    TCSR: 100  CER: 100 SEF: 100
    WEIGHT: 64
      RAW          CP: 48 ZAAP: 64 ZIIP: 64
      PROPORTIONAL CP: 64 ZAAP: 00 ZIIP: 00
    ABNORM: 0000        HEALTH: 100
    ACTCONN:   0000000016
    QOSPLCACT: *DEFAULT*
      W/Q: 16
```

The output includes the following key information:

1. The destination IP address, which is the sysplex distributor IP address.

2. The port number to which connections are being distributed.

3. The destination XCF IP address.

4. The total number of connections that have been forwarded by the sysplex distributor (this is not the number of currently active connections).

5. The number of applications listening on the port number selected.

6. SERVERWLM method is used.

7. The total number of connections that are currently active.

This command provides additional information regarding the WLM weights and related values as part of the sysplex autonomics function: TCSR, CER, SEF, and TSR. These values are used by distributing the IP stack to determine the best-suited target server for the TN3270 connection request. The values are calculated once per minute; that interval can be changed with SYSPLEXWLMPOLL. The example shows the following information:

- WLM: The Workload Manager weight value for the target listener **8**.
- TSR: The Target Server Responsiveness fraction for the target server **9**.
- TCSR: The Target Connectivity Success Rate (TCSR) is a measure of the percentage of connection setup requests routed from the distributor that are successfully received by the target for this server **10**.
- CER: The Connection Establishment Rate (CER) is a measure of the percentage of the connection setup requests received at the target that achieve completion with the client **11**.
- SEF: The Server accept Efficiency Fraction (SEF) is a measure of the efficiency of the server application in accepting new connection requests and managing its backlog queue **12**.
- W/Q: The Workload Manager weight value for the target server after modification using QoS information provided by the Policy Agent **13**. In this example, no Policy Agent was used.

Note: With SERVERWLM method, the connections are distributed based on the WLM weight. Because the WLM weight is 16 for each target, the first 16 connections are distributed to TCPIPC and the next 16 connections are distributed to TCPIPB in this example. Another 16 connections will be distributed to TCPIPA. Connection 49to 64will be distributed to TCPIPC again.

Step 3: Verification that optimized routing is set up correctly and is used

We then verify that the optimized routing (with VIPAROUTE) is set up correctly and in use. We use the **NETSTAT,VCRT,DETAIL** command at our distribution IP stack SC30, as shown in Example 5-11. The output of this command displays the dynamic VIPA Connection Routing Table for SC30. Because this is the distributing IP stack, it shows all the connections between the clients and the participating IP stacks.

Example 5-11 Display of NETSTAT,VCRT from SC30 IP stack

```
D TCPIP,TCPIPA,N,VCRT,DETAIL
EZD0101I NETSTAT CS V1R13 TCPIPA 843
DYNAMIC VIPA CONNECTION ROUTING TABLE:
DEST:      10.1.8.10..23
  SOURCE:  10.1.100.222..1918
  DESTXCF: 10.1.7.21
    POLICYRULE:    *NONE*
    POLICYACTION:  *NONE*
    INTF:  IUTIQDF4L 2
      VIPAROUTE:  YES 1     GW:  10.1.4.21 3
    ACCELERATOR: YES
```

```
DEST:      10.1.8.10..23
  SOURCE:  10.1.100.222..1919
  DESTXCF: 10.1.7.21
    POLICYRULE:    *NONE*
    POLICYACTION:  *NONE*
    INTF:  IUTIQDF5L 2
      VIPAROUTE:  YES 1    GW:  10.1.5.21 3
    ACCELERATOR: YES
...
DEST:      10.1.8.10..23
  SOURCE:  10.1.100.222..1904
  DESTXCF: 10.1.7.31
    POLICYRULE:    *NONE*
    POLICYACTION:  *NONE*
    INTF:  IUTIQDF4L 2
      VIPAROUTE:  YES 1    GW:  10.1.4.31 3
    ACCELERATOR: YES
DEST:      10.1.8.10..23
  SOURCE:  10.1.100.222..1905
  DESTXCF: 10.1.7.31
    POLICYRULE:    *NONE*
    POLICYACTION:  *NONE*
    INTF:  IUTIQDF5L 2
      VIPAROUTE:  YES 1    GW:  10.1.5.31 3
    ACCELERATOR: YES
```

This display shows that the TN3270 connections are being forwarded to the target stacks using HiperSockets and not XCF. The example shows the following key points:

1. VIPAROUTE: YES indicates that an IP interface is used by the sysplex distributor for forwarding this connection request to the chosen target server.
2. INTF: IUTIQDF4 and IUTIQDF5 represents our HiperSockets interfaces, which are used to forward the connection request within our CPC. Because IPCONFIG MULTIPATH is specified and these HiperSockets interfaces have the equal OSPF cost, the link used for forwarding switches on every connection.
3. GW: The IP address of our HiperSockets, which is used as a next hop gateway.

Note: In our OSPF setup for dynamic routing, we want to prefer HiperSockets, if available, before using our shared OSA-Express ports. This can be achieved by setting the appropriate COST0 settings.

Although NETSTAT,VCRT,DETAIL on the distributing IP stack displays all the distributed connections, the same command issued on our target stacks shows only those connections established with the local server instance.

Example 5-12 shows the VCRT list on SC31.

Example 5-12 Display of NETSTAT,VCRT from our target IP stack on SC31

```
SC31
D TCPIP,TCPIPB,N,VCRT
EZD0101I NETSTAT CS V1R13 TCPIPB 471
DYNAMIC VIPA CONNECTION ROUTING TABLE:
DEST:      10.1.8.10..23
  SOURCE:  10.1.100.222..1918
  DESTXCF: 10.1.7.21
DEST:      10.1.8.10..23
  SOURCE:  10.1.100.222..1919
  DESTXCF: 10.1.7.21
DEST:      10.1.8.10..23
  SOURCE:  10.1.100.222..1920
  DESTXCF: 10.1.7.21
DEST:      10.1.8.10..23
  SOURCE:  10.1.100.222..1921
  DESTXCF: 10.1.7.21
```

5.3.2 Sysplex distributor using the BASEWLM method

We start with a typical sysplex distributor situation where three application instances of the TN3270 server are available in a z/OS sysplex environment. Figure 5-12 on page 160 shows how TN3270 connections are load balanced across all three LPARS, based on the standard WLM distribution method (DISTMETHOD BASEWLM).

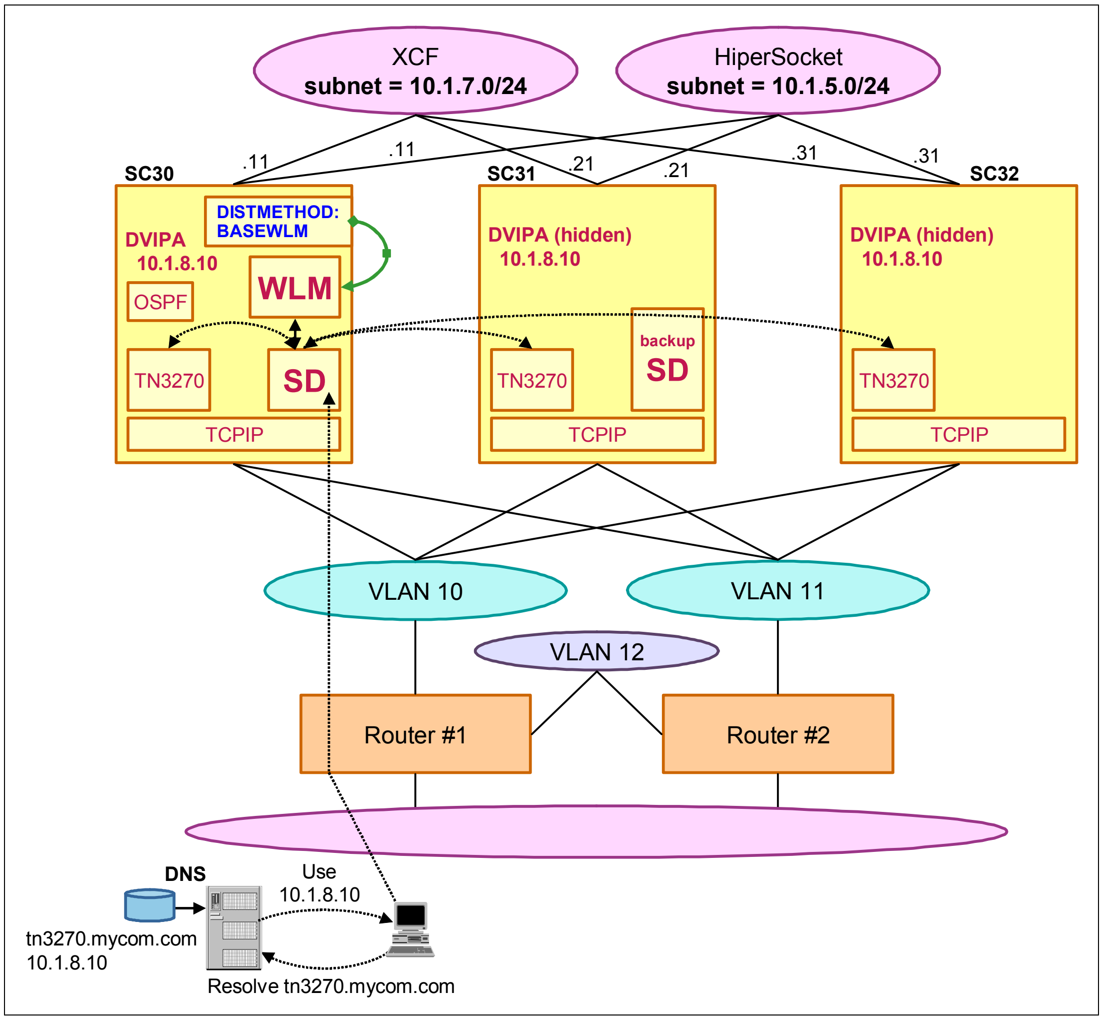


Figure 5-12   Workload balancing of TN3270 using sysplex distributor with DISTMETHOD BASEWLM

In this example, the sysplex distributor uses the default workload distribution method, BASELWLM, to determine which TN3270 instance is best suitable for aTN3270 connection request. The WLM weight given to the sysplex distributor is based on a comparison of the available capacity for new work on each system. OSPF is used as the dynamic routing protocol for advertising of the VIPA addresses, and to ensure connectivity by rerouting connections around failures.

Requirements to implement BasedWLM Method

You must implement either a dynamic routing protocol using OMPROUTE (as discussed in Chapter 4, “VIPA with dynamic routing” on page 85), or use ARP takeover (as discussed in Chapter 3, “VIPA without dynamic routing” on page 61) to propagate the VIPA address.

Furthermore, the TCP/IP stack needs to be configured to support DYNAMICXCF (which must be enabled for nondisruptive movement of DVIPAs) and SYSPLEXROUTING (which is required for WLM-based balancing).

Considerations about the BasedWLM method

The sysplex distributor only works for TCP applications, not for UDP.

A sysplex is required for the sysplex distributor. All target servers must be System z servers and resident within the same sysplex. This might impose some limitations on flexibility.

Implementing the BasedWLM method

This example has a similar implementation process to that shown in 5.3.1, “Sysplex distributor using the server-specific WLM method” on page 150. The only difference is the method used to distribute the sessions. To implement this method, we change, in the TCPIPA profile, only the DISTMethod parameter in the VIPADEFine statement, as shown in Example 5-13.

Example 5-13 Using the distribution method BASEWLM

```
VIPADynamic
VIPADEFine MOVEable IMMEDiate 255.255.255.0 10.1.8.10
VIPADISTribute DISTMethod BASEWLM 10.1.8.10
 PORT 23 DESTIP 10.1.7.11 10.1.7.21 10.1.7.31
```

Verifying the BasedWLM method implementation

To verify that the BaseWLM method is implemented, the same commands can be used as those shown in 5.3.1, “Sysplex distributor using the server-specific WLM method” on page 150.

To confirm that we are using the expected method, we execute the **NETSTAT,VIPADCFG** command, as shown in Example 5-14, on our distribution stack (SC30).

Example 5-14 Display results of the VIPADCFG command issued on distribution stack SC30

```
D TCPIP,TCPIPA,N,VIPADCFG
EZD0101I NETSTAT CS V1R13 TCPIPA 813
DYNAMIC VIPA INFORMATION:
  VIPA DEFINE:
    IPADDR/PREFIXLEN: 10.1.8.10/24                          1
      MOVEABLE: IMMEDIATE  SRVMGR: NO  FLG:
  VIPA DISTRIBUTE:
    DEST:      10.1.8.10..23                                2 3
      DESTXCF: 10.1.7.11                                    4
      DISTMETHOD: BASEWLM                                   5
      SYSPT:   NO   TIMAFF: NO    FLG:
    DEST:      10.1.8.10..23
      DESTXCF: 10.1.7.21
      DISTMETHOD: BASEWLM
      SYSPT:   NO   TIMAFF: NO    FLG:
    DEST:      10.1.8.10..23
      DESTXCF: 10.1.7.31
      DISTMETHOD: BASEWLM
      SYSPT:   NO   TIMAFF: NO    FLG:
  VIPA ROUTE:                                               6
    DESTXCF:     10.1.7.11
      TARGETIP:  10.1.1.10
    DESTXCF:     10.1.7.21
      TARGETIP:  10.1.1.20
    DESTXCF:     10.1.7.31
      TARGETIP:  10.1.1.30
```

The example shows the following key information:

1. This is the DVIPA address representing the TN3270 servers.
2. TN3270 connections are being distributed by the sysplex distributor.
3. We use port number 23 for TN3270.
4. This is the XCF IP address assigned and used.
5. DISTMETHOD: BASEWLM indicates that server-specific WLM is active and will be used.
6. VIPAROUTE indicates that we do not use XCF links, but use any available IP network interface for forwarding sysplex distributor-related packets. Three VIPAROUTE definitions point to the static VIPA in each of our stacks.

5.3.3 Sysplex distributor using the WEIGHTEDActive method

Using this distribution method, we are able to configure, for each target TCP/IP stack, an active connection weight. The distributor balances incoming connection requests across the targets, with a goal of having the number of active connections on each target proportionally equivalent to the configured active connection weight of each target. See Figure 5-13.

Each weight can range in value from 1 to 99, so that the weights can be expressed as percentages if desired. Ideally, each weight should be greater than 10 so that granularity is preserved when autonomic fractions need to be applied to determine a modified weight.

The weight defaults to 10, so if DESTIP ALL is configured, then the default weight of 10 is assumed, which results in a connection distribution goal to have an equal number of active connections on each target.

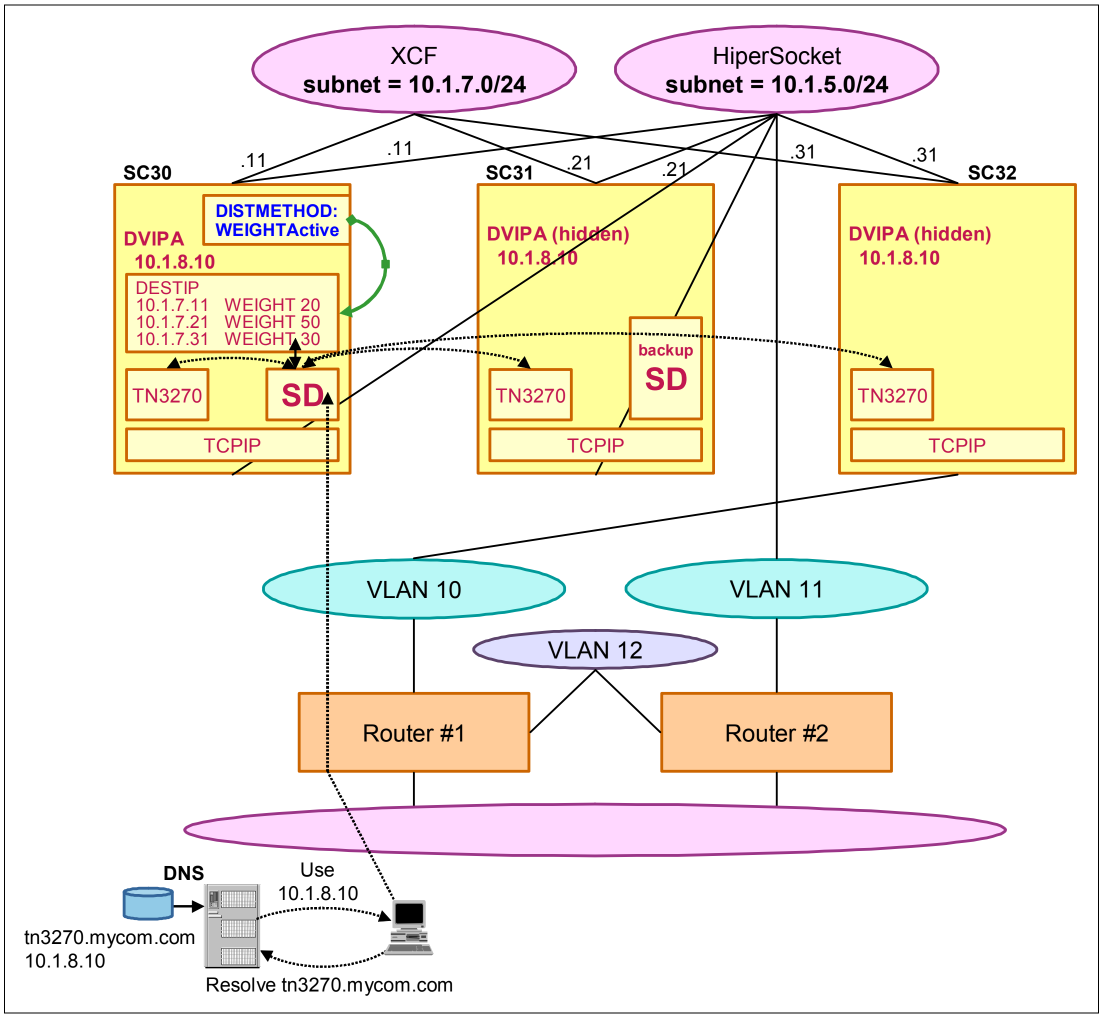


Figure 5-13 Workload balancing of TN3270 using sysplex distributor with WEIGHTEDActive

In this example, the sysplex distributor uses the WEIGHTEDActive workload distribution method to determine which TN3270 instance is best suitable for a TN3270 connection request. The Target Server Responsiveness (TSR) fraction, abnormal completion rate fraction, and General Health fraction are applied against the configured Weight on each target to determine a modified weight. Connection goals are established based on the modified weight and the active connection count on each target.

Considerations about WEIGHTEDActive method

When you implement this method in a mixed z/OS environment, consider the following issues:

- If the sysplex distributor resides on a z/OS V1R9 system or newer, the WEIGHTEDActive distribution method can be used regardless of the release level of the target stacks.
- Each target stack needs to be on a z/OS V1R7 system or higher so that TSR metrics are reported to the distributor. TSR is considered to be 100% when a target is pre-V1R7.
- Each target stack needs to be on a z/OS V1R8 system or higher so that health metrics (abnormal terminations and health) are reported to the distributor. Health and normal termination rate are considered to be 100% when a target is pre-V1R8.
- Each backup stack needs to be on a z/OS V1R9 system or newer to allow WEIGHTEDActive distribution to be inherited during a takeover; otherwise, BASEWLM is used.

Implementing the WEIGHTEDActive method

To use the WEIGHTEDActive distribution method, we follow the same steps used to implement all the other methods, as shown in 5.3.1, "Sysplex distributor using the server-specific WLM method" on page 150. In the TCPIPA profile, we change the DISTMethod parameter in the VIPADEFine statement to use the WEIGHTEDActive option. Using this method, we also configure a weight for each target destination, as shown in Example 5-15.

Example 5-15 Using the WEIGHTEDActive distributed method

```
VIPADYNAMIC
 VIPADEFINE MOVEABLE IMMEDIATE SERVICEMGR 255.255.255.0 10.1.8.10
 VIPADISTRIBUTE DISTMethod WEIGHTEDActive 10.1.8.10
  PORT 23 DESTIP 10.1.7.11 WEIGHT 20
                 10.1.7.21 WEIGHT 50
                 10.1.7.31 WEIGHT 30
ENDVIPADYNAMIC
```

Verifying the WEIGHTEDActive method implementation

To verify that the WEIGHTEDActive method is implemented, you can use the same commands shown in 5.3.1, "Sysplex distributor using the server-specific WLM method" on page 150. To confirm that we were using the expected method, we execute the **NETSTAT,VIPADCFG** command, as shown in Example 5-16, on our distribution stack (SC30).

Example 5-16 Display results of the VIPADCFG command issued on distribution stack SC30

```
D TCPIP,TCPIPA,N,VIPADCFG
EZD0101I NETSTAT CS V1R13 TCPIPA 758
DYNAMIC VIPA INFORMATION:
  VIPA DEFINE:
     IPADDR/PREFIXLEN: 10.1.8.10/24                  1
        MOVEABLE: IMMEDIATE  SRVMGR: NO  FLG:
  VIPA DISTRIBUTE:
    DEST:      10.1.8.10..23                         2 3
      DESTXCF: 10.1.7.11                             4
      DISTMETHOD: WEIGHTEDACTIVE                     5
      SYSPT:   NO   TIMAFF: NO    FLG:
    DEST:      10.1.8.10..23
      DESTXCF: 10.1.7.21
      DISTMETHOD: WEIGHTEDACTIVE
      SYSPT:   NO   TIMAFF: NO    FLG:
    DEST:      10.1.8.10..23
```

```
      DESTXCF: 10.1.7.31
      DISTMETHOD: WEIGHTEDACTIVE
      SYSPT:   NO   TIMAFF: NO    FLG:
  VIPA ROUTE:
    DESTXCF:     10.1.7.11
      TARGETIP:  10.1.1.10
    DESTXCF:     10.1.7.21
      TARGETIP:  10.1.1.20
    DESTXCF:     10.1.7.31
      TARGETIP:  10.1.1.30
END OF THE REPORT
```

This example shows the following key information:

1. This is the DVIPA address representing the TN3270 servers.

2. TN3270 connections are distributed by the sysplex distributor.

3. We use port number 23 for TN3270.

4. This is the XCF IP address assigned and used.

5. WEIGHTEDACTIVE indicates that WEIGHTEDActive method is active and will be used.

The **NETSTAT VIPADCFG,Detail** command shows the same results with more detailed information (Example 5-17).

Example 5-17 D tcpip,tcpipa,n,vipadcfg,detail response

```
D TCPIP,TCPIPA,N,VIPADCFG,DETAIL
EZD0101I NETSTAT CS V1R13 TCPIPA 773
DYNAMIC VIPA INFORMATION:
  VIPA BACKUP:
    IPADDR/PREFIXLEN: 10.1.8.20
      RANK: 100  MOVEABLE:            SRVMGR:     FLG:
  VIPA DEFINE:
    IPADDR/PREFIXLEN: 10.1.8.10/24
      MOVEABLE: IMMEDIATE  SRVMGR: NO  FLG:
  VIPA RANGE:
    IPADDR/PREFIXLEN: 10.1.9.0/24
      MOVEABLE: NONDISR
  VIPA DISTRIBUTE:
    DEST:      10.1.8.10..23
      DESTXCF: 10.1.7.11
      DISTMETHOD: WEIGHTEDACTIVE
      SYSPT:   NO   TIMAFF: NO    FLG:
      OPTLOC:  NO   WEIGHT: 20 1
    DEST:      10.1.8.10..23
      DESTXCF: 10.1.7.21
      DISTMETHOD: WEIGHTEDACTIVE
      SYSPT:   NO   TIMAFF: NO    FLG:
      OPTLOC:  NO   WEIGHT: 50 1
    DEST:      10.1.8.10..23
      DESTXCF: 10.1.7.31
      DISTMETHOD: WEIGHTEDACTIVE
      SYSPT:   NO   TIMAFF: NO    FLG:
      OPTLOC:  NO   WEIGHT: 30 1
```

In the example, **1** is the configured weight for each target.

The **NETSTAT,VDPT** command shows the active distribution method being used and the modified weight of each target ("D tcpip,tcpipa,netstat,vpdt command" on page 166).

Example 5-18 D tcpip,tcpipa,netstat,vpdt command

```
D TCPIP,TCPIPA,N,VDPT
EZD0101I NETSTAT CS V1R13 TCPIPA 775
DYNAMIC VIPA DESTINATION PORT TABLE FOR TCP/IP STACKS:
DEST:        10.1.8.10..23
  DESTXCF:   10.1.7.11
  TOTALCONN: 0000000021  RDY: 001  WLM: 20 1 TSR: 100
  DISTMETHOD: WEIGHTEDACTIVE              2
  FLG:
DEST:        10.1.8.10..23
  DESTXCF:   10.1.7.21
  TOTALCONN: 0000000026  RDY: 001  WLM: 50 1 TSR: 100
  DISTMETHOD: WEIGHTEDACTIVE              2
  FLG:
DEST:        10.1.8.10..23
  DESTXCF:   10.1.7.31
  TOTALCONN: 0000000000  RDY: 001  WLM: 30 1 TSR: 100
  DISTMETHOD: WEIGHTEDACTIVE              2
  FLG:
```

This example shows the following key information:

1. The active weight for each target

2. The active method

The **NETSTAT VDPT,Detail** command includes the active connection counts for each target, as shown in Example 5-19.

Example 5-19 D tcpip,tcpipa,netstat,vpdt,detail command

```
D TCPIP,TCPIPA,N,VDPT,DETAIL
EZD0101I NETSTAT CS V1R13 TCPIPA 805
DYNAMIC VIPA DESTINATION PORT TABLE FOR TCP/IP STACKS:
DEST:        10.1.8.10..23
  DESTXCF:   10.1.7.11
  TOTALCONN: 0000000027 1 RDY: 001  WLM: 20  TSR: 100
  DISTMETHOD: WEIGHTEDACTIVE
  FLG:
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000003 2
DEST:        10.1.8.10..23
  DESTXCF:   10.1.7.21
  TOTALCONN: 0000000039 1 RDY: 001  WLM: 50  TSR: 100
  DISTMETHOD: WEIGHTEDACTIVE
  FLG:
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000005 2
DEST:        10.1.8.10..23
  DESTXCF:   10.1.7.31
  TOTALCONN: 0000000005 1 RDY: 001  WLM: 30  TSR: 100
  DISTMETHOD: WEIGHTEDACTIVE
  FLG:
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000005 2
```

This example shows the following key information:

1. The total number of connections distributed for this target

2. The total number of currently active connections on this target

5.3.4 Sysplex distributor using the round-robin method

This example is similar to the last one, but uses a round-robin distribution method to distribute TN3270 workload across three LPARs.

Important: Be aware that when round-robin distribution is chosen, it supersedes any defined policies.

Figure 5-14 illustrates three incoming TN3270 connections being evenly distributed across three LPARs.

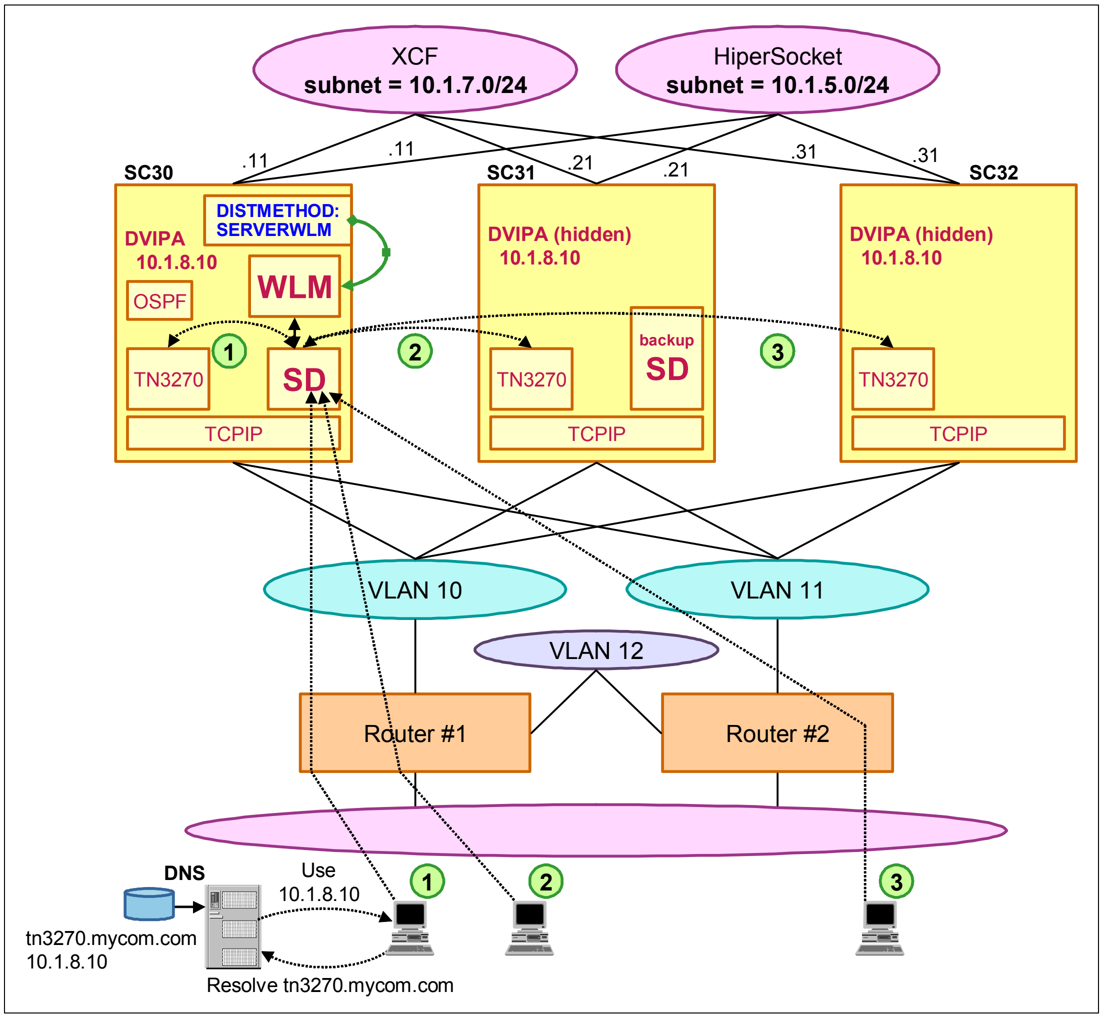


Figure 5-14 Round-robin workload distribution

Considerations of the round-robin method

The round-robin distribution method does not account for server capacity when distributing new connection requests.

Implementing the round-robin distribution method

To implement this method, we follow the same steps shown in 5.3.1, “Sysplex distributor using the server-specific WLM method” on page 150 and in the TCPIPA profile, but change the DISTMethod parameter in the VIPADEFine statement, as shown in Example 5-20.

Example 5-20 Using the round-robin distribution method

```
VIPADynamic
   VIPADEFine MOVEable IMMEDiate 255.255.255.0 10.1.8.10
   VIPADISTribute DISTMethod ROUNDROBIN 10.1.8.10
    PORT 23 DESTIP 10.1.7.11 10.1.7.21 10.1.7.31
```

Verifying the round-robin distribution method implementation

To verify that the round-robin method is implemented, the same commands shown in 5.3.1, “Sysplex distributor using the server-specific WLM method” on page 150 can be used. To confirm that we are using the expected method, we execute the **NETSTAT,VIPADCFG** command, as shown in Example 5-21, on our distribution stack (SC30).

Example 5-21 Display results of the VIPADCFG command issued on distribution stack SC30

```
D TCPIP,TCPIPA,N,VIPADCFG
EZD0101I NETSTAT CS V1R13 TCPIPA 872
DYNAMIC VIPA INFORMATION:
  VIPA DEFINE:
    IPADDR/PREFIXLEN: 10.1.8.10/24                                  1
      MOVEABLE: IMMEDIATE  SRVMGR: NO  FLG:
  VIPA DISTRIBUTE:
    DEST:      10.1.8.10..23                                        2 3
      DESTXCF: 10.1.7.11                                            4
      DISTMETHOD: ROUNDROBIN                                        5
      SYSPT:   NO   TIMAFF: NO    FLG:
    DEST:      10.1.8.10..23
      DESTXCF: 10.1.7.21
      DISTMETHOD: ROUNDROBIN
      SYSPT:   NO   TIMAFF: NO    FLG:
    DEST:      10.1.8.10..23
      DESTXCF: 10.1.7.31
      DISTMETHOD: ROUNDROBIN
      SYSPT:   NO   TIMAFF: NO    FLG:
  VIPA ROUTE:                                                       6
    DESTXCF:     10.1.7.11
      TARGETIP:  10.1.1.10
    DESTXCF:     10.1.7.21
      TARGETIP:  10.1.1.20
    DESTXCF:     10.1.7.31
      TARGETIP:  10.1.1.30
```

This example shows the following key information:

1. This is the DVIPA address representing the TN3270 servers.

2. TN3270 connections are being distributed by the sysplex distributor.

3. We use port number 23 for TN3270.

4. This is the XCF IP address assigned and used.

5. DISTMETHOD: ROUNDROBIN indicates that the round-robin method is active and will be used.

6. VIPAROUTE indicates that we do not use XCF links but use any available IP network interface for forwarding sysplex distributor-related packets. Three VIPAROUTE definitions point to the static VIPA in each of our stacks.

5.3.5 Sysplex distributor using the hot standby method

To implement the distribution method called hot standby, we use three TN3270 servers: TN3270A, TN3270B, and TN3270C. We define TN3270A in LPAR SC30 to be the preferred server; TN3270A and TN3270C in LPARs SC31 and SC32 are defined as the backup servers.

We use TCPIPA stack on SC30 to implement the sysplex distributor definitions. Then we perform the following steps to configure hot standby distribution on the VIPADISTRIBUTE statement, as shown in Example 5-22:

1. Configure HOTSTANDBY on the DISTMETHOD parameter (**1**).
2. Define the AUTOSWITCHBACK parameter to be able to automatically switch distribution back to the preferred target when it is available (**2**).
3. Configure HEALTHSWITCH **3**, which tells the distributor to automatically switch from the active target when it is not healthy. A target is considered to be not healthy when one of the following health metric situations is detected:
   - The target server responsiveness (TSR) value is 0%.
   - The rate of abnormal transaction completions is 1000.
   - The general health of the application is 0%.

   Backup target: When a switch occurs because a target is no longer healthy, the target is not used as a backup target even if its health recovers, unless all available backup targets have previously had health problems.

   You can use the **VARY TCPIP,,SYSPLEX,QUIESCE** and **VARY TCPIP,,SYSPLEX,RESUME** commands to manually bring a server back to the ready state.

4. Configure the PREFERRED option (**4**) or the BACKUP option (**5**) after each XCF address on the DESTIP parameter to designate the preferred server and the backup servers, and configure a rank value for each backup server. In our scenario, we use these definitions.

Example 5-22 Using the HOTSTANDBY distributed method

```
VIPADYNAMIC
VIPADISTRIBUTE DISTMETHOD HOTSTANDBY 1 AUTOSWITCHBACK 2 HEALTHSWITCH 3
                       10.1.8.10     PORT 23
                DESTIP 10.1.7.11 PREFERRED  4
                       10.1.7.21 BACKUP 100 5
                       10.1.7.31 BACKUP 50  5
;------------------------------------------------------------------
```

Verifying the Hot Standby method implementation

To verify that the Hot Standby method is implemented, you can use the same commands shown in 5.3.1, “Sysplex distributor using the server-specific WLM method” on page 150. To confirm that we are using the expected method, we execute the D,VIPADCFG command, as shown in Example 5-23, on our distribution stack (SC31).

Example 5-23 Display results of the VIPADCFG command issued on our distribution stack SC31

```
D TCPIP,TCPIPA,N,VIPADCFG
EZD0101I NETSTAT CS V1R13 TCPIPA 250
DYNAMIC VIPA INFORMATION:
  VIPA DEFINE:
    IPADDR/PREFIXLEN: 10.1.8.10/24
      MOVEABLE: IMMEDIATE  SRVMGR: NO  FLG:
  VIPA DISTRIBUTE:
    DEST:      10.1.8.10..23 1
      DESTXCF: 10.1.7.11 3
      DISTMETHOD: HOTSTANDBY 2    SRVTYPE: PREFERRED 3
      SYSPT:   NO   TIMAFF: NO    FLG:
    DEST:      10.1.8.10..23
      DESTXCF: 10.1.7.21
      DISTMETHOD: HOTSTANDBY      SRVTYPE: BACKUP  RANK: 100
      SYSPT:   NO   TIMAFF: NO    FLG:
    DEST:      10.1.8.10..23
      DESTXCF: 10.1.7.31
      DISTMETHOD: HOTSTANDBY      SRVTYPE: BACKUP  RANK: 050
      SYSPT:   NO   TIMAFF: NO    FLG:
  VIPA ROUTE:
    DESTXCF:     10.1.7.11
      TARGETIP:  10.1.1.10
    DESTXCF:     10.1.7.21
      TARGETIP:  10.1.1.20
    DESTXCF:     10.1.7.31
      TARGETIP:  10.1.1.30
```

This example shows the following key information:

1. This DVIPA address represents the TN3270 servers.
2. The DISTMETHOD being used is HOTSTANDBY.
3. The preferred server is located in LPAR SC30 (DESTXCF 10.1.7.11).
4. The higher rank (100) backup server is located in LPAR SC31 (DESTXCF 10.1.7.21).
5. The next backup server (rank 50) is located in LPAR SC32 (DESTXCF 10.1.7.31).

The **D VIPADCFG,DETAIL** command shows the same results with more detailed information (Example 5-24).

Example 5-24 D tcpip,tcpipb,n,vipadcfg,detail response

```
D TCPIP,TCPIPA,N,VIPADCFG,DETAIL
EZD0101I NETSTAT CS V1R13 TCPIPA 252
DYNAMIC VIPA INFORMATION:
  VIPA BACKUP:
    IPADDR/PREFIXLEN: 10.1.8.20
      RANK: 100  MOVEABLE:            SRVMGR:     FLG:
  VIPA DEFINE:
    IPADDR/PREFIXLEN: 10.1.8.10/24
      MOVEABLE: IMMEDIATE  SRVMGR: NO  FLG:
  VIPA RANGE:
    IPADDR/PREFIXLEN: 10.1.9.0/24
      MOVEABLE: NONDISR
  VIPA DISTRIBUTE:
    DEST:      10.1.8.10..23
      DESTXCF: 10.1.7.11
      DISTMETHOD: HOTSTANDBY      SRVTYPE: PREFERRED
        AUTOSWITCHBACK: YES 1 HEALTHSWITCH: YES 2
      SYSPT:   NO   TIMAFF: NO    FLG:
      OPTLOC:  NO
    DEST:      10.1.8.10..23
      DESTXCF: 10.1.7.21
      DISTMETHOD: HOTSTANDBY      SRVTYPE: BACKUP  RANK: 100
        AUTOSWITCHBACK: YES  HEALTHSWITCH: YES
      SYSPT:   NO   TIMAFF: NO    FLG:
      OPTLOC:  NO
    DEST:      10.1.8.10..23
      DESTXCF: 10.1.7.31
      DISTMETHOD: HOTSTANDBY      SRVTYPE: BACKUP  RANK: 050
        AUTOSWITCHBACK: YES  HEALTHSWITCH: YES
      SYSPT:   NO   TIMAFF: NO    FLG:
      OPTLOC:  NO
  VIPA ROUTE:
    DESTXCF:     10.1.7.11
      TARGETIP:  10.1.1.10
    DESTXCF:     10.1.7.21
      TARGETIP:  10.1.1.20
    DESTXCF:     10.1.7.31
      TARGETIP:  10.1.1.30
```

This example shows the following key information:

1. The statement AUTOSWITCHBACK is being used.

2. The statement HEALTHSWITCH is defined.

The **NETSTAT,VDPT** command shows the active distribution method being used and the status of each target (Example 5-25).

Example 5-25 NETSTAT,VDPT,DETAIL command

```
D TCPIP,TCPIPA,N,VDPT,DETAIL
EZD0101I NETSTAT CS V1R13 TCPIPA 261
DYNAMIC VIPA DESTINATION PORT TABLE FOR TCP/IP STACKS:
DEST:        10.1.8.10..23
  DESTXCF:   10.1.7.11
  TOTALCONN: 0000000007 2 RDY: 001  WLM: 10  TSR: 100
  DISTMETHOD: HOTSTANDBY          SRVTYPE: PREFERRED
  FLG: ACTIVE 1
    TCSR: 100  CER: 100 SEF: 100
    ACTCONN:   0000000007
DEST:        10.1.8.10..23
  DESTXCF:   10.1.7.21
  TOTALCONN: 0000000000  RDY: 001  WLM: 10  TSR: 100
  DISTMETHOD: HOTSTANDBY          SRVTYPE: BACKUP
  FLG: BACKUP 1
    TCSR: 100  CER: 100 SEF: 100
    ACTCONN:   0000000000
DEST:        10.1.8.10..23
  DESTXCF:   10.1.7.31
  TOTALCONN: 0000000000  RDY: 001  WLM: 10  TSR: 100
  DISTMETHOD: HOTSTANDBY          SRVTYPE: BACKUP
  FLG: BACKUP 1
    TCSR: 100  CER: 100 SEF: 100
    ACTCONN:   0000000000
```

This example shows the following key information:

1. The FLG field indicates which server is being used. In this case, the active server is the one defined as the preferred server.
2. All connections are established on the preferred server.

If the preferred server becomes unhealthy or unavailable, the hot standby server assumes the active status. We stopped the TN3270A server running on SC30. The message indicates that the preferred server has become inactive and that a backup server has been activated, as shown in Example 5-26.

Example 5-26 The preferred server is down

```
P TN3270A
EZZ6008I TN3270A STOPPING
EZZ6010I TN3270A SERVER ENDED FOR PORT  5023
EZD1930I HOT STANDBY SERVER FOR 10.1.8.10 PORT 00023 AT TCPIPA
SC30 IS INACTIVE - THE TARGET SERVER IS NOT READY
EZD1970I HOT STANDBY SERVER FOR 10.1.8.10 PORT 00023 AT TCPIPB
SC31 IS ACTIVE
EZZ6010I TN3270A SERVER ENDED FOR PORT    23
EZZ6009I TN3270A SERVER STOPPED
IEF352I ADDRESS SPACE UNAVAILABLE
$HASP395 TN3270A  ENDED
```

Next, we see that all new connections use the backup server, which is now the active server, as shown in the **display** command results shown in Example 5-27.

Example 5-27 D tcpip,tcpipb,netstat,vpdt,detail command

```
D TCPIP,TCPIPA,N,VDPT,DETAIL
EZD0101I NETSTAT CS V1R13 TCPIPA 283
DYNAMIC VIPA DESTINATION PORT TABLE FOR TCP/IP STACKS:
DEST:        10.1.8.10..23
  DESTXCF:   10.1.7.11
  TOTALCONN: 0000000007  RDY: 000  WLM: 10  TSR: 100
  DISTMETHOD: HOTSTANDBY          SRVTYPE: PREFERRED
  FLG: BACKUP 1
    TCSR: 100  CER: 100 SEF: 100
    ACTCONN:   0000000000
DEST:        10.1.8.10..23
  DESTXCF:   10.1.7.21
  TOTALCONN: 0000000006 2 RDY: 001  WLM: 10  TSR: 100
  DISTMETHOD: HOTSTANDBY          SRVTYPE: BACKUP
  FLG: ACTIVE 1
    TCSR: 100  CER: 100 SEF: 100
    ACTCONN:   0000000006
DEST:        10.1.8.10..23
  DESTXCF:   10.1.7.31
  TOTALCONN: 0000000000  RDY: 001  WLM: 10  TSR: 100
  DISTMETHOD: HOTSTANDBY          SRVTYPE: BACKUP
  FLG: BACKUP 1
    TCSR: 100  CER: 100 SEF: 100
    ACTCONN:   0000000000
```

This example shows the following key information:

1. The preferred server now has a flag of BACKUP and the backup server with the highest rank has become the *active* server, receiving all new connections until the preferred server recovers.

2. All new connections are opened with the new active server.

Finally, when the preferred server is back to a healthy state, the parameter AUTOSWITCHBACK changes the preferred server back to active state, which can be confirmed by the message shown in Example 5-28.

Example 5-28 Preferred server returns to active state

```
S TN3270A
...
EZZ6003I TN3270A LISTENING ON PORT  5023
EZD1930I HOT STANDBY SERVER FOR 10.1.8.10 PORT 00023 AT TCPIPB
SC31 IS INACTIVE - AUTOSWITCHBACK TO THE PREFERRED SERVER OCCURRED
EZD1970I HOT STANDBY SERVER FOR 10.1.8.10 PORT 00023 AT TCPIPA
SC30 IS ACTIVE
EZZ6003I TN3270A LISTENING ON PORT    23
```

When the preferred server returns to the active state, all connections with the backup server remain active until the client drops the connection. The **display** command can confirm this situation, as shown in Example 5-29.

Example 5-29 D tcpip,tcpipb,netstat,vpdt,detail command

```
D TCPIP,TCPIPA,N,VDPT,DETAIL
EZD0101I NETSTAT CS V1R13 TCPIPA 299
DYNAMIC VIPA DESTINATION PORT TABLE FOR TCP/IP STACKS:
DEST:        10.1.8.10..23
  DESTXCF:   10.1.7.11
  TOTALCONN: 0000000010  RDY: 001  WLM: 10  TSR: 100
  DISTMETHOD: HOTSTANDBY          SRVTYPE: PREFERRED
  FLG: ACTIVE 1
    TCSR: 100  CER: 100 SEF: 100
    ACTCONN:   0000000003  2
DEST:        10.1.8.10..23
  DESTXCF:   10.1.7.21
  TOTALCONN: 0000000006  RDY: 001  WLM: 10  TSR: 100
  DISTMETHOD: HOTSTANDBY          SRVTYPE: BACKUP
  FLG: BACKUP 1
    TCSR: 100  CER: 100 SEF: 100
    ACTCONN:   0000000006  2
DEST:        10.1.8.10..23
  DESTXCF:   10.1.7.31
  TOTALCONN: 0000000000  RDY: 001  WLM: 10  TSR: 100
  DISTMETHOD: HOTSTANDBY          SRVTYPE: BACKUP
  FLG: BACKUP
    TCSR: 100  CER: 100 SEF: 100
    ACTCONN:   0000000000
```

This example shows the following key information:

1. The preferred server has returned to the active state and the backup server is back to the backup state, so the preferred server is receiving all new connections again.

2. All new connections are opened with the preferred server and the old connections using the backup server remain active until the clients drop their connections.

5.3.6 Sysplex distributor using the zIIP and zAAP specialty engines

Sysplex distributor supports an option for the weight calculation to take zIIP and zAAP specialty engines into account. This option is supported on SERVERWLM and BASEWLM distribution methods.

Using zIIP and zAAP with SERVERWLM distribution method

Enable the sysplex distributor to consider zIIP or zAAP processor capacity for target servers. Apply a crossover cost to penalize specialty processor service units that run on the CP processor and its work importance level weight.

Example 5-30 shows an extract of the profile TCP/IP for the TCPIPA stack.

Example 5-30 TCP/IP definition for SERVERWLM for TCPIPA stack

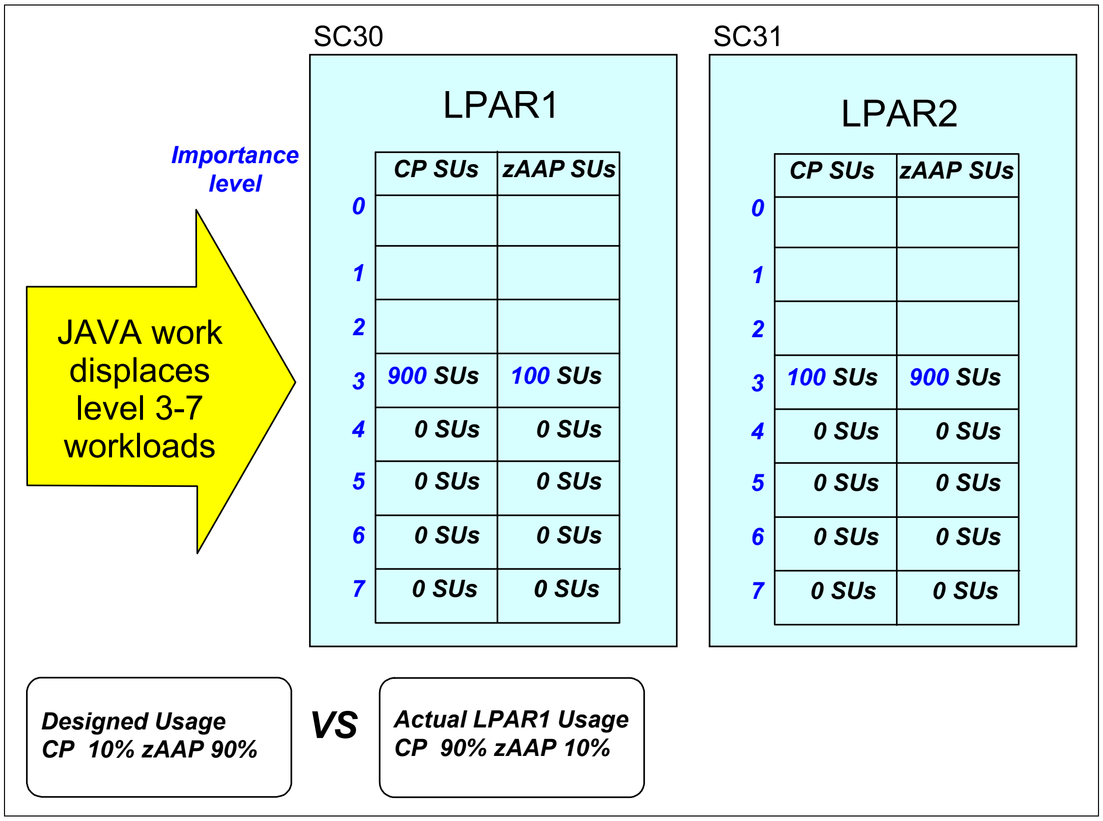
```
VIPADYNAMIC
   VIPADEFINE     MOVE IMMED 255.255.255.0 10.1.8.10
   VIPADISTRIBUTE DISTMETHOD SERVERWLM
   PROCXCOST ZIIP 20 ZAAP 100 ILWEIGHTING 1
                         10.1.8.10 PORT 8080
                  DESTIP ALL
ENDVIPADYNAMIC
```

In the example, a crossover cost of 100 1 is applied on the CP service units that run as zAAP intended workload runs on the CP.

We have a Java workload running at an importance level of 2. Starting with z/OS V1R9, WLM also takes into account the importance level of the new transaction. For more information about z/OS WLM, see *z/OS V1R12 MVS Planning Workload Management*, SA22-7602.

Our Java workload is designed to consume CP SUs 10% and zAAP SUs 90%; both LPARs (SC30 and SC31) have the same displaceable capacity of 1000 SUs available.[1]

Figure 5-15 shows the results of our test runs on SC30 and SC31.



SC30 – LPAR1

Importance level	CP SUs	zAAP SUs
0		
1		
2		
3	900 SUs	100 SUs
4	0 SUs	0 SUs
5	0 SUs	0 SUs
6	0 SUs	0 SUs
7	0 SUs	0 SUs

SC31 – LPAR2

Importance level	CP SUs	zAAP SUs
0		
1		
2		
3	100 SUs	900 SUs
4	0 SUs	0 SUs
5	0 SUs	0 SUs
6	0 SUs	0 SUs
7	0 SUs	0 SUs

Designed Usage
CP 10% zAAP 90%

Actual LPAR1 Usage
CP 90% zAAP 10%

Figure 5-15 Cost of specialty versus conventional processors

[1] A service unit (SU) is the amount of processor capacity that is consumed to execute a certain amount of work. You can use SU as a common comparison metric throughout all of our systems, regardless of release or capacity.

In our example, SC30 has 1000 general CP SUs available and 100 zAAP SUs available. The application is designed to run consuming 10% CP SUs as it consumes 90% zAAP SUs. Complete the following steps:

1. Consume all of the zAAP SUs, using the designed 10/90 split.

   Because 111 SUs are consumed by the application, 10% of those 111 SUs (or 11 SUs) should run on the CP, and 90% of those 111 (or 100 SUs) should run on the zAAP, thus consuming all of the zAAP SUs.

   Therefore, after step 1, the equivalent CP weight is 11.

2. Compute the remaining equivalent CP weight.

   We are left with 889 CP SUs, because the application consumes the remaining 889 SUs. Of those CP SUs consumed, 10% of the 889 CP SUs are intended to run on the CP (89 SUs), but the remaining 90% of the 889 CP SUs (800 SUs) were intended to run on the zAAP. The remaining 89 CP SUs are reduced by the crossover cost, which is the penalty imposed because all 89 CP SUs run at the expense of the remaining 800 SUs, crossing over and running on the CP instead of running on the zAAP processor.

Thus, if the crossover cost is *1*, then no penalty is applied against the 89 SUs. The equivalent CP weight is as follows:

```
11 + ( 89 / (10% + crossover cost of 1 *  90%)
11 + 89 / (.1 + 1 * .9)
11 + 89/1
100
```

However, if the crossover cost is *100*, the highest penalty possible, then the 89 SUs are reduced to 1 as follows:

```
11 + 89/(10% + 100 * 90%)
11 + 1
12
```

See Figure 5-16.

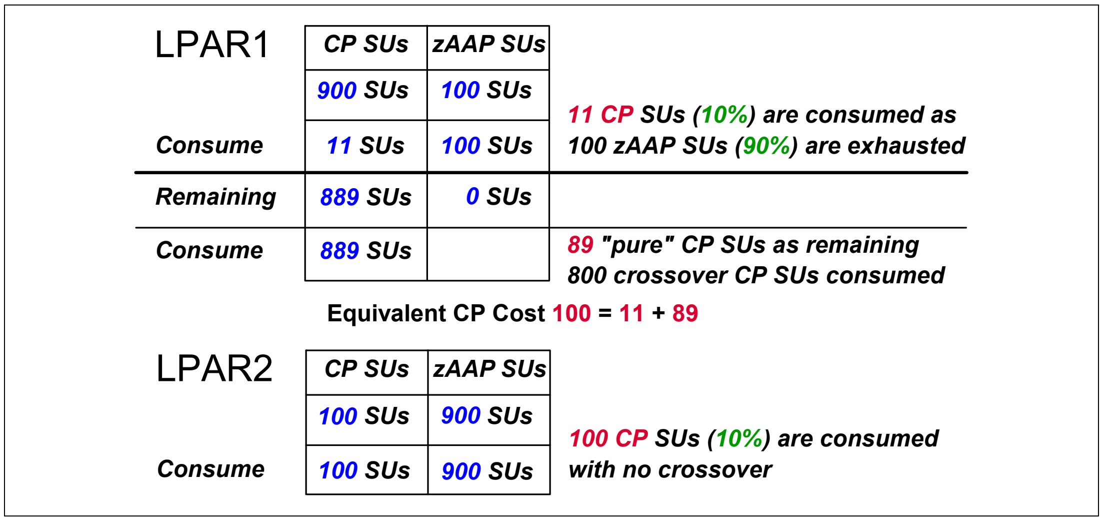

LPAR1
CP SUs
zAAP SUs
900 SUs
100 SUs
Consume
11 SUs
100 SUs
11 CP SUs (10%) are consumed as 100 zAAP SUs (90%) are exhausted
Remaining
889 SUs
0 SUs
Consume
889 SUs
89 "pure" CP SUs as remaining 800 crossover CP SUs consumed
Equivalent CP Cost 100 = 11 + 89
LPAR2
CP SUs
zAAP SUs
100 SUs
900 SUs
Consume
100 SUs
900 SUs
100 CP SUs (10%) are consumed with no crossover

Figure 5-16 Using crossover cost of 100

For LPAR2, as 100 CP SUs run, the designed percentage of 900 zAAP SUs run, so there is no penalty for the 100 CP SUs.

The following examples show the configuration without our Java transaction running.

Example 5-31 shows the output of the **D TCPIP,TCPIPA,N,VIPADCFG,DETAIL** command.

Example 5-31 Output of NETSTAT VIPADCFG command

```
D TCPIP,TCPIPA,N,VIPADCFG,DETAIL
EZD0101I NETSTAT CS V1R13 TCPIPA 010
DYNAMIC VIPA INFORMATION:
  VIPA DEFINE:
    IPADDR/PREFIXLEN: 10.1.8.10/24
      MOVEABLE: IMMEDIATE  SRVMGR: NO  FLG:
  VIPA DISTRIBUTE:
    DEST:      10.1.8.10..8080
      DESTXCF: ALL
      DISTMETHOD: SERVERWLM
      SYSPT:   NO   TIMAFF: NO    FLG:
      OPTLOC:  NO
      PROCXCOST:
        ZAAP: 100  ZIIP: 020
      ILWEIGHTING: 1
END OF THE REPORT
```

Example 5-32 shows the output of the **D TCPIP,TCPIPA,N,VDPT,DETAIL** command.

Example 5-32 Output of NETSTAT VDPT (SERVERWLM) command

```
D TCPIP,TCPIPA,N,VDPT,DETAIL
EZD0101I NETSTAT CS V1R13 TCPIPA 016
DYNAMIC VIPA DESTINATION PORT TABLE FOR TCP/IP STACKS:
DEST:        10.1.8.10..8080
  DESTXCF:   10.1.7.11
  TOTALCONN: 0000000000  RDY: 000  WLM: 00  TSR: 100
  DISTMETHOD: SERVERWLM
  FLG:
    TCSR: 100  CER: 100 SEF: 100
    WEIGHT: 00
      RAW          CP: 00 ZAAP: 00 ZIIP: 00
      PROPORTIONAL CP: 00 ZAAP: 00 ZIIP: 00
    ABNORM: 0000        HEALTH: 100
    ACTCONN:   0000000000
    QOSPLCACT: *DEFAULT*
      W/Q: 00
DEST:        10.1.8.10..8080
  DESTXCF:   10.1.7.21
  TOTALCONN: 0000000000  RDY: 000  WLM: 00  TSR: 100
  DISTMETHOD: SERVERWLM
  FLG:
    TCSR: 100  CER: 100 SEF: 100
    WEIGHT: 00
      RAW          CP: 00 ZAAP: 00 ZIIP: 00
      PROPORTIONAL CP: 00 ZAAP: 00 ZIIP: 00
    ABNORM: 0000        HEALTH: 100
    ACTCONN:   0000000000
    QOSPLCACT: *DEFAULT*
      W/Q: 00
```

```
DEST:        10.1.8.10..8080
  DESTXCF:   10.1.7.31
  TOTALCONN: 0000000000  RDY: 000  WLM: 00  TSR: 100
  DISTMETHOD: SERVERWLM
  FLG:
    TCSR: 100  CER: 100 SEF: 100
    WEIGHT: 00
      RAW         CP: 00 ZAAP: 00 ZIIP: 00
      PROPORTIONAL CP: 00 ZAAP: 00 ZIIP: 00
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000000
    QOSPLCACT: *DEFAULT*
      W/Q: 00
END OF THE REPORT
```

In this case, we use CP only; no application is using a zAAP or zIIP processor.

For more information about the **NETSTAT** command, see *z/OS Communications Server: IP System Administrator's Commands*, SC27-3661.

Using zIIP and zAAP with the BASEWLM distribution method

Enable the sysplex distributor to consider zIIP or zAAP processor capacity for target servers. Example 5-33 shows an extract of the profile TCP/IP for TCPIPA stack.

Example 5-33 TCP/IP definition for BASEWLM for TCPIPA stack

```
VIPADYNAMIC
   VIPADEFINE     MOVE IMMED 255.255.255.0 10.1.8.10
   VIPADISTRIBUTE DISTMETHOD BASEWLM
   PROCTYPE CP 20 ZAAP 40 ZIIP 40 10.1.8.10
   PORT 20 21
   DESTIP ALL
ENDVIPADYNAMIC
```

The PROCTYPE parameter is used in conjunction with BASEWLM and sets the weight for each kind of processor.

Example 5-34 shows the output of the **D TCPIP,TCPIPA,N,VIPADCFG,DETAIL** command.

Example 5-34 Output of NETSTAT VIPADCFG (BASEWLM) command

```
D TCPIP,TCPIPA,N,VIPADCFG,DETAIL
EZD0101I NETSTAT CS V1R13 TCPIPA 024
DYNAMIC VIPA INFORMATION:
  VIPA DEFINE:
    IPADDR/PREFIXLEN: 10.1.8.10/24
      MOVEABLE: IMMEDIATE  SRVMGR: NO  FLG:
  VIPA DISTRIBUTE:
    DEST:      10.1.8.10..20
      DESTXCF: ALL
      DISTMETHOD: BASEWLM
      SYSPT:   NO   TIMAFF: NO    FLG:
      OPTLOC:  NO
      PROCTYPE:
        CP: 20  ZAAP: 40  ZIIP: 40
    DEST:      10.1.8.10..21
      DESTXCF: ALL
      DISTMETHOD: BASEWLM
      SYSPT:   NO   TIMAFF: NO    FLG:
      OPTLOC:  NO
      PROCTYPE:
        CP: 20  ZAAP: 40  ZIIP: 40
END OF THE REPORT
```

Example 5-35 shows the output of the **D TCPIP,TCPIPA,N,VDPT,DETAIL** command.

Example 5-35 Output of NETSTAT VDPT (BASEWLM) command

```
D TCPIP,TCPIPA,N,VDPT,DETAIL
EZD0101I NETSTAT CS V1R13 TCPIPA 026
DYNAMIC VIPA DESTINATION PORT TABLE FOR TCP/IP STACKS:
DEST:        10.1.8.10..20
  DESTXCF:   10.1.7.11
  TOTALCONN: 0000000000  RDY: 000  WLM: 08  TSR: 100
  DISTMETHOD: BASEWLM
  FLG:
    TCSR: 100  CER: 100 SEF: 100
    WEIGHT: 08
      RAW          CP: 08 ZAAP: 08 ZIIP: 08
      PROPORTIONAL CP: 01 ZAAP: 03 ZIIP: 03
    ACTCONN:   0000000000
    QOSPLCACT: *DEFAULT*
      W/Q: 08
DEST:        10.1.8.10..20
  DESTXCF:   10.1.7.21
  TOTALCONN: 0000000000  RDY: 000  WLM: 00  TSR: 100
  DISTMETHOD: BASEWLM
  FLG:
    TCSR: 100  CER: 100 SEF: 100
    WEIGHT: 00
      RAW          CP: 00 ZAAP: 00 ZIIP: 00
      PROPORTIONAL CP: 00 ZAAP: 00 ZIIP: 00
    ACTCONN:   0000000000
    QOSPLCACT: *DEFAULT*
      W/Q: 00
DEST:        10.1.8.10..20
  DESTXCF:   10.1.7.31
  TOTALCONN: 0000000000  RDY: 000  WLM: 00  TSR: 100
  DISTMETHOD: BASEWLM
  FLG:
    TCSR: 100  CER: 100 SEF: 100
    WEIGHT: 00
      RAW          CP: 00 ZAAP: 00 ZIIP: 00
      PROPORTIONAL CP: 00 ZAAP: 00 ZIIP: 00
    ACTCONN:   0000000000
    QOSPLCACT: *DEFAULT*
      W/Q: 00
DEST:        10.1.8.10..21
  DESTXCF:   10.1.7.11
  TOTALCONN: 0000000000  RDY: 000  WLM: 08  TSR: 100
  DISTMETHOD: BASEWLM
  FLG:
    TCSR: 100  CER: 100 SEF: 100
    WEIGHT: 08
      RAW          CP: 08 ZAAP: 08 ZIIP: 08
      PROPORTIONAL CP: 01 ZAAP: 03 ZIIP: 03
    ACTCONN:   0000000000
    QOSPLCACT: *DEFAULT*
      W/Q: 08
DEST:        10.1.8.10..21
  DESTXCF:   10.1.7.21
  TOTALCONN: 0000000000  RDY: 000  WLM: 00  TSR: 100
  DISTMETHOD: BASEWLM
  FLG:
    TCSR: 100  CER: 100 SEF: 100
    WEIGHT: 00
      RAW          CP: 00 ZAAP: 00 ZIIP: 00
      PROPORTIONAL CP: 00 ZAAP: 00 ZIIP: 00
    ACTCONN:   0000000000
    QOSPLCACT: *DEFAULT*
      W/Q: 00
DEST:        10.1.8.10..21
  DESTXCF:   10.1.7.31
  TOTALCONN: 0000000000  RDY: 000  WLM: 00  TSR: 100
  DISTMETHOD: BASEWLM
  FLG:
    TCSR: 100  CER: 100 SEF: 100
    WEIGHT: 00
      RAW          CP: 00 ZAAP: 00 ZIIP: 00
      PROPORTIONAL CP: 00 ZAAP: 00 ZIIP: 00
    ACTCONN:   0000000000
    QOSPLCACT: *DEFAULT*
      W/Q: 00
```

Each port can be reached using the destination address through the XCF address.

5.4 Port sharing

For a TCP server application to support a large number of client connections on a single system, it might be necessary to run more than one instance of the server application. (This situation assumes that the application design allows this usage.) *Port sharing* is a method to distribute workload for IP applications *within* a z/OS LPAR. TCP/IP allows multiple listeners to listen on the same combination of port and interface. Workload destined for this application can be distributed among the group of servers that listen on the same port. Port sharing does not rely on an active sysplex distributor implementation; it works without sysplex distributor. However, you can use port sharing in addition to sysplex distributor operation.

5.4.1 SHAREPORT operation modes

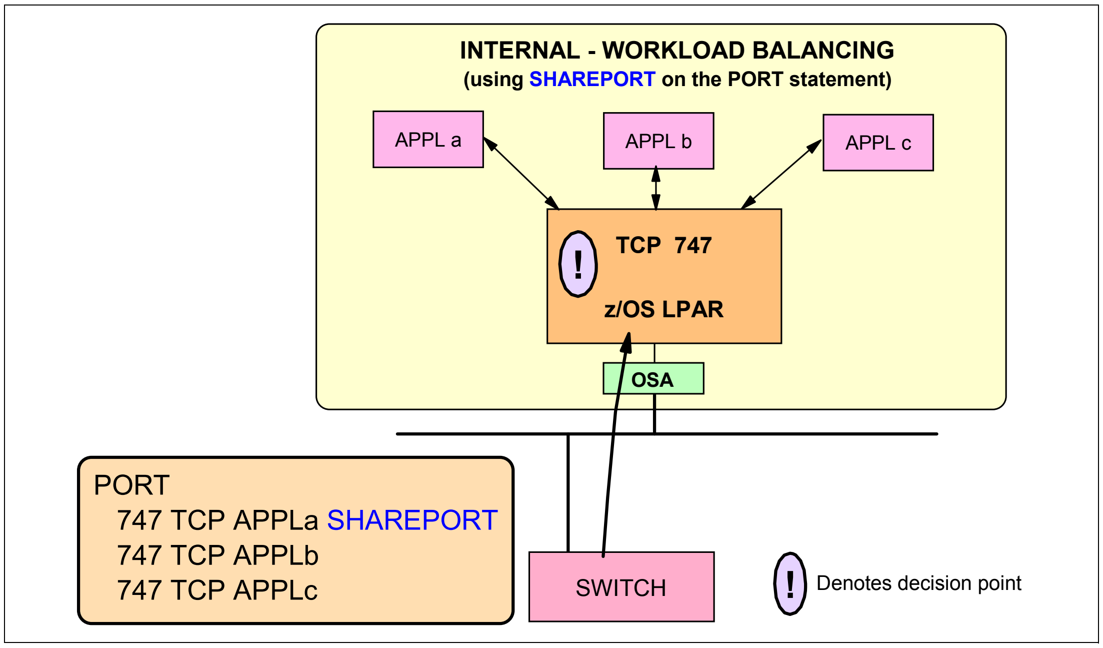
z/OS currently supports the following modes of port sharing:

- SHAREPORT
- SHAREPORTWLM

SHAREPORT

When specified on the PORT statement, incoming client connections for this port and interface are distributed by the TCP/IP stack across the listeners, using a weighted round-robin distribution method based on the Server accept Efficiency Fractions (SEFs) of the listeners sharing the port. The SEF is a measure of the efficiency of the server application, calculated at intervals of approximately one minute, in accepting new connection requests and managing its backlog queue.

Figure 5-17 shows a simple configuration where SHAREPORT is used for internal workload balancing.


INTERNAL - WORKLOAD BALANCING
(using SHAREPORT on the PORT statement)
APPL a
APPL b
APPL c
!
TCP 747
z/OS LPAR
OSA
SWITCH
!
Denotes decision point

```
PORT
  747 TCP APPLa SHAREPORT
  747 TCP APPLb
  747 TCP APPLc
```

Figure 5-17 The TCP/IP stack is the decision-maker using a weighted round-robin method

SHAREPORTWLM

You can use the SHAREPORTWLM option instead of SHAREPORT. Similar to SHAREPORT, SHAREPORTWLM causes incoming connections to be distributed among a set of TCP listeners. However, unlike SHAREPORT, the listener selection is based on WLM server-specific recommendations, modified by the SEF values for each listener. These recommendations are acquired at intervals of approximately one minute from WLM, and they reflect the listener's capacity to handle additional work.

Automatically included: zAAP and zIIP processor capacity is automatically included when the SHAREPORTWLM parameter is specified and all systems in the sysplex are V1R9 or later.

Figure 5-18 shows a simple configuration where SHAREPORTWLM is used for internal workload balancing.

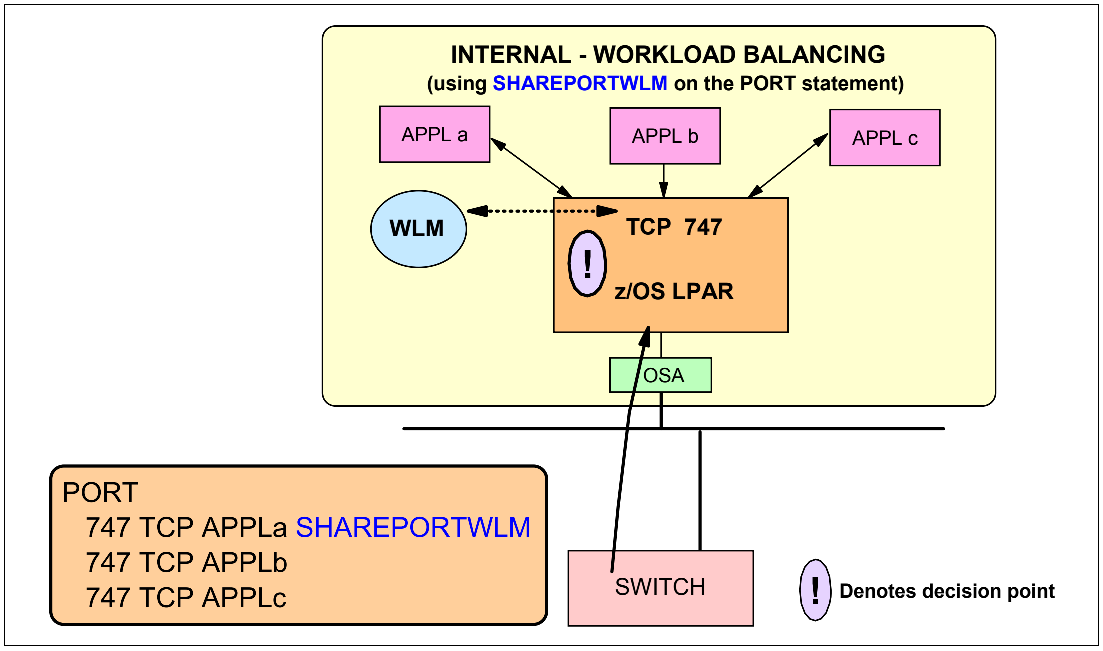


Figure 5-18 The TCP/IP stack is the decision-maker using server-specific WLM data

5.4.2 Implementing port sharing using SHAREPORTWLM

In an environment where you need to support a large number of client connections on a single system while maintaining good performance, the use of SHAREPORT or SHAREPORTWLM might be the best approach. A group of servers that share the same port benefit from using the server-specific WLM recommendations because the workload is more evenly balanced between them.

The SHAREPORTWLM keyword in the PORT profile statements indicates that multiple application instances can use this port. The set of server instances sharing the same TCP port on the same TCP/IP stack is known as a *shareport group*.

In our case, we define a TN3270 server shareport group, consisting of three TN3270 server instances, on our distribution stack SC30. We do not change the remaining TN3270 servers on systems SC31 and SC32.

Our goal is to distribute incoming TN3270 connections among our five TN3270 servers, based on the individual server weight (server-specific WLM) by combining the use of the sysplex distributor and the shareport function, as illustrated in Figure 5-19.

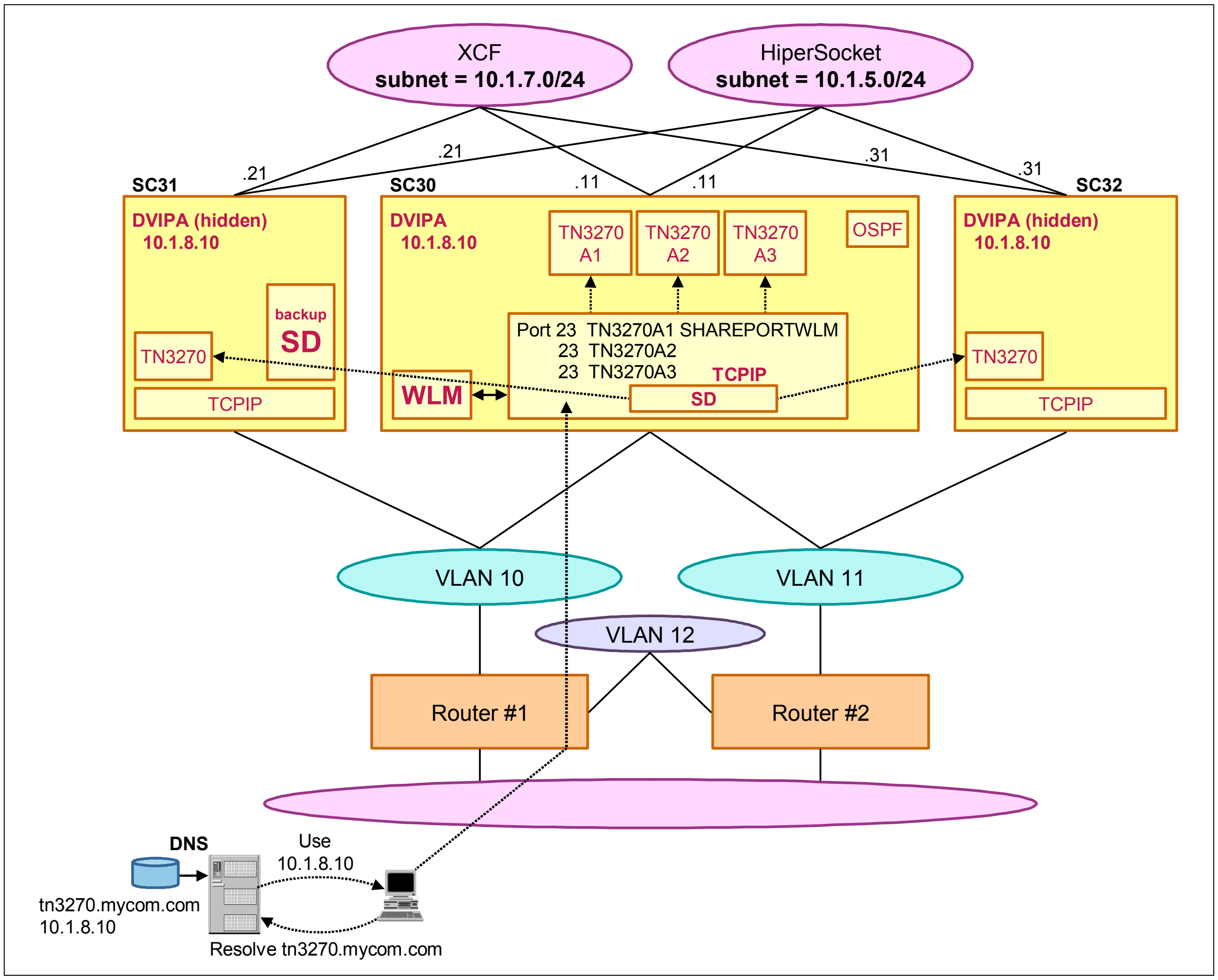


Figure 5-19 Internal workload balancing using SHAREPORTWLM

Implementation tasks

The SHAREPORTWLM parameter in the PORT statement is required to reserve a port that is shared across multiple listeners on the same interface.

We complete the following tasks to implement multiple TN3270 servers sharing a TCP port:

1. Define the TN3270 shareport group in TCP/IP profile.
2. Define TN3270 profile statements.
3. Define the TN3270 procedures in SYS1.PROCLIB.

Define the TN3270 shareport group in TCP/IP profile

As shown in Example 5-36, we allow three TN3270 servers to listen on the same port. We also specify VIPADISTRIBUTE statement load balancing among the three systems: SC30, SC31, and SC32. We use WEIGHTEDActive method to give SC30 system a higher weight than the other two systems, because SC30 has three TN3270 servers and the other two systems have only one TN3270 server each.

> **Note:** We could specify SHAREPORT instead of the SHAREPORTWLM. With SHAREPORT, incoming connection requests would be distributed in a weighted round-robin fashion. We choose SHAREPORTWLM, because we want to use the more accurate server-specific WLM weights.

Example 5-36 Define the TN3270 shareport group on SC30

```
VIPADYNAMIC
 VIPADEFINE      MOVE IMMED    255.255.255.0 10.1.8.10
 VIPADISTRIBUTE DISTMETHOD WEIGHTEDACTIVE 10.1.8.10
 PORT 23 DESTIP 10.1.7.11 WEIGHT 30
                10.1.7.21 WEIGHT 10
                10.1.7.31 WEIGHT 10
ENDVIPADYNAMIC

PORT
     20 TCP *  NOAUTOLOG              ; FTP Server
     21 TCP OMVS                      ; control port
     23 TCP TN3270A1 SHAREPORTWLM     ; MVS Telnet Server sep.addrspace
     23 TCP TN3270A2                  ; MVS Telnet Server sep.addrspace
     23 TCP TN3270A3                  ; MVS Telnet Server sep.addrspace
```

Define TN3270 profile statements

Example 5-37 lists a part of the TN3270 profile for the first of our three TN3270 servers. The others are almost identical. The only difference is the definition of the ranges within the DEFAULTLUS/ENDDEFAULTLUS parameters (**1**), so that we can more easily monitor where our TN3270 connections went.

Example 5-37 Define a separate TN3270 profile member: TN3270A1

```
TelnetParms
...
EndTelnetParms
 ;
BeginVTAM
  Port 23
  DEFAULTLUS
    SC30L101..SC30L199 1
  ENDDEFAULTLUS
...
EndVTAM
```

Define the TN3270 procedures in SYS1.PROCLIB

For each of our three TN3270 servers, we define a separate start procedure in SYS1.PROCLIB pointing to the respective TN3270 parameter member located in our TCPPARMS data set. The three procedures are the same except for the name and the profile name, as shown in Example 5-38.

Example 5-38 Define a TN3270 procedure: TN3270A1

```
SYS1.PROCLIB(TN3270A1) - 01.01                  Columns 00001 00072
===>                                                   Scroll ===> CSR
***************************** Top of Data *****************************
//TN3270A1 PROC PARMS='CTRACE(CTIEZBTN)'
//TN3270A  EXEC PGM=EZBTNINI,REGION=0M,PARM='&PARMS'
//SYSPRINT DD SYSOUT=*,DCB=(RECFM=VB,LRECL=132,BLKSIZE=136)
//SYSOUT   DD SYSOUT=*,DCB=(RECFM=VB,LRECL=132,BLKSIZE=136)
//CEEDUMP  DD SYSOUT=*,DCB=(RECFM=VB,LRECL=132,BLKSIZE=136)
//PROFILE  DD DISP=SHR,DSN=TCPIPA.TCPPARMS(TN3270A1)
//SYSTCPD  DD DSN=TCPIPA.TCPPARMS(DATAA&SYSCLONE),DISP=SHR
=======================================================================
```

Verification

We use the following steps to verify that our TN3270 shareport group implementation was correct:

1. Start all three TN3270 servers
2. Verify TN3270 servers are running and listening on the same port
3. Verify that server-specific WLM is used for distributing TN3270 connections
4. Start several TN3270 connections

Start all three TN3270 servers

Example 5-39 displays the PORTList defined on TCPIPA stack. Notice the port 23 is reserved for TN3270A1, TN3270A2, and TN3270A3 **1**.

Example 5-39 PORTList display

```
D TCPIP,TCPIPA,N,PORTL
EZD0101I NETSTAT CS V1R13 TCPIPA 401
PORT# PROT USER     FLAGS    RANGE       SAF NAME
23    TCP  TN3270A3 DASW 1
23    TCP  TN3270A2 DASW 1
23    TCP  TN3270A1 DASW 1
```

We start our three TN3270 server instances within the same LPAR, as shown in Example 5-40.

Example 5-40 Start TN3270A1

```
S TN3270A1
$HASP100 TN3270A1 ON STCINRDR
IEF695I START TN3270A1 WITH JOBNAME TN3270A1 IS ASSIGNED TO USER
TCPIP   , GROUP TCPGRP
$HASP373 TN3270A1 STARTED
IEE252I MEMBER CTIEZBTN FOUND IN SYS1.IBM.PARMLIB
EZZ6001I TN3270A1 SERVER STARTED
EZZ6044I TN3270A1 PROFILE PROCESSING BEGINNING FOR FILE 392
            TCPIPA.TCPPARMS(TN3270A1)
```

```
EZZ6045I TN3270A1 PROFILE PROCESSING COMPLETE FOR FILE
            TCPIPA.TCPPARMS(TN3270A1)
EZZ6003I TN3270A1 LISTENING ON PORT    23

S TN3270A1
$HASP100 TN3270A1 ON STCINRDR
IEF695I START TN3270A1 WITH JOBNAME TN3270A1 IS ASSIGNED TO USER
TCPIP   , GROUP TCPGRP
$HASP373 TN3270A1 STARTED
IEE252I MEMBER CTIEZBTN FOUND IN SYS1.IBM.PARMLIB
EZZ6001I TELNET SERVER STARTED
EZZ6044I TELNET PROFILE PROCESSING BEGINNING FOR FILE 538
            TCPIPA.TCPPARMS(TNSC30A1)
EZZ6045I TELNET PROFILE PROCESSING COMPLETE FOR FILE 539
            TCPIPA.TCPPARMS(TNSC30A1)
EZZ6003I TELNET LISTENING ON PORT    23

S TN327A2
$HASP100 TN3270A2 ON STCINRDR
...
EZZ6003I TN3270A2 LISTENING ON PORT    23

S TN3270A3
$HASP100 TN3270A3 ON STCINRDR
...
EZZ6003I TN3270A3 LISTENING ON PORT    23
```

Verify TN3270 servers are running and listening on the same port

We verify that all three TN3270 servers are running and listening on the same port by using a **NETSTAT,CONN** command in SC30, as shown in Example 5-41.

Example 5-41 Display NETSTAT,CONN on SC30

```
D TCPIP,TCPIPA,N,CONN
EZD0101I NETSTAT CS V1R13 TCPIPA 433
USER ID  CONN     STATE
TN3270A1 0000004E LISTEN 1
  LOCAL SOCKET:   ::..23 2
  FOREIGN SOCKET: ::..0
TN3270A2 00000059 LISTEN 1
  LOCAL SOCKET:   ::..23 2
  FOREIGN SOCKET: ::..0
TN3270A3 0000005E LISTEN 1
  LOCAL SOCKET:   ::..23 2
  FOREIGN SOCKET: ::..0
```

This output verifies the following information:

1. All three TN3270 servers are running and listening.
2. All three servers are using the same port 23.

Verify that server-specific WLM is used for distributing TN3270 connections

We then verify that server-specific WLM is used for distributing TN3270 connections, as shown in Example 5-42.

Example 5-42 Display NETSTAT,VIPADCFG on SC30, TCPIPA

```
D TCPIP,TCPIPA,N,VIPADCFG
EZD0101I NETSTAT CS V1R13 TCPIPA 502
DYNAMIC VIPA INFORMATION:
  VIPA DEFINE:
    IPADDR/PREFIXLEN: 10.1.8.10/24
      MOVEABLE: IMMEDIATE  SRVMGR: NO  FLG:
  VIPA DISTRIBUTE:
    DEST:      10.1.8.10..23
      DESTXCF: 10.1.7.11
      DISTMETHOD: WEIGHTEDACTIVE
      SYSPT:   NO   TIMAFF: NO    FLG:
    DEST:      10.1.8.10..23
      DESTXCF: 10.1.7.21
      DISTMETHOD: WEIGHTEDACTIVE
      SYSPT:   NO   TIMAFF: NO    FLG:
    DEST:      10.1.8.10..23
      DESTXCF: 10.1.7.31
      DISTMETHOD: WEIGHTEDACTIVE
      SYSPT:   NO   TIMAFF: NO    FLG:
END OF THE REPORT
```

In this output (1), DISTMETHOD: WEIGHTEDACTIVE indicates that WEIGHTActive method is active and is used.

Start several TN3270 connections

We start 10 TN3270 connections from one of our workstations. To verify the distribution among all TN3270 servers, including our three TN3270 servers belonging to the shareport group on system SC30, we first issue the **NETSTAT,VDPT,DETAIL** command, as shown in Example 5-43.

Example 5-43 Display NETSTAT,VDPT,DETAIL on SC30

```
D TCPIP,TCPIPA,N,VDPT,DETAIL
EZD0101I NETSTAT CS V1R13 TCPIPA 533
DYNAMIC VIPA DESTINATION PORT TABLE FOR TCP/IP STACKS:
DEST:        10.1.8.10..23
  DESTXCF:   10.1.7.11
  TOTALCONN: 0000000006  RDY: 003 2 WLM: 30  TSR: 100
  DISTMETHOD: WEIGHTEDACTIVE
  FLG:
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000006 1
DEST:        10.1.8.10..23
  DESTXCF:   10.1.7.21
  TOTALCONN: 0000000002  RDY: 001 2 WLM: 10  TSR: 100
  DISTMETHOD: WEIGHTEDACTIVE
  FLG:
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000002 1
DEST:        10.1.8.10..23
  DESTXCF:   10.1.7.31
  TOTALCONN: 0000000017  RDY: 001 2 WLM: 10  TSR: 100
  DISTMETHOD: WEIGHTEDACTIVE
  FLG:
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000002 1
3 OF 3 RECORDS DISPLAYED
END OF THE REPORT
```

This output shows the following important information:

1. ACTCONN indicates the number of TN3270 connections per LPAR.

2. RDY indicates the number of TN3270 servers listening on the port.

In our implementation, we customize our distribution stack, SC30, to be able to run three TN3270 servers as separate address spaces, all belonging to the same shareport group. These TN3270 servers are active and running, as indicated by `RDY: 003`. Of the 10 total TN3270 connections, system SC30 received 6, SC31 received 2, and SC32 received 2.

To determine the distribution of the 10 TN3270 connections within our shareport group on SC30, we use the specific TN3270 commands shown in Example 5-44, Example 5-45, and Example 5-46 on page 189.

Example 5-44 Display TELNET,CONN for our first TN3270 server TN3270A1 on SC30

```
D TCPIP,TN3270A1,T,CONN
EZZ6064I TN3270A1 CONN DISPLAY 536
         EN                                          TSP
CONN     TY IPADDR..PORT           LUNAME   APPLID   PTR LOGMODE
-------- -- --------------------- -------- --------  --- --------
000001F9    ::FFFF:10.1.100.222..2075
                                  SC30L101 SC30TS03  TAE SNX32702
000001FF    ::FFFF:10.1.100.222..2080
                                  SC30L102 SC30TS06  TAE SNX32702
----- PORT:    23  ACTIVE          PROF: CURR CONNS:      2   1
------------------------------------------------------------
```

Example 5-45 Display TELNET,CONN for our second TN3270 server TN3270A2 on SC30

```
D TCPIP,TN3270A2,T,CONN
EZZ6064I TN3270A2 CONN DISPLAY 540
         EN                                          TSP
CONN     TY IPADDR..PORT           LUNAME   APPLID   PTR LOGMODE
-------- -- --------------------- -------- --------  --- --------
000001FB    ::FFFF:10.1.100.222..2076
                                  SC30L201 SC30TS04  TAE SNX32702
00000201    ::FFFF:10.1.100.222..2081
                                  SC30L202 SC30TS07  TAE SNX32702
----- PORT:    23  ACTIVE          PROF: CURR CONNS:      2  1
------------------------------------------------------------
```

Example 5-46 Display TELNET,CONN for our third TN3270 server TN3270A3 on SC30

```
D TCPIP,TN3270A3,T,CONN
EZZ6064I TN3270A3 CONN DISPLAY 542
         EN                                           TSP
CONN     TY IPADDR..PORT            LUNAME   APPLID   PTR LOGMODE
-------- -- --------------------- -------- --------   --- --------
000001F7    ::FFFF:10.1.100.222..2074
                                   SC30L301 SC30TS02  TAE SNX32702
000001FD    ::FFFF:10.1.100.222..2079
                                   SC30L302 SC30TS05  TAE SNX32702
----- PORT:    23  ACTIVE           PROF: CURR CONNS:      2  1
------------------------------------------------------------
```

When we add the number of connections reported by each TN3270 server on SC30 under `CURR CONNS:` (1), we obtain six connections for the TN3270 port sharing group, which is the expected result.

5.5 Problem determination

To diagnose a sysplex distributor problem, you can use a combination of the **netstat** command from the system console and display sysplex commands to provide a clear picture of the sysplex. Before beginning problem determination, however, you should understand the entire sysplex environment. Creating a diagram of your configuration, including all the IP addresses for all the paths involved, is useful. Saving and reviewing all related log files can also be helpful in narrowing down where the problem might be located.

When the problem is actually occurring, you can also use certain commands to help with the problem determination. The **NETSTAT** command has several sysplex-related reports that can be used to verify the status of your environment.

You can use the following commands to provide the necessary diagnosis information:

- Run the **display NETSTAT CONFIG/-f** command on the distributing stack and all target stacks to confirm that the correct IPCONFIG and IPCONFIG6 options have been specified.
- Run the **display NETSTAT VIPADYN/-v** command on the distributing stack to verify that the DVIPA status is ACTIVE and the distribution status is DIST or DIST/DEST.
- Run the **display NETSTAT VIPADYN/-v** command on the target stacks to verify that they have activated the distributed DVIPA and have it designated as a DEST.
- Run the **Sysplex VIPADyn** command from any stack in the sysplex to get a global view of how and where DVIPAs are defined within the sysplex and what their status is on each stack. Deactivated DVIPA configurations do not appear in this display.
- Run the **NETSTAT VDPT/-O** command on the distributing stack to confirm that there are target stacks available with server applications ready.
- Examine the READY (RDY) count fields. The READY (RDY) count is the number of servers that are currently listening on the DVIPA and PORT specified in the DEST: field on the target stack that was identified by the DESTXCF address.

- Check the TotalConn count to see the distribution history. This is a cumulative count of the number of connections that have been forwarded by the distributing stack to each target stack.
- Use the **`NETSTAT VCRT/-V`** command on the distributing stack to check whether there are any active connections that are being routed by the distributor. If you run the command with the keyword DETAIL (**`d tcpip,tcpcs,net,vcrt,detail`**), you can see the policy rule and policy action that each connection maps to.
- Go to the target stacks represented by the DESTXCF ADDR field in the VCRT or VDPT display and run the following display command to see the connections on the target stack:

  ```
  NETSTAT ALLCONN(/-a),IPA=destxcf-addr
  ```

You may use the following steps to diagnose a sysplex problem on z/OS Communications Server (based on the information presented in *z/OS Communications Server: IP Diagnosis Guide*, GC31-8782):

1. Determine that all the stacks that you expect to be communicating with are in the same sysplex or subplex (if subplexing is being used). Run the **`D XCF,GROUP MVS`** command to determine what groups are being used in the sysplex.
2. For problems where the actual DVIPAs defined on a stack are not what you expected, check the current definitions by using the **`NETSTAT VIPADCFG/-F`** display command on the distributing stack to confirm that it is configured to distribute the DVIPA and determine how it is to be distributed.
3. For sysplex distributor workload monitoring, use the **`NETSTAT VDPT/-O`** and **`NETSTAT VCRT/-V`** commands on the distributing stack. If the output from these commands is not what you expect, use the **`Sysplex VIPADyn`** command to gain an overall picture of all DVIPA activity in your sysplex.
4. If the output from the command Sysplex VIPADyn reveals an expected target stack not listed for a distributed DVIPA, execute the **`NETSTAT CONFIG/-f`** command on the target stack in question. This helps to identify configuration problems on that stack. Note what is required of target stacks. Also, use the following command to verify that a server application has indeed been activated and bound to the correct port:

   ```
   NETSTAT ALLCONN(/-a),IPA=destxcf-addr
   ```

5. To help follow the flow of packets into and throughout the sysplex, use a CTRACE with options XCF, TCP, and SYSTCPDA on participating stacks. This step can help you with the following tasks:
   - Identify the connection being received by the distributing stack
   - Determine the stack to which the connection is forwarded
   - Verify the connection being forwarded
   - Determine the expected target stack receiving and processing the connection

   After the connection has been established, subsequent packets can be followed in the same manner. When the connection is terminated, CTRACE records record target stacks, cleans up the connection, and notifies the distributing stack.

For further information about sysplex distributor diagnosis, see *z/OS Communications Server: IP Diagnosis Guide*, GC31-8782.

6

External application workload balancing

With external application workload distribution, decisions for load balancing are made by external devices. Such devices typically have robust capabilities and are often part of a suite of networking components. They usually have a significant amount of processing capacity, giving them the ability to make decisions using higher-layer information buried deep inside of datagrams rather than just using IP addresses, including application-specific information such as HTTP (or FTP) URLs.

The latest improvement in this area is the ability of external load balancers to be z/OS sysplex-aware, all the way to the application level. This is achieved by implementing the z/OS Load Balancing Advisor (LBA) solution that uses the Server/Application State Protocol (SASP).

This chapter contains the following topics.

Section	Topic
6.1, "Basic concepts of external load balancing" on page 192	Basic concepts of external application workload balancing and key characteristics
6.2, "Example of external load balancer without LBA/SASP" on page 200	► A scenario without LBA/SASP including dependencies, advantages, considerations, and recommendations ► Implementation tasks, configuration examples, and problem determination suggestions
6.3, "Example of external load balancer with LBA/SASP" on page 213	► A scenario with LBA/SASP including its dependencies, advantages, considerations, and recommendations ► Implementation tasks, configuration examples, and problem determination suggestions

6.1 Basic concepts of external load balancing

From a z/OS viewpoint, there are two types of external load balancers available today. One type bases decisions completely on parameters in the external mechanism, and the other type uses sysplex awareness matrixes for each application and each z/OS system as part of the decision process. Which technique is best depends on many factors, but the best method usually involves knowledge of the health and status of the application-instances and the z/OS systems. Enhancements in Workload Manager (WLM) allow the export of status data for each application instance and the z/OS system itself.

The content in this chapter is based on workload balancing with the use of switches and a Content Switching Module (CSM) as the load balancing device. The CSM is one of the external load balancers that supports SASP.

If optimized multitier application load balancing is planned within an intra-sysplex environment in addition to external load balancing, see Chapter 7, “Intra-sysplex workload balancing” on page 239 for further information about this topic.

6.1.1 Understanding directed mode load balancing

Directed mode load balancing works by changing the destination IP address of the inbound IP packets to the IP address of the chosen target stack. One of the advantages of directed mode is that there can be any number of router hops in between the load balancer and the target stacks.

A characteristic of directed mode is that outbound packets must be directed back through the load balancer so that the load balancer can change the source IP address of the outbound IP packets from the IP address of the target stack to the cluster IP address. If this is not done, the remote client rejects the response because it would appear to come from an IP address other than the one to which it sent a request. Another reason that outbound packets must be directed back using the load balancer is that the load balancer keeps track of the flows passing through it and this information is used for fault tolerance purposes.

There are two ways to ensure outbound routing back through the load balancer:

- The load balancer can be configured to change only the *destination* IP address in inbound IP packets, and not the source IP address. In this case, the target stack responds with IP packets back directly to the client IP address. These packets must be directed to the load balancer for it to change the *source* IP address in the outbound packets. This task can be achieved in two ways:
  - By having all outbound packets routed through the load balancer (using a default route definition on the target stacks).

– By having the routing infrastructure between the load balancer and the target node implement policy-based routing (PBR) where the routers recognize IP packets from the clustered servers (based on source IP address, source port number, or both). In this configuration, the router sends only those packets back through the load balancer, while outbound packets for workload that were not balanced are routed directly back to the clients. This is known as server NAT mode and is illustrated in Figure 6-1.

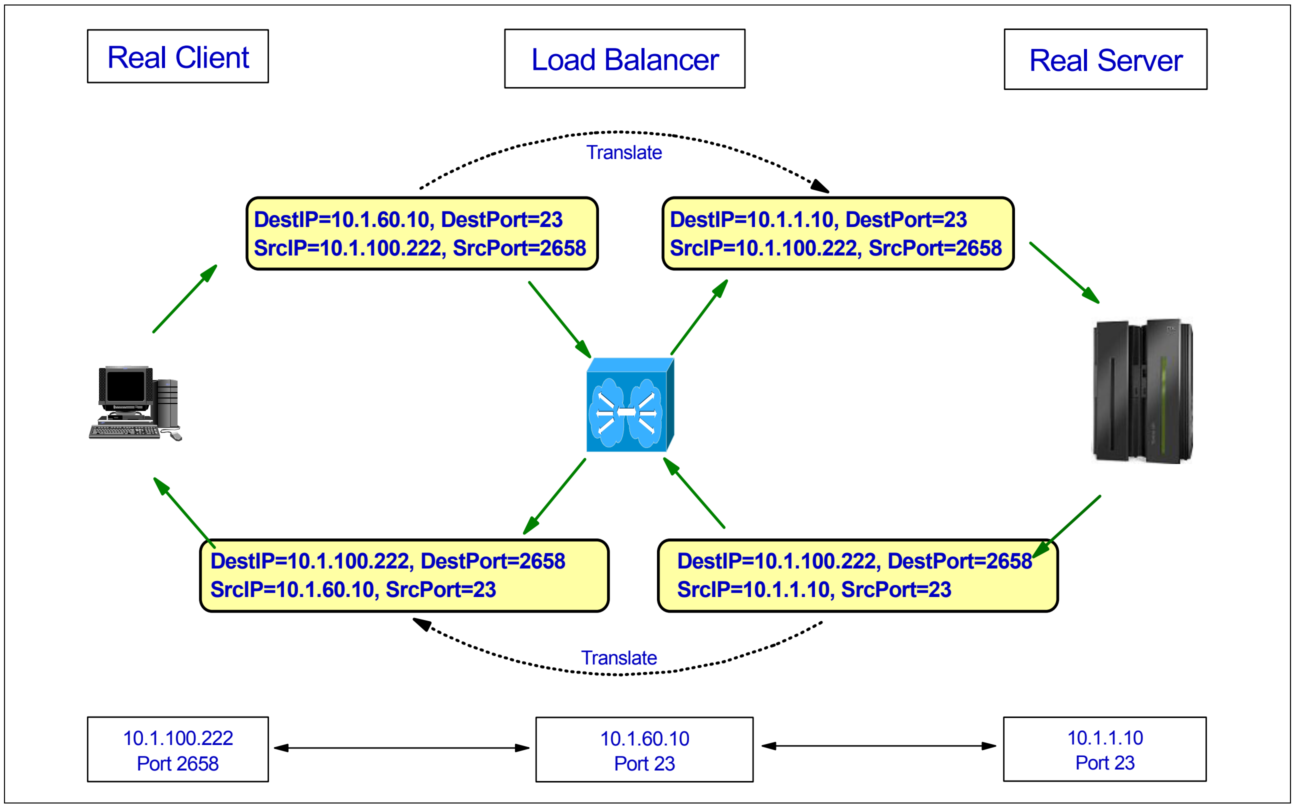

Real Client
Load Balancer
Real Server
Translate
DestIP=10.1.60.10, DestPort=23
SrcIP=10.1.100.222, SrcPort=2658
DestIP=10.1.1.10, DestPort=23
SrcIP=10.1.100.222, SrcPort=2658
DestIP=10.1.100.222, DestPort=2658
SrcIP=10.1.60.10, SrcPort=23
DestIP=10.1.100.222, DestPort=2658
SrcIP=10.1.1.10, SrcPort=23
Translate
10.1.100.222
Port 2658
10.1.60.10
Port 23
10.1.1.10
Port 23

Figure 6-1 Server NAT with policy-based routing

- The load balancer can be configured to change both the destination IP address and the source IP address in the inbound IP packets, known as server NAT and client NAT mode. The advantage of this method is that outbound IP packets from the target stacks are sent with the destination IP address of the load balancer. The load balancer then changes the packet to match the original cluster IP address as source and client IP address as destination. This is illustrated in Figure 6-2.

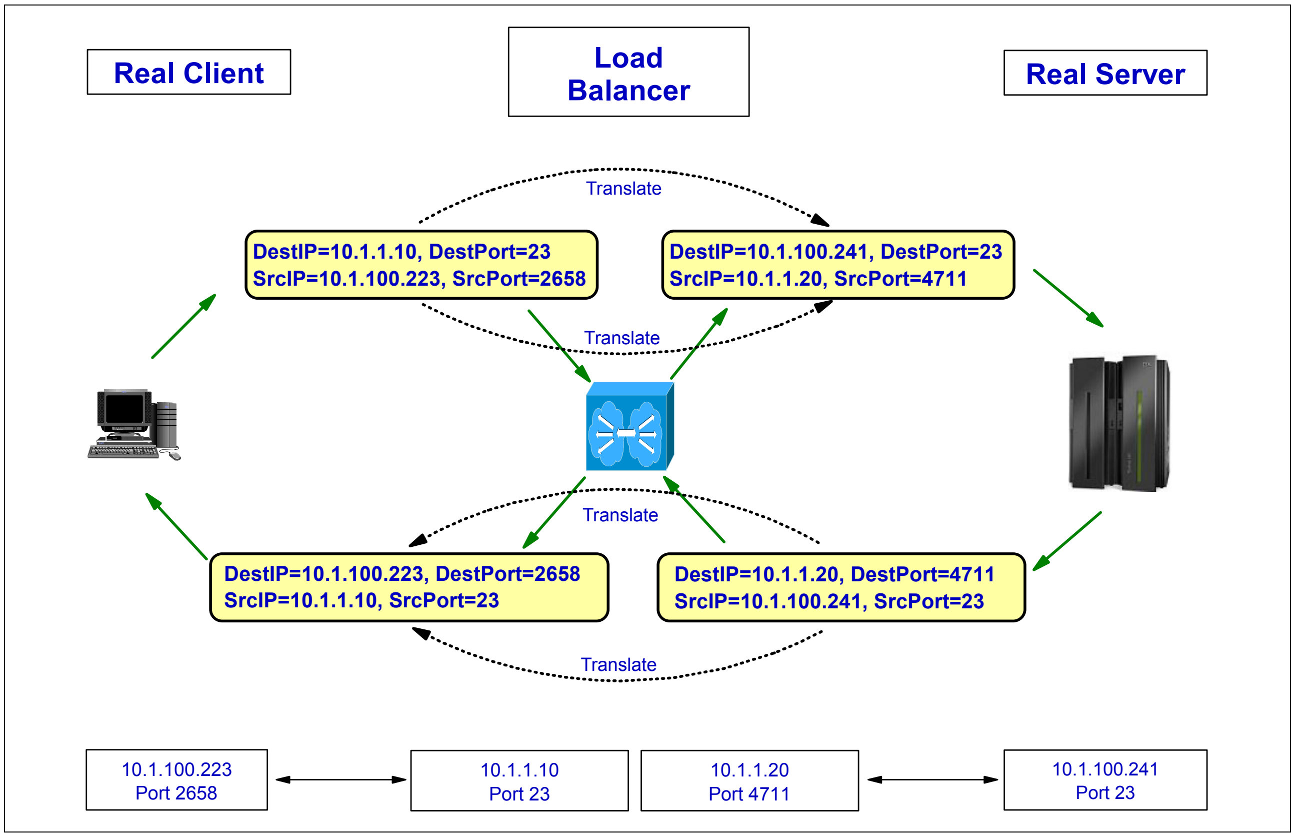

Real Client
Load Balancer
Real Server
Translate
DestIP=10.1.1.10, DestPort=23
SrcIP=10.1.100.223, SrcPort=2658
DestIP=10.1.100.241, DestPort=23
SrcIP=10.1.1.20, SrcPort=4711
Translate
Translate
DestIP=10.1.100.223, DestPort=2658
SrcIP=10.1.1.10, SrcPort=23
DestIP=10.1.1.20, DestPort=4711
SrcIP=10.1.100.241, SrcPort=23
Translate
10.1.100.223 Port 2658
10.1.1.10 Port 23
10.1.1.20 Port 4711
10.1.100.241 Port 23

Figure 6-2 Server NAT with client NAT

From a target server view, it appears that all connections come from one client source IP address (that of the load balancer), but each client connection comes from a separate source port number on that load balancer. One consequence is that servers cannot see the real client IP address, and this can complicate diagnosing network-related problems.

Client NAT can have an impact on z/OS networking policy functions. Networking policies on z/OS might apply network QoS differentiated services, selection of Intrusion Detection Service (IDS) actions, and Traffic Regulation (TR) limitations. z/OS networking policies are specified using policy conditions and actions. The conditions can be defined in various ways, one of which is to use the client source IP address.

One example is to apply high-priority outbound treatment to traffic that is destined for a specific user community, such as all IP addresses that belong to the client query department. If client NAT is used by the load balancer, all inbound packets appear to come from one IP address (that of the load balancer), and networking policy conditions that were defined based on the real client IP addresses are not applied to that traffic.

Another z/OS function that is impacted by client NAT is a NETACCESS rule. A NETACCESS rule can be used to authorize individual z/OS users to communicate with selected sections of a network identified by prefix definitions in the NETACCESS policies in the z/OS TCP/IP configuration files. NETACCESS rules might also be used to assign

Multi Level Security (MLS) labels to inbound IP packets in an MLS-enabled security environment.

If z/OS networking policies are based on client IP addresses, or if NETACCESS rules are in use, client NAT should be used with care, because it might disrupt the operation of those functions.

To complete this discussion, care is also needed when using client NAT to TN3270 servers that use the client source IP address or host name to choose TN3270 connection options, such as selecting an LU name or a primary SNA application for a given connection.

6.1.2 z/OS Load Balancer Advisor

The z/OS Load Balancer Advisor is a component that allows any external load balancing solution to become sysplex-aware. The external load balancer must support the Server Application State Protocol (SASP) to obtain sysplex information through this function. The general Load Balancing Advisor flow is illustrated in Figure 6-3.

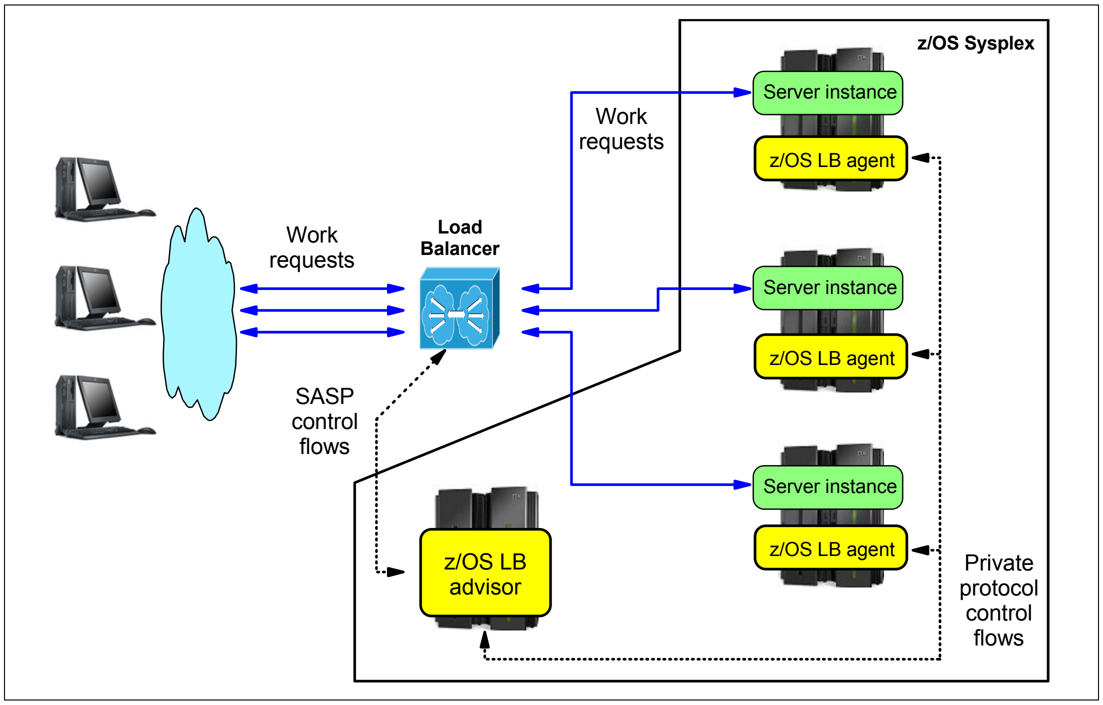


Figure 6-3 z/OS Load Balancing Advisor overview

The z/OS Load Balancing Advisor consists of two z/OS applications:

- z/OS Load Balancing Advisor

  The advisor is an MVS started task and has one primary instance per sysplex. A backup advisor can be implemented as a secondary instance. The advisor collects information from z/OS Load Balancing Agents in the sysplex using a private protocol through a TCP connection. This z/OS sysplex awareness information is then communicated to the external load balancers using the SASP protocol.

  The advisor provides awareness information from any TCP/UDP server application within the sysplex. It acts as the SASP server using TCP Port 3860 (configurable) and can communicate with multiple external load balancers.

- z/OS Load Balancing Agent

  An agent is an MVS started task and has one instance per system. The agent collects information about z/OS and applications. The information is then sent to the advisor using the private protocol.

The sysplex awareness information is collected by the advisor and sent to the external load balancer so the load balancer can decide which application instance is best for the next request. The recommendations are derived from the following key components:

- State of the target application and system

  This component includes an indication of whether the target application and target system are currently active, enabling the load balancer to exclude systems that are not active or do not have the desired application running.

- z/OS Workload Management (WLM) system-wide recommendations

  WLM recommendations provide a relative measure of a target system's ability to handle new workload, as compared to other target systems in the sysplex. WLM recommendations are derived from many measurements, including each system's available CPU capacity or capacity that can be displaced by higher importance workloads. The latter is important where systems might be 100% utilized, but are running work that has a lower importance (as defined by the WLM policy) and can be displaced by higher importance workload.

- z/OS WLM server-specific recommendations

  These recommendations are similar to the WLM system-wide recommendations, but also contain an indication of how well individual server applications are doing compared to the WLM policy goals that have been specified for that workload. These recommendations can be useful in helping load balancers avoid selecting application servers that are experiencing performance problems (that is, not meeting the specified WLM policy goals).

- Application server health from a TCP/IP perspective

  TCP/IP statistics for target applications are monitored to determine whether specific server applications are encountering problems keeping up with the current workload. For example, are requests being rejected because the backlog queue is full? In situations such as this one, the load balancer can direct fewer connections to any application that is experiencing these problems. Recommendations are provided for both UDP and TCP server applications. These recommendations are referred to as Communications Server *weights* in this chapter.

The information sent to the load balancer is represented in the form of a weight that is composed of two main elements:

- WLM weight

  This refers to the WLM weight that is known from other WLM-based load balancing solutions, such as sysplex distributor. The WLM weight has a numeric value between 0 and 64.

- Communications Server weight

  The Communications Server weight is calculated based on the availability of the actual application instances (are they up and ready to accept workload?) and how well TCP/IP and the individual application instance process the workload that is sent to them. The Communications Server weight has a numeric value between 0 and 100.

There are several reasons for the calculation of the Communications Server weight. One reason is to prevent a stalled application instance from being sent more work. Another is to proactively react to an application instance that is becoming overloaded. It can accept new connections, but the size of the backlog queue increases over time and is approaching the max backlog queue size.

The final weight that is sent to the load balancer is calculated by combining the WLM and Communications Server weights into a single metric:

```
Final weight = (WLM weight * CS weight) / 100
```

6.1.3 Server/Application State Protocol

The Server/Application State Protocol (SASP) is an open protocol. The SASP protocol is used for communication between external load balancers and the advisor. The following information is exchanged:

- Registration of members from external load balancers that are interested in load balancing
- Requests from external load balancers
- Recommendations to external load balancers
- Deregistration of members from external load balancers that are no longer interested in load balancing

The registration process covers two types of groups, system-level groups and application-level groups:

- System-level groups

  This group is only represented by a list of IP addresses that are matched to TCP/IP stacks in the sysplex. The group includes WLM weights for the logical partition (LPAR). The Communications Server weight indicates whether the IP address is active in the sysplex. A value of 0 means quiesced and a value of 100 means not quiesced. Load Balancing Advisor displays show a protocol value of 0 for system-level groups.
- Application-level groups

  This group is represented by a list of IP addresses, protocols (TCP and UDP), and ports that are matched to server address spaces. The group includes WLM weights for the server address spaces. Communications Server weights indicate how well the server instances are performing. Load Balancing Advisor displays show protocols as TCP or UDP with the registered port numbers.

When the external load balancer connects to the advisor, it indicates how it wants the information exchanged. This gives the load balancer the ability to select the best fit for itself. The choices available are the pull model and push model:

- Pull model

  The advisor suggests a frequency interval, but it is up to the load balancer to choose the frequency with which it wants to receive the weights.
- Push model

  The load balancer requests the advisor to push weights down at certain intervals or when the weights change.

For both models, the recommendations (weights) can be sent for all registered members or only for those with changes to their weights.

With more frequent updates, the workload is distributed more accurately. The cost of more frequent updates is more flows in the network, both between Load Balancing Advisor and agents, and Load Balancing Advisor and external load balancers, and cycles used in Load Balancing Advisor and load balancers.

6.1.4 External load balancer without LBA/SASP

There are several products available today that perform load balancing of IP traffic. The example in this chapter was built using the Content Switching Module (CSM) and has the general structure shown in Figure 6-4.

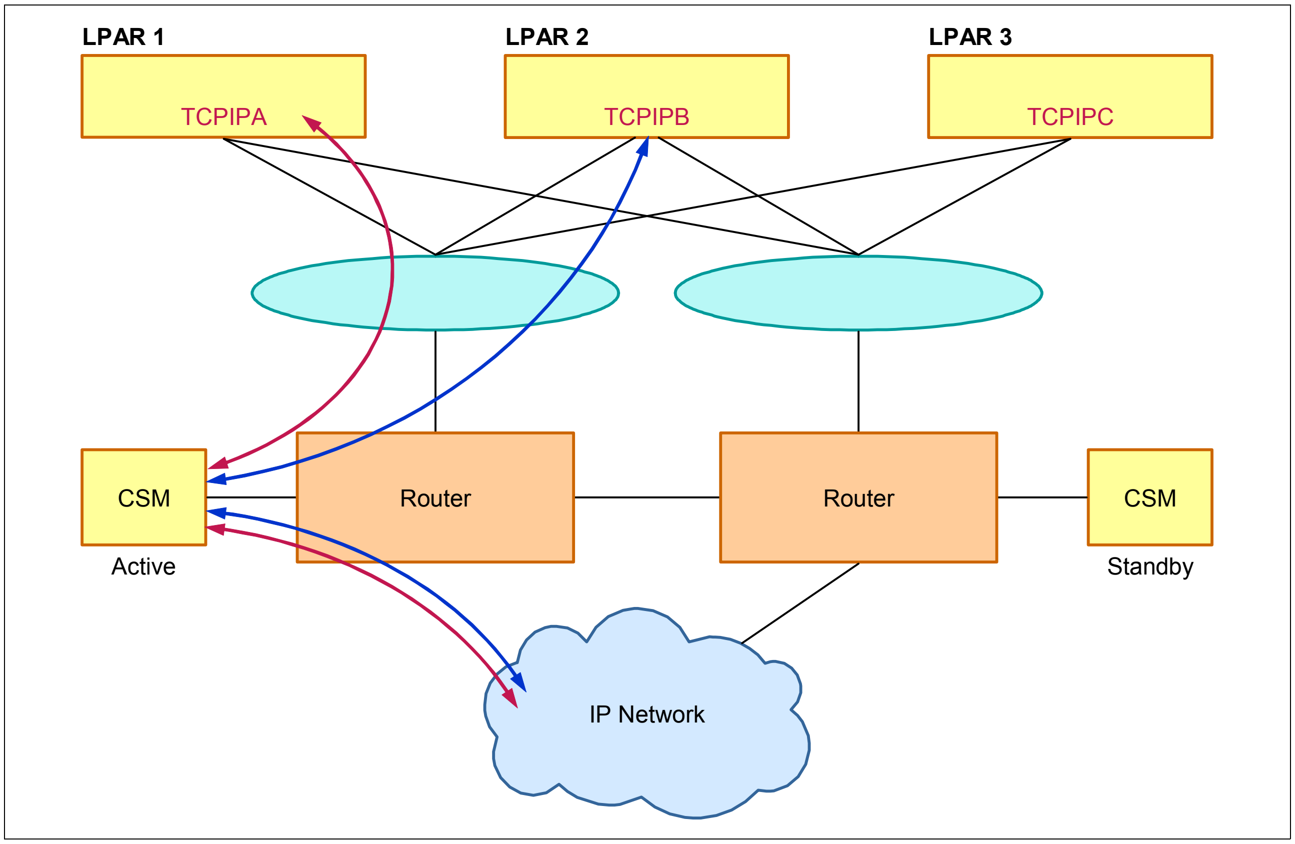


Figure 6-4 External load balancing without LBA/SASP

The external load balancer function is implemented as an active or standby pair for fault tolerance. The CSMs are used to exchange state information so that the existing connections continue nondisruptively in case of a failure in the active CSM.

The external load balancer receives user requests for the application cluster and forwards the requests to an application instance within the application cluster, according to the configuration in the load balancer. The load balancer is responsible for deciding which application instance to use for each new connection. Remember that, in this design, the decision is made without any knowledge of the current workload in z/OS and the application.

A way for the load balancer to keep track of the availability of each application instance is to poll each application instance. This polling technique is handled in several ways and differs for various vendors. An example of a simple polling technique is Internet Control Message Protocol (ICMP), where the load balancer assumes that the application instance is operating correctly if it receives an ICMP reply from the application instance IP address.

6.1.5 External load balancer with LBA/SASP

The example for this mode was built using a product that supports SASP. The general structure of the example is shown in Figure 6-5.

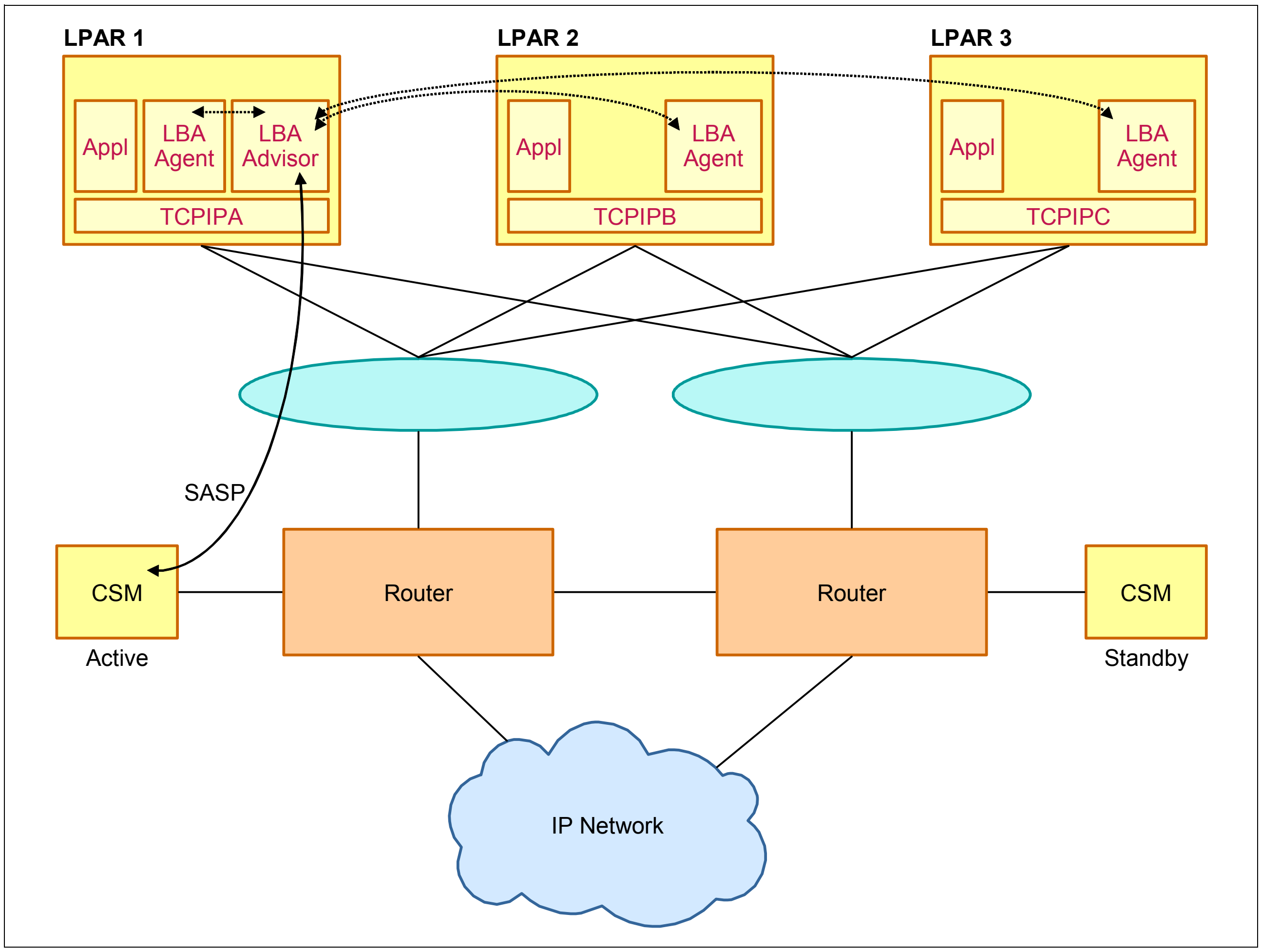


Figure 6-5 External load balancing with LBA/SASP

z/OS sysplex assists the external load balancer with recommendations as to which application instance is the best candidate for the next request. This is done by implementing the z/OS Load Balancing Advisor solution that communicates the recommendations to the external load balancer using the SASP protocol. The load balancer must support the SASP protocol and include the recommendations from Load Balancing Advisor when it decides which application instance to use for the next request. The external load balancer function is implemented as an active or standby pair for fault tolerance. The external load balancer exchange state information so that existing connections continue nondisruptively in case of a failure in the active external load balancer.

The external load balancer receives user requests for the application cluster and forwards the requests to an application instance within the application cluster according to the configuration in the load balancer. The load balancer can combine the recommendations from Load Balancing Advisor with its own techniques, such as ICMP polling.

6.1.6 Importance of external application workload balancing

Many reasons exist for choosing an external device to be responsible for load balancing for a z/OS sysplex environment:

- A requirement for a single load balancing solution that is used across multiple platforms.
- The administration of the load balancing functions can be done without the need for specific z/OS skills.
- A requirement for content-based load balancing using higher-layer information, including application-specific information such as an HTTP (or FTP) URLs, rather than just using IP addresses.
- A need to minimize processor usage on IBM System z9® servers.

External workload balancing offers a different dimension to the z/OS sysplex environment, especially when the load balancer becomes z/OS sysplex-aware. It might be desirable to transform a normal z/OS sysplex environment into z/OS application server farms and to move the responsibility for load balancing of the z/OS server farms to an external environment that is responsible for Content Switching.

In the remainder of this chapter, we describe two scenarios, with implementation examples:

- Example of external load balancer without LBA/SASP
- Example of external load balancer with LBA/SASP

6.2 Example of external load balancer without LBA/SASP

This section describes the implementation of external load balancing for three application instances of TN3270 in a z/OS sysplex environment without LBA/SASP.

6.2.1 External load balancer without LBA/SASP implementation

The infrastructure eliminates single network point of failure by using the following items:

- Two OSA-Express Gigabit Ethernet adapters (one port used per physical OSA Card)
- Two switches
- Two external load balancer with stateful failover
- OSPF to ensure rerouting around failures

Figure 6-6 shows our general structure.

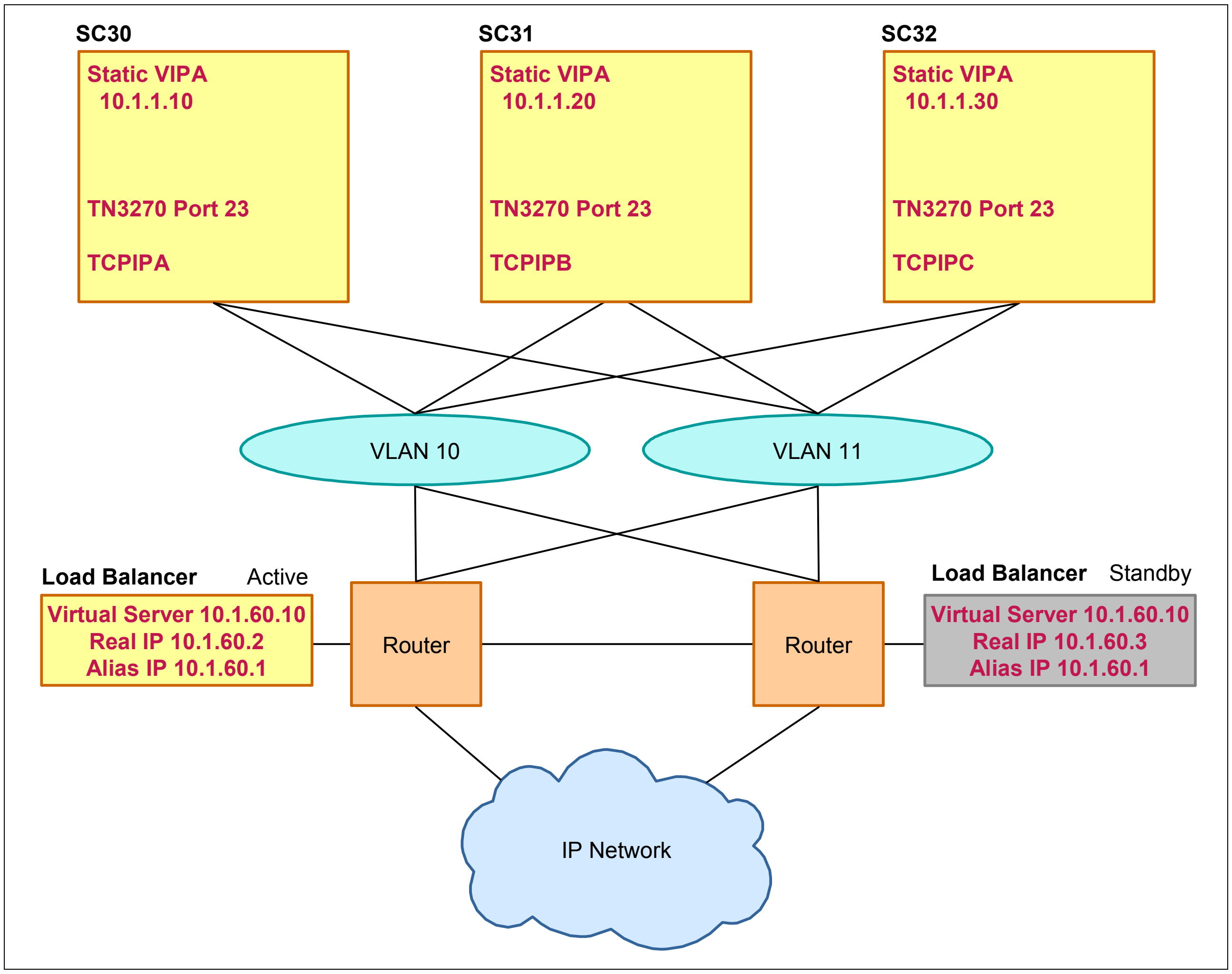


Figure 6-6 External load balancing of TN3270 without LBA/SASP

Overview

This section describes the environment, dependencies, advantages, and considerations.

Environment

Our specific environment contains the following components:

- Three LPARS
- Two OSA-Express Gigabit Ethernet adapters, with shared usage
- A TN3270 server in each LPAR
- TN3270 servers using static VIPAs
- OSPF as the dynamic routing protocol
- Policy-based routing (PBR) used in the routers
- Two switches
- Two external load balancer in active/standby mode

A static VIPA is used to address each instance of a TN3270 server. The load balancer can sense the presence of the VIPA and check whether the TN3270 server is available.

Dependencies

Available application instances must be configured in the external load balancer. Our example uses server NAT and policy-based routing.

Advantages

No single points of failure exist in the network elements of this design.

Considerations

If application instances are intended to move between LPARs, we would use a dynamic VIPA. We do not include this function in our example.

Implementation tasks

Our key tasks are as follows:

1. Plan the IP addressing needed for our configuration
2. Configure the TN3270 server IP and port addresses
3. Define the load balancer active and standby configurations

Plan the IP addressing needed for our configuration

Table 6-1 shows the IP addressing plan that we use.

Table 6-1 IP addressing scheme

Application	Application cluster address	Application instance and IP address
TN3270 - Port 23	10.1.60.10	SC30: 10.1.1.10 SC31: 10.1.1.20 SC32: 10.1.1.30

Configure the TN3270 server IP and port addresses

The key TCP/IP profile statements for our three LPARs are shown here. Example 6-1 shows the profile configuration in SC30.

Example 6-1 TCP/IP profile configuration in SC30

```
DEVICE VIPA1      VIRTUAL 0
LINK   VIPA1L     VIRTUAL 0   VIPA1
;
INTERFACE OSA2080I
DEFINE IPAQENET
PORTNAME OSA2080
SOURCEVIPAINT VIPA1L
IPADDR 10.1.2.11/24
MTU 1492
VLANID 10
VMAC ROUTELCL
;
INTERFACE OSA20A0I
DEFINE IPAQENET
PORTNAME OSA20A0
SOURCEVIPAINT VIPA1L
IPADDR 10.1.2.12/24
MTU 1492
VLANID 10
VMAC ROUTEALL
```

```
;
INTERFACE OSA20C0I
DEFINE IPAQENET
PORTNAME OSA20C0
SOURCEVIPAINT VIPA1L
IPADDR 10.1.3.11/24
MTU 1492
VLANID 11
VMAC  ROUTEALL
;
INTERFACE OSA20E0I
DEFINE IPAQENET
PORTNAME OSA20E0
SOURCEVIPAINT VIPA1L
IPADDR 10.1.3.12/24
MTU 1492
VLANID 11
VMAC  ROUTEALL
;
HOME
   10.1.1.10     VIPA1L 2
;
PORT
23 TCP TN3270A NOAUTOLOG            ; Telnet Server 1
```

Example 6-2 shows the profile configuration in SC31.

Example 6-2 TCP/IP profile configuration in SC31

```
DEVICE VIPA1      VIRTUAL 0
LINK   VIPA1L     VIRTUAL 0   VIPA1
;
INTERFACE OSA2080I
DEFINE IPAQENET
PORTNAME OSA2080
SOURCEVIPAINT VIPA1L
IPADDR 10.1.2.21/24
MTU 1492
VLANID 10
VMAC ROUTELCL
;
INTERFACE OSA20A0I
DEFINE IPAQENET
PORTNAME OSA20A0
SOURCEVIPAINT VIPA1L
IPADDR 10.1.2.22/24
MTU 1492
VLANID 10
VMAC ROUTEALL
;
INTERFACE OSA20C0I
DEFINE IPAQENET
PORTNAME OSA20C0
SOURCEVIPAINT VIPA1L
IPADDR 10.1.3.21/24
MTU 1492
```

```
VLANID 11
VMAC  ROUTEALL
;
INTERFACE OSA20E0I
DEFINE IPAQENET
PORTNAME OSA20E0
SOURCEVIPAINT VIPA1L
IPADDR 10.1.3.22/24
MTU 1492
VLANID 11
VMAC  ROUTEALL
;
HOME
   10.1.1.20     VIPA1L 2
;
PORT
23 TCP TN3270B NOAUTOLOG             ; Telnet Server 1
```

Example 6-3 shows the profile configuration in SC32. Note that 1 indicates TN3270 binding to INADDR_ANY, and 2 indicates static VIPA.

Example 6-3 TCP/IP profile configuration in SC32

```
DEVICE VIPA1      VIRTUAL 0
LINK   VIPA1L     VIRTUAL 0   VIPA1
;
INTERFACE OSA2080I
DEFINE IPAQENET
PORTNAME OSA2080
SOURCEVIPAINT VIPA1L
IPADDR 10.1.2.31/24
MTU 1492
VLANID 10
VMAC ROUTELCL
;
INTERFACE OSA20A0I
DEFINE IPAQENET
PORTNAME OSA20A0
SOURCEVIPAINT VIPA1L
IPADDR 10.1.2.32/24
MTU 1492
VLANID 10
VMAC ROUTEALL
;
INTERFACE OSA20C0I
DEFINE IPAQENET
PORTNAME OSA20C0
SOURCEVIPAINT VIPA1L
IPADDR 10.1.3.31/24
MTU 1492
VLANID 11
VMAC  ROUTEALL
;
INTERFACE OSA20E0I
DEFINE IPAQENET
PORTNAME OSA20E0
```

```
SOURCEVIPAINT VIPA1L
IPADDR 10.1.3.32/24
MTU 1492
VLANID 11
VMAC  ROUTEALL
;
HOME
   10.1.1.30     VIPA1L 2

PORT
23 TCP TN3270C NOAUTOLOG             ; Telnet Server 1
;
```

Define the load balancer active and standby configurations

We use Cisco CSM for the load balancer. Our active CSM definition is shown in Example 6-4.

Example 6-4 Active CSM definitions

```
module ContentSwitchingModule 2 1
 variable ROUTE_UNKNOWN_FLOW_PKTS 1
!
 ft group 61 vlan 61 2
  priority 101
!
 vlan 60 server 3
  ip address 10.1.60.2 255.255.255.0
  gateway 10.1.60.240
  alias 10.1.60.1 255.255.255.255
!
 probe PING-30S icmp 4
  interval 30
  retries 2
  failed 30
!
 real SC30-TN3270 5
  address 10.1.1.10
  inservice
 real SC31-TN3270
  address 10.1.1.20
  inservice
 real SC32-TN3270
  address 10.1.1.30
  inservice
!
 serverfarm TN3270 6
  nat server
  no nat client
  real name SC30-TN3270
   inservice
  real name SC31-TN3270
   inservice
  real name SC32-TN3270
   inservice
!
 vserver TN3270 7
```

```
  virtual 10.1.60.10 tcp telnet
  serverfarm TN3270
  replicate csrp connection
  persistent rebalance
  inservice
!
interface Vlan10 8
 ip address 10.1.2.240 255.255.255.0
 ip policy route-map pbr-to-csm
 ip ospf cost 100
 ip ospf priority 100
 standby 10 ip 10.1.2.230
 standby 10 preempt
!
interface Vlan11 8
 ip address 10.1.3.240 255.255.255.0
 ip policy route-map pbr-to-csm
 ip ospf cost 100
 ip ospf priority 100
 standby 11 ip 10.1.3.230
 standby 11 preempt
!
interface Vlan60 9
 description VLAN 60 for CSM
 ip address 10.1.60.240 255.255.255.0
 ip ospf cost 5
!
interface Vlan61 10
 description CSM Failover
 no ip address
!
router ospf 100 11
 router-id 10.1.3.240
 log-adjacency-changes
 area 2 stub no-summary
 network 10.1.2.0 0.0.0.255 area 2
 network 10.1.3.0 0.0.0.255 area 2
 network 10.1.100.0 0.0.0.255 area 2
 network 10.1.0.0 0.0.255.255 area 0
 network 10.200.1.0 0.0.0.255 area 0
 default-information originate always metric-type 1
!
ip access-list extended tn3270 12
 permit tcp host 10.1.1.30 eq telnet any
 permit tcp host 10.1.1.20 eq telnet any
 permit tcp host 10.1.1.10 eq telnet any
!
route-map pbr-to-csm permit 10 13
 match ip address tn3270
 set ip next-hop 10.1.60.1
```

Note the following key elements in the definitions:

1. CSM is in module 2 of this switch.

2. Fault tolerance uses dedicated virtual local area network (VLAN) 61.

3. CSM server VLAN. Subnet 10.1.60.0/24. This is the subnet for CSM and application clusters. There is no routing within the CSM, only static routes pointing to the routers.

4. This is the ICMP probe used for polling a given application instance for availability.

5. This is the real server definition pointing to the static VIPA per LPAR.

6. This is the server farm definition grouping real servers together and probe indicating *polling* of each real server. If a real server refuses to answer, the real server is marked unavailable.

7. This is the virtual server representing the application cluster. *Replicate csrp connection* implements stateful failover between the CSMs without connection loss of existing connections.

8. VLAN 10. Subnet 10.1.2.0/24. This is the OSA-Express Gigabit Ethernet attachment of z/OS. Policy-based routing is enabled in this VLAN.

9. VLAN 60. Subnet 10.1.60.0/24. This is the subnet for CSM and application clusters.

10. VLAN 61. This is the dedicated VLAN for CSM failover services.

11. The OSPF process 100 includes subnets matching 10.1.0.0/16.

12. This is the extended access list used by policy-based routing.

13. This is the Route Map used by policy-based routing. This ensures that datagrams from extended access list tn3270 are being forwarded back to the CSM.

The standby definition, shown in Example 6-5, differs slightly.

Example 6-5 Standby CSM definitions

```
module ContentSwitchingModule 3 1
 variable ROUTE_UNKNOWN_FLOW_PKTS 1
!
 ft group 61 vlan 61 2
  priority 100
!
vlan 60 server 3
  ip address 10.1.60.3 255.255.255.0
  gateway 10.1.60.220
  alias 10.1.60.1 255.255.255.255
!
 probe PING-30S icmp 4
  interval 30
  retries 2
  failed 30
!
 real SC30-TN3270 5
  address 10.1.1.10
  inservice
 real SC31-TN3270
  address 10.1.1.20
  inservice
 real SC32-TN3270
  address 10.1.1.30
  inservice
 real TN3270-SC30
  inservice
!
 serverfarm TN3270 6
  nat server
  no nat client
  real name SC30-TN3270
   inservice
  real name SC31-TN3270
   inservice
  real name SC32-TN3270
   inservice
  probe PING-30S
!
 vserver TN3270 7
  virtual 10.1.60.10 tcp telnet
  serverfarm TN3270
  replicate csrp connection
  persistent rebalance
  inservice
!
interface Vlan10 8
 ip address 10.1.2.240 255.255.255.0
 ip policy route-map pbr-to-csm
 ip ospf cost 100
 ip ospf priority 100
 standby 10 ip 10.1.2.230
 standby 10 preempt
 standby 10 priority 90
!
interface Vlan11 8
 ip address 10.1.3.240 255.255.255.0
 ip policy route-map pbr-to-csm
 ip ospf cost 100
 ip ospf priority 100
 standby 11 ip 10.1.3.230
 standby 11 preempt
 standby 11 priority 90
!
interface Vlan60 9
 description VLAN 60 for CSM
 ip address 10.1.60.220 255.255.255.0
 ip ospf cost 5
!
interface Vlan61 10
 description CSM Failover
 no ip address
!
router ospf 100 11
 router-id 10.1.3.220
 log-adjacency-changes
 area 2 stub no-summary
 network 10.1.2.0 0.0.0.255 area 2
 network 10.1.3.0 0.0.0.255 area 2
 network 10.1.100.0 0.0.0.255 area 2
 network 10.1.0.0 0.0.255.255 area 0
 network 10.200.1.0 0.0.0.255 area 0
 network 192.168.2.0 0.0.0.255 area 2
 default-information originate always metric-type 1
!
ip access-list extended tn3270 12
 permit tcp host 10.1.1.30 eq telnet any
 permit tcp host 10.1.1.20 eq telnet any
 permit tcp host 10.1.1.10 eq telnet any
!
route-map pbr-to-csm permit 10 13
 match ip address tn3270
 set ip next-hop 10.1.60.1
```

The standby definitions include the following key points:

1. CSM is in module 2 of this switch.
2. Fault tolerance uses dedicated VLAN 61.
3. CSM server VLAN. Subnet 10.1.60.0/24. This is the subnet for CSM and application clusters. There is no routing within the CSM, only static routes pointing to the routers.
4. This is the ICMP probe used for *polling* a given application instance for availability.
5. This is the real server definition pointing to the static VIPA per LPAR.
6. This is the server farm definition grouping real servers together and probe indicating polling of each real server. If a real server refuses to answer, the real server is marked unavailable.
7. This is the virtual server representing the application cluster. *Replicate csrp connection* implements stateful failover between the CSMs without connection loss of existing connections.
8. These are the OSA-Express Gigabit Ethernet attachment of z/OS. Policy-based routing is enabled in these VLANs.
9. VLAN 60. Subnet 10.1.60.0/24. This is the subnet for CSM and application clusters.
10. VLAN 61.This is the dedicated VLAN for CSM failover services.
11. OSPF process 100 includes subnets matching 10.1.2.0/24, 10.1.3.0/24, and 10.1.60.0/24.
12. This is the extended access list used by policy-based routing.
13. This is the Route Map used by policy-based routing. It ensures that datagrams returned from z/OS TN3270 servers are being forwarded back to the CSM (avoid bypassing CSM).

Verification

We verify our setup using the following steps:

1. Verify that TN3270 servers are started in each LPAR.
2. Check the CSM load-balancing environment.
3. Start 12 TN3270 clients and observe the results.

Verify that TN3270 servers are started in each LPAR

We verify that TN3270 servers are running, as shown in Example 6-6 on page 210. (The command in this example is repeated in all three LPARs.)

Example 6-6 TN3270 is ready

```
On SC30
D TCPIP,TCPIPA,N,CONN,PORT=23
EZD0101I NETSTAT CS V1R13 TCPIPA 761
USER ID  CONN     STATE
TN3270A  00000044 LISTEN
  LOCAL SOCKET:   ::..23
  FOREIGN SOCKET: ::..0
1 OF 1 RECORDS DISPLAYED
END OF THE REPORT

On SC31
D TCPIP,TCPIPB,N,CONN,PORT=23
EZD0101I NETSTAT CS V1R13 TCPIPB 955
USER ID  CONN     STATE
TN3270B  0000002B LISTEN
  LOCAL SOCKET:   ::..23
  FOREIGN SOCKET: ::..0
1 OF 1 RECORDS DISPLAYED
END OF THE REPORT

On SC32
D TCPIP,TCPIPC,N,CONN,PORT=23
EZD0101I NETSTAT CS V1R13 TCPIPC 934
USER ID  CONN     STATE
TN3270C  00000030 LISTEN
  LOCAL SOCKET:   ::..23
  FOREIGN SOCKET: ::..0
1 OF 1 RECORDS DISPLAYED
END OF THE REPORT
```

Check the CSM load-balancing environment

The command in Example 6-7 displays the active vserver configuration.

Example 6-7 List active vserver configuration

```
Router1#sh mod csm 2 vservers name TN3270 config
TN3270, type = SLB, state = OPERATIONAL, v_index = 10
  virtual = 10.1.60.10/32:23 bidir, TCP, service = NONE, advertise = F
  idle = 3600, replicate csrp = connection, vlan = ALL, pending = 30,
  max parse len = 2000, persist rebalance = TRUE
  ssl sticky offset = 0, length = 32
  conns = 0, total conns = 34
  Policy <default>
    serverfarm TN3270, type = SLB, predictor = RoundRobin 1
      nat = SERVER
      bind id = 0, fail action = none
      inband health config: <none>
      retcode map = <none>
      Real servers: 2
        SC30-TN3270, weight = 8, OPERATIONAL
        SC31-TN3270, weight = 8, OPERATIONAL
        SC32-TN3270, weight = 8, OPERATIONAL
```

Note that the distribution is round-robin (**1**), and all three application instances (**2**) have the same weight and are operational.

The command in Example 6-8 displays the active server farm configuration.

Example 6-8 List the active server farm configuration

```
Router1#sh mod csm 2 serverfarms name TN3270 detail
TN3270, type = SLB, predictor = RoundRobin
  nat = SERVER
  virtuals inservice = 1, reals = 3, bind id = 0, fail action = none
  inband health config: <none>
  retcode map = <none>
  Real servers:
    SC30-TN3270, weight = 8, OPERATIONAL, conns = 0
    SC31-TN3270, weight = 8, OPERATIONAL, conns = 0
    SC32-TN3270, weight = 8, OPERATIONAL, conns = 0
  Total connections = 0
```

The command in Example 6-9 displays the real servers being used.

Example 6-9 List active real servers

```
Router1#sh mod csm 2 reals sfarm TN3270 detail
SC30-TN3270, TN3270, state = OPERATIONAL
  address = 10.1.1.10, location = <NA>
  conns = 0, maxconns = 4294967295, minconns = 0
  weight = 8, weight(admin) = 8, metric = 0, remainder = 0
  total conns established = 13, total conn failures = 0
SC31-TN3270, TN3270, state = OPERATIONAL
  address = 10.1.1.20, location = <NA>
  conns = 0, maxconns = 4294967295, minconns = 0
  weight = 8, weight(admin) = 8, metric = 0, remainder = 0
  total conns established = 12, total conn failures = 0
SC32-TN3270, TN3270, state = OPERATIONAL
  address = 10.1.1.30, location = <NA>
  conns = 0, maxconns = 4294967295, minconns = 0
  weight = 8, weight(admin) = 8, metric = 0, remainder = 0
  total conns established = 9, total conn failures = 4
```

Start 12 TN3270 clients and observe the results

We then start 12 TN3270 clients (to application cluster address 10.1.60.10) and display the distribution using the command in Example 6-10.

Example 6-10 Display of the vserver in the CSM shows how the 12 connections are distributed

```
Router1#sh mod csm 2 serverfarms name TN3270 detail
TN3270, type = SLB, predictor = RoundRobin
  nat = SERVER
  virtuals inservice = 1, reals = 3, bind id = 0, fail action = none
  inband health config: <none>
  retcode map = <none>
  Real servers:
    SC30-TN3270, weight = 8, OPERATIONAL, conns = 4
    SC31-TN3270, weight = 8, OPERATIONAL, conns = 4
    SC32-TN3270, weight = 8, OPERATIONAL, conns = 4
  Total connections = 12
```

Note that 12 connections seem to be distributed in round-robin.

We verify the TN3270 server usage by displaying the connections in each LPAR. Example 6-11 shows the connections in SC30.

Example 6-11 TN3270 connections in SC30

```
D TCPIP,TCPIPA,N,CONN,PORT=23
EZD0101I NETSTAT CS V1R13 TCPIPA 790
USER ID  CONN     STATE
TN3270A  00000131 ESTBLSH
  LOCAL SOCKET:   ::FFFF:10.1.1.10..23
  FOREIGN SOCKET: ::FFFF:10.1.100.222..2489
TN3270A  00000044 LISTEN
  LOCAL SOCKET:   ::..23
  FOREIGN SOCKET: ::..0
TN3270A  00000134 ESTBLSH
  LOCAL SOCKET:   ::FFFF:10.1.1.10..23
  FOREIGN SOCKET: ::FFFF:10.1.100.222..2492
TN3270A  0000013A ESTBLSH
  LOCAL SOCKET:   ::FFFF:10.1.1.10..23
  FOREIGN SOCKET: ::FFFF:10.1.100.222..2498
TN3270A  00000137 ESTBLSH
  LOCAL SOCKET:   ::FFFF:10.1.1.10..23
  FOREIGN SOCKET: ::FFFF:10.1.100.222..2495
```

Example 6-12 shows the connections in SC31.

Example 6-12 TN3270 connections in SC31

```
D TCPIP,TCPIPB,N,CONN,PORT=23
EZD0101I NETSTAT CS V1R13 TCPIPB 974
USER ID  CONN     STATE
TN3270B  0000324D ESTBLSH
  LOCAL SOCKET:   ::FFFF:10.1.1.20..23
  FOREIGN SOCKET: ::FFFF:10.1.100.222..2490
TN3270B  0000002B LISTEN
  LOCAL SOCKET:   ::..23
  FOREIGN SOCKET: ::..0
TN3270B  00003250 ESTBLSH
  LOCAL SOCKET:   ::FFFF:10.1.1.20..23
  FOREIGN SOCKET: ::FFFF:10.1.100.222..2493
TN3270B  00003256 ESTBLSH
  LOCAL SOCKET:   ::FFFF:10.1.1.20..23
  FOREIGN SOCKET: ::FFFF:10.1.100.222..2499
TN3270B  00003253 ESTBLSH
  LOCAL SOCKET:   ::FFFF:10.1.1.20..23
  FOREIGN SOCKET: ::FFFF:10.1.100.222..2496
```

Example 6-13 shows the connections in SC32.

Example 6-13 TN3270 connections in SC32

```
D TCPIP,TCPIPC,N,CONN,PORT=23
EZD0101I NETSTAT CS V1R13 TCPIPC 968
USER ID  CONN     STATE
TN3270C  00000312 ESTBLSH
  LOCAL SOCKET:   ::FFFF:10.1.1.30..23
  FOREIGN SOCKET: ::FFFF:10.1.100.222..2491
TN3270C  00000030 LISTEN
  LOCAL SOCKET:   ::..23
  FOREIGN SOCKET: ::..0
TN3270C  00000314 ESTBLSH
  LOCAL SOCKET:   ::FFFF:10.1.1.30..23
  FOREIGN SOCKET: ::FFFF:10.1.100.222..2494
TN3270C  0000031C ESTBLSH
  LOCAL SOCKET:   ::FFFF:10.1.1.30..23
  FOREIGN SOCKET: ::FFFF:10.1.100.222..2500
TN3270C  00000317 ESTBLSH
  LOCAL SOCKET:   ::FFFF:10.1.1.30..23
  FOREIGN SOCKET: ::FFFF:10.1.100.222..2497
5 OF 5 RECORDS DISPLAYED
END OF THE REPORT
```

Problem determination

For any problems, we use the following steps to help determine the problem:

1. Check that application instances are running in z/OS (active listener.)
2. Check that there is connectivity between the router and z/OS.
3. Check that the real server is operational.
4. Check that the virtual server is operational.
5. Check for connectivity between the client and CSM (application cluster address = vserver address).
6. Check that policy-based routing definitions are in place.
7. Run packet trace.
8. Run CTRACE.
9. Use a network analyzer.
10. Run debug in the external networking devices.

6.3 Example of external load balancer with LBA/SASP

This section describes the implementation of external load balancing for three application instances of TN3270 servers in a z/OS sysplex environment using LBA/SASP.

6.3.1 External load balancer with LBA/SASP implementation

In this scenario, LBA/SASP is used to send load balancing recommendations to the external load balancer. A static VIPA is used by each instance of a TN3270 server. The CSM can sense the presence of the VIPA to check whether TN3270 is available. Figure 6-7 shows the general design.

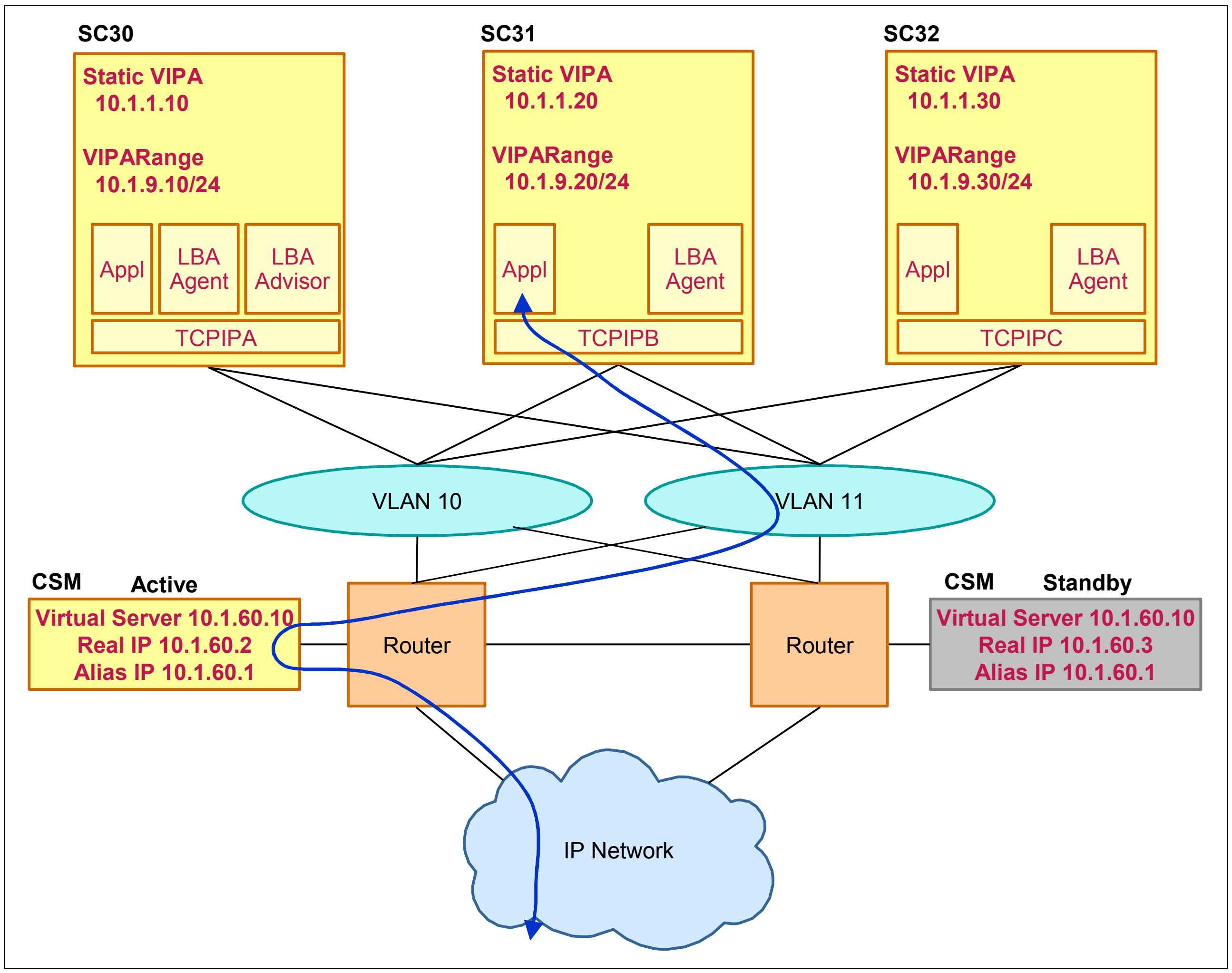


Figure 6-7 External load balancing with LBA/SASP

Overview

This section describes the environment, dependencies, advantages, and considerations.

Environment

The specific environment for this example includes the following components:

- Three LPARS.
- Two OSA-Express Gigabit Ethernet adapters with shared usage.
- A z/OS Load Balancing Advisor running in one LPAR.
- The backup z/OS Load Balancing Advisor can start in another LPAR.
- A z/OS Load Balancing Agent running in each LPAR.
- A TN3270 server running each LPAR.
- A TN3270 uses static VIPA.
- An OSPF used as the dynamic routing protocol.
- A PBR used in the routers.
- Two switches.
- Two CSMs in active/standby mode.

Dependencies

The external load balancer must support SASP for this design. Available application instances must be configured in the external load balancer. Our example uses CSM with server NAT and policy-based routing.

Advantages

No single network points of failure are present in this design. The workload is distributed in a more accurate manner according to current workload of the application instances and the z/OS system.

Considerations

If application instances are intended to move between LPARs, we would use a dynamic VIPA. We do not include this function in our example.

Implementation tasks

The tasks for implementing external load balancing with LBA/SASP are as follows:

1. Create an IP addressing plan.
2. Configure the TCP/IP profile for z/OS Load Balancing Advisor and Agents.
3. Configure the z/OS Load Balancing Advisor on SC30.
4. Configure the z/OS Load Balancing Agents on SC30, SC31, and SC32.
5. Configure the CSM.

Create an IP addressing plan

Table 6-2 shows out IP addressing plan.

Table 6-2 IP addressing scheme

Application	Application cluster address	Application instance and IP address
TN3270 - Port 23	10.1.60.10	SC30: 10.1.1.10 SC31: 10.1.1.20 SC32: 10.1.1.30

Configure the TCP/IP profile for z/OS Load Balancing Advisor and Agents

We provide the TCP/IP profile definitions for the z/OS Load Balancing Advisor and Agents for the three LPARs, as shown in the following examples. Example 6-14 shows the profile definitions in SC30.

Example 6-14 TCP/IP profile definitions for z/OS Load Balancing Advisor and Agent in SC30

```
DEVICE VIPA1      VIRTUAL 0
LINK   VIPA1L     VIRTUAL 0   VIPA1
;
INTERFACE OSA2080I
DEFINE IPAQENET
PORTNAME OSA2080
SOURCEVIPAINT VIPA1L
IPADDR 10.1.2.11/24
MTU 1492
VLANID 10
VMAC ROUTEALL
;
INTERFACE OSA20A0I
DEFINE IPAQENET
```

```
PORTNAME OSA20A0
SOURCEVIPAINT VIPA1L
IPADDR 10.1.2.12/24
MTU 1492
VLANID 10
VMAC ROUTEALL
;
INTERFACE OSA20C0I
DEFINE IPAQENET
PORTNAME OSA20C0
SOURCEVIPAINT VIPA1L
IPADDR 10.1.3.11/24
MTU 1492
VLANID 11
VMAC  ROUTEALL
;
INTERFACE OSA20E0I
DEFINE IPAQENET
PORTNAME OSA20E0
SOURCEVIPAINT VIPA1L
IPADDR 10.1.3.12/24
MTU 1492
VLANID 11
VMAC ROUTEALL
;
HOME
   10.1.1.10     VIPA1L
;
VIPADYNAMIC
 VIPARANGE DEFINE MOVEable NONDISRUPTive 255.255.255.0 10.1.9.0
ENDVIPADYNAMIC
;
AUTOLOG 5
   LBADV                  ; SASP Load Balancing Advisor
   LBAGENT                ; SASP Load Balancing Agent
;
PORT
  3860 TCP LBADV          ; SASP Workload Advisor (LB connections)
  8100 TCP LBADV          ; SASP Workload Advisor (Agent connections)
  8000 TCP LBAGENT NOAUTOLOG 1 ; SASP Workload Agent (Advisor connection)
```

Example 6-15 shows the profile definitions for SC31.

Example 6-15 TCP/IP profile definitions for z/OS Load Balancing Advisor and Agent in SC31

```
DEVICE VIPA1      VIRTUAL 0
LINK   VIPA1L     VIRTUAL 0   VIPA1
;
INTERFACE OSA2080I
DEFINE IPAQENET
PORTNAME OSA2080
SOURCEVIPAINT VIPA1L
IPADDR 10.1.2.21/24
MTU 1492
VLANID 10
VMAC ROUTEALL
```

```
;
INTERFACE OSA20A0I
DEFINE IPAQENET
PORTNAME OSA20A0
SOURCEVIPAINT VIPA1L
IPADDR 10.1.2.22/24
MTU 1492
VLANID 10
VMAC ROUTEALL
;
INTERFACE OSA20C0I
DEFINE IPAQENET
PORTNAME OSA20C0
SOURCEVIPAINT VIPA1L
IPADDR 10.1.3.21/24
MTU 1492
VLANID 11
VMAC  ROUTEALL
;
INTERFACE OSA20E0I
DEFINE IPAQENET
PORTNAME OSA20E0
SOURCEVIPAINT VIPA1L
IPADDR 10.1.3.22/24
MTU 1492
VLANID 11
VMAC ROUTEALL
;
HOME
   10.1.1.20     VIPA1L
;
VIPADYNAMIC
 VIPARANGE DEFINE MOVEable NONDISRUPTive 255.255.255.0 10.1.9.0
ENDVIPADYNAMIC
;
AUTOLOG 5
   LBAGENT

PORT
  3860 TCP LBADV           ; SASP Workload Advisor (LB connections)
  8100 TCP LBADV           ; SASP Workload Advisor (Agent connections)
  8000 TCP LBAGENT NOAUTOLOG 1 ; SASP Workload Agent (Advisor connection)
```

Example 6-16 shows the profile definitions for SC32.

Example 6-16 TCP/IP profile definitions for z/OS Load Balancing Advisor and Agent in SC32

```
DEVICE VIPA1      VIRTUAL 0
LINK   VIPA1L     VIRTUAL 0   VIPA1
;
INTERFACE OSA2080I
DEFINE IPAQENET
PORTNAME OSA2080
SOURCEVIPAINT VIPA1L
IPADDR 10.1.2.31/24
```

```
MTU 1492
VLANID 10
VMAC ROUTEALL
;
INTERFACE OSA20A0I
DEFINE IPAQENET
PORTNAME OSA20A0
SOURCEVIPAINT VIPA1L
IPADDR 10.1.2.32/24
MTU 1492
VLANID 10
VMAC ROUTEALL
;
INTERFACE OSA20C0I
DEFINE IPAQENET
PORTNAME OSA20C0
SOURCEVIPAINT VIPA1L
IPADDR 10.1.3.31/24
MTU 1492
VLANID 11
VMAC  ROUTEALL
;
INTERFACE OSA20E0I
DEFINE IPAQENET
PORTNAME OSA20E0
SOURCEVIPAINT VIPA1L
IPADDR 10.1.3.32/24
MTU 1492
VLANID 11
VMAC ROUTEALL
;
HOME
   10.1.1.30     VIPA1L
;
VIPADYNAMIC
 VIPARANGE DEFINE MOVEable NONDISRUPTive 255.255.255.0 10.1.9.0
ENDVIPADYNAMIC
;
AUTOLOG 5
   LBAGENT                  ; SASP Load Balancing Agent
;
PORT
  3860 TCP LBADV            ; SASP Workload Advisor (LB connections)
  8100 TCP LBADV            ; SASP Workload Advisor (Agent connections)
  8000 TCP LBAGENT NOAUTOLOG 1 ; SASP Workload Agent (Advisor connection)
```

Note that NOAUTOLOG (1) must be coded on the port definition if we use AUTOLOG to start the LBAGENT.

Configure the z/OS Load Balancing Advisor on SC30

We prepare the started procedure for z/OS Load Balancing Advisor on SC30. Example 6-17 shows the sample started procedure for SC30.

Example 6-17 z/OS Load Balancing Advisor started procedure - SYS1.PROCLIB(LBADV)

```
//LBADV      PROC
//LBADV  EXEC PGM=EZBLBADV,REGION=OK,TIME=NOLIMIT,
//   PARM='/'
//CONFIG   DD DSN=TCPIPA.TCPPARMS(LBADVCNF),DISP=SHR
//STDENV   DD DUMMY
//SYSPRINT DD SYSOUT=*,DCB=(RECFM=F,LRECL=80,BLKSIZE=80)
//SYSIN    DD DUMMY
//SYSERR   DD SYSOUT=*
//SYSOUT   DD SYSOUT=*,DCB=(RECFM=F,LRECL=80,BLKSIZE=80)
//CEEDUMP  DD SYSOUT=*,DCB=(RECFM=FB,LRECL=132,BLKSIZE=132)
//CEESNAP  DD SYSOUT=*,DCB=(RECFM=FB,LRECL=132,BLKSIZE=132)
//SYSMDUMP DD DISP=SHR,DSN=your.data.set.name
```

Register the z/OS Load Balancing Advisor as a started task by using a security product such as IBM RACF® product. Example 6-18 shows the RACF command sample.

Example 6-18 Register z/OS Load Balancer Advisor as a started task in RACF

```
RDEFINE STARTED LBADV*.* STDATA(USER(LBADV))
SETROPTS RACLIST(STARTED) REFRESH
```

We configure the z/OS Load Balancing Advisor as shown in Example 6-19. (The z/OS Load Balancing Advisor configuration file is specified on the `CONFIG DD` statement in the advisor start procedure.)

Example 6-19 Configuration file for z/OS Load Balancing Advisor - TCPIPA.TCPPARMS(LBADVCNF)

```
debug_level             7

update_interval         60

agent_connection_port   8100 1

agent_id_list
{
  10.1.1.10..8000 2
  10.1.1.20..8000
  10.1.1.30..8000
# ::1..8000
}

lb_connection_v4        10.1.9.10..3860 3

lb_id_list
lb_id_list
{
  10.1.60.2 4
  10.1.60.3 5
}
wlm serverwlm 6

port_list
{
  23
}
```

This configuration includes the following key elements:

1. Port 8100 is used to receive connections from LBAGENTs.

2. This is the list of valid LBAGENTs that can connect to this z/OS Load Balancing Advisor.

3. z/OS Load Balancing Advisor binds to this IP address and listens on a specified port.

4. This is the IP address of the active load balancer.

5. This is the IP address of the standby load balancer.

6. Server-specific WLM recommendations will be requested of each Agent.

Configure the z/OS Load Balancing Agents on SC30, SC31, and SC32

We prepare the started procedure for z/OS Load Balancing Agent on SC30,SC31, and SC32. Example 6-20 shows the sample started procedure for SC30. Create the started procedure LBAGENTB in SC31 and LBAGENTC in SC32 in the same way (specify the z/OS Load Balancing Agent profile with CONFIG DD).

Example 6-20 z/OS Load Balancing Agent started procedure - SYS1.PROCLIB(LBAGENT) for SC30

```
//LBAGENTA   PROC
//LBAGENTA EXEC PGM=EZBLBAGE,REGION=OK,TIME=NOLIMIT,
//         PARM=('POSIX(ON) ALL31(ON)',
//           'ENVAR("_CEE_ENVFILE=DD:STDENV")/')
//CONFIG   DD DSN=TCPIPA.TCPPARMS(LBAG&SYSNAME),DISP=SHR
//SYSPRINT DD SYSOUT=*,DCB=(RECFM=F,LRECL=80,BLKSIZE=80)
//STDENV   DD DISP=SHR,DSN=TCPIP.SC&SYSCLONE..STDENV(LBAENV&SYSCLONE.)
//SYSIN    DD DUMMY
//SYSERR   DD SYSOUT=*
//SYSOUT   DD SYSOUT=*,DCB=(RECFM=F,LRECL=80,BLKSIZE=80)
//CEEDUMP  DD SYSOUT=*,DCB=(RECFM=FB,LRECL=132,BLKSIZE=132)
//CEESNAP  DD SYSOUT=*,DCB=(RECFM=FB,LRECL=132,BLKSIZE=132)
//SYSMDUMP DD SYSOUT=*,DCB=(RECFM=FB,LRECL=132,BLKSIZE=132)
```

Register the z/OS Load Balancing Agent as a started task using a security product such as RACF. Example 6-21 shows the RACF command sample.

Example 6-21 Register z/OS Load Balancer Advisor as a started task in RACF

```
RDEFINE STARTED LBAGE*.* STDATA(USER(LBAGENT))
SETROPTS RACLIST(STARTED) REFRESH
```

We configure the z/OS Load Balancing Agents in each LPAR. Example 6-22 shows the configuration file for SC30. (The z/OS Load Balancing Agent configuration file is specified on the `CONFIG DD` statement in the start procedure.)

Example 6-22 Configuration file for z/OS LB Agent in SC30 - TCPIPA.TCPPARMS(LBAGSC30)

```
debug_level              7

advisor_id               10.1.9.10..8100 1

host_connection          10.1.1.10..8000 2
```

Example 6-23 shows the configuration file for SC31.

Example 6-23 Configuration file for z/OS LB Agent in SC31 - TCPIPB.TCPPARMS(LBAGSC31)

```
debug_level             7

advisor_id              10.1.9.10..8100 1

host_connection         10.1.1.20..8000 2
```

Example 6-24 shows the configuration file for SC32.

Example 6-24 Configuration file for z/OS LB Agent in SC32 - TCPIPC.TCPPARMS(LBAGSC32)

```
debug_level             7

advisor_id              10.1.9.10..8100 1

host_connection         10.1.1.30..8000 2
```

Note that 1 LBAGENT connects to the z/OS Load Balancing Advisor by this IP address and port, and that 2 LBAGENT uses this statement as the source IP address and port.

Configure the CSM

We use Cisco CSM for the load balancer supporting SASP. We configure the active CSM, as shown in Example 6-25.

Example 6-25 Configuration for active CSM

```
module ContentSwitchingModule 2 1
 variable ROUTE_UNKNOWN_FLOW_PKTS 1
 variable SASP_CSM_UNIQUE_ID Cisco-CSM-6509A 2
 variable SASP_FIRST_BIND_ID 65520
 variable SASP_GWM_BIND_ID_MAX 5
!
 ft group 61 vlan 61 3
  priority 101
!
vlan 60 server 4
  ip address 10.1.60.2 255.255.255.0
  gateway 10.1.60.240
  alias 10.1.60.1 255.255.255.255
!
 probe PING-30S icmp 5
  interval 30
  retries 2
  failed 30
!
 real SC30-TN3270 6
  address 10.1.1.10
  inservice
 real SC31-TN3270
  address 10.1.1.20
  inservice
 real SC32-TN3270
  address 10.1.1.30
  inservice
!
 serverfarm TN3270 7
  nat server
  no nat client
  bindid 65520
  real name SC30-TN3270
   inservice
  real name SC31-TN3270
   inservice
  real name SC32-TN3270
   inservice
!
 vserver TN3270 8
  virtual 10.1.60.10 tcp telnet
  serverfarm TN3270
  replicate csrp connection
  persistent rebalance
  inservice
!
 dfp
 agent 10.1.9.10 3860 65520 9
!
interface Vlan10 10
 ip address 10.1.2.240 255.255.255.0
 ip policy route-map pbr-to-csm
 ip ospf cost 100
 ip ospf priority 100
 standby 10 ip 10.1.2.230
 standby 10 preempt
!
interface Vlan11 10
 ip address 10.1.3.240 255.255.255.0
 ip policy route-map pbr-to-csm
 ip ospf cost 100
 ip ospf priority 100
 standby 11 ip 10.1.3.230
 standby 11 preempt
!
interface Vlan60 11
 description VLAN 60 for CSM
 ip address 10.1.60.240 255.255.255.0
 ip ospf cost 5
!
interface Vlan61 12
 description CSM Failover
 no ip address
!
router ospf 100 13
 router-id 10.1.3.240
 log-adjacency-changes
 area 2 stub no-summary
 network 10.1.2.0 0.0.0.255 area 2
 network 10.1.3.0 0.0.0.255 area 2
 network 10.1.100.0 0.0.0.255 area 2
 network 10.1.0.0 0.0.255.255 area 0
 network 10.200.1.0 0.0.0.255 area 0
 default-information originate always metric-type 1
!
ip access-list extended tn3270 14
 permit tcp host 10.1.1.30 eq telnet any
 permit tcp host 10.1.1.20 eq telnet any
 permit tcp host 10.1.1.10 eq telnet any
!
route-map pbr-to-csm permit 10 15
 match ip address tn3270
 set ip next-hop 10.1.60.1
!
```

The following elements are important:

1. CSM is in module 2 of this switch.
2. A unique ID for the active CSM is required.
3. Fault tolerance uses a dedicated VLAN 61.
4. CSM server VLAN. Subnet 10.1.60.0/24. This is the subnet for CSM and application clusters. There is no routing within the CSM, only static routes pointing to the routers.
5. This is the ICMP probe used for polling a given application instance for availability.
6. This is the real server definition pointing to the static VIPA per LPAR.
7. This is the server farm definition grouping real servers together and probe indicating polling of each real server. If a real server refuses to answer, the real server is marked unavailable.
8. This is the virtual server representing the application cluster. *Replicate csrp connection* implements stateful failover between the CSMs without connection loss of existing connections.
9. This is the DFP agent pointing to z/OS Load Balancing Advisor. Make sure the fourth parameter matches the bind ID specified on the `serverfarm` definition.

   Note: The Cisco CSM might recognize the third parameter as "activity timeout" or "keepalive" instead of bind_id. The syntax applied when enabling SASP is as follows.

   ```
   agent ip-address port bind_id [flags] [keep-alive-interval]
   ```

10. These are the OSA-Express Gigabit Ethernet attachment of z/OS. Policy-based routing is enabled in these VLANs.
11. VLAN 60. Subnet 10.1.60.0/24.This is the subnet for CSM and application clusters.
12. VLAN 61. This is the dedicated VLAN for CSM failover services.
13. OSPF process 100 includes subnets matching 10.1.2.0/24, 10.1.3.0/24, and 10.1.60.0/24.
14. This is the extended access list used by policy-based
15. This is the Route Map used by policy-based routing. It ensures that datagrams returned from z/OS TN3270 servers are being forwarded back to the CSM (avoid bypassing CSM).

Note: After configuring the CSM, you might need to restart the CSM by issuing the following command. CSM is in slot 2 in our environment, so we specify `2`.

```
hw-module module 2 reset
```

We configure the standby CSM as shown in Example 6-26.

Example 6-26 Configuration for standby CSM

```
module ContentSwitchingModule 3 1
 variable ROUTE_UNKNOWN_FLOW_PKTS 1
 variable SASP_CSM_UNIQUE_ID Cisco-CSM-6509B 2
 variable SASP_FIRST_BIND_ID 65520
 variable SASP_GWM_BIND_ID_MAX 5
!
 ft group 61 vlan 61 3
  priority 100
!
 vlan 60 server 4
  ip address 10.1.60.3 255.255.255.0
  gateway 10.1.60.220
  alias 10.1.60.1 255.255.255.255
!
 probe PING-30S icmp 5
  interval 30
  retries 2
  failed 30
!
 real SC30-TN3270 6
  address 10.1.1.10
  inservice
 real SC31-TN3270
  address 10.1.1.20
  inservice
 real SC32-TN3270
  address 10.1.1.30
  inservice
 real TN3270-SC30
  inservice
!
 serverfarm TN3270 7
  nat server
  no nat client
  bindid 65520
  real name SC30-TN3270
   inservice
  real name SC31-TN3270
   inservice
  real name SC32-TN3270
   inservice
  probe PING-30S
!
 vserver TN3270 8
  virtual 10.1.60.10 tcp telnet
  serverfarm TN3270
  replicate csrp connection
  persistent rebalance
  inservice
!
dfp 9
 agent 10.1.9.10 3860 65520
```

```
!
interface Vlan10 10
 ip address 10.1.2.220 255.255.255.0
 ip policy route-map pbr-to-csm
 ip ospf cost 100
 ip ospf priority 90
 standby 10 ip 10.1.2.230
 standby 10 preempt
 standby 10 priority 90
!
interface Vlan11 10
 ip address 10.1.3.220 255.255.255.0
 ip policy route-map pbr-to-csm
 ip ospf cost 100
 ip ospf priority 90
 standby 11 ip 10.1.3.230
 standby 11 preempt
 standby 11 priority 90
!
interface Vlan60 11
 description VLAN 60 for CSM
 ip address 10.1.60.220 255.255.255.0
 ip ospf cost 5
!
interface Vlan61 12
 description CSM Failover
 no ip address
!
router ospf 100 13
 router-id 10.1.3.220
 log-adjacency-changes
 area 2 stub no-summary
 network 10.1.2.0 0.0.0.255 area 2
 network 10.1.3.0 0.0.0.255 area 2
 network 10.1.100.0 0.0.0.255 area 2
 network 10.1.0.0 0.0.255.255 area 0
 network 10.200.1.0 0.0.0.255 area 0
 network 192.168.2.0 0.0.0.255 area 2
 default-information originate always metric-type 1
!
ip access-list extended tn3270 14
 permit tcp host 10.1.1.30 eq telnet any
 permit tcp host 10.1.1.20 eq telnet any
 permit tcp host 10.1.1.10 eq telnet any!
!
route-map pbr-to-csm permit 10 15
 match ip address tn3270
 set ip next-hop 10.1.60.1
!
```

The following elements differ slightly from those used with the active CSM:

1. CSM is in module 3 of this switch.

2. A unique ID for the standby CSM is required.

3. Fault tolerance uses a dedicated VLAN 61.

4. CSM server VLAN. Subnet 10.1.60.0/24. This is the subnet for CSM and application clusters. There is no routing within the CSM, only static routes pointing to the routers.

5. This is the ICMP probe used for polling a given application instance for availability.

6. This is the real server definition pointing to the static VIPA per LPAR.

7. This is the server farm definition grouping real servers together and the probe that indicates polling of each real server. If a real server refuses to answer, the real server is marked unavailable.

8. This is the virtual server representing the application cluster. *Replicate csrp connection* implements stateful failover between the CSMs without connection loss of existing connections.

9. This is the DFP agent pointing to z/OS Load Balancing Advisor.

> **Note:** The Cisco CSM might recognize the third parameter as “activity timeout” or a “keepalive” instead of bind_id. The syntax applied when enabling SASP is as follows.
>
> ```
> agent ip-address port bind_id [flags] [keep-alive-interval]
> ```

10. These are the OSA-Express Gigabit Ethernet attachment of z/OS. Policy-based routing is enabled in these VLANs.

11. VLAN 60. Subnet 10.1.60.0/24. This is the subnet for CSM and application clusters.

12. VLAN 61. This is the dedicated VLAN for CSM failover services.

13. OSPF process 100 includes subnets matching 10.1.2.0/24, 10.1.3.0/24, and 10.1.60.0/24.

14. This is the extended access list used by policy-based routing.

15. This is the Route Map used by policy-based routing. It ensures that datagrams returned from z/OS TN3270 servers are being forwarded back to the CSM (avoid bypassing CSM).

Verification

We verify the correct operation by completing the following steps:

1. Start the Load Balancing Advisor.
2. Start the Load Balancing Agent in all three LPARs.
3. Check the connections between the agents and the switch units.
4. Check the status of the DFP agents in CSM.
5. Verify the DFP agents in CSM is registered with an z/OS LB Advisor.
6. Verify that application members are registered with the agents.
7. Start TCP connection from the client.
8. Observe what happens if one TCP/IP stack is lost.
9. Observe what happens if an agent is lost.
10. Observe what happens if the z/OS Load Balancing Advisor is lost.

Start the Load Balancing Advisor

We start the z/OS Load Balancing Advisor in SC30, as shown in Example 6-27 on page 227. Load Balancing Agent created a DVIPA from VIPARANGE **1**. Load balancer (CSM) has connected to z/OS Load Balancing Advisor **2**.

Example 6-27 z/OS Load Balancing Advisor started

```
S LBADV
$HASP100 LBADV    ON STCINRDR
IEF695I START LBADV    WITH JOBNAME LBADV    IS ASSIGNED TO USER
LBADV   , GROUP OMVSGRP
$HASP373 LBADV    STARTED
EZD1231I LBADV STARTING
EZD1205I DYNAMIC VIPA 10.1.9.10 WAS CREATED USING BIND BY LBADV ON
TCPIPA 1
EZD1232I LBADV INITIALIZATION COMPLETE
EZD1263I LBADV LOAD BALANCER CONNECTED FROM 10.1.60.2 2
```

Example 6-28 shows that the LB Advisor is ready.

Example 6-28 LB Advisor is listening ready and listening

```
D TCPIP,TCPIPA,N,CONN,PORT=3860
EZD0101I NETSTAT CS V1R13 TCPIPA 311
USER ID  CONN     STATE
LBADV    0000619D LISTEN
  LOCAL SOCKET:   10.1.9.10..3860
  FOREIGN SOCKET: 0.0.0.0..0
LBADV    000061A0 ESTBLSH
  LOCAL SOCKET:   10.1.9.10..3860
  FOREIGN SOCKET: 10.1.60.2..1027
2 OF 2 RECORDS DISPLAYED
END OF THE REPORT
```

Start the Load Balancing Agent in all three LPARs

The agents start in all three LPARs, as shown in Example 6-29.

Example 6-29 LB Agent joblog in SC30, SC31, and SC32

```
On SC30
S LBAGENTA
$HASP100 LBAGENTA ON STCINRDR
IEF695I START LBAGENTA WITH JOBNAME LBAGENTA IS ASSIGNED TO USER
LBAGENT , GROUP OMVSGRP
$HASP373 LBAGENTA STARTED
EZD1231I LBAGENTA STARTING
EZD1232I LBAGENTA INITIALIZATION COMPLETE
EZD1259I LBAGENTA CONNECTED TO ADVISOR 10.1.9.10

On SC31
S LBAGENTB
$HASP100 LBAGENTB ON STCINRDR
IEF695I START LBAGENTB WITH JOBNAME LBAGENTB IS ASSIGNED TO USER
LBAGENT , GROUP OMVSGRP
$HASP373 LBAGENTB STARTED
EZD1231I LBAGENTB STARTING
EZD1232I LBAGENTB INITIALIZATION COMPLETE
EZD1259I LBAGENTB CONNECTED TO ADVISOR 10.1.9.10

On SC32
S LBAGENTC
```

```
$HASP100 LBAGENTC ON STCINRDR
IEF695I START LBAGENTC WITH JOBNAME LBAGENTC IS ASSIGNED TO USER
LBAGENT , GROUP OMVSGRP
$HASP373 LBAGENTC STARTED
EZD1231I LBAGENTC STARTING
EZD1232I LBAGENTC INITIALIZATION COMPLETE
EZD1259I LBAGENTB CONNECTED TO ADVISOR 10.1.9.10

On SC30
EZD1261I LBADV AGENT CONNECTED FROM ::FFFF:10.1.1.10
EZD1261I LBADV AGENT CONNECTED FROM ::FFFF:10.1.1.20
EZD1261I LBADV AGENT CONNECTED FROM ::FFFF:10.1.1.30
```

Check the connections between the agents and the switch units

We verify that the agents and load balancer are connected to the advisor. Example 6-30 shows the connection in SC30.

Example 6-30 z/OS Load Balancing Advisor/Agent connection in SC30

```
D TCPIP,TCPIPA,N,CONN
EZD0101I NETSTAT CS V1R13 TCPIPA 373
USER ID  CONN     STATE
LBADV    000061BF ESTBLSH
  LOCAL SOCKET:   ::FFFF:10.1.9.10..8100
  FOREIGN SOCKET: ::FFFF:10.1.1.10..8000 1
LBADV    000061C3 ESTBLSH
  LOCAL SOCKET:   ::FFFF:10.1.9.10..8100
  FOREIGN SOCKET: ::FFFF:10.1.1.20..8000 2
LBADV    00006203 ESTBLSH
  LOCAL SOCKET:   ::FFFF:10.1.9.10..8100
  FOREIGN SOCKET: ::FFFF:10.1.1.30..8000 3
LBADV    0000619D LISTEN
  LOCAL SOCKET:   10.1.9.10..3860 4
  FOREIGN SOCKET: 0.0.0.0..0
LBADV    000061A0 ESTBLSH
  LOCAL SOCKET:   10.1.9.10..3860
  FOREIGN SOCKET: 10.1.60.2..1027 5
LBAGENTA 000061BE ESTBLSH
  LOCAL SOCKET:   10.1.1.10..8000 6
  FOREIGN SOCKET: 10.1.9.10..8100
LBADV    0000619F LISTEN
  LOCAL SOCKET:   ::..8100 7
  FOREIGN SOCKET: ::..0
...
```

This display includes the following relevant points:

1. The z/OS Load Balancing Agent from SC30.
2. The z/OS Load Balancing Agent from SC31.
3. The z/OS Load Balancing Agent from SC32.
4. The z/OS Load Balancing Advisor listener socket for SASP clients.
5. The z/OS Load Balancing Advisor connection from active CSM.
6. The z/OS Load Balancing Advisor listener socket for z/OS Load Balancing Agents.
7. The z/OS Load Balancing Agent connection with z/OS Load Balancing Advisor.

Example 6-31 shows the connection in SC31.

Example 6-31 z/OS Load Balancing Advisor connection in SC31

```
D TCPIP,TCPIPB,N,CONN,PORT=8000
EZD0101I NETSTAT CS V1R13 TCPIPB 857
USER ID  CONN     STATE
LBAGENTB 0000304E ESTBLSH
  LOCAL SOCKET:   10.1.1.20..8000
  FOREIGN SOCKET: 10.1.9.10..8100
```

Example 6-32 shows the connection in SC32.

Example 6-32 z/OS Load Balancing Advisor connection in SC32

```
D TCPIP,TCPIPC,N,CONN,PORT=8000
EZD0101I NETSTAT CS V1R13 TCPIPC 633
USER ID  CONN     STATE
LBAGENTC 00000038 ESTBLSH
  LOCAL SOCKET:   10.1.1.30..8000
  FOREIGN SOCKET: 10.1.9.10..8100
```

Check the status of the DFP agents in CSM

We check the status of the DFP agents in the active CSM, as shown in Example 6-33.

Example 6-33 DFP Agent display in active CSM

```
Router1#sh mod csm 2 dfp det
DFP Agent 10.1.9.10:3860  Connection state: Connected 1
   Keepalive = 65520 2 Retry Count = 0      Interval = 180   (Default)
   Security errors = 0
   Last message received: 14:19:13 est 08/01/11
   Last reported Real weights for Protocol TCP, Port telnet
      Host 10.1.1.10       Bind ID 65520  Weight 1
      Host 10.1.1.20       Bind ID 65520  Weight 1
      Host 10.1.1.30       Bind ID 65520  Weight 1

DFP manager listen port not configured.
No weights to report to managers.
```

Note that the DFP agent (1) in active CSM is connected to the z/OS Load Balancing Advisor. The number 2 indicates it is using bind_id 65520 (although it looks like a Keepalive parameter in the display).

Restarting: After configuring the CSM, you might need to restart the CSM by issuing the following command to start communicating z/OS Load Balancing Advisor. In our environment, CSM is in slot 2 so we specify 2.

```
hw-module module 2 reset
```

We also check the status of the standby CSM agent, as shown in Example 6-34.

Example 6-34 DFP Agent display in standby CSM

```
Router1#sh mod csm 3 dfp det
DFP Agent 10.1.9.10:3860  Connection state: Connected 1
   Keepalive = 65520  Retry Count = 0      Interval = 180   (Default)
   Security errors = 0
   Last message received: 14:19:13 est 08/01/11
   Last reported Real weights for Protocol TCP, Port telnet
      Host 10.1.1.10       Bind ID 65520  Weight 1
      Host 10.1.1.20       Bind ID 65520  Weight 1
      Host 10.1.1.30       Bind ID 65520  Weight 1

DFP manager listen port not configured.
No weights to report to managers.
```

Note that the DFP agent (1) in the standby CSM is connected to the z/OS Load Balancing Advisor.

Verify the DFP agents in CSM is registered with an z/OS LB Advisor

We verify that the DFP (Data Facility Product) agents in CSM is registered with the z/OS Load Balancing Advisor in SC30, as shown in Example 6-35.

Example 6-35 Display a load balancer summary

```
F LBADV,DISP,LB
EZD1242I LOAD BALANCER SUMMARY 389
LB INDEX      : 01       UUID      : 436973636F2D43534D2D3635303941
 IPADDR..PORT : 10.1.60.2..1025
 HEALTH       : 7E       FLAGS     : NOCHANGE PUSH
1 OF 1 RECORDS DISPLAYED
```

We display a detailed list of the data registered with the active CSM under index 01, as shown in Example 6-36. (The LB index numbers are shown in Example 6-35.)

Example 6-36 Display load balancer details about active CSM

```
F LBADV,DISP,LB,I=01
EZD1243I LOAD BALANCER DETAILS 391
LB INDEX      : 01       UUID      : 436973636F2D43534D2D3635303941
 IPADDR..PORT : 10.1.60.2..1025
 HEALTH       : 7E       FLAGS     : NOCHANGE PUSH
 GROUP NAME   : TN3270
  GROUP FLAGS : SERVERWLM
  IPADDR..PORT: 10.1.1.30..23
   SYSTEM NAME: SC32      PROTOCOL  : TCP  AVAIL     : YES
   WLM WEIGHT : 00048     CS WEIGHT : 100  NET WEIGHT: 00001          1
   RAW           CP: 48  ZAAP: 64  ZIIP: 64
   PROPORTIONAL  CP: 47  ZAAP: 00  ZIIP: 00
   ABNORM     : 00000     HEALTH    : 100
   FLAGS      :
  IPADDR..PORT: 10.1.1.20..23
   SYSTEM NAME: SC31      PROTOCOL  : TCP  AVAIL     : YES
   WLM WEIGHT : 00047     CS WEIGHT : 100  NET WEIGHT: 00001          1
   RAW           CP: 47  ZAAP: 64  ZIIP: 64
   PROPORTIONAL  CP: 47  ZAAP: 00  ZIIP: 00
   ABNORM     : 00000     HEALTH    : 100
   FLAGS      :
  IPADDR..PORT: 10.1.1.10..23
   SYSTEM NAME: SC30      PROTOCOL  : TCP  AVAIL     : YES
   WLM WEIGHT : 00048     CS WEIGHT : 100  NET WEIGHT: 00001          1
   RAW           CP: 48  ZAAP: 64  ZIIP: 64
   PROPORTIONAL  CP: 47  ZAAP: 00  ZIIP: 00
   ABNORM     : 00000     HEALTH    : 100
   FLAGS      :
3 OF 3 RECORDS DISPLAYED
```

Note the WLM weight (1), Communications Server weight, and NET weight (the weight that is forwarded to the external load balancer).

The load balancer details displayed in Example 6-37 are also available from the CSM. Remember that the z/OS Load Balancing Advisor sends the NET WEIGHT to the CSM and to the standby CSM.

Example 6-37 Display DFP weights in active CSM

```
Router1#sh mod csm 2 dfp weights

   Real IP : 10.1.1.10 Protocol: TCP Port: telnet Bind_ID: 65520 Weight: 1 1
   Set by Agent 10.1.9.10:3860 at 14:19:13 est 08/01/11

   Real IP : 10.1.1.20 Protocol: TCP Port: telnet Bind_ID: 65520 Weight: 1 1
   Set by Agent 10.1.9.10:3860 at 14:18:31 est 08/01/11

   Real IP : 10.1.1.30 Protocol: TCP Port: telnet Bind_ID: 65520 Weight: 1 1
   Set by Agent 10.1.9.10:3860 at 14:18:31 est 08/01/11
```

Note the NET weight (1) received from the z/OS Load Balancing Advisor.

Verify that application members are registered with the agents

We use the commands shown in the examples to verify the members registered in the agents in each LPAR. Example 6-38 shows the member details in SC30.

Example 6-38 LBAGENT member details in SC30

```
F LBAGENT,DISP,MEM,DET
IEE341I LBAGENT          NOT ACTIVE
F LBAGENTA,DISP,MEM,DET
EZD1245I MEMBER DETAILS 395
LB INDEX      : 01        UUID      : 436973636F2D43534D2D3635303941
 GROUP NAME   : TN3270
  IPADDR..PORT: 10.1.1.10..23
   TCPNAME    : TCPIPA    MATCHES   : 003  PROTOCOL  : TCP
   FLAGS      : ANY
   JOBNAME    : TN3270A3  ASID      : 008D RESOURCE  : 00000075
   JOBNAME    : TN3270A2  ASID      : 008C RESOURCE  : 00000076
   JOBNAME    : TN3270A1  ASID      : 008B RESOURCE  : 00000077
1 OF 1 RECORDS DISPLAYED
```

Example 6-39 shows the member details in SC31.

Example 6-39 LBAGENT member details in SC31

```
F LBAGENTB,DISP,MEM,DET
EZD1245I MEMBER DETAILS 881
LB INDEX      : 01       UUID      : 436973636F2D43534D2D3635303941
 GROUP NAME   : TN3270
  IPADDR..PORT: 10.1.1.20..23
   TCPNAME    : TCPIPB    MATCHES   : 001  PROTOCOL  : TCP
   FLAGS      : ANY
   JOBNAME    : TN3270B   ASID      : 0069 RESOURCE  : 0000002B
1 OF 1 RECORDS DISPLAYED
```

Example 6-40 shows the member details for SC32.

Example 6-40 LBAGENT member details in SC32

```
F LBAGENTC,DISP,MEM,DET
EZD1245I MEMBER DETAILS 658
LB INDEX      : 01       UUID      : 436973636F2D43534D2D3635303941
 GROUP NAME   : TN3270
  IPADDR..PORT: 10.1.1.30..23
   TCPNAME    : TCPIPC    MATCHES   : 001  PROTOCOL  : TCP
   FLAGS      : ANY
   JOBNAME    : TN3270C   ASID      : 0047 RESOURCE  : 0000003D
1 OF 1 RECORDS DISPLAYED
```

Start TCP connection from the client

We connect 12 TN3270 clients using address 10.1.60.10 and verify the distribution, as shown in Example 6-41. As shown in the example, the weights are changed based on updates from the z/OS Load Balancing Advisor. (The weight for SC32-TN3270 changes from 2 to 3 because we made a similar display a few minutes earlier.) This display shows how the 12 connections are distributed across three systems.

Example 6-41 Display of the server farm in the CSM

```
Router1#sh mod csm 2 serverfarms name tn3270 detail
TN3270, type = SLB, predictor = RoundRobin
  nat = SERVER
  virtuals inservice = 1, reals = 3, bind id = 65520, fail action = none
  inband health config: <none>
  retcode map = <none>
  Real servers:
    SC30-TN3270, weight = 1, OPERATIONAL, conns = 4 1
    SC31-TN3270, weight = 1, OPERATIONAL, conns = 4 1
    SC32-TN3270, weight = 1, OPERATIONAL, conns = 4 1
  Total connections = 12
```

Note that the 12 TN3270 connections (1) are now distributed according to the weights sent by the agents.

Observe what happens if one TCP/IP stack is lost

We then stop the TCP/IP stack in SC32, making the TN3270 server in SC32 unavailable. This action breaks TN3270 sessions, as shown in Example 6-42. When we reconnect the sessions, they will be distributed according to the weights in the remaining TN3270 servers.

Note that the weighting recommendations can change rapidly during a recovery situation such as this one and slightly different reconnection timings can produce slightly different connection distributions.

Example 6-42 Display of the server farm in the CSM

```
Router1#sh mod csm 2 serverfarms name tn3270 detail
TN3270, type = SLB, predictor = RoundRobin
  nat = SERVER
  virtuals inservice = 1, reals = 3, bind id = 65520, fail action = none
  inband health config: <none>
  retcode map = <none>
  Real servers:
    SC30-TN3270, weight = 1, OPERATIONAL, conns = 4
    SC31-TN3270, weight = 1, OPERATIONAL, conns = 4
    SC32-TN3270, weight = 0, DFP_THROTTLED, conns = 0 1
  Total connections = 8
```

Note that real server SC32-TN3270 (1) has the DFP_THROTTLED status and lost TCP connections.

After stopping the TCP/IP stack (and the TN3270 server) on SC32, the advisor assigns a weight of zero, as shown in Example 6-43. The zero weight means “Do not forward requests to this server instance.”

Example 6-43 Display load balancer details about active CSM

```
F LBADV,DISP,LB,I=01
EZD1243I LOAD BALANCER DETAILS 410
LB INDEX      : 01        UUID      : 436973636F2D43534D2D3635303941
 IPADDR..PORT : 10.1.60.2..1025
 HEALTH       : 7E        FLAGS     : NOCHANGE PUSH
 GROUP NAME   : TN3270
  GROUP FLAGS : SERVERWLM
  IPADDR..PORT: 10.1.1.30..23
   SYSTEM NAME: N/A       PROTOCOL  : TCP  AVAIL     : NO
   WLM WEIGHT : 00000     CS WEIGHT : 000  NET WEIGHT: 00000 1
   RAW          CP: 47  ZAAP: 64  ZIIP: 64
   PROPORTIONAL  CP: 47  ZAAP: 00  ZIIP: 00
   ABNORM     : 00000     HEALTH    : 100
   FLAGS      : NOTARGETSYS 2
  IPADDR..PORT: 10.1.1.20..23
   SYSTEM NAME: SC31      PROTOCOL  : TCP  AVAIL     : YES
   WLM WEIGHT : 00048     CS WEIGHT : 100  NET WEIGHT: 00001
   RAW          CP: 48  ZAAP: 64  ZIIP: 64
   PROPORTIONAL  CP: 47  ZAAP: 00  ZIIP: 00
   ABNORM     : 00000     HEALTH    : 100
   FLAGS      :
  IPADDR..PORT: 10.1.1.10..23
   SYSTEM NAME: SC30      PROTOCOL  : TCP  AVAIL     : YES
   WLM WEIGHT : 00048     CS WEIGHT : 100  NET WEIGHT: 00001
   RAW           CP: 48  ZAAP: 64  ZIIP: 64
   PROPORTIONAL  CP: 47  ZAAP: 00  ZIIP: 00
   ABNORM     : 00000     HEALTH    : 100
   FLAGS      :
3 OF 3 RECORDS DISPLAYED
```

Note that weights (1) changed to zero, indicating that the application instance is not ready for connections. Also note that LBQ (2) says that the load balancer has quiesced the member. NOTARGETSYS says that the z/OS Load Balancing Advisor advises the load balancer that the application instance should not receive new workload.

Observe what happens if an agent is lost

We restart SC32 and establish 12 new connections as shown in Example 6-44.

Example 6-44 Display of the server farm in the CSM: How the 12 connections are distributed

```
Router1#sh mod csm 2 serverfarms name tn3270 detail
TN3270, type = SLB, predictor = RoundRobin
  nat = SERVER
  virtuals inservice = 1, reals = 3, bind id = 65520, fail action = none
  inband health config: <none>
  retcode map = <none>
  Real servers:
    SC30-TN3270, weight = 1, OPERATIONAL, conns = 4
    SC31-TN3270, weight = 1, OPERATIONAL, conns = 4
    SC32-TN3270, weight = 1, OPERATIONAL, conns = 4
  Total connections = 12
```

Next, we stop the z/OS Load Balancing Agent (LBAGENTC) in SC32. If an agent is down, existing sessions to the LPAR continue. We established four additional TCP connections, but new sessions are not sent to that LPAR, as shown in Example 6-45.

Example 6-45 New sessions are not sent to LPAR SC32

```
Router1#sh mod csm 2 serverfarms name tn3270 detail
TN3270, type = SLB, predictor = RoundRobin
  nat = SERVER
  virtuals inservice = 1, reals = 3, bind id = 65520, fail action = none
  inband health config: <none>
  retcode map = <none>
  Real servers:
    SC30-TN3270, weight = 1, OPERATIONAL, conns = 6
    SC31-TN3270, weight = 1, OPERATIONAL, conns = 6
    SC32-TN3270, weight = 0, DFP_THROTTLED, conns = 4 1
  Total connections = 16
```

In this example, the number corresponds to the following information:

1. Real server SC32-TN3270 has the status DFP_THROTTLED and weight zero, which means that new connections will not be sent.

Observe what happens if the z/OS Load Balancing Advisor is lost

We experiment by taking down the z/OS Load Balancing Advisor. The display in Example 6-46 illustrates this state. When the retry limit (10) is reached, the CSM returns to its internal load-balancing algorithm (round-robin) until the z/OS Load Balancing Advisor is back. Existing connections continue without disruption.

Example 6-46 Connection from DFP fails

```
Router1#sh mod csm 2 dfp detail
DFP Agent 10.1.9.10:3860  Connection state: Failed  Retries: 2 1
   Keepalive = 65520  Retry Count = 0      Interval = 180   (Default)
   Security errors = 0
   Last message received: 14:48:23 est 08/01/11
   Last reported Real weights for Protocol TCP, Port telnet
      Host 10.1.1.10       Bind ID 65520  Weight 1
      Host 10.1.1.20       Bind ID 65520  Weight 1
      Host 10.1.1.30       Bind ID 65520  Weight 1

DFP manager listen port not configured.
No weights to report to managers.
```

Note that the DFP connection to the z/OS Load Balancing Advisor has failed (1). It will be retried 10 times.

After all the retries fail, the CSM uses its default internal balancing, which is round-robin, as shown in Example 6-47. Existing connections are preserved, and the new connections are now distributed based on round-robin.

Example 6-47 Display of the server farm in the CSM: How the 12 connections are distributed

```
Router1#sh mod csm 2 serverfarms name tn3270 detail
TN3270, type = SLB, predictor = RoundRobin
  nat = SERVER
  virtuals inservice = 1, reals = 3, bind id = 65520, fail action = none
  inband health config: <none>
  retcode map = <none>
  Real servers:
    SC30-TN3270, weight = 1, OPERATIONAL, conns = 5 1
    SC31-TN3270, weight = 1, OPERATIONAL, conns = 5 1
    SC32-TN3270, weight = 1, OPERATIONAL, conns = 5 1
  Total connections = 15
```

In this example, the number corresponds to the following information:

1. The external load balancer returns to internal decision-making (round-robin).

Note: The CSM registers application-specific members, provided that each vserver uses separate server farms; otherwise, the CSM only registers system members.

In Example 6-47, the z/OS Load Balancing Advisor used SERVERWLM. Using SERVERWLM usually results in better workload distribution.

Be aware that TN3270 is part of the TCP/IP stack in our example. By using SERVERWLM for TN3270, we actually receive WLM recommendations for the TCP/IP stack and not TN3270 itself. We suggest that you use SERVERWLM for servers running in their own address spaces, such as an HTTP server.

Problem determination

We approach problem determination for this example in the following order:

1. Check that application instances are running in z/OS (active listener).
2. Check that there is connectivity between the router and z/OS.
3. Check that the real server is operational.
4. Check that the virtual server is operational.
5. Check for connectivity between the client and CSM (application cluster address=vserver address).
6. Check that policy-based routing definitions are in place.
7. Run packet trace.
8. Run CTRACE.
9. Use a network analyzer.
10. Run debug in the external networking devices.
11. Run debug in z/OS Load Balancing Advisor, z/OS Load Balancing Agents, or both.

Both the z/OS Load Balancing Advisor and the z/OS Load Balancing Agents can write logs to the syslogd daemon facility. To use this facility, syslogd must be started before starting the z/OS Load Balancing Advisor and the z/OS Load Balancing Agent. The debug level (7) should normally be used unless problem documentation needs to be gathered. Increased levels of debug can result in excessive amounts of information.

Logging levels for the advisor and agent have the following descriptions:

0	None. No debug messages are logged.
1	Error-level messages are logged.
2	Warning-level messages are logged.
4	Event-level messages are logged.
8	Info-level messages are logged.
16	Message-level messages are logged. These are the details of the messages (packets) sent between the advisor and LB, and the advisor and agent.
32	Collection-level messages are logged. These are details of the collection and manipulation of data supporting the calculated weights. This level only has meaning to the Agent. The Advisor does not log any data at this level.
64	Debug-level messages are logged. These are internal debug messages intended for development and service.
128	Trace-level messages are logged. These are function entry and exit traces that show the path through the code.

To log a combination of debug levels, add the debug level numbers. The default debug level is 7, which captures all error, warning, and event messages.

6.3.2 TLS/SSL for z/OS Load Balancing Advisor

The Advisor, Agents, and Automated Domain Name Registration (ADNR) are authorized programs that must be started from a start procedure. The ability to establish a connection to the Advisor needs to be restricted to “authorized parties,” because sensitive interfaces can be exploited after a connection is accepted by the Load Balancing Advisor. Ensure that only the Load Balancing Agents that IBM provides are allowed to connect to the Agent listening port. Agents are responsible for providing sensitive information that indicates server application availability, health, and performance. Ensure that only authorized load balancers are allowed to connect to the Advisor on the external load balancer SASP port. The Advisor to load balancer interface can be used to obtain sensitive information regarding TCP/IP applications that are deployed in a sysplex, processor utilization information for each system, and so on.

The data flowing on the Advisor’s connections, which includes server application availability, health, and performance, might need to be encrypted. An Application Transparent Transport Layer Security (AT-TLS) policy can specify encryption for data flowing outside of the TCP/IP stack.

Using TLS/SSL technologies, you can secure and control access to all communications with the Load Balancing Advisor. TLS/SSL support for the Load Balancing Advisor, Agents, and the ADNR function is provided using the AT-TLS feature of the Communications Server. You have the ability to perform access control checks using System Authorization Facility (SAF) compliant security product profiles.

Client certificates can authenticate external load balancers, z/OS Load Balancing Agents, and ADNR clients connecting to the Load Balancing Advisor.

You can use a combination of TLS/SSL and non-TLS/SSL connections to the Advisor. Your availability of the Advisor and Agents can be improved by removing certain configuration statements; in some cases, a recycling of the Advisor is required, because dynamic reconfiguration is not supported.

Using AT-TLS, an Agent or load balancer instance can be added without affecting the Advisor.

Implementing Load Balancing Advisor AT-TLS (optional)

When you implement Load Balancing Advisor using AT-TLS, complete the following tasks:

1. Define the necessary SERVAUTH profiles and permit authorized users to these profiles. If the appropriate SAF profile is defined, then only authorized Agents, external load balancers, and ADNR are allowed to connect to the Advisor.

   ```
   EZB.LBA.LBACCESS.sysname.tcpsysplexgroupname
   EZB.LBA.AGENTACCESS.sysname.tcpsysplexgroupname
   ```

   The user ID that is associated with each external load balancer or agent must have READ access to either of the SERVAUTH profile.

2. Remove the following Advisor configuration file statements:

   ```
   agent_id_list
   lb_id_list
   ```

3. Remove the agent configuration statement:

   ```
   host_connection
   ```

Suggestions

If you choose to use an external load balancing solution for the z/OS environment, we suggest the z/OS Load Balancing Advisor and SASP approach.

7

Intra-sysplex workload balancing

Previous chapters described internal and external application workload balancing methods. These techniques are based on accessing an application server through one cluster IP address by the client.

In a multitier application environment, however, the path between the separate application servers within the sysplex might become long and can result in a performance impact, for example, when an HTTP server, an IBM WebSphere Application Server, or an IBM DataPower appliance and an enterprise information system (EIS), such as IBM IMS™ or IBM CICS, are involved in a single client connection request. In such situations, optimized paths within the sysplex can provide better performance.

This chapter includes several examples that illustrate how multitier application support can improve existing workload balancing solutions.

This chapter contains the following topics.

Section	Topic
7.1, “Optimizing sysplex distributor intra-sysplex load balancing” on page 240”	Basic goals needed to optimize intra-sysplex application server workload balancing in a multitier environment
7.2, “Optimized multitier z/OS sysplex distributor load balancing” on page 243	Implementation of several optimized multitier load balancing solutions with sysplex distributor and external load balancer
7.3, “WLM reporting abnormal conditions” on page 280	Basics of WLM weight calculation and the use of abnormal conditions detected by WLM to reduce weight recommendations

7.1 Optimizing sysplex distributor intra-sysplex load balancing

In a multitier application environment, situations exist where connection requests can cross logical partitions (LPARs) before reaching the appropriate application instance. The selection of a server that is on a separate LPAR than the client is initiated through workload balancing decision units such as sysplex distributor.

Figure 7-1 illustrates a typical configuration where an LPAR crossing occurs.

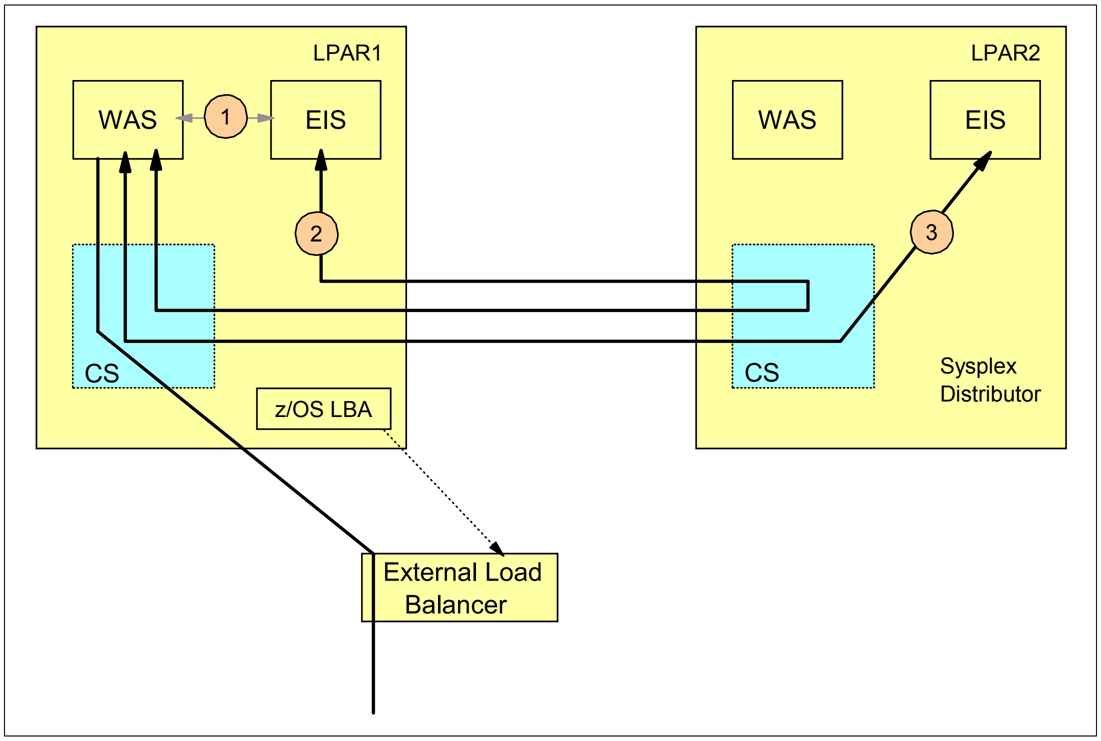


Figure 7-1 Local and remote connections

This configuration shows two load balancing decision points (in the figure, WAS is WebSphere Application Server):

- An external load balancer, which uses Workload Manager (WLM) recommendations from the z/OS Load Balancing Advisor (LBA)
- A sysplex distributor

This example is also valid if you use only sysplex distributor. A backup sysplex distributor is not shown in this figure.

Note: This example is not unique to a WebSphere Application Server environment. Any z/OS sysplex multitier application environment might exhibit similar behavior and have similar issues.

7.1.1 Current connections from WebSphere Application Server to EIS

There are two types of connectors for WebSphere Application Server to enterprise information systems (EIS) communication, shown in Figure 7-1 on page 240 as a *local connection* (1) and as *remote connections* (2) and (3).

Local connection (1)

Connection requests coming from a client through the external load balancer arrive at the TCP/IP stack and are then forwarded directly to the WebSphere Application Server. From there, the client requests are forwarded to EIS through a connector. An EIS can be a system such as CICS, IMS, or DB2.

Local connections provide an optimized, high-speed path, see (1) in Figure 7-1 on page 240, based on local services such as cross-memory services.

Problems occur if the local target (for example, the EIS) is not available. Because local connections are used, there is no way to switch to an alternate target in a separate LPAR. Also, because the WebSphere Application Server transactions are failing, they appear to complete quickly with little CPU usage, thus causing the Workload Manager (WLM) to prefer that LPAR (in our example, LPAR1) for increased workload. This situation is known as a *storm drain issue*.

Remote connections (2) and (3)

WebSphere Application Server uses remote connections for a connection to the EIS. These connections are TCP connections. A load balancer decides which address to use as the connection endpoint for the EIS (in our example, in LPAR1 or LPAR2), and this decision is based on WLM recommendations. In our case, it is the sysplex distributor that selects a target among available targets defined in the sysplex.

If the target is local and the sysplex distributor is remote, as shown in Figure 7-1 on page 240, in LPAR2 using the (2) path, or if the target is remote (in LPAR2 using the (3) path), the communication path is not as efficient as when it remains in one LPAR.

The solution to this problem must include the following aspects:

- Automatically locating a target server in the same LPAR as the client, or at least in the same CPC
- Favoring that local target as long as it is available and has sufficient capacity for new work based on WLM recommendations
- No longer favoring the local target if these conditions are not met

The overall goal of the improved multitier application support should be an optimized path to the application servers with better performance and without losing high availability.

7.1.2 Optimized multitier application workload balancing

Figure 7-2 illustrates a multitier application environment.

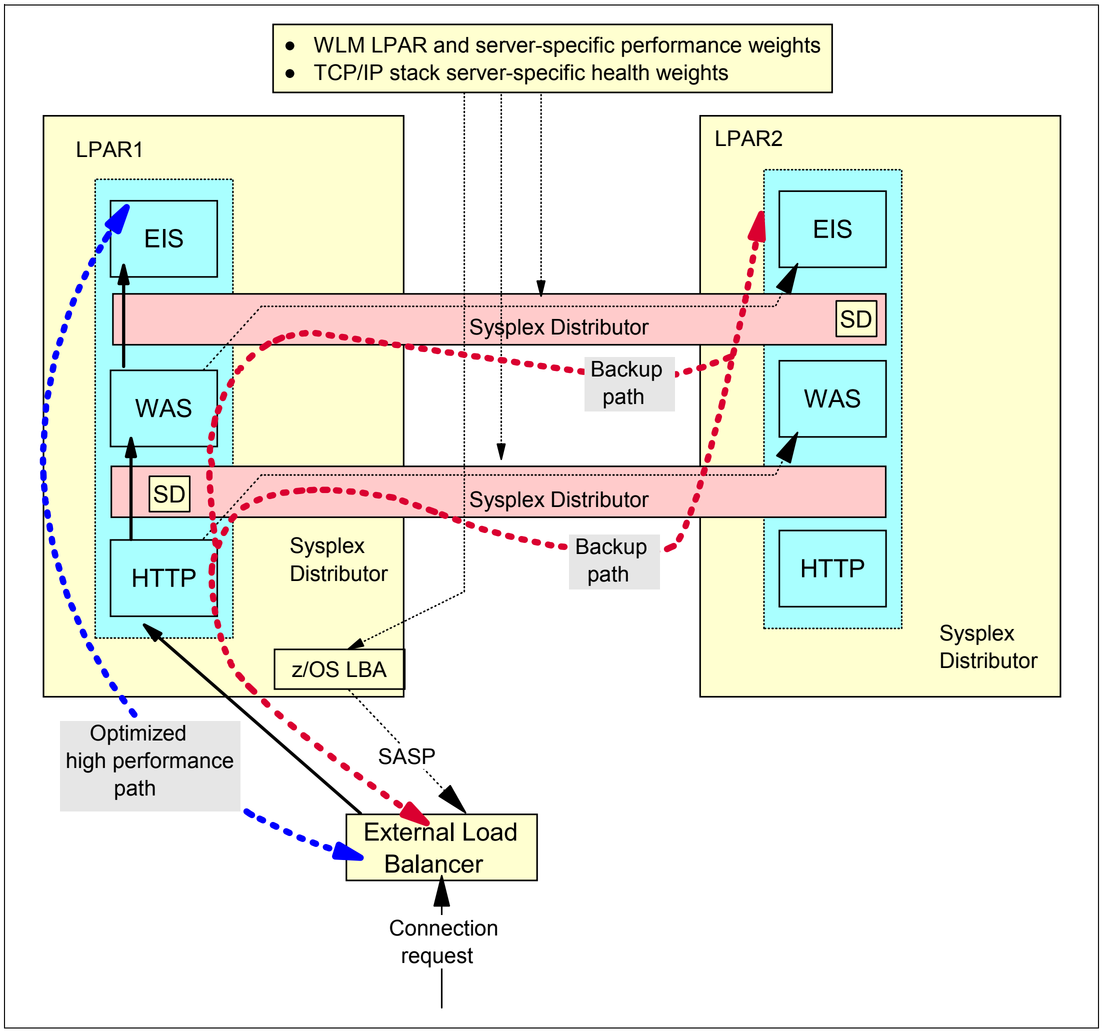


Figure 7-2 Multitier application configuration

In Figure 7-2, two LPARs have the same server applications, and they consist of the following elements:

- An HTTP proxy server that receives TCP requests from clients' browsers through an external load balancer

  The external load balancer has WLM information provided by the z/OS Load Balancing Advisor regarding which HTTP server in LPAR1 or in LPAR2 would best perform. This information is used by the load balancer to select the HTTP server in LPAR1 or LPAR2. In our example, the HTTP request was sent to the TCP/IP stack in LPAR1.

  If no external load balancer is used, then the sysplex distributor is the first address of the client request on LPAR1 that can be used to select the HTTP server instead.

- The WebSphere Application Server, which receives TCP requests from the HTTP server

  This TCP request is controlled by the sysplex distributor only. The sysplex distributor controls the selection of the HTTP server by defining distributed dynamic VIPAs. However, if the sysplex distributor decides to send the HTTP request to a WebSphere Application Server in another LPAR, then the communication impact increases.

  The best performance can be achieved by using a *fast direct local sockets* path to the WebSphere Application Server, which belongs to the same TCP/IP stack as the HTTP server. With this function, the selection of a local server and connection setup can stay within the local LPAR even if the distributor is remote. When both client and selected server are local, the data path uses fast direct local sockets.

By using application endpoint awareness with the enhanced sysplex sockets API, security functions such as authentication impact and data conversions can be avoided because the connection's setup and datapath is local.

When configuring the sysplex distributor to use optimized load balancing, you can determine the level of preference for local targets:

- Always choose a local target or a target running on the same CPC if that target is available and healthy.
- Compare WLM weights after applying a multiplier to the local target weight to determine if the local target should be preferred.

The user controls this function by defining the OPTLOCAL option and CPCSCOPE option on the VIPADISTRIBUTE statement.

7.2 Optimized multitier z/OS sysplex distributor load balancing

This section explains several concepts of the sysplex distributor functions used on a multitier environment and then describes the configuration that we use in our examples. It also explains the flow of client requests to the WebSphere Application Server and EIS, and examines our test cases, which consist of separate multitier solutions.

Multitier applications can sometimes choose between a local and remote connection, depending on the location of the different parts of the application. Running within the same system, a local connection is possible, which gives the highest performance, but it has an availability drawback. Using remote connection has a performance cost, but can provide better availability by running on separate systems.

Sysplex distributor provides support for distributing workload (TCP connections) to target systems other than z/OS. Doing so also means that sysplex distributor cannot rely on XCF communication with the target systems, and it cannot rely on WLM to provide server weights for the targets. Sysplex distributor solves this issue by implementing support for an sysplex distributor-specific agent on the target systems that uses a sysplex distributor-specific protocol to communicate with sysplex distributor. The agent provides metrics back to sysplex distributor, which sysplex distributor uses to determine availability and capacity of the target servers. In addition, the agent also provides sysplex distributor with connection state information so that sysplex distributor can maintain its normal connection routing table information and can allow a nondisruptive takeover of non-z/OS targets by a backup sysplex distributor. Incoming IP packets to connections that are distributed to a non-z/OS target are forwarded to the target using generic routing encapsulation (GRE). The initial target platform is IBM DataPower.

You can achieve optimized multitier z/OS load balancing in the following ways:

- Using sysplex external load balancing (see Chapter 6, “External application workload balancing” on page 191), plus sysplex internal load balancing, such as sysplex distributor (see Chapter 5, “Internal application workload balancing” on page 127)
- Using sysplex internal load balancing only through sysplex distributor (see Chapter 5, “Internal application workload balancing” on page 127)

Sysplex distributor improves the already existing optimized local processing by enabling the distributing stack to factor in metrics for the tier 1 server on each target TCP/IP stack, and also the tier 2 server that is used as a target by that tier 1 server on the same TCP/IP stack. The sysplex distributor can combine the weights of a WebSphere Application Server (tier 1) and the corresponding EIS (tier 2).

In our test environment, we use sysplex internal load balancing only through sysplex distributor. This solution differs only in that the sysplex distributor (instead of the external load balancer) decides which HTTP server in LPAR1 (SC30) or LPAR2 (SC31) receives the TCP SYN request, and that decision is based on the best WLM value.

Note that to switch on optimized load balancing, you must define additional parameters on the VIPADISTRIBUTE statement, as illustrated in Figure 7-3.

```
>>-VIPADynamic---------------------------------------------------------------------->

               +-TIER 1-+-------------+
|-VIPADEFINE--+                     +---------------------+--Options--+------------->
               +-TIER 2-+-----------+-+
               |        +-CPCSCOPE-+  |
               +-CPCSCOPE-------------+

|--VIPADISTRIBUTE------+--Baseoptions-------+----------+--ipv4 addr--+-------------->
                       +--Tier1 parameters--+          +--ipV6 intf--+
                       +--Tier2 parameters--+

Options:
   +-DEFINE-+  +-DISTMethod BASEWLM--(BaseWLMoptions)-------+
|--+        +--+                                            +----------------------->
   +-DELETE-+  +-DISTMethod + ROUNDROBIN--------------------+
                            + SERVERWLM--(ServerWLMoptions)-+
                            + WEIGHTEDactive----------------+

ServerWLMoptions:
   +-PROCXCOST---- ZAAP 1 ZIIP 1-+      +-ILWEIGHTING 0-+    +-NOOPTLOCAL--------+
|--+                             +------+               +----+                   +-->
   |             +-ZAAP 1-+      |      +-ILWEIGHTING 1-+    |         +-1-----+ |
   +-PROCXCOST---+        +-+-----+                   2-+    +OPTLOCAL-+       +-+
               | +-ZAAP x-+ |                         3-+              +-value-+
               |            |
               | +-ZIIP 1-+ |
               +-+        +-+
                 +-ZIIP y-+

|--ENDVIPADynamic--|
```

Figure 7-3 VIPADISTRIBUTE statement

7.2.1 Tier 1 and tier 2 options

The VIPADEFINE statement has parameters to indicate that the DVIPA is used for tier 1 and tier 2 applications. The VIPADISTRIBUTE statement has the same tier parameter followed by the name of the group, which indicates that these tiers work as a group.

Tier 1 and tier 2 servers combined weights are calculated *only* when both distribution methods use WLM weights (that is, either BASEWLM or SERVERWLM). Use SERVERWLM when possible because this method is recommended based on a server's capacity for new work instead of the LPAR's capacity for new work.

Sysplex distributor includes availability, health, and performance metrics for both the tier 1 z/OS server and the tier 2 z/OS server on a target LPAR when determining to which LPAR the tier 1 connection goes. These metrics increase the likelihood of such connections gaining the performance benefits of optimized local support, such as use of fast local sockets.

In Figure 7-4, a connection request comes into SD1 on SC30. SD1 consults with WLM and the TCP/IP stacks to determine availability, health, performance, and capacity of the target systems for both the HTTP tier server instances and the EIS tier server instances, which is CICS in our example, on each LPAR.

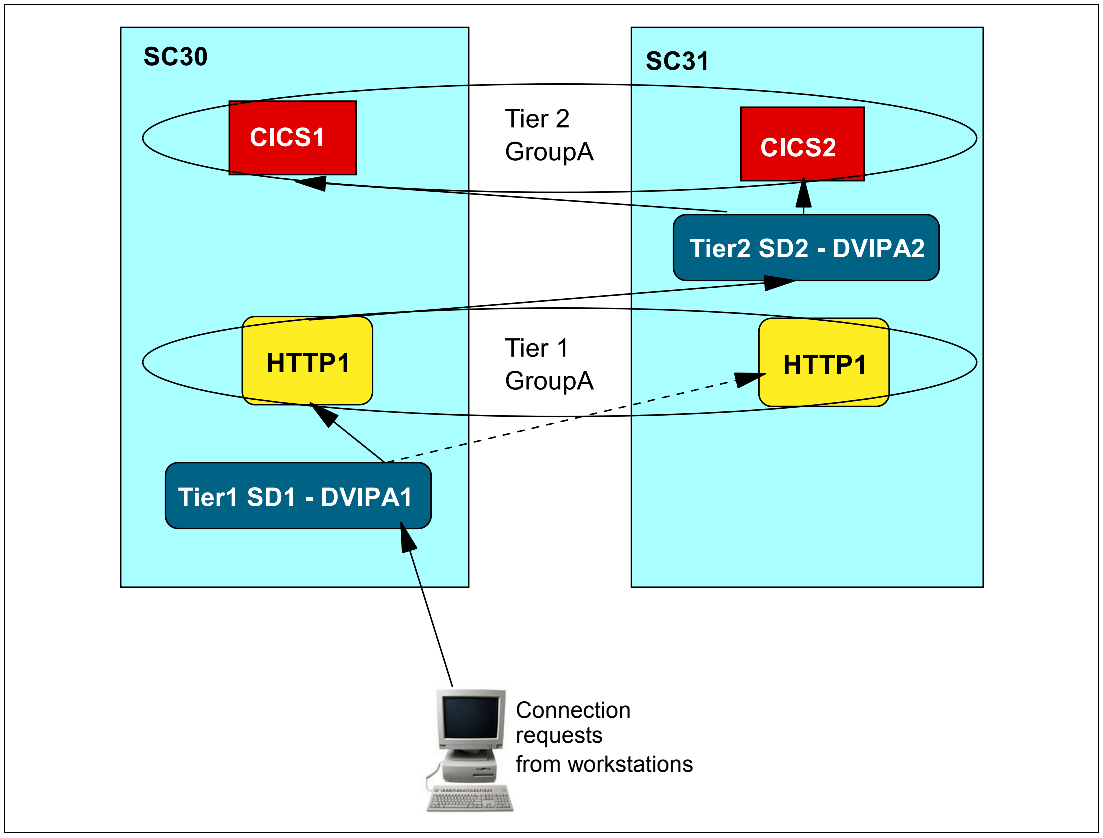


Figure 7-4 Tier 1 and tier 2 applications

When the chosen HTTP server connects to the tier 2 server and optimized local is in effect, that second connection remains on the chosen LPAR. When optimized local is configured with a default value of 1, the second connection remains local if the WLM weight is greater than 0 and the server is healthy. For more information, see 7.2.2, "OPTLOCAL option" on page 246.

Example 7-1 and Example 7-2 show the Dynamic VIPA configurations.

Example 7-1 VIPAD configuration on SC30

```
VIPADEFINE TIER1 MOVE IMMED 255.255.255.0 10.1.8.24  ; TIER 1
VIPADISTRIBUTE TIER1 GROUP1 DISTMETHOD SERVERWLM
                     10.1.8.24 PORT 10002
                     DESTIP ALL

VIPABACKUP 100 TIER2 10.1.8.23
```

Example 7-2 VIPAD configuration on SC31

```
VIPADEFINE TIER2 MOVE IMMED 255.255.255.0 10.1.8.23  ; TIER 2
VIPADISTRIBUTE TIER2 GROUP1 optlocal 1 DISTMETHOD SERVERWLM
                     10.1.8.23 PORT 10000
                     DESTIP ALL

VIPABACKUP 100 TIER1 10.1.8.24
```

When using tier 1 and tier 2 options, consider the following suggestions:

- For every VIPADISTRIBUTE DVIPA, define a corresponding VIPADEFINE and VIPABACKUP.
- On the VIPADEFINE and VIPABACKUP, you can specify the following parameters:
  - TIER1 indicates that this a DVIPA that is used to distribute connections to a tier 1 target and a TIER1 VIPADISTRIBUTE statement follows.
  - TIER2 indicates that this a DVIPA that is used to distribute connections to a tier 2 target and a TIER2 VIPADISTRIBUTE statement follows.
- On the VIPADISTRIBUTE statement for tier 1, the TIER1 group name indicates that this is a distribute statement for a tier 1 DVIPA and port. The group name is used to correlate this group of applications with a corresponding group of tier 2 applications.
- On the VIPADISTRIBUTE statement for tier 2, the TIER2 group name indicates that this is a distribute statement for a tier 2 DVIPA and port. The group name is used to correlate this group of applications with a corresponding group of tier 1 applications.
- Specify OPTLOCAL with a value as required. For more information, see 7.2.2, “OPTLOCAL option” on page 246.

7.2.2 OPTLOCAL option

The OPTLOCAL keyword allows the client to bypass sending the connection request to the sysplex distributor.

The following values influence the conditions in which the connection remains local:

- A value of 0 indicates that the connection should always remain local.
- A value of 1 indicates that the connection should remain local unless the server’s WLM weight is zero (0).
- Values of 2 through 16 are used as multipliers to increase the local WLM weight to favor the local stack.

Regardless of the value specified, the connection request is always sent to the sysplex distributor if *any* of the following situations occur:

- No server application is available on the local stack.
- The Server accept Efficiency Fraction (SEF) value on the local stack is less than 75. A SEF value of 100 is the best value.

  SEF is influenced through monitoring the target server by the stack. This value is based on whether new connections are being established, and, after being established, whether the server is accepting new connections.
- The health indicator for the local stack is less than 75 (available only for applications that provide this information to WLM using the IWM4HLTH or IWMSRSRG services).

  The health indicator provides a general health indication for an application or subsystem. Under normal circumstances, the value of this field is 100, meaning that the server is 100% healthy. Any value less than 100 indicates that the server is experiencing problem conditions that are not allowing it to process new work requests successfully. A value of less than 100 also causes the WLM to reduce the recommendation provided to the sysplex distributor for this server instance.
- The abnormal transactions count for the local stack is greater than 250.

  A non-zero value indicates that the server application has reported abnormal transaction completions to WLM, and that WLM has reduced the server-specific recommendation for this server instance. The higher the value of this field, the greater the reduction in the recommendation provided by WLM.

  For more information regarding the conditions leading to abnormal transaction completions for a given server application, see the documentation provided by the server application.

OPTLOCAL is intended to be used mainly in context with DISTMETHOD SERVERWLM or DISTMETHOD BASEWLM. If ROUNDROBIN is used together with OPTLOCAL, then the OPTLOCAL value must be zero (0), because WLM weights are not being collected. If another value is defined, then the EZD1231I message indicates that the OPTLOCAL value is set to zero (0).

7.2.3 CPCSCOPE option parameter

Dynamic VIPA (DVIPA) addresses can be defined with a scope of a CPC, meaning that these DVIPAs are specific to the central processor complex (CPC) where they are defined. These DVIPAs are never activated on LPARs that reside in other CPCs.

A DVIPA with this characteristic can be a z/OS or non-z/OS target system. In scenarios where Linux on System z acts as the first tier server, you can use CPCSCOPE DVIPAs to keep tier 2 connections and traffic on the same CPC where Linux is running.

For example, the HTTP tier on CPC1 as shown in Figure 7-5 is configured to connect to SD3 for the EIS tier, while the HTTP tier on CPC2 is configured to connect to SD2 for the EIS tier. In our example, LPAR*n* can be a z/OS or a Linux system, and this topology keeps traffic between the Linux systems and the z/OS systems on high speed networks, such as HiperSockets interfaces. The aim is to improve overall response times because of reduced cross-CPC traffic in mixed Linux on System z and z/OS workload scenarios.

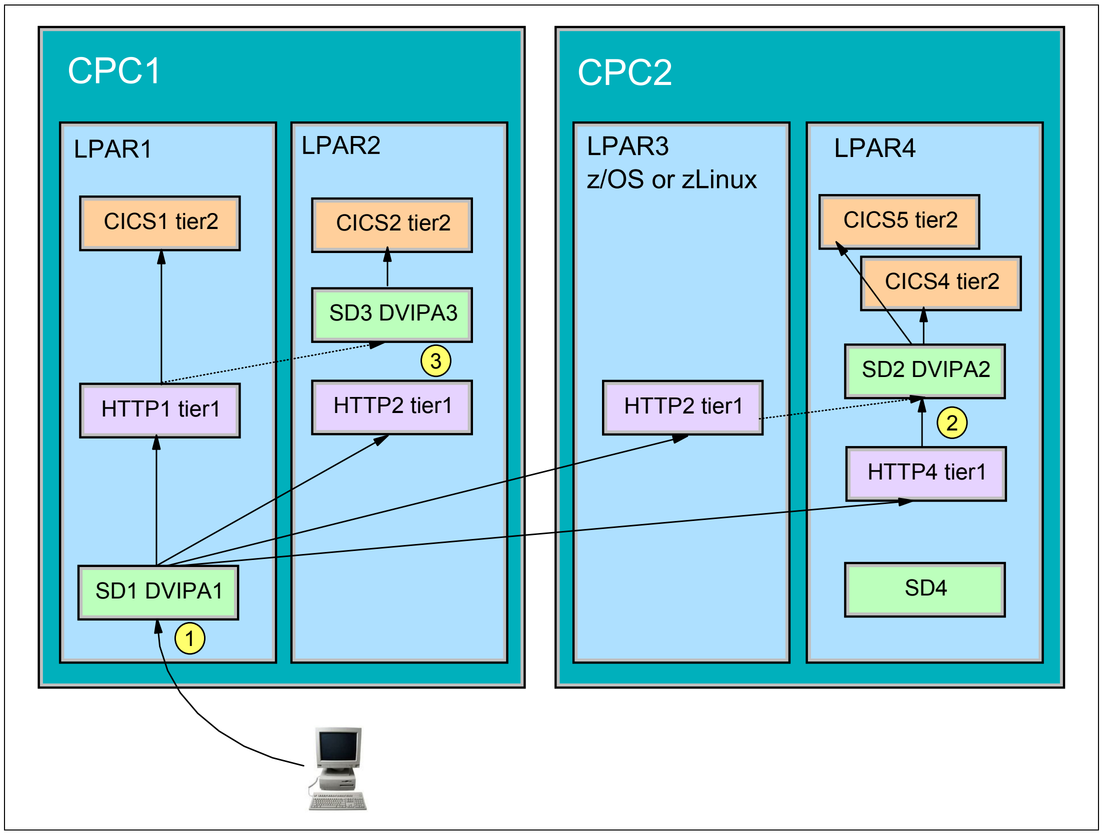


Figure 7-5 Multitier applications and CPC optimization

Example 7-3 through Example 7-6 on page 249 list the definitions that we use to create the configuration shown in Figure 7-5.

Example 7-3 SD1 VIPAD configuration on LPAR1 (SC30)

```
VIPADEFINE TIER1 MOVE IMMED 255.255.255.0 10.1.8.24
VIPADISTRIBUTE TIER1 GROUP2 DISTMETHOD  SERVERWLM
                     10.1.8.24 PORT 8085
                     DESTIP ALL

VIPABACKUP 100 TIER2 10.1.8.25
```

Example 7-4 SD3 VIPAD configuration on LPAR2 (SC31)

```
VIPADEFINE TIER2 CPCSCOPE MOVE IMMED 255.255.255.0 10.1.8.25
VIPADISTRIBUTE OPTLOCAL TIER2 GROUP2 DISTMETHOD  SERVERWLM
                        10.1.8.25 PORT 9001
                        DESTIP 10.1.7.11 10.1.7.12

VIPABACKUP 100 TIER1 10.1.8.24
```

Example 7-5 SD2 VIPAD configuration on LPAR4 (SC33)

```
VIPADEFINE TIER2 MOVE IMMED 255.255.255.0 10.1.8.26
VIPADISTRIBUTE TIER2 GROUP2 DISTMETHOD SERVERWLM
                     10.1.8.26 PORT 9001
                     DESTIP 10.1.7.13 10.1.7.14
```

Example 7-6 SD4 VIPAD configuration on LPAR4 (SC33)

```
VIPABACKUP 100 TIER1 10.1.8.26
```

With this option, consider the following suggestions:

- For every VIPADISTRIBUTE DVIPA, define a corresponding VIPADEFINE or VIPABACKUP.
- On the VIPADEFINE and VIPABACKUP, you can specify the following parameters:
  - TIER1 indicates that this is a DVIPA that is used to distribute connections to a tier 1 target and a TIER1 VIPADISTRIBUTE statement follows.
  - TIER2 indicates that this a DVIPA that is used to distribute connections to a tier 2 target and a TIER2 VIPADISTRIBUTE statement follows.
  - TIER2 CPCSCOPE indicates that this is a DVIPA that is used to distribute connections to a tier 2 target and a TIER2 VIPADISTRIBUTE statement follows. The movement of the DVIPA is restricted to the same CPC as where it is defined.
- On the VIPADISTRIBUTE statement for tier 1, the TIER1 group name indicates that this is a distribute statement for a tier 1 DVIPA and port. The group name is used to correlate this group of applications with a corresponding group of tier 2 applications.
- On the VIPADISTRIBUTE statement for tier 2, the TIER2 group name indicates that this is a distribute statement for a tier 2 DVIPA and port. The group name is used to correlate this group of applications with a corresponding group of tier 1 applications.
- Specify OPTLOCAL with a value as required.
- Define VIPABACKUP definitions for each of the tier 2 CPCSCOPE DVIPA on one of the stacks on an LPAR within the same CPC.
- A key requirement for this configuration is that you need to configure the tier 1 applications on each CPC to use a unique, CPC-specific DVIPA for tier 2 connections.This configuration implies that the tier 1 application server configurations need to be unique based on the CPC on which they reside.

7.2.4 IBM DataPower

DataPower is an IBM division that produces appliances for processing XML messages and any-to-any message transformation, such as COBOL.

z/OS Communications Server continues to focus on the logical integration between DataPower and z/OS by supporting a DataPower feedback technology to z/OS sysplex distributor. This integration allows sysplex distributor to make much higher quality load balancing decisions than any other existing load balancing technology when using connections to DataPower appliances.

DataPower appliances are often deployed as a front-end processing tier to z/OS applications, which provides for transparent web services enablement of z/OS applications.

When the DataPower tier finishes handling a request, it typically routes a request to a tier 2 application that is hosted within the z/OS environment, such as a CICS, IMS, or WebSphere. These tier 2 requests might also require load balancing, especially when the applications are deployed in a sysplex environment.

A z/OS Communications Server feature makes sysplex distributor load balance requests to both the DataPower and z/OS tiers, eliminating the need to deploy an external, network-based load balancer for the DataPower tier. By deploying the sysplex distributor as the load balancing component for both tiers of distribution, z/OS administrators can use a single load balancing solution for the z/OS workload to the DataPower and z/OS application processing tiers, thus simplifying the load balancing administration.

A control connection between sysplex distributor and each DataPower appliance is established to exchange information as follows:

- DataPower to sysplex distributor: CPU capacity and connection state information as connections are established and terminated.
- Sysplex distributor to DataPower: Sysplex distributor sends a list of distributed DVIPA/Ports to the DataPower appliance to start their listeners.

Sysplex distributor does not need to monitor connection traffic to determine when a connection ends, which allows optimized routing for outbound traffic because the packets do not need to traverse the sysplex distributor. It uses Generic Resource Encapsulation (GRE) to forward inbound distributed packets to DataPower. Outbound packets can flow directly from DataPower to the client.

The enhancement optimizes the load balancing support in several ways:

- Routing is optimized so that outbound traffic (from the tier 1 DataPower target server towards the client) does not need to traverse the sysplex distributor.
- Connection information provided by the DataPower appliances allows nondisruptive tier 1 takeover of existing connections between clients and DataPower targets.
- CPU usage information provided by the DataPower appliance allows sysplex distributor to optimize its load balancing decisions.

When using DataPower, consider the following information:

- All TCP/IP stacks that participate in the sysplex distributor support with DataPower must be V1R11 or later.
- Only IPv4 DVIPAs are supported for connections to DataPower targets.

Sysplex distributor configuration for optimized load balancing with DataPower

This scenario shows how to use sysplex distributor with DataPower appliances.

Figure 7-6 on page 251 shows two DataPower appliances, *DATAP1* and *DATAP2*, acting as tier 1 applications, and two WebSphere Application Servers, *WAS1* and *WAS2*, as tier 2 applications.

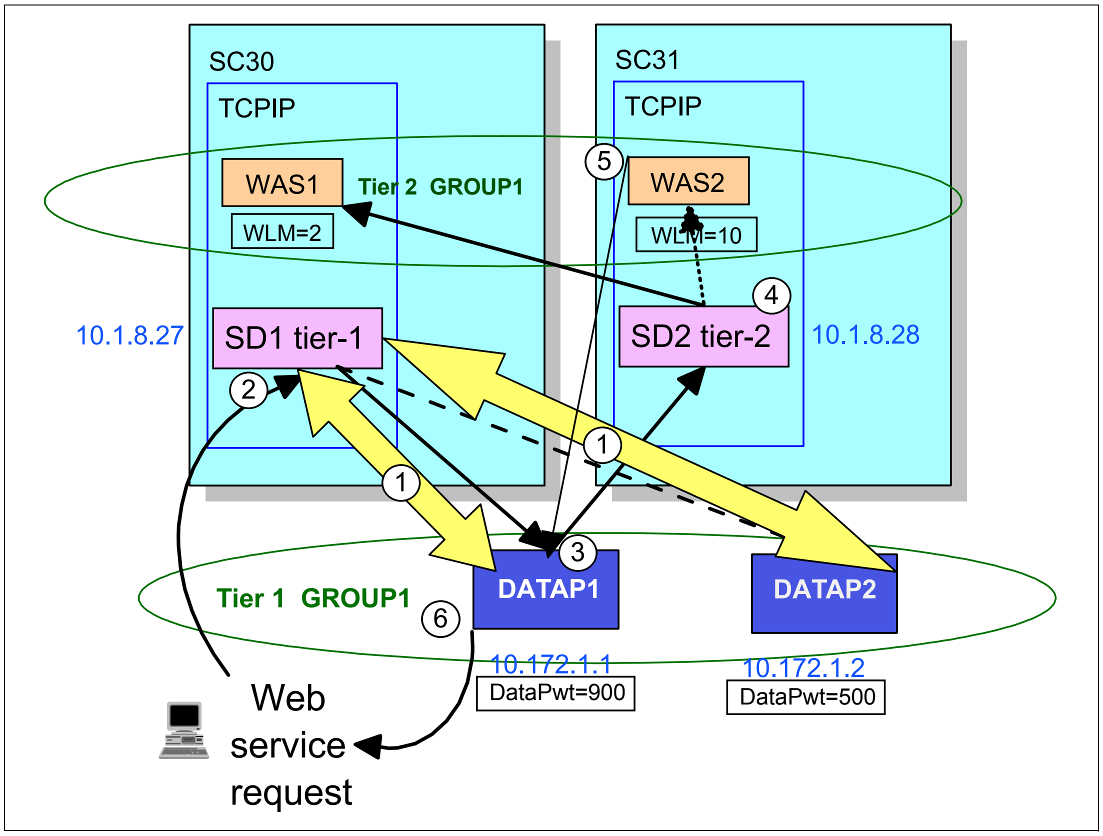


Figure 7-6 Sysplex distributor distributing to DataPower Tier 1 and WAS Tier 2

This scenario has the following steps:

1. Sysplex distributor and DataPower appliances exchange information over a TCP control connection (port 5601 in our example). The information is used to calculate and decide to which DataPower appliance it is going to distribute the tier 1 inbound connections. Periodically, the DataPower sends weights that are based on the overall CPU usage of the appliances, and connection state information to sysplex distributor, so that sysplex distributor does not need to monitor whether the connections are established or terminated.
2. A tier 1 distributed DVIPA (10.1.8.27) is defined to represent the cluster of DataPower appliances that can process a client web service request to TCP (port 8087). For each TCP connection request sent to the tier 1 DVIPA and port, the tier 1 sysplex distributor makes a load-balancing decision and routes the request to one of the eligible DataPower target instances.
3. After the DataPower targets complete their processing of the inbound web service request, they establish a connection and send the work request to sysplex distributor tier 2.
4. Sysplex distributor tier 2 routes the request to the target WebSphere Application Server tier 2 based on WebSphere Application Server tier 2 weights.
5. After WebSphere Application Server tier 2 processes the results of the request, they are sent to the DataPower instance that originated the request.
6. DataPower can then perform any necessary outbound processing and send a response back to the client that originated the web service request.

The tier 1 distributor determines a combined weight of each tier 1 target based on the received DataPower weight and the corresponding tier 2 server weight. The combined weights of all the DataPower appliances are then normalized against each other. For example, the combined weight of DATAP1 is as follows:

```
DATAP1 = (WAS1(2) + WAS2 (10)) * DP Weight 900 = 10800
```

Example 7-7 and Example 7-8 show the VIPADistribute configuration on the TCP/IP profile.

Example 7-7 VIPADISTRIBUTE configuration on SC30

```
VIPADYNAMIC
VIPADEFINE TIER1 255.255.255.0 10.1.8.27
VIPADISTRIBUTE TIER1 GROUP1 GRE CONTROLPORT 1 5601
                     DISTMETHOD TARGCONTROLLED  2
                     10.1.8.27 PORT 8087
                     DESTIP 10.172.1.1 10.172.1.2
VIPABACKUP 100 TIER2 10.1.8.28
ENDVIPADYNAMIC
```

In this example, the numbers correspond to the following information:

1. CONTROLPORT means that the sysplex distributor opens a control connection to the DataPower Sysplex client listening on that port, which is 5601.
2. TARGCONTROLLED means that the distribution is controlled by the target that is using the weights that it sends. The sysplex distributor uses a weighted round-robin distribution to the DataPower targets using the normalized DataPower weights received on the control connection. Weighted Active and Round Robin distribution can also be used.

The addresses specified in the DESTIP parameter for Example 7-7 are the addresses of the DataPower boxes and not the normal z/OS target stacks, which is the case when DISTMETHOD TARGETCONTROLLED is specified.

Example 7-8 VIPADISTRIBUTE configuration on SC31

```
VIPADYNAMIC
VIPADEFINE TIER2 MOVE IMMED 255.255.255.0 10.1.8.28
VIPADISTRIBUTE TIER2 GROUP1 DISTMETHOD  SERVERWLM
                        10.1.8.28 PORT 9003
                        DESTIP 10.1.7.11 10.1.7.12

VIPABACKUP 100 TIER1 10.1.8.27
ENDVIPADYNAMIC
```

Configuration verification

You can use the VIPADCFG display to see the values of the configured VIPADYNAMIC parameters, as shown in Example 7-9.

Example 7-9 NETSTAT VIPADCFG on SC30

```
D TCPIP,TCPIPA,N,VIPADCFG,DETAIL
DYNAMIC VIPA INFORMATION:
  VIPA BACKUP:
    IPADDR/PREFIXLEN: 10.1.8.28
      RANK: 100  MOVEABLE:           SRVMGR:     FLG: 2
  VIPA DEFINE:
    IPADDR/PREFIXLEN: 10.1.8.27/24
```

```
      MOVEABLE: IMMEDIATE  SRVMGR: NO  FLG: 1 1
  VIPA DISTRIBUTE:
    DEST:      10.1.8.27..8087
      DESTXCF: 10.172.1.1
      SYSPT:   NO   TIMAFF: NO    FLG: TARGCTRL TIER1   4
      OPTLOC:  NO
      GRPNAME: GROUP1  2 RTGTYPE: GRE   CTRLPORT: 5601
    DEST:      10.1.8.27..8087
      DESTXCF: 10.172.1.2
      SYSPT:   NO   TIMAFF: NO    FLG: TARGCTRL TIER1   2
      OPTLOC:  NO
      GRPNAME: GROUP1            RTGTYPE: GRE 5 CTRLPORT: 5601 3
END OF THE REPORT
```

In this example, the numbers correspond to the following information:

1. The display has a flag field (Flg) that indicates if tier 1 is configured.
2. This is the name of the group to correlate the two-tier distribution.
3. Port 5601 specifies the port number used for the control connection between sysplex distributor and DataPower boxes.
4. Indicates which distribution method was configured (TARGECONTRolled).
5. Indicates whether Generic Routing Encapsulation (GRE) is used when routing requests to the tier 1 target.

You can use the VDPT display to view the current number of active connections, as shown in Example 7-10 through Example 7-12 on page 254.

Example 7-10 NETSTAT VDPT on SC30

```
D TCPIP,TCPIPA,N,VDPT,DETAIL
DYNAMIC VIPA DESTINATION PORT TABLE FOR NON-Z/OS TARGETS:
DEST:        10.1.8.27..8087
  TARGET ADDR: 10.172.1.1    1
  TOTALCONN: 0000000000  RDY: 000  WT: 00 CWT: 000  3
  FLG: TARGCTRL
    T1WT: 000  2
    ACTCONN:   0000000000
DEST:        10.1.8.27..8087
  TARGET ADDR: 10.172.1.2    1
  TOTALCONN: 0000000000  RDY: 000  WT: 00 CWT: 000  3
  FLG: TARGCTRL
    T1WT: 000  2
    ACTCONN:   0000000000
2 OF 2 RECORDS DISPLAYED
END OF THE REPORT
```

In this example, the numbers correspond to the following information:

1. The target IP address for non-z/OS, DataPower appliances.
2. The weight that is received from the tier 1 target.
3. The value that represents the combined weight of tier 2 target servers that are on the same CPC as the tier 1 target.

Example 7-11 NETSTAT VIPADCFG on SC31

```
D TCPIP,TCPIPA,N,VIPADCFG,DETAIL
DYNAMIC VIPA INFORMATION:
  VIPA BACKUP:
    IPADDR/PREFIXLEN: 10.1.8.27
      RANK: 100  MOVEABLE:           SRVMGR:     FLG: 1  2
  VIPA DEFINE:
    IPADDR/PREFIXLEN: 10.1.8.28/24
      MOVEABLE: IMMEDIATE  SRVMGR: NO  FLG: 2
  VIPA DISTRIBUTE:
    DEST:      10.1.8.28..9003
      DESTXCF: 10.1.7.11
      SYSPT:   NO   TIMAFF: NO    FLG: SERVERWLM TIER2 1
      OPTLOC:  NO
      GRPNAME: GROUP2
      PROCXCOST:
        ZAAP: 001  ZIIP: 001
      ILWEIGHTING: 0
    DEST:      10.1.8.28..9003
      DESTXCF: 10.1.7.12
      SYSPT:   NO   TIMAFF: NO    FLG: SERVERWLM TIER2
      OPTLOC:  NO
      GRPNAME: GROUP2
      PROCXCOST:
        ZAAP: 001  ZIIP: 001
      ILWEIGHTING: 0
END OF THE REPORT
```

In this example, the numbers correspond to the following information:

1. The display has a flag field (Flg), which indicates whether tier 2 was configured.

2. The VIPABACKUP of the tier 1 sysplex distributor.

Example 7-12 NETSTAT VDPT on SC31

```
D TCPIP,TCPIPA,N,VDPT,DETAIL
DYNAMIC VIPA DESTINATION PORT TABLE FOR TCP/IP STACKS:
DEST:        10.1.8.28..9003
  DESTXCF:   10.1.7.12
  TOTALCONN: 0000000000  RDY: 000  WLM: 00  TSR: 100
  FLG: SERVERWLM, TIER2
    TCSR: 100  CER: 100 SEF: 100
    WEIGHT: 00
      RAW          CP: 00 ZAAP: 00 ZIIP: 00
      PROPORTIONAL CP: 00 ZAAP: 00 ZIIP: 00
    ABNORM: 0000        HEALTH: 100
    ACTCONN:   0000000000
    QOSPLCACT: *DEFAULT*
      W/Q: 00
1 OF 1 RECORDS DISPLAYED
END OF THE REPORT
```

7.2.5 Applied system configuration for optimized load balancing

We use the configuration shown in Figure 7-7 for our test scenarios.

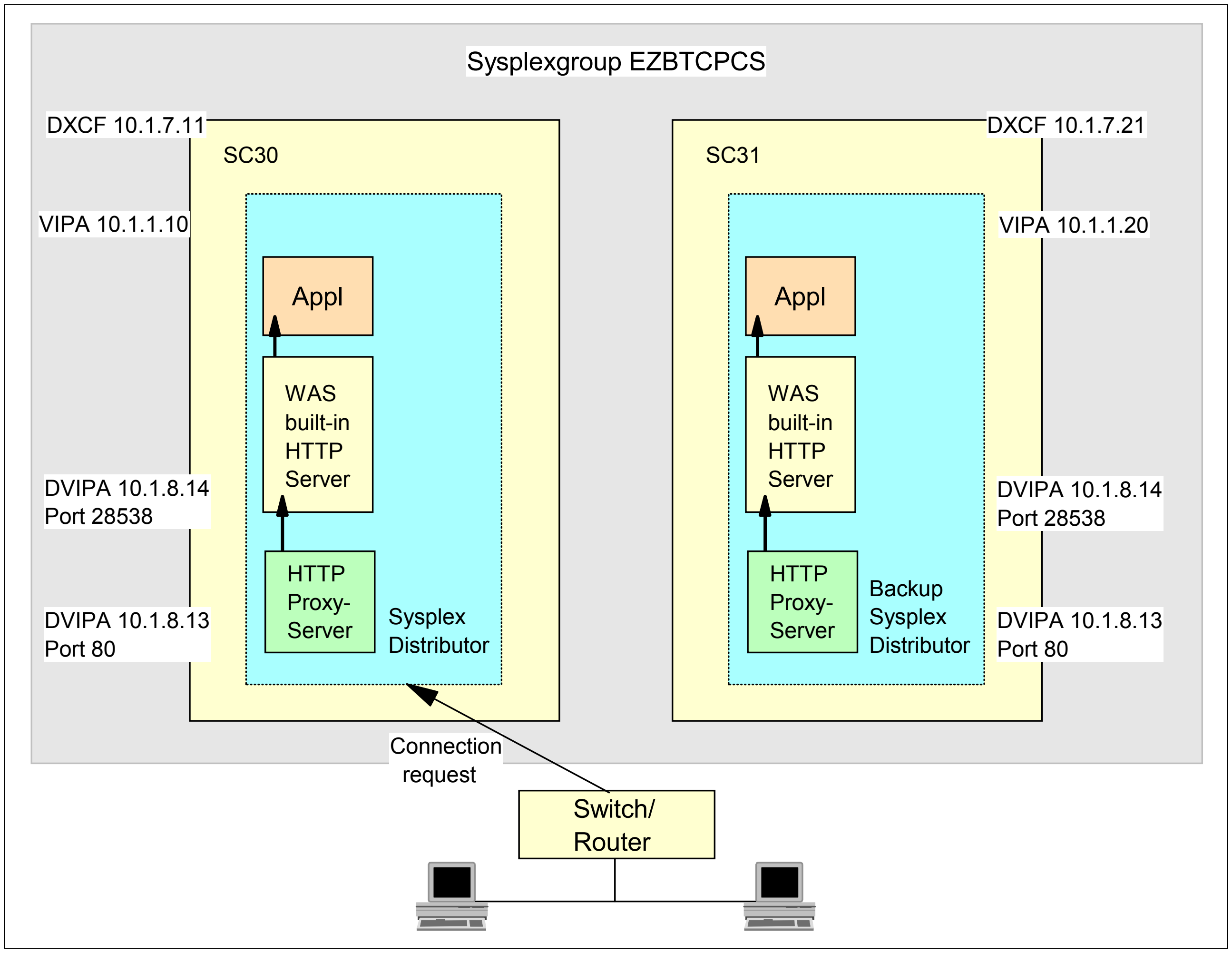


Figure 7-7 Multitier optimized load balancing test environment

This configuration consists of two LPARs (SC30 and SC31). Each LPAR is configured with one TCP/IP stack. The primary sysplex distributor is in SC30, and a backup sysplex distributor is in the SC31 stack. To build a multitier application scenario testing the VIPADISTRIBUTE OPTLOCAL keyword, we install on each stack one HTTP proxy server and a WebSphere Application Server with a deployment manager.

The HTTP proxy server is defined as distributed DVIPA with IP cluster address 10.1.8.13 and port 80 for the sysplex distributor. The WebSphere Application Server with its built-in HTTP server has the distributed DVIPA cluster address 10.1.8.14 with port 28538. We also define additional port numbers for the WebSphere Application Server environment (deployment manager, control region, and so on).

To keep the test scenario simple, we do not use an EIS (such as IMS, DB2 or CICS). Instead, we use a special test application called StockTrade provided by the WebSphere Application Server implementation packet.

We use two kinds of HTTP connection setup requests:

- From a workstation 10.1.100.224 with MS Internet Explorer (see Figure 7-9 on page 259)
- Through a WebSphere Workload Simulator

TCP/IP profile definitions for SC30 and SC31

The definitions in Example 7-13 and Example 7-14 only show specific VIPADYNAMIC statements. OPTLOCAL 0 is defined for IP address 10.1.8.14, with separate ports for WebSphere Application Server applications. This definition forces the selection of the WebSphere Application Server built-in HTTP server in the same LPAR as the HTTP proxy server as long as it is healthy.

The HTTP proxy server receives the client connection requests forwarded from the sysplex distributor. It does not need the OPTLOCAL keyword.

Example 7-13 shows the VIPADYNAMIC definitions for the SC30 primary sysplex distributor.

Example 7-13 VIPADYNAMIC definitions for SC30 primary sysplex distributor

```
VIPADynamic
 VIPADEFine MOVEable IMMEDiate 255.255.255.0 10.1.8.12
   VIPADISTribute DISTMethod BASEWLM 10.1.8.12
   PORT 23 20 21 DESTIP 10.1.7.11 10.1.7.21
 VIPADEFine MOVEable IMMEDiate 255.255.255.0 10.1.8.13
   VIPADISTribute DISTMethod SERVERWLM 10.1.8.13
   PORT 80 DESTIP 10.1.7.11 10.1.7.21
 VIPADEFine MOVEable IMMEDiate 255.255.255.0 10.1.8.14
   VIPADISTribute DISTMethod SERVERWLM 10.1.8.14 OPTLOCAL 0
   PORT 28538 28518 28510 28502 28503 DESTIP 10.1.7.11 10.1.7.21
```

Example 7-14 shows the VIPADYNAMIC definitions for the SC31 backup sysplex distributor.

Example 7-14 VIPADYNAMIC definitions for SC31 backup sysplex distributor

```
VIPADynamic
 VIPABACKUP 100 MOVEABLE IMMEDIATE
   255.255.255.0 10.1.8.12 10.1.8.13 10.1.8.14
VIPADISTribute define DISTMethod BASEWLM 10.1.8.12
  PORT 23 20 21 DESTIP 10.1.7.11 10.1.7.21 10.1.7.31
VIPADISTribute define DISTMethod SERVERWLM 10.1.8.13
  PORT 80 DESTIP 10.1.7.11 10.1.7.21
VIPADISTribute define DISTMethod SERVERWLM OPTLOCAL 0 10.1.8.14
  PORT 28538 28518 28510 28502 28503 DESTIP 10.1.7.11 10.1.7.21
 VIPAROUTE 10.1.7.11 10.1.1.10
 VIPAROUTE 10.1.7.11 10.1.1.20
 VIPAROUTE 10.1.7.11 10.1.1.30
ENDVIPADynamic
```

Request flow between client, WebSphere Application Server, and application endpoint

Figure 7-8 shows the data flow from a client to the WebSphere Application Server application using the URL StockTrade/CPUBound.

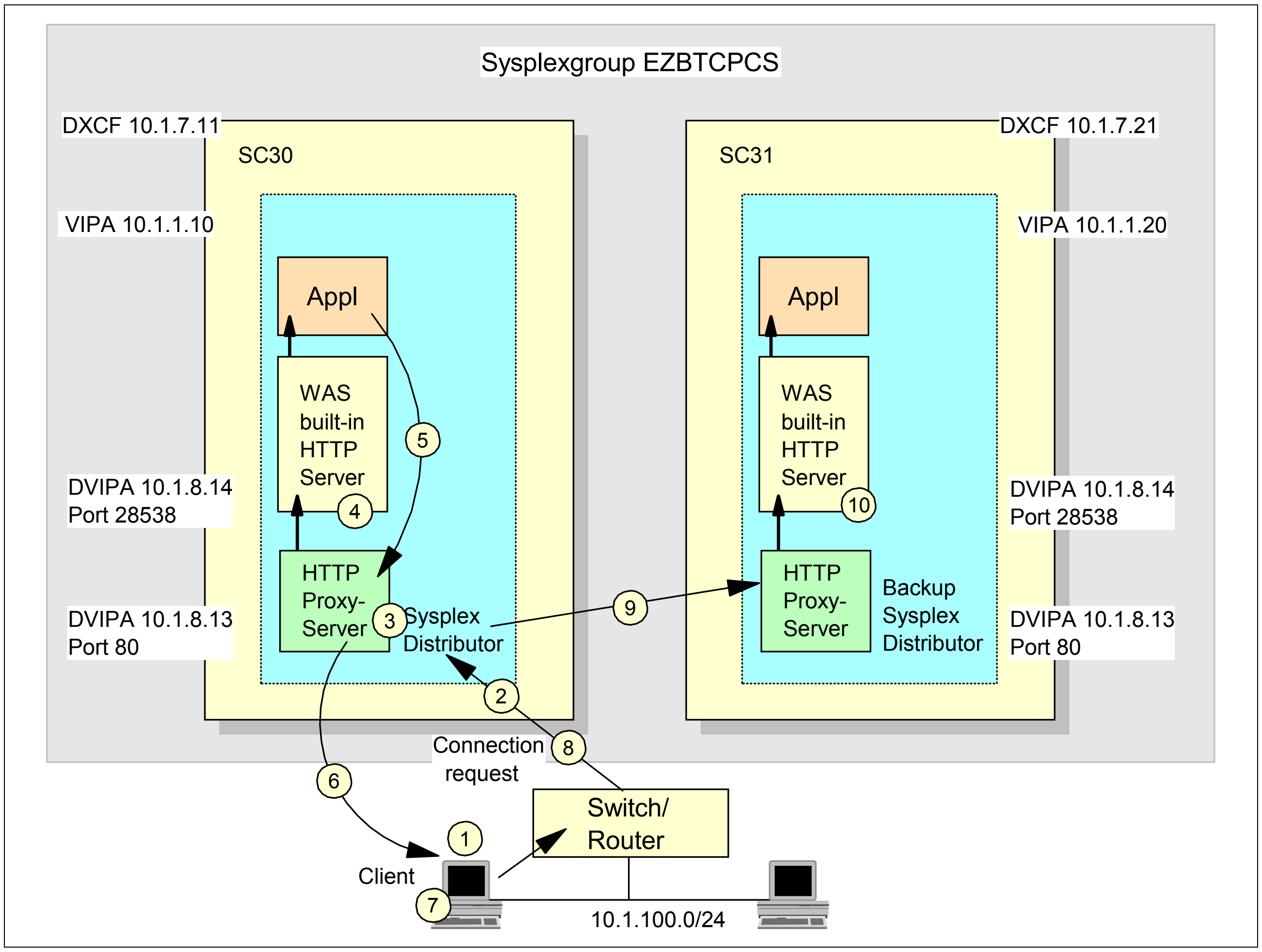


Figure 7-8 HTTP request flow

Figure 7-8 shows the following steps in the HTTP request flow:

1. The user enters an initial request using the URL `StockTrade/CPUBound` in the client browser. The request has no session affinity.
2. The request is resolved to a cluster IP address (10.1.8.13) and port address (80), and is sent to the primary sysplex distributor running in SC30 (or to the backup sysplex distributor SC31, if the primary is down).
3. The sysplex distributor makes its load balancing decision based on the best server-specific WLM values for the HTTP proxy servers on SC30 and SC31. It forwards the client request to the selected HTTP server. Both HTTP servers are configured with the plug-in configuration file of the WebSphere Application Server (`plug-in-cfg.xml`).
4. The configuration files describes which URLs are handled by WebSphere Application Server. In our case, it is the application StockTrade, which can be reached through the distributed DVIPA cluster address 10.1.8.14 and port 28538, in WebSphere Application Server on SC30 and SC31.

The application runs on both target systems SC30 and SC31. The plug-in checks for possible session affinity by scanning the request for session cookies. The first request has no affinity. The plug-in recognizes the URL `/StockTrade/CPUBound`, and routes it to the IP cluster address 10.1.8.14 with port 28538, based on:

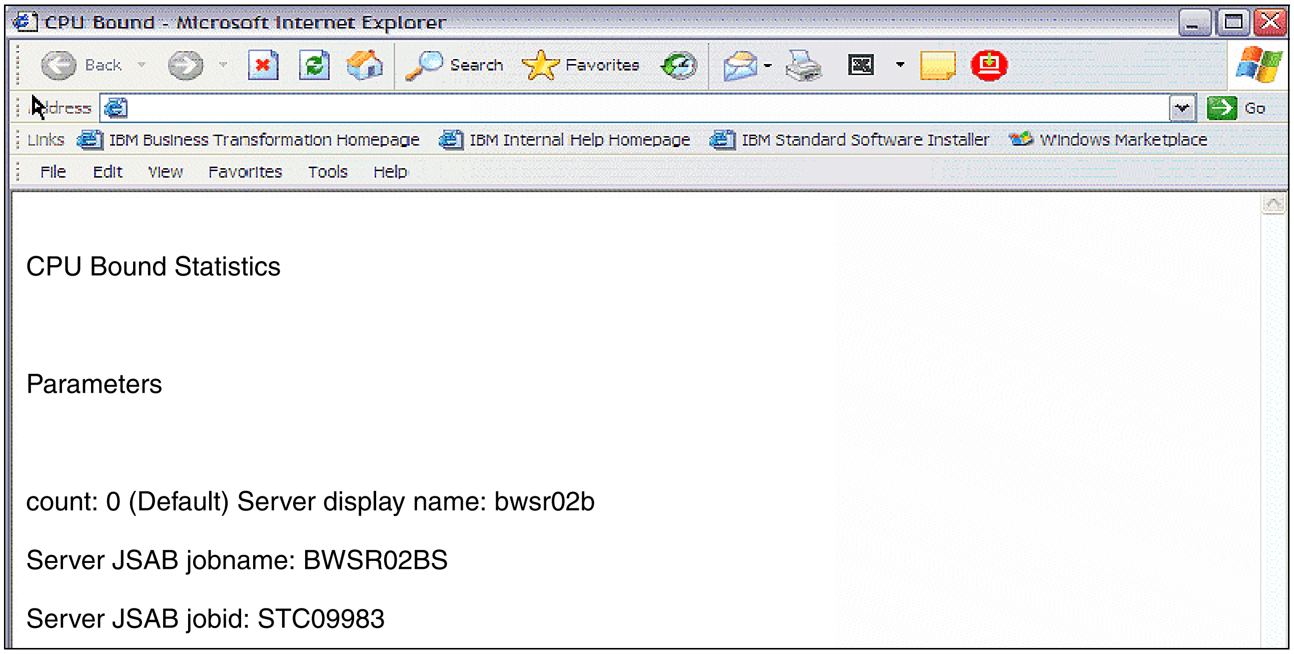
   - The DVIPA address of the sysplex distributor forwarding it to WebSphere Application Server on SC30 or SC31 based on best SERVERWLM values if no OPTLOCAL keyword is defined.
   - Directly to the WebSphere Application Server in the local system if OPTLOCAL 0 is defined (see Figure 7-3 on page 244).
   - Directly to the WebSphere Application Server in the local system if OPTLOCAL 1 (see Figure 7-3 on page 244) is defined and sufficient capacity is provided by the local WebSphere Application Server. If the SERVERWLM values are zero (0), then the sysplex distributor is involved to search for a better WebSphere Application Server in the sysplex group to reach the WLM goal.

   The HTTP listener on port 28538 in the WebSphere Application Server receives the request. There is no session affinity at this time. The session ID is created later when the destination application builds a session object with a session ID. Later on, a session cookie is added to the HTTP data stream in the response to the client.

5. The response with the jsessionID cookie in the HTTP header is sent back to the web server (in our case, to the HTTP proxy server in the system from where the request came).
6. The response is sent back to the client.
7. The browser stores the cookie in its memory. (Session cookies are never stored on a disk.) The cookie stays there as long as the browser is not closed, or until it is deleted (because of expiration) by the server.
8. The cookie is appended to the HTTP request at the next request to the server.
9. The sysplex distributor does not consider any session affinity. Therefore, there is no cookie check and the request could be sent to a separate HTTP server.
10. The plug-in scans the HTTP header of the request and finds the session ID cookie with an additional CloneID. It compares this CloneID with its definition in the plug-in configuration (`plug-in-cfg.xml`) file. If there is a match, the request is sent to the IP address and port of the matched application server instance.

For more details about WebSphere Application Server session handling, see *Architecting High Availability Using WebSphere V6 on z/OS*, SG24-6850.

Figure 7-9 shows a browser connection request to an HTTP proxy server, which is sent to the sysplex distributor. In this case, the sysplex distributor sent the request to the HTTP server on system SC31 where the server with its job name BWSR02B was started.


CPU Bound - Microsoft Internet Explorer
Back
Search
Favorites
Address
Go
Links
IBM Business Transformation Homepage
IBM Internal Help Homepage
IBM Standard Software Installer
Windows Marketplace
File
Edit
View
Favorites
Tools
Help

CPU Bound Statistics

Parameters

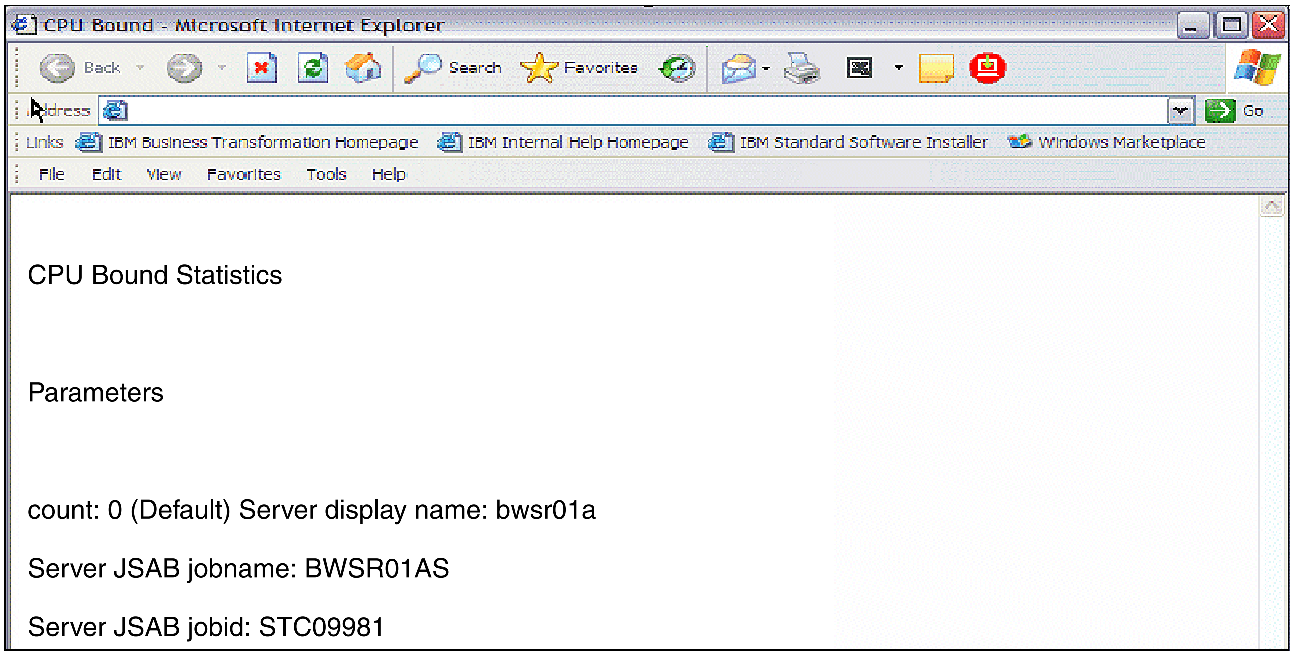
count: 0 (Default) Server display name: bwsr02b

Server JSAB jobname: BWSR02BS

Server JSAB jobid: STC09983

Figure 7-9 Web browser connection to HTTP server in SC31

Another request was directed to the HTTP server on system SC30 with its job name BWSR01A (see Figure 7-10).


CPU Bound - Microsoft Internet Explorer
Back
Search
Favorites
Address
Go
Links
IBM Business Transformation Homepage
IBM Internal Help Homepage
IBM Standard Software Installer
Windows Marketplace
File
Edit
View
Favorites
Tools
Help

CPU Bound Statistics

Parameters

count: 0 (Default) Server display name: bwsr01a

Server JSAB jobname: BWSR01AS

Server JSAB jobid: STC09981

Figure 7-10 Web browser connection to HTTP server in SC30

7.2.6 OPTLOCAL test cases

In this section, we discuss the use of the OPTLOCAL keyword in conjunction with sysplex distributor and an external load balancer that supports Server Application State Protocol (SASP). Figure 7-7 on page 255 describes our configuration with the necessary IP and port addresses of the components that we use.

Optimized path through sysplex distributor using OPTLOCAL 0

The goal here is to show the impact of the OPTLOCAL 0 keyword in the VIPADISTRIBUTE statement for WebSphere Application Server only. Figure 7-11 shows the optimized path between client and the web application. Because the sysplex distributor has two choices, the optimized path can be created in SC30 or SC31, between the HTTP server and WebSphere Application Server.

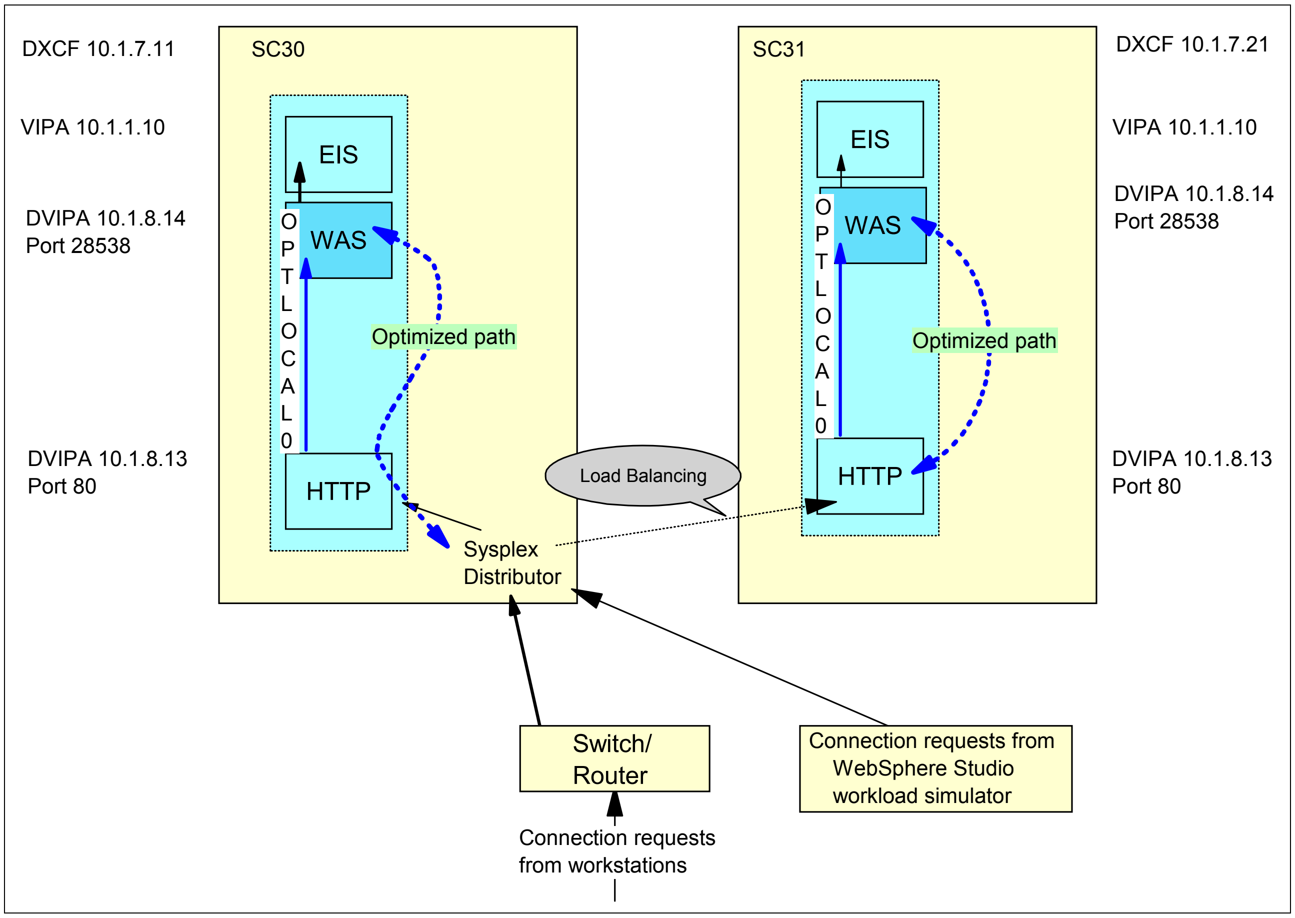


Figure 7-11 Optimized path through OPTLOCAL 0

TCP/IP profile definitions

Example 7-15 shows the TCP/IP profile definitions that we use in our environment.

Example 7-15 VIPADYNAMIC definitions

```
VIPADEFine/VIPADISTRIBUTE
VIPADynamic
 VIPADEFine MOVEable IMMEDiate 255.255.255.0 10.1.8.12
   VIPADISTribute DISTMethod BASEWLM 10.1.8.12
   PORT 23 20 21 DESTIP 10.1.7.11 10.1.7.21 10.1.7.31
 VIPADEFine MOVEable IMMEDiate 255.255.255.0 10.1.8.13
   VIPADISTribute DISTMethod SERVERWLM 10.1.8.13
   PORT 80 DESTIP 10.1.7.11 10.1.7.21
 VIPADEFine MOVEable IMMEDiate 255.255.255.0 10.1.8.14
   VIPADISTribute DISTMethod SERVERWLM OPTLOCAL 0 10.1..8.14
   PORT 28538 28518 28510 28502 28503 DESTIP 10.1.7.11 10.1.7.21
   VIPAROUTE 10.1.7.11 10.1.1.10
   VIPAROUTE 10.1.7.21 10.1.1.20
   VIPAROUTE 10.1.7.21 10.1.1.30
ENDVIPADYNAMIC
```

Example 7-16 points to the flag that displays if OPTLOCAL is switched on for IP address 10.1.8.14 and port address 28538 of WebSphere Application Server. In our case, it is defined as SERVERWLM and OPTLOCAL 0.

Example 7-16 netstat vipadcfg shows the OPTLOCAL definitions

```
D TCPIP,TCPIPC,N,VIPADCFG,DETAIL

DYNAMIC VIPA INFORMATION:
  VIPA DEFINE:
IPADDR/PREFIXLEN: 10.1.8.14/24
    MOVEABLE: IMMEDIATE  SRVMGR: NO

DEST:            10.1.8.14..28538
      DESTXCF:   10.1.7.11
        SYSPT:   NO   TIMAFF: NO    FLG: SERVERWLM OPTLOCAL
        OPTLOC:  0
    DEST:        10.1.8.14..28538
      DESTXCF:   10.1.7.21
        SYSPT:   NO   TIMAFF: NO    FLG: SERVERWLM OPTLOCAL
        OPTLOC:  0
```

Client requests from the web browser are directed to the WebSphere Application Server application (see Figure 7-9 on page 259) on SC30 or SC31. Other client requests are initiated through the WebSphere Studio workload simulator and also directed to the WebSphere Application Server on SC30 or SC31.

The **`netstat conn`** command shown in Example 7-17 on page 262 indicates that the HTTP proxy server on SC31 with the name WEBBW311 receives connections from a client with an IP address 10.30.2.50. This is the WebSphere Studio workload simulator we use to produce client connection requests.

Example 7-17 Current connection check of HTTP server on SC31

```
D TCPIP,TCPIPC,N,CONN,IPPORT=10.1.8.13+80

USER ID  CONN     STATE
WEBBW311 0000A6C2 ESTBLSH
  LOCAL SOCKET:   10.1.8.13..80
  FOREIGN SOCKET: 10.30.2.50..3255
WEBBW311 0000A6C4 ESTBLSH
  LOCAL SOCKET:   10.1.8.13..80
  FOREIGN SOCKET: 10.30.2.50..3256
WEBBW311 0000A6C6 ESTBLSH
  LOCAL SOCKET:   10.1.8.13..80
  FOREIGN SOCKET: 10.30.2.50..3257
```

In regard to the current HTTP TCP connections of the HTTP servers, you notice that those connections disappear at some point in time. This is because of the HTTP architecture, which allows the server to close the connections because they are no longer needed. The HTTP server (working as a client) starts a new connection to the WebSphere Application Server built-in HTTP server to forward the client request.

Example 7-18 shows the VIPA distribution port table used in the sysplex for SC30 and SC31. It also shows how many connections the sysplex distributor forwards to the two HTTP servers using a load balancing service. Because OPTLOCAL 0 is defined, we assume that the depicted TOTALCONN number came from the local HTTP server identified through the DESTXCF address, for example, for 10.1.7.11. This is the address of the TCP/IP stack in SC30. Equivalent values are shown for the second HTTP server on SC31.

Thus, 89 connections came to the HTTP proxy server on SC30 and 157 to SC31. For each request, the HTTP server starts a new connection to IP address 10.1.8.14. and port address 28538 (of the WebSphere Application Server). The local connections in the same LPAR, however, are separated from each other in the sysplex.

Example 7-18 VIPA distribution port table for the WebSphere Application Server

```
D TCPIP,TCPIPC,N,VDPT,DETAIL,IPPORT=10.30.30.34+28538

 DYNAMIC VIPA DESTINATION PORT TABLE:
 DEST:        10.1.8.14..28538
   DESTXCF:   10.1.7.11
   TOTALCONN: 0000000089  RDY: 001  WLM: 08  TSR: 100
   FLG: SERVERWLM, LOCAL
     TCSR: 100  CER: 100 SEF: 100
     ABNORM: 0000       HEALTH: 100
     ACTCONN:   0000000005
     QOSPLCACT: *DEFAULT*
       W/Q: 08
 DEST:        10.1.8.14..28538
   DESTXCF:   10.1.7.21
   TOTALCONN: 0000000157  RDY: 001  WLM: 16  TSR: 100
   FLG: SERVERWLM, LOCAL
     TCSR: 100  CER: 100 SEF: 100
     ABNORM: 0000       HEALTH: 100
     ACTCONN:   0000000009
     QOSPLCACT: *DEFAULT*
       W/Q: 16
 2 OF 2 RECORDS DISPLAYED
 END OF THE REPORT
```

You might wonder why the server WLM values in each system are different with 08 and 16. The proportion of the TOTALCONN values are also a 1:2 ratio. If both LPARs would have been defined equally regarding resources such as logical CPU, storage, and so on, then the number of distributed requests would be nearly equal. We discover that SC31 uses four CPUs and SC30 is defined with two CPUs only.

This 1:2 ratio can also be recognized in Example 7-19 (1) when showing the VIPA distribution table of the HTTP servers with the cluster address of 10.1.8.13 and port address of 80 on both systems. The TOTALCONN values have nearly a 1:2 ratio.

Example 7-19 VIPA distribution port table

```
D TCPIP,TCPIPC,N,VDPT,DETAIL,IPPORT=10.1.8.13+80

DYNAMIC VIPA DESTINATION PORT TABLE:
DEST:        10.1.8.13..80
  DESTXCF:   10.1.7.11
  TOTALCONN: 0000001496  RDY: 001  WLM: 08  TSR: 100        1
  FLG: SERVERWLM
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000000
    QOSPLCACT: *DEFAULT*
      W/Q: 08
DEST:        10.1.8.13..80
  DESTXCF:   10.1.7.21
  TOTALCONN: 0000002863  RDY: 001  WLM: 16  TSR: 100        1
  FLG: SERVERWLM
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000008
    QOSPLCACT: *DEFAULT*
      W/Q: 16
2 OF 2 RECORDS DISPLAYED
END OF THE REPORT
```

The **netstat conn** command shown in Example 7-17 on page 262 also indicates that the HTTP proxy server on SC31 with the name WEBBW311 receives connections from a client with an IP address 10.30.2.50. This is the WebSphere Studio workload simulator we use to produce client connection requests.

One WebSphere Application Server is down

When the WebSphere Application Server service stops, shown in Example 7-20, the output value from the **netstat vdpt detail** command shows RDY: 000 (1), instead of RDY: 001(2), where the value determines how many servers are ready, active, and listening.

Example 7-20 One WebSphere Application Server is down

```
D TCPIP,TCPIPC,N,VDPT,DETAIL,IPPORT=10.1.8.14+28538

DYNAMIC VIPA DESTINATION PORT TABLE:
DEST:        10.1.8.14..28538
  DESTXCF:   10.1.7.11
  TOTALCONN: 0000000707  RDY: 000  WLM: 09  TSR: 100     1  3
  FLG: SERVERWLM
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000000
    QOSPLCACT: *DEFAULT*
      W/Q: 09
DEST:        10.1.8.14..28538
  DESTXCF:   10.1.7.21
  TOTALCONN: 0000002036  RDY: 001  WLM: 06  TSR: 100     2  3
  FLG: SERVERWLM, LOCAL
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000984
    QOSPLCACT: *DEFAULT*
      W/Q: 06
2 OF 2 RECORDS DISPLAYED
END OF THE REPORT
```

Further **display** commands show that the TOTALCONN (3) value does not increase, because the server is no longer being considered for new connections. The actual connection (ACTCONN) value for SC30 is always zero (0). The value for ACTCONN for the other member of the same HTTP cluster in SC31 shows different values.

Checking whether both HTTP servers are active

Example 7-21 shows that the HTTP server on SC31 (10.1.8.13 with DESTXCF address 10.1.7.21) did not start correctly (1, which is RDY: 000 and WLM: 00).

Example 7-21 HTTP server check ID active

```
D TCPIP,TCPIPC,N,VDPT,DETAIL,IPPORT=10.1.8.13+80

DYNAMIC VIPA DESTINATION PORT TABLE:
DEST:        10.1.8.13..80
  DESTXCF:   10.1.7.11
  TOTALCONN: 0000000007  RDY: 001  WLM: 15  TSR: 100
  FLG: SERVERWLM, LOCAL
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000000
    QOSPLCACT: *DEFAULT*
      W/Q: 15
DEST:        10.1.8.13..80
  DESTXCF:   10.1.7.21
  TOTALCONN: 0000000000  RDY: 000  WLM: 00  TSR: 100      1
  FLG: SERVERWLM
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000000
    QOSPLCACT: *DEFAULT*
      W/Q: 00
2 OF 2 RECORDS DISPLAYED
END OF THE REPORT
```

Extended netstat command and displays

The following additional keywords of the **netstat** command allow more convenient operation:

- You can use the server keyword with the **netstat all server** command to filter out application servers in listen status, thus reducing the number of display lines (Example 7-22).

Example 7-22 netstat all server command in listen state

```
===> netstat all server
Client Name: BWSR01A                  Client Id: 000091C6
  Local Socket: 0.0.0.0..28538
  Foreign Socket: 0.0.0.0..0
    BytesIn:           00000000000000000000
    BytesOut:          00000000000000000000
    SegmentsIn:        00000000000000000000
    SegmentsOut:       00000000000000000000
    Last Touched:      15:29:30          State:             Listen
    RcvNxt:            0000000000        SndNxt:            0000000000
    ClientRcvNxt:      0000000000        ClientSndNxt:      0000000000
    InitRcvSeqNum:     0000000000        InitSndSeqNum:     0000000000
    CongestionWindow:  0000000000        SlowStartThreshold: 0000000000
    IncomingWindowNum: 0000000000        OutgoingWindowNum:  0000000000
    SndWl1:            0000000000        SndWl2:            0000000000
    SndWnd:            0000000000        MaxSndWnd:         0000000000
    SndUna:            0000000000        rtt_seq:           0000000000
    MaximumSegmentSize: 0000000536       DSField:           00
  Round-trip information:
    Smooth trip time: 0.000              SmoothTripVariance: 1500.000
    ReXmt:             0000000000        ReXmtCount:        0000000000
    DupACKs:           0000000000
    SockOpt:           8800              TcpTimer:          00
    TcpSig:            00                TcpSel:            20
    TcpDet:            C0                TcpPol:            00
    QOSPolicyRuleName:
    ReceiveBufferSize: 0000016384        SendBufferSize:    0000016384
    ConnectionsIn:     0000000001        ConnectionsDropped: 0000000000
    CurrentBacklog:    0000000000        MaximumBacklog:    0000000010
    CurrentConnections: 0000000000       SEF:               100
    Quiesced: No
```

- You can use the ipport keyword with the **netstat ALL**, **CONN**, **ALLConn**, **SOCKets**, **TELnet**, **VDPT**, and **VCRT** commands to filter a specific server IP address plus port out of the huge display list.

OPTLOCAL with external load balancer

This configuration differs from the example discussed in “Optimized path through sysplex distributor using OPTLOCAL 0” on page 260, because in this configuration, the distribution decision is not performed in the sysplex by the sysplex distributor. Instead, it is performed by an external load balancer, such as Content Switching Module (CSM).

The external load balancer receives workload information for the balancing decision from the z/OS LBAdvisor. The LBAdvisor is informed about active and non-active application servers within the sysplex. System and server WLM information are provided by z/OS LBAgents in each LPAR. For further information about external load balancing, see Chapter 5, “Internal application workload balancing” on page 127.

Figure 7-12 depicts the optimized path from the client to the application server.

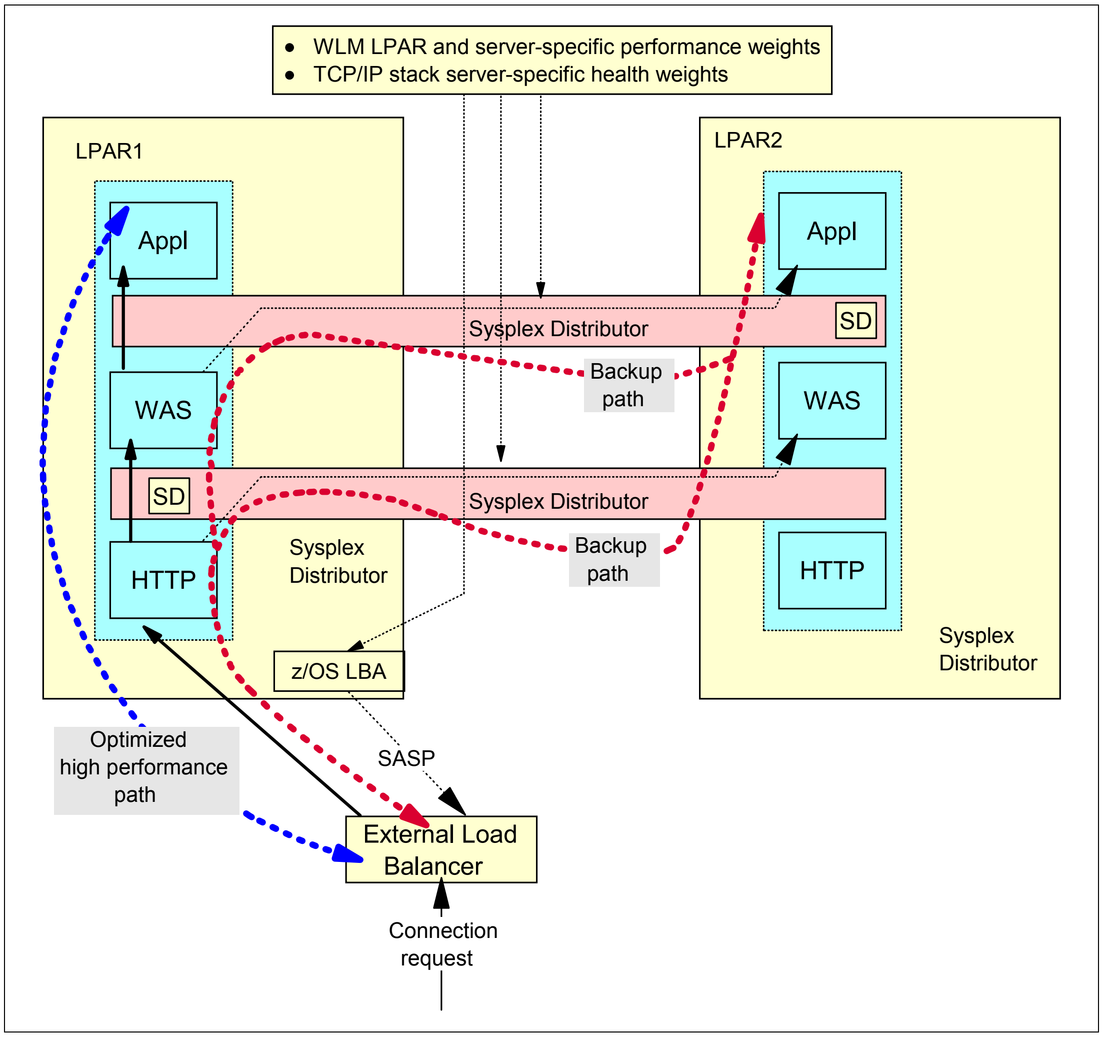


Figure 7-12 Optimized path using external load balancer

As shown in the figure, no sysplex distributor is necessary for the distribution of connections to the HTTP server. The optimized high performance path starts at the HTTP server either in SC30 or SC31, regardless of whether an external load balancer or the sysplex distributor selected the HTTP server. This means that if the external load balancer decides to send the connection request directly to the HTTP server in SC30, the same TCP/IP profile definitions for the path to the WebSphere Application Server can be used, as defined and tested in "Optimized path through sysplex distributor using OPTLOCAL 0" on page 260.

TCP/IP profile definition for OPTLOCAL 0

Example 7-23 shows the definitions that we used previously.

Example 7-23 TCP/IP profile definitions used in context with external load balancer

```
; VIPADEFine/VIPADISTRIBUTE
VIPADynamic
 VIPADEFine MOVEable IMMEDiate 255.255.255.0 10.1.8.14
   VIPADISTribute DISTMethod SERVERWLM OPTLOCAL 0 10.1.8.14
   PORT 28538 28518 28510 28502 28503 DESTIP 10.1.7.11 10.1.1.21
ENDVIPADynamic
```

Verification

Because nothing differs from Figure 7-15 on page 283, we do not repeat the displays for the components in the sysplex here.

OPTLOCAL 1 with sysplex distributor only

In the previous test case using OPTLOCAL 0, only local connections should be used for the optimized path between the HTTP servers and the WebSphere Application Server, depending on which HTTP server was selected on SC30 or on SC31.

In this section, we discuss how the high availability path can be achieved automatically, even if the WLM values do not recommend taking the local connection when the value for the local server is zero (0).

Figure 7-13 shows additional paths to WebSphere Application Server server within the sysplex controlled by the sysplex distributor. If the local connections cannot be used because the WLM value for the WebSphere Application Server during connection setup indicates 00, then the sysplex distributor must select another remote WebSphere Application Server within the sysplex.

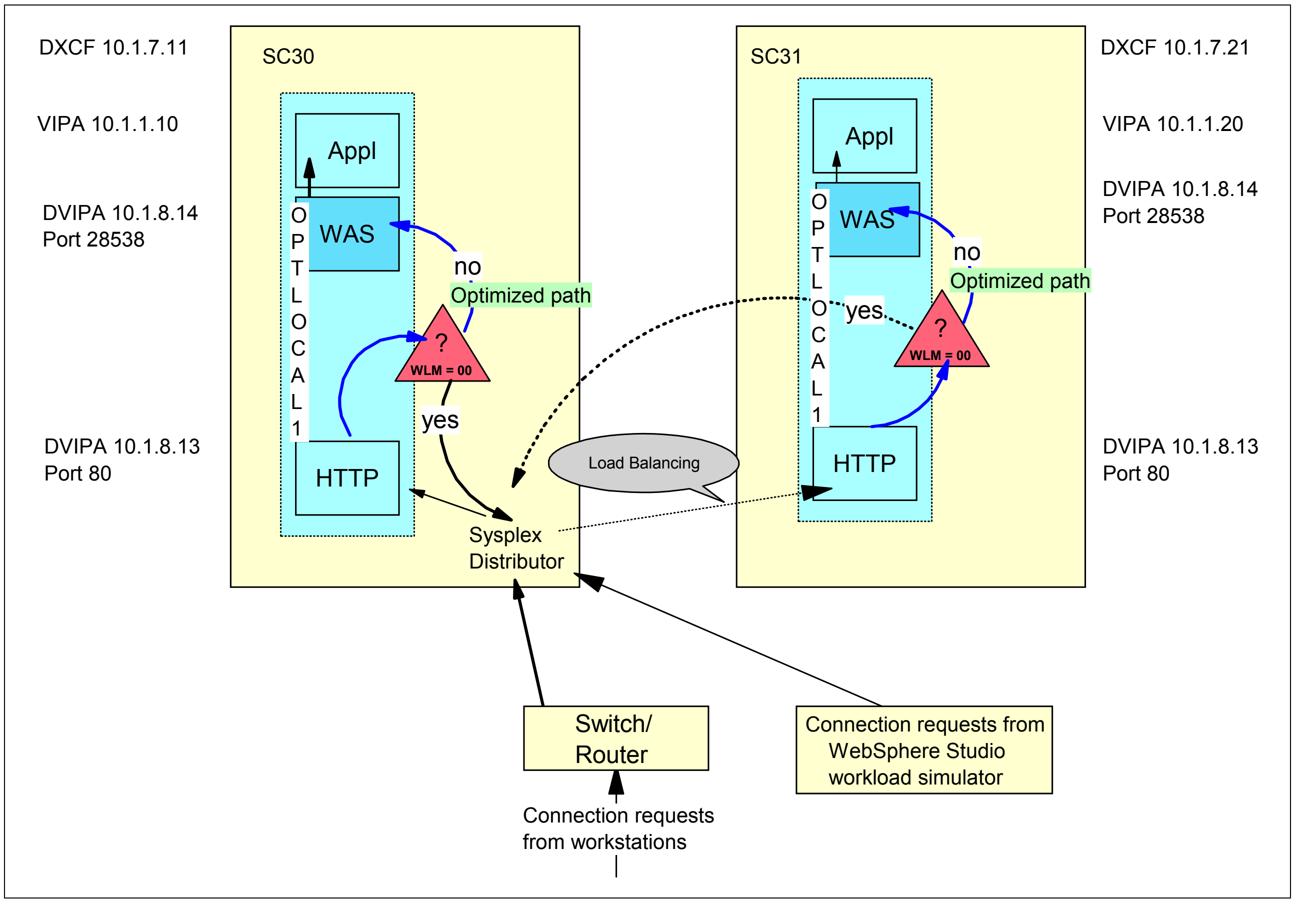


Figure 7-13 Optimized path using OPTLOCAL 1

TCP/IP profile definitions

Example 7-24 shows the OPTLOCAL 1 definitions that we use for this test case.

Example 7-24 TCP/IP profile definitions using OPTLOCAL 1

```
VIPADynamic
VIPADEFine MOVEable IMMEDiate 255.255.255.0 10.1.8.13
   VIPADISTribute DISTMethod SERVERWLM 10.1.8.13
   PORT 80 DESTIP 10.1.7.11 10.1.7.21
 VIPADEFine MOVEable IMMEDiate 255.255.255.0 10.1.8.14
   VIPADISTribute DISTMethod SERVERWLM optlocal 1 10.1.8.14
   PORT 28538 28518 28510 28502 28503 DESTIP 10.1.7.11 10.1.7.21
ENDVIPADYNAMIC
```

Verification

We use the **NETSTAT VIPADCFG DETAIL** command to verify that the OPTLOCAL 1 is active (Example 7-25).

Example 7-25 NETSTAT VIPADCFG detail

```
D TCPIP,TCPIPC,N,VIPADCFG,DETAIL

DYNAMIC VIPA INFORMATION:
DEST:        10.1.8.14..28538
    DESTXCF:   10.1.7.11
      SYSPT:   NO   TIMAFF: NO    FLG: SERVERWLM OPTLOCAL
      OPTLOC:  1
  DEST:        10.1.8.14..28538
    DESTXCF:   10.1.7.21
      SYSPT:   NO   TIMAFF: NO    FLG: SERVERWLM OPTLOCAL
      OPTLOC:  1
```

Example 7-26 shows the start of the WebSphere workload simulator and a check performed by the **netstat vdpt** command for the WebSphere Application Server. Notice that both WLM values are equal but that the number of total connections (TOTALCONN) differs slightly.

Example 7-26 NETSTAT VDPT of WebSphere Application Server using filter ipport

```
D TCPIP,TCPIPC,N,VDPT,DETAIL,IPPORT=110.1.8.14+28538

 DYNAMIC VIPA DESTINATION PORT TABLE:
 DEST:        10.1.8.14..28538
   DESTXCF:   10.1.7.11
   TOTALCONN: 0000000318  RDY: 001  WLM: 06  TSR: 100
   FLG: SERVERWLM, LOCAL
     TCSR: 100  CER: 100 SEF: 100
     ABNORM: 0000       HEALTH: 100
     ACTCONN:   0000000004
     QOSPLCACT: *DEFAULT*
       W/Q: 06
 DEST:        10.1.8.14..28538
   DESTXCF:   10.1.7.21
   TOTALCONN: 0000000258  RDY: 001  WLM: 06  TSR: 100
   FLG: SERVERWLM, LOCAL
     TCSR: 100  CER: 100 SEF: 100
     ABNORM: 0000       HEALTH: 100
     ACTCONN:   0000000005
     QOSPLCACT: *DEFAULT*
       W/Q: 06
 2 OF 2 RECORDS DISPLAYED
```

After a few minutes, we issue **netstat vdpt** for WebSphere Application Server to obtain a second snapshot (Example 7-27). Notice that the WLM values are no longer equal.

Example 7-27 NETSTAT VDPT again

```
D TCPIP,TCPIPC,N,VDPT,DETAIL,IPPORT=10.1.8.14+28538

DYNAMIC VIPA DESTINATION PORT TABLE:
DEST:        10.1.8.14..28538
  DESTXCF:   10.1.7.11
  TOTALCONN: 0000000428  RDY: 001  WLM: 08  TSR: 100
  FLG: SERVERWLM, LOCAL
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000006
    QOSPLCACT: *DEFAULT*
      W/Q: 08
DEST:        10.1.8.14..28538
  DESTXCF:   10.1.7.21
  TOTALCONN: 0000000359  RDY: 001  WLM: 11  TSR: 100
  FLG: SERVERWLM, LOCAL
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000008
    QOSPLCACT: *DEFAULT*
      W/Q: 11
```

After additional snapshots are taken, we see that the WLM values on both systems increased to 16, and that sometimes SC30 (10.1.7.11) had better WLM values, and other times SC31 (10.1.7.21) had better WLM values.

Takedown of the HTTP server on SC30

Next, we purge the HTTP server address space in SC30 to check whether all connection requests go to HTTP server on SC31.

Example 7-28 on page 270 shows that the RDY indicator is 000 (1), but WLM and other values do not indicate problems. So all connections do go to the HTTP server on SC31. This situation can be analyzed only through observing the TOTALCONN values in subsequent displays. The TOTALCONN value is frozen on 18880 (2) and the active connection count (ACTCONN) remains zero (0).

We notice that the values for WLM, TSR, and so on remain the same, because no new calculations are done for a not ready server.

Example 7-28 After purging HTTP server address space

```
D TCPIP,TCPIPC,N,VDPT,DETAIL,IPPORT=10.1.8.13+80

DYNAMIC VIPA DESTINATION PORT TABLE:
DEST:        10.1.8.13..80
  DESTXCF:   10.1.7.11
  TOTALCONN: 0000018880 2 RDY: 000 1 WLM: 13  TSR: 100
  FLG: SERVERWLM
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000000
    QOSPLCACT: *DEFAULT*
      W/Q: 13
DEST:        10.1.8.13..80
  DESTXCF:   10.1.7.21
  TOTALCONN: 0000017030 2 RDY: 001  WLM: 08  TSR: 100
  FLG: SERVERWLM
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000009
    QOSPLCACT: *DEFAULT*
      W/Q: 08
2 OF 2 RECORDS DISPLAYED
```

Subsequent displays show the frozen TOTALCONN value of 18880 (1) in SC30 and that this value increased in SC31 from 17030 (2) to 21171 (3), and only the SC31 display indicates that there are active connections (ACTCONN) (Example 7-29).

Example 7-29 Frozen TOTALCONN in SC30

```
D TCPIP,TCPIPC,N,VDPT,DETAIL,IPPORT=10.1.8.13+80

 DYNAMIC VIPA DESTINATION PORT TABLE:
 DEST:        10.1.8.13..80
   DESTXCF:   10.1.7.11
   TOTALCONN: 0000018880 1 RDY: 000  WLM: 13  TSR: 100
   FLG: SERVERWLM
     TCSR: 100  CER: 100 SEF: 100
     ABNORM: 0000       HEALTH: 100
     ACTCONN:   0000000000
     QOSPLCACT: *DEFAULT*
       W/Q: 13
 DEST:        10.1.8.13..80
   DESTXCF:   10.1.7.11
   TOTALCONN: 0000021171 3 RDY: 001  WLM: 06  TSR: 100
   FLG: SERVERWLM
     TCSR: 100  CER: 100 SEF: 100
     ABNORM: 0000       HEALTH: 100
     ACTCONN:   0000000010
     QOSPLCACT: *DEFAULT*
       W/Q: 06
 2 OF 2 RECORDS DISPLAYED
```

After a restart of the HTTP server on SC30, TOTALCONN (1) increased again, from 18880 to 19772 (Example 7-30).

Example 7-30 Restart of HTTP server in system SC30

```
D TCPIP,TCPIPC,N,VDPT,DETAIL,IPPORT=10.1.8.13+80

DYNAMIC VIPA DESTINATION PORT TABLE:
DEST:        10.1.8.13..80
  DESTXCF:   10.1.7.11
  TOTALCONN: 0000019772 1 RDY: 001 WLM: 12  TSR: 100
  FLG: SERVERWLM
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000000
    QOSPLCACT: *DEFAULT*
      W/Q: 12
DEST:        10.1.8.13..80
  DESTXCF:   10.1.7.21
  TOTALCONN: 0000024253  RDY: 001  WLM: 13  TSR: 100
  FLG: SERVERWLM
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000011
    QOSPLCACT: *DEFAULT*
      W/Q: 13
2 OF 2 RECORDS DISPLAYED
```

During the takedown of the HTTP server on SC30, the sysplex distributor sends all connection requests to the HTTP server on SC31 (Example 7-31).

Example 7-31 Displays for the WebSphere Application Server: HTTP server on SC30 is down

```
D TCPIP,TCPIPC,N,VDPT,DETAIL,IPPORT=10.1.8.14+28538

DYNAMIC VIPA DESTINATION PORT TABLE:
DEST:        10.1.8.14..28538
  DESTXCF:   10.1.7.11
  TOTALCONN: 0000001990 1 RDY: 001  WLM: 07  TSR: 100
  FLG: SERVERWLM, LOCAL
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000000
    QOSPLCACT: *DEFAULT*
      W/Q: 07
DEST:        10.1.8.14..28538
  DESTXCF:   10.1.7.21
  TOTALCONN: 0000002587  RDY: 001  WLM: 06  TSR: 100
  FLG: SERVERWLM, LOCAL
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000009
    QOSPLCACT: *DEFAULT*
      W/Q: 06
2 OF 2 RECORDS DISPLAYED
```

Because the optimized local path of the local connections to the WebSphere Application Server takes effect, the TOTALCONN 1990 (1) value of the WebSphere Application Server display sequences on SC30 shows that it is frozen. Only the value for SC31 increased (Example 7-32).

Example 7-32 Second display in a sequence for the WebSphere Application Server

```
D TCPIP,TCPIPC,N,VDPT,DETAIL,IPPORT=10.1.8.14+28538

 DYNAMIC VIPA DESTINATION PORT TABLE:
 DEST:        10.1.8.14..28538
   DESTXCF:   10.1.7.11
   TOTALCONN: 0000001990 1 RDY: 001  WLM: 08  TSR: 100
   FLG: SERVERWLM, LOCAL
     TCSR: 100  CER: 100 SEF: 100
     ABNORM: 0000       HEALTH: 100
     ACTCONN:   0000000000
     QOSPLCACT: *DEFAULT*
       W/Q: 08
 DEST:        10.1.8.14..28538
   DESTXCF:   10.1.7.21
   TOTALCONN: 0000002692  RDY: 001  WLM: 06  TSR: 100
   FLG: SERVERWLM, LOCAL
     TCSR: 100  CER: 100 SEF: 100
     ABNORM: 0000       HEALTH: 100
     ACTCONN:   0000000010
     QOSPLCACT: *DEFAULT*
       W/Q: 06
 2 OF 2 RECORDS DISPLAYED
```

During the takedown of the HTTP server on SC30, the optimized path with the local path between the HTTP server and the WebSphere Application Server instance on SC31 is used. No sysplex distributor is involved in the connection setup path between the HTTP server and WebSphere Application Server on SC31; this action is only necessary if the WLM value on SC31 falls to the value of 00.

After a restart of the HTTP on SC30, the TOTALCONN increases (Example 7-33).

Example 7-33 Restart HTTP server on SC30: WebSphere Application Server point of view

```
D TCPIP,TCPIPC,N,VDPT,DETAIL,IPPORT=10.1.8.14+28538

DYNAMIC VIPA DESTINATION PORT TABLE:
DEST:        10.1.8.14..28538
  DESTXCF:   10.1.7.11
  TOTALCONN: 0000002028  RDY: 001  WLM: 07  TSR: 100
  FLG: SERVERWLM, LOCAL
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000003
    QOSPLCACT: *DEFAULT*
      W/Q: 07
DEST:        10.1.8.14..28538
  DESTXCF:   10.1.7.21
  TOTALCONN: 0000003070  RDY: 001  WLM: 07  TSR: 100
  FLG: SERVERWLM, LOCAL
```

```
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000009
    QOSPLCACT: *DEFAULT*
      W/Q: 07
2 OF 2 RECORDS DISPLAYED
```

Overloaded WebSphere Application Server server on SC30

We drive the WebSphere Workload Simulator on SC30 with the WebSphere Application Server weight set to WLM = 000 to test whether the sysplex distributor gets control.

As shown in Example 7-34, the WLM value is 00 (1), and TSR (2) and SEF(3) values show 000 for the WebSphere Application Server instance.

Example 7-34 Overloaded WebSphere Application Server server on SC30

```
D TCPIP,TCPIPC,N,VDPT,DETAIL,IPPORT=10.1.8.14+28538

DYNAMIC VIPA DESTINATION PORT TABLE:
DEST:        10.1.8.14..28538
  DESTXCF:   10.1.7.11
  TOTALCONN: 0000003491  RDY: 001 4 WLM: 00 1 TSR: 000 2
  FLG: SERVERWLM
    TCSR: 100 5 CER: 100 6 SEF: 000 3
    ABNORM: 0000 8 HEALTH: 100 7
    ACTCONN:   0000000022
    QOSPLCACT: *DEFAULT*
      W/Q: 00
DEST:        10.1.8.14..28538
  DESTXCF:   10.1.7.21
  TOTALCONN: 0000004646  RDY: 001  WLM: 06  TSR: 100
  FLG: SERVERWLM, LOCAL
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000014
    QOSPLCACT: *DEFAULT*
      W/Q: 06
2 OF 2 RECORDS DISPLAYED
```

The Server accept Efficiency Fraction (SEF, 3) indicates that the WebSphere Application Server is unable to receive connection requests, because the application server queue is overloaded accepting new connection requests. The SEF value of 000 influences also caused the target server responsiveness (TSR, 2) value of zero (0). If the SEF value is under 075, all connection requests are sent to the sysplex distributor to make the routing decision.

Other indicators (such as RDY, TSCR, CER, HEALTH, and abnorm) do not point to any problems:

- RDY = 001 (4) means the server (only one) is still running.
- TCSR (target connectivity success rate) = 100 (5) means that all connection requests sent by the distribution stack are received by the target stack. A low value could indicate a problem with the connection between the distribution and target stack.

- CER (connection establishment rate) = 100 (6) means that all connections can be established between the HTTP proxy server (in this case, working as a client) and the WebSphere Application Server built-in HTTP server. The problems in our case arose in the next step, when the built-in HTTP WebSphere Application Server did not accept the new connections.
- HEALTH (7) is an indicator for the specific server. The field affects the WLM weight and operation of the OPTLOCAL distributor setting. If this value is lower than 75, all connection requests go to the sysplex distributor.
- abnorm (8) counts all abnormal ended transactions.

  For example, a CICS server might work without any problems, but some transactions are in trouble because of slow database access. Because all indicators for the CICS server show values with a favorable state, the sysplex distributor continues sending new connection requests to the CICS server. Now the abnorm count is also included in the WLM calculation. If the abnorm count for the local stack is greater than 250, then no OPTLOCAL function for transactions is executed. All connection requests are directed to the sysplex distributor.

In the case of the overloaded WebSphere Application Server on SC30, the result of this situation is that the HTTP server in SC30 loses the local connection (the WebSphere Application Server has a WLM weight of zero). The sysplex distributor now has to search for another appropriate WebSphere Application Server in the sysplex.

In our case, it is the WebSphere Application Server on SC31. New client HTTP requests, which initiate TCP connection requests, are sent to the sysplex distributor and forwarded to the HTTP server with the best WLM value. If the request reaches the HTTP server on SC30, this server is not able to use the optimized setup path, because the stack signals WLM = 00 for WebSphere Application Server on SC30.

Therefore, the HTTP server sends its connection request to the sysplex distributor. The sysplex distributor uses the normal distribution path to the WebSphere Application Server instance on SC31 through HiperSockets within the server or using a defined VIPAROUTE in the case of a server-to-server path, or, if these paths are not available, through an XCF link.

Figure 7-13 on page 267 shows the situation if SERVER WLM = 00 occurs for the WebSphere Application Server on SC30. The figure also shows the same situation if the WebSphere Application Server on SC31 might fall into a SERVER WLM value of 00. In this case, the HTTP server on SC31 has to send the connection request to the sysplex distributor in SC30, which forwards the request to the WebSphere Application Server on SC30.

Returning to our first case, as illustrated in Example 7-35 on page 275, the next display in this sequence shows that the TOTALCONN of `3494` (1) is frozen for WebSphere Application Server on SC30, although the `RDY: 001` (2) shows that the server is still available. The WLM (3), the TSR (4), and the SEF (5) show the actual status through indication of 000 for all measurements.

We notice that the ACTCONN (6) value for the WebSphere Application Server on SC30 is not zero compared with the previous display. The 17 HTTP requests are still kept, because active connections continue to be displayed until the HTTP timeout is reached for these connections. The TOTALCONN (7) for the HTTP server on SC31 increased from 4646 to `5006`.

Example 7-35   Second display with frozen connections

```
D TCPIP,TCPIPC,N,VDPT,DETAIL,IPPORT=10.1.8.14+28538

DYNAMIC VIPA DESTINATION PORT TABLE:
DEST:         10.1.8.14..28538
  DESTXCF:    10.1.7.11
  TOTALCONN: 0000003494 1 RDY: 001 2 WLM: 00 3 TSR: 000 4
  FLG: SERVERWLM
    TCSR: 100  CER: 100 SEF: 000 5
    ABNORM: 0000        HEALTH: 100
    ACTCONN:   0000000017 6
    QOSPLCACT: *DEFAULT*
      W/Q: 00
DEST:         10.1.8.14..28538
  DESTXCF:    10.1.7.21
  TOTALCONN: 0000005006 7 RDY: 001  WLM: 06  TSR: 100
  FLG: SERVERWLM, LOCAL
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000        HEALTH: 100
    ACTCONN:   0000000014
    QOSPLCACT: *DEFAULT*
      W/Q: 06
2 OF 2 RECORDS DISPLAYED
```

OPTLOCAL 4 with sysplex distributor only

In previous sections, we discussed OPTLOCAL 0 and 1. The values 2 through 16 can also be used. They are applied to the amount of preference for the local server based on a comparison of WLM weights.

To give the local stack a higher preference even if it does not have the best WLM value, use an OPTLOCAL value of 2 to 16 as a multiplier to manipulate the WLM calculation. This allows you to prefer the local server even if the server WLM value for the local stack is much lower than others of the same servers in the server group.

For example, server WLM = 05 is defined on SC30. On the other LPARs, server WLM values are 12, 14, or 15. If OPTLOCAL 4 is defined, then the local WLM value is multiplied by the defined OPTLOCAL value. If OPTLOCAL 4 is defined on SC30, then the local WLM value is multiplied by the defined OPTLOCAL value. This means 20 (5 X4) is compared with all servers' WLM values of the same server group. Thus, the local server (SC30) is favored because it has the highest value.

TCP/IP profile definitions

Only OPTLOCAL 4 is defined on the VIPADISTRIBUTE statement, as shown in Example 7-36.

Example 7-36   TCP/IP profile for OPTLOCAL 4

```
VIPADynamic
VIPADEFine MOVEable IMMEDiate 255.255.255.0 10.1.8.13
   VIPADISTribute DISTMethod SERVERWLM 10.1.8.13
   PORT 80 DESTIP 10.1.7.11 10.1.7.21
 VIPADEFine MOVEable IMMEDiate 255.255.255.0 10.1.8.14
   VIPADISTribute DISTMethod SERVERWLM optlocal 4 10.1.8.14
   PORT 28538 28518 28510 28502 28503 DESTIP 10.1.7.11 10.1.7.21
ENDVIPADYNAMIC
```

Verification

Use the **netstat vipadcfg** command to show the correct OPTLOCAL 4 definition for the distributed DVIPA on SC30 and SC31 (Example 7-37):

- SC30 with DXCF IP address 10.1.7.11
- SC31 with DXCF IP address 10.1.7.21

Example 7-37 TCP/IP profile for OPTLOCAL 4

```
D TCPIP,TCPIPC,N,VIPADCFG,DETAIL

DYNAMIC VIPA INFORMATION:
  VIPA DEFINE:
    IPADDR/PREFIXLEN: 10.1.8.13/24
      MOVEABLE: IMMEDIATE  SRVMGR: NO
    IPADDR/PREFIXLEN: 10.1.8.14/24
      MOVEABLE: IMMEDIATE  SRVMGR: NO
DEST:        10.1.8.13..80
  DESTXCF:   10.1.7.11
    SYSPT:   NO   TIMAFF: NO    FLG: SERVERWLM
    OPTLOC:  NO
DEST:        10.1.8.13..80
  DESTXCF:   10.1.7.21
    SYSPT:   NO   TIMAFF: NO    FLG: SERVERWLM
    OPTLOC:  NO
DEST:        10.1.8.14..28538
  DESTXCF:   10.1.7.11
    SYSPT:   NO   TIMAFF: NO    FLG: SERVERWLM OPTLOCAL
    OPTLOC:  4
DEST:        10.1.8.14..28538
  DESTXCF:   10.1.7.21
    SYSPT:   NO   TIMAFF: NO    FLG: SERVERWLM OPTLOCAL
        OPTLOC:  4
```

The **netstat vipadyn** command displays the date and time when the DVIPAs are activated, as shown in Example 7-38.

Example 7-38 Date and time of DVPA activation

```
D TCPIP,TCPIPC,N,VIPADYN

DYNAMIC VIPA:
  IPADDR/PREFIXLEN: 10.1.8.12/24
    STATUS:  ACTIVE     ORIGIN: VIPADEFINE       DISTSTAT: DIST/DEST
    ACTTIME: 10/08/2010 17:06:01
  IPADDR/PREFIXLEN: 10.1.8.13/24
    STATUS:  ACTIVE     ORIGIN: VIPADEFINE       DISTSTAT: DIST/DEST
    ACTTIME: 10/08/2010 17:06:01
  IPADDR/PREFIXLEN: 10.1.8.14/24
    STATUS:  ACTIVE     ORIGIN: VIPADEFINE       DISTSTAT: DIST/DEST
    ACTTIME: 10/08/2010 17:06:01
  IPADDR/PREFIXLEN: 10.1.8.10/24
    STATUS:  ACTIVE     ORIGIN: VIPARANGE BIND   DISTSTAT:
    ACTTIME: 10/08/2010 17:10:52                 JOBNAME: LBADV
VIPA ROUTE:
  DESTXCF: 10.1.7.11
    TARGETIP: 10.1.1.10
    RTSTATUS: DEFINED
  DESTXCF: 10.1.7.21
    TARGETIP: 10.1.1.10
    RTSTATUS: ACTIVE
  DESTXCF: 10.1.7.31
    TARGETIP: 10.1.1.10
    RTSTATUS: ACTIVE
7 OF 7 RECORDS DISPLAYED
```

Example 7-39 shows the first display of the VIPA distribution port table after a restart of SC30 with OPTLOCAL option 4. Both WebSphere Application Servers received equal numbers of connections. The load distribution is equal.

Example 7-39 First display of VIPA distribution port table with OPTLOCA 4

```
D TCPIP,TCPIPC,N,VDPT,DETAIL,IPPORT=10.1.8.14+28538

DYNAMIC VIPA DESTINATION PORT TABLE:
DEST:         10.1.8.14..28538
  DESTXCF:    10.1.7.11
  TOTALCONN: 0000000038  RDY: 001  WLM: 08  TSR: 100
  FLG: SERVERWLM, LOCAL
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000        HEALTH: 100
    ACTCONN:   0000000005
    QOSPLCACT: *DEFAULT*
      W/Q: 08
DEST:         10.1.8.14..28538
  DESTXCF:    10.1.7.21
  TOTALCONN: 0000000038  RDY: 001  WLM: 08  TSR: 100
  FLG: SERVERWLM, LOCAL
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000        HEALTH: 100
    ACTCONN:   0000000007
    QOSPLCACT: *DEFAULT*
      W/Q: 08
```

The VIPA connection routing table for the two WebSphere Application Servers displays the following distributions, as shown in Example 7-40:

- Six connections are distributed from the SOURCEVIPA 10.1.1.10, which uses the HTTP server on SC30 to the WebSphere Application Server on SC30 with DXCF IP address 10.1.7.11 using cluster IP address `10.1.8.14` with a port address of 28538.
- Nine connections are distributed from the SOURCEVIPA 101.1.20, which uses the HTTP server on SC31 to the WebSphere Application Server on SC31 with DXCF IP address 10.1.7.21, using cluster address `10.1.8.14` with a port address of 28538.

Example 7-40 NETSTAT VCRT of first connections to WebSphere Application Server

```
D TCPIP,TCPIPC,N,VCRT,DETAIL,IPPORT=10.1.8.14+28538

DYNAMIC VIPA CONNECTION ROUTING TABLE:
......... first two connections from HTTP server on SC30 to WAS on SC30 ........
DEST:       10.1.8.14..28538
  SOURCE:   10.1.1.10..1132
  DESTXCF: 10.1.7.11
```

```
    POLICYRULE:    *NONE*
    POLICYACTION:  *NONE*
DEST:      10.1.8.14..28538
  SOURCE:  10.1.1.10..1133
  DESTXCF: 10.1.7.11
    POLICYRULE:    *NONE*
    POLICYACTION:  *NONE*
.......... first two connections from HTTP server on SC31 to WAS on SC31 .........
DEST:      10.1.8.14..28538
  SOURCE:  10.1.1.20..1172
  DESTXCF: 10.1.7.21
    POLICYRULE:    *NONE*
    POLICYACTION:  *NONE*
DEST:      10.1.8.14..28538
  SOURCE:  10.1.1.20..1173
  DESTXCF: 10.1.7.21
    POLICYRULE:    *NONE*
    POLICYACTION:  *NONE*
```

Stopping WebSphere Application Server on SC30

During the test with the workload simulator, we cannot increase the load of one system to discover a recalculation of a fictive WLM value. Therefore, we decide to stop the WebSphere Application Server application on SC30 and check whether the distribution works with the OPTLOCAL 4 option, as shown in Example 7-41.

When the WebSphere Application Server on SC30 is purged, the RDY = 001, the WLM = 0, and the TSR and SEF were 000, as expected. TOTALCONN is frozen with 1328 connections for SC30. TOTALCONN of 1448 on SC31 will increase in the next display.

Example 7-41 WebSphere Application Server on SC30 was stopped, service is still running

```
D TCPIP,TCPIPC,N,VDPT,DETAIL,IPPORT=10.1.8.14+28538

DYNAMIC VIPA DESTINATION PORT TABLE:
DEST:        10.1.8.14..28538
  DESTXCF:   10.1.7.11
  TOTALCONN: 0000001328  RDY: 001  WLM: 00  TSR: 000
  FLG: SERVERWLM
    TCSR: 100  CER: 100 SEF: 000
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000024
    QOSPLCACT: *DEFAULT*
      W/Q: 00
DEST:        10.1.8.14..28538
  DESTXCF:   10.1.7.21
  TOTALCONN: 0000001448  RDY: 001  WLM: 06  TSR: 100
  FLG: SERVERWLM, LOCAL
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000012
    QOSPLCACT: *DEFAULT*
      W/Q: 06
2 OF 2 RECORDS DISPLAYED
```

Although the WebSphere Application Server on SC30 is now down, both HTTP servers are distributed to the SC31 WebSphere Application Server, as shown in Example 7-42.

Example 7-42 WebSphere Application Server on SC30 is down

```
D TCPIP,TCPIPC,N,VCRT,DETAIL,IPPORT=10.1.8.13+80

 DYNAMIC VIPA CONNECTION ROUTING TABLE
.............. first two connections from workload simulator to HTTP server on SC30 ......
DEST:      10.1.8.13..80
   SOURCE:  10.30.2.50..2084
   DESTXCF: 10.1.7.11
     POLICYRULE:    *NONE*
     POLICYACTION:  *NONE*
 DEST:      10.1.8.13..80
   SOURCE:  10.30.2.50..2232
   DESTXCF: 10.1.7.11
............. first two connections from workload simulator to HTTP server on SC31 ......
DEST:      10.1.8.13..80
  SOURCE:  10.30.2.50..2230
  DESTXCF: 10.1.7.21
    POLICYRULE:    *NONE*
    POLICYACTION:  *NONE*
DEST:      10.1.8.13..80
  SOURCE:  10.30.2.50..2231
  DESTXCF: 10.1.7.21
    POLICYRULE:    *NONE*
    POLICYACTION:  *NONE*
```

Example 7-43 shows the relationship between connections.

The HTTP server WEBBW311 on SC31 (1) establishes a connection with SOURCEVIPA 10.1.1.20..2665 to the WebSphere Application Server BWSR02B and address 10.1.8.14..28538. This same connection can be viewed with reverse addresses.

Another pair of connections is established from the WebSphere Application Server on SC30 with address 10.1.1.10 routed to the WebSphere Application Server on SC31 BWSR02B (2). The corresponding partner connection cannot be displayed on SC30. The pair was already closed when the **netstat** command was entered.

Example 7-43 NETSTAT conn displays HTTP and WebSphere Application Server connections

```
D TCPIP,TCPIPC,N,CONN,IPPORT=10.1.8.14+28538

USER ID  CONN     STATE
BWSR02B  0006539F ESTBLSH
  LOCAL SOCKET:   10.1.8.14..28538 2
  FOREIGN SOCKET: 10.1.1.10..3148
BWSR02B  000653A1 ESTBLSH
  LOCAL SOCKET:   10.1.8.14..28538 2
  FOREIGN SOCKET: 10.1.1.10..3149
.......... further connections .........................................
BWSR02B  0006537F ESTBLSH
  LOCAL SOCKET:   10.1.8.14..28538
  FOREIGN SOCKET: 10.1.1.20..2665 1
.......... further connections .........................................
WEBBW311 0006537E ESTBLSH
   LOCAL SOCKET:   10.1.1.20..2665 1
   FOREIGN SOCKET: 10.1.8.14..28538
```

7.3 WLM reporting abnormal conditions

Workload Manager (WLM) provides system weight and server-specific weight values.

The system weight value is issued for each target LPAR based on comparisons:

- Comparison of available capacity
- Comparison of displaceable capacity (lower importance work that can be displaced)

System weights do not reflect how well the server is performing, as explained in 7.3.2, “Calculation of WLM weight and TSR” on page 281.

Server-specific weights are issued for each application server running in an LPAR. They are based on certain information:

- How well each server is meeting the goals for its service class
- Comparison of displaceable capacity on each system based on the importance of the server’s work.

The following sections explain the situations and conditions that impact the complexity of workload decisions, and how they are resolved in a design for the sysplex distributor environment.

7.3.1 Situation of current workload distribution decisions

WLM is not aware of all problems experienced by load balancing targets; this might occur, for example, when a server application needs a resource such as a database, but the resource is unavailable. Another example is a server application that acts as a transaction router for other back-end applications on other systems, but the path to the back-end application is unavailable.

In each of these scenarios, the server appears to be completing the transactions quickly (using little CPU capacity), although it is actually failing. This situation is known as a *storm drain problem*, with the following results:

- The server is favored by WLM, because it is using little CPU capacity.
- As workloads increase, the server is favored more and more over other servers.
- All this work goes “down the drain.”

Although the sysplex distributor is able to reduce the WLM weight values by using the Target Server Responsiveness (TSR) fraction, the storm drain problem cannot be fully resolved.

Note: Implementing Sysplex Distribution with multitier applications as described in 7.2, “Optimized multitier z/OS sysplex distributor load balancing” on page 243 can mitigate some of the effects of the storm drain problem.

The TSR fraction is built based on the following factors:

- Is the connectivity between the distributing stack and the target stack stable? Are new connections being received by the target stack?

  This factor is the Target Connectivity Success Rate (TCSR).
- Is the network connectivity between server and client in a good state? Can new connections be established?

  This factor is the Connection Establishment Rate (CER).
- Is the target server application accepting new work? What target server responsiveness does the application show? Is the backlog queue overloaded?

  This factor is the Server accept Efficiency Fraction (SEF).

Figure 7-14 on page 282 illustrates these factors.

7.3.2 Calculation of WLM weight and TSR

The calculation of WLM weights and the TSR determines which target application server receives the work requests, such as the TCP connection request forwarded by the sysplex distributor or the external load balancer. The following list explains this information:

- WLM weights

  When determining a system weight, WLM assigns a relative weight to each system in the sysplex, with the highest weight going to the system with the most available CPU capacity. The weights range between 0 - 64.

  If all systems in the sysplex are running at or near 100% utilization, WLM assigns the highest weights to the systems with the largest amounts of lower importance work. In this way, new connection requests are distributed to the systems with the highest displaceable capacity.

  However, note the following points:

  – This method does not reflect how well the server application is actually meeting the goals of its service class.

  – If all systems are using close to 100% of capacity, then the WLM weight is based on a comparison of displaceable capacity, which is the amount of lower importance work on each system. However, if the service class of the server is of low importance, then it might not be able to displace this work.

  When determining a server-specific weight, WLM assigns a relative weight to each server based on how well each server is meeting the goals of its service class. The weights range between 0 - 64. If all systems in the sysplex are running at or near 100% utilization, WLM assign the highest weights to the servers running on systems with the largest amounts of work that can be displaced by that server (based on the importance of its service class)
- Calculation of TSR

  – SEF: This value is based on whether the server is processing new connections:

    • New connections are being established (Connection Establishment Rate (CER)).
    • The server is accepting the new connections.

  – TCSR: The distributor determines this value from the number SYNs it has sent to the target and the statistics returned from the target.

  – TSR: This is based on the SEF value (which includes CER) and TCSR values.

Figure 7-14 shows that distributed DVIPA1 for port 8000 is defined with DISTMETHOD SERVERWLM to DESTIP target 1 and target 2.

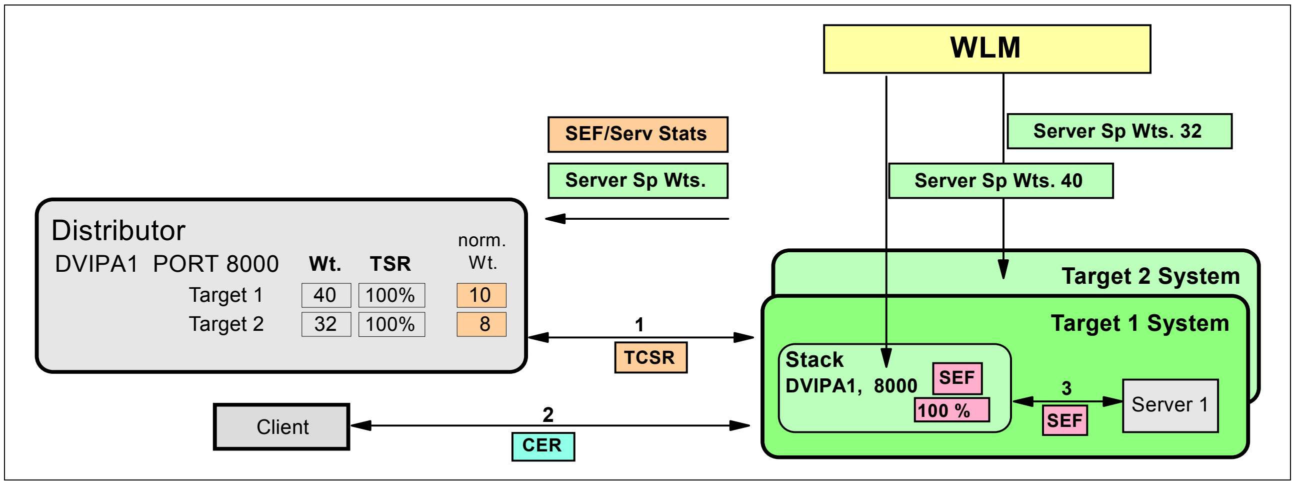


Figure 7-14 Workload distribution weight fractions

The sysplex distributor receives a calculated weight value of 40 for Target 1, and 32 for Target 2. Because the TSR for both targets is reported as 100%, both weight values are not minimized. At a lower percentage, the calculation would be as follows:

```
Weight * TSR% = Weight fraction
```

The next step is normalizing the weight, which is done by dividing the Weight fraction by the integer 4. This is done only to continue working with smaller values.

- For Target 1, the calculation is as follows:

  Normalized weight is `10 = (40 / 4)`

- For Target 2, the calculation is as follows:

  Normalized weight is `8 = (32 / 4)`

7.3.3 WLM interface for abnormal transactions and health status

WLM provides an interface that allows a server to pass additional information about its overall health. This overall health information consists of two values:

- Abnormal transaction completion rate

  Applications such as CICS transaction server for z/OS, that act as subsystem work managers, can report an abnormal transaction completion rate to WLM. The value is in the range of 0 and 1000, with 0 meaning no abnormal completions.

- General health of the application

  Applications can report their general health to WLM. The value is between 0 and 100, with 100 meaning that a server has no general health problems (100% healthy).

WLM reduces the reported weight based on abnormal completion rate and the general health.

Figure 7-15 shows how the abnormal transaction completion rate of 1000 impacts the server-specific weight value, and also how the sysplex distributor uses the normalized value of zero (0) instead the previous displayed value of 10 for Target 1.

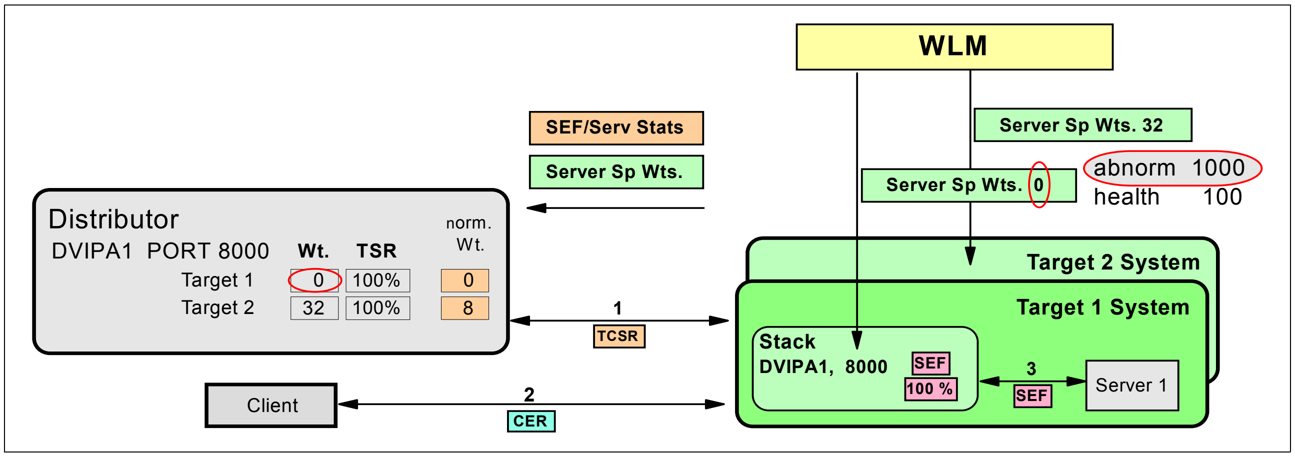


Figure 7-15 Workload distribution with additional weight fractions

Server scenarios

The TCP/IP stack retrieves the information about abnormal transaction termination and health of the application using the IWM4SRSC interface:

- Abnormal termination

  This information solves the problem where the registered server is not the transaction consumer. It does not, however, resolve the problem where another connector is between the TCP/IP stack and the consumer.

- Health

  Address spaces that are not instrumented can use the IWM4HLTH interface to WLM to set a health status, which is also returned by IWM4SRSC.

Figure 7-16 shows the differences between the information TCP/IP receives through these two interfaces.

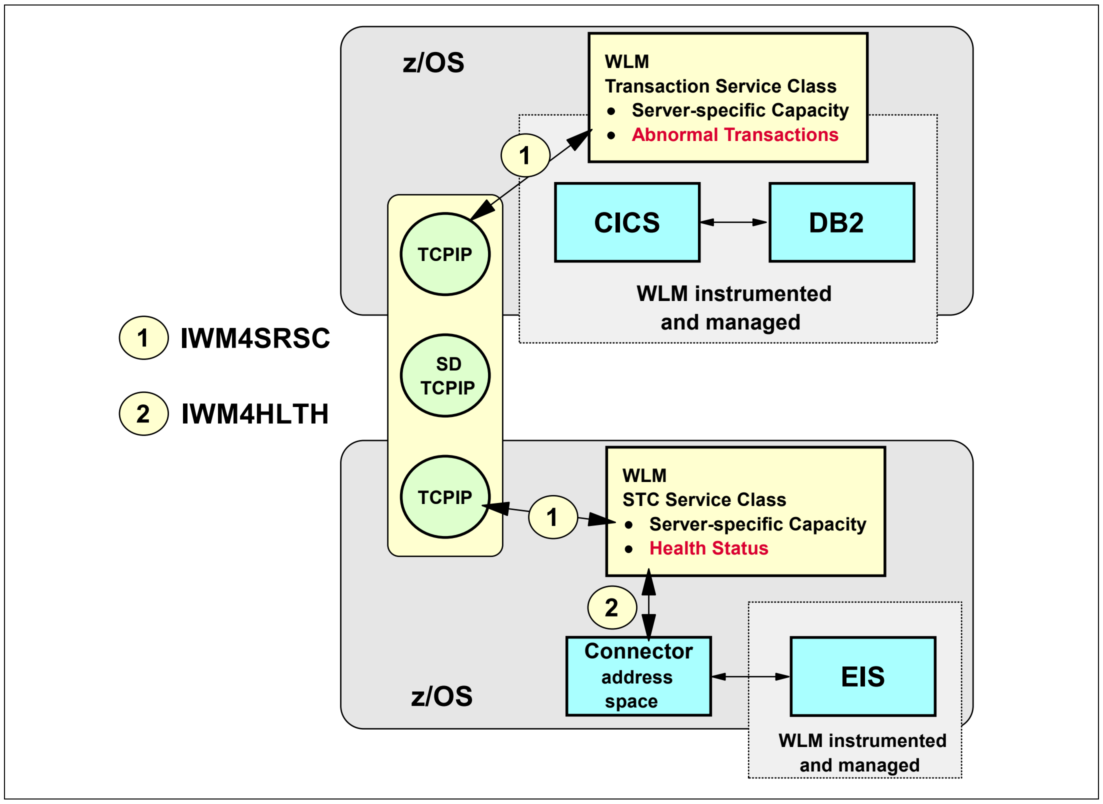


Figure 7-16 WLM target application awareness

Verification

The **netstat** commands in Example 7-44 show samples for the health indicator, active connections, and abnormal termination.

Example 7-44 The netstat commands for VIPA distribution port table, short format

```
D TCPIP,TCPIPC,N,VDPT

DYNAMIC VIPA DESTINATION PORT TABLE:
DEST:          10.1.8.12..23
  DESTXCF:     10.1.7.31
  TOTALCONN: 0000000000  RDY: 001  WLM: 15  TSR: 100
  FLG: BASEWLM
DEST:          10.1.8.13..80
  DESTXCF:     10.1.7.11
  TOTALCONN: 0000000000  RDY: 000  WLM: 00  TSR: 100
  FLG: SERVERWLM
```

If you use the **netstat** command with the format detail, you receive the desired information about WLM, TSR, TCSR, CER, SEF, ABNORM, and HEALTH values. You also see the active connections for the distributed server (Example 7-45).

Example 7-45 netstat command for VIPA distribution port table, long format

```
D TCPIP,TCPIPC,N,VDPT,DETAIL

DYNAMIC VIPA DESTINATION PORT TABLE:
DEST:        10.1.8.12..23
  DESTXCF:   10.1.7.11
  TOTALCONN: 0000000000  RDY: 001  WLM: 05  TSR: 100
  FLG: BASEWLM
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000000
    QOSPLCACT: *DEFAULT*
      W/Q: 05
DEST:        10.1.8.12..23
  DESTXCF:   10.1.7.21
  TOTALCONN: 0000000000  RDY: 001  WLM: 04  TSR: 100
  FLG: BASEWLM
    TCSR: 100  CER: 100 SEF: 100
    ABNORM: 0000       HEALTH: 100
    ACTCONN:   0000000000
    QOSPLCACT: *DEFAULT*
      W/Q: 04
```

When issuing the **netstat all** command, you receive information indicating how many connections were dropped if the backlog is overloaded (current backlog and maximum backlog). This situation is defined through the SMAXCONN statement in the TCP/IP profile (the default is 10). See Example 7-46.

Example 7-46 The netstat all command

```
===> netstat all

Client Name: BWSR02B                  Client Id: 000013AB
  Local Socket: ::..28530
  Foreign Socket: ::..0
    BytesIn:            00000000000000000000
    BytesOut:           00000000000000000000
    SegmentsIn:         00000000000000000000
    SegmentsOut:        00000000000000000000
    Last Touched:       16:03:39         State:              Listen
    RcvNxt:             0000000000       SndNxt:             0000000000
    ClientRcvNxt:       0000000000       ClientSndNxt:       0000000000
    InitRcvSeqNum:      0000000000       InitSndSeqNum:      0000000000
    CongestionWindow:   0000000000       SlowStartThreshold: 0000000000
    IncomingWindowNum:  0000000000       OutgoingWindowNum:  0000000000
    SndWl1:             0000000000       SndWl2:             0000000000
    SndWnd:             0000000000       MaxSndWnd:          0000000000
    SndUna:             0000000000       rtt_seq:            0000000000
    MaximumSegmentSize: 0000000536       DSField:            00
    Round-trip information:
    Smooth trip time: 0.000              SmoothTripVariance: 1500.000
    ReXmt:              0000000000        ReXmtCount:         0000000000
    DupACKs:            0000000000
    SockOpt:            8000              TcpTimer:           00
    TcpSig:             01                TcpSel:             20
    TcpDet:             C0                TcpPol:             08
    QOSPolicyRuleName:
    ReceiveBufferSize:  0000016384        SendBufferSize:     0000016384
    ConnectionsIn:      0000000000        ConnectionsDropped: 0000000000
    CurrentBacklog:     0000000000        MaximumBacklog:     0000000010
    CurrentConnections: 0000000000        SEF:                100
   Quiesced: No
```

You can check the distribution method and the OPTLOCAL value by using the **netstat VIPDCFG** command, as shown in Example 7-47.

Example 7-47 netstat vipadcfg short format

```
D TCPIP,TCPIPC,N,VIPADCFG

DYNAMIC VIPA INFORMATION:
  VIPA DEFINE:
    IPADDR/PREFIXLEN: 10.1.8.13/24
      MOVEABLE: IMMEDIATE  SRVMGR: NO
    IPADDR/PREFIXLEN: 10.1.8.14/24
      MOVEABLE: IMMEDIATE  SRVMGR: NO
  VIPA DISTRIBUTE:
    DEST:       10.1.8.13..80
      DESTXCF:   10.1.7.11
        SYSPT:   NO   TIMAFF: NO    FLG: SERVERWLM
    DEST:       10.1.8.13..80
      DESTXCF:   10.1.7.21
        SYSPT:   NO   TIMAFF: NO    FLG: SERVERWLM
```

The **netstat vipadcfg** command shows the defined OPTLOCAL value (Example 7-48).

Example 7-48 netstat vipdcfg long format

```
D TCPIP,TCPIPC,N,VIPADCFG,DETAIL

DYNAMIC VIPA INFORMATION:
  VIPA DEFINE:
    IPADDR/PREFIXLEN: 10.1.8.13/24
      MOVEABLE: IMMEDIATE  SRVMGR: NO
    IPADDR/PREFIXLEN: 10.1.8.14/24
      MOVEABLE: IMMEDIATE  SRVMGR: NO
     DEST:       10.1.8.14..28538
       DESTXCF:   10.1.7.11
         SYSPT:   NO   TIMAFF: NO    FLG: SERVERWLM OPTLOCAL
         OPTLOC:  4
     DEST:       10.1.8.14..28538
       DESTXCF:   10.1.7.11
         SYSPT:   NO   TIMAFF: NO    FLG: SERVERWLM OPTLOCAL
         OPTLOC:  4
```

You can also obtain ABNORM and HEALTH information through the LBAdvisor to check if the WLM weight is being influenced by these factors (Example 7-49).

Example 7-49   F LBADV, DISP

```
F LBADV,DISP,LB,I=0
EZD1243I LOAD BALANCER DETAILS
LB INDEX : 00 UUID : 637FFF175C
...
GROUP NAME : CICS_SERVER
GROUP FLAGS : SERVERWLM
IPADDR..PORT: 10.1.8.11..8000
SYSTEM NAME: SC30 PROTOCOL : TCP AVAIL : YES
WLM WEIGHT : 00000 CS WEIGHT : 100 NET WEIGHT: 00001
ABNORM : 01000 HEALTH : 100
FLAGS :
```

8

Performance and tuning

A system delivering poor response times to a user can be perceived as unavailable from the user's viewpoint. TCP/IP performance is influenced by a number of parameters that can be tailored for the specific operating environment, which includes not only TCP/IP stack performance that benefits all applications using the stack, but also applications that are part of the IBM z/OS Communications Server shipment, such as TN3270 and FTP.

Because every TCP/IP environment differs, optimum performance can be achieved only when the system is tuned to match its specific environment. In this chapter, we highlight the most important tuning parameters, and also suggest parameter values that have maximized performance in many client installations.

This chapter contains the following topics.

Section	**Topic**
8.1, "General performance considerations" on page 290	Factors influencing performance
8.2, "TCP/IP configuration files" on page 293	Significant configuration files for z/OS TCP/IP
8.3, "z/OS UNIX System Services tuning" on page 301	Useful tuning information
8.4, "Storage requirements" on page 301	Storage usage summaries for typical applications
8.5, "Application performance and capacity" on page 307	Telnet (TN3270) capacity planning, FTP tuning, and FTP capacity planning information
8.6, "z/OS Communications Server TCP/IP performance highlights" on page 310	z/OS Communications Server TCP/IP performance enhancements (all automatically enabled)
8.7, "TCP/IP performance quick checklist" on page 316	Performance items to consider
8.8, "IBM Health Checker for z/OS" on page 317	Health Checker checks information

8.1 General performance considerations

When discussing performance and response times, keep in mind that performance can be influenced by many factors:

- Application programs

  Performance is influenced by obvious elements, such as application path lengths, large memory moves, and I/O operations. I/O response is subject to considerable tuning in a variety of ways. Furthermore, the structure of the application itself must be considered, for example, the choice of single-thread or multiple thread design is important.

  An application design that permits multiple instances of itself to be active has obvious advantages. This chapter concentrates on network aspects of performance; application design is largely outside the scope of the current discussion.

- TCP window size

  The TCP *window* governs the amount of data that the sender can transmit to the receiver before an acknowledgement is returned. A larger window can optimize normal traffic, but has a higher processing impact if frame retransmission is needed.

  The size of the TCP window is adjustable. The maximum standard window size is 65,535 bytes. Optionally, RFC 1323 (window scaling) can be employed. The maximum window with RFC 1323 is 1,073,725,440 bytes.

  With z/OS, the maximum allowable window and the use of window scaling is determined by the TCP send and receive buffer settings. Window scaling is automatically turned on when the TCP send buffer is set above 64 KB.

- HiperSockets MTU size

  HiperSockets TCP/IP devices are configured similar to OSA-Express QDIO devices. Each HiperSockets requires the definition of a channel path identifier (CHPID), which is similar to any other I/O interface.

  Real LANs have a maximum frame size limit defined by their protocol. The maximum frame size for Ethernet is 1492 bytes. For Gigabit Ethernet, there is the jumbo frame option for a maximum frame size of 9000 bytes.

  The maximum frame size for a HiperSockets is assigned when the HiperSockets CHPID is defined. You can select frame sizes of 16 KB, 24 KB, 40 KB, and 64 KB. The selection depends on the data characteristics transported over a HiperSockets, which is also a trade-off between performance and storage allocation. The MTU size used by the TCP/IP stack for the HiperSockets interface is also determined by the maximum frame size. Table 8-1 lists the maximum frame size and maximum transmission unit (MTU) size.

  Table 8-1 Maximum frame size and MTU size

Maximum frame size	MTU size
16 KB	8 KB
24 KB	16 KB
40 KB	32 KB
64 KB	56 KB

Note: The default maximum frame size is 16 KB.

- Frame size/MTU size

  Data is transported across the Ethernet in *frames*. Frame size is limited by the type of Ethernet architecture in use, by the equipment in use, and by the settings of the system.

  The Ethernet type determines the maximum payload size, and thus the frame size. For Ethernet-DIX, the maximum payload is 1500 bytes. For Ethernet-IEEE 802.3 LAN, the maximum is 1492 bytes (which results in 1500 bytes after including additional headers). In practice, most Ethernet usage involves the DIX format.

  Note: To avoid incompatibilities between DIX and 802.3 ports, keep the MTU size at or below 1492 bytes for standard frames.

  With z/OS, the MTU is set in the TCP/IP profile. Some vendor equipment allows frames to exceed the maximum allowed by the standards cited here. A frame that is larger than the standard is a *jumbo* frame. When operating in QDIO mode and above 1000 Mbps speed, OSA-Express, OSA-Express2 and OSA-Express 3 support jumbo frames. The largest jumbo supported holds an MTU of 8992 bytes (9000 bytes for IPv6).

  Use the PMTU option on the **`ping`** command to determine where fragmentation is necessary in the network. The PMTU YES option differs from the PMTU IGNORE option in the way the ping completes its echo function. See *z/OS Communications Server: IP System Administrator's Commands*, SC27-3661 for a detailed discussion about the PMTU option.

- OSA-Express, OSA-Express2, and OSA-Express3 features

  The OSA-Express, OSA-Express2, and OSA-Express3 features contain hardware and firmware that enable the flow of traffic between the Ethernet link and host memory when operating in QDIO mode. Traffic flowing through the OSA is stored in OSA-memory before being forwarded to the host or LAN.

  This design optimizes host memory access. The OSA microprocessor manages the flow of traffic through the OSA. A utilization of over 90% might indicate that the OSA is nearing capacity. In some cases OSA becomes more efficient as traffic increases, even at high utilizations, because OSA can transfer more packets per block when moving data between host memory and OSA memory.

  Note: At high loads, response time might be more of a concern than utilization, especially when running interactive traffic.

- Dynamic LAN idle

  Dynamic LAN idle is designed to reduce latency and improve network performance by dynamically adjusting the inbound blocking algorithm.

  When enabled, the TCP/IP stack adjusts the inbound blocking algorithm to best match the application requirements. The TCP/IP stack dynamically determines the best setting for the current running application based on system configuration, inbound workload volume, CPU utilization, and traffic patterns. See 8.2.2, "OSA-Express adapter interruption" on page 298 for configuration examples.

- Nagle algorithm relaxation

  The Nagle algorithm has been a standard component of TCP send-side flow control since the mid-1990s. Its intent is to preserve bandwidth by limiting the number of small data segments that can be sent-and-unacknowledged on the TCP connection. If an application performs a Socket Send of a small number of bytes and there is already unacknowledged data outstanding on the connection, the Nagle algorithm disallows this new data from being transmitted immediately. Instead, the new data queues and is pushed out some time in the future, in response to receipt of *acknowledgements* for the already-outstanding data. The Nagle algorithm is enabled by default and can be disabled on a per-connection basis using the TCP_NODELAY SetSockOpt.

  On the receive side, the concept of *delayed acknowledgements* is in place to both conserve bandwidth and minimize CPU consumption. Most TCP stacks employ an ACK-EVERYOTHER packet scheme. If a workload pattern is an *inbound data packet-outbound data packet*, it is common for no immediate, stand-alone ACK to be generated for the inbound data packet. Instead, the ACK of the inbound packet is piggy-backed on the next outbound data packet, thereby avoiding one flow on the link.

  This approach works well to reduce the number of packets flowing, and because there is some CPU consumption involved in generating and processing a stand-alone ACK, this approach also reduces CPU consumption on both sides of the connection.

  However, there is a type of traffic pattern that is exposed to traffic stalls because of the Nagle algorithm. The traffic pattern is not of a symmetric inbound packet-outbound packet variety; instead, this traffic pattern has multiple small packets heading in one or both directions.

  In this example, the first flow from the client is a control packet that simply primes the server for the next flow. The second flow from the client is the actual request portion of the transaction. The server receives the request, does some processing, and generates a response. So conceptually, the transaction is back-to-back send flows from client to server, with a single send flow from server back to client.

  The Nagle algorithm causes 200-millisecond delays between the first control flow from the client and the second actual transaction flow from the client if the server has not disabled DELAYACKS. A stall occurs because this new application employs back-to-back socket sends and does not disable the Nagle algorithm.

  With the relaxation of the Nagle algorithm, the TCP/IP stack transparently allows exactly two small packets on a connection to be outstanding. Allowing the second packet to flow results in the remote node (which uses a delayed acknowledgement scheme) to immediately generate an ACK when the second packet arrives. This way avoids the 200-millisecond stallings.

  Performance testing in the IBM z/OS Communications Server lab has demonstrated the dramatic effect of having removed Nagle stalls: transaction rate for such applications jumped from three transactions per second to 2650 transactions per second.

- msg-waitall deadlock relief

  The msg_waitall Socket Read flag is used generally by applications that receive large amounts of data in a burst. This read flag instructs the TCP layer to delay completion of a Socket Receive or Read call until the full length of the requested data is available in the TCP receive buffer. If an application issues this socket call for a large amount of data (for example, 32 KB) but the application is operating with a smaller TCP read buffer (for example, 16 KB), a *deadlock* situation can occur. The buffer fills up, but the application does not issue a read because it is still waiting for the full 32 KB of data.

Deadlock relief in the z/OS TCP/IP stack increases the size of the read buffer transparently in such situations to 32 KB, which is expected by the application. In fact, the receive buffer can be expanded to a size less than or equal to the TCPMAXRCVBufrsize specification on TCPCONFIG statement. The default for TCPMAXRCVBufrsize is 256 KB.

Note: This scenario illustrates the importance of following IBM best practices in establishing the send and receive buffer sizes in the z/OS TCP/IP stack and in heeding the warnings from the z/OS Health Checker about an adequate buffer size.

8.2 TCP/IP configuration files

The following TCP/IP confirmation files are important for z/OS TCP/IP:

- `PROFILE.TCPIP`

  The `PROFILE.TCPIP` file contains TCP buffer sizes, LAN device definitions, server ports, home IP addresses, gateway and route statements, VTAM LUs for Telnet use, and so on. Buffers are dynamically allocated by the Communications Storage Manager (CSM) and are not specified in `PROFILE.TCPIP`.

- `FTP.DATA`

  The `FTP.DATA` file is used by the FTP server and FTP client to establish the initial configuration options. `FTP.DATA` contains items such as default DCB parameters for new data sets, the checkpoint interval, and so on.

- `TCPIP.DATA`

  `TCPIP.DATA` contains host name, domain origin, and name server definitions.

Suggestion: Keep the `TRACE RESOLVER` statement commented out to avoid complete tracing of all name server queries. This trace should be used for debugging purposes only.

8.2.1 MTU considerations

The maximum transmission unit (MTU) specifies the largest packet that TCP/IP transmits over a given interface. Be certain to specify a packet size explicitly instead of using DEFAULTSIZE. The DEFAULTSIZE produces a value of 576 bytes, which is unlikely to be optimal.

Every network consists of many components that must be carefully coordinated with each other. This requirement also applies to finding the parameter setting of the largest possible MTU size in your installation.

Table 8-2 provides an overview of the largest MTU sizes supported by various interfaces.

Table 8-2 Maximum MTU sizes of interfaces by link type

Link type	Connectivity	Maximum MTU size
Ethernet (DIX)	OSA-Express in QDIO mode, operated in 10/100 Mps speed	1492
Ethernet (DIX)	OSA-Express in QDIO mode, operated in 1000 Mps(1 Gbps), 10 Gbps speed	8992
Ethernet (DIX)	OSA-Express in Non-QDIO mode (LCS)	1500
802.3	Ethernet 802.3	1492
CTC	z/OS using CTC	65527
IPAQIDIO	HiperSockets	57344

The MTU size used for a given outbound frame depends on several values:

- interface_MTU

  This value is either a hardcoded size that is based on the physical device or a value that is obtained from the device during activation. For an active link or interface, TCP/IP reports the interface_MTU in the ActMtu field of the **`NETSTAT DEVLINKS -d`** command.

- configured_route_MTU

  This value is the MTU size configured for a route.

  – For static routes, specify `configured_route_MTU` on either a ROUTE statement in a BEGINROUTES block or on a GATEWAY statement in the TCP/IP profile.

  – For dynamic routes, the configured_route_MTU value comes from the value of the MTU keyword specified on the RIP_INTERFACE, OSPF_INTERFACE or INTERFACE statement for that interface in the OMPROUTE configuration file. If you do not specify an MTU for an interface, OMPROUTE uses 576.

- actual_route_MTU

  This value is the minimum of the interface_MTU and the configured_route_MTU. When path MTU discovery is not in effect, TCP/IP uses the actual_route_MTU to send outbound packets.

- path_MTU

  This value is the value that is determined by the path MTU discovery function. When path MTU discovery is in effect, TCP/IP uses path_MTU to send outbound packets. You can enable path MTU discovery for IPv4 using IPCONFIG PATHMTUDISCOVERY.

Path MTU discovery starts by setting path_MTU to the actual_route_MTU of the route. If packets require fragmentation to get to the final destination, path MTU discovery finds the path_MTU by repeatedly decreasing the value until it can send packets to the final destination without fragmentation. Figure 8-1 illustrates this function.

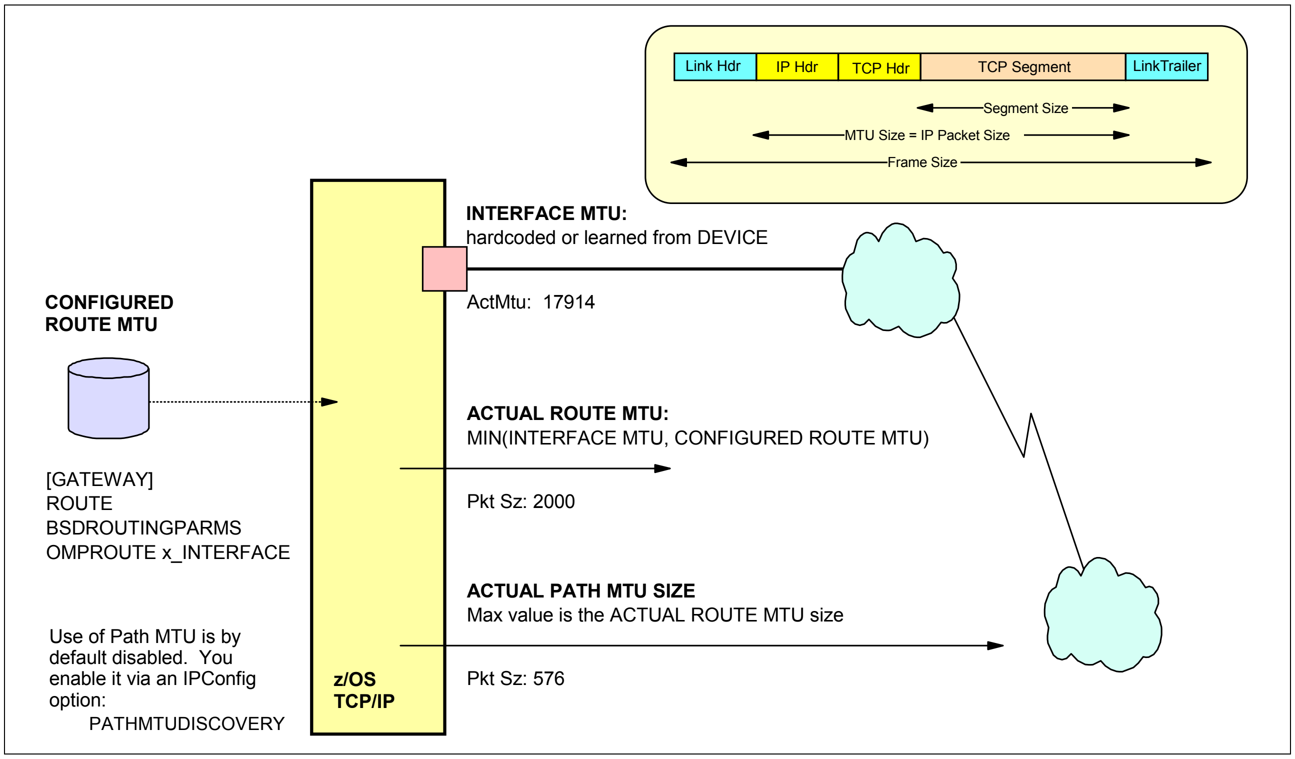


Figure 8-1 Large MTU sizes have a positive impact on file transfer type of workloads

Use the PMTU option with the **`ping`** command to determine where fragmentation is necessary in the network. The PMTU YES option differs from the PMTU IGNORE option in the way the ping completes its echo function. See *z/OS Communications Server: IP System Administrator's Commands*, SC27-3661 for a detailed discussion about the PMTU option.

Note the following guidelines:

- Enable path MTU discovery in configurations where traffic originating in the z/OS TCP/IP stack traverses multiple hops with different MTU sizes.
- When using OSA-Express Gigabit Ethernet (which supports an interface MTU of 8992), be aware that not all routers and switches support a value this large. Either ensure that all routers and switches in your configuration support 8992, or specify a lower configured_route_MTU.
- When using OMPROUTE, specify the MTU keyword for each IPv4 interface and configure all nodes on a LAN to use the same MTU value. Otherwise, you might encounter problems, such as OSPF adjacency errors.

The ping command detection of network MTU

You may use the **ping** command in z/OS Communications Server as a diagnostic tool to determine MTU and fragmentation problems in the network. Path MTU parameters are added to the TSO and z/OS UNIX versions of the command to prevent the outbound echo request packets from being fragmented and to specify the type of path MTU discovery support for the command.

Example 8-1 shows the output of the TSO command:

```
ping 10.1.1.240 (tcp tcpipa count 4 pmtu ignore length 4096
```

The command has the following values:

`count 4`:	Sets the number of echo requests that are sent to the host.
`pmtu ignore`:	Specifies that the outbound echo request packets are not fragmented at the local host or in the network, and that any MTU values determined by path MTU discovery for the destination are ignored.
`length 4096`:	Sets the number of data bytes for the echo request.

Example 8-1 Output of TSO command ping PMTU

```
CS V1R13: Pinging host 10.1.1.240
 Ping #1 needs fragmentation at: 10.1.3.12 (10.1.3.12)
   Next-hop MTU size is 1492
 Ping #2 needs fragmentation at: 10.1.3.12 (10.1.3.12)
   Next-hop MTU size is 1492
 Ping #3 needs fragmentation at: 10.1.3.12 (10.1.3.12)
   Next-hop MTU size is 1492
 Ping #4 needs fragmentation at: 10.1.3.12 (10.1.3.12)
   Next-hop MTU size is 1492
***
```

For more information about the **ping** command, see *z/OS Communications Server: IP System Administrator's Commands*, SC27-3661.

Path MTU discovery for Enterprise Extender

Path MTU discovery for Enterprise Extender (EE) enables VTAM to determine dynamically any MTU size changes that are associated with IPv4 and IPv6 EE connections in the IP network. VTAM can segment the HPR data to avoid IP packet fragmentation.

A VTAM start option, PMTUD, controls whether path MTU discovery is enabled for Enterprise Extender:

- When PMTUD=NO, VTAM disables path MTU discovery for IPv4 and IPv6 EE connections. VTAM only learns of local MTU changes associated with the first hop of the IP routes.
- When PMTUD=TCPVALUE, VTAM accepts the TCP/IP stack (associated with EE) setting. For IPv6 EE connections, path MTU discovery is enabled by default. For IPv4 EE connections, path MTU discovery is enabled when the PATHMTUDISCOVERY operand is coded on the IPCONFIG profile statement.

When VTAM detects the EE connection MTU size has changed during the transmission of an EE packet, the MTU size is altered. You can check the IST2029I message for the current MTU size by running **DISPLAY NET,EE,ID=name,LIST=DETAIL**, as shown in Example 8-2.

Example 8-2 Output of command D NET,EE,ID=name,DETAIL

```
D NET,EE,ID=EEPUCS04,DETAIL
IST097I DISPLAY ACCEPTED
IST350I DISPLAY TYPE = EE 392
IST2001I ENTERPRISE EXTENDER CONNECTION INFORMATION
IST075I NAME = EEPUCS04, TYPE = PU_T2.1
...
IST2030I PORT PRIORITY = SIGNAL
IST2029I   MTU SIZE =  1433                   1
...
IST2031I PORT PRIORITY = NETWORK
IST2029I   MTU SIZE =  1433
...
IST2032I PORT PRIORITY = HIGH
IST2029I   MTU SIZE =  972                     2
...
IST2033I PORT PRIORITY = MEDIUM
IST2029I   MTU SIZE =  972                     2
...
IST2034I PORT PRIORITY = LOW
IST2029I   MTU SIZE =  1433
IST314I END
```

In this example, the numbers correspond to the following information:

1. This MTU size has already been reduced to account for various header lengths, such as the IP, UDP, and LLC headers necessary for EE traffic.
2. EE learns of MTU changes only when HPR data is transmitted across each unique port. Because not all of the EE ports might be transmitting data simultaneously, you might see different MTU sizes for some of the EE ports.

Take into account the following implementation considerations:

- The learned path MTU is considered to be stale information every 20 minutes. By that time, the path MTU is reset to the first hop MTU size. The system experiences the same processing impact of learning the path MTU at 20 minutes intervals.
- A firewall must permit ICMP messages when *Path MTU Discovery* is enabled. Otherwise, an HPR transmission stall occurs if the path MTU is smaller than that of the “first hop” MTU size.

In Figure 8-2, HPR transmits a large packet base on the path MTU size, and the TCP/IP stack turns on the “do not fragment” bit in the IPv4 header **1**. When the packet arrives at the router with the smaller “next hop” MTU **2**, an ICMP is returned, and the packet is discarded **3**. If the firewall does not allow ICMP package, it drops the ICMP **4**. The TCP/IP stack and VTAM will not learn of the path MTU. It retransmits these large missing packets when the partner reports a packet gap. This process repeats indefinitely and causes the “transmission stall” with message IST2245I.

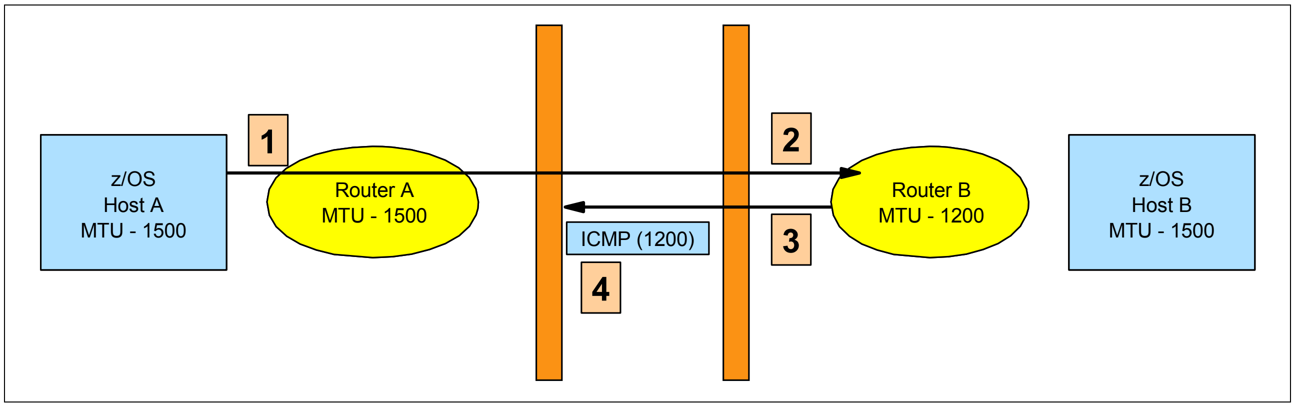


Figure 8-2 ICMP message blocked by firewall

For more information about the path MTU discovery for EE, see *z/OS Communications Server: SNA Network Implementation*, SC31-8777.

Note: We can also use an alternative solution to control Enterprise Extender’s MTU size by using the VTAM MTU operand in the switch major node’s PU statement, EE XCA major node’s GROUP statement (Connection Network only), or model major node’s PU statement. See *z/OS Communications Server: SNA Resource Definition*, SC31-8778.

8.2.2 OSA-Express adapter interruption

OSA-Express supports an inbound “blocking” (or packing) function over the QDIO interface. This function affects how long OSA-Express holds packets before presenting those packets to the host. In this case, “presenting” means assigning the read buffer to the host, which is a matter of updating the state of the host buffer to host owned. In most cases, this same action results in an interrupt to the host for this QDIO data device. Therefore, this function indirectly affects the QDIO interrupt processing.

The host can pass various time intervals to OSA when the QDIO data device is activated. In the z/OS case, the system administrator can adjust this setting. However, the setting is static and cannot be changed unless the connection to OSA-Express is terminated (device is stopped) and reestablished (restart the device).

In the TCP/IP profile, the user can define a LAN Idle setting for an OSA- Express2 port (in QDIO mode), which is performed by specifying the INBPERF parameter in the TCP/IP profile. INBPERF is an optional parameter indicating how frequently the adapter should interrupt the host for inbound traffic.

Four static settings are supported: DYNAMIC, MINCPU, MINLATENCY, and BALANCED.

The MINCPU, MINLATENCY, and BALANCED settings use static interrupt-timing values. The static values are not always optimal for all workload types or traffic patterns, and cannot account for changes in traffic patterns. DYNAMIC setting causes the TCP/IP stack to dynamically adjust the timer-interrupt value while the device is active and in use. This function relies an OSA-Express2 or OSA-Express3 function called Dynamic LAN idle.

The following static settings are valid subparameters of the INBPERF parameter:

- DYNAMIC

  This setting is effective only for OSA-Express2 or OSA-Express3. This setting causes the TCP/IP stack to dynamically signal the OSA-Express2/OSA-Express3 feature to change the timer-interrupt value, based on current inbound workload conditions.
- MINCPU

  This setting uses a static interrupt-timing value, selected to minimize TCP/IP stack interrupts without regard to throughput.
- MINLATENCY

  This setting uses a static interrupt-timing value, selected to minimize latency (delay), by more aggressively presenting received packets to the TCP/IP stack.
- BALANCED

  This setting uses a static interrupt-timing value, selected to achieve reasonably high throughput and reasonably low CPU consumption.

Note: BALANCED mode is the default value for the INBPERF statement.

The INBPERF parameter can be specified on the LINK or INTERFACE statement (Example 8-3).

Example 8-3 TCP/IP profile definition

```
INTERFACE OSA2080I
DEFINE IPAQENET
PORTNAME OSA2080
IPADDR 10.1.2.21/24
INBPERF DYNAMIC
MTU 1492
VLANID 10
VMAC
;
```

Example 8-4 displays the output of the following **TCPIP** command:

```
D TCPIP,TCPIPC,NETSTAT,DEV
```

Example 8-4 Output of display netstat command

```
INTFNAME: OSA2080I         INTFTYPE: IPAQENET   INTFSTATUS: READY
    PORTNAME: OSA2080   DATAPATH: 2082     DATAPATHSTATUS: READY
    SPEED: 0000001000
    IPBROADCASTCAPABILITY: NO
    VMACADDR: 020019749925   VMACORIGIN: OSA    VMACROUTER: ALL
    ARPOFFLOAD: YES                  ARPOFFLOADINFO: YES
    CFGMTU: 1492                     ACTMTU: 1492
    IPADDR: 10.1.2.31/24
    VLANID: 10                       VLANPRIORITY: DISABLED
    DYNVLANREGCFG: NO                DYNVLANREGCAP: YES
    READSTORAGE: GLOBAL (4096K)      INBPERF: DYNAMIC
    CHECKSUMOFFLOAD: YES
    SECCLASS: 255                    MONSYSPLEX: NO
  MULTICAST SPECIFIC:
    MULTICAST CAPABILITY: YES
    GROUP            REFCNT        SRCFLTMD
    -----            ------        --------
      224.0.0.1        0000000001    EXCLUDE
        SRCADDR: NONE
    INTERFACE STATISTICS:
      BYTESIN                          = 0
      INBOUND PACKETS                  = 0
      INBOUND PACKETS IN ERROR         = 0
      INBOUND PACKETS DISCARDED        = 0
      INBOUND PACKETS WITH NO PROTOCOL  = 0
      BYTESOUT                         = 420
      OUTBOUND PACKETS                 = 5
      OUTBOUND PACKETS IN ERROR        = 0
      OUTBOUND PACKETS DISCARDED       = 0
```

Note: When specified for an OSA device that does not support this function, the BALANCED option is used for the INBPERF parameter.

For detailed information about this topic, see *z/OS Communications Server: IP Configuration Reference*, SC27-3651.

8.2.3 Tracing

From a performance perspective, you need to disable all tracing because tracing activity can have a significant impact on system performance.

To disable tracing, include the following line in the `TCPIP.PROFILE` file:

```
ITRACE OFF
```

To turn off **ctrace** for TCP/IP, issue the following command:

```
TRACE  CT,OFF,COMP=SYSTCPIP,SUB=(tcp_proc_name)
```

If you want to use tracing, use the appropriate parameters on the ITRACE statement. For example, to trace the configuration component, specify the ITRACE parameters as follows:

```
ITRACE ON CONFIG 1
```

In this ITRACE command, `CONFIG 1` specifies tracing level 1 for the configuration component. See *z/OS Communications Server: IP Configuration Reference*, SC27-3651, for more information about ITRACE.

8.3 z/OS UNIX System Services tuning

The *z/OS UNIX System Services Planning*, GA22-7800 publication provides useful tuning information. Note the following information:

- Be certain that the UNIXMAP RACF class is populated and cached.
- Update the `PROFILE.TCPIP`, `TCPIP.DATA`, and `FTP.DATA` files with the applicable recommendations discussed in this chapter.
- Estimate how many z/OS UNIX users, processes, PTYs, sockets, and threads are needed, and update the appropriate BPXPRMxx members in PARMLIB. These parameters include MAXPROCSYS, MAXPROCUSER, MAXUIDS, MAXFILEPROC, MAXPTYS, MAXTHREADTASKS, and MAXTHREADS.
- Set MAXSOCKETS(n) to a high number to avoid a shortage.

  As an example, each z/OS UNIX Telnet session requires one z/OS UNIX socket, and each FTP session requires one z/OS UNIX socket. After the MAXSOCKETS limit is reached, no more Telnet, FTP sessions, or other applications that require z/OS UNIX sockets are allowed to start.
- Optimize HFS and zFS usage. In general, zFS provides better performance. If usage exceeds cache usage, consider spreading HFS and zFS data sets over more DASD volumes. Consider whether shared (multiple LPAR) usage is needed, because this adds functionality (sharing), but with some performance expense. (Information about file system tuning is beyond the scope of this book.)
- Monitor z/OS UNIX resources usage with RMF or system commands (**`DISPLAY ACTIVE`**, **`DISPLAY OMVS`**, and so on).

8.4 Storage requirements

For a system with significant network activity, estimate the storage requirements for CSM, CSA, and SQA. We provide storage usage summaries for typical applications, such as Telnet, FTP, a CICS socket, and a web server, which can serve as a starting point for estimating CSA, SQA, and CSM storage requirements for these and other applications.

8.4.1 TCP and UDP buffer sizes

When send/receive buffer sizes are not specified in the PROFILE, a default size of 16 KB is used for send/receive buffers and a default of 32 KB is used for the TCP window size. If send/receive buffer sizes are specified, they are used as specified and the TCP window size is set to twice the TCP receive buffer size, up to the maximum TCPMAXRCVBUFSIZE value (the default is 256 KB).

You can specify the send/receive buffer sizes on the TCPCONFIG and UDPCONFIG statements, as shown in Example 8-5.

Example 8-5 Send/receive buffer sizes definition

```
TCPCONFIG   TCPSENDBFRSIZE    65535
            TCPRCVBUFRSIZE    65535
UDPCONFIG   UDPSENDBFRSIZE    65535
            UDPRCVBUFRSIZE    65535
```

Socket applications can override these values for a specific socket using the `setsockopt` call:

```
setsockopt(SO_SNDBUF)
setsockopt(SO_RCVBUF)
```

Note: The FTP server and client applications override the default settings and use 180 KB for send/receive buffers.

If the TCPMAXRCVBUFRSIZE parameter is used in the TCP/IP profile, ensure that the value specified is 180 KB or greater. If the value specified is lower than 180 KB, FTP will be limited to the TCPMAXRCVBUFRSIZE value for the receive buffer.

TCP throughput for high-latency networks

Streaming workload over large bandwidth and high latency networks (such as satellite links) is in general constrained by the TCP window size. However, it takes time to send data over such a network. At any given point in time, data that fills the full window size is “in transit” and cannot be acknowledged until it arrives at the receiver. The sender can send data up to the window size and then must wait for an ACK to advance the window size before the next chunk of data can be sent.

If the possibility existed to dynamically adjust the window size to the amount necessary to fill the network between sender and receiver, higher throughput might be achieved.

To help improve performance for inbound streaming workloads over networks with large bandwidth delay, z/OS Communications Server implements Dynamic Right Sizing (DRS). The DRS function keeps the pipe full for inbound streaming TCP connections over networks with a large capacity and high latency and prevents the sender from being constrained by the receiver’s advertised window size. This function improves performance for inbound streaming workloads over such networks. The stack enables this function automatically with no configuration needed.

How DRS works

The stack automatically detects which TCP connections might benefit from dynamic right sizing. Specifically, the stack looks for a high latency inbound streaming TCP connection that is using a receive buffer size of at least 64 KB. For such a connection, the stack attempts to not constrain the sender by increasing the receive buffer size for the connection, which in turn causes the stack to adjust the advertised receive window (up to a max of 2 MB). Note that the intent of DRS is not to buffer 2 MB of data. Instead, the idea is to advertise *up to that size* to allow more data to be in the pipe so the sender can keep the pipe full.

In reality, DRS, on the receiver side, adjusts dynamically the window size upward (beyond 180 KB if needed) in an attempt to fill the pipe between the sender and the receiver. The aim is that as soon as the sender has sent the end of its window, the sender receives an ACK from the receiver. That ACK allows the sender to advance the window and send another chunk of data onto the network.

If the stack detects evidence that the application is not keeping up by reading the data fast enough, then the stack disables DRS for that connection and resets the receive buffer to its original size.

Receive buffer size: This function allows the stack to grow the TCP receive buffer size up to 2 MB for certain inbound streaming TCP connections, regardless of the value specified with the TCPMAXRCVBUFRSIZE parameter on the TCPCONFIG statement. Applications can request a TCP receive buffer size on the SO_RCVBUF socket option on SETSOCKOPT(). This function does not take effect for applications that request a size smaller than 64 KB on this socket option. The TCPRCVBUFRSIZE parameter on TCPCONFIG defines the default receive buffer size for applications that do not use this socket option. Thus, if this value is less than 64 KB, then this function does not take effect for applications that do not use this socket option.

Activation and verification

DRS is activated automatically. You need not do anything to activate it. You can use the **`netstat ALL/-A`** command to see if the stack is using the dynamic right sizing function for a specific TCP connection, as shown in Example 8-6.

Example 8-6 UNIX netstat -A command display

```
CS01 @ SC30:/u/cs01>netstat -p TCPIPC -A
MVS TCP/IP NETSTAT CS V1R13    TCPIP Name: TCPIPC       13:23:08
...
ReXmt:              0000000000      ReXmtCount:         0000000000
DupACKs:            0000000001      RcvWnd:             0002097151   1
SockOpt:            A500            TcpTimer:           00
TcpSig:             01              TcpSel:             C0
TcpDet:             C0              TcpPol:             00
TcpPrf:             F0    2
QOSPolicy:          No
RoutingPolicy:      No
ReceiveBufferSize:  0002097151    3 SendBufferSize:    0000184320
```

In this example, the numbers correspond to the following information:

1. The RcvWnd field shows the receive window size that is currently being advertised.
2. The TcpPrf field shows that the DRS function is active for this connection because the x40 bit (11110000) in the TcpPrf byte is *on*.
3. The ReceiveBufferSize field shows the receive buffer size currently in effect (which might be because of an adjustment made by the DRS function).

8.4.2 Communications Storage Manager use of storage

Communications Storage Manager (CSM) storage consists of the buffer pools that are shared between SNA and TCP/IP for each z/OS system image. Use at least the default (120 MB) unless you are storage-constrained and need to reduce the size of your estimated usage (CSM has always adjusted the requested maximum ECSA value when it exceeds 90% of the ECSA available on the z/OS system).

Migration tip: z/OS Communications Server now uses CSM more than the previous releases because SCBs have been moved to 64-bit common storage to reduce ECSA usage. Nevertheless, keep in mind that the capacity planning workloads used to derive the numbers in the CSM usage table drive the system much harder than is likely to be the case in a customer shop. Therefore, continue to use common migration techniques of capturing CSM usage pre- and post-migration to determine whether you need to adjust the `hlq.PARMLIB(IVTPRM0)` values on the new system.

Table 8-3 summarizes CSM storage usage based on an internal performance benchmark. This table provides a starting point for tuning.

Table 8-3 z/OS CSM usage table

Application	**Number of users or clients**	**Workload**	**Maximum CSM (ECSA)**	**Maximum CSM (DataSpace)**	**Maximum CSM (FIXED)**
CICS Sockets (IBM z10™, transaction = 200/200)	50 250 500 1000	98.9 Trans/Sec 495.5 989.7 1975.6	780 KB 1.02 MB 1.06 1.00	24.38 MB 30.49 24.54 24.47	32.44 MB 38.44 32.44 32.44
TN3270 (z10, with Think Time, Echo transactions, transaction = 100/800)	8000 16000 32000 64000 128000 256000	266.6 Trans/Sec 533.0 1066.2 2131.1 4255.1 8368.8	900 KB 2.82 MB 2.85 1.18 3.18 7.53	31.60 MB 54.38 54.72 35.86 61.45 63.44	63.56 MB 85.35 85.35 31.90 57.11 84.75
FTP Inbound Data (z10, with and without Think Time, transaction = 2 MB/1)	1 (Binary Put) 2 4 8 16 32 64 128 128 (no TT[a])	1.38 MBps 2.75 5.50 10.99 21.95 43.79 87.41 164.90 311.58	884 KB 776 800 820 904 800 996 1.18 MB 1.43	32.61 MB 30.24 30.41 31.18 31.55 32.34 34.71 41.01 69.70	41.12 MB 39.96 40.76 41.12 41.16 41.16 42.14 49.52 74.16
FTP Outbound Data (z10, with and without Think Time, transaction = 1/2 MB)	1 (Binary Get) 2 4 8 16 32 64 128 128 (no TT)	1.36 MBps 2.72 5.44 10.83 21.67 43.40 86.09 158.55 239.11	816 KB 1.16 MB 856 KB 1.55 MB 1.96 1.24 2.18 7.94 25.50	30.44 MB 30.40 30.68 31.84 31.95 32.06 33.44 32.38 33.90	39.96 MB 39.96 40.72 42.10 41.88 41.12 41.62 49.00 90.18

a. Think Time (TT)

If you use the maximum values from these four workloads, we suggest the following definitions in the IVTPRM00 member of PARMLIB:

- FIXED MAX(433M), which includes 288.5 MB (38.84 + 85.35 + 74.16 + 90.18 MB) for the four workloads plus 144 MB (or 50%) of additional storage for expected growth in the workloads.
- ECSA MAX(54M), which includes 35.5 MB (1.06 + 7.53 + 1.43 + 25.50 MB) for the four workloads plus 18 MB (or 50%) of additional storage for expected growth in the workloads.
- FIXED MAX and ECSA MAX usage should be monitored and adjusted based on one’s workload.

With a different application mix, CSM requirements might change. You can monitor CSM and VTAM buffer usage using the following commands:

```
D NET,BFRUSE,BUFFER=SHORT
D NET,STORUSE
D NET,CSM
D NET,CSM,ownerid=all
```

To temporarily change the amount of storage used by CSM, use the following command and specify the parameters you want to change on the ECSA and FIXED operands:

```
F procname,CSM,ECSA=maxecsa,FIXED=maxfix
```

To permanently change the amount of storage used by CSM or tuning parameters for CSM buffer pools, edit the IVTPRM00 member and issue the command without specifying any operands.

Note: Changing a parameter that decreases the specification of a limit might not take effect immediately. Reducing the usage of the resource to comply to the new limit might require users to free buffers to contract a storage pool's size. This type of change could also result in a CSM constraint condition being indicated to users who are monitoring CSM resource usage.

In z/OS Communications Server, CSM issues `IVT559*I` messages (found in the system log) to indicate its “water level.” Table 8-4 lists some useful CSM messages.

Table 8-4 CSM useful messages

Message number	When issued
IVT5590I	► At CSM initialization time when the ECSA MAX value in IVTPRM00 is larger than 90% of the ECSA available on the system. ► During **`DISPLAY CSM`** command processing when the ECSA value in effect has been adjusted by CSM. ► During **`MODIFY CSM`** command processing when the maximum ECSA requested is larger than 90% of the ECSA available on the system.
IVT5591I	**`MODIFY CSM`** command processing when the maximum ECSA requested is larger than 90% of the ECSA available on the system.
IVT5592I	Fixed storage usage is above 80% of the MAX FIXED value, approaching 85% of the MAX FIXED value.
IVT5564I	Current ECSA storage usage goes below 80% of the MAX ECSA value.
IVT5565I	Current fixed storage usage goes below 80% of the MAX FIXED value.

CSM activates the Dynamic CSM Monitor function in the following situations:

- When current ECSA storage usage reaches 80% or higher of the MAX ECSA value or the current fixed storage usage reaches 80% or higher of the MAX FIXED value.
- When current ECSA storage usage goes below 75% of the MAX ECSA value and the current fixed storage usage goes below 75% of the MAX FIXED value.

The following command changes the CSM Monitor function:

```
F procname,CSM,MONITOR=DYNAMIC|YES|NO
```

CSM usage can be specific to a z/OS Communications Server release. Therefore, review the performance summary reports based on your release level. You can find the reports at the following address:

http://www.ibm.com/support/docview.wss?rs=852&context=SSSN3L&dc=DA480&uid=swg27005524

8.4.3 VTAM buffer settings

Typically, VTAM buffers are important for TN3270 workload. For a large number of Telnet (TN3270) sessions, we suggest that you change the default VTAM buffer settings for IOBUF, LFBUF, CRPLBUF, TIBUF, and CRA4BUF. Table 8-5 provides guidelines for initial settings.

Table 8-5 z/OS VTAM buffer usage table

Application	Number of users/clients	Workload throughput (transactions per second)	VTAM buffer (IO00)	VTAM buffer (LF00)	VTAM buffer (CRPL)	VTAM buffer (TI00)	VTAM buffer (CRA4)
CICS Sockets (z10, transaction = 200/200)	50	98.9	5	5	54	21	3
	250	495.5	5	5	54	21	4
	500	990.1	5	5	54	21	4
	1000	1978.6	5	5	54	21	4
TN3270 (z10, with Think Time, Echo transactions, transaction = 100/800)	8000	266.6	201	8004	1636	459	11
	16000	533.0	201	16004	1636	459	19
	32000	1066.2	358	32004	1636	473	19
	64000	2131.1	663	64004	1636	727	28
	128000	4255.1	2256	128004	1636	2457	59
	256000	8363.8	2256	256004	1636	2457	128
FTP Inbound Data (z10, with and without Think Time, transaction = 2 MB/1)	1 (Binary Put)	1.38	5	4	2	28	4
	2	2.75	5	4	2	28	4
	4	5.50	5	4	2	28	4
	8	10.99	5	4	2	28	4
	16	21.95	5	4	2	28	4
	32	43.79	5	4	2	28	4
	64	87.41	5	4	2	28	4
	128	164.90	5	4	2	28	4
	128 (no TT)	311.58	5	4	2	28	4
FTP Outbound Data (z10, with Think Time transaction = 1/2 MB)	1 (Binary Get)	1.36	4	4	2	28	4
	2	2.72	5	4	2	28	4
	4	5.44	5	4	2	28	4
	8	10.83	5	4	2	28	4
	16	21.67	5	4	2	28	4
	32	43.40	5	4	2	28	4
	64	86.09	5	4	2	28	4
	128	158.55	5	4	2	28	4
	128 (no TT)	239.11	5			28	4

The same commands used previously can help verify the settings:

```
D NET,BFRUSE,BUFFER=SHORT
D NET,STORUSE
Telnet (TN3270) storage utilization
```

You can check Telnet storage utilization using the normal RMF monitor functions to see the storage usage in the Telnet address space.

8.5 Application performance and capacity

This section includes tips on capacity planning and performance for Telnet and FTP.

8.5.1 Telnet (TN3270) capacity planning

A key element in determining capacity is to determine the CPU cost of performing a transaction of interest on a specific machine type. For example, we use a TN3270 workload in which 100 bytes of data is sent from the client to an echo application and 800 bytes of data is sent by the application as a reply to the client. From our benchmarks, we derive the CPU cost in terms of milliseconds per TN3270 transaction using an IBM System z196 2817-M32 (3-CP LPAR).

For example, if we want to determine the capacity needed for 8000 users, each performing six of these transactions per user per minute on an IBM System z196 2817-M32 (3-CP LPAR), we can use the formula shown in Figure 8-3. The key factor in this formula is .000157 CPU-seconds per transaction.

```
  # trans/user  x # users x CPU secs/tran      CPU secs
  ---------------------------------------   =  ---------
             # of Elap secs                    Elap secs

 Example:   z/OS V1R7 IP,  8000 users,   6 tr/min/user

  6 tr/u x 8000u x 0.000157 CPU secs/tr           cpu sec
  ------------------------------------- =  0.126--------
            60  elap. sec                           elap sec
```

Figure 8-3 TN3270 CPU requirements

If the CPU secs/Elap sec ratio is greater than 1, then more than one CPU processor would be required. This is a simplistic approach, of course, and must be used with care. For example, the application involved (our echo program) performed no I/O, used no data sets, and did little processing. This is not a realistic workload, but it can provide a starting point for capacity planning for TN3270 sessions.

Assuming we recognize the limitations of these calculations, we can calculate the percentage use of the processing power (three CPs) available to the LPAR, as shown in Figure 8-4.

```
CPU secs/Elap Sec
-----------------  *  100 %   =  CPU Util %
 # of processors

# of processors:  3 ( This will be equal to number of
                  390 processors used for the LPAR)

Example:   Therefore, Percentage of CPU utilization on three CP
LPAR to drive 6 tran/user/minute for 8000 users will be


0.126 CPU secs/Elap sec
-----------------------  *  100 %  =  4.2 %
```

Figure 8-4 TN3270 CPU utilization

8.5.2 FTP tuning

The FTP.DATA file is used by the FTP server and client to establish the initial configuration options for an FTP session. The search order for FTP.DATA varies, depending on the execution environment. For a detailed description of the search order, see *z/OS Communications Server: IP Configuration Reference*, SC27-3651.

Sample specifications in FTP.DATA include the following parameters:

```
PRIMARY   15
SECONDARY 20
LRECL     64
BLKSIZE   27968
RECFM     FB
CHKPTINT  0
DIRECTORY 27
SQLCOL    ANY
INACTIVE  0
```

z/OS data set attributes play a significant role in FTP performance. Normal z/OS advice is relevant. This means using half-track blocking. If large volumes of FTP data are expected, then the normal advice about the use of multiple channels, disk control units, and disk volumes becomes important. For best performance, define CHKPTINT = 0.

Note that several parameters can be changed during an FTP session by using the SITE or LOCSITE user commands.

The use of preallocated data sets for FTP transfers to z/OS is usually recommended. If new data set allocations are required, then using BLKSIZE=0 usually allows the system to determine the best block size.

8.5.3 FTP capacity planning

Our methodology for estimating FTP capacity planning is similar to our Telnet methodology. In this case, the key factor is the capacity needed to transfer 1 KB of data. In our environment, we found this to be .00000656 CPU-seconds per KB, which varies for separate processors. Our measurement includes TCP/IP, VTAM, and FTP address space usage, using a OSA-Express Gigabit Ethernet port as a network gateway (2-CP LPAR).

Our total (TCP/IP + VTAM + FTP) CPU requirements for FTP transfer are given by the formula shown in Figure 8-5. Our formula and key factor are probably more realistic for FTP than the equivalent numbers were for TN3270 because there are fewer additional factors involved in FTP usage.

```
Max KB         CPU  secs       CPU secs
---------   *  ---------   =  ----------
Elap secs         KB          Elap  secs
```

Figure 8-5 General formula to calculate FTP CPU requirements

Consider a load of 69529.6 KBps for transferring data from client workstations to our z990 (using eight parallel binary PUT operations) doing eight 20 MB file transfers; the results are shown in Figure 8-6.

```
  69529.6 KB       .00000656            .456 CPU secs
  ---------   *  ------------   =        ----------
  Elap secs         KB                     Elap  secs
```

Figure 8-6 Formula to calculate FTP CPU requirements

If the `CPU secs/Elap Sec` ratio is 1 or greater, we need more than one processor capacity to drive the desired throughput. The percentage of system capacity is obtained as shown in Figure 8-7.

```
  CPU secs/Elap Sec
  -----------------  *  100 %  =  CPU Util %
   # of processors

  # of processors:  4 ( This will be equal to number of
                    390 processors used for the LPAR)

 Example: For our example we are using z990 / 2084-332 2 processor
 LPAR.  Therefore, Total CPU utilization will be


  0.456 CPU secs/Elap sec
  -----------------------   *   100 %   = 22.8 %
       2 processor
```

Figure 8-7 FTP CPU requirements example

Thus, the total z/OS CPU (TCP/IP + VTAM + FTP) requirements for driving 69,529 KBps throughput would require an average CPU utilization of 22.8% of a 2-processor z196 (2817-M32, two-CP LPAR).

8.6 z/OS Communications Server TCP/IP performance highlights

Every release update of z/OS Communications Server delivers a number of improvements that are related to TCP/IP performance. The following list provides an overview of the enhancements in this release:

- Improvements to Application Transparent Transport Layer Security (AT-TLS) performance
- Performance improvement for fast local sockets (the feature is called faster local sockets)

Several of these enhancements are described in this general chapter on performance and tuning. Other enhancements are described elsewhere when it makes sense to present them in the context of the application or TCP/IP function that is directly affected by the performance improvement.

Consult the following resources for more details about performance improvements that we do not describe in this chapter:

- *z/OS Communications Server: IP Configuration Guide*, SC27-3650
- *z/OS Communications Server: IP Configuration Reference*, SC27-3651
- *z/OS Communications Server: SNA Network Implementation*, SC31-8777
- *IBM z/OS V2R1 Communications Server TCP/IP Implementation Volume 1: Base Functions, Connectivity, and Routing*, SG24-8096
- *IBM z/OS V2R1 Communications Server TCP/IP Implementation Volume 2: Standard Applications*, SG24-8097
- *IBM z/OS V2R1 Communications Server TCP/IP Implementation Volume 4: Security and Policy-Based Networking*, SG24-8099

8.6.1 Detailed information about selected performance enhancements

This section describes enhancements that affect the operations of the TCP/IP stack. As noted, many other performance enhancements are presented in chapters that describe individual TCP/IP implementations and applications; review those chapters for more information.

TCP throughput improvements for high-latency networks

z/OS Communications Server improves performance for inbound streaming TCP connections over networks with large bandwidth and high latency by automatically tuning the ideal window size for such TCP connections.

Virtual storage constraint relief

The single most important ECSA relief comes from moving the socket control blocks (SCB) out of ECSA and into 64-bit common storage.

Each data area that maps a socket, called *socket control blocks* (SCB), requires roughly 384 bytes of ECSA common storage. Needing a large number of socket connections results in a substantial amount of storage being used. ECSA virtual storage is a limited resource and the maximum amount allowed is 2,031 MB, and using 64-bit common storage, this limit goes from 2 GB to a maximum size of 1 TB. For example, a customer who is supporting a large number of TN3270 connections might experience a need for a substantial amount of this storage.

The 64-bit Common Area size can be specified using the HVCOMMON keyword in IEASYSxx or with a system parameter.

Handling storage congestion on TCP data queues

The TCP layer maintains data queues for each connection that is established. The receive queue holds in-order data that is received at the TCP layer from the remote stack but that is not yet read by the local application. The out-of-order queue holds out-of-order data that is received at the TCP layer. The send queue holds data that is sent by the local application but is not yet sent by the TCP layer to the remote stack or is not yet acknowledged by the remote stack. An application that is not reading the data that it is sent causes data to remain on the receive queue of its local TCP layer. In addition, after the receive queue of the local TCP layer is full, data remains on the send queue of the remote TCP layer.

When data is added to the send queue for a local connection (that is, for a connection with both endpoints on *the same* TCP/IP stack), the storage that is obtained to hold the data is marked as *pageable* storage. (Formerly the storage was fixed and non-pageable.) This pageable storage keeps TCP from holding fixed storage for data on the send queue for a local connection.

When new data is added to the send queue for a non-local connection (that is, a connection with endpoints on *separate* TCP/IP stacks), TCP determines whether the application is not making progress or whether fixed storage is constrained. If either is true, the storage obtained to hold the data is marked as pageable storage. This pageable storage keeps TCP from holding a large amount of fixed storage for data on the send queue of an application that is not making progress. Also, when fixed storage is constrained, it keeps TCP from requesting additional fixed storage for the send queues of all applications.

When fixed storage becomes constrained, all non-local TCP connections are checked for unsent data on the send queue. Storage holding any unsent data is marked as pageable storage, which helps to resolve the fixed storage constrained state.

Because the Data Link Control (DLC) needs the data it receives in fixed storage, data that TCP marks as pageable is changed back to "fixed" before it is passed to the DLC for transmission.

Determining which TCP connections have old data on the queues can be difficult if you have to issue multiple **netstat** commands to determine which connections are affected. However, alerts are now issued to syslogd using TRMD to advise you of the connections suffering from storage constraints. Alerts are issued when a TCP data queue enters a constrained state, indicating that there is old data on the queue. Alerts are also issued when the queue later exits a constrained state. All alerts include the information necessary to identify the connection.

Note: Both syslogd and TRMD must be started for the constraint messages to be recorded.

Two thresholds are used to indicate old data on a TCP data queue:

- When the quantity of data on the queue equals the queue buffer size and the oldest data on the queue is at least 30 seconds old.
- When there is any amount of data on the queue and the oldest data on the queue is at least 60 seconds old.

An alert is issued when a queue enters or exits a constrained state. Example 8-7 shows the text of the alerts that can be issued to indicate this constraint situation.

Example 8-7 Storage constraint alerts if SYSLOGD and TRMD are running

```
EZZ8662I TRMD TCP receive queue constrained entry 1 logged: date time , connid=
connid , jobname= jobname , lipaddr= lipaddr , lport= lport , ripaddr= ripaddr ,
rport= rport ,correlator= correlator 3, probeid= probeid , sensorhostname=
sensorhostname , trigger= trigger , dataage= dataage , bytesqueued= bytesqueued ,
queuesize= queuesize

EZZ8663I TRMD TCP receive queue constrained exit 2 logged: date time , connid=
connid , jobname= jobname , lipaddr= lipaddr , lport= lport , ripaddr= ripaddr ,
rport= rport ,correlator= correlator 3, duration= duration , probeid= probeid ,
sensorhostname= sensorhostname , dataage= dataage , bytesqueued= bytesqueued ,
queuesize= queuesize

EZZ8664I TRMD TCP send queue constrained entry logged: date time , connid= connid
,jobname= jobname , lipaddr= lipaddr , lport= lport , ripaddr= ripaddr , rport=
rport ,correlator= correlator , probeid= probeid , sensorhostname= sensorhostname
, trigger= trigger , dataage= dataage , bytesqueued= bytesqueued , queuesize=
queuesize

EZZ8665I TRMD TCP send queue constrained exit logged: date time , connid= connid
,jobname= jobname , lipaddr= lipaddr , lport= lport , ripaddr= ripaddr , rport=
rport ,correlator= correlator , duration= duration , probeid= probeid ,
sensorhostname= sensorhostname , dataage= dataage , bytesqueued= bytesqueued ,
queuesize= queuesize

EZZ8666I TRMD TCP out-of-order queue constrained entry logged: date time connid=
connid jobname= jobname lipaddr= lipaddr lport= lport ripaddr= ripaddr rport=
rport trigger= trigger dataage= dataage bytesqueued= bytesqueued queuesize=
queuesize correlator= correlator probeid= probeid sensorhostname= sensorhostname

EZZ8667I TRMD TCP out-of-order queue constrained exit logged: date time connid=
connid jobname= jobname lipaddr= lipaddr lport= lport ripaddr= ripaddr rport=
rport dataage= dataage bytesqueued= bytesqueued queuesize= queuesize correlator=
correlator duration= duration probeid= probeid sensorhostname= sensorhostname
```

Messages EZZ8662I and EZZ8663I are issued respectively for constraints and constraint relief on the receive queues. EZZ8662I is issued when the constraint is entered (1) and EZZ8663I is issued when the connection exits (2) from the constraint. The correlator field in the messages (3) identifies which entry and exit alerts are pairs for the same connection.

An entry message with no corresponding exit message is an indication of a queue that is still in a constrained state.

You can configure an Intrusion Detection Services (IDS) policy that will give you some control over the handling of storage constraints on TCP data queues. Using policy, you can do the following tasks:

- Specify the amount of data that must remain on a queue for at least thirty seconds before the queue will become constrained.
- Provide a list of remote IP addresses, and optionally ports, that are to be excluded when monitoring for constraints on TCP send queues.

- Indicate whether you want alerts to be issued when constrained state is entered and exited for a queue.
- Request that a TCP connection be reset when constrained state is detected for any of its data queues.

For detailed information about configuring this IDS policy, see the TCP Queue Size IDS attack type in *z/OS Communications Server: IP Configuration Guide*, SC27-3650, and *z/OS Communications Server: IP Configuration Reference*, SC27-3651.

Throttling service request blocks for the device drivers

Although multiprocessing of inbound QDIO is necessary, allowing an unchecked number of threads to run is unacceptable. Therefore, the TCP/IP stack limits the number of execution threads allowed to process inbound QDIO data. For 1 Gb Ethernet, there is a maximum of four execution threads per QDIO data device; for 10 Gb Ethernet, the maximum number of execution treads per QDIO data device is represented by the following formula:

```
Min(LPAR CPUs + 1, 4) * 2
```

The number of service request blocks (SRBs) on the available queue is hard coded internally and cannot be tailored.

Discarding inbound packets to the device drivers

To avoid storage constraints in ECSA and CSM used to hold inbound data, the stack can start discarding packets. On a Gigabit Ethernet device, the stack imposes a limit of 2 MB of storage if CSM is critical or constrained. If there is no congestion, then the limit is 4 MB. On a 10 Gb Ethernet or HiperSockets device, the stack imposes a limit of 4 MB if CSM has reached a critical or constrained stage. It imposes a 6 MB limit if CSM is not critical or not constrained.

If a congestion situation is encountered, the operator is notified with an unsolicited message, as shown in Example 8-8. The message remains on the console until either cancelled by the operator or cancelled automatically by the stack after congestion is relieved.

Example 8-8 Unsolicited console message IST2273 for read queue congestion

```
IST2273E PACKETS DISCARDED FOR jobname - READ QUEUE CONGESTION
```

The response to the command to display `TRLE (D NET,TRL,TRLE=<trlename>)` can contain a message that includes the count of SBALs of 64 KB that are discarded. See **1** in Example 8-9.

Example 8-9 Solicited message IST2305 to indicate discarded packets

```
D NET,TRL,TRLE=TRL001

IST2305I NUMBER OF DISCARDED INBOUND READ BUFFERS = sbalcnt 1
```

The alternative command, **`D NET,E,ID=<trlename>`**, can also produce message IST2305I.

Each SBAL represents a container of packets that have been discarded.

Improvements to AT-TLS performance

AT-TLS improvement provides reduced CPU usage when encrypting and decrypting application data, and system SSL also provides a new API that can access data space storage and encrypt/decrypt directly into the storage. Figure 8-8 illustrates the system SSL improvement:

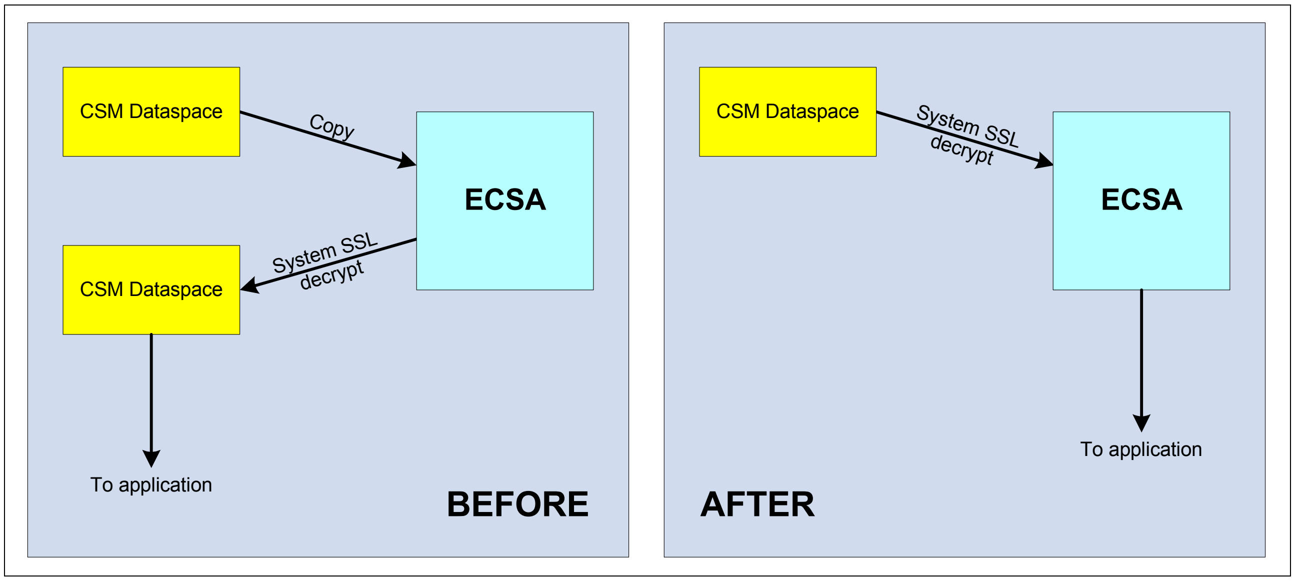
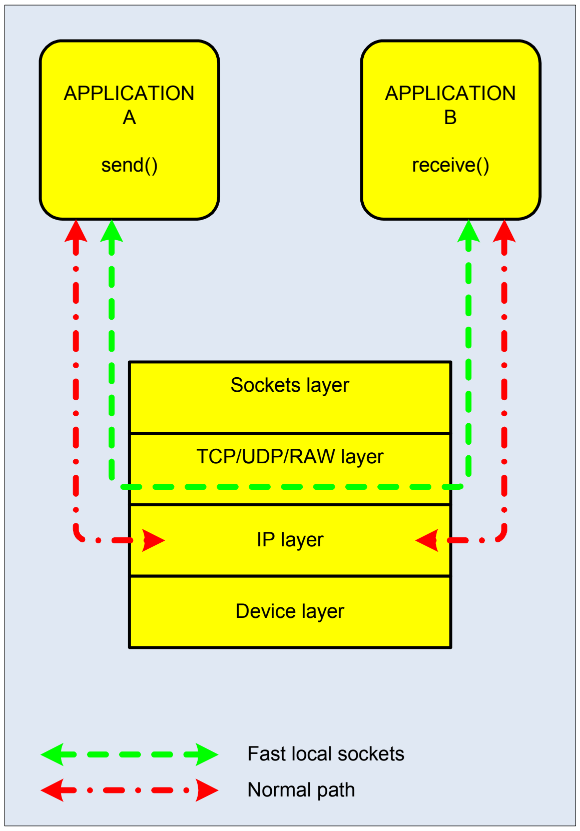


Figure 8-8 AT-TLS encrypt/decrypt performance improvement

Performance measurement shows significant improvement in the number of transactions per second when the processor is fully utilized.

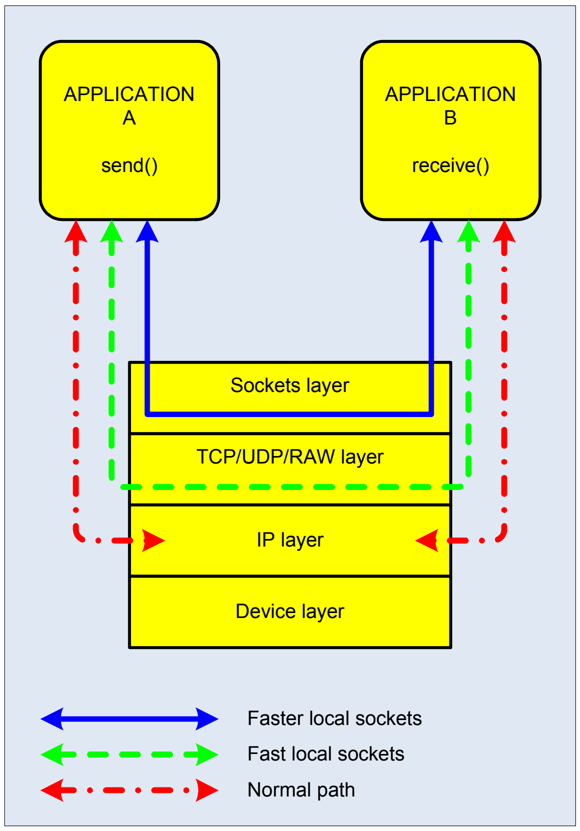
Fast local sockets and faster local sockets

z/OS Communications Server optimizes TCP/IP communication a step further by implementing features called *fast local sockets* and *faster local sockets*, and these features are automatically enabled on the system. Figure 8-9 and Figure 8-10 on page 316 give a short explanation of how it works.



When application A is sending data to application B, the z/OS Communication Server checks whether the connection endpoints are on the same TCP/IP stack. If they are on the same stack, the system bypasses the network layer (IP) and sends the data directly through the transport layer (TCP/UDP/RAW). This action saves a small amount of processing time for every single packet, thus producing better TCP/IP communication performance.

Figure 8-9 Fast local sockets



Faster local sockets take TCP/IP optimization to a whole new level by placing the data on the TCP send queue, transferring the data directly to the receive queue, and bypassing TCP inbound processing, thus saving more processing time by not doing data packet acknowledgements (ACKs). The z/OS Communications Server automatically reverts to fast local sockets if packet trace or AT-TLS is enabled for this connection.

Figure 8-10 Faster local sockets

8.7 TCP/IP performance quick checklist

Use the following checklist when you consider TCP/IP performance:

- The z/OS Workload Manager (WLM) definitions for VTAM, TCP/IP, FTP, OMPROUTE, FTPD, INETD, and any other network functions should be set to the SYSSTC level for best performance.
- Make client and server TCP send and receive buffers at least 64 KB. The TCP window size should be set to twice the TCP receive buffer size up to a maximum of the TCPMAXRCVBUFRSIZE value (default is 512 KB).
- When using FTP, use large data set block sizes for traditional z/OS data sets.
- Telnet parameters TIMEMARK, SCANINTERVAL, and INACTIVE are set up with default values that in most cases will not require modification. Information about the default settings is as follows:
  - To minimize potential traffic, the default for the TIMEMARK parameter is TIMEMARK = 10800 (3 hours). Setting the TIMEMARK value too low could cause excessive flooding of the network with TIMEMARK commands or high storage usage, particularly around typical low-activity times such as during lunch breaks.

  – To avoid CPU issues, the default for the SCANINTERVAL parameter is SCANINTERVAL = 1800 (30 minutes). Setting a low SCANINTERVAL value can cause a significant increase in CPU utilization when there are large numbers of TN3270 users.
  – The INACTIVE default is 0, which means that an inactive user will never be disconnected. If you choose to set a non-zero INACTIVE value, we suggest that you set it to INACTIVE = 5400 (90 minutes).

Note: TIMEMARK and SCANINTERVAL are intended to help with cleaning up idle connections on the TCP/IP side of a TN3270 session. INACTIVE is intended to do the same for the SNA side of things.

Therefore, if a user is not currently logged in to any SNA application (for example, the user has an unformatted system services message 10 panel open), INACTIVE will not terminate the TCP/IP side of the user's TN3270 connection. Instead, the SCANINTERVAL and TIMEMARK are supposed to handle that job.

- For sockets applications, use large message sizes (> 1 KB) for better performance.
- Ensure that TCP/IP and all other traces are turned off for optimal performance. Trace activity can create significant additional processing impact.

8.8 IBM Health Checker for z/OS

The objective of IBM Health Checker for z/OS is to identify potential problems before they impact your availability or, in worst cases, cause outages. It checks the current active z/OS and sysplex settings and definitions for a system, and compares the values to those suggested by IBM or defined by you. It is not meant to be a diagnostic or monitoring tool, but rather a continuously running preventative that finds potential problems.

IBM Health Checker for z/OS produces output in the form of detailed messages to let you know of both potential problems and suggested actions to take. Note that those messages do not mean that IBM Health Checker for z/OS has found problems that you need to report to IBM. IBM Health Checker for z/OS output messages simply inform you of potential problems, so that you can take action on your installation.

There are several parts to IBM Health Checker for z/OS:

- The framework of the IBM Health Checker for z/OS is the interface that allows you to run and manage checks. The framework is a common and open architecture, supporting check development by IBM, independent software vendors (ISVs), and users.
- Individual checks look for component-, element-, or product-specific z/OS settings and definitions, checking for potential problems. The specific component or element owns, delivers, and supports the checks.

  Checks can be either local, and run in the IBM Health Checker for z/OS address space, or remote, and run in the caller's address space.

The following sections describe checks that are related only to TCP/IP.

8.8.1 What is a check

A *check* is actually a program or routine that identifies potential problems before they impact your availability or, in worst cases, cause outages. A check is owned, delivered, and supported by the component, element, or product that writes it. Checks are separate from the IBM Health Checker for z/OS framework.

A check might analyze a configuration in the following ways:

- Changes in settings or configuration values that occur dynamically over the life of an IPL. Checks that look for changes in these values should run periodically to keep the installation aware of changes.
- Threshold levels approaching the upper limits, especially those that might occur gradually or insidiously.
- Single points of failure in a configuration.
- Unhealthy combinations of configurations or values that an installation might not check.
- Applications or functions that are scheduled to be removed in a future release. (This is known as a *migration health check*.)

8.8.2 Checks owned by TCP/IP

Several checks are owned by TCP/IP:

- `CSTCP_SYSTCPIP_CTRACE_`*`tcpipstackname`*

  This check checks whether TCP/IP Event Trace (SYSTCPIP) is active with options other than the default options (MINIMUM, INIT, OPCMDS, or OPMSGS). By default, this check is performed once at stack initialization, and then is repeated once every 24 hours. This default can be overridden by either a POLICY statement in the HZSPRMxx parmlib member, or by a **`MODIFY`** command.

  The check name is suffixed by *`tcpipstackname`*, which is the job name of each TCP stack that is started, to define a separate check for each stack.

- `CSTCP_TCPMAXRCVBUFRSIZE_`*`tcpipstackname`*

  This check checks whether the configured TCP maximum receive buffer size is sufficient to provide optimal support to the z/OS Communications Server FTP Server. By default, this check is performed once at stack initialization and when a **`VARY TCPIP,,OBEYFILE`** command changes the **`TCPMAXRCVBUFRSIZE`** parameter.

  By default, it checks that TCPMAXRCVBUFRSIZE is at least 180 KB. These defaults can be overridden by either a POLICY statement in the HZSPRMxx parmlib member or on a **`MODIFY`** command.

  The check name is suffixed by *`tcpipstackname`*, which is the job name of each TCP stack that is started, to define a separate check for each stack.

- `CSTCP_SYSPLEXMON_RECOV_`*`tcpipstackname`*

  This check checks whether the IPCONFIG DYNAMICXCF or IPCONFIG6 DYNAMICXCF parameters have been specified and the GLOBALCONFIG SYSPLEXMONITOR RECOVERY parameter has been specified. This check produces an exception message if the IPCONFIG DYNAMICXCF or IPCONFIG6 DYNAMICXCF parameters are specified, but the GLOBALCONFIG SYSPLEXMONITOR NORECOVERY parameter is in effect.

  By default, this check is performed once at stack initialization. This default can be overridden by either a POLICY statement in the HZSPRMxx parmlib member, or by a **`MODIFY`** command.

The check name is suffixed by `tcpipstackname`, which is the job name of each TCP stack that is started, to define a separate check for each stack.

- `CSTCP_CINET_PORTRNG_RSV_tcpipstackname`

  This check is used for a z/OS check in a Common INET (CINET) environment. It determines whether the port range specified by the INADDRANYPORT and INADDRANYCOUNT parameters in the BPXPRMxx parmlib member are reserved for OMVS on the TCP/IP stack. Reserving a port range prevents the stack from allocating a port that can later be allocated by CINET. See Example 8-11 on page 321 for more details.

- `CSTCP_IPMAXRT4_tcpipstackname` and `CSTCP_IPMAXRT6_tcpipstackname`

  The `CSTCP_IPMAXRT4_tcpipstackname` check is used to determine whether the total number of IPv4 indirect static and dynamic routes in the TCP/IP stack's routing table have exceeded the maximum threshold (default 2000). You can use the `CSTCP_IPMAXRT6_tcpipstackname` check for IPv6.

  By default, these checks are performed once every 30 minutes after stack initialization, at once when the total number of routes exceeds the threshold, and then are repeated once for every one of the specified intervals (the default is 168 hours for a week). This default can be overridden by either a POLICY statement in the HZSPRMxx parmlib member, or by a **`MODIFY`** command.

  The check name is suffixed by `tcpipstackname`, which is the job name of each TCP stack that is started, to define a separate check for each stack. You can use CSTCP_IPMAXRT4_* and CSTCP_IPMAXRT6_* to reference these checks for all stacks.

8.8.3 Migration health check

The migration health checks are available for IBM Health Checker to help prepare for a migration, because you must run migration checks on the existing system before you migrate to a new release.

You must install the PTFs on your current system. Similar to other IBM Health Checker for z/OS checks, you can find migration checks using the functional PSP bucket HCHECKER. Alternatively, you can find all IBM Health Checker for z/OS checks at the following address:

`http://www.ibm.com/systems/z/os/zos/hchecker/check_table.html`

After you migrate to the current release, you need to obtain any updates to the migration health check function and rerun Health Checker to verify that you have implemented the necessary migration steps.

For more detailed information about IBM Health Checker for z/OS, see *IBM Health Checker for z/OS: User's Guide*, SA22-7994 and Appendix D "IBM Health Checker for z/OS" of *z/OS Communications Server: IP Diagnosis Guide*, GC31-8782.

8.8.4 Health Monitor checks with commands

Use Health Checker system commands to get a summary of its checks and their status, as shown in Example 8-10. This is only a partial list of checks. The TCP/IP checks are highlighted in bold.

Example 8-10 Display Health Checks status using a command

```
F HZSPROC,DISPLAY,CHECKS
HZS0200I 16.12.04 CHECK SUMMARY     261
CHECK OWNER      CHECK NAME                       STATE STATUS
IBMCS            CSTCP_IPMAXRT6_TCPIPA             AE   SUCCESSFUL
IBMCS            CSTCP_IPMAXRT4_TCPIPA             AE   SUCCESSFUL
IBMCS            CSTCP_CINET_PORTRNG_RSV_TCPIPA    AE   SUCCESSFUL
IBMCS            CSTCP_SYSPLEXMON_RECOV_TCPIPA     AE   EXCEPTION-LOW
IBMCS            CSTCP_TCPMAXRCVBUFRSIZE_TCPIPA    AE   SUCCESSFUL
IBMCS            CSTCP_SYSTCPIP_CTRACE_TCPIPA      AE   SUCCESSFUL
...
IBMCS            CSTCP_IPMAXRT6_TCPIP              AE   SUCCESSFUL
IBMCS            CSTCP_IPMAXRT4_TCPIP              AE   SUCCESSFUL
IBMCS            CSTCP_CINET_PORTRNG_RSV_TCPIP     AE   EXCEPTION-MED
IBMCS            CSTCP_SYSPLEXMON_RECOV_TCPIP      AE   SUCCESSFUL
IBMCS            CSTCP_TCPMAXRCVBUFRSIZE_TCPIP     AE   SUCCESSFUL
IBMCS            CSTCP_SYSTCPIP_CTRACE_TCPIP       AE   SUCCESSFUL
...
IBMCS            CSVTAM_T1BUF_T2BUF_NOEE           AD   ENV N/A
IBMCS            CSVTAM_T1BUF_T2BUF_EE             AE   SUCCESSFUL
IBMCS            CSVTAM_VIT_OPT_ALL                AE   SUCCESSFUL
IBMCS            CSVTAM_VIT_DSPSIZE                AE   SUCCESSFUL
IBMCS            CSVTAM_VIT_OPT_PSSSMS             AE   SUCCESSFUL
IBMCS            CSVTAM_VIT_SIZE                   AE   SUCCESSFUL
IBMCS            CSVTAM_CSM_STG_LIMIT              AE   SUCCESSFUL
...
IBMCS            CSTCP_SYSTCPIP_CTRACE_TCPIPE           DELETED
IBMCS            CSTCP_TCPMAXRCVBUFRSIZE_TCPIPE         DELETED
IBMCS            CSTCP_SYSPLEXMON_RECOV_TCPIPE          DELETED
IBMCS            CSTCP_CINET_PORTRNG_RSV_TCPIPE         DELETED
IBMCS            CSTCP_IPMAXRT4_TCPIPE                  DELETED
IBMCS            CSTCP_IPMAXRT6_TCPIPE                  DELETED
...
```

The STATE column can have the following letters or other symbols:

A	**ACTIVE:**	The specified check is in the ACTIVE state.
I	**INACTIVE:**	The specified check is in the INACTIVE state.
E	**ENABLED:**	There are no conditions that would prevent the check from running if it is active.
D	**DISABLED:**	At least one condition exists that prevents the check from running on this system.
G	**GLOBAL:**	The specified check is global, and therefore may be active on only one system in the sysplex.
+		The check issued execution warning messages the last time it ran.

The STATUS field of the display shows the status of the check, that is, whether the check was successful or generated an exception message. If an exception message was generated, it indicates whether the exception severity level is low, medium, or high.

The status field can also indicate if a check was not run because it was not applicable in the current environment, because of an unexpected error during check processing, or deleted.

In the SDSF panel, enter `SDSF CK`, and then select CSTCP_CINET_PORTRNG_TCPIPA. The message that is issued is then displayed when the following check is invoked and discovers that the configuration does not agree with the best practice suggested (Example 8-11):

CSTCP_CINET_PORTRNG_RSV_*tcpipstackname*

Example 8-11 Display health check message in SD.CK panel

```
CHECK(IBMCS,CSTCP_CINET_PORTRNG_RSV_TCPIPA)
START TIME: 07/20/2011 20:54:44.339210
CHECK DATE: 20070901  CHECK SEVERITY: MEDIUM

* Medium Severity Exception *

EZBH008E The port range defined for CINET use has not been reserved for
OMVS on this stack.
.....

END TIME: 07/20/2011 20:54:44.375023  STATUS: EXCEPTION-MED
```

8.8.5 Health Monitor checks with GUI

The IBM Tivoli® OMEGAMON® XE on z/OS Management Console can be used as the Health Checker's graphical user interface (GUI) on your workstation.

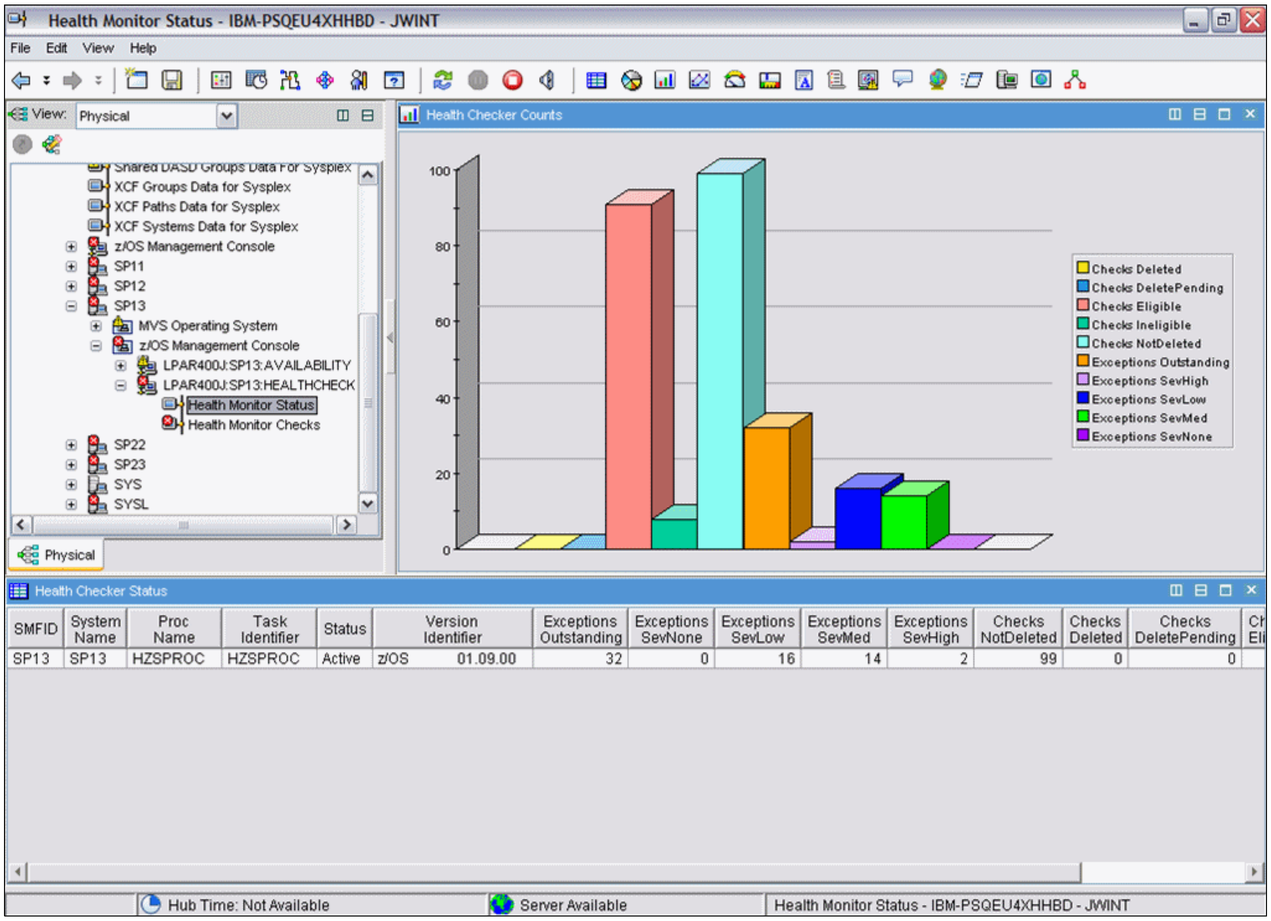
The IBM Tivoli OMEGAMON XE on z/OS Management Console Quick Install Option includes software for z/OS and Windows. You may download the software from the z/OS downloads website (and you may also order it as tape and DVD); instructions are in the *program directory*:

http://www.ibm.com/servers/eserver/zseries/zos/downloads/

For complete documentation, see the IBM Tivoli Monitoring and IBM Tivoli OMEGAMON XE on z/OS Information Center at the following address:

http://publib.boulder.ibm.com/infocenter/tivihelp/v15r1/index.jsp?topic=/com.ibm.omegamon_mancon.doc/welcome.htm

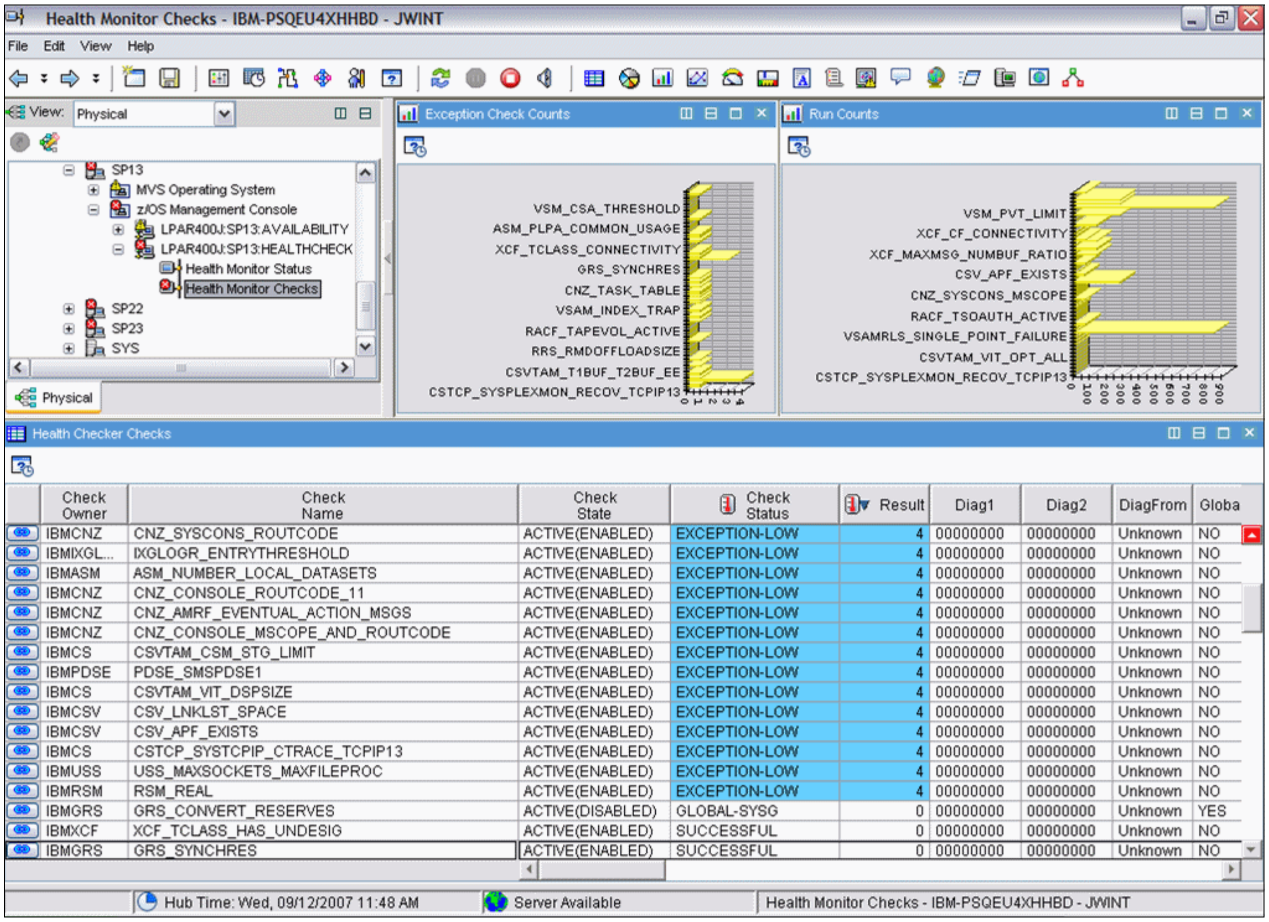
Figure 8-11 shows the Health Monitor Status in the IBM Tivoli OMEGAMON XE on z/OS Management Console.



SMFID	System Name	Proc Name	Task Identifier	Status	Version Identifier	Exceptions Outstanding	Exceptions SevNone	Exceptions SevLow	Exceptions SevMed	Exceptions SevHigh	Checks NotDeleted	Checks Deleted	Checks DeletePending	Ch Eli
SP13	SP13	HZSPROC	HZSPROC	Active	z/OS 01.09.00	32	0	16	14	2	99	0	0	

Figure 8-11 Health Checker GUI window with IBM Tivoli OMEGAMON XE on z/OS Management Console

When you double-click **Health Monitor Checks**, the window shown in Figure 8-12 opens. It shows the current status of all checks. The CSTCP_* checks are the TCP/IP health checks. The OMEGAMON z/OS Management Console automatically updates the check status using the refresh interval values customized in z/OS and the GUI (the default is 5 minutes).

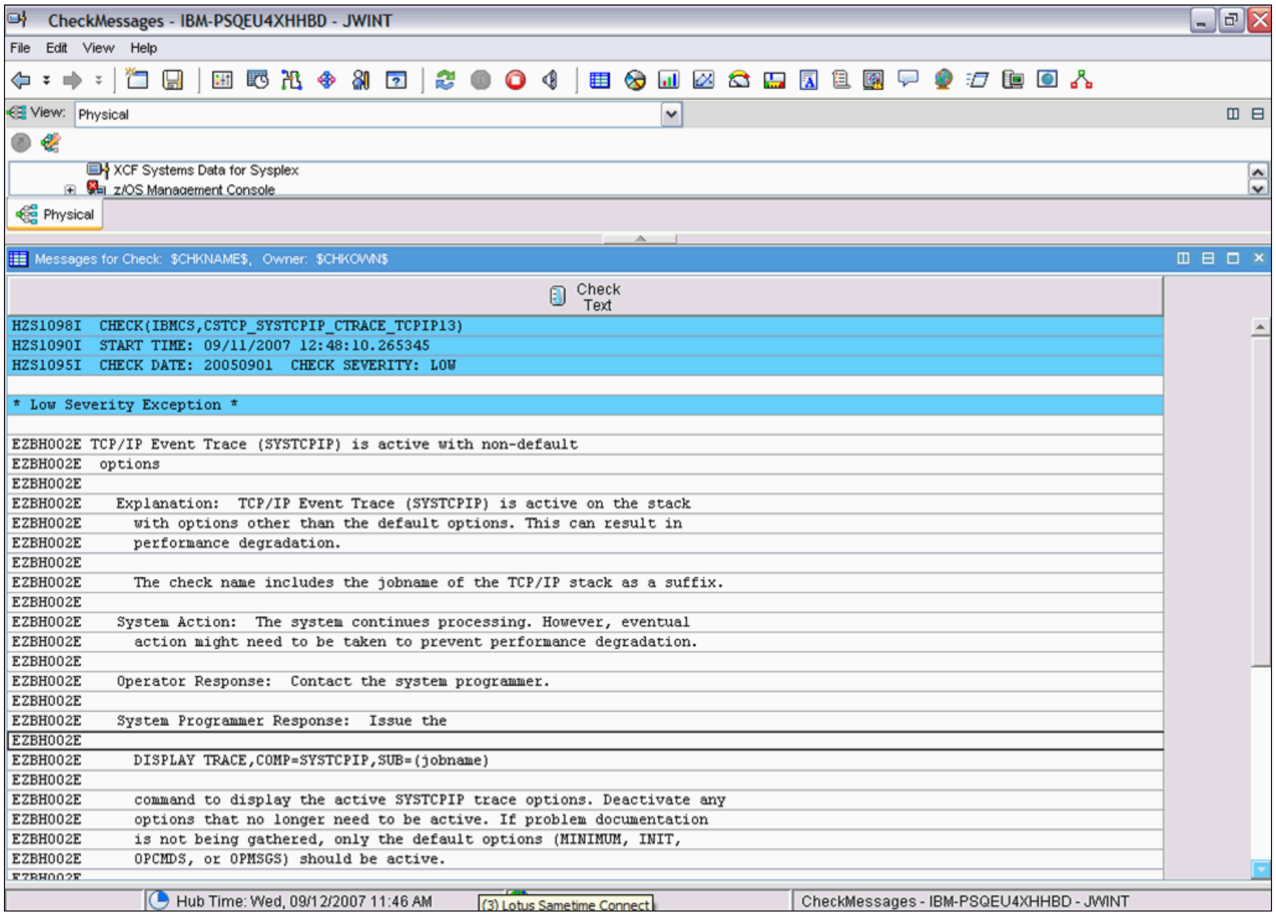


Check Owner	Check Name	Check State	Check Status	Result	Diag1	Diag2	DiagFrom	Globa
IBMCNZ	CNZ_SYSCONS_ROUTCODE	ACTIVE(ENABLED)	EXCEPTION-LOW	4	00000000	00000000	Unknown	NO
IBMIXGL...	IXGLOGR_ENTRYTHRESHOLD	ACTIVE(ENABLED)	EXCEPTION-LOW	4	00000000	00000000	Unknown	NO
IBMASM	ASM_NUMBER_LOCAL_DATASETS	ACTIVE(ENABLED)	EXCEPTION-LOW	4	00000000	00000000	Unknown	NO
IBMCNZ	CNZ_CONSOLE_ROUTCODE_11	ACTIVE(ENABLED)	EXCEPTION-LOW	4	00000000	00000000	Unknown	NO
IBMCNZ	CNZ_AMRF_EVENTUAL_ACTION_MSGS	ACTIVE(ENABLED)	EXCEPTION-LOW	4	00000000	00000000	Unknown	NO
IBMCNZ	CNZ_CONSOLE_MSCOPE_AND_ROUTCODE	ACTIVE(ENABLED)	EXCEPTION-LOW	4	00000000	00000000	Unknown	NO
IBMCS	CSVTAM_CSM_STG_LIMIT	ACTIVE(ENABLED)	EXCEPTION-LOW	4	00000000	00000000	Unknown	NO
IBMPDSE	PDSE_SMSPDSE1	ACTIVE(ENABLED)	EXCEPTION-LOW	4	00000000	00000000	Unknown	NO
IBMCS	CSVTAM_VIT_DSPSIZE	ACTIVE(ENABLED)	EXCEPTION-LOW	4	00000000	00000000	Unknown	NO
IBMCSV	CSV_LNKLST_SPACE	ACTIVE(ENABLED)	EXCEPTION-LOW	4	00000000	00000000	Unknown	NO
IBMCSV	CSV_APF_EXISTS	ACTIVE(ENABLED)	EXCEPTION-LOW	4	00000000	00000000	Unknown	NO
IBMCS	CSTCP_SYSTCPIP_CTRACE_TCPIP13	ACTIVE(ENABLED)	EXCEPTION-LOW	4	00000000	00000000	Unknown	NO
IBMUSS	USS_MAXSOCKETS_MAXFILEPROC	ACTIVE(ENABLED)	EXCEPTION-LOW	4	00000000	00000000	Unknown	NO
IBMRSM	RSM_REAL	ACTIVE(ENABLED)	EXCEPTION-LOW	4	00000000	00000000	Unknown	NO
IBMGRS	GRS_CONVERT_RESERVES	ACTIVE(DISABLED)	GLOBAL-SYSG	0	00000000	00000000	Unknown	YES
IBMXCF	XCF_TCLASS_HAS_UNDESIG	ACTIVE(ENABLED)	SUCCESSFUL	0	00000000	00000000	Unknown	NO
IBMGRS	GRS_SYNCHRES	ACTIVE(ENABLED)	SUCCESSFUL	0	00000000	00000000	Unknown	NO

Hub Time: Wed, 09/12/2007 11:48 AM | Server Available | Health Monitor Checks - IBM-PSQEU4XHHBD - JWINT

Figure 8-12 Checks Status window

The Checks Status column alerts you by using different colors for the checks that have exception statuses. To see more detailed information about a specific check, double-click the links at the bottom portion of the window (Figure 8-13).



CheckMessages - IBM-PSQEU4XHHBD - JWINT
File Edit View Help
View: Physical
XCF Systems Data for Sysplex
z/OS Management Console
Physical
Messages for Check: $CHKNAME$, Owner: $CHKOWN$
Check Text
Hub Time: Wed, 09/12/2007 11:46 AM
(3) Lotus Sametime Connect
CheckMessages - IBM-PSQEU4XHHBD - JWINT

```
HZS1098I  CHECK(IBMCS,CSTCP_SYSTCPIP_CTRACE_TCPIP13)
HZS1090I  START TIME: 09/11/2007 12:48:10.265345
HZS1095I  CHECK DATE: 20050901  CHECK SEVERITY: LOW

* Low Severity Exception *

EZBH002E TCP/IP Event Trace (SYSTCPIP) is active with non-default
EZBH002E  options
EZBH002E
EZBH002E    Explanation:  TCP/IP Event Trace (SYSTCPIP) is active on the stack
EZBH002E      with options other than the default options. This can result in
EZBH002E      performance degradation.
EZBH002E
EZBH002E      The check name includes the jobname of the TCP/IP stack as a suffix.
EZBH002E
EZBH002E    System Action:  The system continues processing. However, eventual
EZBH002E      action might need to be taken to prevent performance degradation.
EZBH002E
EZBH002E    Operator Response:  Contact the system programmer.
EZBH002E
EZBH002E    System Programmer Response:  Issue the
EZBH002E
EZBH002E      DISPLAY TRACE,COMP=SYSTCPIP,SUB=(jobname)
EZBH002E
EZBH002E      command to display the active SYSTCPIP trace options. Deactivate any
EZBH002E      options that no longer need to be active. If problem documentation
EZBH002E      is not being gathered, only the default options (MINIMUM, INIT,
EZBH002E      OPCMDS, or OPMSGS) should be active.
```

Figure 8-13   TCP/IP Check Message window

A

HiperSockets Multiple Write

In IBM z/OS Communications Server, a HiperSockets interface can move multiple output data buffers in a single write operation. CPU usage can be reduced and there might be a performance improvement for large outbound messages typically generated by traditional streaming workloads such as FTP.

This appendix includes three scenarios to demonstrate the CPU utilization reduction that is obtained by using the HiperSockets Multiple Write facility.

In the TCP/IP profile, we used the following statements:

- GLOBALCONFIG NOTCPIPSTATISTICS
- GLOBALCONFIG NOTCPIPSTATISTICS IQDMULTIWRITE
- GLOBALCONFIG NOTCPIPSTATISTICS IQDMULTIWRITE ZIIP IQDIOMULTIWRITE

For a description of HiperSockets Multiple Write, see *IBM z/OS V2R1 Communications Server TCP/IP Implementation Volume 1: Base Functions, Connectivity, and Routing*, SG24-8096.

A.1 The environment used for our tests

We transmit a large file from SC30 to SC31 using FTP. We stop all the other HiperSockets and OSA-Express devices (Figure A-1).

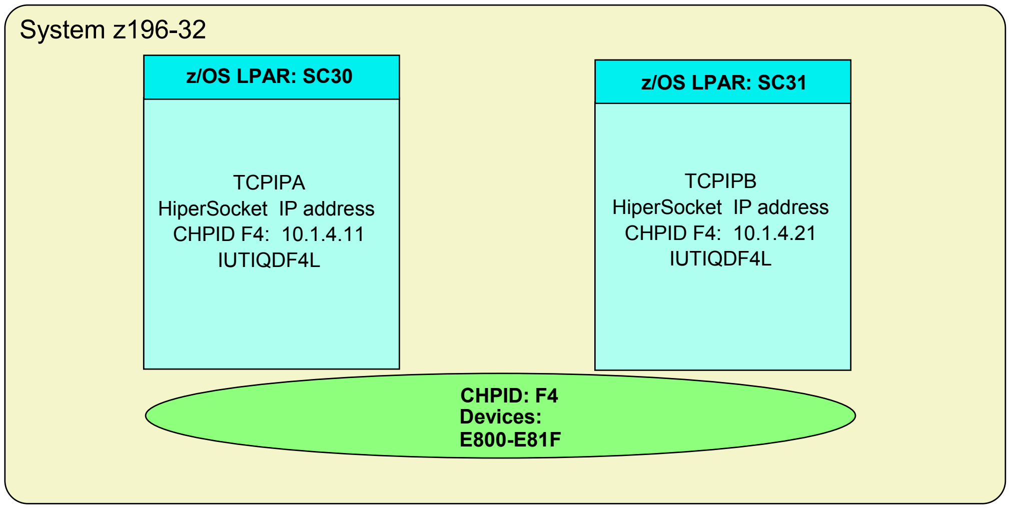


Figure A-1 HiperSockets Multiple Write test environment

A.2 Our test job streams

The job used to test the HiperSockets Multiple Write is shown in Example A-1.

Example A-1 FTP job with large files

```
//FTPBAT1 JOB (999,POK),'Batch FTP',CLASS=A,MSGCLASS=T,
// NOTIFY=&SYSUID,TIME=1440,REGION=0M
/*JOBPARM L=999,SYSAFF=SC30
//FTP      EXEC PGM=FTP PARM='/-d (EXIT'
//SYSTCPD  DD  DISP=SHR,DSN=TCPIPA.TCPPARMS(DATAA30)
//SYSFTPD  DD  DISP=SHR,DSN=TCPIPA.TCPPARMS(FTPDA30)
//SYSPRINT DD  SYSOUT=*
//OUTPUT   DD  SYSOUT=*,LRECL=160,BLKSIZE=1600,RECFM=FB
//INPUT    DD  *
 10.1.4.21
 cs09
 ******
 ebcdic
 mode b
 site primary=1611 secondary=50
 site recfm=u blksize=27998 cylinders volume=WORK01 unit=3390
 PUT 'RC33.HOM.SEQ1.D070926' SEQ1
 PUT 'RC33.HOM.SEQ1.D070926' SEQ2
 PUT 'RC33.HOM.SEQ1.D070926' SEQ3
 site recfm=u blksize=27998 cylinders volume=WORK02 unit=3390
 PUT 'RC33.HOM.SEQ1.D070926' SEQ4
 PUT 'RC33.HOM.SEQ1.D070926' SEQ5
 PUT 'RC33.HOM.SEQ1.D070926' SEQ6
 site recfm=u blksize=27998 cylinders volume=WORK01 unit=3390
 PUT 'RC33.HOM.SEQ1.D070926' SEQ7
 PUT 'RC33.HOM.SEQ1.D070926' SEQ8
 PUT 'RC33.HOM.SEQ1.D070926' SEQ9
 site recfm=u blksize=27998 cylinders volume=WORK02 unit=3390
 PUT 'RC33.HOM.SEQ1.D070926' SEQA
 PUT 'RC33.HOM.SEQ1.D070926' SEQB
 PUT 'RC33.HOM.SEQ1.D070926' SEQC
 quit
/*
```

In the first test, we use the parameters shown in Example A-2 in the TCP/IP profile for LPAR SC30 and LPAR SC31.

Example A-2 Extract of each profile TCP/IP

```
TCPIPA.TCPPARMS(PROFA30)

GLOBALCONFIG NOTCPIPSTATISTICS

DEVICE IUTIQDF4   MPCIPA
LINK   IUTIQDF4L  IPAQIDIO    IUTIQDF4

HOME
   10.1.4.11     IUTIQDF4L

START IUTIQDF4

*************************************************************************************
*********
TCPIPA.TCPPARMS(PROFB31)

GLOBALCONFIG NOTCPIPSTATISTICS

DEVICE IUTIQDF4   MPCIPA
LINK   IUTIQDF4L  IPAQIDIO    IUTIQDF4

HOME
   10.1.4.21     IUTIQDF4L

START IUTIQDF4
```

To verify the options in effect, we issue the following command. Example A-3 shows the output of this command:

```
D TCPIP,TCPIPA,N,CONFIG
```

Example A-3 Extract of NETSTAT, CONFIG

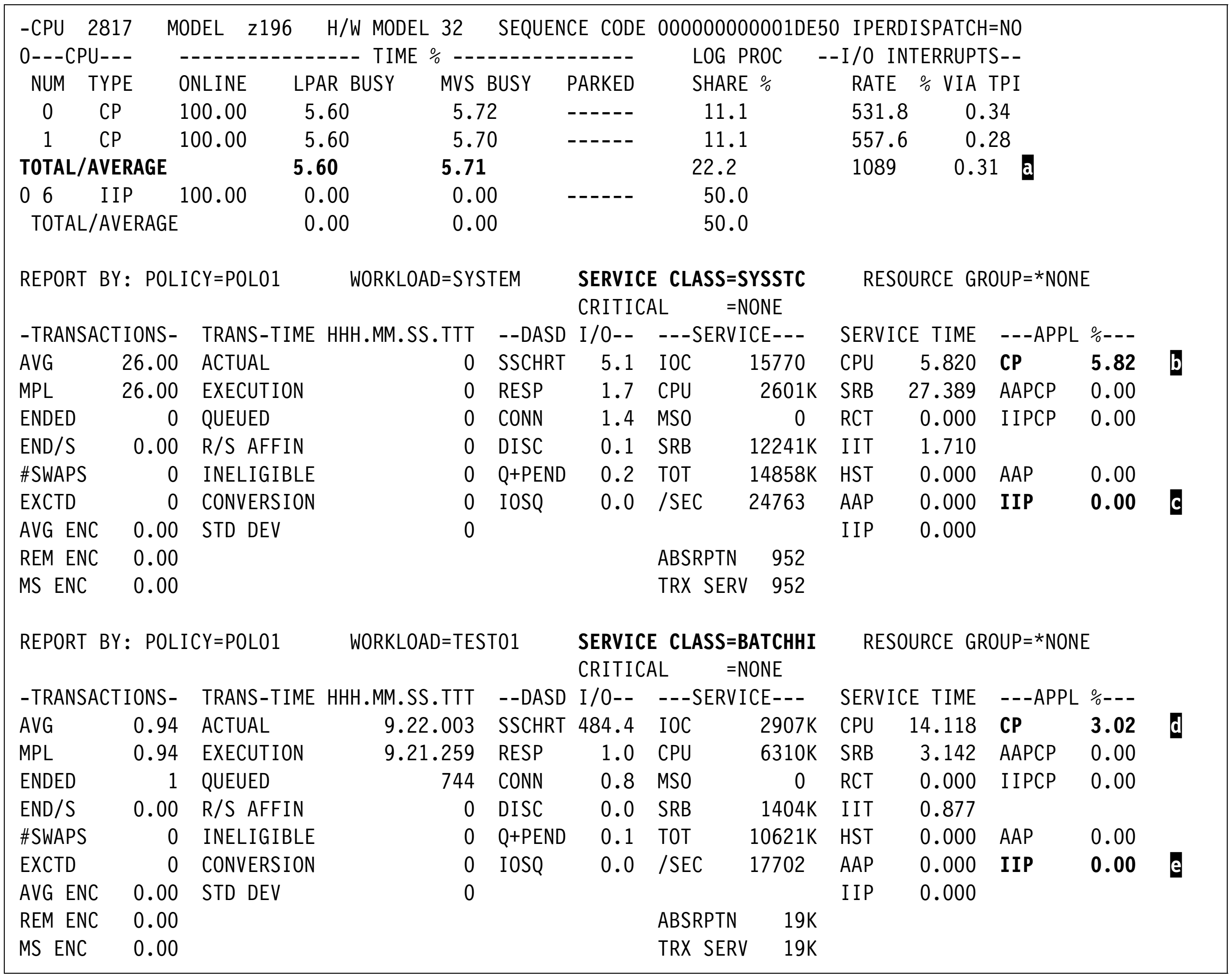
```
TCP CONFIGURATION TABLE:
DEFAULTRCVBUFSIZE:  00065536  DEFAULTSNDBUFSIZE: 00065536
DEFLTMAXRCVBUFSIZE: 00262144  SOMAXCONN:         0000000010
MAXRETRANSMITTIME:  120.000   MINRETRANSMITTIME: 0.500
ROUNDTRIPGAIN:      0.125     VARIANCEGAIN:      0.250
VARIANCEMULTIPLIER: 2.000     MAXSEGLIFETIME:    30.000
DEFAULTKEEPALIVE:   00000120  DELAYACK:          YES
RESTRICTLOWPORT:    NO        SENDGARBAGE:       NO
```

```
TCPTIMESTAMP:       YES       FINWAIT2TIME:      600
TTLS:               NO
GLOBAL CONFIGURATION INFORMATION:
TCPIPSTATS: NO   ECSALIMIT: 0000000K  POOLLIMIT: 0000000K
MLSCHKTERM: NO   XCFGRPID:            IQDVLANID: 0
SEGOFFLOAD: YES  SYSPLEXWLMPOLL: 060  MAXRECS:   100
EXPLICITBINDPORTRANGE:  07000-07002   IQDMULTIWRITE: NO  1
SYSPLEX MONITOR:
  TIMERSECS: 0060  RECOVERY: NO   DELAYJOIN: NO   AUTOREJOIN: NO
  MONINTF:   NO    DYNROUTE: NO
ZIIP:
  IPSECURITY: NO   IQDIOMULTIWRITE: NO  2
```

In this example, the numbers correspond to the following information:

1. No IQDMUTIWRITE.
2. No zIIP is involved.

The CPU RMF and WLM RMF report (service class SYSSTC for TCP/IP and FTP and service class BATCHHI for the FTP batch job) are shown in Figure A-2.



```
-CPU  2817   MODEL  z196   H/W MODEL 32   SEQUENCE CODE 000000000001DE50 IPERDISPATCH=NO
0---CPU---    ---------------- TIME % ----------------     LOG PROC   --I/O INTERRUPTS--
 NUM  TYPE    ONLINE    LPAR BUSY    MVS BUSY   PARKED     SHARE %       RATE  % VIA TPI
  0    CP     100.00     5.60         5.72      ------      11.1         531.8     0.34
  1    CP     100.00     5.60         5.70      ------      11.1         557.6     0.28
TOTAL/AVERAGE            5.60        5.71                  22.2         1089     0.31  a
0 6    IIP    100.00     0.00         0.00      ------      50.0
 TOTAL/AVERAGE           0.00         0.00                  50.0

REPORT BY: POLICY=POL01      WORKLOAD=SYSTEM     SERVICE CLASS=SYSSTC     RESOURCE GROUP=*NONE
                                                 CRITICAL     =NONE
-TRANSACTIONS-  TRANS-TIME HHH.MM.SS.TTT  --DASD I/O--  ---SERVICE---   SERVICE TIME  ---APPL %---
AVG      26.00  ACTUAL                 0  SSCHRT   5.1  IOC     15770   CPU    5.820  CP     5.82   b
MPL      26.00  EXECUTION              0  RESP     1.7  CPU     2601K   SRB   27.389  AAPCP  0.00
ENDED        0  QUEUED                 0  CONN     1.4  MSO         0   RCT    0.000  IIPCP  0.00
END/S     0.00  R/S AFFIN              0  DISC     0.1  SRB    12241K   IIT    1.710
#SWAPS       0  INELIGIBLE             0  Q+PEND   0.2  TOT    14858K   HST    0.000  AAP    0.00
EXCTD        0  CONVERSION             0  IOSQ     0.0  /SEC    24763   AAP    0.000  IIP    0.00   c
AVG ENC   0.00  STD DEV                0                                IIP    0.000
REM ENC   0.00                                          ABSRPTN   952
MS ENC    0.00                                          TRX SERV  952

REPORT BY: POLICY=POL01      WORKLOAD=TEST01     SERVICE CLASS=BATCHHI    RESOURCE GROUP=*NONE
                                                 CRITICAL     =NONE
-TRANSACTIONS-  TRANS-TIME HHH.MM.SS.TTT  --DASD I/O--  ---SERVICE---   SERVICE TIME  ---APPL %---
AVG       0.94  ACTUAL          9.22.003  SSCHRT 484.4  IOC     2907K   CPU   14.118  CP     3.02   d
MPL       0.94  EXECUTION       9.21.259  RESP     1.0  CPU     6310K   SRB    3.142  AAPCP  0.00
ENDED        1  QUEUED               744  CONN     0.8  MSO         0   RCT    0.000  IIPCP  0.00
END/S     0.00  R/S AFFIN              0  DISC     0.0  SRB     1404K   IIT    0.877
#SWAPS       0  INELIGIBLE             0  Q+PEND   0.1  TOT    10621K   HST    0.000  AAP    0.00
EXCTD        0  CONVERSION             0  IOSQ     0.0  /SEC    17702   AAP    0.000  IIP    0.00   e
AVG ENC   0.00  STD DEV                0                                IIP    0.000
REM ENC   0.00                                          ABSRPTN    19K
MS ENC    0.00                                          TRX SERV   19K
```

Figure A-2   Test result for no IDQMULTIWRITE and no ZIIP

The total CPU usage for LPAR is 5.60 (a). The APPL% for service class SYSSTC is 5.82 for CP and 0 for IIP (b and c). The APPL% for service class BATCHHI is 3.02 for CP and 0 for IIP (d and e).

In the next test, we use the parameters shown in Example A-4 in the TCP/IP profile for LPAR A11 (SC30) and LPAR A13 (SC31).

Example A-4 TCP/IP profile extract

```
TCPIPA.TCPPARMS(PROFA30)

GLOBALCONFIG NOTCPIPSTATISTICS IQDMULTIWRITE

DEVICE IUTIQDF4   MPCIPA
LINK   IUTIQDF4L  IPAQIDIO    IUTIQDF4

HOME
   10.1.4.11     IUTIQDF4L

START IUTIQDF4

*******************************************************************************************
TCPIPA.TCPPARMS(PROFB31)

GLOBALCONFIG NOTCPIPSTATISTICS IQDMULTIWRITE

DEVICE IUTIQDF4   MPCIPA
LINK   IUTIQDF4L  IPAQIDIO    IUTIQDF4

HOME
   10.1.4.21     IUTIQDF4L

START IUTIQDF4
```

To verify that the options are in effect, we issue the following command. Example A-5 shows the output of this command.

```
D TCPIP,TCPIPA,N,CONFIG
```

Example A-5 Output of NETSTAT CONFIG command

```
TCP CONFIGURATION TABLE:
DEFAULTRCVBUFSIZE:  00262144  DEFAULTSNDBUFSIZE: 00262144
DEFLTMAXRCVBUFSIZE: 00524288  SOMAXCONN:         0000000010
MAXRETRANSMITTIME:  120.000   MINRETRANSMITTIME: 0.500
ROUNDTRIPGAIN:      0.125     VARIANCEGAIN:      0.250
VARIANCEMULTIPLIER: 2.000     MAXSEGLIFETIME:    30.000
DEFAULTKEEPALIVE:   00000120  DELAYACK:          YES
RESTRICTLOWPORT:    NO        SENDGARBAGE:       NO
TCPTIMESTAMP:       YES       FINWAIT2TIME:      600
TTLS:               NO
GLOBAL CONFIGURATION INFORMATION:
TCPIPSTATS: NO   ECSALIMIT: 0000000K  POOLLIMIT: 0000000K
MLSCHKTERM: NO   XCFGRPID:            IQDVLANID: 0
SEGOFFLOAD: YES  SYSPLEXWLMPOLL: 060  MAXRECS:   100
EXPLICITBINDPORTRANGE:  07000-07002   IQDMULTIWRITE: YES 1
SYSPLEX MONITOR:
  TIMERSECS: 0060  RECOVERY: NO   DELAYJOIN: NO   AUTOREJOIN: NO
  MONINTF:   NO    DYNROUTE: NO
ZIIP:
  IPSECURITY: NO   IQDIOMULTIWRITE: NO   2
```

In this example, the numbers correspond to the following information:

1. HiperSockets Multiple Write is enabled.

2. zIIP is not used.

The CPU RMF and WLM RMF reports (service class SYSSTC for TCP/IP and FTP and service class BATCHHI for the FTP batch job) are shown in Figure A-3.

```
-CPU  2817   MODEL  z196  H/W MODEL 32    SEQUENCE CODE 000000000001DE50    HIPERDISPATCH=NO
0---CPU---    ---------------- TIME % ----------------     LOG PROC      --I/O INTERRUPTS--
 NUM  TYPE    ONLINE    LPAR BUSY    MVS BUSY   PARKED     SHARE %       RATE     % VIA TPI
  0    CP     100.00     5.13         5.26      ------      11.1         282.3     0.61
  1    CP     100.00     5.12         5.23      ------      11.1         286.4     0.43
 TOTAL/AVERAGE           5.12         5.25                  22.2         568.7     0.52         a
0 6    IIP    100.00     0.00         0.00      ------      50.0
 TOTAL/AVERAGE           0.00         0.00                  50.0

REPORT BY: POLICY=POL01      WORKLOAD=SYSTEM     SERVICE CLASS=SYSSTC     RESOURCE GROUP=*NONE
                                                 CRITICAL     =NONE

-TRANSACTIONS-  TRANS-TIME HHH.MM.SS.TTT  --DASD I/O--  ---SERVICE---   SERVICE TIME  ---APPL %---
AVG      26.00  ACTUAL                 0  SSCHRT   4.7  IOC     15298   CPU    5.755  CP      4.42   b
MPL      26.00  EXECUTION              0  RESP     1.8  CPU     2572K   SRB   20.716  AAPCP   0.00
ENDED        0  QUEUED                 0  CONN     1.5  MSO         0   RCT    0.000  IIPCP   0.00
END/S     0.00  R/S AFFIN              0  DISC     0.1  SRB     9258K   IIT    0.051
#SWAPS       0  INELIGIBLE             0  Q+PEND   0.2  TOT    11846K   HST    0.000  AAP     0.00
EXCTD        0  CONVERSION             0  IOSQ     0.0  /SEC    19742   AAP    0.000  IIP     0.00   c
AVG ENC   0.00  STD DEV                0                                IIP    0.000
REM ENC   0.00                                          ABSRPTN   759
MS ENC    0.00                                          TRX SERV  759

REPORT BY: POLICY=POL01      WORKLOAD=TEST01     SERVICE CLASS=BATCHHI    RESOURCE GROUP=*NONE
                                                 CRITICAL     =NONE

-TRANSACTIONS-  TRANS-TIME HHH.MM.SS.TTT  --DASD I/O--  ---SERVICE---   SERVICE TIME  ---APPL %---
AVG       0.93  ACTUAL          9.18.587  SSCHRT 484.3  IOC     2907K   CPU   15.033  CP      3.18   d
MPL       0.93  EXECUTION       9.18.304  RESP     1.0  CPU     6719K   SRB    3.169  AAPCP   0.00
ENDED        1  QUEUED               283  CONN     0.8  MSO         0   RCT    0.000  IIPCP   0.00
END/S     0.00  R/S AFFIN              0  DISC     0.0  SRB     1416K   IIT    0.884
#SWAPS       0  INELIGIBLE             0  Q+PEND   0.1  TOT    11042K   HST    0.000  AAP     0.00
EXCTD        0  CONVERSION             0  IOSQ     0.0  /SEC    18403   AAP    0.000  IIP     0.00   e
AVG ENC   0.00  STD DEV                0                                IIP    0.000
REM ENC   0.00                                          ABSRPTN    20K
MS ENC    0.00                                          TRX SERV   20K
```

Figure A-3 Test result for IDQMULTIWRITE and no ZIIP

The total CPU usage for LPAR is 5.12 (a). APPL% for service class SYSSTC is 4.42 for CP and 0 for IIP (b and c). APPL% for service class BATCHHI is 3.18 for CP and 0 for IIP (d and e).

In the third test, we use the parameters shown in Example A-6 in the TCP/IP profile for LPAR A11 (SC30) and LPAR A13 (SC31).

Example A-6 Extract of each profile TCP/IP

```
TCPIPA.TCPPARMS(PROFA30)

GLOBALCONFIG NOTCPIPSTATISTICS IQDMULTIWRITE ZIIP IQDIOMULTIWRITE

DEVICE IUTIQDF4   MPCIPA
LINK   IUTIQDF4L  IPAQIDIO    IUTIQDF4

HOME
   10.1.4.11     IUTIQDF4L

START IUTIQDF4

*********************************************************************************
TCPIPA.TCPPARMS(PROFB31)

GLOBALCONFIG NOTCPIPSTATISTICS IQDMULTIWRITE ZIIP IQDIOMULTIWRITE

DEVICE IUTIQDF4   MPCIPA
LINK   IUTIQDF4L  IPAQIDIO    IUTIQDF4

HOME
   10.1.4.21     IUTIQDF4L

START IUTIQDF4
```

To verify the options in effect, we issue the following command. Example A-7 shows the output of the command.

```
D TCPIP,TCPIPA,N,CONFIG
```

Example A-7 Output of NETSTAT CONFIG command

```
TCP CONFIGURATION TABLE:
DEFAULTRCVBUFSIZE:  00262144  DEFAULTSNDBUFSIZE: 00262144
DEFLTMAXRCVBUFSIZE: 00524288  SOMAXCONN:         0000000010
MAXRETRANSMITTIME:  120.000   MINRETRANSMITTIME: 0.500
ROUNDTRIPGAIN:      0.125     VARIANCEGAIN:      0.250
VARIANCEMULTIPLIER: 2.000     MAXSEGLIFETIME:    30.000
DEFAULTKEEPALIVE:   00000120  DELAYACK:          YES
RESTRICTLOWPORT:    NO        SENDGARBAGE:       NO
TCPTIMESTAMP:       YES       FINWAIT2TIME:      600
TTLS:               NO
GLOBAL CONFIGURATION INFORMATION:
TCPIPSTATS: NO   ECSALIMIT: 0000000K  POOLLIMIT: 0000000K
MLSCHKTERM: NO   XCFGRPID:            IQDVLANID: 0
SEGOFFLOAD: YES  SYSPLEXWLMPOLL: 060  MAXRECS:   100
EXPLICITBINDPORTRANGE:  07000-07002   IQDMULTIWRITE: YES  1
SYSPLEX MONITOR:
  TIMERSECS: 0060  RECOVERY: NO   DELAYJOIN: NO   AUTOREJOIN: NO
  MONINTF:   NO    DYNROUTE: NO
ZIIP:
  IPSECURITY: NO   IQDIOMULTIWRITE: YES  2
```

In this example, the numbers correspond to the following information:

1. HiperSockets Multiple Write is enabled.

2. zIIP Adjunct Processor is used

Then, we use the following command to see the status of the device used. Example A-8 shows the output of the command:

```
D TCPIP,TCPIPA,N,DEV
```

Example A-8 Output of NETSTAT DEVICE command

```
DEVNAME: IUTIQDF4          DEVTYPE: MPCIPA
  DEVSTATUS: READY
  LNKNAME: IUTIQDF4L         LNKTYPE: IPAQIDIO   LNKSTATUS: READY
    IPBROADCASTCAPABILITY: NO
    CFGROUTER: NON                  ACTROUTER: NON
    ARPOFFLOAD: YES                 ARPOFFLOADINFO: YES
    ACTMTU: 8192
    VLANID: NONE
    READSTORAGE: GLOBAL (2048K)
    SECCLASS: 255                   MONSYSPLEX: NO
    IQDMULTIWRITE: ENABLED (ZIIP)
  BSD ROUTING PARAMETERS:
    MTU SIZE: 8192             METRIC: 80
    DESTADDR: 0.0.0.0          SUBNETMASK: 255.255.255.0
```

The CPU RMF and WLM RMF reports (service class SYSSTC for TCP/IP and FTP and service class BATCHHI for the FTP batch job) are shown in Figure A-4.

```
-CPU  2817   MODEL  z196   H/W MODEL 32   SEQUENCE CODE 000000000001DE50    HIPERDISPATCH=NO
0---CPU---    ---------------- TIME % ----------------     LOG PROC      --I/O INTERRUPTS--
 NUM  TYPE    ONLINE    LPAR BUSY    MVS BUSY    PARKED     SHARE %       RATE     % VIA TPI
  0    CP     100.00     4.63         4.69       ------      11.1         285.7     0.56
  1    CP     100.00     4.63         4.68       ------      11.1         282.1     0.46
 TOTAL/AVERAGE           4.63         4.68                   22.2         567.9     0.51        a
0 6    IIP    100.00     3.15         3.14       ------      50.0
 TOTAL/AVERAGE           3.15         3.14                   50.0                               f

 REPORT BY: POLICY=POL01      WORKLOAD=SYSTEM      SERVICE CLASS=SYSSTC     RESOURCE GROUP=*NONE
                                                   CRITICAL     =NONE

 -TRANSACTIONS-  TRANS-TIME HHH.MM.SS.TTT  --DASD I/O--  ---SERVICE---   SERVICE TIME  ---APPL %---
 AVG      26.00  ACTUAL                 0  SSCHRT   4.8  IOC     15346   CPU   24.302  CP      2.92    b
 MPL      26.00  EXECUTION              0  RESP     1.8  CPU    10861K   SRB   11.555  AAPCP   0.00
 ENDED        0  QUEUED                 0  CONN     1.5  MSO         0   RCT    0.000  IIPCP   0.00
 END/S     0.00  R/S AFFIN              0  DISC     0.1  SRB     5164K   IIT    0.051
 #SWAPS       0  INELIGIBLE             0  Q+PEND   0.2  TOT    16041K   HST    0.000  AAP     0.00
 EXCTD        0  CONVERSION             0  IOSQ     0.0  /SEC    26735   AAP    0.000  IIP     3.06    c
 AVG ENC   0.00  STD DEV                0                                IIP   18.374
 REM ENC   0.00                                          ABSRPTN  1028
 MS ENC    0.00                                          TRX SERV 1028

REPORT BY: POLICY=POL01      WORKLOAD=TEST01      SERVICE CLASS=BATCHHI     RESOURCE GROUP=*NONE
                                                  CRITICAL     =NONE
-TRANSACTIONS-  TRANS-TIME HHH.MM.SS.TTT  --DASD I/O--  ---SERVICE---   SERVICE TIME  ---APPL %---
AVG       0.93  ACTUAL           9.21.352  SSCHRT 484.4  IOC      2907K  CPU   15.166  CP      3.18     d
MPL       0.93  EXECUTION        9.20.829  RESP     1.0  CPU      6778K  SRB    3.006  AAPCP   0.00
ENDED        1  QUEUED                523  CONN     0.8  MSO          0  RCT    0.000  IIPCP   0.00
END/S     0.00  R/S AFFIN               0  DISC     0.0  SRB      1344K  IIT    0.880
#SWAPS       0  INELIGIBLE              0  Q+PEND   0.1  TOT     11029K  HST    0.000  AAP     0.00
EXCTD        0  CONVERSION              0  IOSQ     0.0  /SEC    18382   AAP    0.000  IIP     0.00     e
AVG ENC   0.00  STD DEV                 0                                IIP    0.000
REM ENC   0.00                                          ABSRPTN    20K
MS ENC    0.00                                          TRX SERV   20K
```

Figure A-4 Test result for IDQMULTIWRITE and ZIIP

The total CPU usage for LPAR is 4.63 (a) and 3.15 for ZIIP (f). The APPL% for service class SYSSTC is 2.92 for CP and 3.06 for IIP (b and c). The APPL% for service class BATCHHI is 3.18 for CP and 0 for IIP (d and e).

In summary, when you use HiperSockets Multiple Write and zIIP-Assisted HiperSockets Multiple Write, you see a performance improvement and reduction in CPU utilization for large outbound messages, as shown in Table A-1 and Table A-2.

Table A-1 CPU utilization

Options	**LAPR BUSY**		**MVS BUSY**	
	CP	**zIIP**	**CP**	**zIIP**
No IQDMULTIWRITE	5.60	0.00	5.71	0.00
IQDMULTIWRITE	5.12	0.00	5.25	0.00
IQDMULTIWRITE + ZIIP	4.63	3.15	4.68	3.14

Table A-2 APPL% in WLM report

Options	**SYSSTC APPL%**		**BATCHHI APPL%**	
	CP	**zIIP**	**CP**	**zIIP**
NO IDQMULTIWRITE	5.82	0.00	3.02	0.00
IQDMULTIWRITE	4.42	0.00	3.18	0.00
IQDMULTIWRITE + ZIIP	2.92	3.06	3.18	0.00

B

Our implementation environment

We wrote the four *IBM z/OS Communications Server TCP/IP Implementation* books at the same time. Given the complexity of this project, we needed to be creative in organizing the test environment so that each team could work with minimal coordination and interference from the other teams. In this appendix, we show the complete environment that we used for the four books and the environment that we used for this book.

B.1 The environment used for all four books

To enable concurrent work on each of the four books, we set up and shared the test environment illustrated in Figure B-1.

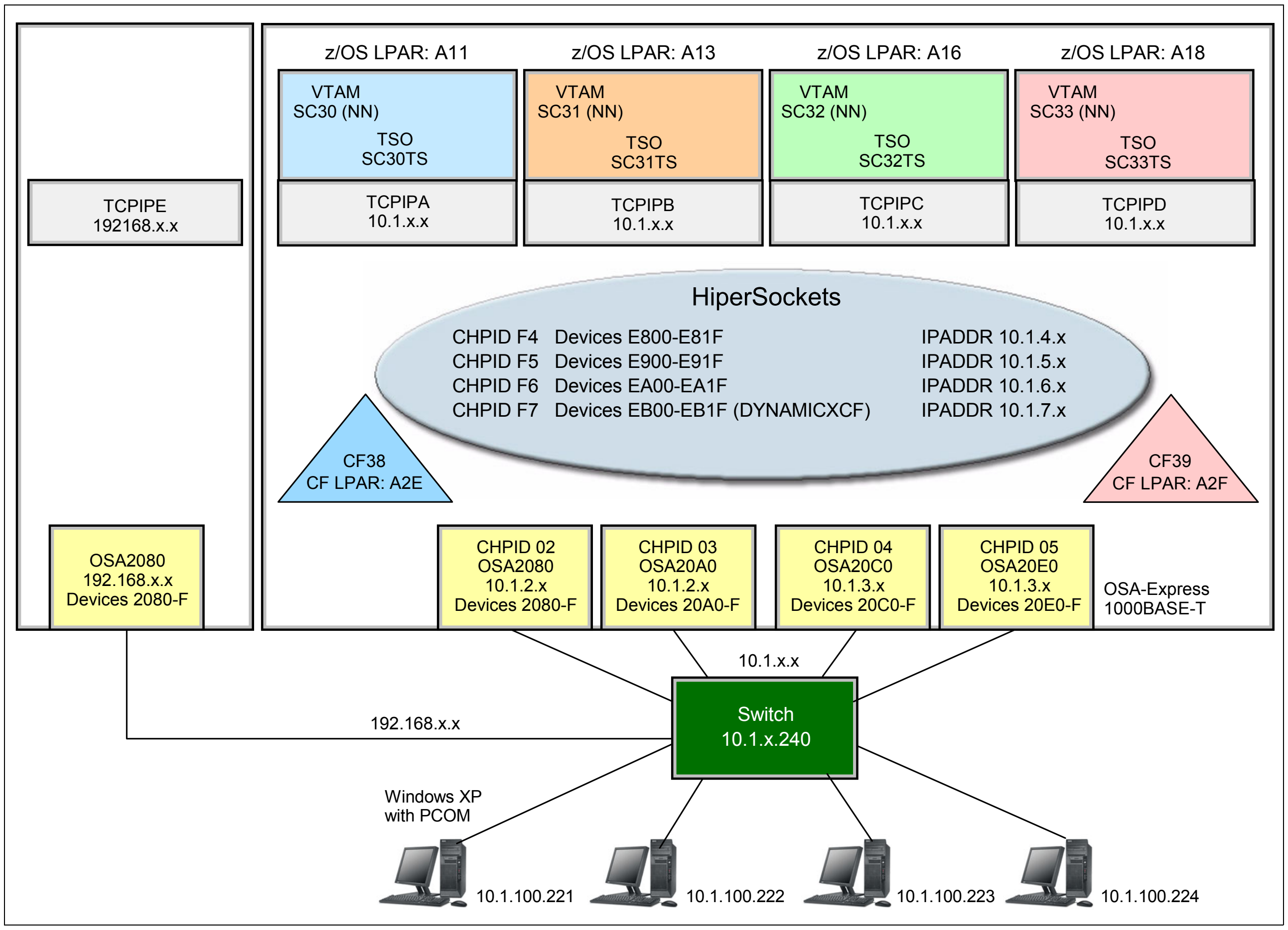


Figure B-1 Our implementation environment

We wrote our books (and ran our implementation scenarios) using four logical partitions (LPARs) on an IBM System z196-32 (referred to as LPARs A11, A13, A16, and A18). We implemented and started one TCP/IP stack on each LPAR. Each LPAR shared the following resources:

- HiperSockets inter-server connectivity
- Coupling facility connectivity (CF38 and CF39) for Parallel Sysplex scenarios
- Eight OSA-Express3 1000BASE-T Ethernet ports connected to a switch

Finally, we shared four Windows workstations, representing corporate network access to the z/OS networking environment. The workstations are connected to the switch. For verifying our scenarios, we used applications such as TN3270 and FTP.

The IP addressing scheme that we used allowed us to build multiple subnetworks so that we would not impede ongoing activities from other team members.

VLANs were also defined to isolate the TCP/IP stacks and portions of the LAN environment (Figure B-2).

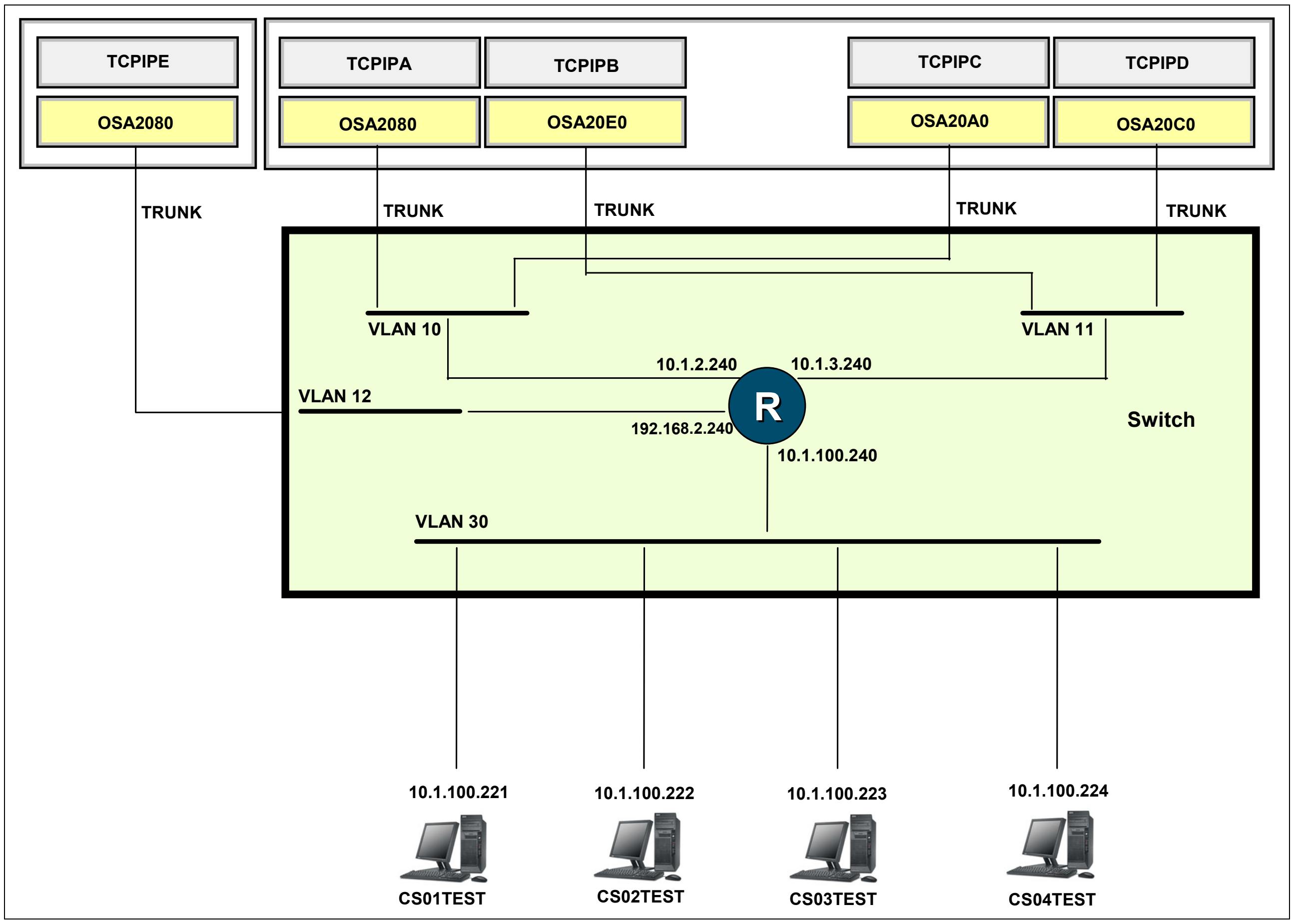


Figure B-2 LAN configuration: VLAN and IP addressing

B.2 Our focus for this book

Figure B-3 depicts the environment that we worked with, as required for our basic function implementation scenarios.

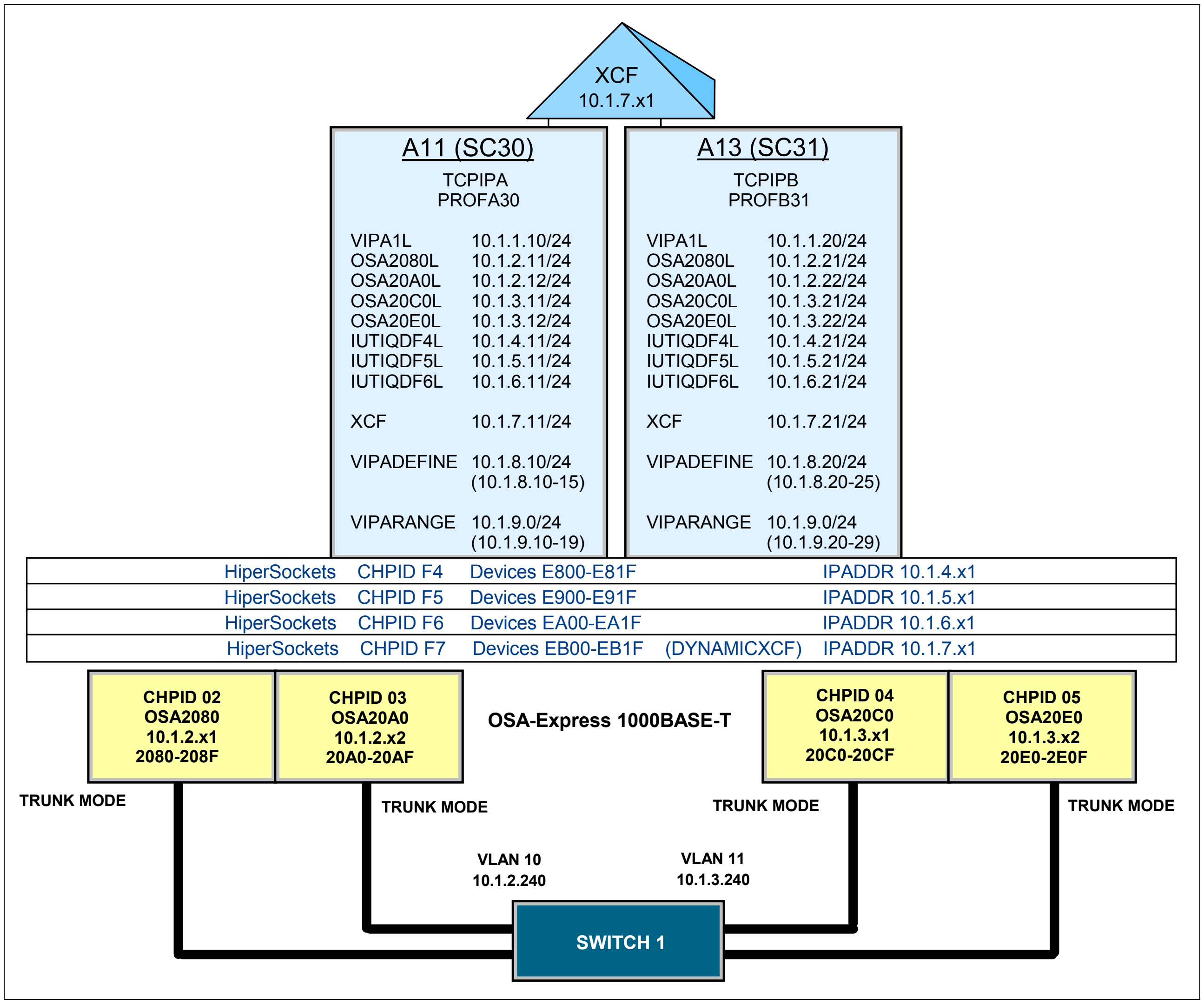


Figure B-3 Our environment for this book

Related publications

The publications listed in this section are considered particularly suitable for a more detailed discussion of the topics covered in this book.

IBM Redbooks

The following IBM Redbooks publications provide additional information about the topic in this document. Note that some publications referenced in this list might be available in softcopy only.

- *HiperSockets Implementation Guide*, SG24-6816
- *IBM z/OS V2R1 Communications Server TCP/IP Implementation Volume 1: Base Functions, Connectivity, and Routing*, SG24-8096
- *IBM z/OS V2R1 Communications Server TCP/IP Implementation Volume 2: Standard Applications*, SG24-8097
- *IBM z/OS V2R1 Communications Server TCP/IP Implementation Volume 4: Security and Policy-Based Networking*, SG24-8099
- *Implementing PKI Services on z/OS*, SG24-6968
- *IP Network Design Guide*, SG24-2580
- *Migrating Subarea Networks to an IP Infrastructure Using Enterprise Extender*, SG24-5957
- *OSA-Express Implementation Guide*, SG24-5948
- *SNA in a Parallel Sysplex Environment*, SG24-2113
- *TCP/IP Tutorial and Technical Overview*, GG24-3376
- *z/OS 1.6 Security Services Update*, SG24-6448
- *z/OS Infoprint Server Implementation*, SG24-6234

You can search for, view, download or order these documents and other Redbooks, Redpapers, Web Docs, draft and additional materials, at the following website:

ibm.com/redbooks

Other publications

These publications are also relevant as information sources:

- *OSA-Express Customer's Guide and Reference*, SA22-7935
- *z/OS Communications Server: CSM Guide*, SC31-8808
- *z/OS Communications Server: IP Configuration Guide*, SC27-3650
- *z/OS Communications Server: IP Configuration Reference*, SC27-3651
- *z/OS Communications Server: IP Diagnosis Guide*, GC31-8782
- *z/OS Communications Server: IP Messages Volume 1 (EZA)*, SC31-8783

- *z/OS Communications Server: IP Messages Volume 2 (EZB, EZD)*, SC31-8784
- *z/OS Communications Server: IP Messages Volume 3 (EZY)*, SC31-8785
- *z/OS Communications Server: IP Messages Volume 4 (EZZ, SNM)*, SC31-8786
- *z/OS Communications Server: IP Programmer's Guide and Reference*, SC31-8787
- *z/OS Communications Server: IP and SNA Codes*, SC31-8791
- *z/OS Communications Server: IP Sockets Application Programming Interface Guide and Reference*, SC31-8788
- *z/OS Communications Server: IP System Administrator's Commands*, SC27-3661
- *z/OS Communications Server: IP User's Guide and Commands*, SC31-8780
- *z/OS Communications Server: IPv6 Network and Application Design Guide*, SC31-8885
- *z/OS Communications Server: New Function Summary*, GC31-8771
- *z/OS Communications Server: Quick Reference*, SX75-0124
- *z/OS Communications Server: SNA Operation*, SC31-8779
- *z/OS Migration*, GA22-7499
- *z/OS MVS IPCS Commands*, SA22-7594
- *z/OS MVS System Commands*, SA22-7627
- *z/OS TSO/E Command Reference*, SA22-7782
- *z/OS UNIX System Services Command Reference*, SA22-7802
- *z/OS XL C/C++ Run-Time Library Reference*, SA22-7821
- *z/OS UNIX System Services Command Reference*, SA22-7802
- *z/OS UNIX System Services File System Interface Reference*, SA22-7808
- *z/OS UNIX System Services Messages and Codes*, SA22-7807
- *z/OS UNIX System Services Parallel Environment: Operation and Use*, SA22-7810
- *z/OS UNIX System Services Planning*, GA22-7800
- *z/OS UNIX System Services Programming: Assembler Callable Services Reference*, SA22-7803
- *z/OS UNIX System Services Programming Tools*, SA22-7805
- *z/OS UNIX System Services User's Guide*, SA22-7801

Online resources

These websites are also relevant as information sources:

- Mainframe networking

  `http://www.ibm.com/servers/eserver/zseries/networking/`
- z/OS Communications Server product overview

  `http://www.ibm.com/software/network/commserver/zos/`
- z/OS Communications Server product support

  `http://www-306.ibm.com/software/network/commserver/zos/support/`
- z/OS Communications Server publications

  `http://www-03.ibm.com/systems/z/os/zos/bkserv/r9pdf/#commserv`

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Redbooks

IBM z/OS V2R1 Communications Server TCP/IP Implementation Volume 3: High Availability, Scalability, and Performance

(0.5” spine)
0.475”<->0.873”
250 <-> 459 pages

IBM z/OS V2R1 Communications Server TCP/IP Implementation Volume 3: High Availability, Scalability, and Performance

Describes z/OS Communications Server TCP/IP high availability capabilities

Includes TCP/IP high availability implementation examples

Provides insights into performance and tuning

For more than 40 years, IBM mainframes have supported an extraordinary portion of the world's computing work, providing centralized corporate databases and mission-critical enterprise-wide applications. IBM System z, the latest generation of the IBM distinguished family of mainframe systems, has come a long way from its IBM System/360 heritage. Likewise, its IBM z/OS operating system is far superior to its predecessors in providing, among many other capabilities, world-class and state-of-the-art support for the TCP/IP Internet protocol suite.

TCP/IP is a large and evolving collection of communication protocols managed by the Internet Engineering Task Force (IETF), an open, volunteer organization. Because of its openness, the TCP/IP protocol suite has become the foundation for the set of technologies that form the basis of the Internet. The convergence of IBM mainframe capabilities with Internet technology, connectivity, and standards (particularly TCP/IP) is dramatically changing information technology and driving requirements for even more secure, scalable, and highly available mainframe TCP/IP implementations.

The IBM z/OS Communications Server TCP/IP Implementation series provides understandable, step-by-step guidance for enabling the most commonly used and important functions of z/OS Communications Server TCP/IP.

This IBM Redbooks publication is for people who install and support z/OS Communications Server. It starts by describing virtual IP addressing (VIPA) for high-availability, with and without a dynamic routing protocol. It describes several workload balancing approaches with the z/OS Communications Server. It also explains optimized sysplex distributor intra-sysplex load balancing. This function represents improved application support using optimized local connections together with weight values from extended Workload Manager (WLM) interfaces. Finally, this book highlights important tuning parameters and suggests parameter values to maximize performance in many client installations.

SG24-8098-00 ISBN 0738438812