IBM

Redpaper

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IBM System z Qualified Wavelength Division Multiplexing: Ciena 6500 Packet-Optical Platform Release 8.0

This IBM® Redpaper™ publication is one in a series that describes IBM System z® qualified optical Wavelength Division Multiplexing (WDM) vendor products. IBM Geographically Dispersed Parallel Sysplex™ (IBM GDPS®) solutions with Server Time Protocol (STP) are covered. This series also describes IBM supported solutions for applications that are not GDPS. Applications that are not GDPS include the protocols needed for cross-site connectivity of a multisite Parallel Sysplex or one of the remote copy technologies described in this paper. GDPS qualification testing is conducted at the IBM Vendor Solutions Connectivity (VSC) Lab in Poughkeepsie, NY, US.

IBM and Ciena successfully completed qualification testing of the Ciena 6500 Packet-Optical Platform. This paper describes the applicable environments, protocols, and topologies that are qualified and supported by System z for connecting to the Ciena 6500 Packet-Optical Platform hardware and software, Release 8.0.

This paper is intended for anyone who wants to learn more about Ciena 6500 Packet-Optical Platform Release 8.0. This document is not meant to be used to determine qualified products. To ensure that the planned products to be implemented are qualified, registered users can see the IBM Resource Link® library for current information about qualified WDM vendor products:

https://www.ibm.com/servers/resourcelink/lib03020.nsf/pages/systemzQualifiedWdmProductsForGdpsSolutions?OpenDocument&pathID=

For more information about IBM Redbooks® publications for System z qualified WDM vendor products, see this website:

http://www.redbooks.ibm.com/cgi-bin/searchsite.cgi?query=qualified+AND+wdm&SearchOrder=1&SearchFuzzy=

System z qualification overview

GDPS is an enterprise-wide continuous availability (CA) and disaster recovery (DR) automation solution that can manage recovery from planned and unplanned outages across distributed servers and System z servers. GDPS can be configured in either a single site or in a multisite configuration. It is designed to manage remote copy configuration between storage subsystems, automate Parallel Sysplex operational tasks, and affect failure recovery. This configuration is done from a single point-of-control, which leads to improved application availability. Historically, this solution was known as a GDPS. Today, GDPS continues to be applied as a general term for a suite of business continuity solutions. This term includes solutions that do not require a dispersed or multisite sysplex environment.

GDPS supports the following forms of remote copy in multisite solutions:

► IBM System Storage® Metro Mirror, a synchronous form of remote copy previously known as Peer-to-Peer Remote Copy (PPRC)

► IBM System Storage Global Mirror, an asynchronous form of remote copy for System z and distributed systems

► IBM System Storage z/OS® Global Mirror, an asynchronous form of remote copy for System z, previously known as Extended Remote Copy (XRC)

Depending on the form of remote copy that is implemented, the GDPS solution is known as one of these configurations:

► GDPS with Metro Mirror
► GDPS with Global Mirror
► GDPS with z/OS Global Mirror

GDPS also offers two solutions that combine the technologies of Metro Mirror with either Global Mirror or z/OS Global Mirror. This combination allows clients to meet requirements for CA with zero data loss locally within metropolitan distances (for most failures). The combination also provides a disaster recovery solution in the case of a region-wide disaster.

The disaster recovery solutions include the following options:

► GDPS with Metro and Global Mirror (GDPS with MGM), which is a cascading data replication solution for both System z and distributed systems data

► GDPS with Metro and z/OS Global Mirror (GDPS with MzGM), which is a multitarget data replication solution for System z data

The GDPS solution is also independent of the disk vendor, if the vendor meets the specific levels of Metro Mirror, Global Mirror, and z/OS Global Mirror architectures.

For more information about GDPS, see this website:

http://www.ibm.com/systems/z/advantages/gdps/index.html

IBM supports WDM products that are qualified by System z for use in GDPS solutions. To obtain this qualification, WDM vendors obtain licensed IBM patents, intellectual property, and know-how that are related to the GDPS architecture. This licensing provides vendors access to the proprietary IBM protocols and applications that are used in a GDPS environment. These proprietary items include IBM Sysplex Timer®, InterSystem Channel (ISC), STP, Metro Mirror, Global Mirror, and z/OS Global Mirror.

Licensing of IBM patents also provides the WDM vendor with technical information that pertains to future IBM releases. Qualified vendors typically license this information for an extended period. This license allows vendors to subscribe to the latest GDPS architecture changes and to be among the first to the market with offerings that support these features.

> **Licensing:** It is suggested that you check with your WDM vendor for your current IBM technology and patent licensing status.

In addition, IBM tested and qualified these vendor products. The same test environment and procedures were used on the products that were used on the protocols that provide the required connectivity of a GDPS configuration. This testing includes functionality, recovery, and, in some cases, performance measurements. Having access to these test facilities allows IBM to configure a fully functional sysplex. By using the test facilities, you can simulate failure and recovery actions that cannot be tested as part of a working client environment.

IBM has the facilities to test and qualify these products with both current and previous generation equipment within the VSC Lab in Poughkeepsie, NY. With this qualification testing, IBM can reproduce any concerns that might arise when using this equipment in a client application.

Figure 1 shows the GDPS test environment that is used for WDM vendor qualification.
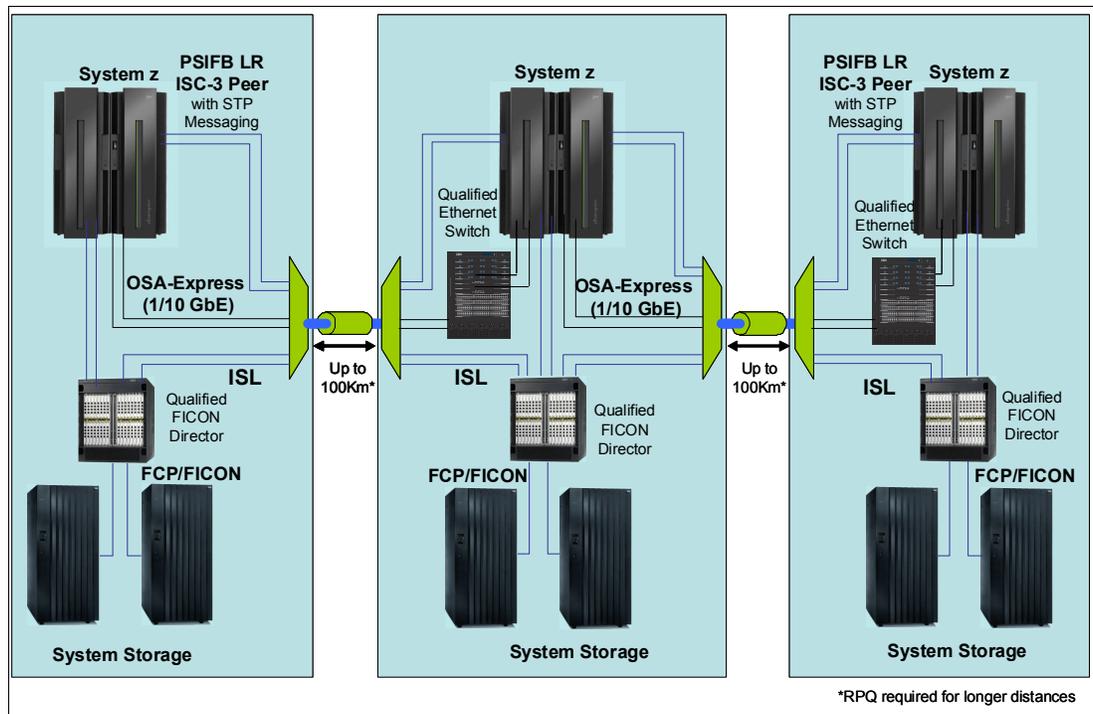

Figure 1   VSC Lab environment

Qualification testing

The VSC Lab contains System z hardware with software applications that test the interoperability of WDM products within a GDPS. A typical qualification test cycle is six to eight weeks in length.

The hardware that was used for testing purposes includes (but is not limited to) the following components:

► IBM System z servers enabled for STP
► IBM 9037 Model 2 Sysplex Timers
► IBM System Storage
► IBM 9032 Enterprise Systems Connection (ESCON®) Directors
► IBM System z qualified Fibre Connection (FICON®) Directors
► IBM Ethernet products

WDM links of varying distances are deployed by using spools of single-mode fiber in lengths of 5 - 50 km (3.11 - 31.07 miles). Multiple spools are interconnected to test WDM link protocols up to the maximum supported distances. To achieve the maximum distances that are qualified for GDPS protocols, vendors can use optical amplifiers (OAs) and dispersion compensation units (DCUs). They can insert the OAs and DCUs, at various link points, to condition the signals on the fiber links. These links are connected to the WDM equipment.

Qualified DCUs: Fiber-based DCUs are not qualified for use in STP applications unless stated in the qualification letter.

The operating system and application software are installed to create and to stress test the GDPS environment. The software used in the test environment includes, but is not limited to, the following components:

► z/OS, Linux on System z, and Parallel Sysplex software exploiters
► Coupling Facility Control Code (CFCC)
► IBM proprietary software and microcode utility test suites

As part of the GDPS qualification test, IBM proprietary software and microcode utility test suites are used. The software and test suites drive the various GDPS components and protocols to the full data rate of each link type that is transported by the WDM equipment. This level of testing ensures that the maximum channel utilization is achieved and tested to levels well beyond typical client environments.

The test suites are used for verification of System z architecture functionality. For a trial to be classified as successful during these functionality tests, no errors can be detected by the attached subsystems. Any errors that are detected during this testing are captured and analyzed by the test suites.

The test suites are also used for verification of System z architecture recovery by creating various fault and error conditions. The recovery tests check for the correct detection of a fault or error condition by the attached subsystems. The tests also ensure that the recovery adheres to the System z architecture rules.

Several of the recovery tests conducted for each link type include the following actions:

► Link state change interrupt detection and recovery: Links are deliberately broken and reestablished to ensure that detection and error recovery occur correctly.

► Link error threshold and link synchronization error detection and recovery: Errors are deliberately injected, at the application and channel subsystem levels, into the link protocol data streams to ensure that detection and error recovery take place correctly.

► Link service and maintenance package recovery: Link hardware maintenance actions are conducted to ensure that link state change detection and recovery take place correctly.

- Link protection schemes and recovery: Vendor-specific protection methods are tested to ensure that the expected link errors are detected and that recovery takes place correctly.

- STP timing link recovery: STP timing links are broken to ensure that changes to the Coordinated Timing Network behave correctly when the break occurs and when the links are reconnected.

GDPS components and protocols

The IBM technologies featured in this section are functional components of GDPS and are tested during the qualification process. Clients can also use these components in environments that do not require a full GDPS solution. The testing provides a level of assurance that the components function when used with a qualified WDM platform.

Components

The following GDPS components are tested during the qualification process:

- IBM System z servers
- IBM Parallel Sysplex
- IBM System Storage
- IBM System Storage Metro Mirror (PPRC)
- IBM System Storage Global Mirror
- IBM System Storage z/OS Global Mirror (XRC)
- Optical Wavelength Division Multiplexer (WDM)
- IBM Ethernet products

Protocols

Table 1 lists the GDPS connectivity protocols and their data transfer rates. Not all protocols were tested on the Ciena 6500 Packet-Optical Platform. For a complete list of the protocols and interface cards that were qualified, see Table 2 on page 13.

Table 1   GDPS supported protocols

Protocol	Data transfer rate
Enterprise Systems Connection (ESCON)	200 Mbps[a]
Control Link Oscillator (CLO)	8 Mbps
External Time Reference (ETR)	8 Mbps
Fibre Connection (FICON)	1 Gbps
Fibre Connection (FICON) Express2	1, 2 Gbps
Fibre Connection (FICON) Express4	1, 2, 4 Gbps
Fibre Connection (FICON) Express8	2, 4, 8 Gbps
Fibre Channel FC100/ 200/ 400/ 800	1/ 2/ 4/ 8 Gbps
Inter-Switch Link (ISL) FC100/ 200/ 400/ 800/ 1000	1/ 2/ 4/ 8/ 10 Gbps
InterSystem Channel-3 (ISC-3) Compatibility Mode	1 Gbps
InterSystem Channel-3 (ISC-3) Peer Mode	2 Gbps

Protocol	Data transfer rate
InterSystem Channel-3 (ISC-3) Peer Mode[b]	1 Gbps
STP (ISC-3 Peer Mode with STP message passing)	2 Gbps
STP (ISC-3 Peer Mode with STP message passing)[b]	1 Gbps
STP (Parallel Sysplex InfiniBand Long Reach (PSIFB LR) 1x IB-single data rate (SDR) with STP message passing)	2.5 Gbps
STP (PSIFB LR 1x IB-double data rate (DDR) with STP message passing)	5 Gbps
Ethernet	1, 10 Gbps

a. Effective channel data rate of an ESCON channel is affected by distance.
b. Requires a request for price quotation (RPQ) 8P2197. This RPQ provides an ISC-3 Daughter Card that clocks at 1.062 Gbps in peer mode.

Often, these supported protocols are also used in environments that are not GDPS. Robust testing is conducted during the qualification process. The results must provide clients with a high level of confidence when using these System z qualified optical WDM vendor products in environments that are not GDPS.

Server Time Protocol (STP)

STP is designed to provide the capability for multiple servers and Coupling Facilities (CFs) to maintain time synchronization with each other without requiring an IBM Sysplex Timer. STP can help provide functional and economic benefits when compared to the Sysplex Timer. STP allows concurrent migration from an ETR network and can coexist with an ETR network.

STP is a message-based protocol in which STP timekeeping information is passed over externally defined coupling links: InterSystem Channel-3 (ISC-3) peer mode and PSIFB links. ISC-3 links in peer mode and PSIFB Long Reach (LR) are the only coupling links that can be used to transport STP messages between data centers over a WDM.

The STP design introduced a concept called *Coordinated Timing Network* (CTN), which is a collection of servers and CFs that are time synchronized to a time value. This value is called *Coordinated Server Time* (CST). The CST represents the time value for the entire network of servers. A CTN can be configured as either an STP-only CTN or a Mixed CTN. For more information, see the *Server Time Protocol Planning Guide*, SG24-7280; *Server Time Protocol Implementation Guide*, SG24-7281; and *Server Time Protocol Recovery Guide*, SG24-7380.
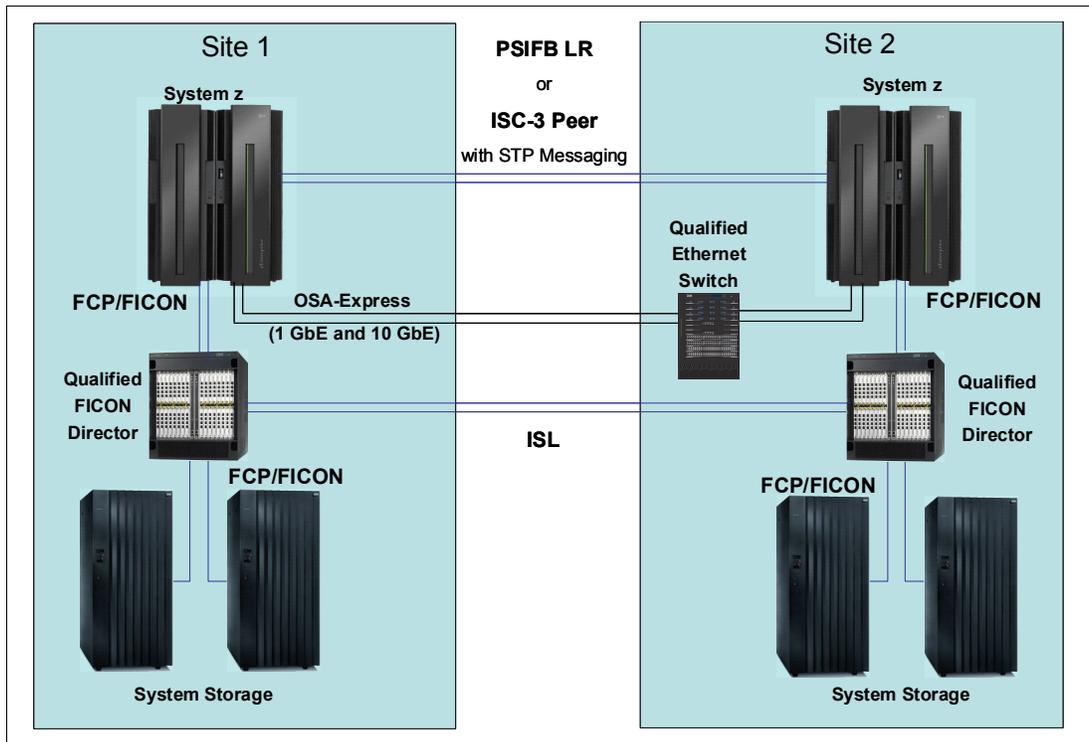
Figure 2 shows a multisite STP-only CTN.

Figure 2   Multisite STP-only CTN

IBM Sysplex Timer

The IBM Sysplex Timer is a mandatory component of an ETR network and an STP Mixed CTN. The Sysplex Timer provides an External Time Reference (ETR) to synchronize the time-of-day (TOD) clocks on attached System z servers in a GDPS or PPRC environment.
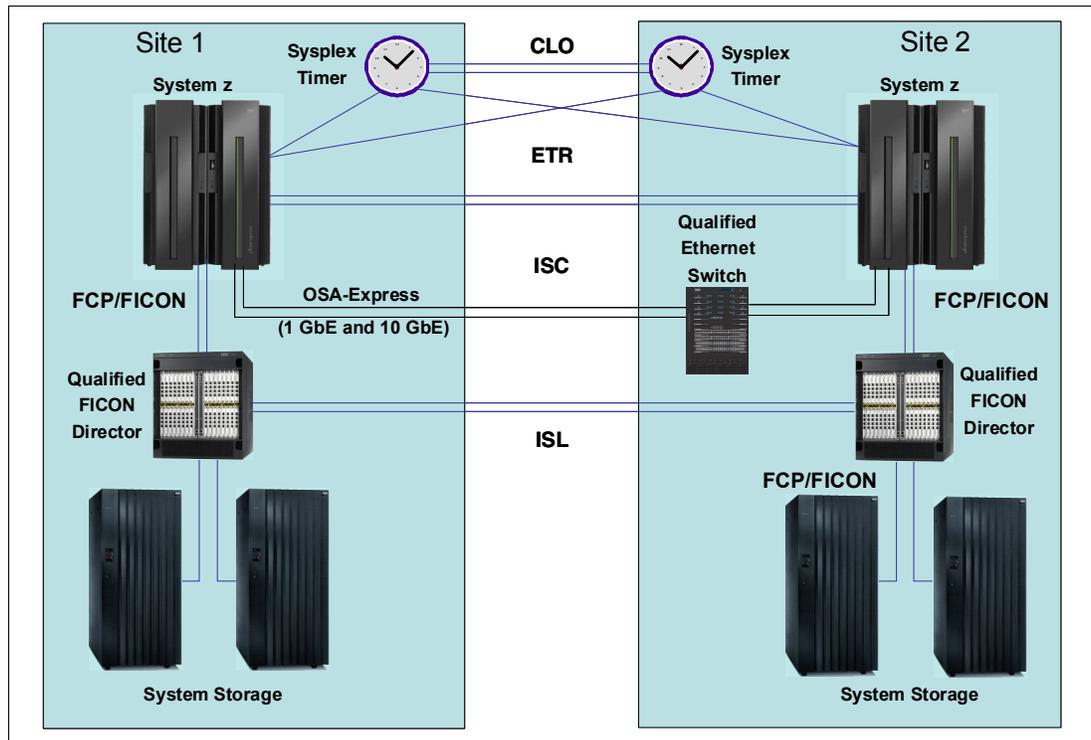
Figure 3 shows a multisite ETR network.

Figure 3   Multisite ETR network with Sysplex Timers

The Sysplex Timer uses two link types:

► External Time Reference (ETR)

ETR links are connections between the Sysplex Timer and the System z server ETR ports that provide TOD clock synchronization between multiple servers.

► Control Link Oscillator (CLO)

CLO links are connections between the two Sysplex Timer units in an expanded availability configuration that allow synchronization of the Sysplex Timer timing signals.

GDPS connectivity considerations with WDM

When planning WDM intersite connectivity for GDPS environments, consider the following items:

► Differential Delay: The difference in the distance or latency between a transmit fiber and a receive fiber in a single fiber pair of a timing link. When configuring, adhere to the following requirements:

– To ensure correct server time synchronization, examine the end-to-end lengths of the transmit and receive fibers within an individual STP link (ISC-3 Peer Mode with STP messaging or PSIFB). The lengths must not exceed the equivalent of *900 meters (984.25 yards)* differential delay between the transmit and receive paths of the link. This stipulation includes all dense wavelength division multiplexing (DWDM) components, OAs, DCUs[1], dark fiber links, and any time-division multiplexing (TDM)-based aggregation.

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[1] Fiber-based DCUs are not qualified for use in STP applications unless stated in the qualification letter.

- To ensure correct Sysplex Timer and server time synchronization, the end-to-end lengths of the transmit and receive fibers within an individual ETR or CLO link must be equal (within *10 meters) (10.94 yards)*. This stipulation includes all DWDM components, OAs, DCUs, and dark fiber links.

> **Supported devices:** OAs and DCUs might contain significant lengths of fiber that must be included in the differential delay calculation for timing links. Not all DCUs and OAs are supported. We suggest that you check the qualification letters for supported devices.

► If both CF data and STP timing information must be transmitted between two servers, you cannot select a subset of coupling links to be used just for the STP timing information.

► Protection schemes, for individual timing links or for fiber trunks that transport timing links, must be bidirectional (switch both transmit and receive paths in the event of a failure). This configuration ensures that the correct differential delay is maintained.

► WDM configurations must have high availability topologies to ensure that there are no single points of failure.

► Fiber trunk protection schemes must be designed with two trunk switching modules and four site-to-site fiber pairs that are carried over at least two diverse routes. STP, ETR, and CLO links must connect by using separate trunk switching modules to ensure that a fiber trunk protection event does not interrupt all timing links simultaneously.

► TDM-based aggregation WDM hardware can be used for STP links (ISC-3 Peer Mode or PSIFB LR with STP message passing) only if it is qualified for STP usage.

► GDPS WDM configuration must be a point-to-point fixed dark fiber network.

For more information about the STP recovery process, see the *Server Time Protocol Recovery Guide*, SG24-7380.

Technical description

The Ciena 6500 Packet-Optical Platform is a scalable, high-speed fiber-optic data transport system. It consists of a modular chassis, which can be interconnected to form an optical network that supports International Telecommunications Union (ITU)-specific wavelengths. The wavelengths are multiplexed onto a single pair of fibers by using optical WDM.

The optical network that connects the Ciena 6500 Packet-Optical Platform can be configured in a two-site point-to-point, multisite ring or meshed network. For GDPS, IBM qualifies point-to-point topologies only.

Multiple client interfaces can be aggregated onto a single wavelength with the use of Muxponder interface cards.

The Ciena 6500 Packet-Optical Platform was qualified by using software Release 8.0. It has a modular chassis that can house multiple optical interface cards, depending on the chassis. Multiple Ciena 6500 Packet-Optical Platform chassis can be interconnected to support larger quantities of client interfaces.

Interface cards and modules

This section includes a detailed list of the Ciena 6500 Packet-Optical Platform optical interface cards and modules that are qualified by System z GDPS.

The following optical interface cards and modules are qualified by System z GDPS testing:

► Transponder

Transponder cards connect client equipment to the WDM platform. The transponder card converts client optical signals to an ITU-compliant DWDM wavelength for transmission to the remote site.

Ciena 6500 Packet-Optical Platform Transponder cards have pluggable client optical transceivers.

The 2x10G Optical Transponder (OTR) with Strong FEC[2] and FC800/FC1200 is a qualified card type of the Ciena 6500 Packet-Optical Platform.

► Muxponder

The Ciena 6500 Packet-Optical Platform supports the aggregation of client signals. Muxponder cards use TDM to aggregate multiple client optical interfaces for transport over a single ITU-specific wavelength.

Muxponder cards have pluggable client optical transceivers that support different client protocols and fiber types.

The following Ciena 6500 Packet-Optical Platform Muxponder card types are qualified:

– eDC40G OCLD MetroHRSx with 4xOC-192/STM-64/10 GbE/OTU2/FC Mux OCI XFP
– Flex MOTR 8x SFP, 2x XFP, 8 client, and 2-line port card
– SuperMux 24 Port I/O 1x XFP and 10x SFP, 24-port card
– SuperMux 10 Port SFP 10G DWDM, 10-port card

► Optical Filter Modules

Optical Filter Modules are optical components that combine (multiplex) or separate (demultiplex) multiple optical signals on a fiber link.

The reconfigurable optical add-drop multiplexer (ROADM) allows adding or dropping of optical signals at the wavelengths layer. This configuration is allowed without an optical-electrical-optical conversion in multiple directions in an optical cross-connect system.

The main component of the ROADM is the Wavelength Selective Switch (WSS), which combines the multiplexing and demultiplexing functionality with per-wavelength optical signal switching.

► Optical Amplifier (OA)

The OA module provides in-line optical amplification of multiple ITU-specific wavelengths within a fiber. For particular extended distances, the use of these erbium-doped fiber amplifiers (EDFAs) might be required. EDFAs cannot be used to amplify Cisco Coarse Wavelength Division Multiplexing (CWDM) signals.

► Dispersion Compensation Unit (DCU)

The DCU provides compensation to chromatic dispersion fiber impairment, which causes signal degradation and limits the transmission distance.

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[2] FEC - Forward Error Correction

The fixed DCU modules from the Ciena 4200 Advanced Services Platform can be used with the Ciena 6500 Packet-Optical Platform operating with the following card types only:

– eDC40G OCLD MetroHRSx with 4xOC-192/STM-64/10 GbE/OTU2/FC Mux OCI XFP
– 2x10G OTR with Strong FEC and FC800/FC1200
– Flex MOTR 8x SFP, 2x XFP, 2-, or 8-port card
– SuperMux 24 Port I/O 1x XFP / 10x SFP, 24-port card

Delay calculation for timing links: OAs and DCUs contain significant lengths of fiber, which must be included in the differential delay calculation for timing links.

► Protection Switch Module (PSM)

The Ciena 6500 Packet-Optical Platform supports optically switched fiber protection for point-to-point DWDM links with the use of the PSM. The PSM protects site-to-site traffic from physical damage to a fiber or fiber pair by switching to a redundant fiber or fiber pair.

The following Ciena 6500 Packet-Optical Platform PSM types are qualified:

– Photonic Trunk Switch (PTS): Bidirectional optical splitter and switch module
– Enhanced Trunk Switch (ETS): Optical splitter and switch module

Topologies and protection schemes

System z qualifies a two-site point-to-point WDM network topology and protection against failures in site-to-site fiber links or failures in individual components within the WDM network for GDPS.

GDPS is a high-availability solution that can use several protection schemes. Some restrictions apply for particular protocols, for example, Sysplex Timer (ETR and CLO) and STP (ISC-3 Peer Mode and PSIFB LR) links.

Important: Protection schemes must guarantee the correct differential delay for individual timing links:

► STP links must not exceed the equivalent of *900 meters (984.25 yards)* differential delay between the transmit and receive paths of the link.

► ETR and CLO links must not exceed the equivalent of *10 meters (10.94 yards)* differential delay between the transmit and receive paths of the link.

Protection schemes

The Ciena 6500 Packet-Optical Platform provides the following protection schemes:

► Unprotected

An unprotected transponder or Muxponder card is connected to one client interface and to one site-to-site fiber link only. A failure of the transponder or Muxponder card or the site-to-site fiber link results in a loss of client communications.

► Client-based protection

Client-based protection uses at least two client interfaces that are connected to the WDM. These interfaces are arranged so that the transponder or Muxponder cards that connect the two sites are distributed over two diverse site-to-site fiber links. The client device is responsible for ensuring that a failure of a WDM module or of a single site-to-site fiber link does not result in a total loss of client communications.

GDPS timing links (ETR, CLO, and STP) are qualified for use in a client-based protection scheme if they are using separate paths (routes).

Diagram Components: For simplicity, all the components in the optical path are not shown in the diagrams in this section.

Figure 4 shows a high-level view of the client-based protection scheme. In this case, a client device has two separate site-to-site connections: one through Card A and the other through Card B. Transponder card-based and Muxponder card-based schemes for the Ciena 6500 Packet-Optical Platform are shown separately.
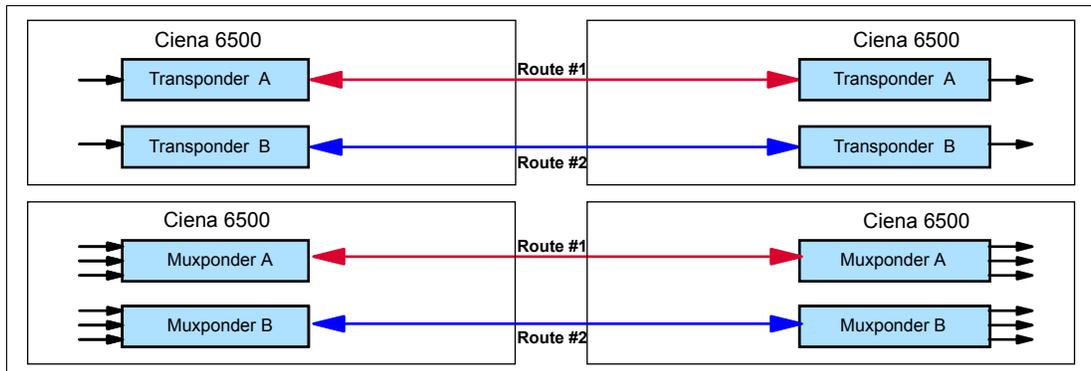

Figure 4   Client-based protected scheme

▶ Optically Switched Fiber protection

The PSM provides protection at the site-to-site fiber level. The PSM protects all wavelengths that are being carried on a fiber pair simultaneously. If a site-to-site fiber failure occurs, all traffic is switched to the backup link.

The PSM is only available for point-to-point WDM network topologies.

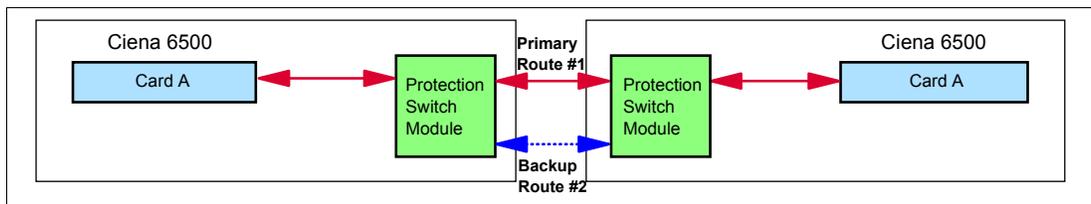Figure 5 shows a high-level view of the Optically Switched Fiber protection scheme.

Figure 5   Optically Switched Fiber protection

GDPS timing links (STP, ETR, and CLO) are not qualified for use with a single PSM at each site. A single PSM-based, Optically Switched Fiber protection scheme must not be used with a GDPS or PPRC. It must be used in conjunction with a client-based protection scheme.

If a GDPS or PPRC solution is to use Optically Switched Fiber protection, dual PSMs at each site with four site-to-site fiber pairs (trunks) are suggested. The GDPS timing links must connect by using different cards and PSMs.

Figure 6 shows a high-level view of the dual Optically Switched Fiber protection scheme.
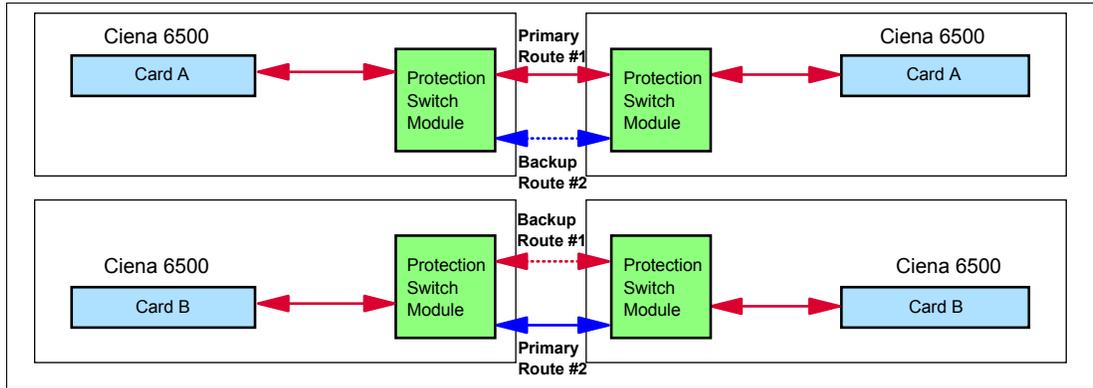

Figure 6   Dual Optically Switched Fiber protection

Protection scheme intermix

All protection schemes can be intermixed within the same Ciena 6500 Packet-Optical Platform chassis or network on an individual client interface basis.

Interface card specifications

Table 2 lists the specifications of the qualified Ciena 6500 Packet-Optical Platform interface cards and tested protocols.

Ciena 6500 Packet-Optical Platform interface cards do not support auto-negotiation of link speeds. For System z FICON and Fibre Channel Protocol (FCP) client links, the wanted link speed must be configured in the WDM card client interface at both ends of the link.

For particular extended distances, the use of OAs and DCUs might be required. For distance and link budget specifications, reference the WDM vendor documentation.

Table 2   Qualified client interface card details

Card type and protocol	Fiber type	Light source	Qualified distance[a,b]
2x10G OTR with Strong FEC and FC800/FC1200[c]			
FICON (8 Gbps)	SM	1310 nm	100 km (62 miles) 135 km (84 miles)
Fibre Channel (8 Gbps)	SM	1310 nm	100 km 135 km
ISL (8, 10 Gbps)[d]	SM	1310 nm	100 km 135 km
ISL (10 Gbps)[d]	MM	850 nm	100 km 135 km
Ethernet (10 Gbps)[e]	SM	1310 nm	100 km, 135 km
Ethernet (10 Gbps)[e]	MM	850 nm	100 km, 135 km
IFB 1x IB-DDR LR (5 Gbps) with STP	SM	1310 nm	100 km, 135 km
eDC40G OCLD MetroHSRx with 4xOC-192/STM-64/10 GbE/OTU2/FC Mux OCI XFP[c]			
FICON (8 Gbps)	SM	1310 nm	100 km, 135 km
Fibre Channel (8 Gbps)	SM	1310 nm	100 km, 135 km

Card type and protocol	Fiber type	Light source	Qualified distance[a,b]
ISL (8, 10 Gbps)[d]	SM	1310 nm	100 km, 135 km
ISL (10 Gbps)[d]	MM	850 nm	100 km, 135 km
Ethernet (10 Gbps)[e]	SM	1310 nm	100 km, 135 km
Ethernet (10 Gbps)[e]	MM	850 nm	100 km, 135 km
IFB 1x IB-DDR LR (5 Gbps) with STP	SM	1310 nm	100 km, 135 km
SuperMux 10-port SFP 10G DWDM[c]			
FICON (1, 2, 4 Gbps)	SM	1310 nm	100 km
FICON (1, 2, 4 Gbps)	MM	850 nm	100 km
Fibre Channel (1, 2, 4 Gbps)	SM	1310 nm	100 km
Fibre Channel (1, 2, 4 Gbps)	MM	850 nm	100 km
ISL (1, 2, 4 Gbps)[d]	SM	1310 nm	100 km
ISL (1, 2, 4 Gbps)[d]	MM	850 nm	100 km
Ethernet (1 Gbps)	SM	1310 nm	100 km
Ethernet (1 Gbps)	MM	850 nm	100 km
SuperMux 24-port I/O 1x XFP / 10x SFP, 10-port card[c]			
FICON (1, 2, 4 Gbps)	SM	1310 nm	100 km, 135 km
FICON (1, 2, 4 Gbps)	MM	850 nm	100 km, 135 km
Fibre Channel (1, 2, 4 Gbps)	SM	1310 nm	100 km, 135 km
Fibre Channel (1, 2, 4 Gbps)	MM	850 nm	100 km, 135 km
ISL (1, 2, 4 Gbps)[d]	SM	1310 nm	100 km, 135 km
ISL (1, 2, 4 Gbps)[d]	MM	850 nm	100 km, 135 km
Ethernet (1 Gbps)	SM	1310 nm	100 km, 135 km
Ethernet (1 Gbps)	MM	850 nm	100 km, 135 km
Flex MOTR 8x SFP / 2x XFP, 8-port card[c]			
FICON (1, 2, 4 Gbps)	SM	1310 nm	100 km, 135 km
FICON (1, 2, 4 Gbps)	MM	850 nm	100 km, 135 km
Fibre Channel (1, 2, 4 Gbps)	SM	1310 nm	100 km, 135 km
Fibre Channel (1, 2, 4 Gbps)	MM	850 nm	100 km, 135 km
ISL (1, 2, 4 Gbps)[d]	SM	1310 nm	100 km, 135 km
ISL (1, 2, 4 Gbps)[d]	MM	850 nm	100 km, 135 km
Ethernet (1 Gbps)	SM	1310 nm	100 km, 135 km
Ethernet (1 Gbps)	MM	850 nm	100 km, 135 km
ISC-3 Peer (1, 2 Gbps)[f] with STP	SM	1310 nm	100 km, 135 km
ISC-3 Peer (1, 2 Gbps)[f] with STP	MM	850 nm	100 km, 135 km
SM = single-mode fiber (9/125 micron) MM = multimode fiber (50/125 or 62.5/125 micron)			

a. Qualified distance is based on the VSC Lab test environment, which is a physical point-to-point topology without any intermediate nodes besides OAs and DCUs.

b. Requires a request for price quotation (RPQ) 8P2263 or 8P2340 for distances over 100 km (62.14 miles).

c. Protocol and wavelength support depends on a pluggable client interface transceiver.

d. Protocol is configured as Fibre Channel protocol on WDM.

e. The 10 GbE connection is qualified for use with the IBM zEnterprise® intraensemble data network (IEDN).

f. Multiple STP links can be supported on the same card.

Qualified distances: Consult your storage area network (SAN) switch vendors for qualified ISL-supported distances.

References

For more information about System z connectivity, see these resources:

► System z I/O connectivity home page:

http://www.ibm.com/systems/z/hardware/connectivity/index.html

► *IBM System z Connectivity Handbook*, SG24-5444

http://www.redbooks.ibm.com/abstracts/sg245444.html?Open

► *FICON Planning and Implementation Guide*, SG24-6497

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► *Getting Started with InfiniBand on System z10 and System z9*, SG24-7539

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For more information about GDPS, see these resources:

► GDPS home page:

http://www.ibm.com/systems/z/advantages/gdps/index.html

► *GDPS Family: An Introduction to Concepts and Capabilities*, SG24-6374

http://www.redbooks.ibm.com/abstracts/sg246374.html?Open

For more information about STP, see these resources:

► Parallel Sysplex home page:

http://www.ibm.com/systems/z/advantages/pso/index.html

► *Server Time Protocol Planning Guide*, SG24-7280

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► *Server Time Protocol Implementation Guide*, SG24-7281

http://www.redbooks.ibm.com/abstracts/sg247281.html?Open

► *Server Time Protocol Recovery Guide*, SG24-7380

http://www.redbooks.ibm.com/abstracts/sg247380.html?Open

For more information about optical communications, see this resource:

► *Understanding Optical Communications*, SG24-5230

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For more information about the Ciena 6500 Packet-Optical Platform, see this website:

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