

# IBM Z Functional Matrix

Octavian Lascu  
Bill White  
Ewerson Palacio



IBM Z





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This IBM® Redpaper™ publication provides a list of features and functions that are supported on IBM Z, including:

- ▶ IBM z16™ - Machine type 3931;
- ▶ IBM z15™ - Machine types 8561 and 8562;
- ▶ IBM z14™ - Machine types 3906 and 3907.

On June 30, 2021 the IBM z14 (M/T 3906) was withdrawn from marketing (WDMF) - see the [Announcement letter](#).

Field installed features and all associated conversions that are delivered solely through a modification to the machine's Licensed Internal Code (LIC) are still possible until June 29, 2022.

[https://www.ibm.com/common/ssi/cgi-bin/ssialias?infotype=an&subtype=ca&apname=gpa\\_team&supplier=897&letternum=ENUS920-114](https://www.ibm.com/common/ssi/cgi-bin/ssialias?infotype=an&subtype=ca&apname=gpa_team&supplier=897&letternum=ENUS920-114)

This publication is divided into the following topics:

- ▶ “Application programming interfaces” on page 3
- ▶ “Cryptographic features” on page 4
- ▶ “I/O characteristics and features” on page 10
- ▶ “Storage Connectivity” on page 12
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**Note:** This publication is not intended to include information about services, requests for price quotation (RPQs), or specific quantities or measurements that are related to performance, memory size, bandwidth, and so on. The intention of this publication is to compare the standard and optional features for the various IBM Z configurations. For more information about the features and functions that are listed in the tables, see the system-specific reference guide documentation.

This IBM Redpaper publication can help you quickly understand the features, functions and connectivity alternatives that are available when planning and designing their IBM Z infrastructures.

The following key is used in the tables in this IBM Redpaper publication:

- ▶ **S**: Standard
- ▶ **O**: Optional
- ▶ **n**: Not supported
- ▶ **na**: not applicable
- ▶ **CF**: Carry forward only

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## Application programming interfaces

System management applications that provide integrated hardware and software management solutions are supported through the console programming interfaces. Detailed information that includes console application programming interfaces (API) objectives, architecture, data structures, usage, and console-managed object definitions and identifications is provided. An API is a set of routines, protocols, and tools that are used for building software applications.

The API interfaces provide the capability to use object-based, industry-standard programming interfaces instead of building home-grown, release-specific programs for collecting the hardware information that is needed to provide an integrated hardware and software system management solution. The firmware support for APIs is listed in Table 1.

Table 1 Firmware support for APIs

Application programming interface <sup>a</sup> (API)	IBM z16	IBM z15	IBM z14
Hardware Management Console Web Services (Web Services) <sup>b</sup>	S	S	S
Simple Network Management Protocol (SNMP)	S	S	S
Secure Service Container (SSC)	S	S	S
Base Control Program internal interface (BCPii)	S	S	S
Ability to use APIs to access Unified Resource Manager function	n	n	S
Hardware Management Console Common Information Model (CIM)	n	n	n

a. Consult "HMC Web Services API, SC27-2642" for available APIs per HMC version.

b. Web Services are disabled by default for security reasons and must be enabled by the user.

# Cryptographic features

The hardware cryptographic services that are provided in IBM Z are intended to cover the full range of industry standard cryptographic operations.

The Trusted Key Entry (TKE) workstation is another optional feature that consists of an IBM-specific workstation that provides a highly secure environment for the centralized management of the Crypto Express features (in one or more systems) to which the TKE workstation has TCP/IP connectivity.

For more information about TKE hardware support, see Table 6 on page 8.

The following types of hardware cryptographic features are available with IBM Z systems:

- ▶ CP Assist for Cryptographic Functions (CPACF) is implemented as a set of cryptographic instructions in IBM Z firmware to improve performance when encrypting and decrypting data.
- ▶ The Crypto Express PCIe feature - optional feature which is plugged into the system's PCIe I/O or PCIe+ IO drawers.

The following Tables are provided:

- ▶ The cryptographic functions are listed in Table 2.
- ▶ The Crypto Express features are listed in Table 3 on page 5.
- ▶ The Crypto Express adapters are listed in Table 4 on page 6.
- ▶ TKE Workstation features are listed in Table 5 on page 7.

Table 2 Cryptography

Cryptographic functions	IBM z16 A01	IBM z15 T01	IBM z15 T02	IBM z14 M0x	IBM z14 ZR1
Secure Hash Standard SHA1	S	S	S	S	S
Secure Hash Standard SHA2 (224, 256,384 and 512)	S	S	S	S	S
Secure Hash Standard SHA3 (224, 256,384 and 512)	S	S	S	S	S
GHASH	S	S	S	S	S
SHAKE support for 128-, and 256 bit	S	S	S	S	S
<b>CP Assist Cryptographic Function (CPACF)<sup>a</sup></b>					
Advanced Encryption Standard (AES) AES-128; AES-192, 256;	S	S	S	S	S
Data Encryption Standard (DES); TDES	S	S	S	S	S
Message authentication code (MAC)	S	S	S	S	S
True Random Number Generation (TRNG)	S	S	S	S	S
Deterministic Random Number Generation DRNG (NIST SP-800-90A SHA-512 based)	S	S	S	S	S
Pseudo Random Number Generator (PRNG)	S	S	S	S	S
Cipher Message with CFB (KMF)	S	S	S	S	S

<b>Cryptographic functions</b>	<b>IBM z16 A01</b>	<b>IBM z15 T01</b>	<b>IBM z15 T02</b>	<b>IBM z14 M0x</b>	<b>IBM z14 ZR1</b>
Cipher Message with Counter (KMCTR)	S	S	S	S	S
Cipher Message with OFB (KMO)	S	S	S	S	S
Elliptic Curve Cryptography (ECC)	S	S	S	S	S
EdDSA, ECDH - Support for NIST P256, NIST P386, NIST P 521	S	S	S	na	na
EdDSA for Ed25519 and Ed448 curves	S	na	na	na	na
ECDH for X25519 and X448 curves	S	na	na	na	na

a. The enablement feature (FC 3863) for CPACF is a no-charge option.

Table 3 *Crypto Express functions*

<b>Crypto functions</b>	<b>IBM z16 A01</b>	<b>IBM z15 T01</b>	<b>IBM z15 T02</b>	<b>IBM z14 M0x</b>	<b>IBM z14 ZR1</b>
Common Cryptographic Architecture (CCA)	S	S	S	S	S
Concurrent internal code changes on segment 3 to add/update a CCA application	S	S	S	S	S
Compute Intermediate Message Digest (CIMD)	S	S	S	S	S
Enable/Disable the encrypt DEA key or encrypt AES key function using the Support Element (SE)	S	S	S	S	S
Europay MasterCard Visa (EMV)	S	S	S	S	S
Protected key CPACF for high-performance data encryption	S	S	S	S	S
Remote key loading for ATM/POS	S	S	S	S	S
RSA – Optimal Asymmetric Encryption Padding (OAEP) method with SHA-256	S	S	S	S	S
Secure Keyed-Hash Message Authentication Code (HMAC)	S	S	S	S	S
TR-31 wrapping method for secure key exchange	S	S	S	S	S
Crypto Automation Toggling w/OS Toleration <sup>a</sup>	S	n	n	n	n

a. Provides a method to serially config on/off Crypto features. Requires Crypto Express adapters to be configured redundantly.

Table 4 Crypto Express adapters

Crypto Adapters features, functions or attributes	IBM z16A01	IBM z15 T01	IBM z15 T02	IBM z14 M0x	IBM z14 ZR1
<b>Crypto Express8S features<sup>a</sup></b>					
Crypto Express8S feature FC 0908 (2xHSMs) and/or Crypto Express8S feature FC 0909 (1xHSM)	O	n	n	n	n
AES GMAC, AES GCM, AES XTS, CMAC	S	S	S	na	na
Key generation for NIST, Ed and X-Curves	S	na	na	na	na
Enterprise Public Key Cryptography Standards #11 (EP11)	S	na	na	na	na
Max, domains	85	na	na	na	na
Max. operational key part registers	512	na	na	na	na
Payment Card Industry (PCI) Hardware Security Module (HSM) PCI-HSM	S	S	S	na	na
Prime Number Generator (PNG)	S	S	S	na	na
Secure AES Galois Counter Mode (GCM) encryption mode	S	na	na	na	na
True Random Number Generation (TRNG)	S	na	na	na	na
Visa Data Secure Platform P2PE	S	na	na	na	na
Visa Format Preserving Encryption	S	na	na	na	na
<b>Crypto Express7S features<sup>a</sup></b>					
Crypto Express7 feature 1xHSM FC 0899 and/or Crypto Express7 feature 2xHSM FC 0898	CF	O	O		
AES GMAC, AES GCM, AES XTS, CMAC	S	S	S	na	na
Enterprise Public Key Cryptography Standards #11 (EP11)	S	S	S	na	na
Max, domains	85	85	40	na	na
Max. operational key part registers	512	512	512	na	na
Payment Card Industry (PCI) Hardware Security Module (HSM) PCI-HSM	S	S	S	na	na
Prime Number Generator (PNG)	S	S	S	na	na
Secure AES Galois Counter Mode (GCM) encryption mode	S	S	S	na	na
True Random Number Generation (TRNG)	S	S	S	na	na
Visa Data Secure Platform P2PE	S	S	S	na	na
Visa Format Preserving Encryption	S	S	S	na	na
<b>Crypto Express6S features<sup>a</sup></b>					
Crypto Express6 feature	CF	CF	CF	O	O



AES GMAC, AES GCM, AES XTS, CMAC	S	S	S	S	S
ECDSA, ECDH	S	S	S	S	S
Enterprise Public Key Cryptography Standards #11 (EP11)	S	S	S	S	S
Max, domains	85	85	40	85	40
Max. operational key part registers	512	512	512	512	512

a. This feature is optional.

Table 5 TKE - Trusted Key Entry

<b>TKE Workstation<sup>a,b</sup> features, functions, or attributes</b>	<b>IBM z16A01</b>	<b>IBM z15 T01</b>	<b>IBM z15 T02</b>	<b>IBM z14 M0x and z14 ZR1</b>
TKE additional smart cards (10 pack) FC 0900	O	O	O	O
TKE Smart Card Reader FC 0891	O	O	O	O
TKE Tower or TKE workstation	O	O	O	O
TKE Rack Mounted	O	O	O	O
TKE 10.0 Licensed Internal Code	S	S	S	S
TKE 9.2 Licensed Internal Code	S	S	S	S
PCI-compliant with CCA 6.3	S	S	S	S
TKE 9.1 Licensed Internal Code or TKE 9.0 LIC (superseded by TKE 9.1 LIC)	CF	CF	CF	CF
Key material copy to alternative zone	S	S	S	S
Save TKE data directory structure with files to USB	S	S	S	S
Create key parts without opening a host	S	S	S	S
Audit Log for Privileged Mode Access ID	S	S	S	S
Secure key entry on EP11	S	S	S	S
X.509 certificates manager for domains	S	S	S	S
Domain mode management	S	S	S	S
Set clock	S	S	S	S
Domain-specific Host Crypto Module Audit Log management	S	S	S	S

<b>TKE Workstation<sup>a,b</sup> features, functions, or attributes</b>	<b>IBM z16A01</b>	<b>IBM z15 T01</b>	<b>IBM z15 T02</b>	<b>IBM z14 M0x and z14 ZR1</b>
Domain-specific roles and authorities	S	S	S	S
Domain Cloning	S	S	S	S
Certificate Authority Wizards (smart card wizards creating for TKE zone and for configuration migrations)	S	S	S	S
Coordinated Master Key roll from TKE	S	S	S	S

a. This feature is optional.

b. TKE must be at a higher or the same level as the latest Crypto Express feature installed in the systems (see also Table 6 on page 8).


Table 6 on page 8 shows the supported feature codes of the TKE related to the License Internal Code (LIC) release and the different Crypto Express features.

For some functionality, requirements must be considered; for example, the characterization of a Crypto Express adapter in EP 11 mode always requires the use of a TKE.

The TKE is unaware of the CPC type where the host crypto module is installed. That is, the TKE does not consider whether a Crypto Express is running on IBM z16, IBM z15, or IBM z14, system. Therefore, the LIC can support any CPC where the coprocessor is supported, but the TKE LIC must support the specific crypto module.

*Table 6 TKE Compatibility Matrix*

<b>TKE workstation</b>	<b>TKE Release LIC</b>	<b>9.0</b>	<b>9.1</b>	<b>9.2</b>	<b>10.0</b>
	HW Feature Code <sup>a</sup>	0085 or 0086	0085 or 0086	0087 or 0088	0145 or 0144
	LICC	0879	0880	0881	0882
	Smart Card Reader	0885 0891	0891	0891	0891
	Smart Card	0884 0892	0900	0900	0900
<b>Manage Host Crypto Module</b>	CEX8C (CCA)	no	no	no	Yes
	CEX8P (EP11)	no	no	no	Yes
	CEX7C (CCA)	no	no	Yes	Yes
	CEX7P (EP11)	no	no	Yes	Yes
	CEX6C (CCA)	Yes	Yes	Yes	Yes
	CEX6P (EP11)	Yes	Yes	Yes	Yes
	CEX5C (CCA)	Yes	Yes	Yes	Yes
	CEX5P (EP11)	Yes	Yes	Yes	Yes

- 
- a. TKE Hardware features can be carried forward and upgraded to support the highest Crypto Express feature installed in the system.

## I/O characteristics and features

The system input/output (I/O) operations for IBM Z are handled by the channel subsystem (CSS). The role of the CSS is to control communication between internal or external channels and control units and devices.

From a central processor standpoint, the CSS is independent of the processors of the IBM Z platform. Therefore, I/O within IBM Z can be done asynchronously. This requirement is critical in a system that is designed to handle massive numbers of concurrent transactions.


IBM Z technology can handle a high volume of transactions and I/O operations in parallel. Because of the ability to do parallel I/O operations, IBM Z configurations can serve many different devices such as disk storage, printers, other attached computers and networks.

The I/O characteristics are listed in Table 7.

- ▶ Connectivity for Storage features are listed in Table 8 on page 12.
  - FICON Express features are listed in Table 9 on page 13.
  - zHyperLink features are listed in Table 10 on page 13
- ▶ Connectivity for Network features are listed in Table 11 on page 14
  - OSA Express features are listed in Table 12 on page 15
  - z HiperSockets features are listed in Table 13 on page 16
  - IBM Shared Memory Communications features are listed in Table 14 on page 16

Table 7 I/O Characteristics

I/O Features, functions or attributes	IBM z16 A01	IBM z15 T01	IBM z15 T02	IBM z14 M0x	IBM z14 ZR1
Cancel Subchannel (XSCH)	S	S	S	S	S
Dynamic I/O configuration	S	S	S	S	S
Dynamic I/O configuration for standalone CF <sup>a</sup>	S	S	S	S	S
Dynamic reconnect	S	S	S	S	S
Fiber Quick Connect (FQC)	O	O	O	O	O
I/O drawers <sup>b</sup>	n	n	n	n	n
Nondisruptive I/O removal	S	S	S	S	S
PCIe I/O drawers <sup>b</sup>	n	n	n	O	n
PCIe+ I/O drawer <sup>b</sup>	O	O	O	n	O
PCIe+ Gen3 Fanout	S	n	n	n	n
System-initiated CHPID reconfiguration	S	S	S	S	S
IBM z/OS® discovery and autoconfig (zDAC)	S	S	S	S	S
<b>Logical Channel Subsystems (LCSS): up to 256 CHPIDs per LCSS</b>					
Multiple image facility (MIF)	S	S	S	S	S
Support of LCSS (max. supported)	S(6)	S(6)	S(3)	S(6)	S(3)
Subchannel sets per LCSS (max. supported)	S(4)	S(4)	S(3)	S(4)	S(3)

- 
- a. Dynamic I/O for standalone CF is available with IBM z14 Driver Level 36, IBM z15 Driver Level 41 or IBM z16 Driver Level 51 CPCs. Requires HCD and IOCP PTFs.
  - b. At least one PCIe I/O drawer or PCIe+ I/O drawer is required, depending on the system (except certain configurations which are used as standalone Coupling Facility).

## Storage Connectivity

Storage connectivity is provided on IBM Z through FICON Express and the IBM zHyperLink Express features.

FICON Express features follow the established Fibre Channel (FC) standards to support data storage and access requirements. zHyperLink Express was created to provide fast access to data by way of direct low-latency connections between the Z platform and storage. A zHyperLink channel does not replace a FICON channel, but rather complements it. FICON remains the main data driver and is mandatory for zHyperLink usage.

Table 8 FICON Storage Connectivity functions

Functions <sup>a</sup>	IBM z16 A01	IBM z15 T01	IBM z15 T02	IBM z14 M0x	IBM z14 ZR1
CHPID Type FC					
FICON multihop cascaded directors (max 4)	S	S	S	S	S
FICON CTC	S	S	S	S	S
FICON Dynamic Routing (FIDR)	S	S	S	S	S
FICON purge path extended	S	S	S	S	S
Forward Error Correction (FEC) for FICON Express16S and newer	S	S	S	S	S
High-Performance FICON for IBM z Systems (zHPF)	S	S	S	S	S
High FICON (zHPF) Extended Distance II	S	S	S	S	S
MIDAW facility	S	S	S	S	S
Number of devices per FICON channel	32 K	32 K	32 K	32 K	32k
IBM Fibre Channel Endpoint Security (FC 1146) <sup>b</sup>	O	O	n	na	na
CHPID Type FCP					
FCP channels – T10-DIF support	S	S	S	S	S
FCP full-fabric connectivity to SCSI storage devices	S	S	S	S	S
FCP program directed restart	S	S	S	S	S
FCP SCSI IPL	S	S	S	S	S
FCP support for IBM z/VM®, IBM z/VSE® and Linux on IBM Z (attach to SCSI devices)	S	S	S	S	S
N_Port ID Virtualization (NPIV) for FCP	S	S	S	S	S
WWPN prediction tool for virtual ports	S	S	S	S	S
WWPN prediction tool for physical ports	S	S	S	S	S
IBM Fibre Channel Endpoint Security (FC 1146) <sup>b</sup>	O <sup>c</sup>	O <sup>c</sup>	n	na	na

a. FICON adapters are optional

- b. Requires FC 3863 (CPACF enablement); subject to export regulations.  
 c. FICON Express32S, FICON Express16SA - Encryption of Data in Flight and Endpoint Authentication; FICON Express 16S+ - only Endpoint Authentication.

Table 9 IBM FICON Adapters

IBM FICON adapters	IBM z16 A01	IBM z15 T01	IBM z15 T02	IBM z14 M0x	IBM z14 ZR1
<b>FICON Express32S<sup>a</sup>(8, 16, 32 Gbps)</b>					
10 KM LX (2 ports) FC 0461	O	n	n	n	n
SX (2 ports) FC 0462	O	n	n	n	n
<b>FICON Express16SA<sup>a</sup> (8, 16 Gbps)</b>					
10 KM LX (2 ports) FC 0436	CF	O	n	n	n
SX (2 ports) FC 0437	CF	O	n	n	n
<b>FICON Express16S+<sup>a</sup> (4, 8, 16 Gbps)</b>					
10 KM LX (2 ports) FC 0427	CF	CF	O, CF	O	O
SX (2 ports) FC 0428	CF	CF	O, CF	O	O
<b>FICON Express16S (4, 8, 16 Gbps)</b>					
10 KM LX (2 ports) FC 0418	n	CF	CF	CF	CF
SX (2 ports) FC 0419	n	CF	CF	CF	CF
<b>FICON Express8S (2, 4, 8 Gbps)</b>					
10 KM LX (2 ports) FC 0409	n	CF	CF	CF	CF
SX (2 ports) FC 0410	n	CF	CF	CF	CF

a. Both ports on this FICON Express feature must be defined as the same CHPID type (FC or FCP).

Table 10 IBM zHyperLink functions and features

CHPID type HYL	IBM z16 A01	IBM z15 T01	IBM z15 T02	IBM z14 M0x	IBM z14 ZR1
zHyperLink read support	S	S	S	S	S
zHyperLink write support <sup>a</sup>	S	S	S	S	S
<b>zHyperLink Express features</b>					
zHyperLink Express (FC 0431) <sup>b</sup>	CF	CF	CF	O	O
zHyperLink Express 1.1 (FC 0451) <sup>b</sup>	O, CF	O	O	n	n

a. Support for zHyperLink Writes requires compatible levels of DS8000 hardware and firmware R8.5.1 or newer, as well as Db2® 12 with PTFs.

b. This feature is optional.

## Network Connectivity

High speed network connectivity between the IBM Z platform and external networks is supported with Open Systems Adapter-Express (OSA-Express) and Remote Direct Memory Access (RDMA) over Converged Ethernet (RoCE) Express features. Internal connections for IBM Z is provided via fast memory-to-memory communications by using HiperSockets and Internal Shared Memory (ISM).

Table 11 Network Connectivity

Functions	IBM z16 A01	IBM z15 T01	IBM z15 T02	IBM z14 M0x	IBM z14 ZR1
640 TCP/IP address	S	S	S	S	S
Checksum offload	S	S	S	S	S
Display OSAINFO for z/OS	S	S	S	S	S
Inbound workload queuing for z/OS	S	S	S	S	S
Large send	S	S	S	S	S
Link aggregation for z/VM	S	S	S	S	S
OSA dynamic LAN idle	S	S	S	S	S
OSA-Express Network Traffic Analyzer	S	S	S	S	S
PCI-IN (PCIe Interconnect®)	O	O	O	O	O
Virtual MAC address support	S	S	S	S	S
VLAN mgmt - GVRP support	S	S	S	S	S
<b>Supported CHPID types</b>					
CHPID type OSC for integrated console controller (ICC) at all 1000BASE-T Ethernet features	S	S	S	S	S
CHPID type OSC for integrated console controller (ICC) for OSA-Express 7S 1.2 GbE features	S	n	n	n	n
CHPID type OSC for integrated console controller (ICC) for OSA-Express 7S GbE features	S	S	n	na	na
OSA-ICC support for Secure Sockets Layer	S	S	S	S	S
CHPID type OSD (for QDIO) supported on all OSA-Express features	S	S	S	S	S
QDIO data connection isolation	S	S	S	S	S
QDIO Diagnostic Synchronization facility	S	S	S	S	S
QDIO Optimized latency mode for the z/OS environment	S	S	S	S	S
QDIO Layer 2/Layer 3	S	S	S	S	S
CHPID type OSE for non QDIO at all 1000BASE-T Ethernet features	S	S	S	S	S



Functions	IBM z16 A01	IBM z15 T01	IBM z15 T02	IBM z14 M0x	IBM z14 ZR1
CHPID type OSM for intranode management network (INMN) at all 1000BASE-T Ethernet features	n <sup>a</sup>	n <sup>a</sup>	n	S	S
CHPID type OSX for all 10 GbE features	n	n	n	S	S
CHPID type OSX for 25 GbE <sup>b</sup> features	n	n	n	S	S

a. CHPID type OSM is not available for definitions in user configurations. This CPID type is used in DPM mode for intern.

b. Requires IBM z14 Driver Level 36.

Table 12 IBM Open Systems (OSA)-Adapters

Features <sup>a</sup>	IBM z16 A01	IBM z15 T01	IBM z15 T02	IBM z14 M0x	IBM z14 ZR1
<b>Open Systems Adapter-Express 7S 1.2 (OSA-Express7S 1.2)</b>					
25 Gigabit Ethernet LR (1 port) FC 0460 <sup>b</sup>	O	n	n	n	n
25 Gigabit Ethernet SR (1 port) FC 0459 <sup>b</sup>	O	n	n	n	n
10 Gigabit Ethernet LR (1 port) FC 0456	O	n	n	n	n
10 Gigabit Ethernet SR (1 port) FC 0457	O	n	n	n	n
1000BASE-T Ethernet (2 ports /1 CHPID) FC 0458	O	n	n	n	n
Gigabit Ethernet LX (2 ports/1 CHPID) FC 0454	O	n	n	n	n
Gigabit Ethernet SX (2 ports/1 CHPID) FC 0455	O	n	n	n	n
<b>Open Systems Adapter-Express7S (OSA-Express7S)</b>					
25 Gigabit Ethernet SR1.1 (1 port) FC 0449 <sup>b</sup>	CF	O	n	O	O
25 Gigabit Ethernet SR (1 port) FC 0429 <sup>b</sup>	n	CF	O	O	O
10 Gigabit Ethernet LR (1 port) FC 0444	CF	O	n	n	n
10 Gigabit Ethernet SR (1 port) FC 0445	CF	O	n	n	n
1000BASE-T Ethernet (2 ports /1 CHPID) FC 0446	CF	O	n	n	n
Gigabit Ethernet LX (2 ports/1 CHPID) FC 0442	CF	O	n	n	O
Gigabit Ethernet SX (2 ports/1 CHPID) FC 0443	CF	O	n	n	n
<b>Open Systems Adapter-Express6S (OSA-Express6S)</b>					
10 Gigabit Ethernet LR (1 port) FC 0424	CF	CF	O, CF	O	O
10 Gigabit Ethernet SR (1 port) FC 0425	CF	CF	O, CF	O	O
1000BASE-T Ethernet (2 ports /1 CHPID) FC 0426	CF	CF	O, CF	O	O
Gigabit Ethernet LX (2 ports/1 CHPID) FC 0422	CF	CF	O, CF	O	O
Gigabit Ethernet SX (2 ports/1 CHPID) FC 0423	CF	CF	O, CF	O	O
<b>Open Systems Adapter-Express5S (OSA-Express5S)</b>					

Features <sup>a</sup>	IBM z16 A01	IBM z15 T01	IBM z15 T02	IBM z14 M0X	IBM z14 ZR1
10 Gigabit Ethernet LR (1 port) FC 0415 <sup>c</sup>	n	CF	CF	CF	CF
10 Gigabit Ethernet SR (1 port) FC 0416 <sup>c</sup>	n	CF	CF	CF	CF
1000BASE-T Ethernet (2 ports /1 CHPID) FC 0417	n	CF	CF	CF	CF
Gigabit Ethernet LX (2 ports/1 CHPID) FC 0413	n	CF	CF	CF	CF
Gigabit Ethernet SX (2 ports/1 CHPID) FC 0414	n	CF	CF	CF	CF

a. These features are optional.

b. Requires 25 GbE switch. Does not negotiate to 10 Gbps.

c. Requires 10 GbE switch. Does not negotiate to lower speed.

Table 13 IBM HiperSockets

Features, functions or attributes	IBM z16 A01	IBM z15 T011	IBM z15 T02	IBM z14 M0X	IBM z14 ZR1
32 HiperSockets	S	S	S	S	S
Completion queue function	S	S	S	S	S
IPv6 support	S	S	S	S	S
Integration with intraensemble data network (IEDN)	S	S	S	S	S
Layer 2 support	S	S	S	S	S
Multiple Write facility	S	S	S	S	S
Network Traffic Analyzer	S	S	S	S	S

Table 14 IBM Shared Memory Communications features and functions

Features	IBM z16 A01	IBM z15 T01	IBM z15 T02	IBM z14 M0X	IBM z14 ZR1
10 GbE RoCE Express3 SR FC 0440	O	n	n	n	n
10 GbE RoCE Express3 LR FC 0441	O	n	n	n	n
25 GbE RoCE Express3 SR FC 0452	O	n	n	n	n
25 GbE RoCE Express3 LR FC 0453	O	n	n	n	n
25 GbE RoCE Express2.1 FC 0450	CF	O	O	n	n
10 GbE RoCE Express2.1 FC 0432	CF	O	O	n	n
25 GbE RoCE Express2 FC 0430 <sup>b</sup>	CF	CF	CF	O	O
10 GbE RoCE Express2 FC 0412	CF	CF	CF	O	O
10 GbE RoCE Express FC 0411	n	CF	CF	CF	CF
Shared Memory Communications-Remote Direct Memory Access (SMC-R) <sup>a</sup> .	S	S	S	S	S

Features	IBM z16 A01	IBM z15 T01	IBM z15 T02	IBM z14 M0x	IBM z14 ZR1
Shared Memory Communications-Direct Memory Access (SMC-D)	S	S	S	S	S
Shared Memory Communications V2 (SMC-R and DV2) <sup>b</sup>	S	S	S	S	S

a. One OSA Express feature defined for TCP communications.

b. SMC Version 2 (SMCv2) defines the specifications that enable multiple IP subnet capability for SMC.

## On-demand functions

Capacity Upgrade on Demand (CUoD) is an inherent capability of the current IBM Z architecture. It allows you to concurrently add capacity and features to the IBM Z hardware. Concurrence depends on the hardware.

Customer Initiated Upgrade (CIU) is a tool that supports clients ordering permanent and temporary upgrades for their IBM Z hardware. It helps to provide CUoD. CUoD upgrades can be ordered through CIU or by using the standard IBM Sales/MES order process.

Although all CIU upgrades support CUoD, not all CUoD capabilities are available through CIU. For example, a new drawer for IBM Z hardware can be ordered and installed concurrently. This capability is part of the CUoD capabilities of IBM Z. However, it cannot be ordered by using CIU. For more information, see the CIU column in Table 15.

Capacity for Planned Event (CPE), Capacity Backup (CBU), and On/Off Capacity on Demand (OOCoD) are temporary upgrade capabilities that allow clients to add capacity to their processor. These upgrades are all part of CUoD. Only one CUoD upgrade capability is available through CIU, which is On/Off CoD.

The available on-demand functions are listed in Table 15.

Table 15 On-demand functions

On-Demand function	CIU	IBM z16 A01	IBM z15 T01	IBM z15 T02	IBM z14 M0x	IBM z14 ZR1
<b>Capacity Upgrade on Demand (CUoD)</b>						
API for capacity provisioning management (CPM)	n/a	S	S	S	S	S
Capacity Backup (CBU)	O	O	O	O	O	O
Capacity for Planned Event (CPE)	O	O	O	O	O	O
CIU-Express with extended staging	O	O	O	O	O	O
Concurrent memory upgrades	O	O	O	O	O	O <sup>a</sup>
Concurrent permanent processor upgrade	O	O	O	O	O	O <sup>b</sup>
Concurrent processor CPC drawer add <sup>c</sup>	O	O <sup>c</sup>	O	O	O	n
Concurrent upgrades while temporary capacity is active	O	O	O	O	O	O
Flexible memory	O	O	O	n	O	n
High Water Mark (HWM) Increase total model capacity and IFLs without changing the active model capacity and IFLs	O	O	O	O	O	O
On/Off Capacity on Demand (OOCoD)	S	O	O	O	O	O
Plan ahead memory	n	n	n	n	O	O
Up to 8 installed or active (On/Off CoD, CBU, CPE) records at any specific time	O	S	S	S	S	S

On-Demand function	CIU	IBM z16 A01	IBM z15 T01	IBM z15 T02	IBM z14 M0x	IBM z14 ZR1
<b>Capacity Backup (CBU): Temporary upgrade</b>						
Ability to replenish an ordered record to extend the expiration date, add processing resources, order tests, and restore real activation		S	S	S	S	S
Ability to select the contract length 1 - 5 years		S	S	S	S	S
Automatic deactivation at expiration date		S	S	S	S	S
CPs, IFLs, ICFs, zIIPs, and SAPs		CF	O	O	O	O
Manufacturing installation of up to four Flex Capacity and CBU records, when ordered		S	S	S	S	S
Maximum of 15 test activations (free and purchased) per CBU record		S	S	S	S	S
Number of free test activations equates to the number of years purchased with the CBU record		S	S	S	S	S
Replenishment/Reuse record		S	S	S	S	S
Subcapacity CBU processors		O	O	O	O	S
Uninstalled LICCC records can be staged on the Support Element		O	O	O	O	S
<b>Capacity for Planned Event (CPE): Temporary upgrade</b>						
CPs, IFLs, ICFs, zIIPs, and SAPs		CF	O	O	O	O
Manufacturing installation of up to four CPE <sup>d</sup> and CBU records when ordered		S	S	S	S	S
Nondisruptive hardware CP capacity setting changes		S	S	S	S	S
Select model capacity and type/quantity of engines based on business needs		S	S	S	S	S
<b>On/Off Capacity on Demand (On/Off CoD): Temporary upgrade</b>						
Ability to replenish an ordered record		S	S	S	S	S
Administrative On/Off CoD testing		S	S	S	S	S
API for On/Off CoD activation		S	S	S	S	S
Automatic deactivation at expiration date		S	S	S	S	S
Automatic renewal to extend expiration date		O	O	O	O	O
CPs, IFLs, ICFs, zIIPs, and SAPs		O	O	O	O	O
On/Off CoD test		S	S	S	S	S
On/Off CoD with extended staging		O	O	O	O	O
Post-paid upgrades with spending limits controlled by tokens <sup>e</sup>		O	O	O	O	O
Pre-paid upgrades controlled by tokens <sup>f</sup>		O	O	O	O	O

On-Demand function	CIU	IBM z16 A01	IBM z15 T01	IBM z15 T02	IBM z14 M0x	IBM z14 ZR1
Replenishment/Reuse record		S	S	S	S	S
Subcapacity engine support		S	S	S	S	S
Uninstalled LICCC records can be staged on the Support Element		O	O	O	O	O
<b>System Recovery Boost Upgrade (temporary records, pre-paid)</b>						
System Recovery Boost Upgrade - zIIP records for temporary capacity boost		O	O	n	n	n
<b>Tailored Fit Pricing for IBM Z Hardware</b>						
Tailored Fit Pricing for IBM Z - HW Consumption solution		O	O	O	n	n
Ability to select the contract length 1 - 5 years		S	S	S	n	n
<b>Flexible Capacity for Cyber Resilience</b>						
Flexible Capacity for Cyber Resilience <sup>g</sup>		O	n	n	n	n

- a. Memory upgrades are concurrent only if there is enough physical memory installed (LICCC upgrades only). Max. physical memory installed depends on the CPC drawer feature.
- b. Concurrent processor upgrades are possible only if there are installed but not active processors available (LICCC upgrades only). Max. number of processors installed depends on the CPC drawer feature.
- c. IBM z16 Model A01 Concurrent CPC Drawer is restricted going from 1-> 2 drawers and from 2 -> 3 drawers. (4 CPC drawer machines are factory only).
- d. With IBM z16, CPE has been replaced by Flex Capacity. CPE can be carried forward but cannot be ordered for IBM z16.
- e. Post-paid; Requires contract. CP only
- f. Pre-paid; Requires contract. CP only.
- g. Production capacity shift cross sites between IBM z16 machines for DR test, planned maintenance, proactive outage avoidance and actual DR scenarios.

## IBM Parallel Sysplex

IBM Parallel Sysplex is a clustering technology that allows you to operate and manage up to 32 z/OS systems as a single system image from a single point of control. The underlying structure of the Parallel Sysplex remains virtually transparent to users, networks, applications, and even operations.

To realize these benefits, the z/OS Parallel Sysplex combines two critical capabilities: Parallel processing and enabling read/write data sharing across multiple systems with full data integrity.

This combination makes the z/OS Parallel Sysplex unique from every other system, solution, and architecture that is available today. The Parallel Sysplex matrix is listed in Table 16.

Table 16 Parallel Sysplex1

Parallel Sysplex	IBM z16 A01	IBM z15 T01	IBM z15 T02	IBM z14 M0x	IBM z14 ZR1
CFLevel=25 <sup>a</sup>	S	n	n	n	n
Structure Full Recovery	S	n	n	n	n
Cache and Lock structures retry enhancements	S	n	n	n	n
Additional Cache Structure Metrics	S	n	n	n	n
CF Support for 224 tasks	S	n	n	n	n
CFLevel=24	n	S	S	n	n
CFCC Fair Latch Manager	S	S	S	n	n
CFCC Message Path Resilience Enhancement	S	S	S	n	n
CF Monopolization Avoidance	S	S	S	n	n
CFLevel=23	n	n	n	S <sup>b</sup>	S
CFLevel=22	n	n	n	S	S
System-managed CF structure duplexing	S	S	S	S	S
Coupling facility dynamic dispatch ON/OFF	n	S	S	S	S
Coupling Facility Thin Interrupt	S	S	S	S	S
Coupling facility shared processors	S	S	S	S	S
Integrated Coupling Facility (ICF)	O	O	O	O	O
z/VM guest coupling	S	S	S	S	S
<b>Coupling Links features for Parallel Sysplex clustering</b>					
Integrated Coupling Adapter (ICA SR1.1) (2 port/8 CHPIDs) FC 0176	O,CF	O	O	n	n
Integrated Coupling Adapter (ICA SR) (2 ports/8 CHPIDs) FC 0172	CF	CF	CF	O	O
Coupling Express2 LR - (2 ports/8CHPIDs)FC 0434	O	n	n	n	n

Parallel Sysplex	IBM z16 A01	IBM z15 T01	IBM z15 T02	IBM z14 M0x	IBM z14 ZR1
Coupling Express Long Reach (2 ports/8 CHPIDs) FC 0433	n	O, CF	O, CF	O, CF	O, CF
Internal Coupling link (IC) <sup>c</sup>	S	S	S	S	S
HCA3-O LR fanout for 1xIFB (4 ports/16 CHPIDs) FC 0170	n	n	n	O	n
HCA3-O fanout for 12x IFB (2 ports/8 CHPIDs) FC 0171	n	n	n	O	n
Server Time Protocol (STP) <sup>d</sup>					
External Time Source direct Ethernet connectivity to zCPC (NTP, PTP)	S <sup>e</sup>	n	n	n	n
Graphical setup and configuration at the HMC	S	S <sup>f</sup>	S <sup>g</sup>	S	S
CTN Dynamic Split or Merge <sup>g</sup>	S	S	S	S	S
Additional stratum level (4)	S	S	S	S	S
Continuous availability of NTP servers	S	S	S	S	S
HMC used as an NTP server <sup>h</sup>	S	S	S	S	S
NTP server with pulse per second (PPS) <sup>i</sup>	S	S	S	S	S
NTP client	S	S	S	S	S
IEEE 1588 Precision Time Protocol (PTP) support as External Time Source <sup>j</sup>	S	S <sup>k</sup>	S <sup>l</sup>	n	n
PTP server with pulse per second (PPS)	S	S	S	n	n
Improved STP recovery and availability when an Internal Battery Feature (IBF) is installed on one or more servers in the CTN	na <sup>m</sup>	S	na <sup>n</sup>	S	na <sup>n</sup>
Going away signal to improve recovery	S	S	S	S	S
Sysplex Time with PTP direct to CPC	O	n	n	n	n
n-mode Power STP imminent Disruption signal <sup>n</sup>	S	n	n	n	n
Enhanced Console Assisted Recovery	S	S	S	S	S
Save STP configuration and time information across power-on resets (POR) or power outages for a single or dual server STP-only CTN	S	S	S	S	S
z/OS messaging when events occur related to accessing an ETS	S	S	S	S	S

- a. Enhancements for CFCC Level 25. CF Level 25 includes enhancements from previous CFCC levels. Require OS support.
- b. CFCC Level 23 was delivered with IBM z14 Driver Level 36.
- c. 64 per CPC for IBM z16 and IBM z15, up from 32 per CPC for previous generations. Total Coupling CHPIDs per CEC allowed: 384 for IBM 15 and IBM z16 and 256 for previous servers.
- d. STP feature is optional.
- e. Setting up STP for a IBM z16 requires HMC 2.16.0.



- f. Setting up STP for a IBM z15 requires HMC 2.15.0 or newer. Support element (Driver 41) Sysplex Timer task has been discontinued.
- g. Requires HMC 2.14.1 or newer.
- h. The HMC must be at level 2.10.1 for an STP-only CTN to obtain its external time. Not available when the HMC is used as NTP server.
- i. Not available when the HMC is used as NTP server.
- j. Requires PTP capable infrastructure (including networking support). Requires PPS.
- k. For IBM z15 PTP Server connectivity is provided via SE management network connection.
- l. Available only if PTS/CTS (Current Time Server) & BTS are IBM z 16 CPCs. Note: Other CPCs in the Timing Network (including Arbiter) can be a mix of IBM z16 or legacy CPCs.
- m. IBF feature is not available for this CPC.
- n. Must be configured (opt-in). Requires that both PTS and BRS are IBM z16 CPCs.

# Performance

Workload capacity performance is sensitive to three major factors: Instruction path length, instruction complexity, and memory hierarchy.

The IBM Z configurations are designed to deliver the highest levels of performance and capacity for large-scale consolidation and growth. Attributes and design points of the IBM Z systems that contribute to overall performance and throughput are listed in Table 17.

Table 17 Performance

Performance	IBM z16 A01	IBM z15 T01	IBM z15 T02	IBM z14 M0x	IBM z14 ZR1
16 floating point registers	S	S	S	S	S
64-bit addressing	S	S	S	S	S
Branch and set authority facility	S	S	S	S	S
Compare and move extended facility	S	S	S	S	S
Data hardware compression (CMPSC)	S	S	S	S	S
IBM Integrated Accelerator for zEDC	S	S	S	n	n
IBM Integrated Accelerator for IBM Z SORT	S	S	S	n	n
Dedicated move page engine	S	S	S	S	S
Dynamic CF dispatching	S <sup>a</sup>	S	S	S	S
Dynamic Address Translation (DAT)	S	S	S	S	S
Enhanced Move Page/VM	S	S	S	S	S
Extended translation facility	S	S	S	S	S
Extensions for virtual machine (VM)	S	S	S	S	S
Flexible memory configurations <sup>b</sup>	O	O	n	O	n
Floating point instruction <sup>c</sup>	S	S	S	S	S
Hardware decimal floating point facility	S	S	S	S	S
HFP square root instruction <sup>c</sup>	S	S	S	S	S
HiperDispatch function	S	S	S	S	S
Immediate and relative instruction <sup>c</sup>	S	S	S	S	S
Large Page Support	S	S	S	S	S
1 MB large page support (pageable)	S	S	S	S	S
2 GB large page support	O	O	O	O	O
Level 1 cache size (Instruction/Data in KB)	128/128	128/128	128/128	128/128	128/128
Level 2 cache size (Instruction/Data in MB)	32 <sup>d</sup>	4/4	4/4	2/4	2/4
Level 3 cache size (in MB)	256 <sup>e</sup>	256	256	128	128

Performance	IBM z16 A01	IBM z15 T01	IBM z15 T02	IBM z14 M0X	IBM z14 ZR1
Level 4 cache size (in MB) <sup>f</sup>	2048 <sup>e</sup>	960	960	672	672
Logical string assist	S	S	S	S	S
Long displacement facility	S	S	S	S	S
Number of cores per processor unit <sup>g</sup>	8/16	12	12 <sup>h</sup>	10	10
Move page	S	S	S	S	S
Runtime Instrumentation	S	S	S	S	S
Out of Order Instruction Execution	S	S	S	S	S
Perform locked operation facility	S	S	S	S	S
Plan ahead memory	n	n	n	O	O
Processor frequency (Ghz)	5.2	5.2	4.5	5.2	4.5
Server/Application State Protocol (SASP) support for load balancing across virtual servers	S	S	S	S	S
On-chip AIU engine	S	n	n	n	n
Start Interpretive Execution (SIE)	S	S	S	S	S
Superscalar	S	S	S	S	S
Suppression on protection facility	S	S	S	S	S
Simultaneous Multi Threading (SMT) on zIIPs, IFLs, and SAPs	S	S	S	S	S
Single Instruction Multiple Data (SIMD)	S	S	S	S	S
System Recovery Boost <sup>i</sup>	S	S	S	n	n
z/OS recovery process boost <sup>j</sup>	S	S	S	n	n
System Recovery Boost Upgrade (FC 6802)	O	O	n	n	n
IBM z Integrated Information Processors (zIIPs)	O	O	O	O	O
Transactional Memory	S	S	S	S	S
Trimodal addressing (24-, 31- and 64-bit addressing) support	S	S	S	S	S
zHyperLink support	S	S	S	S	S
Maximum supported memory (in TB) <sup>k</sup>	40	40	16	32	8
<b>zEnterprise Data Compression Express (zEDC)</b>					
zEnterprise Data Compression Express FC 0420 <sup>l</sup>	n	n	n	O	O
<b>Virtual Flash Memory (VFM)</b>					
Virtual Flash Memory (VFM)	O	O	O	O	O

a. Coupling Facility Dynamic Dispatching ON/OFF is not supported on IBM z16.

- b. Flexible Memory is an option for multi-drawer systems to alleviate memory requirements when a CPC drawer is replaced (concurrently).
- c. For more information, see *Principles of Operation*, SA22-7832.
- d. IBM z16 has unified L2 cache, 32 MB semi private to each core.
- e. Virtual L3 and L4 caches. For IBM z16, L3 and L4 caches are logical constructions.
- f. At CPC drawer level. Multiple CPC system uses SMP connectivity for L4 cache coherency at system level.
- g. Eight (8) cores per PU chip and sixteen (16) cores per DCM (Dual Chip Module). The maximum number of cores is not available on all PUs chips.
- h. 12 cores by design; 7-11 active cores.
- i. Requires Operating System opt-in. For more information refer to Redpaper REDP-5563.
- j. Short duration boost for speeding up sysplex recovery; based on System Recovery Boost functionality. Requires OS opt-in.
- k. The maximum amount of memory depends on the system configuration and number of CPC drawers.
- l. For the IBM z16 server generation (M/T3931) and for the IBM z15 server generation (M/T 8561 and 8562) the FC 0420 PCIe Feature has been replaced by the on-chip IBM Integrated Accelerator for zEnterprise Data Compression.

# Processor Resource/Systems Manager

IBM Processor Resource/Systems Manager™ (PR/SM™) consists of hardware and microcode that is built into IBM Z to support the sharing of available hardware resources into logical partitions (LPARs). LPARs allow you to run multiple system images on a single processor complex. Each image includes a full complement of CPUs (dedicated or shared), main storage, expanded storage, and channels. Channels can be shared across images by using the multiple image facility (MIF) feature.

The PR/SM functionality ensures the highest level of optimized resources usage and an unparalleled utilization in the IT world of the IBM Z near to 100%. The main characteristics of PR/SM for the IBM z16, IBM z15, IBM z14 M0x, IBM z14 ZR1 are listed in Table 18.

Table 18 PR/SM Characteristics

PR/SM Characteristics	IBM z16 A01	IBM z15 T01	IBM z15 T02	z14 M0x	z14 ZR1
128-bit TOD clock (Extended TOD clock facility) <sup>a</sup>	S	S	S	S	S
Absolute capping support of PUs (all types)	S	S	S	S	S
Absolute capping support of an LPAR Group	S	S	S	S	S
Add/delete logical partition name	S	S	S	S	S
Automatic Reconfiguration Facility (ARF)	S	S	S	S	S
Defined capacity I/O	S	S	S	S	S
Dynamic Memory Management	S	S	S	S	S
Dynamic Storage Reconfiguration	S	S	S	S	S
Dynamic PU reassignment	S	S	S	S	S
EAL5 certification	S <sup>b</sup>	S	S	S	S
HSA size (in GB)	256	256	160	192	64
Hypervisor support for virtualization: z/VM	S	S	S	S	S
Hypervisor support for virtualization: KVM	S	S	S	S	S
Individual management of PU types	S	S	S	S	S
Logical partition time offset	S	S	S	S	S
LPAR group capacity limit	S	S	S	S	S
LPAR management time report	S	S	S	S	S
LPAR preferred path	S	S	S	S	S
Max number of configurable processors	200	190	65	170	30
Max number of CPs	200	190	6	170	6
Max number of supported LPARs	85	85	40	85	40
Max number of supported LCSS	6	6	3	6	3
Max number of subchannel sets per LCSS	4	4	3	4	3

PR/SM Characteristics	IBM z16 A01	IBM z15 T01	IBM z15 T02	z14 M0x	z14 ZR1
Simultaneous multithreading (SMT) for IFLs, zIIPs, and SAPs	S	S	S	S	S
Single Instruction Multiple Data (SIMD)	S	S	S	S	S
Single storage pool	S	S	S	S	S
Secure Service Container (SSC)	S	S	S	S	S
Secure Execution for Linux <sup>c</sup>	S	S	S	n	n
Dynamic Partition Manager (DPM)	O	O	O	O	O
<b>Intelligent Resource Directory (IRD)</b>					
Channel subsystem priority queueing	S	S	S	S	S
Dynamic Channel Path Management (DCM)	S	S	S	S	S
LPAR CPU management	S	S	S	S	S
<b>Processor Types</b>					
CP	O	O	O	O	O
SAP <sup>d</sup>	S,O	S,O	S,O	S,O	S,O
ICF	O	O	O	O	O
IFL	O	O	O	O	O
IFP	O	O	O	O	O
zIIP	O	O	O	O	O

- a. The Extended-TOD-Clock Facility is a hardware facility that provides a 128-bit time-of-day (TOD) clock.
- b. Common Criteria EAL5 certification for the security of the LPARs that run under the control of PR/SM is in process.
- c. Secure Execution for Linux for second level Linux guests (FC 0115).
- d. SAPs are standard. The initial number of SAPs is model dependant. Additional (optional) SAPs can be added via FC 1963 on IBM z16, FC 1949 on IBM z15 and FC 1935 on IBM z14.

## Reliability, availability, and serviceability

The IBM Z design is focused on providing higher availability by reducing planned and unplanned outages, which is commonly known as *Reliability, availability, and serviceability (RAS)*. RAS can be accomplished by using improved concurrent replace, repair, and upgrade functions for processors, memory, and I/O. RAS also extends to the nondisruptive capability for installing Licensed Internal Code (LIC) updates.

As an extension to the RAS capabilities, environmental controls are implemented in the system to help reduce power consumption and meet cooling requirements. Continuous improvements in RAS are associated with new features and functions to ensure that IBM Z machines deliver exceptional value.

The main RAS features of the IBM z16, IBM z15, and IBM z14 are listed in Table 19.

Table 19 RAS functionality

RAS	IBM z16 A01	IBM z15 T01	IBM z15 T02	z14 M0X	z14 ZR1
50/60 Hz power	S	S	S	S	S
Three-phase AC power	S	S	O	S	n
DC power	n	n	n	O	n
Ability to display and track historical power, temperature, and utilization data	S	S	S	S	S
Alternate HMC <sup>a</sup>	O	O	O	O	O
Alternate Support Element	S	S	O	S	S
Hardware Management Appliance	O	O <sup>b</sup>	O	n	n
Bolt down kit for low-raised floor and high-raised floor installation <sup>c</sup>	O	O	O	O	O
Bolt down kit for nonraised floor installation“ <i>This feature applies to a raised-floor environment. This feature supplies the kit of parts that is designed to help secure the frames and their contents from damage when exposed to vibrations and shocks such as those in a seismic event.</i> ” on page 32 <sup>c</sup>	O	O	O	O	O
Concurrent channel adapter add	S	S	S	S	S
Concurrent book/processor drawer add	S <sup>d</sup>	S <sup>d</sup>	n	S	n
Concurrent PCIe I/O drawer add	S <sup>e</sup>	S <sup>e</sup>	S <sup>e</sup>	S	S <sup>e</sup>
Dynamic Fabric repair	S	S	S	S	S
Concurrent PU conversions	O	O	O	O	O
Console Integration (CI)	S	S	S	S	S
Digitally signed firmware provided by the HMC and SE	S	S	S	S	S
Dynamic change to partition cryptographic coprocessor configuration	S	S	S	S	S

RAS	IBM z16 A01	IBM z15 T01	IBM z15 T02	z14 M0x	z14 ZR1
Dynamic add of a logical processor to an LPAR	S	S	S	S	S
Dynamic LCSS add without preplanning	S	S	S	S	S
Dynamic memory bit lane sparing	S	S	S	S	S
Dynamic memory sparing <sup>f</sup>	S	S	S	S	S
Dynamic oscillator switchover	S	S	S	S	S
Dynamic partition add without preplanning	S	S	S	S	S
Dynamic subchannel set add without preplanning	S	S	S	S	S
Enhanced application preservation	S	S	S	S	S
Enhanced drawer availability (EDA) for processor drawer <sup>g</sup>	S	S	S	S	n
Fault tolerant design	S	S	S	S	S
FCP program directed IPL	O	O	O	O	O
FICON channel link error problem analysis	S	S	S	S	S
FICON dynamic routing (FIDR)	S	S	S	S	S
FICON forward error correction (FEC) for FICON <sup>h</sup>	S	S	S	S	S
FICON link incident reporting	O	O	S	O	O
FICON SAN Fabric I/O Priority for WLM	S	S	S	S	S
FICON multihop cascaded directors (max number of directors)	4	4	4	4	4
Fixed HSA	S	S	S	S	S
HMC and SE IPv6 support	S	S	S	S	S
HMC FCP Problem Determination panels	S	S	S	S	S
HMC instant messenger	S	S	S	S	S
I/O interface reset	S	S	S	S	S
Internal Battery Feature (IBF)	n	O	n	O	n
IPL from alternative subchannel set	S	S	S	S	S
LICCC memory upgrade	S	S	S	S	S
LICCC processor upgrade	S	S	S	S	S
Memory RAIM	S	S	S	S	S
Monitor and track power consumption, internal temperature, and utilization data of the CPC using monitor dashboard task on the HMC	S	S	S	S	S
Multipath IPL - with z/OS	S	S	S	S	S
Nondisruptive I/O removal	S	S	S	S	S



RAS	IBM z16 A01	IBM z15 T01	IBM z15 T02	z14 M0x	z14 ZR1
N+1 power supplies	S	S	S	S	S
Partial CP restart	S	S	S	S	S
Partial memory restart	S	S	S	S	S
PDU Power Option	O	O	S	n	S
BPA Power Option	O	O	na	S	na
Balanced Power - Plan ahead (BPA models only)	O	O	n	O	n
Power - dual power feeds	S	S	S	S	S
Power - Plan ahead power cords <sup>i</sup>	O	O	n	O	n
Power consumption estimator tool (IBM Resource Link®)	S	S	S	S	S
Manage Power Service State (HMC) - (CPC Power redundancy check)	S	S	S	S	S
Precheck function to detect conflicts between a new permanent upgrade and any active temporary resources	S	S	S	S	S
Processor drawer degradation mode	S	S	S	S	S
PU sparing (if spare available, config dependent)	S	S	S	S	S
SAP reassignment	S	S	S	S	S
Sparing for storage protect keys <sup>f</sup>	S	S	S	S	S
Subspace group facility	S	S	S	S	S
Subsystems storage protect	S	S	S	S	S
Symbol Error Correction Code (ECC) on L2, L3 and L4 cache	S <sup>j</sup>	S	S	S	S
System-initiated CHPID reconfiguration	S	S	S	S	S
Top exit I/O cabling	O	O	O	O	O
Top exit power cabling	O	O	O	O	O
Water manifold for processor cooling as FRU	S	S	n	S	n
Worldwide port name (WWPN) tool to help with preplanning and setting up SAN environment before installation	S	S	S	S	S
<b>Concurrent maintenance</b>					
Channel - Adapter	S	S	S	S	S
Cooling units (water cooled) <sup>k</sup> Water Cooling Unit-WCU)	n	S	n	S	n
Cooling units (air cooled) <sup>l</sup> Radiator Cooling Unit-RCU)	S	S	n	S	n

RAS	IBM z16 A01	IBM z15 T01	IBM z15 T02	z14 M0x	z14 ZR1
CPC drawer (including memory DIMMs) <sup>g</sup>	S	S	S	S	n
Enhanced driver maintenance	S	S	S	S	S
Hardware Management Console (HMC)	S	S	S	S	S
IFB-MP	na	na	na	O <sup>m</sup>	n
Oscillator	S	S	S	S	S
PCIe I/O drawer or PCIe+ I/O drawer <sup>p</sup>	S	S	S	S	S
PCI-IN (PCIe Interconnect)	S	S	S	S	S
Point of Load (POL) - CPC drawer power regulators <sup>n</sup>	S	S	S	S	S
Single Chip Modules (SCM)	na	S	S	S <sup>g</sup>	S <sup>g</sup>
Dual Chip Module (DCM)	S <sup>g</sup>	n	n	n	n
Support Element (SE)	S	S	S	S	S
<b>Concurrent MCL apply</b>					
CFCC <sup>o</sup>	S	S	S	S	S
Channel features					
CE LR <sup>p</sup>	n	S	S	S	S
CE2 LR <sup>p</sup>	S	na	na	na	na
RoCE Express <sup>p</sup>	S	S	S	S	S
Crypto-Express <sup>p</sup>	S	S	S	S	S
FICON-Express	S	S	S	S	S
IC	S	S	S	S	S
ICA SR	S	S	S	S	S
HCA3 features	na	na	na	S <sup>m</sup>	na
OSA-Express	S	S	S	S	S
zHyperLink <sup>p</sup>	S	S	S	S	S
Hardware Management Console (HMC)	S	S	S	S	S
Support Element (SE)	S	S	S	S	S
PU core engineering data	S	S	S	S	S

a. With HMA (FC 0129), two HMCs are always available.

b. Hardware Management Console running on the Support Element hardware; Available with initial order only (no MES).

c. This feature applies to a raised-floor environment. This feature supplies the kit of parts that is designed to help secure the frames and their contents from damage when exposed to vibrations and shocks such as those in a seismic event.

- d. On IBM z16 A01, field addition (MES) of the fourth CPC drawer is not supported (upgrades from IBM z16 A01 Max39 to Max82 or Max125 only). For IBM z15 T01, field addition of fourth or fifth CPC drawers is not supported (upgrades from IBM z15 T02 Max31 to Max65 or Max108 only). CPC reserve feature must be present in the initial order for supported upgrades.
- e. The IBM z16, IBM z15 and IBM z14 ZR1 is housed in a industry standard, 19-inch format frame. A new PCIe+ I/O drawer (capable of hosting up to 16 PCIe features) was designed and built to fit the 19-inch rack. IBM z16, IBM z15 and IBM z14 ZR1 does not support PCIe I/O drawer (capable of hosting 32 PCIe features).
- f. Sparing can be done with steering or marking technology.
- g. Applies to systems with two or more processor drawers.
- h. All FICON features newer than FICON EXPRESS16S have FICON Error Correction (FEC) implemented.
- i. Available for BPA models only.
- j. For IBM z16, L3 and L4 levels are implemented as virtual shared victim cache.
- k. IBM z15 T01 and IBM z14 M0X only. WCU not offered for IBM z16.
- l. Exchanging the RCU is not concurrent. Within the RCU, The RPUs (Radiator Pump Unit) and the CFAs (Cooling Fan Assembly) are concurrent replaceable.
- m. IFB feature is excluded from Sysplex/CTN when a IBM z16 is part of the configuration.
- n. POL - Point Of Load is a CPC drawer power distribution system. Replacement is concurrent for models with 2 or more CPC drawers.
- o. CF partition restart may be required.
- p. Require planning for maintenance and redundant adapters.

This paper was produced by a team of specialists from around the world working at the IBM Redbooks, Poughkeepsie Center.

**Octavian Lascu** is an IBM Redbooks Project Leader with over 30 years of experience. He specializes in designing, implementing, and supporting complex IT infrastructure environments (systems, storage, and networking), including high availability and disaster recovery solutions and high-performance computing deployments. He has developed materials for and taught over 50 workshops for technical audiences around the world. He is the author of several IBM publications.

**Bill White** is an IBM Redbooks Project Leader and Senior Networking and Connectivity Specialist at IBM Redbooks, Poughkeepsie Center.

**Ewerson Palacio** is an IBM Redbooks Project Leader. He holds Bachelors's degree in Math and Computer Science. Ewerson worked for IBM Brazil for over 40 years and retired in 2017 as an IBM Distinguished Engineer. Ewerson co-authored a large number of IBM Z publications created and presented at IBM Redbooks seminars around the globe.

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