



Product Guide

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IBM BladeCenter HS12

Product Overview

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Entry single-socket blade server with the power of a traditional 2-socket server

Suggested uses: *File-and-print, collaboration, Web serving, retail, branch office/departamental server.*

Today's data center environment is more challenging than ever. You need to reduce IT costs, complexity, power consumption and heat output, without sacrificing flexibility, utilization and manageability. Incorporating IBM® **X-Architecture™** features, the **single-socket IBM BladeCenter® HS12 blade server**, combined with the various BladeCenter chassis, can help you accomplish all of these goals.

Reducing an entire server into as little as **.5U** of rack space does *not* mean trading away features and capabilities for smaller size. Each HS12 blade server offers features comparable to many 1U rack-optimized full-featured servers: The single-wide (30mm) HS12 blade server supports the latest high-performance **quad-** and **dual-core Intel® Xeon®** processors, as well as economical **dual-core Core 2 Duo** and **single-core Celeron** processors. The Xeon processors are designed with **2MB** (dual-core), or **6MB** or **12MB** (quad-core) of **L2** cache, a leading-edge **1066MHz** or **1333MHz** front-side bus (FSB), and **64-bit extensions (EM64T)**, to help provide the computing power you require. The Core 2 Duo and Celeron processors include **2MB** or **512KB** (respectively) of L2 cache and a **1066MHz** FSB.

The HS12 supports up to **24GB** of **667MHz PC2-5300** registered **ECC** (Error Checking and Correcting) double data rate II (**DDR2**) memory in **6** DIMM slots, with **Chipkill™** protection, for high performance and reliability.

All HS12 models offer impressive features at an entry-server price, including up to **two hot-swap SAS** hard disk drives with **RAID-0** data striping or **RAID-1** disk mirroring support standard (**RAID-5** optional), or **two fixed SATA II** HDDs, or **two hot-swap** or **fixed solid-state drives**. Moreover, the HS12 is **optimized** for diskless operation, offering each blade server access to essentially unlimited storage capacity via Fibre Channel or iSCSI.

An integrated **dual-port Gigabit Ethernet¹** controller is standard, providing high-speed data transfers, load-balancing and failover support. Via optional expansion cards, each blade can also connect to additional Gb Ethernet, **10Gb Ethernet**, **Myrinet**, **4Gb Fibre Channel**, **4X InfiniBand™**, and other high-speed communication switches housed in the chassis. This blade is designed with **power management capability** to provide the maximum uptime possible for your systems. In extended thermal conditions or power brownouts, rather than shut down completely, or fail, the HS12 automatically reduces the processor frequency to maintain acceptable thermal and power levels.

A single **BladeCenter E** or **BladeCenter H** chassis supports up to **14 hot-swappable** 30mm-wide HS12 blades in only **7U** (BladeCenter E) or **9U** (BladeCenter H) of rack space or up to **8** hot-swappable blades in the rugged **8U BladeCenter T** chassis or up to **12** in the **12U BladeCenter HT** high-speed telecommunications chassis. In addition to the blade servers, these chassis also hold up to **four** (BladeCenter E/BladeCenter T) **communication switches**, or up to **eight** or **ten switches/bridges** (BladeCenter HT and H, respectively) internally. The **BladeCenter S**, designed for SMB and mid-market customers, takes integration and affordability to a new level, combining up to **12 hot-swap SAS/SATA** HDDs with **6 blade servers** and **4 switches**. Not only can this save significant data center space (and therefore the cost of floor space and rack hardware) compared to 1U servers, it also consolidates switches/bridges and cables for reduced complexity and lower cabling costs, and allows clients to manage everything in the solution as one. Using a BladeCenter E chassis, up to **84** HS12 servers (**84** processors/**336** processor cores) can be installed in one **industry-standard 42U** rack but the value of BladeCenter extends far beyond high density data center environments.

¹ Actual data transfer speed will vary and is often less than the maximum possible. Gigabit Ethernet transfer speed requires support on both system and server, and appropriate network infrastructure.

The various BladeCenter chassis are designed to monitor environmental conditions in the chassis and each blade and send alerts to the administrator. Advanced standard features, such as **Active Memory™**, **Predictive Failure Analysis™**, **light path diagnostics**, **hot-swap redundant power supplies and blower modules with Calibrated Vectored Cooling™**; **IPMI 1.5** support, including **highly secure remote power control**; **text-console redirect over LAN**, a **Management Module** (upgradeable with a redundant MM), **IBM Director** management software including **IBM Systems Director Active Energy Manager for x86** (formerly known as PowerExecutive), **Remote Deployment Manager**, and **IBM ServerGuide™** help maintain system availability with increased uptime.

If you need highly manageable, high-performance computing power in a space- or power-constrained environment, at a budget price, the HS12 is the ideal system.

Selling Features

Price/Performance

There is an HS12 model to fit all budgets and performance requirements:

- The HS12 offers a choice of **high-performance quad- and dual-core Xeon processors**, as well as **low-cost dual-core Core 2 Duo** and **single-core Celeron** processors with 64-bit extensions, **1.86GHz to 2.83GHz** clock rates, **1066MHz or 1333MHz** front side bus, and **512KB to 12MB** (processor-specific) of integrated Level 2 cache, and **65W to 80W** maximum power draw.
- **Energy-efficient processors** draw less power and produce less waste heat than high-voltage processors, thus helping to reduce data center energy costs. **Dual-core Xeon** and **Core 2 Duo** processors use only **65W (32.5W per core)**. This is half the wattage consumed by older 130W processors. On a per-core basis, the **quad-core** processors are even more economical, consuming only **80W (20W per core)**.
- **Registered PC2-5300 ECC** memory operates at **667MHz** with **dual-interleaving**, for high performance.
- A choice of **high-performance hot-swap SAS** or **low-cost fixed SATA** HDDs.
- **RAID-1** provided standard offers high-performance disk access for SAS HDDs.
- Selected HS12 blade servers will be **NEBS3/ETSI-compliant** (when testing is complete) and feature long-life availability. These blades are ideal for telecom or Next Generation Network (NGN) applications such as IPTV, IP Multimedia Subsystem (IMS) and security.
- The **extremely high degree of integration** in the various BladeCenter chassis reduces the need for server **components**, replacing numerous fans, KVM and Ethernet cables, power supplies, external switches and other components with fewer *shared* hot-swap/redundant components in the chassis itself. This integration also can greatly **reduce** the amount of **power consumed and heat produced**, relative to an equivalent number of 1U servers. This can significantly reduce a data center's power bill. The **reduced datacenter footprint** can also save on infrastructure cost.
- The chassis **midplane** provides **high-speed blade-to-blade, blade-to-switch-module and module-to-module communication** internally as well as externally. The midplane in the BladeCenter H provides **four 10Gb** data channels to each blade, and supports **4X InfiniBand** and **10Gb Ethernet** high-speed switch modules.
- The various BladeCenter chassis use **ultrahigh efficiency power supplies**. Most industry-standard servers use power supplies that are between **65-75% efficient** at converting power from AC wall current to the DC power used inside servers. BladeCenter power modules can be **more than 90% efficient**. This helps **save** even more money, as more of the power input you are paying for is used for processing, rather than released into the data center as waste heat.
- BladeCenter also **reduces the number of parts required** to run the system. Sharing fans, systems management, floppy devices and media means fewer parts to buy and maintain, and fewer items that can bring the solution down.

Flexibility

The **HS12** has the ability to grow with your application requirements, thanks to:

- A choice of high-performance **quad- or dual-core Xeon** processor or low-cost **dual-core Core 2 Duo** or **single-core Celeron** processor.
 - A choice of speeds from **1.86 to 2.13GHz** (*single- and dual-core*), and **2.5 to 2.83GHz** (*quad-core*), a choice of **1066MHz or 1333MHz** FSB, a choice of **512KB, 2MB, 6MB, or 12MB** of L2 cache, and a choice of power draw of **65W or 80W**.
 - Up to **24GB** of registered **667MHz PC2-5300 DDR2** error checking and correcting (ECC) system memory with optional **Chipkill** protection, using **6** DIMM slots. Having 6 slots allows for less-expensive memory configurations than a 4-slot server does. For example, to install **12GB** of memory in the HS12 requires **six** inexpensive **2GB** DIMMs; a 4-slot server would require **two 2GB** DIMMs and **two** expensive **4GB** DIMMs.
 - Up to **two** internal **2.5-inch hot-swap SAS** or **fixed SATA** HDDs and access to terabytes of
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external **IBM System Storage™** and **IBM TotalStorage™** SAN and NAS storage devices. **2.5-inch** drives consume approximately *half the power* of 3.5-inch drives, helping to save you power and cooling costs in the data center.

- Two optional internal **hot-swap 15.8GB or 31.4GB Solid State Drives** in place of the HDDs, as either higher-reliability/higher-availability storage or as a boot-to-SAN drive.
- **Two** Gigabit Ethernet ports standard; plus more, using either a **2-port Gigabit Ethernet Expansion Card** or a **PCI I/O Expansion Unit 3**.

In addition, the various **BladeCenter chassis** offer a high degree of flexibility:

- A 30mm HS12 blade server (SAS models only) can be upgraded, via a **Storage and I/O Expansion Unit 3** and/or a **PCI I/O Expansion Unit 3**. This expandability allows configurations that are **30mm, 60mm, or 90mm** wide, with a variety of memory, storage and I/O options, depending on need.
- Xeon processor-based **HS12** blades can be used in the same chassis as Intel processor-based **HC10, HS20, HS21, HS21 XM** and **HS40** blades; AMD Opteron processor-based **LS20, LS21, and LS41** blades; IBM PowerPC® processor-based **JS12, JS20, JS21** and **JS22** blades, and Cell Broadband Engine™ processor-based **QS21** blades. Depending on the blade servers used, the various BladeCenter chassis support Microsoft **Windows, Linux, Netware, IBM AIX®** and Sun **Solaris 10** operating systems in the same chassis.
- *Every HS/LS/JS blade server ever released by IBM is supported in BladeCenter H, and most are supported in every BladeCenter chassis ever released, going back to 2002. Every switch module released by IBM is equally compatible. (Ask HP and Dell how far back their compatibility goes.)* Future blades and fabric switches are expected to continue to be compatible with previous chassis for the foreseeable future.
- A blade server has access to as many as **10 communication switches** and/or bridges in one **BladeCenter H** chassis. (Up to **6** switches in a BladeCenter E or BladeCenter T chassis.) And the switches can be Ethernet, iSCSI, InfiniBand, Fibre Channel, Myrinet, or anything else designed and ServerProven® for BladeCenter use. Switches, bridges and interface cards are currently available from such vendors as Brocade, Cisco, Intel, McData, Nortel, QLogic, Cisco Topspin and others, in addition to IBM.

Manageability

- The HS12 blade server includes a **Baseboard Management Controller (BMC)** to monitor server availability, perform Predictive Failure Analysis, etc., and trigger IBM Director alerts.
- Each BladeCenter chassis includes an **Advanced Management Module** to provide additional systems management capabilities, including *Web-based out-of-band control; virtual floppy and CD-ROM support; Windows “blue screen” error capture; LDAP and SSL support; and remote redirection of video, text, keyboard and mouse.*
- Integrated industry-standard **IPMI 1.5** support works with the BMC to alert IBM Director to anomalous environmental factors, such as voltage and thermal conditions. It also supports **highly secure remote power control**.
- **IBM Systems Director Active Energy Manager for x86**, an IBM-exclusive, is designed to take advantage of new system power management features, by monitoring *actual* power usage and providing power consumption capping features. More accurate power usage data helps with data center construction planning and the sizing of power and cooling needs, as well as allowing you to use available power more efficiently.
- The HS12 supports an optional feature card that provides **concurrent KVM (cKVM)** and **concurrent media (cMedia)** access by multiple administrators at once. (This card uses a dedicated slot and does not affect the use of PCI-X/PCIe adapters.)
- **IBM Director** is included for proactive systems management and works with both the blade's internal BMC and the chassis' management module. It comes with a portfolio of tools, including *IBM Systems Director Active Energy Manager for x86, Management Processor Assistant, RAID Manager, Update Assistant, and Software Distribution*. In addition, IBM Director offers extended systems management tools for additional server management and increased availability. When a problem is encountered, IBM Director can issue administrator alerts via e-mail, pager, and other methods.

Availability and Serviceability

- BladeCenter chassis are designed for operation with **greatly reduced potential for single points of failure**. Most aspects of operation, from blade servers to communication modules, to management modules, to power and blower modules, are **hot-swappable**. The midplane connections are **redundant** and the other features can be made so, when used in pairs.
 - **Solid-state drives** offer up to *triple* the availability (MTBF rates) of conventional SAS HDDs. This can lessen the need for redundant drives.
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- HS12 blade servers support the use of **Chipkill-enabled** memory (using 1GB or larger DIMMs). Chipkill memory can be up to **16X** better than standard ECC memory at correcting some types of memory errors. This can help reduce downtime caused by memory errors.
 - **IPMI 1.5** supports highly secure remote system power on/off using data encryption. This allows an administrator to restart a server without having to visit it in person, saving travel time and getting the server back up and running quickly and securely.
 - **Environmentally tuned blower modules** in the chassis adjust to compensate for changing thermal characteristics. At the lower speeds they draw less power and suffer less wear. Equally important in a crowded data center, temperature-controlled blowers produce less ambient noise in the data center than if they were constantly running at full speed.
 - **Text and graphics console redirection** support allows the administrator to remotely view HS12 text and graphic messages over serial or LAN connections.
 - A **standard three-year (parts and labor) limited onsite warranty**² on selected Xeon-processor-based models affords you peace of mind and greater potential investment protection.
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Right, Open, Easy, Green

You need to make IT decisions that will drive business success. You face management challenges and technological complexity such as space constraints, power and cooling limitations, heterogeneous environments and I/O connectivity issues. IBM brings together the widest choice of compatible chassis, blade servers, storage and networking offerings and solution providers in the industry to help you build an open and flexible IT environment. And regardless of the size of your business, you want to be up and running 24/7. With built-in redundancy, innovative power and cooling and the latest I/O and management tools, IBM BladeCenter is easy to own—so you can focus on your business demands and stay ahead of the competition.

The **RIGHT** choice, tailored to fit your diverse needs:

- It's flexible and modular. As needs evolve, a one-size-fits-all solution doesn't work.
 - Meet your needs with BladeCenter: everything from a high-performance data center to a small office with limited IT skills—IBM has you covered
 - Get flexibility with 5 compatible chassis and 5 blade types supporting multiple I/O fabrics, all managed from a common point
- It's robust and reliable, providing redundancy throughout and the information you need to keep your business up and running.
 - Provide redundancy for no single point of failure with IBM BladeCenter
 - Preserve application uptime with IBM Predictive Failure Analysis[®] and light path diagnostics
 - Make decisions based on accurate data for quick problem diagnosis with First Failure Data Capture

OPEN and innovative, for a flexible business foundation:

- It's comprehensive, providing broad, fast, and reliable networking and storage I/O with BladeCenter Open Fabric.
 - Match your data center needs and the appropriate interconnect using a common management point, and 5 I/O fabrics to choose from
 - Extract the most from your third-party management solutions by utilizing the BladeCenter Open Fabric Manager
- It's collaborative, enabling you to harness the power of the industry to deliver innovation that matters.
 - Get flexibility from a myriad of solutions created by Blade.org members and industry leaders that have downloaded our open specification

EASY to deploy, integrate and manage:

- It enables efficient integrated management, which allows you to minimize costs with the tools you need for effective management.
 - Automate OS installation and BIOS updates remotely with IBM Director tools
 - Administer your blades at the chassis or rack level with the Advanced Management Module
 - Plug into your enterprise management software
 - It enable deployment simplicity without tradeoffs by speeding the deployment of new hardware in minutes rather than days, using BladeCenter Open Fabric Manager
 - Get significantly faster deployment of servers and I/O than from rack solutions
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² For terms and conditions or copies of the IBM Statement of Limited Warranty, call 800-772-2227 in the U.S. In Canada call 800-426-2255. Telephone support may be subject to additional charges. For warranties including onsite labor, a technician is sent after IBM attempts to resolve the problem remotely. International warranty service is available in any country in which this product is sold.

- Reduce costly downtime with integrated failover capability
- Manage from a single point of control via the Advanced Management Module
- Use with virtually all IBM switches, blades and chassis

GREEN today for a better tomorrow:

- It offers control via powerful tools that help you optimize your data center infrastructure so you can be responsive.
 - Understand your power requirements with IBM Power Configurator
 - Monitor, control and virtualize your power with IBM Systems Director Active Energy Manager for x86
 - Reduce data center hot spots with the IBM Rear Door Heat eXchanger
 - Optimize and future-proof your data center with IBM Data Center Energy Efficiency services
- Our eco-friendly servers and services can help you be environmentally responsible.
 - Become more energy efficient with IBM expertise

Key Features



Multicore Intel Xeon Processors

The HS12 supports one **quad-core** or **dual-core** Xeon processor. The choice of processors includes:

- **80W quad-core** Xeon processor models **X3323**, **X3353**, and **X3363** at 2.5, 2.66, or 2.83GHz (respectively), with 64-bit extensions, *reduced power draw* (only **20W** per core), a **1333MHz** FSB, and **12MB** of L2 processor cache (2 x 6MB); supported in all BladeCenter chassis.
- **65W dual-core** Xeon processor model **E6405** at 2.13GHz, with 64-bit extensions, *reduced power draw*, a **1066MHz** FSB, and **2MB** of **shared** L2 processor cache; supported in all BladeCenter chassis.
- **65W dual-core Core 2 Duo** processor model **E6305** (operating at **1.86GHz**) with 64-bit extensions, *low power draw* (**32.5W** per core), an **1066MHz** FSB, and **2MB** of L2 processor cache (1 x 2MB)
- **65W single-core Celeron** processor model **445** running at **1.86GHz**, with 64-bit extensions, an **1066MHz** FSB, and **512KB** of L2 processor cache

The **dual-core** processors contain **two complete processor cores**; **quad-core** processors, similarly, contain **four** cores. The processors also contain one (dual-core) or two (quad-core) shared caches. The shared cache is dynamically allocated between pairs of cores as needed. The two cores appear to software as two physical processors. The dual-core processors offer considerably higher performance than a same-speed Xeon processor with a single core. Likewise, quad-core processors offer considerably higher performance than a same-speed Xeon processor with dual cores.

Intelligent Power Capability powers individual processor elements on and off as needed, to reduce power draw.

Intel **Extended Memory 64 Technology (EM64T)** 64-bit extensions allow Xeon processors to use large memory addressing when running with a 64-bit operating system. This can result in higher performance. Additional registers and instructions (SSE3) can further boost performance for applications written to use them. Contact your software providers to determine their software support for EM64T.

DDR II ECC Registered Memory with Chipkill Protection

The HS12 ships with **PC2-5300 registered** double data rate II (DDR II) VLP (very low profile) memory (operating at **667MHz**) for fast access, and provides Active Memory features, including advanced **Chipkill** memory protection (using 1GB or larger DIMMs), for **up to 16X** better error correction than standard ECC memory. The HS12 supports up to **24GB** of memory in **six** DIMM slots.



For increased availability, the HS12 offers an additional level of IBM Active Memory protection: **online hot-spare memory**. The 6 DIMM slots are divided into 2 channels of 3 DIMMs apiece. When *online hot-spare memory* is enabled, using single and/or dual-rank DIMMs **one rank** is set aside per channel as online spares in case one of the other ranks in that channel fails. *The spare rank must have capacity at least that of the largest active rank.* (In other words, if a combination of 2GB and 4GB DIMMs are used in a channel, one rank on one 4GB DIMM per channel will be used for sparing.) In an HS12 with **24GB** installed, up to **20GB** (using 6 *dual-rank* 4GB DIMMs) of memory is available when the hot-spare feature is active.

Sparing is handled at the hardware level; no operating system support is required.

PC2-5300 memory is available in **512KB**, **1GB**, **2GB**, and **4GB** memory **kits** (**one** 512KB or **two** 512MB, 1GB, or 2GB DIMMs per kit, respectively). DIMMs are installed in pairs for increased performance, provided by **2-way interleaving**.

Flexible Storage

The HS12 offers a choice of internal storage, supporting up to **two 2.5-inch hot-swap SAS** or **fixed SATA II** drives, or **two hot-swap** or **fixed solid-state** drives, as well as an expansion unit that offers additional direct-attached storage.



- **SAS 10K RPM 2.5-inch HDD** — 73.4 or **146.8GB** capacities (**293.6GB** maximum)
- **SAS 15K RPM 2.5-inch HDD** — **73.4GB** capacities (**146.8GB**)
- **SATA II 7.2K RPM 2.5-inch HDD** — **80GB** capacities (**160GB** maximum)
- **Solid-state** — 15.8GB or **31.4GB** capacities (**62.8GB** maximum)

Due to the statistically higher failure rates for traditional spinning media, IBM recommends the use of the solid-state drives (SSDs) as an alternative. They store data on flash memory chips, rather than on magnetic media. Like HDDs, SSDs can be used as boot media and for random access storage. However, SSDs offer higher thresholds of shock and vibration, and a higher operating temperature range (between 0 and 70 degrees C). This yields a failure rate only 1/3 that of HDDs (approximately 3,000,000 hours MTBF vs. 1,000,000 hours). In addition, the **IBM 15.8GB 2.5" Solid State Drive** uses as little as **1W** of power per drive vs. as much as **10W** for a 2.5-inch HDD. Similarly, the **IBM 31.4GB 2.5" Solid State Drive** requires only **2W**. This reduces the storage power requirement and heat output by as much as **90%**, compared to 2.5-inch HDDs. If used as a boot device, no special device drivers are required.

For additional in-chassis storage, an optional "sidecar" storage blade is available. The **Storage and I/O Expansion Unit 3** is a 30mm blade that supports up to **three 2.5-inch hot-swap SAS** HDDs (up to **440.4GB** total). It is installed in the slot adjacent to the blade server. Fully populating both the HS12 blade and the expansion unit provides either up to **734GB** of direct-attach **hot-swap SAS** storage (in **five** SAS drives), or up to **80GB** of SATA HDD storage plus **440.4GB** of hot-swap SAS storage, to the blade server. In SAS-based HS12 models, the storage can be configured as two separate SAS RAID arrays—one in the expansion unit and the other in the base blade—for even more flexibility. If you need more storage space, terabyte capacities are possible with optional external iSCSI and SAN storage solutions.



External Tape Storage

The HS12 supports various external rack-mounted SAN-attached tape drives. Supported tape technologies include:

- **IBM LTO3 2U Autoloader**
- **IBM LTO3 4U Tape Library**

High-Performance Adapter Slots

The HS12 blade server includes **one x8 PCIe** and **one 133MHz PCI-X** adapter slot on each blade. *Either one SFF (small form factor) PCI-X expansion card or one SFF PCIe adapter, or two CFF (compact form factor) cards (one CFFv and one CFFh) can be installed in this blade.* (The CFFh card or the SFF PCIe card uses the high-speed expansion connector as a second I/O slot.)

One of two possible expansion units may be added to increase the number of expansion card slots available. *Each will utilize the expansion connector* in the HS12:

- The 30mm **BladeCenter PCI I/O Expansion Unit 3** provides **two PCI-X** slots in addition to the **one** on the HS12 blade (**3 PCI-X** slots usable).
- The 30mm **BladeCenter Storage and I/O Expansion Unit 3** provides **two** adapter slots: either **two PCI-X** cards or **one PCI-X** and **one PCIe** slot in addition to the **one PCI-X** slot on the HS12 blade. (The first PCI-X card installed in the expansion unit must be a Gigabit Ethernet card, because it is routed to module bays 1 and 2.) It connects to the blade server via the high-speed expansion connector. (If this expansion unit is used, a CFFh card can be plugged into the expansion unit's expansion connector, instead of in the HS12 blade's expansion connector.)

The HS12 also supports an optional feature card (in a dedicated slot) that provides **concurrent KVM (cKVM)** and **concurrent media (cMedia)** access by multiple administrators at once. Adapters can also be used to add interfaces to BladeCenter communication modules, including 4Gb Fibre Channel, Myrinet, additional Gigabit Ethernet modules, 10Gb Ethernet, 4X InfiniBand, etc.



Disk Controllers

All HS21 models include an integrated **LSI 1064E SAS** controller. This controller supports up to **two** internal **SAS** or **SATA II** HDDs or **two** internal **solid-state drives** and offers **hardware RAID-0/1** support for the SAS drives.



If an optional **Storage and I/O Expansion Unit 3** is used, the integrated **ServeRAID-8k-I** controller offers **hardware RAID-0/1/1E** support and **32MB** of **PC2-4200 DDR2** cache for the internal drives. A **ServeRAID-8k** option adds **RAID-5** support for up to **five** direct-attached SAS drives, along with **256MB** of cache memory for higher performance, and battery backup, *without* consuming a valuable adapter slot.

The **SAS** controller provides data transfer speeds of up to **300MB** per second³ in *each* direction (**full-duplex**) across the SAS bus, for an aggregate speed of **600MBps**, nearly double that of Ultra320 SCSI's **320MBps** (half-duplex) bandwidth. When SATA II drives are installed, the SAS controller provides the same data transfer speeds, but in **half-duplex** mode. Due to the lower latency of the SAS controller, SATA II performance is approximately equal to that of Ultra320 SCSI. The serial design of the SAS bus allows maximum performance to be maintained as additional drives are added.

Gigabit Ethernet Controllers

The HS12 includes an integrated **dual-port Broadcom BCM5714S** Gigabit Ethernet controller, for up to 10X higher maximum throughput than a 10/100 Ethernet controller, plus load-balancing and failover support. The controller also supports highly secure remote power management using **IPMI 1.5**, plus Wake on LAN[®] and PXE (Preboot Execution Environment) Flash interface. An optional **2-port Ethernet** expansion card adds two additional Gigabit Ethernet ports per HS12 server.



BladeCenter Chassis

IBM's blade architecture offers **five choices** of compatible and interoperable chassis in which to use various blade servers. Each chassis serves different customer needs. The new **BladeCenter S** is a small, entry-level chassis designed for mid-market environments. The original **BladeCenter E** chassis offers maximum density, great flexibility and a wide variety of expansion options at an entry-level price. The next-generation **BladeCenter H** chassis offers all of BladeCenter's capabilities, and adds new high-performance features. If you need a **ruggedized** chassis (for example, government/military or telecom), **BladeCenter T** offers special features optimized for those environments. The next-generation **BladeCenter HT** is a high-performance **ruggedized** telecommunications platform. There is a high degree of interchangeability and compatibility of features among the chassis. Any or all of these chassis can be installed in a rack along with other rack-optimized equipment.

See the separate *BladeCenter Chassis Sales Guide* for details.

Light Path Diagnostics

Light path diagnostics enables a technician to quickly identify and locate a failed or failing system component, such as a specific blower module or memory DIMM. This enables quick replacement of the component, which helps increase server uptime and lower servicing costs.

The front of each blade server—and the chassis itself—has an LED indicator light to show possible component failures. This lets the servicer identify the failing component without the need to or remove the blade server from the chassis. The light path diagnostics panel tells the servicer which component of the affected server requires attention.

In addition, many components have their own identifying LEDs. For example, each of the memory modules has an LED next to the socket, as does the processor. This allows the servicer to easily identify exactly which component needs servicing. By following the "light path," the component can be replaced quickly, and without guesswork. (**Note:** In the event of a failed DIMM, the system will restart and mark the DIMM as bad while offline, thus allowing the system to continue running, with reduced memory capacity, until serviced.)

Extensive System Support Features

The IBM services and technical support portfolio provides world-class, consistent, high-quality service and support. From the start, IBM programs make it easier for you to plan for, configure and purchase BladeCenter servers, get them running and keep them running long-term. These features include IBM ServerProven[®], the IBM Standalone Solutions Configuration Tool, IBM System x and BladeCenter Power Configurator IBM ServerGuide, IBM Electronic Service

³ Data transfer rates depend on many factors and are often less than the maximum possible.



Agent™, Product Customization Services and extensive technical support offerings.

The IBM **ServerProven** program provides the confidence that specific options and operating systems have been tested on the blade servers and are officially supported to work together. It is updated frequently to keep the latest compatibility information at your fingertips.

The IBM **Standalone Solutions Configuration Tool (SSCT)** is a downloadable tool that simplifies the often complex chore of configuring a full rack of servers (including blade servers) and confirming that you have all the cables, power distribution units, KVM (keyboard, video and mouse) switch boxes and other components you need, as well as the proper airflow clearances, electrical circuits and other environmental conditions.

IBM **System x and BladeCenter Power Configurator** helps IT managers plan for data center power needs, by providing the following information for specific configurations of System x and BladeCenter systems: *power input* (watts), *PDU sizing* (amps), *heat output* (BTUs), *airflow requirements through chassis* (CFM), *VA rating*, *leakage current* (mA), and *peak inrush current* (amps).

IBM **ServerGuide** (installed from CD) simplifies the process of installing and configuring System x servers. ServerGuide goes beyond mere hardware configuration by assisting with the automated installation of the Microsoft® Windows® Server 2000 and 2003 operating systems, device drivers and other system components, with minimal user intervention. (Drivers are also included for support of Novell NetWare, Red Hat Linux and SUSE LINUX.) This focus on deployment helps you reduce both your total cost of ownership and the complexity that administrators and technical personnel face.

IBM **Electronic Service Agent™** is an innovative “call home” feature that allows System x and BladeCenter servers to automatically report hardware problems to IBM support, which can even dispatch onsite service⁴ if necessary to those customers entitled to onsite support under the terms of their warranty or an IBM Maintenance Agreement. Electronic Service Agent resides on a server and provides electronic support and problem management capabilities through a highly secure electronic dialogue between your systems and IBM. It monitors networked servers for hardware errors and it can perform hardware and software inventories and report inventory changes to IBM. All information sent to IBM is stored in a highly secure database and used for improved problem determination.

Additional services include hardware warranty upgrades and factory-installed **Product Customization Services (PCS)**, such as asset tagging, hardware integration, software imaging and operating systems personalization.

IBM offers extensive **technical support** by phone and via the Web. Support options include links to forums/newsgroups, problem submission, online shopping support, service offerings, device drivers for all IBM product lines, software downloads and even upcoming technical seminar worldwide schedules and registration. Also available are remote installation, configuration and usage support for both System x hardware and software, as well as onsite custom services to provide the level of expertise you require.

Advanced Systems Management Capabilities

Each BladeCenter chassis offers a high level of systems management capabilities that are well-suited to remote locations as well as to stand-alone environments. Features include the Advanced Management Module (AMM), Baseboard Management Controller (BMC), Automatic Server Restart, Systems Director Active Energy Manager for x86, Wake on LAN® support, PXE 2.0 support, text and graphics console redirect, Predictive Failure Analysis, IBM Director and Remote Deployment Manager.

The **AMM**, in combination with the HS12 blade server **BMC**, provides industry-standard **Intelligent Platform Management Interface (IPMI) 1.5**-compliant systems management. It provides a number of important system functions, including:

- Monitoring of system and battery voltage, system temperature, fans, power supplies, processor and DIMM status
- Fan speed control
- Product ID and Family ID detection
- Highly secure remote power on/off
- System reset control
- NMI/SMI detection and generation
- System diagnostic LED control (power, HDD, activity, alerts, heartbeat)
- IPMI over LAN
- Proxy server support

⁴ For onsite labor, IBM will attempt to diagnose and resolve the problem remotely before sending a technician.

-
- LAN messaging and alerting
 - Local update of BMC firmware
 - Support for IPMI v1.5 compliant management software (e.g., xCAT)
 - Other mandatory and optional IPMI BMC functions

The BMC, via the management module, alerts IBM Director to anomalous environmental factors, such as voltage and thermal conditions—even if the server has failed.

Other systems management features offered for the combination of blade server and chassis include:

- Predictive Failure Analysis for system processors, memory and HDDs, as well as chassis switch modules, blower modules and power modules
- Web-based out-of-band control
- Windows “blue screen” capture
- Remote virtual media
- High-speed remote redirection of PCI video, keyboard and mouse
- SSL (Secure Socket Layer) and LDAP (Lightweight Directory Access Protocol) support

In order to put control of processor power-saving features at the fingertips of administrators, IBM developed **IBM Systems Director Active Energy Manager for x86**. Active Energy Manager is designed to take advantage of new processor features, such as balancing the performance of the system according to available power input. It provides the ability to plan and predict power consumption based on your BladeCenter hardware configuration. It also allows you to reduce the infrastructure required for redundancy, by using fewer servers on smaller power feeds and potentially lowering your overall data center support costs. It does this by inventorying all components at the blade level, then adding up the power draw for each blade and tracking that usage. In failure mode, Active Energy Manager (through the BladeCenter Management Module) might request that certain blades in each domain throttle down to reduce power consumption.

Automatic Server Restart (ASR) helps reduce downtime by restarting the server automatically in the event of a system lockup. ASR technology is a combination of hardware circuitry tied into the server’s system reset function and a device driver. As long as the server continues running, the ASR watchdog timer will keep being reset, but if the operating system crashes or the hardware freezes somehow the ASR software will be unable to reset the hardware timer. If the timer is not reset within five minutes, it automatically triggers the ASR hardware, which immediately restarts the server (and logs an ASR event with IBM Director). These features are designed so that *no more than five minutes can pass before the server is restarted*.

Text and Graphics Console Redirect support allows the administrator to remotely view HS12 text and graphics messages over serial or LAN.

Wake on LAN permits the server to be remotely powered on if it has been shut off. Once powered up, the server can be controlled across the network, using the **Preboot Execution Environment (PXE)**.

Like Wake on LAN, **PXE** is system firmware. It allows software such as the **IBM Remote Deployment Manager** to take control of a system before the BIOS, operating system or applications are loaded (using Wake on LAN/PXE) and lets an administrator perform many low-level tasks remotely that would otherwise require a visit to each system. These tasks may include such things as formatting a hard disk drive, updating system firmware, or deploying a Windows or Linux operating system.

Predictive Failure Analysis (PFA) enables the MM/AMM and the BMC to detect impending failure of supported components (processors; memory; expansion cards; switch, blower and power supplies; and hard disk drives) *before* actual failure, and alert the administrator through IBM Director. This gives you the ability to replace the failing component *before* it fails, resulting in increased uptime.

IBM Director software for advanced workgroup management is included with the server. IBM Director comes with a portfolio of tools, including *Management Processor Assistant*, *Rack Manager*, *RAID Manager*, *Update Assistant* and *Software Distribution*. *System Availability* (a no-charge download) and *Capacity Manager* (sold separately) are available as add-ons for additional server management and increased availability. IBM Director provides a single uniform graphical interface for all of these systems management functions.

IBM Director enables you to customize thresholds and monitor system components (for things like temperature, voltage regulation, etc.) to help maximize uptime.

Key Options

IBM options for System x servers let you take your systems to a higher level

You can rely on blade options to supply a comprehensive solution for your business needs.

Options help you create an optimized server system to meet your data protection, storage and availability needs. Every IBM option is designed and tested for peak performance and flexibility, helping to maximize your return on investment. The combination of System x servers and options lets you keep your fingers on the pulse of your e-business.

Memory — Memory is a significant factor in systems application performance. Adding more memory to a BladeCenter server is one of the most effective ways to increase application performance. For best performance in a server with a dual-core processor, there should be twice as much memory available as for a single-core processor.

Hard Disk Drives — IBM hard disk drives help you improve the transaction and cost performance of your HS12 servers. The choice of hard disk drives can be a critical aspect of maximizing the I/O throughput of the system. Hot-swap **SAS** hard disk drives (**2.5-inch**) are available for the HS12 with capacities up to **146.8GB** at **10,000** RPMs or up to **73.4GB** at **15,000** RPMs; fixed SATA II HDDs are available in capacities up to **80GB** at **7,200** RPMs. Additionally, a **Storage and I/O Expansion Unit 3** can be attached to the HS12 to add up to **three** additional **2.5-inch** SAS drives.

Solid State Drives — IBM offers a choice of **hot-swap 15.8GB** or **31.4GB 2.5" Solid State Drive** as an alternative to internal HDDs. It can be used as a highly available boot drive or for storing disk images.

I/O slots — The HS12 supports the addition of a **PCI I/O Expansion Unit 3**, which provides **two front-accessible PCI-X slots**. Also, the **Storage and I/O Expansion Unit 3** provides **two** additional adapter slots: either **two legacy PCI-X** cards or **one PCI-X** and **one PCIe** slot. (The first PCI-X card added must be a Gigabit Ethernet card.)

External Storage — The IBM **TotalStorage DS3000, DS4000, DS6000, and DS8000** series, as well as the **System Storage DS4000, N3000, N5000, and N7000** series, comprise a powerful and broad shared storage family with integrated management software designed to meet midrange and enterprise needs.

Additionally, external LAN-attached tape storage is available.

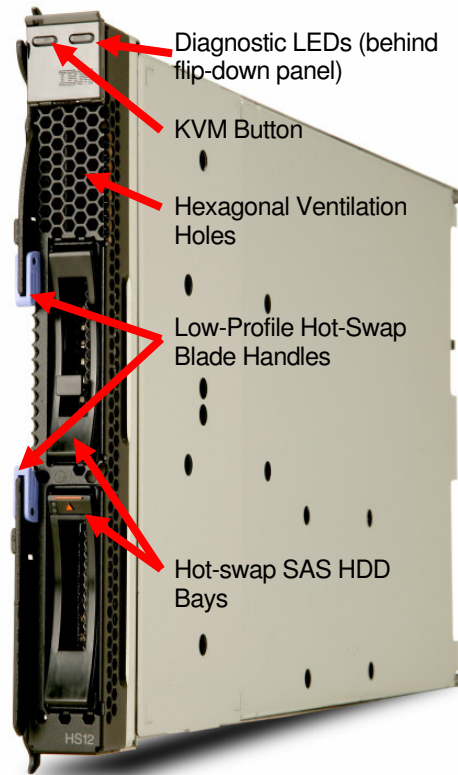
Communication Modules — The various BladeCenter chassis support integrated communication and I/O switches and/or bridges for Gigabit Ethernet, Myricom, Fibre Channel, InfiniBand, and others. Expansion adapters for individual HS12 blades are available to interface with these modules.

Rear Door Heat eXchanger — The unit attaches to the back of an IBM S2 42U Enterprise Rack. It is capable of removing up to 50,000 BTUs (14KV_a) from the data center using water lines under the raised floor. The door swings open for servicing.

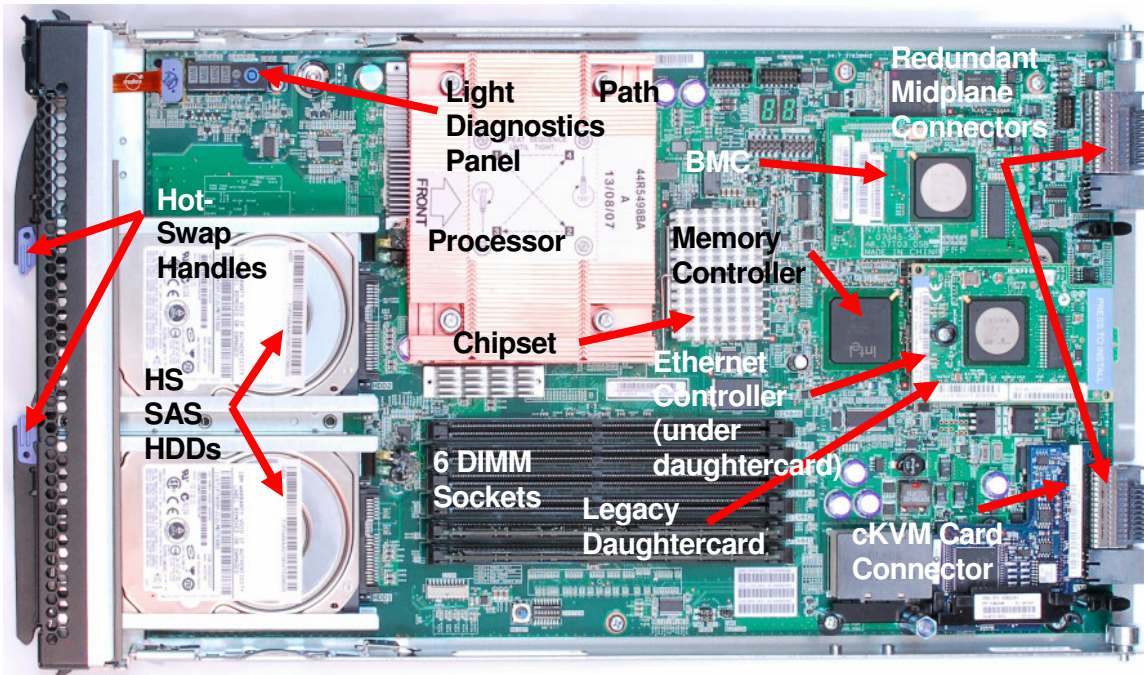
Redundant features — Optional power supply modules, blower modules, management modules, switches and bridges provide redundancy for the various BladeCenter chassis.

HS12 Images

Front View



Interior View



BladeCenter HS12 Specifications				
Machine type	8014-1xX/1xY, 2xX/2xY (1 yr. warranty) 8028-2xX/2xY, 4xX/4xY (3 yr. warranty)			
Form factor	30mm blade			
Processor type	Quad-core Xeon (X33xx) 2.5GHz X3323 (44X/44Y), 2.66GHz X3353 (45X/45Y), 2.83GHz X3363 (46X/46Y)	Dual-core Xeon (E64xx) 2.13GHz E6405 (23X/23Y)	Dual-core Core 2 Duo (E63xx) 1.86GHz E6305 (2BX/2BY)	Single-core Celeron (4xx) 1.86GHz 445 (1AX/1AY)
Processor power draw	80W (4xX/4xY)		65W (1AX/1AY, 2xX/2xY)	
Internal L2 cache	12MB (2 x 6MB shared cache)—44X/44Y, 45X/45Y, 8028-46X/46Y	2MB (1 x 2MB cache)—23X/23Y, 2BX/2BY	512KB (1 x 512KB cache)—1AX/1AY	
Front-side bus (FSB) speed	1333MHz (23X/23Y, 44X/44Y, 45X/45Y, 8028-46X/46Y)		1066MHz (1AX/1AY, 2BX/2BY)	
# of processors standard / maximum	1 / 1			
NEBS3/ETSI Compliance	Select blades will be NEBS3/ETSI-compliant. (Contact IBM sales for details.)			
Chipset	Intel 5100			
Standard / maximum memory⁵	2GB (2x1GB) dual-core or quad-core / 24GB		512MB (1 x 512MB) single-core / 24GB	
Standard memory type	PC2-5300 (667MHz) registered DDR II ECC			
Memory interleaving	Yes (2-way with two or more DIMMs)			
DIMM capacities supported	512MB, 1GB, 2GB, 4GB			
Chipkill protection supported	Yes (using 1GB or larger DIMMs)			
Memory sparing / mirroring supported	Hot-spare memory			
# of DIMM sockets total / available	6 / 5 (1AX/1AY)		6 / 4 (all other models)	
# of 2.5-inch drive bays total / available	2 / 2 SAS or SATA II			
# of 3.5-inch drive bays total / available	None			
Maximum internal 2.5" HDD capacity	Standard 293.6GB (2 x 146.8GB) hot-swap SAS; 160GB (2 x 80GB) fixed SATA II		Using a Storage and I/O Expansion Unit 3 440.4GB (3 x 146.8GB)— three hot-swap SAS HDDs in the expansion unit, in addition to the two SAS drives in the server blade	
2.5-inch HDD capacities supported	Hot-swap SAS 73.4, 146.8GB — 10K RPMs; 73.4GB — 15K RPMs		Fixed SATA II 80GB — 7.2K RPMs	
2.5-inch solid-state drives supported	2 x 15.8GB or 31.4GB (hot-swap or fixed)			
# of HDDs standard	None			
# of optical drives standard	None (one standard in chassis)			
# of diskette drives standard	None (one standard in BladeCenter E or BladeCenter H chassis)			
Internal tape drives supported	None (SAN-attached)			

⁵ Maximum memory and disk capacity may require the replacement of standard components with the largest supported component available.

BladeCenter HS12 Specifications		
Disk drive technology	SAS / SATA II	
Integrated disk controller	LSI Logic 53C1046E (standard in HS12)	ServeRAID-8k-I (using a Storage and I/O Expansion Unit 3)
Optional RAID controller	None	ServeRAID-8k (using a Storage and I/O Expansion Unit 3)
RAID levels supported	RAID-0/1 (standard)	RAID-0/1/1E (ServeRAID-8k-I); RAID-0/1/1E/5 (ServeRAID-8k)
External disk drive support	NAS/SAN-attach	
# of adapter slots standard	1 legacy PCI-X slot, plus 1 PCIe <i>or</i> a second PCI-X slot on the blade	
# of PCIe slots	1 (in place of second PCI-X slot); 1 PCIe slot available with the optional Storage and I/O Expansion Unit 3 (2 total)	
# of PCI-X slots	1 or 2 (in place of PCIe slot); 2 extra via optional PCI Expansion Unit 3 (3 total); 1 or 2 extra via optional Storage and I/O Expansion Unit 3 (3 total)	
# of legacy PCI slots	None	
# of video ports	None (chassis-attached)	
Video controller	ATI Radeon ES1000	
Video memory	64MB SDRAM	
Maximum video resolution at 32-bit color	1024 x 768 x 32-bit color at 75Hz	
Gigabit controllers	Dual-port Broadcom BCM5714S (standard)	
# of Gigabit Ethernet ports	2 (standard)	Up to 8 when using the 2-Port Ethernet Expansion Card .
# of RS485 ports	None	
# of serial ports	None (1 direct via BladeCenter H chassis, or Serial over LAN in BladeCenter E and BladeCenter H)	
# of parallel ports	None	
# of mouse ports	None (via chassis)	
# of keyboard ports	None (via chassis)	
# of USB ports	None (via chassis)	
Systems management controller	Integrated BMC	
Diagnostic LEDs (front panel)	Power good, blade location, over temperature, information, general fault	
Predictive Failure Analysis support	Processor, memory, HDDs, expansion cards	
Power supply size	Contained in chassis	
# of power supplies standard / maximum	Contained in chassis	
# of fans/blowers standard / maximum	Contained in chassis	
Operating temperature range	50 – 95° F; 10 – 35° C (up to 3,000 ft / 914.4 m)	50 – 90° F; 10 – 32° C (3,000 ft to 7,000 ft / 914.4m to 2,133m)
Dimensions (HWD) / weight	9.7" (245mm) H 1.14" (29mm) W 17.6" (446mm) D	12 lbs (maximum) 5.44 kg (maximum)
Operating systems supported	Microsoft Windows Server 2003 and R2 (Standard/Web/Enterprise Editions) 32-bit and	

BladeCenter HS12 Specifications	
	64-bit, Windows Small Business Server 2003 and R2, RHEL 4/5 64-bit, SLES 9/10 64-bit, Sun Solaris 10, IBM 4690 V6
Length of limited warranty	1 or 3 years (parts and labor) onsite (model-specific)

The Bottom Line

The HS12 offers maximum bang for the buck by incorporating outstanding features in a tiny package:

Price/Performance:

- **Multi-core processors** — One **2.5 to 2.83GHz quad-core** or **2.13GHz dual-core Xeon** processor, or **1.86GHz dual-core Core 2 Duo** processor
- **Low-cost processors** — One **dual-core Core 2 Duo** or **single-core Celeron** processor
- **Fast front-side bus** — **1066MHz** or **1333MHz** FSB
- **Large cache** — **12MB** or **8MB** (quad-core Xeon), or **4MB** (dual-core Xeon) of L2 processor cache
- **Fast memory** — **667MHz registered PC2-5300 DDR II ECC** memory, with **2-way interleaving**
- **Fast disk technology** — Internal **hot-swap SAS** storage (**2 HDDs**), with the option for **three** additional SAS HDDs in an adjacent **Storage and I/O Expansion Unit 3** (**5 HDDs** total); **RAID-0** data striping standard (**RAID-1E/5** with the Storage and I/O Expansion Unit 3)
- Optional **hot-swap** or **fixed 15.8GB** or **31.4GB Solid State Drives** as an energy-saving alternative to hard disk drives
- **Fast I/O** — **Gigabit Ethernet, 10Gb Ethernet, 4Gb InfiniBand, Myrinet, or 4X Fibre Channel** connectivity via an optional expansion card
- **Fast communications** — Integrated **dual Gigabit Ethernet**, with the option for two additional Gigabit Ethernet ports via expansion cards (total **8** ports per blade) and expansion unit

Flexibility:

- **Single- (30mm), double- (60mm), or triple- (90mm)** configurations (using storage and PCI expansion units)
- **High-capacity disk storage** — Up to **293.6GB** of internal **hot-swap SAS** storage or up to **160GB** of internal **fixed SATA II** storage, with the option for **three** additional 2.5-inch hot-swap SAS HDDs in an adjacent **Storage and I/O Expansion Unit 3** (**3 HDDs, 440.4GB** total)
- A choice of **hard disk** or **solid-state** storage
- Integrated RAID — **RAID-0/1** arrays standard; enhanced **RAID-1E** arrays optional (using a **Storage and I/O Expansion Unit 3**); **RAID-5** arrays available using the optional **ServeRAID-8k** controller
- Up to **two available adapter slot** standard —
 - One **legacy** slot for standard PCI-X adapters, *and either*
 - One high-speed x8 **PCIe** slot, or
 - A second **PCI-X** slot
- Additional **optional** adapter slots —
 - Two **legacy PCI-X** slots or one **PCI-X** and one high-speed **PCIe** slot provided by the **Storage and I/O Expansion Unit 3**⁶
 - Two standard **PCI-X** slots provided by the **PCI I/O Expansion Unit 3**⁷

Manageability and Availability:

- IBM **Director** systems management software, including:
 - IBM Systems Director Active Energy Manager for x86
 - IBM Management Processor Assistant
 - IBM Rack Manager
 - IBM RAID Manager
 - IBM Update Assistant
 - IBM Software Distribution
 - IBM System Availability
- Integrated **Baseboard Management Controller**:
 - IPMI 1.5** compliance, including highly secure remote power control

⁶ The Storage and I/O Expansion Unit 3 requires an adjacent blade slot.

⁷ The PCI I/O Expansion Unit 3 requires an adjacent blade slot.

- Interface to one or two **Advanced Management Modules** in the chassis for advanced systems management capability
 - Supports **LDAP** and **SSL** industry standards
 - Text and graphics console redirection** systems management
 - Serial over LAN**
- Optional **IBM 15.8GB** or **31.4GB Solid State Drive** as a high-reliability alternative to internal storage (with up to three times the MTBF of spinning disk drives)
- Optional **concurrent KVM** and **concurrent media** support
- Numerous **hot-swap/redundant capabilities** provided via the chassis
- **Hot-swap SAS storage** standard and/or via an optional **Storage and I/O Expansion Unit 3**

Blade Workload Matrix

The following table suggests the best HSxx server blade to use with the following usages and workload levels:

Workloads	Light Usage	Medium Usage	Heavy Usage
HPC	HS21 XM	HS21 XM	HS21 XM
Virtualization	HS21 XM	HS21 XM	HS21 XM
Database	HS21	HS21 XM	HS21 XM
General business	HS12	HS21 to HS21 XM	HS21 XM
Collaboration	HS21	HS21 XM	HS21 XM
VoIP	HS12	HS12	HS12
Web server	HS12	HS21	HS21 XM
Video server	HS12	HS21	HS21
Application server	HS12	HS21 to HS21 XM	HS21 XM
Mail Server	HS12	HS12	HS21
Print Server	HS12	HS12	HS12
File Server	HS12	HS12	HS21
Citrix/Terminal Services	HS12	HS21 XM	HS21 XM



For More Information

IBM BladeCenter Servers and Options
Electronic Service Agent
IBM System x and BladeCenter Power Configurator
Standalone Solutions Configuration Tool (SSCT)
Configuration and Options Guide
ServerProven Program
Technical Support
Other Technical Support Resources

ibm.com/systems/bladecenter
ibm.com/support/electronic
ibm.com/systems/bladecenter/powerconfig
ibm.com/servers/eserver/xseries/library/configtools.html
ibm.com/servers/eserver/xseries/cog
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ibm.com/servers/eserver/techsupport.html

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Some machines are designed with a power management capability to provide customers with the maximum uptime possible for their systems. In extended thermal conditions, rather than shutdown completely, or fail, these machines automatically reduce the processor frequency to maintain acceptable thermal levels.

MB, GB and TB = 1,000,000, 1,000,000,000 and 1,000,000,000,000 bytes, respectively, when referring to storage capacity. Accessible capacity is less; up to 3GB is used in service partition. Actual storage capacity will vary based upon many factors and may be less than stated.

Performance is in Internal Throughput Rate (ITR) ratio based on measurements and projections using standard IBM benchmarks in a controlled environment. The actual throughput that any user will experience will depend on considerations such as the amount of multiprogramming in the user's job stream, the I/O configuration, the storage configuration and the workload processed. Therefore, no assurance can be given that an individual user will achieve throughput improvements equivalent to the performance ratios stated here.

Maximum internal hard disk and memory capacities may require the replacement of any standard hard drives and/or memory and the population of all hard disk bays and memory slots with the largest currently supported drives available. When referring to variable speed CD-ROMs, CD-Rs, CD-RWs and DVDs, actual playback speed will vary and is often less than the maximum possible.