IBM @server xSeries
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Question and Answer Document

Enterprise X-Architecture Technology

Q1: **What is X-Architecture technology?**

A1: IBM first announced the X-Architecture™ strategy in September of 1997. X-Architecture technology takes state-of-the-art, industry-leading technologies from other IBM @server platforms and incorporates those technologies into the xSeries™ product line. Leveraging more than a half-century of enterprise expertise, IBM has brought innovative technology, application flexibility and new tools to Intel® processor-based, industry-standard servers in order to offer mainframe-inspired performance, scalability and availability at very attractive prices.

Q2: **Why did IBM develop X-Architecture technology?**

A2: X-Architecture technology was developed by IBM to introduce proven mainframe-inspired technologies into the Intel processor-based server market for improved reliability, availability and scalability. As the largest computer company in the world, IBM has continuously led the industry in delivering quality and value to customers. The X-Architecture model is a blueprint for taking industry-standard servers to an all new level—a level achievable only by a company with the experience, expertise and vision of IBM.

Q3: **What did X-Architecture technology originally introduce?**

A3: The first release introduced the following:

- Support for 4-way symmetrical multiprocessing (SMP)
- Error checking and correcting (ECC) memory
- Redundant power and cooling
- Integrated System Management processor — An independent service processor embedded in most xSeries servers that monitors vital hardware conditions—such as system temperature, system voltages, power supply and fan status—and issues alerts should any thresholds be exceeded or other abnormalities occur

Q4: **What technologies have emerged through the evolution of the X-Architecture blueprint?**

A4: The evolution of X-Architecture technology has brought forth more powerful, reliable and scalable servers with the following features:

- Support for 8-way SMP
- Chipkill™ memory — Corrects single, 2- or 4-bit memory errors, using off-the-shelf, industry-standard ECC memory, for an even higher level of availability
- Enhanced System Management processor — Now includes new Web site features, advanced alerting and graphical console redirection
- IBM Director — A portfolio of server software management tools and utilities that provide detailed software and hardware asset inventory and proactive problem notification. This offering, included with most xSeries servers, has built-in intelligence and powerful alert management features with automated customized actions for quick resolution of problems

- Active™ PCI — Lets you add, remove and replace I/O adapters while your xSeries server is running, without taking the server down

Q5: **Then what is *Enterprise* X-Architecture technology?**

A5: Enterprise X-Architecture[1] technology is the next step in the evolution of X-Architecture technology. Building on the IBM @server commitment to provide you with innovative technology, application flexibility and new tools, this groundbreaking server design enables a whole new set of enterprise-class capabilities in the Intel processor-based server industry. Enterprise X-Architecture technology is achieved through a new set of IBM-developed logic chips, which are designed to make better use of industry-standard technologies (processors, memory, I/O adapters). With Enterprise X-Architecture innovations, we introduce leading technologies from other IBM @server product lines into the xSeries line of Intel processor-based servers. These innovations build on the original X-Architecture strategy by delivering capabilities designed to maximize availability, scalability and performance. Additionally, Enterprise X-Architecture technology is delivering **revolutionary economics and investment protection** through the IBM @server xSeries 440 scalable enterprise node. With support for up to 16-way SMP capability and remote I/O, the x440 scalable enterprise node offers a new way of thinking about scalability and upgradeability.

Q6: **What do you mean by revolutionary economics?**

A6: With Enterprise X-Architecture technology, we are redefining what customers should expect from their IBM @server investments by enabling them to "pay as they grow" through modular 4-way x440 nodes that can be scaled to create 8-, 12- or 16-way servers in building-block fashion. IBM calls this XpandOnDemand™ scalability. XpandOnDemand scalability enables us to offer customers a revolutionary economic model for maximizing their IT budgets and IT staff by helping them better invest their limited IT dollars. And it provides customers a penalty-free path for flexible growth into the future without expensive up front infrastructure or headroom.

Q7: **What are the key components of Enterprise X-Architecture technology?**

A7: Enterprise X-Architecture technology will deliver the following high-end capabilities:

- 2-way to 16-way servers using a modular building-block design
- Physical and logical system partitioning that facilitates server consolidation, provides better system re-utilization and failover and enables clustering for high availability and scalability
- High-speed system caching that reduces contention on the 400MHz front side bus (FSB) and main memory, which now becomes much more able to service I/O requests
- Support for remote I/O that triples available I/O capacity by collocating with Enterprise X-Architecture systems for XpandOnDemand scalability
- A common platform that supports 32-bit and 64-bit processors from Intel, to ease the transition for enterprise customers
- Support for the new industry-standard extended peripheral component interconnect (PCI-X) bus. With Active™ PCI-X, this groundbreaking server architecture is ready to support the new hot-add/hot-swap PCI-X technology for high-performance and bandwidth
- Support for the forthcoming InfiniBand™ switched fabric I/O, to which IBM is contributing as co-chair of the InfiniBand Trade Association
- Support for third-generation Chipkill memory using industry-standard ECC SDRAM or double data rate (DDR) DRAM DIMMs
- Memory ProteXion™, which offers improved data protection at the memory controller level using hot-spare bits
- Memory subsystem redundancy through memory mirroring

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[1] See the white paper entitled "Introducing Enterprise X-Architecture Technology" at http://ibm.com/eserver/enterprise_xarchitecture for more information.

- Improved server availability with support for hot-add/hot-swap memory (planned availability year end 2002 with operating system support)
- Full exploitation of copper microprocessor technologies from IBM Research for high-performance data transmission and improved cooling in the IBM XA-32™ and IBM XA-64™ chipsets

Q8: **What value do the Enterprise X-Architecture chipsets add?**

A8: Because the chipsets (XA-32 for 32-bit and XA-64 for 64-bit servers) are the controllers of data in a server system, they play a vital role in handling the flow of information between processors, memory and I/O. By introducing leading-edge technology into the heart of the system, IBM developers have created an exceptional high-end Intel processor-based server—a system designed to provide mainframe-inspired capabilities with industry-standard components: Intel processors, standard hard disk drives, memory DIMMs and I/O adapters—to help maximize performance and minimize cost at the same time. High-end IBM @server xSeries systems built with the latest Intel 32-bit and 64-bit processors offer greater speed, scalability and reliability than competitive systems, thanks to the Enterprise X-Architecture chipsets.

Chipset value to the processor

- Modular building-block design enables you to pay as you grow, with support for 2- to 4- to 8- to 12- to 16-way systems.
- Logical partitioning enables multiple operating systems and applications to run simultaneously on one server. This gives customers the ability to fine-tune applications for a specific operating system in order to optimize application performance. It also allows customers to change the configuration of the server so that it can better handle the demands of business requirements, by adding, removing or resizing partitions. Additionally, partitioning provides tremendous opportunities for customers to lower the cost of computing through server consolidation. With logical partitioning, the xSeries 440 and 360 servers can be divided into individual partitions, each of which can replace an existing, stand-alone server and provide a centralized point of management control.
- SMP Expansion Ports provide an easy way to integrate additional processors, I/O, disk storage and other system resources into the overall system infrastructure using modular 4-way nodes.
- Enterprise X-Architecture features are common both to 32-bit and 64-bit xSeries servers, which will ease the transition for enterprise customers.

Chipset value to memory

- In its third generation of use in industry-standard servers, Chipkill memory is now integrated into the Enterprise X-Architecture chipset. This new functionality allows multiple errors to be corrected using low-cost, standard ECC DIMMs.
- Memory ProteXion significantly improves memory reliability by providing hot-spare bits to write to in case of memory errors that can't be corrected. This level of protection, in combination with Chipkill memory, gives the x440 a near-bulletproof memory subsystem.
- Similar to the function of RAID-1 in a disk drive array, memory mirroring *writes* data to two identically configured banks of memory, but *reads* only from the one designated as active. In the event the active memory bank becomes unavailable because of a DIMM failure, the system remains online by dynamically activating the inactive memory bank and performing *reads* from it until replacement of the failed DIMM.
- A new DIMM can be hot swapped to replace a failed one, or hot added for expandability without server downtime (planned availability year end 2002 with operating system support).
- A huge Level 4 system cache (32MB in an Intel Xeon™ MP server/per 4-way) is available in selected servers in addition to the 512KB-to-1MB of cache included with the new Intel Xeon Processors MP. This industry-first technology for industry-standard servers, called XceL4™ Server Accelerator Cache, speeds up your most complex jobs. The more high-speed cache memory there is, the more often the processor finds the data it needs and the less often it has to contend with the latency of the more distant main memory.

Chipset value to I/O

- Active PCI-X — Enterprise X-Architecture technology supports hot swapping and hot adding of high-performance PCI-X adapters.
- Remote I/O — Remote I/O can increase your I/O capacity on supported systems—via the attachment of external I/O expansion units—for a fraction of the cost of buying and managing another server.
- InfiniBand I/O — Enterprise X-Architecture technology will support the standards currently being defined for the InfiniBand switched fabric I/O.

Q9: **What are the key features and benefits of Enterprise X-Architecture technology?**

A9: The following key features and benefits are delivered via Enterprise X-Architecture technology:

- **Performance via Level 4 cache** — While the industry has pushed the upper limits of most system components, maximum processor cache sizes have actually decreased—from 2MB in the Intel Pentium® III Xeon to 1MB in the newer Intel Xeon MP. As a result, cache size has become increasingly inadequate to serve the internal demands of the other system components. If you look at the speed increases of the processor and the front side bus as well as the maximum memory the processor has access to, you can see that the internal processor cache doesn't measure up:
  - **Processor speed** increased from 400MHz to 2.0GHz in four years (a **5-fold** improvement)
  - **Memory capacity** increased from 4GB to 256GB in four years (a **64X** improvement)
  - **Front side bus speed** increased from 66MHz to 400MHz in three years (a **6X** improvement)
  - **Processor cache size** increased from 512KB to 2MB (on Pentium III Xeon) *then back to 1MB* in one year (and *therefore only a **2X** improvement*)

  Given the critical importance of cache technology in mediating the internal communications between the processor and main memory, IBM has invested in delivering 32MB of dedicated high-speed Level 4 (L4) system cache memory per 4-way x440, in order to boost system performance to a level unmatched by other industry-standard server vendors. This innovative cache technology, called XceL4 Server Accelerator Cache, was designed by IBM specifically to alleviate the memory bandwidth demands that the new Intel processors would place on the memory subsystem, especially over the scalability cables of the x440 16-way SMP. XceL4 Server Accelerator Cache also enables speedier access to memory for the PCI-X I/O, Gigabit Ethernet, SCSI and Fibre Channel interfaces—yielding better overall system utilization, and therefore higher throughput—for up to 20 percent overall improvement.
- **Scalability** — Enterprise X-Architecture technology offers x440 node-based systems for a rack-optimized building-block design. Each node consists of up to four Intel processors. The nodes are connected via SMP Expansion Ports—a high-speed bus-to-bus communications interconnect that directly links up to four nodes for communication at a rate over 30 times faster than Gigabit Ethernet. This will allow customers to buy what they want, when they need it—or pay as they grow— without having to buy more than they need up front. Growth can be supported incrementally by adding the required number of nodes: from 4-to-8, 8-to-12 and 12-to-16, as well as with remote I/O expansion units. As a result of this space-efficient, modular design, we can keep the base server systems quite small (only 4U per 8-way or 8U per 16-way), but still give customers the ability to grow their systems as business demands.
- **I/O Capability** — Remote I/O technology was adopted from the technology already successfully implemented in our IBM @server iSeries and pSeries systems. Enterprise X-Architecture technology provides support for the IBM RXE-100 Remote Expansion Enclosure that attaches to the x440 and x360 systems to offer increased I/O capability at a fraction of the system cost. The RXE-100 can be configured with six or 12 PCI-X slots (to attach additional Gigabit Ethernet and SCSI RAID or Fibre Channel host bus adapters, for example). Remote I/O provides three key benefits to customers:
  - The ability to triple the number of PCI-X slots per server.

- Smaller base servers that don't limit the customer's expansion potential. Competitors will have to offer *all* their PCI slots *in* the base servers, increasing the up-front cost to customers.
- An unprecedented combination of flexibility and fault tolerance, made possible by multisystem configurations with multiple I/O units per system, and even I/O cabinets shared by two servers.

- **Availability** — Enterprise X-Architecture technology enables several memory enhancements to help keep your systems up and running continuously. These new tools include support for Active Memory™ including hot swap capability memory mirroring, Chipkill memory and Memory ProteXion.

  Hot-swap and **hot-add** capability of Active Memory enables memory to be replaced or added while the system is still running, thus helping to reduce downtime (planned availability year end 2002 with operating system support):

  - When the customer needs to repair a system with failed memory, the memory can be swapped without requiring the system to be powered down (hot-swap capability). This does not require any support in the network operating system. This capability is implemented entirely within the Enterprise X-Architecture memory controller using memory mirroring.
  - Similarly, when the customer needs more memory, it can be added without requiring the system to be powered down (hot-add capability). However, this facility requires the future provision of new memory management functions in the network operating system.

  Chipkill memory is approximately **100 times** more effective than ECC technology, providing correction for up to four bits per DIMM (eight bits per memory controller), whether on a single chip or multiple chips. If a memory error does occur, Chipkill is designed to automatically and gracefully take the inoperative memory chip offline while the server keeps running. The memory controller provides memory protection similar in concept to disk array striping with parity, writing the memory bits across multiple memory chips on the DIMM. In essence, each DIMM acts as a separate memory array. If any one chip fails, it affects only a single bit from a byte of data, because the other bits are stored on other, working chips. The controller is then able to reconstruct the "missing" bit from the failed chip and continue working as usual. Chipkill memory is available on both the x440 and x360 servers.

  Memory ProteXion comes into play only if a server encounters so many errors in a short span of time that standard ECC and Chipkill memory can't handle them all. It uses spare bits analogous to a hard disk drive hot spare, automatically rerouting data in the event of an on-DIMM chip failure to keep the server running smoothly. This allows correction of as many as four sequential bit failures per pair of DIMMs—eight per *memory controller* (and a server may have more than one controller). The next time the server is restarted it rechecks the memory status. In the case of a soft (temporary) memory error, the hot-spare bits are freed up for reuse. If a hard (permanent) error occurs, the hot-spare bits are again utilized to keep the DIMM operating until it is replaced. IBM reliability testing and analysis show that a server protected with Memory ProteXion is nearly **200 times** less likely to fail than one using standard ECC protection. For example, given identical servers with 8GB of RAM, users can expect to experience approximately one failure per year for every **132** servers using ECC memory. By comparison, servers using Memory ProteXion should see approximately only one memory failure for each **26,042** servers per year! Memory ProteXion is only available on the x440.

  Memory mirroring allows supported systems to mirror data across the memory subsystem—just like a RAID-1 disk drive array. The memory mirroring function is done in hardware with no network operating system overhead or dependency. The memory mirroring feature of Enterprise X-Architecture technology delivers reliability through two functions:

  - The processor writes the data to two separate memory cards.
  - When an error occurs in one of the DIMMs causing one of the two memory boards to become unavailable, the system remains operational because the data continues to be processed from the other bank of memory.

These memory features are designed to correct virtually all the memory errors an x440 server is likely to encounter helping to provide a solution to customer concerns about system availability.

Q10: **What major IT concerns do customers have and how can Enterprise X-Architecture technology address them?**

A10: There are many pressing customer issues that the Enterprise X-Architecture-based x440 and x360 address:

The rising cost of IT infrastructure

As IT solutions become more complex, infrastructure and maintenance costs rise but IT budgets are not growing at the same rate (many are flat or declining). Therefore, customers need innovative technology to help keep costs to a minimum with solutions that are preconfigured, easy to install and maintain, scalable and affordable. With Enterprise X-Architecture features such as XpandOnDemand scalability (SMP and remote I/O built into the rack-optimized x360 or the extremely scalable x440), IBM can deliver flexibility and industry-standard capability, all at an affordable price.

Proliferation of server systems

Many customers have deployed departmental servers where needed over the last few years as new applications have been rolled out, which has led to a proliferation of widespread systems being managed in an uncoordinated way. This has added significant hidden costs to the enterprise and created a demand for application flexibility. Server proliferation can be minimized with Enterprise X-Architecture solutions through server consolidation, leveraging a virtualization application such as VMware™ ESX Server™, allowing dispersed servers to be replaced and centralized on individual, customized partitions that are optimally configured to support a particular user workload. Each of these partitions can replace one or more existing servers and can be located with other partitions in a single rack, further lowering costs by providing a centralized point of management control.

Cost of management and ongoing maintenance

Whether systems continue to proliferate or consolidate, there is a need to optimize available IT staff and their productivity in managing systems maintenance tasks. IBM helps solve these issues with new tools, in particular, the systems management tools available from IBM Director. IBM will be offering its customers a powerful combination of products along with Enterprise X-Architecture technology that remedy the following customer concerns:

- **Lack of a sufficient window for scheduled maintenance tasks** — As more systems are deployed to support the business, the need to extend online hours to 24x7 is cutting into the time available to perform essential systems management tasks. Many customers simply don't have a window of opportunity during the day, or weekend, to perform maintenance. The IBM OnForever™ high-availability initiative, part of the X-Architecture strategy, makes it possible to perform many maintenance tasks while your server stays up and running.
- **Limited skill base** — The challenge of finding the skills appropriate for managing deployment, operation and maintenance of IT systems is persistent. A focus on industry-standard technologies ensures that skills carry over within the enterprise.
- **Internet economy is driving 24x7 operations** — Many businesses are now using the Internet for business-to-consumer (B2C) or business-to-business (B2B) applications, a reality that makes it imperative that their systems are up and running all the time. Enterprise X-Architecture technology offers the promise of "e-business as usual."
- **Having to "buy up" to overcome scalability concerns** — As demand for access requiring 24x7 operation increases, data centers must plan for demand by purchasing additional capacity—driving the requirement for systems scalability. However, IT managers do not want to invest up front in monolithic systems with excessive capacity. They prefer to add systems incrementally, as required. This leads to the need for greater flexibility and ease in adding capacity as demand grows. The Enterprise X-Architecture promise of XpandOnDemand scalability offers the epitome of application and configuration flexibility. By introducing

revolutionary, scalable 4-way nodes, this new technology enables customers to pay as they grow, making headroom available when needed rather than buying more than they need up front and under utilizing it.

- **Lack of space in the data center** — Customers are running out of room in terms of both floor space and rack capacity. The need for smaller systems with high functionality is growing. Enterprise X-Architecture technology makes the most of rack space without sacrificing functionality by building more features into smaller systems and allowing for later growth using external expansion units.

Q11: **How does this new technology affect your partners, Intel and Microsoft?**

A11: In developing the new Enterprise X-Architecture chipsets, we worked closely with Intel to ensure that we have an operating environment that is ideal for their next-generation Xeon and Itanium processors. These chipsets will provide higher performance and availability for our customers. In fact, IBM @server xSeries systems with Enterprise X-Architecture features built-in were used by Intel as the validation platform for their new family of Xeon MP processors, allowing IBM to be the first to market with the Xeon MP on the x360.

In addition, the new IBM chipset technology will complement Microsoft® applications. Enterprise X-Architecture technology working with Microsoft applications and operating systems, such as Exchange, SQL Server™, Windows® 2000 Advanced Server and Datacenter, provides unheard-of reliability and availability.

The powerful combination of IBM Enterprise X-Architecture technology, Intel's Xeon and Itanium processors and Microsoft's operating systems and applications, will deliver economical, scalable, high-performance customer solutions for enterprise-class computing.

In fact, our powerful new customer solutions using Enterprise X-Architecture technology will not only be optimized for use in conjunction with offerings from Intel and Microsoft, but are ideally suited for use with products from our other hardware, software and ISV partners as well, including Red Hat and SuSE for Linux distributions.

Q12: **Is Enterprise X-Architecture technology available on all IBM @server xSeries servers?**

A12: As a high-end set of technologies, the Enterprise X-Architecture blueprint is focused on providing mainframe-inspired capabilities for the industry-standard server market. While elements of the X-Architecture design are found in varying degrees in all xSeries servers, Enterprise X-Architecture technology is focused solely on the high-end xSeries server line. Differing levels of Enterprise X-Architecture features are implemented on high-end x440 and x360 systems to ensure that customers have choices in pairing their business needs with the most appropriate set of system capabilities and solutions.

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