



IBM X-Architecture Blueprint: An Overview

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Executive Overview

A decade ago, our biggest IT concerns were such things as processor frequency, memory and storage capacity and network bandwidth. Who would have thought that in 2008 we'd be more concerned about energy costs, virtualization/consolidation, data center density, security, and how best to utilize servers built around multi-core processors? Yet IBM foresaw the need for flexible, expandable servers that could evolve with market demands.

In 1998, recognizing that x86 servers were no longer mere commodities and needed many of the same reliability, serviceability, availability, and performance attributes as mainframes and other advanced servers, IBM® introduced x86 servers designed with the IBM X-Architecture® blueprint. This game-changing design philosophy incorporated x86 industry firsts such as Chipkill™ memory protection, light path diagnostics and Predictive Failure Analysis®, and helped elevate x86 servers from their previously limited roles to their present status as mission-critical, mainstream enterprise servers. The competition has been playing catch-up ever since.

The X-Architecture blueprint encompasses IBM System x™ and IBM BladeCenter® servers, IBM System x iDataPlex™ solutions, energy-efficiency and cooling via IBM Cool Blue™ technology, and proactive management.

The X-Architecture blueprint takes a comprehensive approach—using innovative hardware, software and services—to solve customer challenges today, and it embraces an evolving design approach to address tomorrow's challenges. We take the best of industry-standard technologies—even helping to shape some of them through participation in standards groups—and combine them with IBM innovations to provide the greatest possible flexibility in System x, BladeCenter, and iDataPlex servers. The fundamental *premise* of the X-Architecture blueprint will not change over time; however, the underlying *technologies* and how they are delivered will constantly evolve to meet the needs of our customers.

This paper describes how the melding of industry-standard components with IBM innovation produces servers that offer you a unique set of capabilities with which to effectively manage your business. You'll see why IBM systems designed with the X-Architecture blueprint run faster—yet cooler—use less energy, and are more reliable, easier to manage and better for virtualization than competitive servers, *and* offer a lower total cost of ownership (TCO). (**Note:** This paper is merely an overview. For more details, refer to the companion *IBM X-Architecture Blueprint: 2008* white paper.)

Market Trends

Gone are the days when IT personnel could throw a bunch of cheap servers in a room and call it a data center. Today, careful planning must be undertaken to validate the data center's ability to provide the necessary energy to servers, to cool them, and to grow over time without running out of room or overtaxing the data center's energy and thermal envelope.

Some long-term market trends continue, such as the ever-increasing need for performance. Meanwhile, new trends are emerging, including a greater concern over security and energy/thermal issues and a growing interest in virtualization. IBM has been visionary in recognizing these trends early and providing solutions via X-Architecture design to ready your business for the future.

Balanced System Performance

The x86 world has changed. Once, servers were divided into scale-up vs. scale-out. While scale-out servers were relegated to running only single-threaded, single-processor applications—such

as e-mail, and printing—the focus of monolithic scale-up systems was on running multithreaded, multiprocessor-capable applications, such as relational database managers.

Today, the line between scale-up and scale-out servers has blurred. Multi-core processors allow *all* servers to run *scale-up* workloads to some extent. At the same time, scale-up servers can run multiple virtualized *scale-out* workloads. Performance becomes about utilization through virtualization, which is crucial to unlocking the value of multicore processors. It's an intelligent sharing of computing, storage or information resources across different disciplines and departments in your organization. System resources are gathered into one pool—and can be allocated dynamically as needed—allowing servers and storage resources to be utilized more efficiently.

As the number of processor cores increase, system resources must keep up to avoid potential bottlenecks. For example, for six-core processors to achieve maximum performance, they require six times as much memory as single-core processors. IBM, utilizing its decades of experience in designing mainframes and multi-core supercomputers, leads in the design of x86 servers. IBM takes a holistic approach to balanced system design, optimizing its x86 servers to deliver outstanding performance and utility around the processors, memory, I/O, and network fabrics.

Enterprise Rack Servers

Using the mainframe-inspired IBM-designed eX4 chipset, the **x3850 M2** and **x3950 M2** with XpandOnDemand™ modular expansion capability are the only switchless x86 servers from a Tier-1 vendor capable of scaling to **16** sockets and **96** processor cores, **1TB** of RAM, **1GB** of L4 cache, and **28** PCIe slots (including **8** hot-plug PCIe slots) in only 16U of rack space.



The **x3850 M2** is a 4U Intel® Xeon® MP-based 4-socket rack server, with support for up to 256GB of DRAM, 256MB of L4 cache, seven high-speed adapter slots (including two hot-plug slots) and four HDDs.

If you ever find the need for more resources, simply install the ScaleXpander Option Kit to turn it into an **x3950 M2**, then attach another x3950 M2 chassis to the first using an XpandOnDemand cable. It immediately doubles your processors, memory, adapter slots, HDD bays and L4 cache capacity. Still not enough? Add up to two more x3950 M2 chassis. No other x86 server on the market offers this level of flexibility, scalability, or performance.

Rack Servers

Simply put, our philosophy regarding rack-based servers is “innovation comes standard.” We’re delivering next-generation technology today that the competition can’t match. Some server vendors view uni and 2-socket servers as commodities, using off-the-shelf components to produce cookie-cutter servers with no added value. Instead, IBM X-Architecture system design begins with standard parts and adds practical innovation to create something better: outstanding quad-core and six-core performance, high availability, scalability, energy efficiency, and proactive manageability.

For example, the IBM System **x3650**, a 2U server, holds up to 12 DIMMs, for a total of up to 48GB, more than competitive systems. This ability is enabled by the innovative **IBM Calibrated Vektored Cooling™**. For those concerned with the security of their data, the **x3650** is the only 2U server from a Tier-1 vendor to offer **removable tape media** internally. Other vendors require external media, adding thousands of dollars in cost.



The 4-socket 4U **x3755** and the 2-socket 1U **x3455** each offer **Xcelerated Memory Technology™**. Because of this innovation, *all* 48GB in the x3455 run at the full 667MHz, unlike competitive systems that have to drop to 533MHz when fully populated.

Another innovative feature used in several System x servers is **IBM eXtended I/O™** technology. IBM understands that to achieve balanced system performance, you must match your I/O throughput to the performance of the rest of your system. There isn't much point in having ultrafast processors and memory if your I/O lags behind. Although tower servers have plenty of room to accommodate different types of adapter slots, 1U and 2U rack servers are another story. With eXtended I/O, you needn't worry about getting stuck with the wrong configuration. eXtended I/O provides adapter slots on replaceable riser cards. This means you can mix-and-match PCI-X and PCIe slots as needed—even HTX slots (in our Opteron-based 1U and 2U servers).

BladeCenter Chassis

Unlike the competition, IBM doesn't have a one-size-fits-all mentality. For the ultimate in flexibility, IBM offers *five* different blade chassis: **BladeCenter S** (with integrated mass storage, 110V power, and office-friendly acoustics) for small and medium businesses or departmental needs. **BladeCenter E** for typical data center requirements, and **BladeCenter H** for higher-performance needs, supporting 10Gb fabrics. For telecom environment, we offer **BladeCenter T**, a ruggedized NEBS 3/ETSI-certified platform, and **BladeCenter HT**, a higher-performance version supporting 10Gb fabrics.



In addition to high-speed switches—including 10Gb Ethernet and 4X InfiniBand™—supported by BladeCenter H and BladeCenter HT, all BladeCenter chassis support a number of 1Gb switch or bridge modules and fabrics. Due to the high degree of integration in the chassis, all blades have two 1Gb paths to the switches and bridges natively. By adding a daughter card to each blade, two *additional* 1Gb or 10Gb ports can be added. Using an optional **IBM Multi-Switch Interconnect Module (MSIM)** in a BladeCenter H high-speed switch bay *doubles* the number of ports available to *any* blade server in the chassis.

QLogic Ethernet and **Fibre Channel InfiniBand Bridge** modules provide gateway functions in conjunction with the **Cisco 4X InfiniBand Switch** for one or more InfiniBand-connected groups of BladeCenter H or BladeCenter HT systems to external Gb Ethernet or Fibre Channel networks. This further **lowers the cost of ownership** from an acquisition cost and total cost of ownership perspective.

To further advance next-generation thinking around blades, IBM formed **Blade.org**. It supports openness and collaborative innovation around new products and systems. Blade.org has invested more than \$1 billion in the last few years to fund companies developing emerging technologies and solutions to simplify computing with blade servers. Membership includes leaders in blade software and hardware, developers, distribution partners and end users. Collectively, the community has introduced dozens of solutions to the market to help customers choose with confidence from the blade portfolio. We currently offer networking switches from QLogic, Brocade, Cisco and BNT. Whether you're looking for low-cost Level 2 Ethernet, advanced Level 2/3 or Level 2-7 Ethernet, 10Gb Ethernet, 4Gb Fibre Channel, 4X InfiniBand, SAS or iSCSI, BladeCenter offers them all. You won't be locked out of the latest-and-greatest technology with BladeCenter.

BladeCenter Blade Servers

When it comes to blade servers, IBM has no equal. The competition offers dual-socket server blades containing either Intel or AMD processors. We offer single-, dual-, and quad-socket servers, a choice of Intel, AMD, IBM POWER6®, or Cell Broadband Engine™ processors, even a workstation blade—and they can all be mixed-and-matched within a single chassis.

On a budget, or have workloads that can't take advantage of multiple processors anyway? The **IBM BladeCenter HS12** offers a single processor, up to **24GB** of memory, a choice of two 2.5-inch HDDs or **solid-state** drives, and does so at a lower cost than competitive two-socket blades.

support is enabled for processors, memory, hard disk drives, power supplies, fans, voltage regulator modules, and the XceL4v Dynamic Server Cache. By comparison, many competitive systems offer PFA only for memory, HDDs, and sometimes processors.

IBM **Dynamic System Analysis** (DSA) collects and analyzes system information to aid in diagnosing system problems. DSA also compares device driver and firmware on the system to the versions available on an UpdateXpress CD, providing a summary of the differences.

Energy Use and Thermal Efficiency

Managing energy and cooling resources has become a critical issue in the data center as energy consumption and thermal loads increase. Successfully meeting these energy and cooling challenges requires well-thought-out IT products, smart data center design, and a method for efficiently controlling and monitoring your systems' energy and heat requirements.

Taking this philosophy to heart, the IBM Cool Blue™ portfolio of tools demonstrates leadership thinking and sets the industry direction for optimal thermal efficiency.

IBM offers a number of technologies common to both System x and BladeCenter to help improve your server and data center energy management:

- **IBM Rear Door Heat eXchanger** — This is a water-cooled door that attaches to the back of an **IBM S2 42U Enterprise Rack**. It's designed to dissipate heat exiting the back of your servers before it leaves the rack. It can remove up to 50,000 BTUs (14KV_a) per hour from the data center using chilled water lines under the raised floor. Improved cooling from the heat exchanger enables you to populate individual racks more densely using the same air conditioning, while freeing up valuable floor space. (The **Rear Door Heat eXchanger for iDataPlex** is a double-wide version of this, removing up to 100,000 BTU.)
- **Calibrated Vectored Cooling**™ — Utilized in System x and BladeCenter servers, it provides extremely efficient cooling. This enables increased density of components without overheating. Innovations include using *tandem counterrotating fans*, angling fans to increase the cooling for specific components, and other features that promote greater airflow.
Another thermal implementation, *isolated zone cooling*, requires only *some* fans in a specific "cooling zone" to switch to full speed in response to higher temperatures in that zone, rather than shifting *all* of them into high gear. Because of this design, the fans use less energy and create less ambient noise.
- **Energy-efficient power supplies** — The typical power supplies used in the server industry are approximately **65-75%** efficient at converting AC wall current into the DC power used inside a server. By contrast, the power supplies IBM uses in System x servers and BladeCenter chassis are significantly more efficient—up to **91%** efficient in the case of BladeCenter H. This helps save you money both on energy consumption up front and on cooling at the back end.
- **Low-voltage processors** — Intel, AMD, and IBM offer low-voltage versions of some processors, which run at the same clock rates as their higher-voltage cousins but consume less energy. Not all server vendors offer these low-voltage processors, which costs you money in wasted energy and cooling.
- **Low-power memory** — eX4 systems use Buffer on Board technology with DDR memory, which can save over 200 watts over competitive systems using Fully Buffered DIMMs.
- **2.5-inch HDDs** — 2.5-inch drives use approximately **40%** less¹ energy than 3.5-inch HDDs, saving you a considerable amount of energy. (How many HDDs does your data center contain?) They also run cooler and require less airflow, permitting greater density.
- **Solid-state storage** — The solid-state drives (SSDs) offered in HS12, HS21, HS21 XM, LS21, and JS22 blade servers consume only **1 to 2W** of power, compared with 9-10W for

¹ Seagate Technologies, "2.5-Inch Enterprise Disk Drives: the Key to Cutting Data Center Costs."
<http://www.seagate.com/content/pdf/whitepaper/TP-534.pdf>.

2.5-inch HDDs and up to 16W for 3.5-inch HDDs. Not only does this save even more power, but SSDs, with no moving parts, offer triple the reliability of spinning media².

The innovative and efficient cooling designs of System x and BladeCenter have helped make us more energy efficient than the competition. For example, BladeCenter uses up to **58%** less power than Dell 1U servers (with a similar reduction in excess heat production) and up to **32%** less power than HP 1U offerings³. IBM BladeCenter H requires nearly 10 percent less power than the equivalently configured HP BladeSystem c-Class 7000⁴. Extrapolated over 224 servers and with an energy cost of 9.4 cents per kilowatt hour, this can save you up to \$12,000 per year.

IBM Systems Director Active Energy Manager

In order to put control of processor energy-saving features at the fingertips of administrators, IBM developed IBM **Systems Director Active Energy Manager™ for x86**. Active Energy Manager (AEM) is a powerful software tool, designed to take advantage of new processor features, such as balancing the performance of the system according to available energy input. A plug-in for IBM Systems Director (described below) AEM provides the ability to plan, predict, monitor and cap energy consumption based on your System x or BladeCenter hardware configuration.

IBM Power Configurator

The **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: energy input in watts, PDU sizing in amps, heat output in BTUs, airflow requirements through the chassis in CFM, VA rating, leakage current in mA, and peak inrush current in amps.

Virtualization and Security

Even the smallest servers become SMP-capable via multi-core processors. Because of this, IBM is investing in system and data center management technologies to help you achieve higher utilization levels. Having better control allows you to proactively reassign workloads to other assets and temporarily shift bandwidth as needed. This can help you delay the need for more servers, manage electricity usage, assign failover servers for improved redundancy, and so on.

Virtualization means more applications per server, which puts more demands on the system. As a result of virtualization, the focus of high-end scalable x86 systems has shifted from a hardware-centric view to one of flexibility and cost-per-virtual-machine. Running 20 or 50 or 100 applications on the same server instead of one task per server is far more cost-effective. And it allows the applications to share a dynamically allocated pool of common system resources for improved efficiency.

IBM offers servers that are extraordinarily well suited for virtualization. For example, the x3850 M2 and the BladeCenter HS21 XM now offer selected models *integrated* with VMware ESXi 3.5 preloaded on a 4GB flash drive. The integrated hypervisor operates in a diskless configuration, offers a smaller memory footprint, extremely high performance, and stronger security, making getting a system up and running in a virtualized environment faster and easier than ever before.



Virtualization, naturally, doesn't involve only hardware. One tool, **IBM Virtualization Manager** allows you to manage physical and virtual machines from a single console. Another offering, **IBM BladeCenter H and Cisco VFrame Solution**, provides fabric sharing and I/O consolidation, scales to **512** servers—far more than competitive offerings—and is simple to use. It virtualizes the

² MTBF of 73GB SFF 10K RPM for first 12 months = 305,167. MTBF of solid-state SanDisk SDD SATA 5000 2.5 16GB = 918,298.

³ IBM BladeCenter H with HS21, 10 servers, 20 processors = 2,703W and 9,220 BTUs. Dell 1950 1U, 10 servers, 20 processors = 4,276W and 14,584 BTUs. HP DL 360 G5 1U, 10 servers, 20 processors = 3,570W and 12,173 BTUs. IBM power engineering test data. Numbers are average worst-case for P6 Burn exerciser program, tested in the IBM lab. Blade power is the average power of total chassis solution.

⁴ Edison Group Blade Server Power Study, *IBM BladeCenter and HP BladeSystem*, November, 2007.

server, workload and network connectivity, offering policy-driven automated blade failover. IBM **BladeCenter Address Manager** allows for the I/O virtualization of Ethernet and Fibre Channel connections *within a system* by providing users the option to assign Ethernet and Fibre Channel port addresses used by their server blades via software as an alternative to the addresses that are burned in to the hardware during manufacturing. IBM **BladeCenter Open Fabric Manager** allows you to deploy servers and I/O in minutes, rather than hours and it provides automated blade failover (inter- and intra-chassis) for up to 100 chassis. It's supported across all BladeCenter chassis, blades, and switches. If you use third-party management software for your networking equipment, you can seamlessly leverage the I/O virtualization capabilities that Open Fabric Manager delivers without disrupting your current management structure.

The increased spread of SANs, both Fibre Channel and iSCSI, is driving the need for **storage virtualization** as well. IBM storage virtualization tools can help transform the economics of enterprise storage by enabling users to simplify their infrastructure, protect their data and efficiently manage information. IBM **System Storage™** tools allow you to virtualize disk and tape storage. Solutions include the **System Storage SAN Volume Controller, SAN File System, IBM Tivoli® Intelligent Orchestrator** and **IBM Tivoli Provisioning Manager**.

Security concerns will eclipse TCO as the driver of *recentralization* and server consolidation will spread to desktops via virtual clients. To this end, IBM's **Virtual Client solution** allows users to enjoy all of the benefits and personal control of a stand-alone desktop—including print capabilities, USB drive support, and audio—while reducing many of the challenges related to current stand-alone desktop environments. These include limiting susceptibility to theft and viruses, ease of deployment of new users, extended downtime during a hard drive failure, or having to rebuild their preferences and settings after each client “refresh.”

Proactive Management

Inexpensive servers aren't inexpensive if they require excessive administrative or servicing time to bring them online and keep them that way. Labor is becoming the most expensive element in server deployment and ownership. Tools that simplify deployment, monitor system health, limit energy usage and report pending problems, are crucial to keeping costs under control.

IBM offers a number of tools to help you tame the complexity of systems management and administration, while managing costs:

- **IBM Systems Director** for advanced workgroup management is included with all BladeCenter and most System x servers. From a single user interface, IBM Systems Director enables monitoring and event management across a heterogeneous IT environment. If problems arise, IBM Systems Director can send alerts to administrators via e-mail, cell phone, pager and other means. And unlike the competitors' offerings, IBM Systems Director is vendor neutral and supports a number of compatible non-IBM systems.
- **IBM Continuous Availability Manager (CAM)**, an extension for IBM Systems Director, manages the availability of virtual containers, virtual machines, hypervisors and physical hardware. It can predict unplanned outages and react to prevent or reduce their duration. Its “hypervisor-neutral” design allows it to work equally with Xen, VMware, Microsoft Virtual Server, or none at all. CAM requires no internal agents and supports multiple open interfaces.
- **IBM Virtualization Manager** (described previously) is another optional extension for IBM Systems Director.
- **IBM Systems Director Active Energy Manager for x86** (described previously) is a no-cost extension for IBM Systems Director that allows the administrator to plan, predict, monitor, and even limit energy consumption by System x and BladeCenter servers.
- **IBM Remote Deployment Manager (RDM)**, an IBM Systems Director module, supports the deployment, update and retirement of servers, personal computers, workstations and point-of-sale terminals across the computing environment.
- **IBM UpdateXpress™**, a no-charge Web-based tool, can help reduce your cost of computing by providing a simple yet effective way for administrators to update the server or client

system firmware from anywhere on the network.

Support and Services

IBM has been renowned for decades for its award-winning, world-class technical support and services. For example, in October 2007 IBM received the prestigious Service & Support Professionals Association (SSPA) STAR award for Service Excellence in Continual Improvement for System x, BladeCenter and IntelliStation. The award is presented to the company that demonstrates exceptional service levels and customer satisfaction for three or more years, with year-over-year improvements and a plan in place for continued future improvement. Similarly, in a report of service and support customer satisfaction, Technology Business Research, Inc. (TBR) has ranked IBM Global Services (IGS) #1 for 10 consecutive quarters⁵.

Some of the innovative services we offer, to help you optimize and maintain your BladeCenter and System x solutions and overall data center, include:

- **IBM Electronic Service Agent™**
- **Data Center Consolidation and Relocation**
- **Scalable Modular Data Center**
- **High Density Thermal Assessment**
- **High Density Readiness Assessment**
- **High Density Integrated Rack Solution**
- **IBM Asset Recovery Solutions**

Additional services are available, including **hardware warranty upgrades** and factory-installed **Product Customization Services (PCS)**. For more on these services, contact an IBM sales rep, or read the companion white paper: *IBM X-Architecture Blueprint: 2008*.

Conclusion

IBM is the world's most innovative technology company. We've delivered the most powerful supercomputers and server innovations ever, and for fifteen years straight we've led the industry in IT patents⁶. (In fact, we've been issued more than double the number of patents of #2 HP.) We apply our deep heritage and rich business portfolio to develop insights across a variety of industries and create integrated solutions for your more difficult business problems, to help you gain a competitive advantage. In the x86 market, powerful technology from IBM Research has surrounded commodity parts with an unprecedented level of added value. Our goal is simple: to provide you with the best investment value for your technology dollars. To this end, the IBM X-Architecture blueprint—which encompasses hardware, software, and services—provides you with an incredible degree of flexibility, integration, data center simplification, performance, availability, and serviceability. This helps your servers run faster and cooler, use less energy, and be superior virtualization platforms.

These capabilities combine to help reduce your total cost of ownership. Equally importantly, they can help you sleep soundly at night, knowing that your data center is functioning as smoothly, efficiently, and cost-effectively as possible. x86 technology has grown into serious mainstream, mission-critical technology, and IBM X-Architecture servers are the best value in the marketplace. Can you afford to be saddled with a weak technology partner? Can you afford *not* to choose IBM?

⁵ TBR Corporate IT Service & Support Customer Satisfaction Study, 1Q/08.

⁶ <http://ibm.com/press/us/en/pressrelease/23280.wss>.



For More Information

IBM System x Servers

IBM BladeCenter Server and options

IBM Rack Configurator

IBM ServerProven Program

IBM Technical Support

IBM Configuration and Options Guide

ibm.com/systems/x

ibm.com/systems/bladecenter

ibm.com/servers/eserver/xseries/library/configtools.html

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September 2008
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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.