White Paper

Creating World-Leading Systems Using a Common Processor Microarchitecture: Combining the Best from Mainframes, Unix Servers, and HPC

Sponsored by: Fujitsu

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EXECUTIVE SUMMARY

Fujitsu is a global technology leader in the development of an advanced SPARC-based processor line, which it uses to support mainframes, Unix servers, and supercomputers. These products make up the foundation of Fujitsu's high-end offerings for the most advanced enterprise business, scientific, and analytics applications. To accomplish this, Fujitsu centers its processor development on the use of a common microarchitecture that allows designers to continually develop and improve a standard base processor that then can be readily customized to meet the unique computational requirements of different system designs. The benefits of a common microarchitecture provide customers of Fujitsu mainframes, Unix servers, and supercomputers with strong performance, advanced reliability, and robust security features.

Fujitsu is the only vendor in the world that currently employs such a powerful common microarchitecture design philosophy to help drive its processor development, allowing the firm to continuously roll out an impressive array of computing products, each uniquely designed to address key and often distinct user requirements.

Fujitsu's mainframe product line, the GS21 2400 and GS21 2600 lines, is targeted for infrastructure systems and mission-critical enterprise systems that need to run reliably 24 x 7. The GS21 mainframe uses Fujitsu's common microarchitecture in a specialized system-on-a-chip (SoC) design. This consolidates what had previously been 14 separate chipsets into a single chip and increases processing performance by as much as 40%, slashing power consumption by up to an impressive 50% and reducing the required floor space by approximately 70%.

The Fujitsu M10 line of Unix servers runs Oracle Solaris 10 and 11 and is targeted for business applications, including those handling a wide range of big data requirements. For these systems, Fujitsu developed the SPARC64 X and SPARC64 X+ processors that feature powerful software-on-a-chip (SWoC) functionality in the areas of SIMD vector processing, extended floating-point registers, decimal floating-point processing, and cryptographic processing. These features were integrated in both Oracle Solaris 11 and Oracle Database 12c, allowing for easy access by software developers and users.

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Fujitsu's supercomputer product line is the PRIMEHPC FX100, which uses yet another Fujitsu SPARC variant, the SPARC64 XIfx, and adds a number of unique features to address the requirements of leadership-class supercomputers. Fujitsu and its SPARC design skills were integral in the development of Japan's current leadership-class supercomputer, the K computer system installed at RIKEN Advanced Institute for Computational Science.

Fujitsu plans to continue to use its industry-unique common microarchitecture capabilities to design a wide range of systems that can serve both the business community and the technical community with specialized high-performance processors. Fujitsu is committed to continue developing and building world-class SPARC-based servers for at least the next five years.

Indeed, the recent announcement by Fujitsu to adopt an ARMv8 instruction set architecture (ISA) for the planned Post-K supercomputer does not signal a flagging interest in SPARC; instead, it serves as the most recent example of the ability of the Fujitsu common microarchitecture model to adapt to changing technical requirements.

IN THIS WHITE PAPER

This white paper looks at how Fujitsu has created a common microarchitecture to address the computing requirements of a broad set of diverse users around the world. It looks at the collection of Fujitsu high-end servers — its mainframe, Unix server, and supercomputer product lines — highlighting the use of different variations of Fujitsu's CPU processor line that are each designed to meet the specific technical and related user requirements within each segment:

- Fujitsu's mainframe product line targets infrastructure and mission-critical enterprise systems that need to run reliably 24 x 7 and uses Fujitsu's common microarchitecture in a specialized SoC design to consolidate what had previously been 14 separate chipsets into a single chip. This leads to increased processing performance by as much as 40% over previous-generation systems, slashing power consumption by up to 50% and reducing the required floor space by approximately 70%.
- The Fujitsu M10 line of Unix servers runs Oracle Solaris 10 and 11 and is targeted for business applications, including those handling a wide range of big data requirements. For these systems, Fujitsu developed the SPARC64 X and SPARC64 X+ processors that feature powerful SWoC functionality in the areas of SIMD vector processing, extended floating-point registers, decimal floating-point processing, and cryptographic processing. SWoC provides tremendous performance improvements, especially in Oracle Database environments.
- Fujitsu's PRIMEHPC supercomputer product line first appeared on the June 2015 Top500 list, with two new petaflops-class systems. PRIMEHPC FX100 is based on yet another Fujitsu SPARC variant, the SPARC64 XIfx, and adds a number of features unique to the requirements of a leadership-class supercomputer, including wide SIMD capabilities, enhancements to handle stride and indirect loads and stores, and the inclusion of two on-chip assistant cores that manage tasks such as asynchronous MPI communication, freeing up the processor's 32 computational cores from administrative tasks.
- The recent announcement by Fujitsu to adopt an ARMv8 ISA for the planned Post-K supercomputer does not signal a flagging interest in SPARC; instead, it serves as the most recent example of the ability of the Fujitsu common microarchitecture model to adapt to changing technical requirements as well as new demands from the marketplace for new options in high-performance computing (HPC).

Fujitsu's road maps make it clear that the company will continue to use its industry-unique common microarchitecture capabilities to design a wide range of systems that can serve both the business community and the technical community with specialized high-performance and reliable processors. Dating back to 1995 with its first SPARC processor, Fujitsu has a long history of SPARC processor development. IDC expects that Fujitsu will continue and expand its processor development in the future.

SITUATION OVERVIEW

Overall Server Market Trends

The server market focus has begun to shift toward software-defined infrastructure as organizations begin to transform their IT infrastructure as well as prepare for the compute demands expected over the next few years from next-generation IT domains such as the Internet of Things and cognitive analytics.

IDC continues to see a server market that is largely about meeting the needs of two separate and distinct sets of customer workloads. The first is the traditional 2nd Platform defined by IDC as a system built around a client/server architecture that continues to need richly configured integrated systems for a wide range of applications. At the same time, a new and rapidly growing 3rd Platform is impacting the server market.

The 3rd Platform of computing, where cloud, social, mobile, and big data/analytics come together, has the potential to underpin business process transformation and, in some cases, business model transformation. As businesses increasingly operate on the 3rd Platform, they will be able to transform how they engage with customers, the speed at which they deliver products and services, how they innovate, the reliability of their operations, and their resiliency to market changes.

The 3rd Platform is an IT architecture built on the notion that new and interdependent technologies, including mobile computing, social media, cloud computing, information/analytics (big data), and the Internet of Things, will drive the need for fabric-based, disaggregated software-defined environments to serve a host of important and innovative new applications:

- This 3rd Platform market continues to be a build-versus-buy battleground for next-generation workloads, which are stateless, scale horizontally, and do not assume infrastructure resiliency.
- The movement toward 3rd Platform deployments in day-to-day business operations will help buyers transform their traditional businesses into innovative enterprises.

However, moving to the 3rd Platform comes with its share of challenges. The ways in which projects are funded, sponsored, and executed require deep collaboration between IT and the business. It also requires IT organizations to significantly change the way in which they operate.

IDC believes that Fujitsu's common microarchitecture provides the ability to meet the requirements of both platforms. Fujitsu's common microarchitecture has already demonstrated its ability as an effective processor base for a wide range of 2nd Platform systems in mainframes, Unix servers, and supercomputers across a wide range of traditional client/server installations spanning both technical and business applications. Going forward, the common microarchitecture is uniquely configured among all other processor options to react quickly and effectively with a customized chip to a wide range of architectural and related performance demands from a host of available and future 3rd Platform devices such as Internet of Things hardware as well as cloud, big data, and mobile computing products.

Customer Requirements

We believe that the decision-making process for purchasing server hardware will be largely driven by many of the same underlying elements as in the past. Therefore, IDC expects that customer spending on server systems will be significantly influenced by form factors, energy specifications, consolidation, and virtualization technologies. The growth of density-optimized servers, combined with rising energy costs, will result in power and cooling system requirements becoming just as important as performance and price in terms of purchasing criteria.

Buyers are looking for integrated IT solutions that provide improved performance with greater availability and ease of use, all at a lower price. In addition, key requirements include:

- Ease of migrating applications to new platforms
- Improved price/performance and lower total cost of ownership (TCO)
- Reduced power consumption
- Scalability without pain
- Higher reliability
- Strong support services
- Reduced operation costs by improving CPU performance
- Long-term support for key applications and software

How Fujitsu Addresses These Requirements: A Common Microarchitecture

Fujitsu Microarchitecture: Leveraging Key Technology Advances Across Multiple System Lines

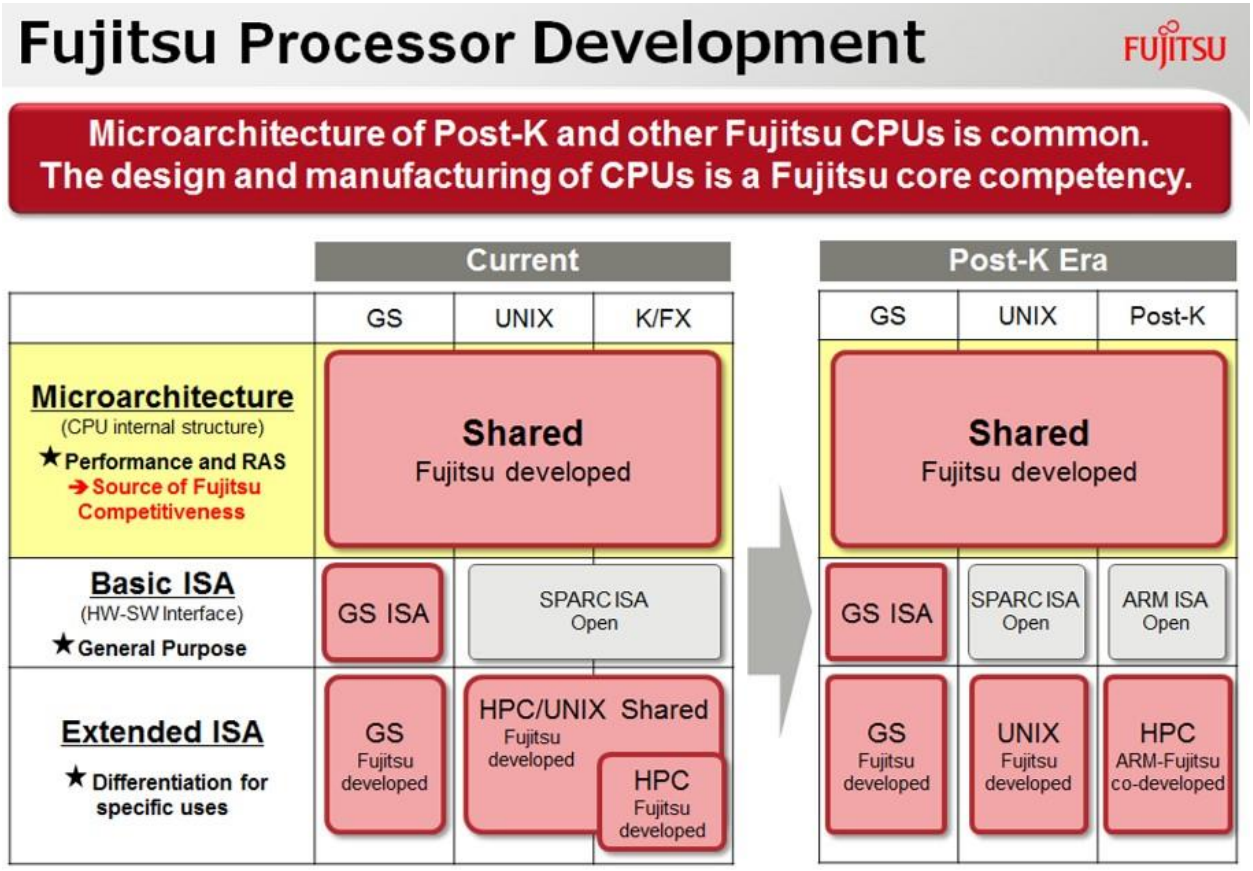
Fujitsu is a global technology leader in the development of advanced processor technologies used to support mainframes, Unix servers, and supercomputers. These product lines form the heart of Fujitsu's high-end offerings for the most advanced enterprise business, scientific, and analytics applications. In addition, the same processor base is used as the computational engine behind some of Japan's most powerful HPC systems to date, such as the K computer at RIKEN Advanced Institute for Computational Science, which was the most powerful HPC system in the world when it first appeared on the Top500 list in 2011 and still ranks among the top 5 most powerful in the world. A follow-on Post-K computer is planned and will harness much of the same Fujitsu SPARC processor expertise and capabilities, but it will operate with an ARM ISA.

Fujitsu: Many Product Lines, One Processor Microarchitecture Base

To capitalize on its long history of excellence in processor design, Fujitsu has developed a number of different variations of its SPARC processor, each possessing custom features and performance enhancements designed for a specific product line and market as depicted in Figure 1. To make this possible, over time, Fujitsu has centered its SPARC development on the use of a common microarchitecture that allows designers to use a base processor architecture that can be customized for different systems.

FIGURE 1

Fujitsu Common Microarchitecture Approach



Source: Fujitsu, 2016

Fujitsu is the only vendor that currently employs this common microarchitecture design philosophy. Other processor and computer makers base their overall processor and system architectures on a specific ISA. An ISA is a rigidly defined interface between a processor's hardware and the set of basic computer instructions to which it can respond.

For example, Intel and AMD follow the x86 ISA, while IBM's POWER ISA defines the hardware/software interface for IBM POWER servers. An advantage here is that the same software runs on any processor that adheres to a specific ISA as long as the same operating system is used.

Although an ISA defines the interface between the processor hardware and software, it does not expressly define the internal structure of that processor. Indeed, a processor can have any number of hardware design features or unique architectural implementations, with the only requirement being that it ultimately meets the interface requirement of the ISA.

Fujitsu is the only vendor that currently employs a common microarchitecture design philosophy.

In contrast, Fujitsu has chosen to concentrate its efforts on a common microarchitecture that allows for the development of processors that interface to a number of different ISAs but that enjoy the efficiencies, economies of scale, and performance enhancements of a shared microarchitecture design.

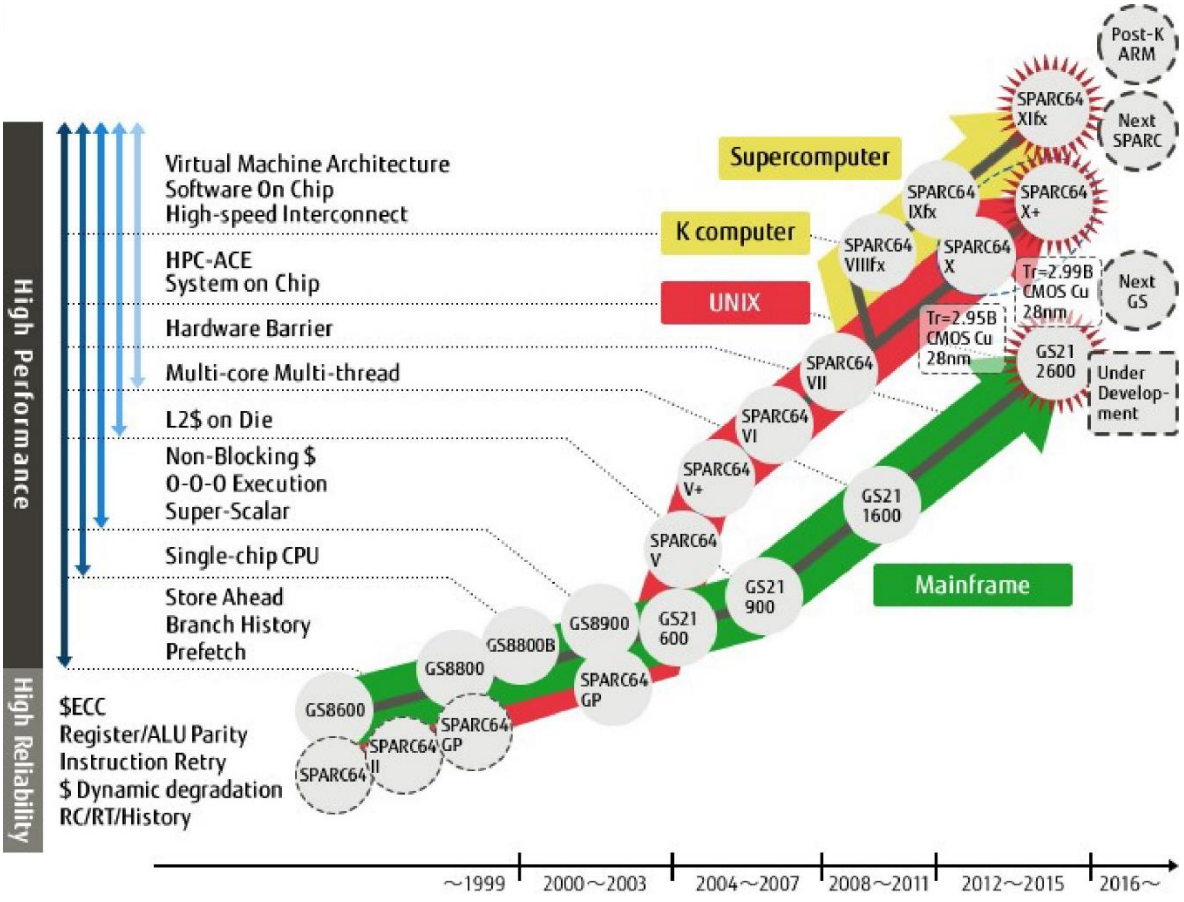
For example, the internal microarchitectures of both Fujitsu mainframe and Fujitsu Unix server processors share much of the same architectural design but differ in how specific incoming instruction is decoded by the processor – based on the ISA being supported – for dispatch, execution, and finally storage.

Reliance on this common microarchitecture allows Fujitsu to design and roll out multiple high-performance processors optimized for different product lines in a timely and reliable manner.

Within the Fujitsu SPARC family and using the common microarchitecture, the firm has produced a number of SPARC processors bound for inclusion in each of its three main high-end computing lines – mainframes, Unix servers, and supercomputers – as depicted in Figure 2.

FIGURE 2

Fujitsu Processor Development



Source: Fujitsu, 2016

Mainframes

The Fujitsu mainframe product line, which currently consists of the GS21 2400 and GS21 2600 models, was launched in April 2014. The higher-end 2600 model comes equipped with 1 to 16 CPUs, a maximum of 256GB of main memory, and a maximum of 256 channels. The GS21 mainframes are targeted for social infrastructure systems and mission-critical enterprise systems that need to run reliably 24 x 7.

The GS21 mainframe uses Fujitsu's common microarchitecture plus a specialized SoC design, with the latest CMOS technology to boost transaction processing performance up to 40% over previous models while increasing reliability. In addition:

- Each processor hosts up to 8 cores and is equipped with a 256KB primary cache, as well as a secondary cache of up to 24MB, an I/O processor, a memory controller, and a system controller.
- The new SoC processor design consolidates 14 separate chipsets into a single chip.

Fujitsu's Impressive Worldwide Mainframe Installed Base

Fujitsu has a long history of installing high-quality, top-of-the-line mainframe computers around the world:

- Systems are sold under the Fujitsu brand in Japan, Spain, Australia, and South Korea.
- Systems are sold under the Fujitsu Technology Solutions brand in Germany, England, Denmark, Australia, Belgium, Spain, and Hungary.

Fujitsu has a long history of installing high-quality, top-of-the-line mainframe computers around the world.

Unix Servers

Fujitsu's current Unix server offering is the Fujitsu M10 SPARC server product line, which targets business applications, especially those handling a wide range of big data requirements. The product line consists of three major offerings:

- Fujitsu M10-1 is a 1U rackmount system equipped with one Fujitsu SPARC64 X+ or Fujitsu SPARC64 X processor with up to 16 cores, a maximum main memory capacity of 1TB, and a maximum internal disk storage capacity of 7.2TB.
- Fujitsu M10-4 is a 4U rackmount system equipped with up to four Fujitsu SPARC64 X+ or Fujitsu SPARC64 X processors with up to 64 cores, a maximum main memory capacity of 4TB, and a maximum internal disk storage capacity of 7.2TB.
- Fujitsu M10-4S offers scalable configurations that utilize a four-processor building block architecture and Fujitsu proprietary interconnect technology to dynamically grow from a single four-socket 4U building block up to a configuration of 16 building blocks equipped with up to 64 Fujitsu SPARC64 X+ or Fujitsu SPARC64 X processors with up to 1,024 cores, a maximum main memory capacity of 64TB, and a maximum internal disk storage capacity of 115.2TB.

All Fujitsu M10 systems run Oracle Solaris 10 and 11, one of the most used Unix operating systems today, and the systems run all Oracle Solaris SPARC applications. Fujitsu M10 series systems, which debuted in 2013, are targeted for enterprise-class workloads such as online transaction processing, cloud computing applications, and emerging workloads in the big data analytics field.

To power its Fujitsu M10 product line, Fujitsu designed the SPARC64 X and SPARC64 X+ processors, drawing on Fujitsu's common microarchitecture and including optimizations to meet the specific requirements of enterprise business workloads. In addition:

- In essence, the SPARC64 X processor was the result of a convergence of two processor lines created by Fujitsu: the SPARC64 VII+ built for the commercial Solaris servers sold by Sun Microsystems, Oracle, and Fujitsu and the SPARC64 VIIIfx processor developed specifically for the 10.5 petaflops K computer built by the company for the RIKEN Advanced Institute for Computational Science.
- Each SPARC64 X and SPARC64 X+ processor can support 32 simultaneous multithreads and has up to 24MB of on-chip L2 cache implemented in two segments, four DDR3 memory controllers, two PCI Express 3.0 root complexes, and system interconnects on the die.
- New SWoC functionality was added to SPARC64 X processors, and enhanced on SPARC64 X+ processors, as instruction set extensions in the areas of SIMD vector processing, extended floating-point registers, decimal floating-point processing, and cryptographic processing. These features were integrated in both Oracle Solaris 11 and Oracle Database 12c, allowing for easy access by software developers and users.

Fujitsu's Impressive Worldwide Unix Server Installed Base

Fujitsu M10 servers have proven to be popular around the world and across a wide range of industry segments. Fujitsu M10 servers are currently installed in more than 70 countries around the world including Japan and countries throughout Asia/Pacific, the Americas, Europe, and Africa.

Supercomputers

Fujitsu's current supercomputer product line is the PRIMEHPC FX100. Notable PRIMEHPC FX100 installations include Japan's National Institute for Fusion Science (NIFS) and the Japan Aerospace Exploration Agency. The system at NIFS has achieved an impressive LINPACK efficiency of over 90%.

The overall design of the FX100 — which builds on Fujitsu's predecessor FX10 supercomputer line — includes a number of striking performance features, all of which are unique to the Fujitsu supercomputer product line and together implement a seamless and integrated HPC-specific architecture:

- The foundation of the FX100 supercomputer is another variant of the Fujitsu common microarchitecture processor, the SPARC64 XIfx, which delivers 1.1 teraflops peak performance. The processor is built using state-of-the-art 20nm semiconductor process technology and integrates 32 compute cores and 2 assistant cores into a single processor chip.
- The FX100 provides an expansion to the traditional SPARC-V9 ISA called HPC-ACE2 (High Performance Computing-Arithmetic Computational Extensions 2) that features two 256-bit wide SIMD units per core with advanced operation functions, improving the computational throughput of the processor.
- To support rapid data transfers between the processor and the memory fabric, Fujitsu was one of the first makers of high-performance computers to implement a 32GB HMC (Hybrid Memory Cube) construct with a memory bandwidth of 480GBps per node (240GBps reads and 240GBps writes), allowing the one-processor-per-node architecture to fully exploit the high memory bandwidth.
- The Fujitsu custom-built Tofu Interconnect 2 (Tofu2) is integrated into the SPARC64 XIfx processor and enhances node-to-node communication bandwidth for up to 12.5GBps x2 (in/out) per link with low latency.

As with other Fujitsu common microarchitecture processors, the SPARC64 XIfx builds on the common SPARC design but adds a number of features unique to the requirements of a leadership-class supercomputer. These enhancements include wider SIMD capabilities over the FX10 predecessor, better abilities to handle stride loads and stores and indirect loads and stores, and the inclusion of two on-chip assistant cores that manage tasks such as asynchronous MPI communication, freeing up the 32 computational cores from administrative tasks.

It is important to note that Fujitsu and its SPARC design were integral in the development of Japan's current leadership-class supercomputer, the K computer installed at the RIKEN Advanced Institute for Computational Science, a leading Japanese government-funded R&D center.

CUSTOMER EXPERIENCES

Fujitsu processors and systems have been adopted worldwide, and there are many real-world examples of customers obtaining major value from these systems. These customers have seen improvements in data processing performance while reducing complexity and energy consumption. Mainframe and Unix systems have been installed in sectors such as government, finance, and manufacturing.

Customer Example: Dai Nippon Printing

Dai Nippon Printing Co. Ltd. is a Japanese printing company established in 1876 with interests in a broad range of business areas including information communication, lifestyle, industrial supplies, and electronics. The company was looking to expand its business operations, and it needed to migrate from an existing HP-UX-based infrastructure to Oracle Database on Oracle Solaris for its export control system.

Requirements included availability and improved system performance as well as a solution that could:

- Reduce TCO
- Provide consolidated support
- Optimize middleware licenses and reduce operation costs by improving CPU performance
- Maintain high reliability and high availability
- Provide long-term support for Oracle Solaris

To meet these requirements, Fujitsu provided a complete solution to Dai Nippon by installing Fujitsu M10 servers that deliver uninterrupted service during user expansion and data volume increases. From a systems viewpoint, Dai Nippon reported significant performance improvement from the Fujitsu solution, plus much higher availability and reduced operational costs.

Customer Example: Frontier Science

Frontier Science is a not-for-profit research foundation established to advance the application of statistical science and data management techniques in science, healthcare, and education. The foundation is engaged in large-scale national and international clinical trials, many of which have had a direct impact upon the treatment of patients with various diseases, particularly AIDS and cancer, throughout the world. In addition to the 250 Frontier Science staff, the foundation is also connected to 6,000 researchers globally, all of whom need to upload vital data on a daily basis. As such, maximum availability is crucial. The foundation has developed software and general computing techniques specifically tailored to the needs of data collection, categorization, and analysis.

"We initially purchased one Fujitsu M10-4 for testing and benchmarking purposes and determined that it provided 50-70% greater throughput. We could also run considerably more routines simultaneously."

— Frontier Science official

The key requirement for Frontier Science was a new, more powerful SPARC-based solution that would maintain optimal reliability while avoiding the costs associated with porting its data and applications. It also needed systems with considerably lower power demands in order to deploy them more easily to geographically separated sites called for by its customers.

Frontier Science decided to implement multiple Fujitsu M10-4 and M10-1 servers, as well as Fujitsu ETERNUS DX200 storage solutions, at several sites. This included production systems as well as segregated development and testing systems. A key consideration for Frontier Science was the 16-core SPARC64 X processor that delivers optimal performance, mainframe-class reliability, availability, and maximum scalability to handle mission-critical workloads. The Fujitsu M10 servers also required less power than what was previously installed.

Customer Example: DEPFA Bank

DEPFA is a Dublin-based bank with a network of international subsidiaries, including New York, Tokyo, and Luxembourg, that focuses on financial services to the public sector. During a recent reorganization, the bank was faced with a requirement to refresh all systems and infrastructure within a strict time frame to ensure DEPFA could operate as a standalone entity.

Fujitsu was able to successfully refresh core operations functions without disrupting the operation of over 70 applications managed by Fujitsu and its partners.

Fujitsu teamed with a local commercial banking application specialist to provide a comprehensive technical solution that took into account specific regulatory requirements for each market in which DEPFA operated. The Fujitsu solution included a total refresh of end-user devices in each of DEPFA's offices and the implementation of an online cloud VoIP offering.

The Fujitsu solution had to support DEPFA's day-to-day operations, which included the datacenter, telephone network, networks and application support, and development functions to support banking applications for trading and payments. Fujitsu was able to successfully refresh these functions without disrupting the operation of over 70 applications managed by Fujitsu and its partners.

"Fujitsu was able to build the application ecosystem in parallel over 10 weeks to ensure zero downtime."

"We trade in millions of dollars per day and, if we can't make collateral calls, the penalties would be extreme," said a company official. *"Fujitsu was able to build the application ecosystem in parallel over 10 weeks to ensure zero downtime."*

FUTURE OUTLOOK

The Future of Fujitsu's Common Microarchitecture

Fujitsu's road maps make it clear that the company will continue to use its industry-unique common microarchitecture capabilities to design a wide range of systems that can serve both the business community and the technical community with specialized high-performance and reliable processors. Dating back to 1995 with its first SPARC processor, Fujitsu has a long history of SPARC processor development. IDC expects that Fujitsu will continue and expand its processor development in the future.

Fujitsu is committed to continue developing and building world-class SPARC-based servers for at least the next five years. IDC expects that the Fujitsu common microarchitecture will not only power future mainframe, Unix server, and supercomputer product lines but also be expanded to meet new challenges in next-generation IT domains such as the Internet of Things, cognitive analytics, and other upcoming areas. Indeed, the recent announcement by Fujitsu to adopt an ARMv8 ISA for the planned Post-K supercomputer does not signal a flagging interest in SPARC; instead, it serves as the most recent example of the ability of the Fujitsu common microarchitecture model to adapt to changing technical requirements as well as new demands from the marketplace for new options in high-performance computing.

OPPORTUNITIES AND CHALLENGES

Opportunities

Going forward for Fujitsu, its unique use of a common microarchitecture presents the firm with a number of significant opportunities as well as a few challenges. Because Fujitsu offers processor variants in at least three high-end product lines, the firm can readily take advantage of the design and manufacturing economies of scale normally associated with high volume processor suppliers, such as Intel. Simply put, the use of a common microarchitecture enables Fujitsu to pursue the development of new, innovative, and aggressive processor designs knowing that development costs and resource expenditures can be spread across a wide base of product lines.

Conversely, by being able to customize specific processors based on a common microarchitecture, Fujitsu can add highly useful performance features — as evidenced in its SPARC64 XIfx, which includes hardware explicitly designed for rigorous HPC use — with lower cost, complexity, and time constraints than those typically seen when designing a completely new processor.

In addition, with its common microarchitecture, Fujitsu is better positioned than most traditional processor suppliers to respond with a newly designed processor for rapidly changing market demands. Because the common microarchitecture allows for flexibility in the processor's instruction decoding hardware without having to change any other part of the processor design, Fujitsu is able to offer products that can work with any ISA it chooses. In detail:

- The new ARMv8 ISA processor that Fujitsu will supply for the planned Post-K supercomputer will enable RIKEN to use all of the systems and applications software that the ARM ecosystem supports while still running what internally is a common microarchitecture.
- Fujitsu processors can be designed to easily and efficiently handle at the hardware level a wide range of in-house technical or user-defined instruction set additions in the decoding process — an option simply not available to any other processor vendor.

From the user perspective, Fujitsu's common microarchitectures offer the opportunity for users to buy computer systems with new architectures and processor features that may not be available from other more general-purpose processors – a significant value-added opportunity in cases where those general-purpose processors are not well suited to their specific performance requirements. In detail:

- HPC users can take advantage of the Fujitsu SPARC64 XIfx-based PRIMEHPC FX100 supercomputer line that employs features at the hardware level that would not generally be included on other general-purpose processors targeted for a wide, primarily non-HPC-centric, user base. At the same, HPC users can realize significant advantages over the use of custom processor designs that are technologically riskier and that generally come with a higher price tag.

Challenges

Despite these opportunities, Fujitsu does face some challenges. Fujitsu must be able to continue to roll out new processors that meet the technical and market requirements of a wide customer base and that accurately reflect the needs of its most important applications. Accomplishing this will entail Fujitsu accurately understanding, and in many cases accurately anticipating, customer needs for new processors and their related hardware features in order to offer new processors and system products in a timely manner.

Fujitsu must continue to clearly demonstrate that its common microarchitecture expertise translates directly into better performance across its entire range of product lines. To do this, Fujitsu must maintain and build upon its world-class expertise in systems, applications, and IT solutions across a number of somewhat diverse market spaces with different user requirements and expectations.

Dealing with this issue will require Fujitsu to stay on top of a number of critical new spaces that include big data, real-time predictive analysis, and Internet of Things applications. In addition, these new systems, applications, and solutions must appeal not only to existing customers looking for seamless upgrades or new added capabilities but also to new customers exploring the best possible options to meet their high-end computing requirements.

About IDC

International Data Corporation (IDC) is the premier global provider of market intelligence, advisory services, and events for the information technology, telecommunications and consumer technology markets. IDC helps IT professionals, business executives, and the investment community make fact-based decisions on technology purchases and business strategy. More than 1,100 IDC analysts provide global, regional, and local expertise on technology and industry opportunities and trends in over 110 countries worldwide. For 50 years, IDC has provided strategic insights to help our clients achieve their key business objectives. IDC is a subsidiary of IDG, the world's leading technology media, research, and events company.

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