

# Bringing 64bit UltraSPARC computing to the embedded world

*The UltraSPARC IIe was developed to meet the specific needs of embedded 64-bit high-end embedded computing. The processor is designed to deliver impressive throughput in a highly integrated package with the right balance of power consumption to facilitate compact, low cost system design. This article explains how this is possible.*

## INTRODUCTION - EMBEDDED DRIVERS

In the new emerging world of the net economy, many traditional companies have realised tremendous productivity gains and cost savings by building a new e-business infrastructure. This "Net Effect" has changed the way the world does business, both in communications to customers and relationships with vendors. However, these new environments have created new complexities that have changed the needs customers place on processors especially in high-end embedded applications.

For example, in the telco market, companies are differentiating themselves by their unique set of services and their ability to handle the increasing demand on their networks. Moving away from proprietary systems towards standards-based embedded platforms to keep on top of the evolving demands of customers, requires the biggest embedded computing engine available. Another feature of this evolution is the expanding number of companies finding benefits in outsourcing to ASPs. As a result these are being put under the increasing demands of simultaneously hosting large, high-end applications for dozens if not hundreds of businesses. Based in this environment they are a primary market for high-end 64-bit embedded processing. A similar kind of development is in store for SANs that will be called upon to store and retrieve massive amounts of data in real time. Performance is becoming a progressively important issue for designers of high-end embedded applications.

In the new world of internet communications multiple metrics of performance have become more important than single metrics, like clock speed, or individual benchmarks, like Specmarks. Sun has focused on delivering multi-dimensional levels of performance in its processors and optimising its chip technologies for embedded applications. Recently it has released the UltraSPARC IIe. The E series provides a balance of cost, power consumption and performance for individual workstation applications, rack-mount servers in the network, high-performance embedded applications such as data communication firewalls and security, storage area network control, and telecommunication network control.

## THE ARCHITECTURE

Like all the processors in the UltraSPARC family, it is based on the SPARC V9 architecture and includes a four-way, 6 pipe, super-scalar pipeline. Composed of 23 million transistors, the processor delivers a peak performance of 20 SPECint95 and 21 SPECfp95 at 500MHz. It achieves this performance by providing 64-bit addressing and data with two integer, two floating point/VIS, one block load/store and branch prediction units. The processor also includes a high-performance 256 Kbyte, four-way set associative Level-2 cache that delivers 2-GB/sec bandwidth and a high-speed memory interface with an 800-MB/sec peak bandwidth. The 64-bit wide memory interface and internal buses provides a broad data pathway, delivering significantly higher data throughput than 32-bit processors operating at the same clock rate. In addition, an on-chip block load and store mechanism permits very efficient, high bandwidth, 64-byte block memory-to-CPU and CPU-to-memory transfers that occur in parallel with normal instruction execution. Finally, the highly efficient 4-way set associative, Level 2 cache, along with accurate branch prediction and explicit fetch-to-cache capability, ensures data is available on-chip when needed, eliminating the lengthy delay associated with fetching data from external memory.

## MULTIMEDIA FUNCTIONALITY

The UltraSPARC IIe supports the VIS instruction set for multimedia and graphics operations, enabling it to provide a balance of general-purpose computing and DSP-like capabilities. As a result, the processor can accelerate the most common operations related to two-dimensional image processing, two- and three-dimensional graphics, VoIP, MPEG-2, MP3 and many other compression/decompression algorithms and numerous network operations. The VIS instruction set permits single instruction multiple data (SIMD) operations in which eight-bit, four 16-bit or two 32-bit operations are executed in parallel in a single clock cycle.

## PROCESSOR INTEGRATION

Manufactured on a 0.18-micron 6 layer AL metal CMOS process, it integrates the memory controller, PCI controller and Level-2 cache in addition to the CPU, which includes the two integer units and two floating point/VIS units, along with the Level-1 data (16K, direct

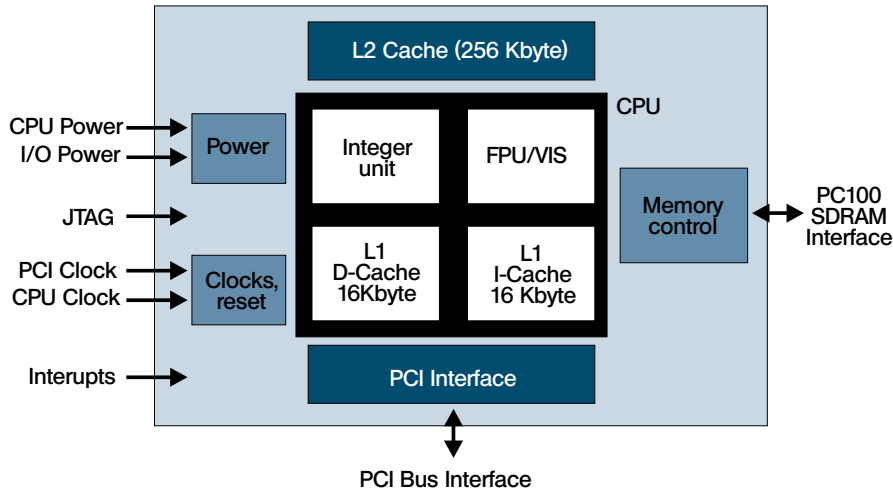


Figure 1. ULTRASPARC-IIe PROCESSOR DIAGRAM.

mapped), and instruction (16K, 2 way associative) caches. Consequently, all that is needed to create a basic system are the clock, power, interrupt controller, boot ROM, PC-100 SDRAM memory and PCI bus peripheral chips. These integrated capabilities eliminate the need for an external Northbridge chip and the associated proprietary process bus interfaces required for other processes.

Being PCI 2.1 compliant, the IIe's PCI bus interface can be directly connected up to four 32-bit PCI devices running at either 33 MHz or 66MHz. The processors design permits each of the directly connected devices to be a bus-master capable of initiating DMA transactions. The controller supports 32- and 64- byte transfers and provides industry-standard 3.3-volt signalling on the PCI bus interface.

The on-chip 256-Kbyte secondary cache is a unified instruction-plus-data memory that can operate in either four-way set associative mode or direct-mapped mode. Preliminary analysis has shown that in many applications the on-chip, four way set associative cache performs as well as or better than an external direct-mapped cache over twice its size. An integrated cache control unit interfaces the Level-2 cache to the CPU, memory and PCI subsystems, arbitrating their requests for data from the external SDRAM memory.

The UltraSPARC IIe consumes 8 watts (max) when operating at 400MHz/1.5 volts and 13 watts (max) at the peak 500MHz. Typical power consumption is lower, estimated to be 6.7 watts (typ) at 400 MHz and 10 watts (typ) 500MHz. The low wattage enables designers to use a much smaller heat sink on the chip. This, combined with the higher degree of integration, makes it particularly well suited for ultra-slim server appliances and 1u rackmount, NEBS-compliant telecommunications computing applications.

To support the design of systems compliant with the Energy Star initiative, the processor includes software controlled power management. The processor can be slowed using software to one-half and, under certain operating conditions, to one-sixth the normal operating frequency, thereby reducing power consumption.

Software can further minimise system power consumption by controlling system I/O devices that provide power-down capabilities.

## SOFTWARE SUPPORT

High-end embedded applications span a range of operating systems needs. From telecommunications systems requiring a general-purpose operating system for controller operations through to storage area networks (SANs) that are exclusively real time environments. All the microprocessors in Sun's 64-bit UltraSPARC range offers binary compatibility with over 12,000 applications and directly supports the industry-leading UNIX Solaris Operating System Environment as well as Wind River's VxWorks real-time operating system (RTOS).

The Solaris Operating Environment has been offered as an evolutionary product, and is being continuously improved in terms of performance, availability, interoperability and security. This makes it particularly well suited to mission-critical business applications such as telecommunications, SANs and Internet services providers (ISPs). It integrates direct support for superior availability levels and scales from small uniprocessor platforms to massive, clustered enterprise servers with 64 or more processors per system. The Solaris Operating Environment offers developers the possibility to deploy one consistent operating system in both the development environment and throughout the networks.

VxWorks from Wind River Systems is among the most popular real time operating systems (RTOS) on the market today. Its kernel is relatively small, and using a building-block approach, it can be optimised for a wide variety of applications and configured to run across multiple processors in a loosely coupled way. VxWorks runs on a wide variety of processor chips and platforms, enhancing its appeal for developers that require heterogeneous processor environment. A wide range of development tools are available from Wind river in its Tornado-II development software tool kit. Still more are available from third parties, such as GNU

compilers and tools.

### **REDUCING COST WITH PROVEN ARCHITECTURE**

Sun reports that through higher levels of integration and by leveraging industry-standard low-cost and ceramic pin grid array packaging (370 pins), it has been able to significantly lower the cost of the UltraSPARC IIe. Beside this decrease in the initial cost, the overall lifetime system costs for an embedded application can be reduced through combining the processor, the memory controller, the PCI bus controller, the level-2 cache, and support for industry standard PCI peripherals and memory on a single chip. Also designed to lower overall system costs, the IIe is supported by design kits to form an end-to-end solution that works to ensure optimal processor performance and improve life cycle system reliability.

The 64-bit UltraSPARC architecture has been in commercial use for over four years. One of the objectives of the end-to-end solution approach by Sun is to provide a way to significantly reduce development time. Over the past four years, this optimised technology has been easily and seamlessly integrated into demanding datacom, Internet, telecom, and network environments, significantly reducing development time. The product manager for Force Computers, Jochen Saal said, "Sun's new UltraSPARC IIe embedded processor enables us to continue to deliver the 'perfect fit' solution for OEM customers who are looking for next-generation products of our successfully implemented VMEbus-based SPARC products to be deployed in industrial, C41 and telecoms applications."

### **CONCLUSION**

The UltraSPARC IIe was developed to meet the specific needs of embedded 64-bit high-end embedded computing. The processor is designed to deliver impressive throughput in a highly integrated package with the right balance of power consumption to facilitate compact, low cost system design. The combination of the features of the IIe processor with comprehensive support, development environment and software solutions results in more people being able to access this optimised technology to build advanced high-end embedded solutions and bring these solutions to market faster ■

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*Peter Palm is Group Marketing Manager for Sun Microsystems, responsible for Market Development in Europe. He has twenty years experience in embedded and network computing with Hewlett Packard, Intel, and Sun Microsystems. Recently he was chairman of the business team that delivered Sun's first CompactPCI motherboards. Peter is currently based in Camberley, UK to be near Telecom customers interested in building highly-available, open-standard systems based on Sun motherboards, Solaris, ChorusOS, and Java technologies. Peter holds a BS in Electrical Engineering from Tufts University, and Masters in Business Administration from Stanford University.*



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