Chapter 7 Sun Computer Architecture

7.1 Overview

One architecture: three instruction sets

Sun offers one powerful computer architecture with three instruction sets. The main components of Sun's computer architecture are the CPU, floating-point processor (FPP), memory management unit (MMU), and peripheral bus. (see Figure 7-1) Sun's open architecture approach extends to each component within the Sun product line.

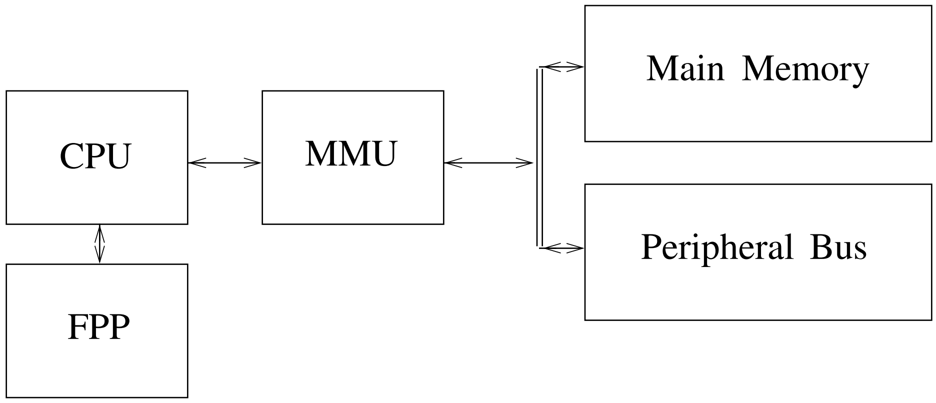

Figure 7-1. Sun Hardware Architecture

Sun's computer architecture allows virtual addressing by both software and direct memory access (DMA) devices. The FPP acts as a coprocessor and is closely coupled with the CPU. Figure 7-2 describes how Sun's family relates to CPU and architecture. For a detailed description of product family configurations refer to the *Sun Configuration Guide*.

Sun Family	CPU	Bus Architecture
Sun-2	680X0	Multibus, VME, SCSI
Sun-3	680X0	VME, SCSI
Sun-4	SPARC	VME, SCSI
Sun386*i*	80386	AT, SCSI

Figure 7-2. Sun Product Family

All Sun workstations have the same operating system, program development tools, compilers, libraries, windowing system, and other software. This means that applications developed for any Sun family (Sun-2™, Sun-3, Sun-4, and Sun386i) are easily ported to another family because the architectures are source-code compatible. Because SunOS is a converged version of 4.3/4.2BSD and System V.3, many applications written in C, FORTRAN, or Pascal on other UNIX systems are also source-code compatible.

To port a SunOS or other UNIX application to any Sun workstation, the basic procedure is to copy the source-code files to the machine and recompile it. Instances of incompatibility are usually related to the way the processor stores binary data. Based on the experience of software developers, the porting procedure generally takes a few days.

For applications that currently run on computers that do not use the UNIX operating system, you need to rewrite code to port the application to SunOS. If the application has not been written for SunOS, we recommend porting first to the SPARC based Sun-4 family.

7.2 CPU/MMU/FPP Overview

Sun offers three different instruction sets: Motorola 680X0, SPARC, and the Intel 80386. Each has its own floating-point coprocessor (FPP).

Sun-2, Sun-3, and Sun-4 systems share Sun's virtual memory architecture, which supports the demand-paging requirements of large application programs. It provides mapping for processes up to 256 megabytes and features exceptionally fast context switching, as well as a large number of translation entries. It also supports virtual input/output procedures as well as direct virtual memory access (DVMA™) from I/O devices.

All of Sun's floating-point solutions perform single- and double-precision, binary floating-point arithmetic according to the IEEE 754 standard.

7.2.1 Motorola 680X0

Used in Sun-2 and Sun-3

The Sun-3 series uses the powerful Motorola 68020 family single-chip microprocessor. The Sun-2 series uses the older Motorola MC68010 CPU, which is binary compatible with the MC68020. Thus, executable programs on the Sun-2 family run unchanged on the Sun-3. Vendors often distribute Sun-2 binaries (MC68010) instead of both executable versions.

The Sun-3 family includes the Motorola 68881 floating-point coprocessor, which allows overlapped execution of 68020 and 68881 instructions.

7.2.2 SPARC (Scalable Processor ARChitecture)

Used in Sun-4

The SPARC CPU is a Reduced Instruction Set Computer (RISC) designed by Sun Microsystems and is licensed to other computer manufacturers. It is composed of an Integer Unit (IU) that performs basic processing and a Floating-Point Unit (FPU) to perform floating-point calculations.

The Sun-4 family incorporates SPARC and is designed for high performance. The Sun-4 systems achieve this performance by utilizing the latest ideas in computer architecture, gate-array technology, memory, cache technology, and compiler technology. The Sun-4 family of workstations and servers addresses application areas that previously required special-purpose computer architectures or large, expensive mainframe systems.

For porting information pertinent to SPARC, refer to *Porting Software to SPARC Systems.*

7.2.3 Intel 80386

Used in Sun386i

The Sun386*i* CPU is the Intel 80386 microprocessor, running at a clock frequency of either 20 or 25 megahertz, depending on the model. The Memory Management Unit (MMU) is on the 80386 CPU itself, rather than in a separate component. As a result, virtual to physical address translation takes place within the CPU. The CPU provides protection, sharing, and memory allocation for multiple processes.

The 80386 has a virtual 8086 mode, so it can run multiple PC processes simultaneously in virtual mode while the operating system runs in protected mode. This capability allows multiple MS-DOS windows to operate on the Sun386*i* concurrently with UNIX.

For floating-point processing, the Sun386*i* architecture uses the Intel 80387 processor, running synchronously with the 80386. DOS applications can use the floating-point processor to execute code written for Intel 8087 or 80287 processors.

The 80386 also is binary compatible with 8086 and 80286 processors, which are earlier processors in the same Intel family.

For porting information pertinent to the 80386, refer to the *Sun386i Developer's Guide*.

7.2.4 Floating Point Accelerator (FPA)

Floating-point hardware for Sun-3

The Floating Point Accelerator (FPA) is a single VME-card, high-performance option for Sun-3 systems. The FPA increases floating-point performance over the floating-point coprocessor by an average factor of four.

For optimal performance, the FPA is directly coupled to the CPU's VME P2-Bus. CPU processing and FPA operations automatically overlap. A two-stage pipeline and dual-ported registers further improve simultaneous operation of the CPU and FPA.

The FPA is software transparent. That is, binary application programs are transportable between machines with or without the FPA option. To achieve the highest performance, however, applications written for workstations without the FPA option should be recompiled when used with the FPA.

7.3 Byte Ordering in a Heterogeneous Environment

Use XDR, byte swapping, bit flipping for byte ordering problems

Binary data is stored on the Sun386*i* workstation the same as it is on some 32-bit processors (such as DEC VAX) but different from the way it is on others (such as Sun MC680X0 and SPARC workstations). Although this arrangement has no impact on most programs, ''byte swapping'' is potentially a problem if processors with different architectures try to interpret the same binary data. The following are general areas where byte swap problems can exist:

- Passing binary data over the network. Use Sun's External Data Representation (XDR) format or another standard network format to avoid problems.
- Porting raster graphics images between architectures. SunView, Pixrect, the icon editor, and other Sun graphics routines handle byte order appropriately for the architecture, so programs containing these routines can be ported without change. If your application uses graphic images that are in binary form and was not produced by Sun routines, convert them.
- Performing conversions from character to integer or from integer to integer between architectures. Again, use XDR.
- Reading binary data created on an architecture with a different byte order. Before reading the data, you need to filter it to correct the byte order.
- Latent bugs. For example, using *strlen* and *malloc* system calls improperly can cause problems that do not occur on other architectures.

7.4 Bus Architectures

Sun supports VMEbus, Multibus I, and AT bus architectures. The sections below present an overview.

7.4.1 VMEbus

Sun-3 and Sun-4 use 32-bit VMEbus revision B

The Sun-3 and Sun-4 families use the industry-leading 32-bit VMEbus revision B, which is compatible with a large number of board-level components. Sun's VMEbus interface allows 16-, 24-, and full 32-bit device addressing and 8-, 16-, and 32-bit data access. For more detailed information, please refer to Sun's *User's Guide to the Sun-3/100 VMEbus*.

Sun conforms to the triple-height, full-depth Eurocard/VMEbus board format in most of its models. Single- and double-size Eurocard boards may be accommodated with Sun VMEbus adapters.

The Sun-3 Eurocard board set implements the Sun-3 architecture on a double-height VMEbus standard, allowing OEMs and system integrators to incorporate Sun's environment into their products.

7.4.2 Multibus

Sun-2 uses Multibus I standard

Most of the older Sun-2 family supports the Multibus I standard. Users wishing to port Multibus devices to either Sun-3 or Sun-4 systems may use the Sun VME - Multibus Adapter board.

7.4.3 VME to Multibus Adapter

Multibus boards can be plugged into the Sun VMEbus backplane using the adapter

Sun's VME to Multibus Adapter board allows Multibus boards to plug into Sun's VMEbus backplane. The Multibus card physically installs in the VME to Multibus Adapter and translates Multibus protocols into those of the VMEbus.

For more information, please refer to the *User's Manual for the Sun VME - Multibus Adapter Board*.

7.4.4 AT Bus

Sun386i uses AT bus

The Sun386*i* peripheral expansion bus is the industry-standard AT bus. An interface converts CPU and Direct Memory Access (DMA) signals from the system bus to AT bus signals and serves as a buffer between the 32-bit high-speed system bus and the 16-bit AT bus.

The Sun386*i* has three slots for IBM PC/AT-compatible add-on cards and one slot for an XT-compatible card. These two types of cards differ in the size of the data path used for access (XT cards are 8-bit; AT cards are 16-bit) and in the connectors that attach to the bus. (AT cards have an additional connector.)

Peripherals on the AT bus can be controlled by DOS drivers from a Sun386*i* DOS window, or they can be controlled by SunOS drivers. For further information, please refer to the *Sun386i Porting Guide*.

The AT bus speed is one-fourth the processor speed, or 6.25 MHz on the Sun386*i*/250 model and 5 MHz on the Sun386*i*/150 model. Nine interrupt channels and five direct memory access DMA channels are available for AT bus cards.

7.4.5 SCSI

High-level interface to disk, tape, and other devices

The SCSI (Small Computer Systems Interface) provides an industry-standard, high-level interface that works with disks as well as tapes and other devices. Devices may be daisy-chained to the SCSI bus through the external ports of the system box or the peripheral box.

Sun currently uses the SCSI bus for disk and tape units. Customers are discouraged from porting devices to Sun's SCSI because it is an undocumented and unsupported external interface. Sun Consulting is the sole resource for customers determined to port to the SCSI.

7.5 UNIX Device Drivers

UNIX can extend its peripheral control to new devices attached to the peripheral bus. The code that controls a device and interfaces to the UNIX operating system is termed a *device driver*.

7.5.1 Porting Device Drivers

Device drivers can be designed to be portable across multiple instruction sets

Because device drivers recognize hardware and the architecture it resides in, they are inherently more difficult to port between UNIX systems than an application program. Within Sun's single architecture, however, a device driver can be designed to be portable even between multiple instruction set computers.

Sun's *Writing Device Drivers for the Sun Workstation* is an excellent programmer's guide for designing and writing device drivers across the Sun family of workstations. Refer to this manual for more detailed information.

The Sun386*i* implements loadable modules that allow ease of installation and device driver development. For more detailed information, refer to the loadable driver chapters in *Writing Device Drivers for the Sun Workstation*.

7.6 Sun Memory Cache

High-speed memory

The Sun-3/200 and Sun-4/200 series systems incorporate a high-speed memory called a cache, which contains copies of "frequently requested" data from main memory. Device driver and application developers interested in optimal performance on systems with cache need to understand porting issues to these machines. For more detailed information refer to the document, *The Sun Cache*.

7.7 Future Directions

As new technologies and standards evolve, Sun will incorporate them to facilitate the development of third-party products and portable applications. Future Sun products will further utilize the advances in SPARC technology.