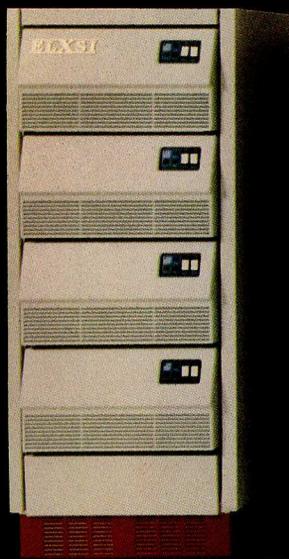
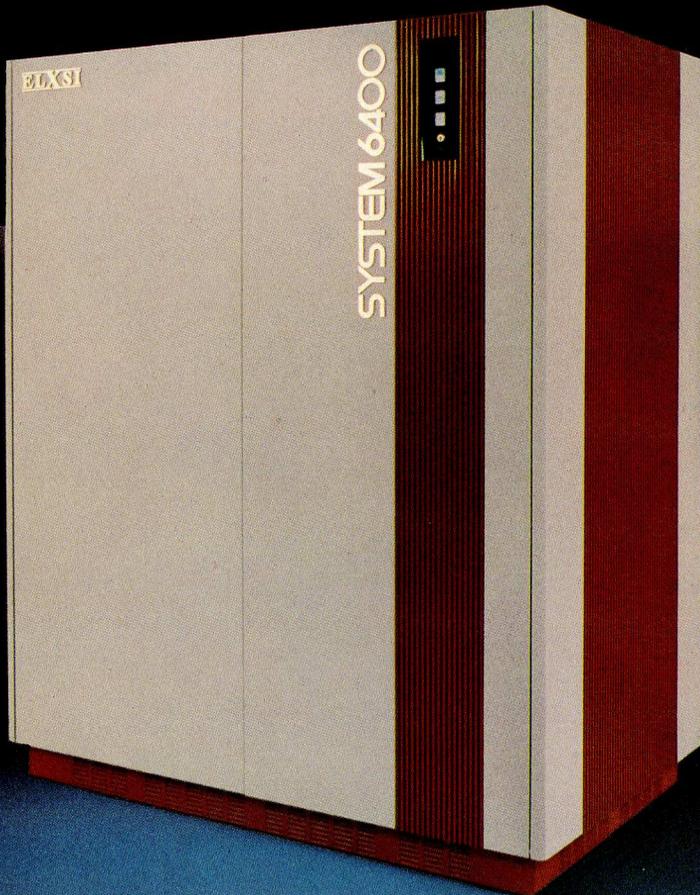


ELXSI

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System 6400

**ELXSI System 6400.
Changing the realm of the possible
in computing technology.**



A breakthrough in computer systems architecture

Now there's a computer system so advanced, it literally changes the realm of the possible: the 64-bit multiprocessor, ELXSI System 6400.

The culmination of a five year design and development effort, the System 6400 offers general purpose computing capabilities never before available at such an economical price. That's because the system's totally new bus-oriented architecture has moved beyond the limiting design concepts of the past 20 years.

Widest range of performance

Through the use of modular, tightly coupled processing units, ELXSI offers an unparalleled range of performance. The System 6400 is easily expanded from 1 to 10 CPUs without modification to software, user environment or existing hardware. With minimal disruption, a new CPU, I/O Processor or memory system is simply added to the system configuration, making expansion easy in any direction. A single processor configuration delivers 6 Million Whetstone Instructions per Second (MIPS). A multiple CPU system delivers up to 60 MIPS. Therefore, ELXSI spans a performance range from the superminicomputer to the largest mainframes on the market. Moreover, in tests of CPU performance, the System 6400 Multi-Processing (MP) ratio shows a linear increase in processing power as CPUs are added, making the system very well-suited to multi-processing and parallel processing applications.

Fastest system bus in existence

The key to ELXSI's high performance is its extremely fast main system bus, GIGABUS.[™] A synchronous, 64-bit wide channel, GIGABUS provides a gross system bandwidth of 320 megabytes per second. Since all major system components attach to this bus, ELXSI can offer a true multiple processor environment: one

where multiples of a single low cost CPU can be added easily, and where a single operating system can be used throughout—even for applications with vastly different processing workloads.

Largest real memory space

To open up new memory intensive applications, ELXSI offers up to 192 million bytes of main MOS memory—the largest available on any system today.

More productive user environment

To take advantage of the system's hardware architecture, the System 6400 incorporates two operating systems uniquely designed for a multi-user, multi-process environment — AT&T's UNIX[™] System V and EMBOS[™], the ELXSI Message-Based Operating System. These systems are implemented with advanced operating system technology that allows them to run concurrently on a single System 6400.

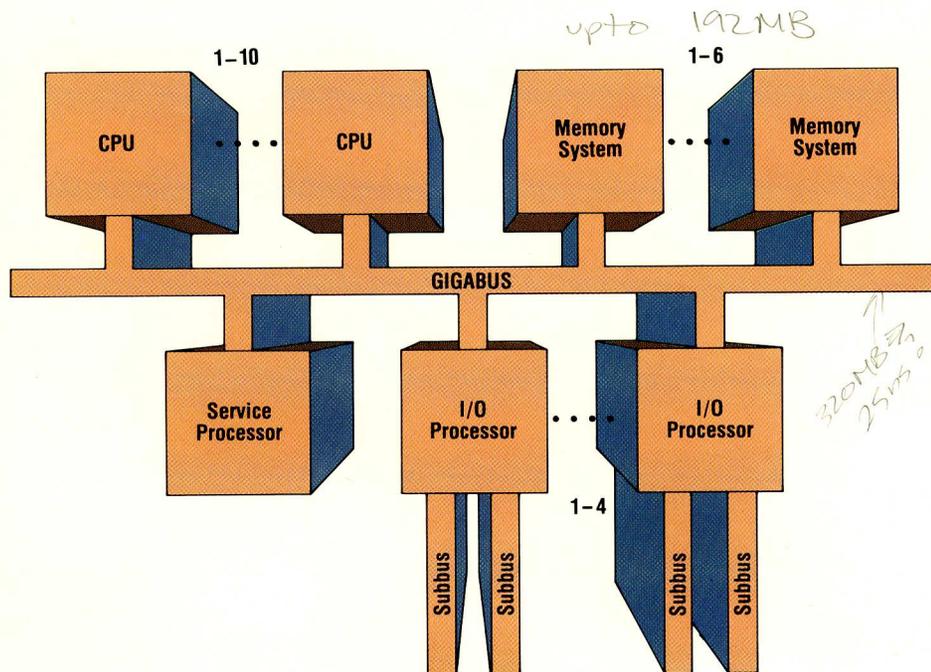
Compact systems packaging

ELXSI packs more computational power into less space than any other commercially available system. Through the use of ECL and high-density LSI components, a five CPU system fits neatly into a single air-cooled cabinet, 32" deep by 59" wide. This single configuration provides approximately 30 MIPS of computational power while requiring only 22 KVA of electrical power. To expand to a ten processor system, a second identical cabinet is added.

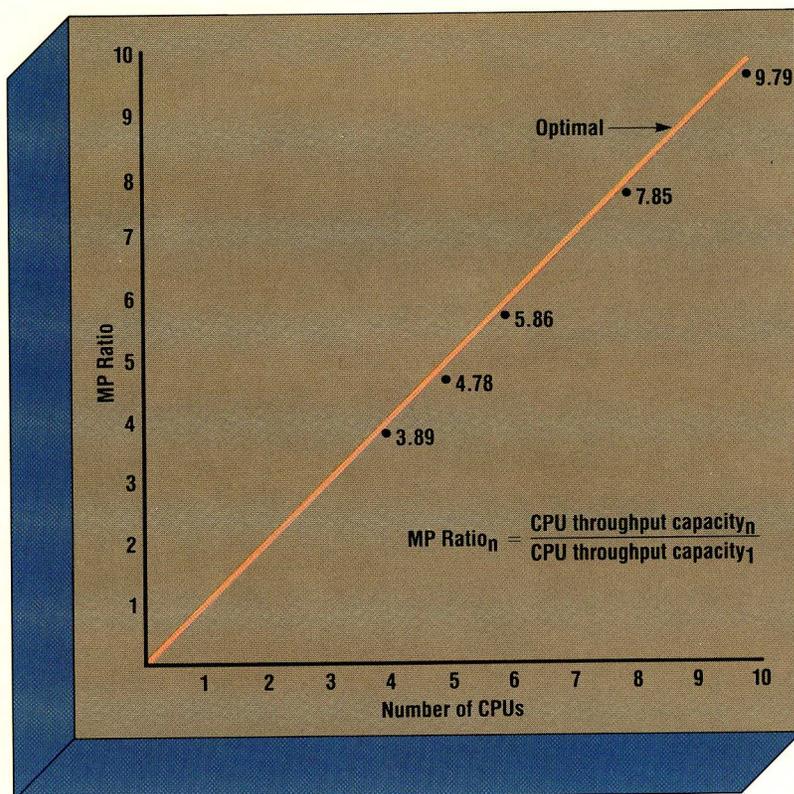
Best price/performance ratio

Because of its multiple CPU architecture, the System 6400 competes with a wide range of systems. Throughout this range, ELXSI is setting a new price/performance standard. That cost factor—coupled with ELXSI's ease of expansion, user orientation, and low cost of ownership—makes it clearly the best value for scientific, engineering and commercial applications.

DAVIS



The ELXSI System 6400



Linear Performance Gains With Multiple CPUs

A new world of application opportunities



The ELXSI system is designed to handle a variety of processing types efficiently: from time-sharing

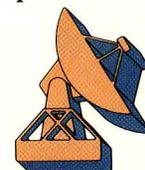
to real-time and batch, and from large number-crunching

tasks to transaction processing. ELXSI's multiple CPU architecture is ideal for jobs such as large sorts, 3-D analysis of seismic data, and graphics processing. Yet, because of its easy-to-use operating environment it handles small, one-shot analysis tasks and fast, interactive program development as readily as large compute-bound jobs. Powerful floating point, integer and decimal arithmetic instructions enable ELXSI to process both engineering and commercial applications. To further accommodate different application types, ELXSI provides a variety of programming languages, including Pascal, the C language, high-level COBOL-74, FORTRAN 77 and MAINSAIL.



ELXSI also supports a wide variety of third party software packages for specific computer applications. Tasks for which the ELXSI System 6400 is particularly well-suited include:

- Scientific/engineering.
- Seismic data processing and reservoir simulation.
- Simulation.
- Real-time processing.
- Parallel processing.
- CAE/CAD/CAM.
- Interactive color graphics.
- Data base management.



Ignore the usual processing and bandwidth restrictions

ELXSI's unique internal structure makes processing and bandwidth restrictions a thing of the past. The backbone of the ELXSI system is the GIGABUS, a high-speed, synchronous, 64-bit system bus with an effective bandwidth of 320 megabytes per second. The GIGABUS allows the attachment of multiple identical modules, providing redundant resources in any given ELXSI system. This capability allows the ELXSI system to perform in high uptime applications.

Internal CPU structures that optimize multi-processing

Each ELXSI CPU consists of a high performance ECL processor, packaged on three boards. From 1 to 10 central processors can be included in a System 6400, providing calculation speeds ranging from 6 to 60 Whetstone MIPS.

Each CPU includes many features aimed at maximizing throughput in a multi-processing, message-based environment:

- 64-bit wide data paths.
- 50 ns cycle time.
- 16-Kbyte, 2-way set-associative cache (100 ns access time).
- 16 sets of 2-way set-associative Translation Look-aside Buffers.
- 16 sets of 64-bit general purpose registers.

Multiple "contexts" allow exceptionally high-speed context switching (typically 10 μ s), while operating in a multi-stream, multi-programming environment.

Low-level kernel functions implemented in firmware

Each CPU includes Messenger and Scheduler functions as firmware. This section of the CPU is responsible for managing, synchronizing and scheduling all interprocess communication and most context switching. Implementing these functions in firmware improves performance and reduces operating system complexity.

Variable length instructions for efficient memory use

The instruction set includes variable length instructions designed to facilitate the use of high-level programming languages. The instructions offer a high degree of code compaction and a complete set of primitives, selected on the basis of actual program behavior.

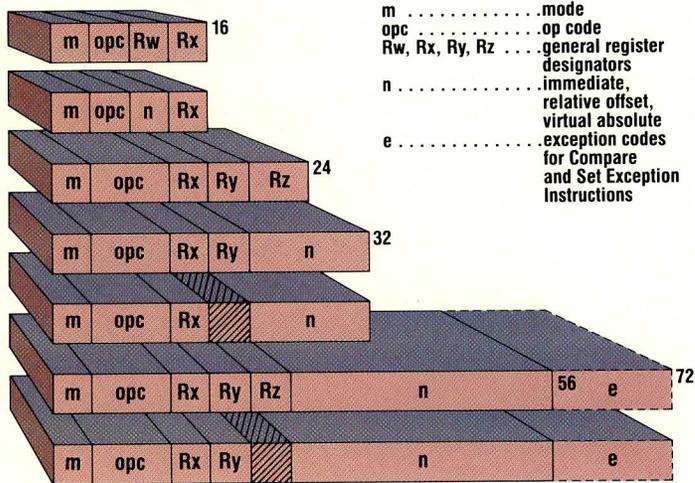
The ELXSI instruction set is designed to allow easy code generation and to reduce the cost and complexity of future high speed non-microcoded implementations.

An unusual feature of the instruction set is the absence of "privileged" instructions or addressing modes. Data movement from one protection domain to another is handled strictly through the message system; that includes validating the right to use a particular message path.

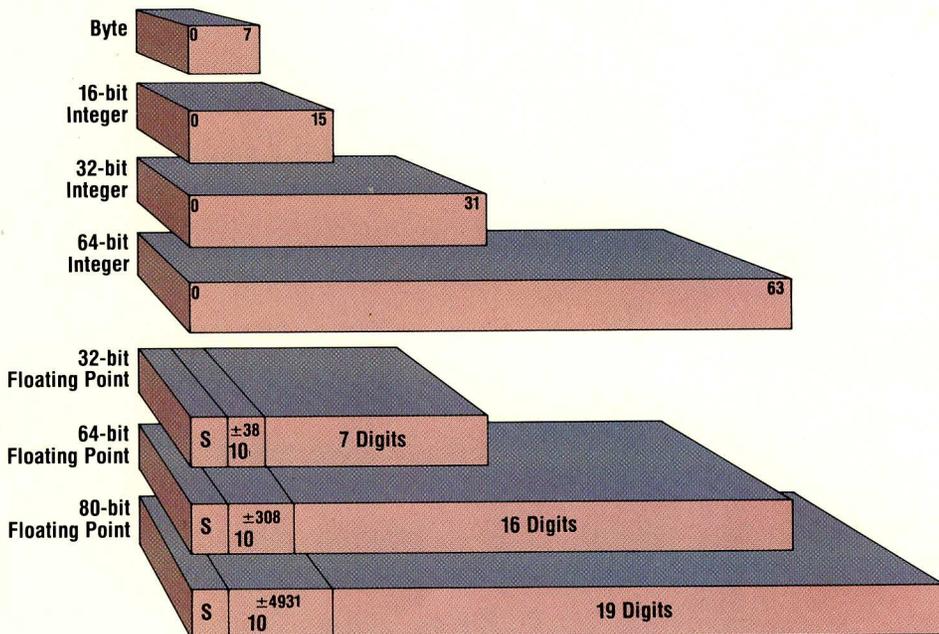
Variable length data formats for efficient processing

ELXSI allows variable length data to be manipulated in either integer or floating point format.

- Fixed point Operands: Integer arithmetic may be performed on 16-, 32-, or 64-bit signed integers. Integers are represented in two's complement form.
- Floating point Operands: Floating point arithmetic may be performed on 32-, 64-, or 80-bit data according to the proposed IEEE floating point standard.
- ASCII character string and arithmetic. The system 6400 is byte addressable.



ELXSI Instruction Formats



ELXSI Data Formats

Performance Accelerator for arithmetic-intensive operations

A Performance Accelerator (PA) is attached to each CPU for higher processing speeds. Each PA communicates directly with the CPU under its control. The PA offers these enhancements:

- 32-, 64-, and 80-bit floating point arithmetic including four rounding modes, denormalized numbers with gradual underflow, and unbiased rounding via the sticky bit.
- Integer multiply and divide.
- Single- and double-precision square root.
- ASCII-to-Binary conversion.
- ASCII (or display format) arithmetic and conversion.

Integrated array processing

The System 6400 can include a 32-bit floating point array processor designed for a variety of applications. Extremely fast processing times, very large and flexible memories, and ease of user programming make the processor well-suited for medical, seismic, scientific and signal processing applications.

Program and data memories are provided that are compatible with programs written for today's array processor applications. For example, large seismic and image processing applications can be completely contained within the data memory. As a result, I/O transactions can be minimized and the resulting overall throughput can be maximized.

Forget about system hardware limitations

To solve complex scientific, commercial and engineering problems efficiently, ELXSI offers virtually unlimited memory and I/O capacities.

**192 million bytes of real memory;
4 billion bytes of virtual memory**

The combination of very large real and virtual memory per user process enables ELXSI to handle large tasks efficiently. It also simplifies the programming task by eliminating the need for complicated overlays or program segmentation.

Main memory in the System 6400 can range from 8 to 192 megabytes. Important memory features include:

- Internal Memory Array Interleaving. Helps increase access speed.
- Error Detection/Correction. Single- and double-bit error detection; single-bit correction; detection of most multiple-bit errors.
- Memory Management. Virtual memory management enhanced by Cache and Translation Look-aside Buffers.
- 32-bit addressing provides 4 billion bytes of virtual space per user process.

High performance I/O processing

The heart of the I/O Section consists of a dedicated I/O Processor (IOP) capable of driving two 8 megabytes per second sub-channels. Multiple IOPs can be configured in a single system. Key performance features include:

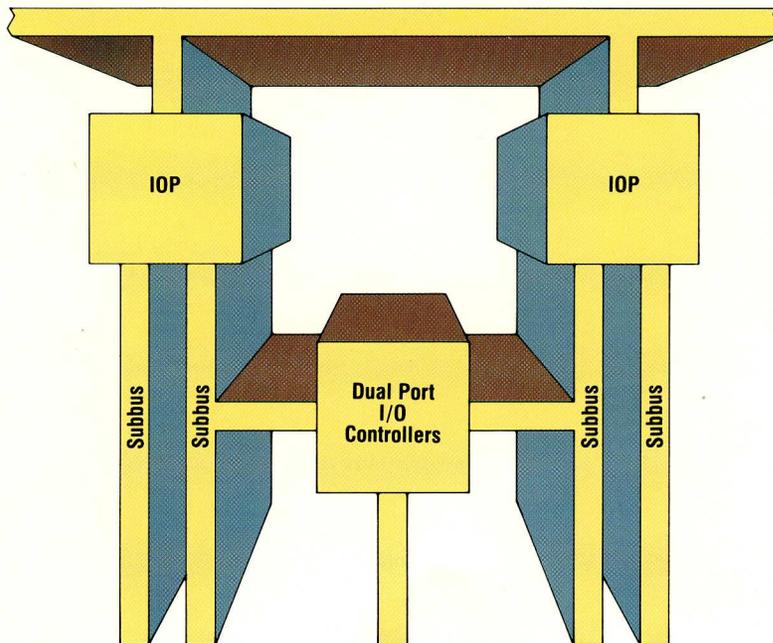
- 50 ns processor cycle time.
- Microcoded control of all I/O.
- Each subbus has 16 ports with subbus length up to 160 feet while maintaining 8 megabytes per second speeds.
- Device controllers are dual-ported and buffered.

ELXSI supports a variety of peripherals, including:

- Disk. Either fixed or removable. Each controller supports from 1 to 8 drives of any mix, at 300 or 474 megabytes per drive.
- Magnetic Tape/Line Printer. One controller supports up to 8 tape drives, 6250/1600 bpi at 125 ips, or 1600/800 bpi at 125 ips, plus 2 high-speed line printers.
- Communications Multiplexor. Asynchronous support for 32 full-duplex lines at 110 to 19,200 bps each, utilizing RS232 or RS422.
- Network Systems Corporation HYPERchannel.™
- DR11-compatible interface.
- Ethernet,™ XNS,™ TCP/IP.
- X.25 public packet networking.
- 2780/3780 HASP.
- 3770 (IBM SNA RJE).



High-density packaging of ELXSI Processor and Service Processor boards, using ECL/LSI Components.



ELXSI I/O Processor (IOP)

Service Processor to improve system maintainability

ELXSI includes a dedicated Service Processor to provide performance and diagnostic monitoring of the system. This helps reduce the impact of system downtime caused by hardware faults, as well as the time required to locate and repair malfunctions when they do occur.

The Service Processor is also used to download system microcode from disk at startup time, and to configure the system based on parameter files.

Designed for high system availability

The ELXSI GIGABUS allows for the attachment of multiple identical modules. These modules can be configured in various quantities to provide precisely the level of performance and availability that each user application requires. Modules can be field installed with minimal downtime. Failed units can be deallocated from the system configuration, allowing processing to continue while waiting for remedial maintenance.

Take advantage of advanced operating system technology

ELXSI offers two powerful operating systems which can run separately or concurrently on a single System 6400. ELXSI's version of UNIX is a true port of AT&T's UNIX System V and provides an industry standard operating system environment. EMBOS, ELXSI's proprietary operating system, features an easy-to-use operating system environment with advanced file system and database management capabilities. Both operating systems are implemented with the ELXSI System Foundation which provides load balancing by distributing processes across multiple CPUs and performs low-level services.

Distributed system architecture for efficient multi-processing

The ELXSI system environment can be thought of as a collection of user and system processes, communicating with each other and various hardware modules according to a standard message-passing protocol. By implementing the system as a group of separately communicating processes, operating system tasks can be performed in parallel in multi-processor systems, thereby increasing throughput and avoiding potential bottlenecks. In ELXSI systems, user processes as well as the operating system are automatically distributed across multiple CPUs. The automatic migration system means that CPUs can be added without necessitating any change to user software.

The flexibility of message-based designs

Distribution of processing across multiple CPUs relies on the ELXSI message system which is implemented in hardware and microcode to maintain high performance and security. This message system provides:

- A natural high performance interprocess communication and scheduling method for supporting processing distribution.

- A set of CPU instructions for sending and receiving messages which can be accessed by any process.
- Firewall Protection through numerous efficient security mechanisms that protect user processes, system processes, and memory from unauthorized access. This means that users can add or modify any process without changing any other.

Powerful and efficient memory management

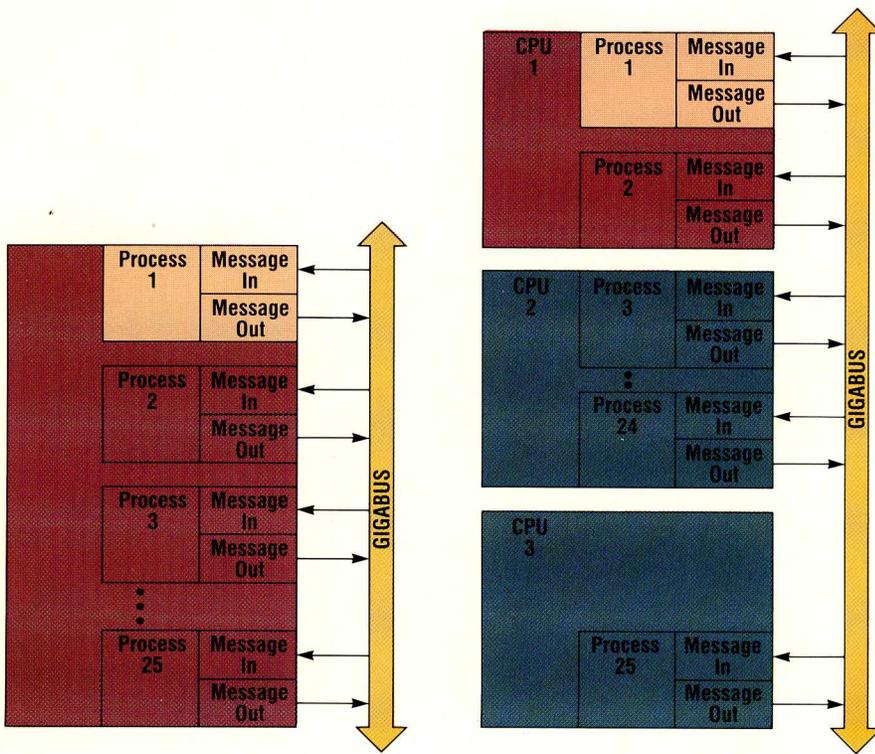
ELXSI operating systems support high performance virtual memory management with the following features:

- Hardware and microcode integration for high speed access to memory and efficient processing of page faults.
- Four-Gbyte address space per process for efficient handling of extremely large programs.
- Copy-on-write feature which eliminates unnecessary data movement by sharing pages until a write occurs.

Hierarchical scheduler for high performance

ELXSI's hierarchical scheduler plays a key role in ensuring a linear increase in performance as CPUs are added to the System 6400. Scheduling occurs at multiple levels with low level functions executed by the microcode and more complex operations done by progressively higher levels of the system.

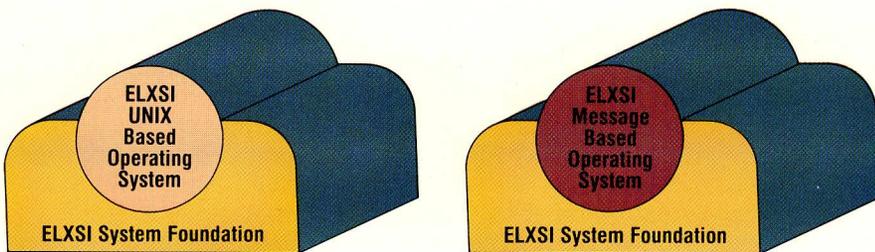
This scheduling hierarchy allows frequently executed operations such as context switching to take place at the microcode level for maximum efficiency (10 microsecond switching) while performing global resource allocation and CPU load balancing at a higher level of the system where appropriate information is available.



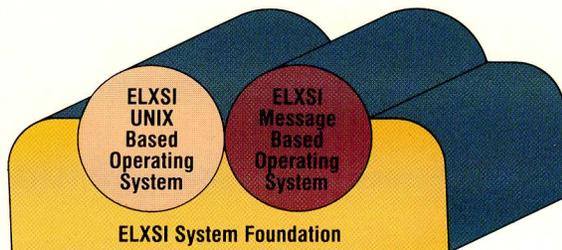
One CPU System

Multiple-CPU System

Automatic Process Migration Across Multiple CPUs



Separate Operation



Concurrent Operation

Separate or Concurrent Operating Systems

Standard UNIX System V with Berkeley extensions

ELXSI offers a true port of AT&T's UNIX System V with Berkeley extensions, including networking support. This operating system provides all of the advantages associated with running an industry standard operating system, including the reliability of time-tested code supported by AT&T.

Portability features protect investments in program development and ensure vendor independence for software products. Moreover, the widespread popularity of the UNIX system has resulted in a large number of computer users and programmers who are experienced with UNIX software.

With an operating speed that can range from supermini to giant mainframe depending on hardware configuration, ELXSI's UNIX-based system supports these important features:

- C and Bourne shells.
- Vi, ctags, make, and sccs for efficient program development.
- Nroff, troff, pic, eqn, and tbl for document development.
- Terminfo and curses for terminal management.
- Job control with shell layers.
- Full TCP/IP support over Ethernet.
- All other capabilities of the standard System V environment and many Berkeley capabilities.
- Ability to coexist and communicate with EMBOS.
- Highly optimizing C and FORTRAN compilers.

EMBOS for high performance and ease of use

EMBOS combines technologically advanced performance features with a friendly, flexible user environment. EMBOS features include:

- Parallel processing capability at the subroutine level.
- Mapped files for direct access to disk files with no operating system intervention.
- A relational data base management system fully integrated with the EMBOS file system.
- Extensive library of user-callable subroutines.
- A powerful command interpreter with extensive on-line Help.
- A standard terminal interface.
- A flexible batch processing facility.

Parallel processing under EMBOS

EMBOS goes beyond multiprocessing, offering the most advanced parallel processing capability commercially available. With lengthy and frequently used processes partitioned over multiple CPUs, the system can dramatically decrease the time of execution for many computationally intensive tasks.

Queuing and parameter isolation controls are available through the message system and through atomic locks, spin locks, and binary and counting semaphores. A special runtime library of EMBOS routines facilitates parallel processing at the subroutine level.

Powerful EMBOS command shell

EMBOS commands are designed to be simple to learn and easy to remember, with each

command performing a single task. The shell provides extensive facilities for combining these single-function commands to perform complex tasks which otherwise would require the use of a programming language or complicated subsystem. Pipes allow the output of one command to be used as the input for another. Shell files allow long sequences of commands to be combined with looping, conditional execution, and variables. An extensive automated parameter processing facility gives shell programs the same user interface as other commands.

EMBOS delivers on-line help

EMBOS contains an extensive on-line Help facility with detailed information about each command and library subroutine on the system. Items can be retrieved by name if the name is known; otherwise the Help facility will search its detailed keyword and phrase index, and return the names and brief descriptions of likely candidates.

Users and local administrators can add their own entries to the Help system easily.

The on-line Help facility is complemented by larger on-line documents and comprehensive user manuals.

EMBOS features a standard terminal interface

EMBOS handles all interactive sessions through a Terminal Interface Program (TIP). Important TIP benefits are:

- Basic text editing capabilities including insertion, deletion, replacement, and copying of text are integrated into the TIP.
- Uniform access to terminals, other devices and files.
- Convenient support for writing terminal-independent programs using the Termcap data base.

Flexible EMBOS batch facility

The EMBOS batch facility allows a high degree of control over batch processing and uses the same command language as interactive sessions. It allows multiple batch queues with a unique set of parameters governing each. Users can set job parameters within limits that are definable on an individual basis by the system administrator. Job control parameters include priority within a queue, execution priority, maximum job CPU time, CPUs on which the job may run, and the time and date to start the job. Operators can cancel or hold jobs in a queue and abort any job, while users can abort only their own jobs.

EMBOS libraries speed program development

EMBOS is supplied with many comprehensive libraries of user-callable subroutines which can greatly decrease the writing and debugging time needed for program development. Subroutines are available for file manipulation, string handling, process management, parameter processing, pattern matching, error reporting, shell variable access, symbol table management, data formatting and conversion, time and date manipulation and many other common programming tasks. Each library is described extensively in the user documentation, and each routine has an entry in the Help facility describing its behavior in detail.

The adaptability of ELXSI application development tools

ELXSI supports application development with powerful data base systems and those high-level programming languages most often used for scientific, engineering and commercial applications.

Data Base Management

Data Management Systems under ELXSI's version of UNIX and EMBOS are fully relational data base systems based on INGRES. Specific data management subsystems include a Query Facility (interactive, programmatic, and compiled), Report Writer, Application By Forms, Query By Forms, Report By Forms, Graph By Forms, and Visual Forms Editor.

Under EMBOS, the data base management system is fully integrated into the file system and contains enhancements to improve performance, take advantage of multiple CPUs, and incorporate new features or subsystems. A number of EMBOS data base management system features are available through the file system interface. This means that standard programming language read and write statements can be used to access the data base and offers the benefits of concurrency control, "crash" recovery, and security mechanisms. The EMBOS data base management system also provides the following features:

- Makes data base files simultaneously available through file system and data base interfaces, eliminating the need for import and export of data.
- Allows easy portability of existing applications.
- Permits high- and low-level access in a single application for enhanced performance.

Pascal

The Pascal programming language is a block structured language that has proven highly effective in modern program development. ELXSI Pascal allows modules to be written independently and then brought

together into an integrated system. Pascal generates highly optimized code and was used to write EMBOS and several of the compilers and system utilities.

FORTRAN 77

ELXSI FORTRAN conforms to the full language specifications of ANSI FORTRAN, X3.9-1978. The compiler is globally optimizing. Included in ELXSI's optimizations are global common sub-expression elimination, extensive array subscript optimization, register allocations (especially for loops), global register allocation, and in-line expansion of subroutines and functions. The mapped file structure provides for uniquely efficient handling of large FORTRAN arrays from disk. Up to 2 billion bytes can be mapped into a user's virtual space. Programs or data files alike can be mapped into and made an integral part of the virtual space.

COBOL-74

ELXSI's high performance COBOL conforms to the ANSI COBOL X3.23-1974 and FIPS PUB 21-1 (HIGH) language standards. Performance is enhanced through hardware implementation of ASCII arithmetic, format conversion and string manipulation.

C LANGUAGE

C is a general purpose language developed as the primary language of UNIX. Its main features are economy of expression, powerful control and data structures, and a rich set of operators and data types.

MAINSAIL™

MAINSAIL by XIDAK is a modern high-level general purpose programming language designed to provide true source-level portability across a broad range of computers and operating systems.

**System Specifications:
ELXSI System 6400**

General

Multiple CPU 1-10 CPUs, 1-4 IOPs
 Bus-Oriented
 Message-Based
 Operating System

System Bus (GIGABUS)

Cycle Time 25 nanoseconds
 Width 64 data bits (110 bits total)
 Transfer Rate 320 Mbytes per second
 Error Checks Full Internal Parity

Central Processing Unit (CPU)

Type Microprogrammed General Purpose
 Digital Computer
 Logic LSI/ECL
 Word Length 64 bits (byte addressable)
 Cycle Time 50 nanoseconds
 Registers 16 sets of general purpose and internal registers
 Cache 16-Kbyte, 2-way set associative, 32-byte blocks
 100 nanoseconds access
 16 sets of Translation Look-aside Buffers (TLB)
 Address Space 4 Gbytes
 Floating Point IEEE Proposed Standard, 32-, 64-, 80-Bit

Memory System

Type 64-Kbit MOS with error detection/correction
 Minimum Size 8 Mbytes
 Maximum Size 192 Mbytes
 Cycle Time 400 nanoseconds (128-bit read, 64-bit write)

I/O Processor

Type Microprogrammed Digital Computer
 Logic LSI/ECL
 Word Length 64 bits
 Cycle Time 50 nanoseconds
 I/O Rate Two 8-Mbyte per second subbusses

Service Processor

Full Remote support capability

Peripherals

Disk 300 and 474 Mbyte drives
 Mag Tape 6250/1600 and 1600/800 bpi at 125 ips
 Printers 600, 1200 and 1800 lines per minute

Software

Operating Systems EMBOS — ELXSI Message-Based Operating System
 ELXSI UNIX — a true port of AT&T UNIX System V
 Languages Pascal, FORTRAN 77, COBOL-74, MAINSAIL
 DBMS Relational Model — INGRES

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 HYPERchannel is a trademark of Network Systems Corporation.
 MAINSAIL is a trademark of XIDAK, Inc.
 UNIX is a trademark of Bell Laboratories.

ELXSI

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