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ThinServer Technology Overview

Executive Summary

Fueled by recent innovations and web technologies, networks are undergoing major changes in order to provide content that drive business and improve competitiveness. By providing non-PC devices, such as printers, scanners, hard disks, video cameras, in-house control systems, and manufacturing equipment, with the intelligence to act as an independent server on the network, businesses can increase their productivity by enabling shared access to these devices. Similar to the trends of thin client network computers, a new breed of thin servers is evolving that provides affordable and seamless connection of any device directly to networks, independent of file server resources.

Developed specifically to provide plug-and-play network connectivity for non-PC devices, Axis' ThinServer™ Technology provides industry-leading capabilities in a robust and miniaturized self-contained design. It combines "thin" embedded server software, web-based management and 32-bit RISC network hardware, optimized in order to deliver superior price/performance, ease of use and usability compared to general purpose servers. And because it provides an open, non-proprietary and compatible interface to the network, existing LAN infrastructures are leveraged, simplifying system integration and use – ultimately providing access to everything. From mass storage to toasters.

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Rev 1.4, 970513

Introduction

The distinction between networks and peripheral devices is fading. No matter where users are located, having quick and easy access to non-PC devices can give businesses a clear competitive advantage. Internet technologies play a major role in driving this change and industry visionaries predict that the role of contemporary peripheral devices – printers, storage devices, scanners, etc. – will expand to include industrial equipment and household appliances. However, any networked device must have embedded intelligence, perform efficiently and reliably, and be affordable.

Although the deployment of non-PC devices is an essential part of Internet growth, many businesses are uncertain regarding connectivity within this evolving infrastructure. What's needed is a strategy that is cost-effective, interoperable across dissimilar network environments, secure and manageable. It must also protect current investments and support future networking technologies. And to fully leverage the potential of these devices, this strategy must give end users access to everything – no matter where they are located.

To successfully execute its vision, Axis consistently applies four essential principles:

- Connect all peripheral devices and other appliances to the network for true access to everything.
- Provide access to network resources where users work, not just where PCs and servers are located.
- Develop "smart" peripheral connectivity devices that are uniquely addressable, server-independent, compatible with standards and existing network operating systems, and performance leaders.
- Leverage the network itself to install and manage all connected peripheral devices.

Technology Overview

Axis' ThinServer Technology is a comprehensive approach to enable non-PC devices to be effectively used on networks. It combines embedded server software, web-based management and optimized hardware. Collectively, ThinServer Technology is designed to provide cost-effective and performance leading network capabilities to any device.

The ThinServer Technology fits onto a wide range of **applications**:

- **Office peripherals** – such as printers, scanners, CD-ROM drives, and hard drives – can be connected and shared where needed, reducing file server overhead and network traffic.
- **Industrial equipment** – such as surveillance cameras and building controls – can replace traditional equipment in favor of open network standards, such as using the Web.
- **Consumer products** – such as video players, home security systems and heating – can be controlled from anywhere.
- **Networking hardware** – such as hubs and routers – can be managed using the web interface.

The **benefits** of this technology are significant in delivering more efficient processes:

- Increases the value of the network by providing shared availability of resources and content.
- Reduces cost and increases performance compared to traditional file server technology.
- Relieves file servers and minimizes network traffic as devices communicate directly with clients.
- Enhances device functionality and usability.

Using state-of-the-art technology, ThinServer Technology **features**:

- Concurrently running thin implementations of Windows NT, NetWare, UNIX, OS/2, and a web server, enable plug-and-play installation, transparent use and native security functionality on all major networks.
- ETRAX, a high-performance network processor that integrates a 32-bit RISC CPU, Ethernet and Token Ring controllers, and device I/O on the chip.
- Web management provides an open cross-platform tool to monitor and configure devices. In addition, SNMP management platforms and the operating system's standard tools can be used.
- Software can be downloaded over the network to flash memory.

Architecture

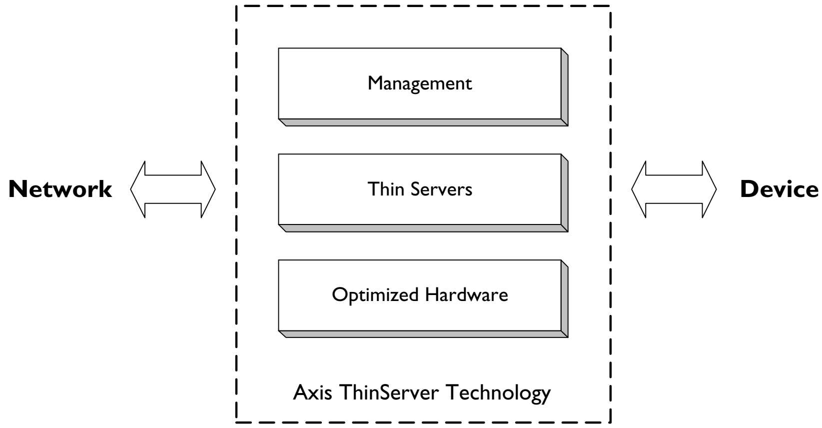

Figure 1. Main Parts of the Axis ThinServer Technology

Thin Servers

Thin servers integrate streamlined implementations of Windows NT, NetWare, OS/2, UNIX and web servers, optimized to support device connectivity and access. Complying with industry standards, they allow a device to be recognized as a native server, providing familiar plug-and-play operation, native security functionality and easy integration to applications. For example, Windows and UNIX users can access the same device using the native desktop systems and graphical user interfaces they are accustomed to. Designed for embedded systems, the software is portable and modular in a Lego-type fashion, allowing embedded designs in a large variety of configurations to meet different requirements for performance, cost, capabilities and functionality.

Management

Web technologies unleash a range of powerful capabilities for device management and connectivity. It provides a platform-independent, consistent, and flexible network-centric base from which devices can be easily monitored, integrated into applications, and become empowered servers to carry out tasks. The built-in web server provides network managers with easy and consistent cross-platform management capabilities using a standard browser. Internal dynamically generated HTML pages provide menu-based configuration, management, context-sensitive help and links for on-line manuals and support. In addition, native operating system management functions are supported, such as NWAdmin for NetWare, and SNMP tools, such as OpenView. Administrators can also down-load new versions of embedded software over the network, a necessary function given the wide range of standards that are emerging today.

Optimized Hardware

As with most embedded network designs, there are high, and seemingly conflicting, demands on performance, cost, size, code efficiency, scaleability and power consumption. Axis has addressed this issue by developing a network CPU for embedded applications, the ETRAX. By having on-chip network controllers, a 32-bit RISC CPU and device I/O, ETRAX optimizes price/performance for non-PC embedded server designs. Unlike processors designed for general computing, such as the Intel Pentium, ETRAX is specifically designed for network systems and has optimized its chip area to include high-performance DMA-controlled network and device I/O. Demanding less memory than most other CPUs, its instruction set has been tailored to give high performance, and generate small code-size while remaining code efficient. Although Axis' thin server software and web management can be ported to run on other CPU platforms, the full synergy benefit is not as robust as when the embedded software makes use of ETRAX' benefits.

Software Architecture

Introduction

The software is architected to provide a high degree of performance, code-efficiency, modularity and portability. Aimed at embedded server applications, the software is designed to optimize resource utilization, create minimal context switches, and prioritize scheduling commands and tasks. It is therefore primarily built on non-preemptive scheduling, while supporting some preemptive scheduling, such as high-priority I/O tasks and time-sliced background tasks. In doing so, the software system avoids potential programming errors by reducing the need for resource synchronization. Time-critical services are tightly optimized, with the frameworks designed to avoid overhead for unused services. Where hardware support can be envisioned for critical functionality, abstractions allow applications to take advantage of these performance benefits without being dependent on whether this support is available or not. Performance, flexibility and ease of understanding can be conflicting concerns, and the Axis architecture is optimized for ease of use in the context of high-performance embedded systems.

The architecture is organized around a number of object-oriented frameworks. Within the framework, a set of task-specific classes combine to provide a series of services and define a common programming interface to these services, which are then used in other parts of the system.

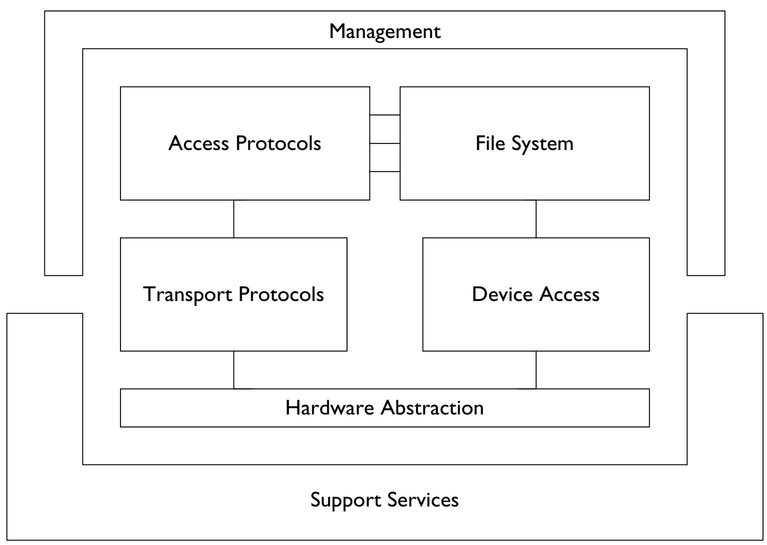

Figure 2. The Software Architecture Modules

The Hardware Abstraction handles network and device I/O hardware communications. The device to be connected is made accessible by the Device Access module, which interfaces to the File System.

The Access Protocols and the File System modules handle the connection of the device to the network. In turn, the Transport Protocols and the Device Access modules relay the results of this interaction to and from the network and the peripheral device. The network is accessible through the Transport Protocols, such as TCP/IP and IPX/SPX, and the Access Protocols like HTTP, SMB, NFS or NCP.

Support Services is the foundation upon which the remainder of the software is built. It contains a real-time OS with task/process scheduler, and support services such as memory management, software timers, string and list manipulation and error handling, that are used in most parts of the software.

Access and Transport Protocols

The network functionality of the ThinServer Technology is provided by supporting a wide range of de facto standard access and transport protocols. The protocols are based on the Axis Network Protocol Framework, which enables them to connect to and exchange data with each other in an efficient way. It also makes it easier to add new protocols to existing stacks.

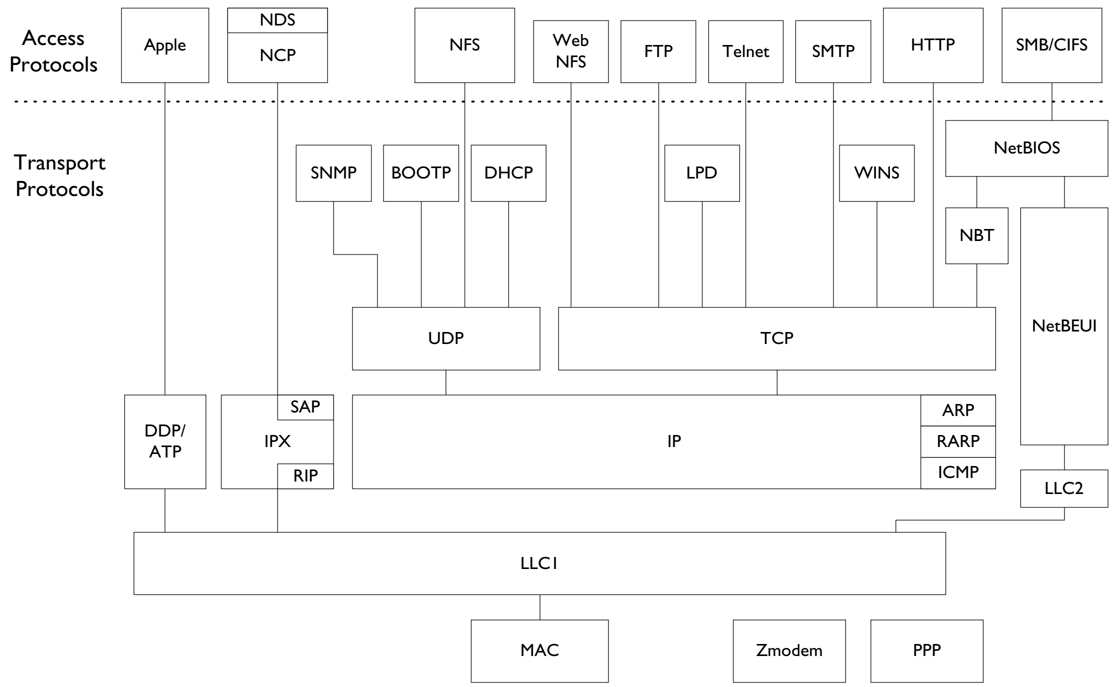

Figure 3. The Access and Transport Protocol Modules

A major design criteria for the implementation of the protocols has been to provide clear framework application programming interfaces (APIs) to facilitate adaptations to upcoming standards and extensions. The implementation of the access and transport protocols are specifically designed for a high-performing embedded system, fulfilling high demands on minimal overhead, high data-transport bandwidth and code efficiency.

File System and Device Access

The Access Protocols provide a link to peripheral devices through the File System Framework. This can be a device that is normally accessed through some sort of file system, such as a hard disk. It can also include devices such as printers, cameras or scanners.

The basic purpose of connecting peripheral devices to a network is to be able to transfer data to and from the devices, and to allow access to users, applications and other servers. The file system abstraction enables this in a comprehensive and familiar way. In the same way files on a hard disk can be read or written, pictures from a camera or scanned documents can be presented as files that can be read. Configuration parameters for any device can be listed in a file to allows changes by reading, modifying and writing the file. Another fact that speaks in favor of the File System abstraction is that most access protocols are in fact file-sharing protocols.

The Axis File System Framework is the interface to peripheral devices. The File System Device Access modules are open and specialized by assigning framework classes into a framework package to implement some variant of services. Different network protocol are implemented as different packages to the network protocol framework. ISO 9660 and Multi User Protocol Prepared File System (MUPP-FS) are examples of file system framework packages. By being specialized from the same framework, different packages provide exactly the same interface and need not duplicate the implementation of common functionality

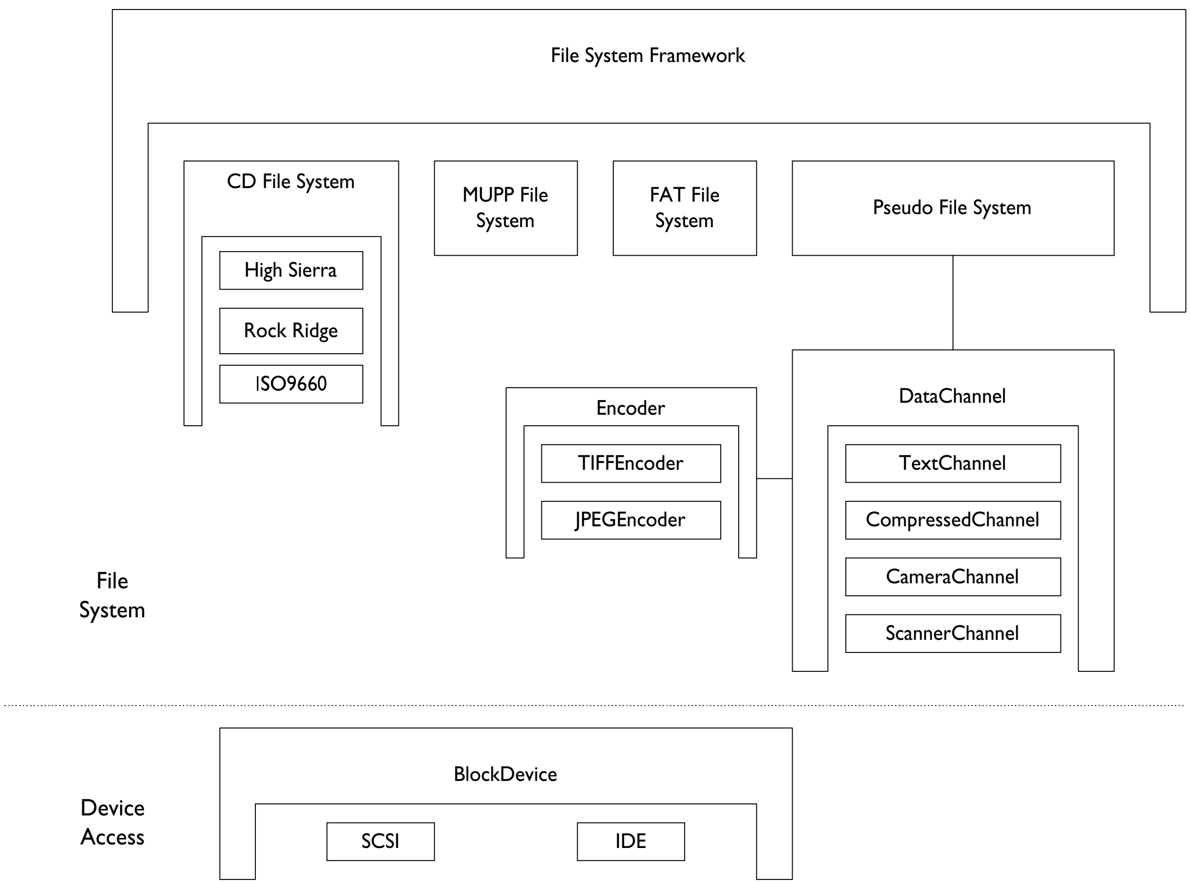

Figure 4. The File System and Device Access Framework Modules

Support Services

At the base of the Axis Architecture are the Support Services, which provide several base system functions, such as real-time OS, threads, job scheduling, timing, memory management, strings, DataChunks, and error handling.

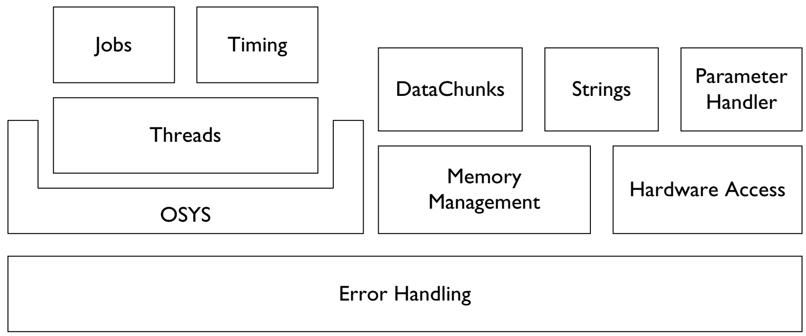

Figure 5. The Support Services

The core of the Support Services are Axis' real-time kernel OSYS and the Threads and Jobs Frameworks. The Axis software is primarily aimed at server applications where the job load is created by many, relatively small requests from clients. In this context, the capacity, such as resource utilization, is the most important performance aspect. The architecture is therefore primarily built on non-preemptive scheduling which minimizes context switches and synchronization overhead. The Threads and Jobs Frameworks work together in a way that resembles the EventQueue in Windows. Jobs are generated by events such as arriving network packets and are put in a JobQueue. In contrast to the event queue in Windows, where events are processed sequentially, the JobQueue is serviced by a collection of threads which process several jobs in parallel.

The embedded OSYS real-time kernel is optimized for fast task switching and providing priority-driven preemptive scheduling and mail messaging. It also offers a compact and consistent user interface, similar to many real-time kernels such as OS-9, pSOS, QNX or Windows CE. This makes porting OSYS-based applications to other real-time kernels fairly easy if required.

The DataChunk Framework provides handling of several chunks of memory as one contiguous memory segment, which minimizes the need for memory copying and increases performance. It is heavily used in the Access and Transport Protocol modules for containing data from network packets and in the File System and Device Access modules for representing data, such as files, that are passed to and from peripheral devices. The next generation of the ETRAX will include DataChunk support in silicon which will increase performance even more. Memory is managed in two ways: by dynamic allocation from the heap using a best-fit algorithm, and by allocation from static or dynamic memory pools. Memory pools may be used for resources whose memory needs are well known, or for allocation of very small objects to avoid fragmentation.

The Parameter Handler handles all parameters and status variables. Management and configuration of networked equipment is performed by accessing the Parameter Handler through different Access Protocols. SNMP supports both standard MIBs and private MIBs for full access to all parameters. The complete parameter list can be read or set by reading and writing ASCII or HTML files. These files can be accessed through the Pseudo File System using any access protocol. As Axis' servers acts as a web server on the network, configuration is easily done by accessing the server with your browser.

Management Software

Overview

User interface is the best way of ensuring access compatibility to peripherals and other device access. Since the network is organized in a consistent and easy-to-access manner, management and control over peripheral objects offer a high level of efficiency and productivity. Central to Axis management software is the emergence of management standard for the Internet and intranets. The built-in web server in the ThinServer Technology provides network managers with cross-platform management from any browser, and a standard interface for easy integration to Inter/intranet applications. Built-in dynamically generated HTML pages provide menu based configuration and management capabilities, as well as context-sensitive help and links for on-line manuals and support. Another critical function is the ability to download new versions of embedded software over the network to accommodate changes.

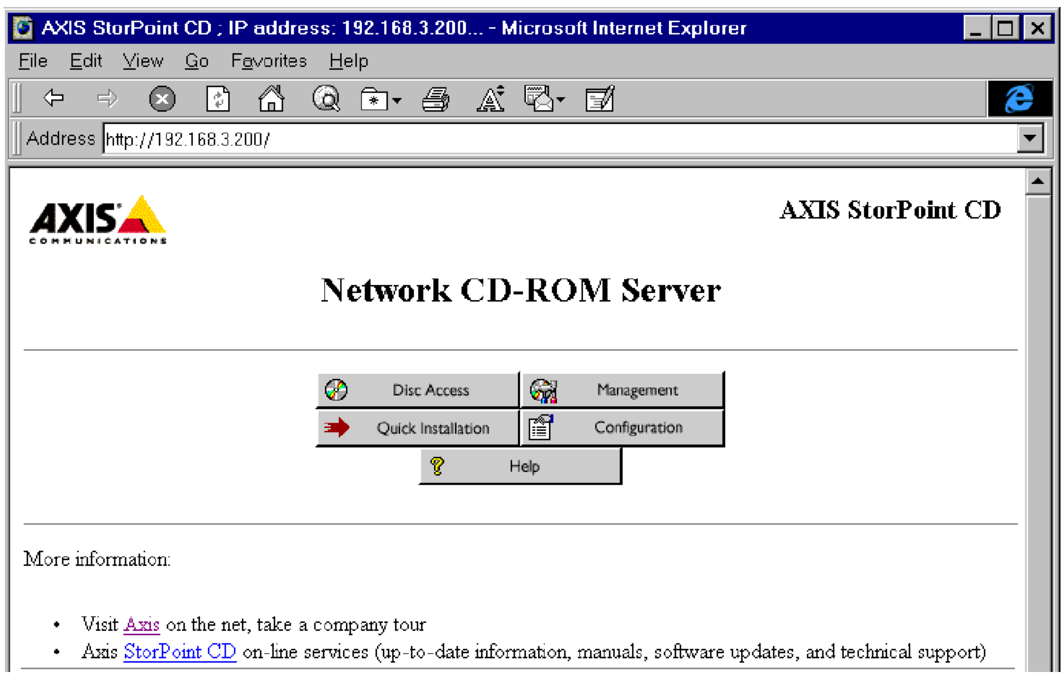

Figure 6. AXIS StorPoint CD Server Web Management Homepage

However, currently missing is a formal standard governing the use of web-based management to allow more powerful handling, such as event traps, group monitoring, load balancing, relocation and finding units on the network.

ThinServer Technology also includes support a set of Windows based utilities, that allows users and administrators to leverage on existing network operating system and desktop. All of them are developed with internationalization and OEM in mind making them easy to translate into any language and support any international version of products based on the Axis Software Architecture. AXIS NetPilot is a Windows utility that integrates an Axis Server into a Novell NetWare system. With NetPilot, network administrators can perform a complete installation by setting up queues and definitions under NDS or Bindery modes. This utility vastly simplifies this task by using a series of Wizard steps. AXIS Print Monitor is a print server utility that integrates network printing fully into the Windows system, allowing servers on the network to be handled within native Window menus.

SNMP is also supported, to allow units to be monitored and managed using SNMP-based platforms, like HP's OpenView. Specific system utility tools are also supported, such as NWAdmin for NetWare.

WinPoint

WinPoint is a management center for networked devices that is integrated into the Windows 95 and NT 4.0 Explorer application. Devices found on the network appear in folders in the namespace visible in the left pane of an Explorer window. The WinPoint Framework allows modules to be added at run-time to support new types of devices. The Access Modules locate all ThinServer devices on the network. It allows configuration of a server either by viewing the server's built-in web pages in a standard web browser or in a Windows Dialog similar to the web interface. WinPoint uses COM technology to communicate with the Explorer and the different modules.

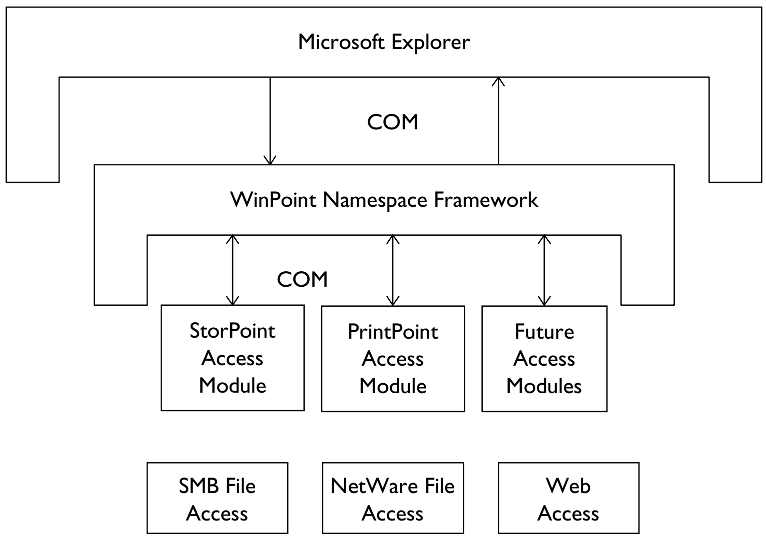

Figure 7. WinPoint Framework

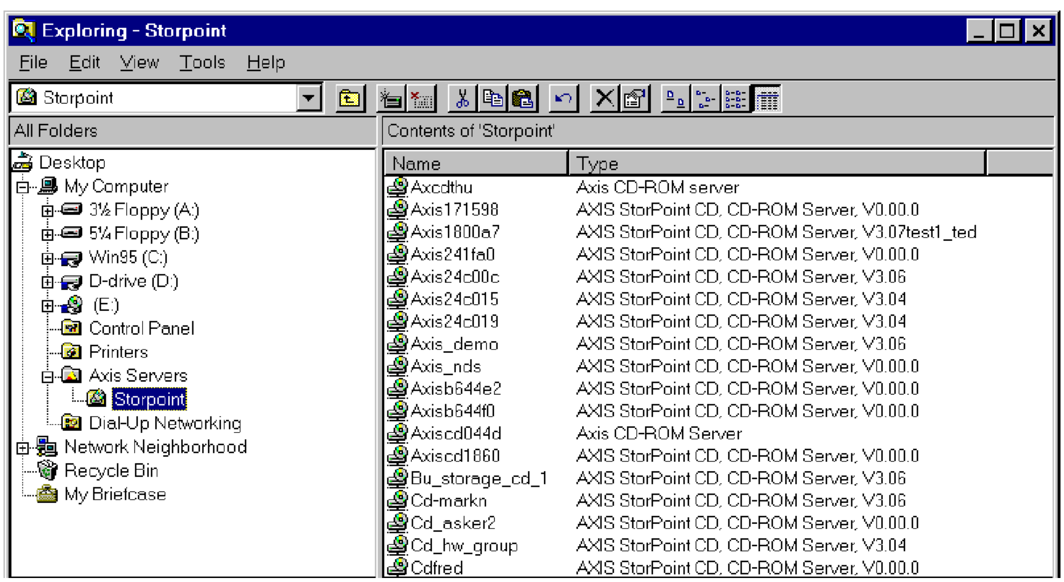

Figure 8. Screenshot example of WinPoint browsing AXIS servers

Hardware Architecture

Overview

The hardware itself is less complex than high-maintenance PCs and requires a minimal amount of residential applications to run. Similar to the thin client of the Network Computer (NC) as specified by Oracle, a ThinServer Technology based server requires little memory, and no hard disk. Furthermore, since the hardware is designed for a specific purpose instead of for general applications, significant gains can be made in ease of installation, cost and performance by optimizing the hardware according to requirements. Important for any embedded design is scaleability and flexibility to meet new requirements.

The Axis hardware architecture is based on the following principles:

- Provide superior price/performance capabilities compared to general purpose file servers
- Make use of state-of-the-art ASIC design to increase reliability and performance
- Use low amounts of memory, and provide scaleability for performance and future upgrades
- Provide a compact design with low power consumption
- Provide remote management for monitoring hardware and upgrading software

An integral part of ThinServer Technology is the use of embedded, optimized hardware, rather than using file server or PC technology. Axis architecture can be ported to the hardware platform of choice, but is optimized to run on an embedded network CPU, the ETRAX (**E**thernet & **T**oken **R**ing by **AX**is).

Since 1987 Axis has made use of specialized, custom-built CPUs. Compared to general purpose CPUs, such as Intel Pentium or Motorola 68K, Axis processors are optimized exclusively for peripheral connectivity and provide superior price/performance. Launched in 1992, the ETRAX chip is now in its fourth generation and is used in all Axis network products and numerous OEM designs. Using state-of-the-art ASIC technology and development tools, it was the first processor to integrate a CPU, Ethernet and Token Ring controllers and device I/O on the same chip. Design criteria included low total system cost by using a high level of integration, low memory usage, low power consumption, enough system performance to saturate the network, powerful compiler/linker, and portable ASIC description for third-party manufacturability. Motorola and TSMC are currently used for chip manufacturing.

ETRAX, in turn, is based on an Axis developed processor core known as Code Reduced Instruction Set (CRIS). CRIS has an instruction set specifically designed to use little memory and have high bus bandwidth efficiency. In fact, in spite of being a 32-bit RISC, it uses less memory than most CISC CPUs. The integration of the processor, the network controller and I/O makes it possible to achieve high throughput because there are no external interfaces with which to communicate on a standard memory read/store and driver API handshake principle. ThinServer Technology utilizes DMA-controlled data transport, delivering an optimized, short-circuited data path. The vast functionality of the ETRAX allows embedded systems to be built using a minimal amount of components.

ETRAX is designed to be suitable in a wide range of applications. It is scaleable to run in 8-bit or 16-bit data bus mode, which makes it suitable for inexpensive, lower-performance embedded systems, as well as in systems with relatively high performance. The built-in DRAM controller makes it also easy and transparent to add more memory, such as SIMM modules for data caching purposes or to accommodate support for more simultaneous sessions.

ETRAX 4 Specifications

ETRAX 4 is the latest version in the ETRAX family of embedded processors. It is based on the same CPU technology, embedded network controller and I/O design. ETRAX 4 is an all-digital design and consists of a 32-bit RISC CPU, Ethernet and Token Ring controllers, SCSI port, parallel ports, serial port, timers, DRAM controllers, address decoding, flash bootstrap logic, clock generator, and DMA channels.

In order to provide a platform for entry as well as high-end products, memory data bus width is selectable between 8 and 16 bits, and memory timing wait states are programmable in a wide combination of modes.

Specific design considerations have been taken to keep power consumption down. By using innovative internal bi-phase clocking, it requires only 150 mA at 5 volts.

ETRAX 4

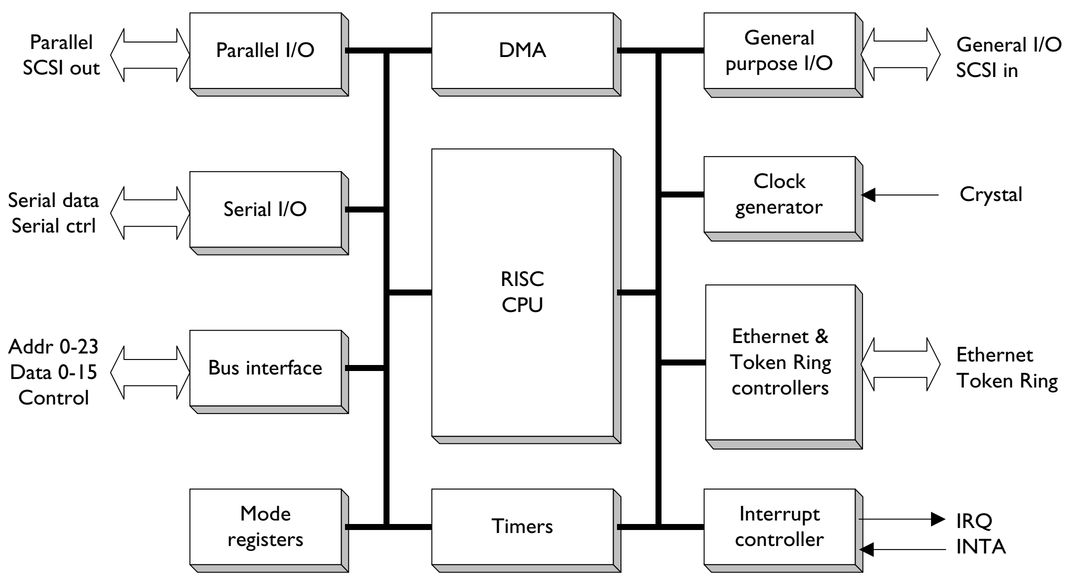

Figure 9. ETRAX 4 Functional Block Diagram

ETRAX 4 Fact Sheet:

Central Processing Unit	32-bit RISC, CRIS architecture
Ethernet (10 Mbps)/ Token Ring Controllers (4 and 16 Mbps)	Receiver/Transmitter Controller Token Ring includes MAC implementation
	Latency Buffer
	Packet Control
	Interfaces to standard analog drivers: NS DP8391A (Ethernet), TI TMS38054 (Token Ring))
Dual DMA Channels	SCSI-2 port
	Parallel port
	Serial port
	External I/O
Two Parallel I/O Ports	Centronics (IBM XT/AT, IBM PS/2)
	HP Fast Mode (HP III Si)
	Lexmark Fastbyte (IBM 4029)
	IEEE 1284 / HP Boise
	Shared RAM (HP MIO)
Serial Port	RS-232C, 300 to 115 200 baud
	Full buffering, parity control, two sets of I/O pins
SCSI-2 Interface	8-bit wide
Bus Interface	Support for: SRAM, DRAM, EPROM/flash, EEPROM, External I/O's
	32-bit (internal) and 24-bit (external) address space
	16 Mbyte per memory bank
	Programmable 8 or 16-bit data bus width
	Bus status outputs
	Individually configurable wait states
	Bootstrap logic to program flash
Timer	Programmable 10 µs - 850 ms
Interrupt Control	External source
	Serial Port
	Parallel Port
	System timer
	Ethernet/Token Ring interface
	Shared RAM interface
	DMA counter
Operation Frequency Range	15-40 MHz
Power Requirement	5 Volts +/- 0.5V, max 150 mA
Technology	CMOS 0.6u standard cell ASIC
Packaging	160-pin PQFP
Manufacturing	Motorola, TSMC

Implementation

Product Examples

Axis is currently distributing products designed for business computing needs. These products assist in immediate document availability, storage solutions and the entire cycle of capturing, processing and distributing information via networks. All products incorporate the Axis ThinServer Technology and use the same base of optimized hardware and software components.

The following table shows existing products that use the ThinServer Technology

AXIS StorPoint CD	Network CD-ROM server. Supports plug-and-play installation and enables direct high-performance user access to CD-ROM information from Windows NT/95/3.11, NetWare, OS/2, UNIX and web clients over Ethernet and Token Ring networks. Web management and software upgradeable over the network.
AXIS NetEye 200	Network camera. Enables users to capture, view and store images over the Internet using a standard browser. Contains a video camera, a web server and Ethernet and modem connection in a palm-sized unit for plug-and-play network installation. Web management, and software upgradeable over the network.
AXIS PrintPoint 560/100	Network print server for 10 and 100 Mbit Ethernet. Enables users to share and use printer resources on major networks, including Windows NT/95/3.x, NetWare, OS/2, UNIX, SNA and Apple. Web management, and software upgradeable over the network.

More products are currently under development. New products will integrate ThinServer Technology based servers for document scanning, removable storage media, hard drives, industrial control and various web appliances.

Development

All code is written in portable ANSI C++, allowing development to be done using standard platforms, such as Visual C++ on Windows NT, or on UNIX workstations. Final target compilation for the ETRAX embedded system is done with Axis' compiler/linker on a UNIX server.

Although the thin server software is optimized for and makes use of the built-in I/O functions of the ETRAX, a general purpose CPU can also be used.

System Requirements

A superb price/performance ratio is of utmost importance for an embedded system. Axis software is specifically designed to provide a streamlined, thin, and yet high-performing system.

Memory requirements vary between configurations. A web server implementation, (Support Services, TCP/IP Transport Protocols and HTTP Access Protocol) would require about 400 KB of flash memory and 500 KB of total RAM. This configuration would guarantee a minimum of 50 simultaneous user sessions, but this number could be increased depending on available RAM (every session occupies about 5 Kbytes of RAM). A full-blown multi-protocol server supporting all file systems requires about 1 MB of flash memory and 1 MB or more of RAM, depending on how much is used for caching and how many simultaneous sessions are required.

Individual parts of the ThinServer Technology, such as the HTTP server core, or the TCP/IP protocol stack, will naturally take up considerably less code space.

Design Example Block Diagram

The following describes a storage server for SCSI-2 hard disks as a sample implementation of the ThinServer Technology. Requirements has been to support simultaneous access from Windows 95/NT, OS/2, NetWare, UNIX and web clients, provide plug-and-play installation, connect to Ethernet, and have throughput comparable to a higher end PC server configuration.

Fast memories are used to keep the amount of wait states to a minimum, resulting in high system throughput. Memory expansion up to 32 Mbytes is provided through SO-DIMM modules. Upgrading the embedded software residing in flash memory is performed from either a port on the board (factory configuration port) or via the network. A serial EEPROM stores permanent data, such as network address and configuration settings.

The SCSI-2 interface is implemented in the ETRAX, and requires external analog drivers.

The Ethernet interface is connected to the network via a dual serial transceiver (Intel 82503).

A debug port has been provided for a serial terminal to provide target debugging during development.

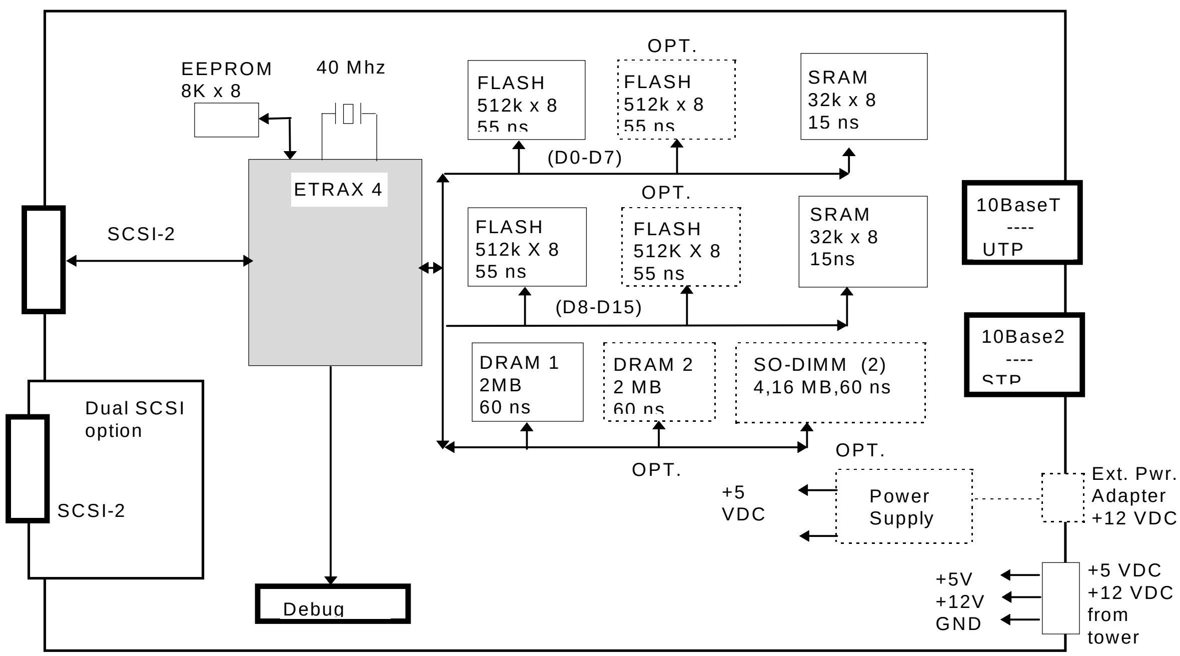

Figure 10. Example design principle diagram

Future

Several coinciding technologies have made network connectivity of non-PC devices practical, affordable and beneficial. But the evolution has just started. The number of devices that could be connected is considerably higher than the number of PCs in the world today. Web technologies, with their open and flexible functionality, have paved the way for a new breed devices called web appliances. Different from server-oriented devices that serve as resources, these web appliances utilize a new principle of communications – the network-centric model. While traditional server models rely on specific clients and dissimilar operating system controls, the web offers a uniform interface that is easily adaptable. However, the web today lacks fundamental file system support, directory services and file system support. The standardization work in progress is therefore one of the most important activities for Axis at this time.

Providing open and standard interfaces is essential for any design to become widely adopted in a world of constant change. The web interface is one such interface, and the embedded software that takes advantage of it will open up many more possibilities. Offering more than just monitoring and configuring preprogrammed devices, newer easily developed software could be downloaded to perform services, application interaction, and local computing of information. Examples of such capabilities include workflow implementations, where a scanner directly communicates with a hard disk on the network that stores the images, and then sends an email to the user with a link to the images. Another example is the ability to interact intelligently with a user without communicating with a file server.

Axis recently launched a longer-term "Web-on-a-Chip" project, which seeks to miniaturize and cut cost on web server implementations. The idea is to allow virtually any device to be connected to and utilized on a network. It will be based on the ETRAX architecture, but implement more of the web server function on the chip itself . In 1997, new versions of ETRAX will become available to increase throughput and support more devices and networks on chip, such as 100Mbit Fast Ethernet.

Conclusions

While other software and hardware developers and manufacturers strive to create new and useful products to meet consumer demands, Axis' goal is to deliver a system that is useful to every user interested in deploying low-cost, low-maintenance management within and throughout their network infrastructures. By creating a seamless, consistent and compatible architecture, Axis seeks to capitalize on the diversity of the industry.

Axis expands its efforts in the distribution and utilization of its technology and products by partnering with leading complementary vendors and working organizations which develop industry standards. Axis has already teamed with such companies as IBM and Xerox in manufacturing peripherals and electronic devices while developing relationships with leading networking vendors including Microsoft, Netscape, Oracle and Sun. These partnerships will strengthen and extend the reach of the Axis architecture and broaden the use and dependency of Axis technologies and products. Axis is also active in the Internet Engineering Task Force (IETF), the Internet Society, and is a Board Member of the Salutation Consortium, groups directly involved in the development and promulgation of network industry standards.

The potential for Axis products and architecture is boundless. By providing access to more information for more people, reducing costs, and delivering unique products, Axis is committed to continuing its development and promotion of technologies that deliver connectivity for practical needs and greater business efficiency. To meet the growing need for access to network peripherals and devices, and to satisfy the demand for compatibility and less complex systems Axis will leverage its 10 years of networking experience and expertise to deliver powerful, revolutionary solutions for today's users.