

Time Warner Cable Full Service Network - Silicon Graphics Technology and Architecture Overview

Gary Sager
Silicon Graphics, Inc., USA

1 The dawn of a new age

Sixty years after Philo T. Farnsworth first demonstrated a television system, his amazing invention remains in some respects exactly as he left it. Though television has received wide spread distribution around the world and the quality of the picture has steadily improved, it remains for the most part a passive display system for broadcasting images into the home. Even telephone technology has experienced more evolutionary development than television, with individualized, interactive services such as voice mail, call waiting, conference calling and others. Television is about to undergo a revolutionary transformation, with the introduction of the Time Warner Cable's Full Service Network (FSN), the world's first digital, interactive television network.

Debating in Orlando, Florida, the FSN includes movies-on-demand, home shopping in a "video mall", interactive multiplayer video games, the ability to print material via a color printer, and much more. In 1995, expected additions to the network include the "News Exchange", from Time Inc., HBO (pay-TV channel) on demand, the Magic Music Store, a virtual supermarket and drugstore, other interactive shopping and services, interactive educational services, and other new world innovations.

Time Warner Cable selected Silicon Graphics to develop this extremely complex system because of Silicon Graphics' unrivaled experience with visual computing and distributed network operating systems. This paper will examine the Silicon Graphics technology that lies at the heart of the FSN, and show how Silicon Graphics' adherence to a standards-based, open, scalable, system architecture positions the FSN as the basis for a solid standard for the entire interactive television industry.

2 Interactive Digital Networks (IDN): What are they?

The widespread digital distribution of interactive information, services and entertainment is a technological development as significant and exciting as the introduction of personal computers (PCs). Both interactive television - which channels digital information and services to home televisions-and interactive digital media - which pipes information to workstations, PCs and other devices - blend elements of computing, telephone and television technologies. When these technologies are woven together in an expansive network that links consumers, businesses and government agencies with massive and powerful data repositories, the average household or business soon will have access to information services and compute power previously limited to a privileged few.

Yet these new solutions promise to reach even further into people's lives than PCs: interactive digital networks (IDNs) will transform the way people view the world from their living rooms, offices and laboratories, providing them with a simple-to-use and affordable window into the powerful Information Superhighway.

To live up to the much-touted destiny of the interactive age, architects of the Information Superhighway will have to pave the communications landscape with technologies capable of delivering useful applications today and 20 years from now. The scope of these applications must stretch from simple consumer video-on-demand services to other, more fundamentally significant deployments: delivering interactive 911 emergency medical services to rural areas, for example, or teaming powerful supercomputers around the globe to collaborate on the world's most perplexing and critical scientific problems. To reach subscribers using all types of today's information tools - from televisions and personal data assistants to PCs and supercomputers - governments, businesses and consumer services providers will likely access the same overarching digital network (see fig. 1), a network that must be designed with enough technological headroom to evolve and expand its services into the next century.

2.1 Consumer

Today, the video rental business is a \$12 billion industry. The idea of supplying home viewers with movies on line has provided a catalyst for investment in interactive television (ITV) - the primary vehicle for delivering interactive services to consumers. While video-on-demand will likely be one of the first home applications, the industry's most advanced technology suppliers understand that video-on-demand is among the simplest of services to implement. Those who comprehend the significant investment required to erect the IDN infrastructure also realize that delivering video to the home will play only a part - and perhaps a very small part - in defining the importance of ITV, and justifying its very existence.

When implemented properly, ITV's first mission is to serve the consumer, and that service will take many forms. When the consumer wants to be entertained,

such entertainment services as video-on-demand, interactive games and customized sports programming will be readily available. But when the consumer has a more specific goal in mind, ITV will deliver such services as interactive shopping, news-on-demand, travel planning, custom traffic updates and on-line postal services.

Business	Government	Consumer	
Private Medical Networks	Entertainment	Entertainment	Services
Training	911 Services	Video-On-Demand	News-On-Demand
Collaborative Computing	Municipal Services	Games	Concierge
Service & Entertainment	Research Networks	Sports	Weather
Private Entertainment Networks	Security	Programming-On-Demand	Value-Added Advertising
Location-Based Entertainment & Amusements	Defense	Home Shopping	
Retail Distribution			
Point-of-Purchase Kiosks			

Fig. 1. Information Superhighway applications

Interactive television also encourages remarkable enhancements to today's already lucrative network and cable television business models. While the public consciousness seems fixed on the entertainment aspects of interactive services for the home, IDN deployment brings an opportunity for service providers to reach customers and constituents in more efficient and targeted ways than ever before. Today, television advertisers already spend millions of dollars in attempts to target their message at specific audiences: sporting goods manufacturers advertise heavily on sports networks, for example. When ITV is deployed from coast to coast, advertisers (with the appropriate permissions from viewers) will know - down to the name and address - which individuals spend time watching sports, or which potential customers have an affinity for classic motion pictures. Interactive television will take much of the guesswork out of targeting customer demographics, providing advertisers with the most focused marketing vehicle in history - a dynamic, on-line database whose research can be updated with an individual's programming preferences and purchasing habits daily, and even hourly.

The advantage is dramatic for the consumer as well. A new car advertisement can offer viewers an option to receive copies of the latest auto magazine reviews of the car. Or, with a mere click of the remote control, viewers can shedule a test drive at

the auto dealer nearest them. Suddenly, a product advertisement can itself become a service, and advertising - today the bane of the television experience for many viewers - becomes a useful tool for both advertiser and viewer.

2.2 Business

Involving business is a critical step in building the global data infrastructure, and businesses are certain to reap similarly dramatic benefits from its use. By plugging into the Information Superhighway, commercial users will be able to enhance their existing approaches to doing business. For instance, by accessing massive databases stored centrally or regionally, corporate users can collaborate on projects that demand participation from separate departments, buildings, campuses, even geographical regions. Today, those same users must depend on telephone communication or, in some cases, expensive proprietary videoconferencing systems, but with the advent of IDNs, collaboration and communication can happen with desktop computers, or even PDAs (Personal Digital Assistants). Only those users with powerful media workstations such as Silicon Graphics' Indy workstation are able to collaborate in real time today.

Health care, racked by skyrocketing costs and facing greater medical challenges than ever before, can make critical use of IDNs. Physicians, who today use the traditional communication vehicles of phone, fax and overnight shipping to consult, communicate and deliver data, will soon exchange information and guidance in more effective, media-rich environments. Using televisions, PCs or 3D workstations linked by IDN-based private medical networks, hospitals all around the world can instantly and interactively share X-rays, MRI output or patient data. The result is clear and instant communication, more effective consultation, and better and more efficient health care.

The prospects for expansion in the entertainment industry are intriguing as well. Location-based entertainment today is defined by amusement centers and hotel closed-circuit concierge services. These types of services can burgeon under the options available through IDNs. By accessing distributed databases, amusement centers can deliver dozens of "virtual worlds" to a single site. The same model applies to hotels, who today either subscribe to strictly scheduled video broadcasts or video-tape based motion picture services. With IDNs, hotel guests - or even cruise ship passengers - will access interactive services that span far beyond watching a simple motion picture, thus expanding revenue streams for lodging concerns and their suppliers.

2.3 Government

The groups that may gain the most from accessing IDN services are educational institutions, municipalities and other government agencies. In the face of shrinking budgets and heightening demands to improve services, these institutions are voraciously seeking new ways to modernize and streamline their operations. IDNs hold more promise for this class of user than any single technological development since the advent of computing itself.

Take education, for instance. Interactive networks will give financially strapped schools access to the kinds of on-line services that for years have been held up as the ultimate promise of modern education. Guest lectures by leaders of government, sciences or the arts; access to on-line film and video libraries; video teleconferences with school children in other areas; on-line multimedia encyclopedias that can be updated daily; virtual laboratories stocked with the latest and most expensive equipment; and interactive news services enhanced by analysis and comment: all of these services could be accessed via low-cost television/set-top devices, PCs or workstations. Government agencies also are in line to garner the rewards of IDNs. Municipalities will expand their ability to communicate with city, state and federal government, as well as with citizens. For instance, police will be able to access photographs, fingerprints and other data about crime suspects from police departments in other areas. They can also use interactive network technology to quickly and efficiently pinpoint locations when responding to 911 emergency calls. City, state and federal governments can leverage existing IDNs to transact routine business: motorists, for example, can register their automobiles or renew their drivers licences through the IDN, reducing traffic both on the streets and in motor vehicle departments. The prospects are just as positive for large federal offices which currently transact business over the telephone or through the postal service.

Full deployment of interactive digital networks will occur as technology evolves and conforms to user interests. Communication and computer companies are already testing their systems in trials throughout the world, and these tests are likely to continue for years. With computing performance relative to price increasing 10-fold 3 1/2 years, companies pursuing the interactive market must invest today in advanced technologies that will keep pace with future price/performance structures.

2.4 Paving the Information Superhighway

The potential applications of interactive digital networks are limitless. While many have focused on video-demand and other entertainment applications, the real implications are much more profound. The Data Superhighway promises people a new way to communicate and unprecedented access to information. Some observers believe interactive networks will lead to sweeping changes in society. Without question, it will alter the business landscape, perhaps leading to fundamental ways in the way people work, and even learn.

The manner in which interactive technology evolves and how it will be used are matters that are bound only by the imagination. Any attempt to define technology based solely on what is currently known is perilous indeed. What is important is to understand the elements necessary for the broadest, most flexible infrastructure, and to realize implementations and trials are the only means to progress. Therefore, one of the most advanced trials, the Time Warner Full Service Network in Orlando, Florida, will be described in detail.

3 The Full Service Network system software

The Full Service Network (FSN) is controlled by a system software environment developed by Silicon Graphics for current and future interactive television systems. It offers many features - here and now - that are far more advanced than those found in systems under development. This technology is a natural outgrowth of Silicon Graphics' recognized leadership in developing advanced:

- MIPS® RISC microprocessors
- 3D graphics computing systems
- symmetric multiprocessing system architecture
- supercomputing servers
- real-time operating system software
- distributed computing environments
- 3D graphical user interfaces

The FSN system software is much more than a continuous media delivery system for video-on-demand. Its modular architecture encompasses all aspects of an interactive television operation, from the underlying hardware up through the applications and creative content available to subscribers.

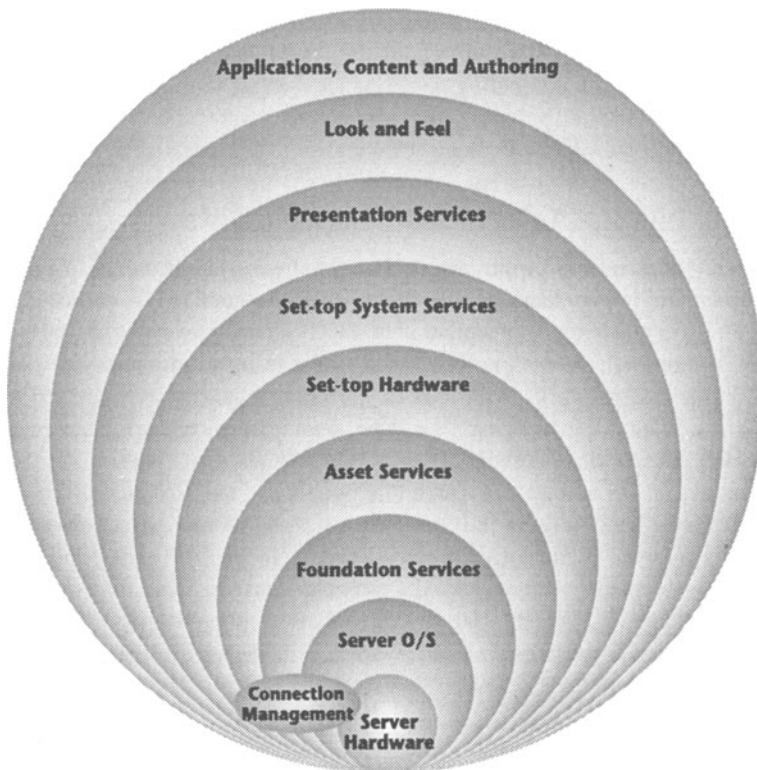


Fig. 2. The modular architecture of the FSN system software

The FSN system software architecture can perhaps best be understood by imagining its modular construction in the form of a layered “onion”. As this image suggests, modular layers can be peeled away so that network operators, system integrators, and service providers can take advantage of as much - or as little - of the functionality as they wish (see fig. 2).

The key benefits of the FSN system include:

- *Recoverability* - The FSN system software has been designed to recover instantly and gracefully from hardware and software failures.
- *Scalability* - Both the FSN system software and the underlying Silicon Graphics hardware platform offer an open architecture and can be scaled to a level of performance no other system currently can obtain.
- *Flexibility* - The FSN system software is designed to incorporate off-the-shelf third party solutions wherever possible.
- *Network neutrality* - The IRIX operating system at the heart of the FSN system software allows for a variety of network connectivity solutions.
- *Security* - The FSN system software protects network resources while maintaining the privacy of users.
- *Autonomy* - The FSN system software allows service providers to create autonomous “domains” within the system that can be managed independently from those belonging to a network operator. The boundaries of these domains are completely invisible to network subscribers.
- *A deterministic environment* - IRIX features built-in REACT real-time extensions for deterministic performance. Silicon Graphics’ Challenge XL media servers provide the supercomputing performance needed in a demanding real-time environment.

For application developers and content providers, key benefits include:

- *An open and accessible architecture* - The FSN system software was designed to be open and accessible to developers of services and programs.
- *Authoring Tools* - Innovative software authoring tools are available to enable developers and content providers to create compelling applications and services. A Style Guide is available.
- *Media Integration* - Advanced media integration tools provide a complete library of media - audio, video, animation, images, 2D graphics, 3D graphics, and text - with built-in synchronization and MPEG support.
- *Data management* - The FSN system software features the UNIX-based IRIX operating system as well as information management and database management software tools.

4 Welcome to the Full Service Network

Time Warner Cable’s Full Service Network in Orlando, Florida, will offer subscribers a vast array of interactive applications in addition to video-on-demand and the programming currently found on existing cable television systems.

The Full Service Network is perceived by the viewer not as a simple sequence of channels, but rather as a cyberspace world complete with a shopping mall, a movie theater, a news center, a game arcade and several other venues.

The viewer is presented with a dazzling 3D graphical interface carefully designed and thoroughly tested to provide intuitive access to all available services. The interface is built around a network navigator known as the Carousel, which presents the viewer with a beautiful, 3D, rotating "location selector." The viewer selects a location on Carousel with a special remote control device, and can quickly jump from location to location within the world of the Full Service Network.

Each location the viewer visits exists in a time frame determined by the viewer's activities on the Full Service Network. For example, a viewer might experience the following scenario:

1. The viewer goes to the movie theater and selects a movie.
2. The viewer watches the movie, and can pause, fast forward, and rewind it at will.
3. During the movie, the viewer decides to play a game, so he or she pauses the movie and jumps to the Playway Games center.
4. If the viewer chooses to exit the game, he or she quits the game and jumps to the Shopping Mall to browse for new clothing.
5. After selecting a new outfit and paying for it by entering a credit card number, the viewer decides to go back to the movie theater and finish the movie.
6. When the movie is over, the viewer goes to the Program Guide and identifies programs of interest.
7. During the next few days, the viewer periodically calls up the Program Guide and then jumps to the desired programs.

The Carousel is but one possible interface that might be implemented with the flexible FSN system software. As the FSN grows, a viewer might travel through gateways to different networks and encounter a new, standards-based interface with a slightly different look-and-feel for each network - much like the experience of traveling to a foreign country.

5 Major components of the Full Service Network

At the highest level, there are three major hardware components that make up the Full Service Network (see fig. 3):

- the *server complex* where the bulk of services available over the network are provisioned
- the *distribution network* which provides connectivity between the server complex and the set-top installed in subscribers homes
- the *set-top* which consists of a computer that's interfaced into the network, the television, and a hand-held remote control.

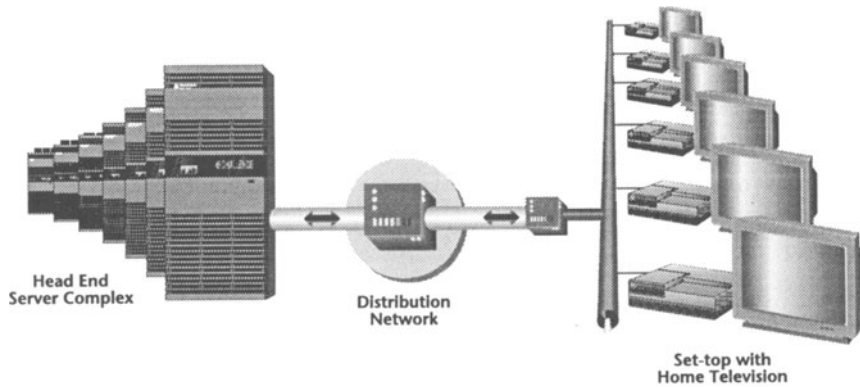


Fig. 3. Components of the Full Service Network

5.1 Head-end server complex

The head-end server complex in the Full Service Network consists of server computers, storage systems, and an interconnection network that provides high-speed, two-way communication between different elements of the complex (see fig. 4).

The complex is built around the Silicon Graphics' Challenge XL line of symmetric multiprocessing (SMP), media servers. The Challenge XL server is based on a general purpose MIPS RISC processor and an open, scalable architecture - a very important feature in a system that's expected to grow rapidly in terms of both services and subscribers. Each Challenge server provides 1.2 gigabytes per second of sustained system bandwidth and can be configured with up to:

- 36 MIPS R4400 64-bit processors 200MHz
- 16 gigabytes of main memory
- 6 terabytes of disk storage

Networking connectivity includes Ethernet, FDDI and ATM. The Challenge media servers are capable of automatic recovery and isolation of failed elements so they can provide a high degree of unattended service.

The architecture of the FSN server complex allows services to reside on any server or combination of servers. In order to permit introduction of services that do not have to meet stringent real-time requirements, the architecture partitions servers into front-end - those that must provide real-time interactive services to the viewer - and back-end - those that indirectly provide services such as billing through the front-end systems. This partitioning permits more flexibility in connecting a rich set of services to the network, including the ability to interface existing service provider information management systems.

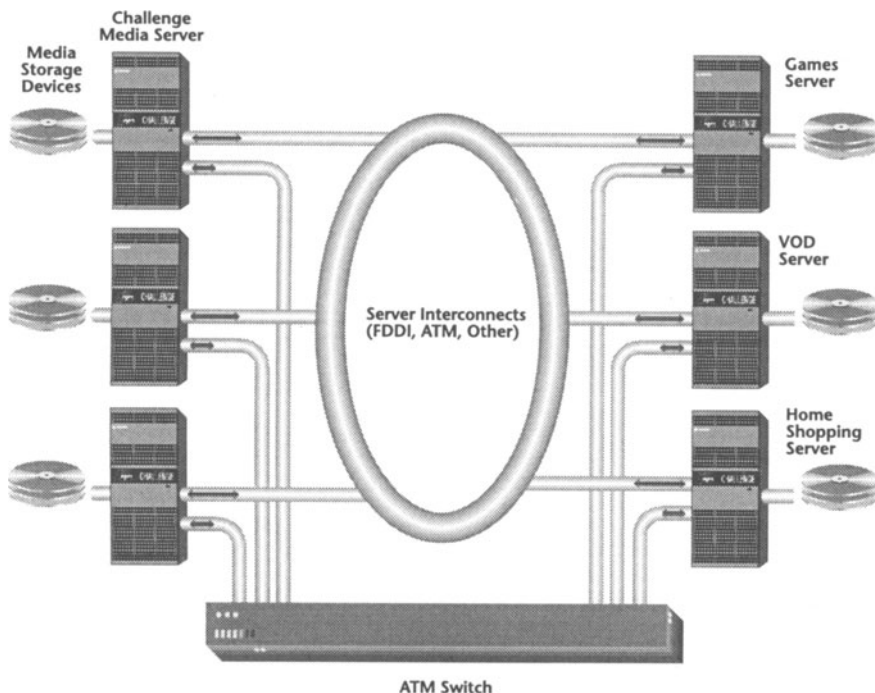


Fig. 4. Head-end server complex

5.1.1 IRIX operating system

To achieve the responsive performance that interactive television requires, the network architecture is designed as a single integrated system. The Silicon Graphics head-end servers use the IRIX operating system that is used throughout Silicon Graphics' entire product line.

IRIX is an adaptation of the UNIX® operating system and offers a feature-rich software environment and an extensive collection of programming tools and libraries. It is designed to run on multiprocessor systems and is able to support multiple threads of execution which significantly enhances the capacity of the system and application services.

Some of the key benefits of IRIX include:

- IRIX provides an industry standard operating system, and a rich and time-tested set of applications and development tools. Additional disks drives, memory, and different network interfaces can easily be added to the network without modifying the software.
- Silicon Graphics developed a new file system - XFS - to expand the UNIX file size limit to 264 bytes, a number so large that file size is virtually unlimited. The total amount of data space that a single IRIX-based device can manage is now 289 bytes. XFS is fully compatible with NFS and existing applications.

- The IRIX file system provides an abstraction of the contents of the storage system so the entire disk array is treated as contiguous data space. Data can be broken up and laid across multiple disks to provide the most efficient use of resources. For example, this allows the use of “data striping” to provide the highest possible I/O access.
- IRIX provides real-time features (REACT extensions), including flexible schemes for processor, memory, bus bandwidth and file input/output allocations that can guarantee the delivery of time critical services even while the system is being used for background tasks.

5.1.2 Foundation services

The basic mechanisms for participation in the FSN are provided by the system software foundation services. The implementation of foundation services is based on the industry-standard Object Management Group (OMG) and Common Object Request Broker Architecture (CORBA). Silicon Graphics intends to make the specifications and implementations of these services available to vendors who desire to add higher level services.

Resources and services in the FSN system software are implemented as objects, thus adding a layer of abstraction that hides underlying implementation details. Access to resources and services is provided by Application Programming Interfaces (APIs), which are defined using the industry-standard OMG Interface Definition Language (IDL). This makes it possible, in spite of any differences in underlying hardware or system software, to access any of the services from any part of the network. It also enables the development of distributed services capable of accommodating devices as diverse as legacy systems, PCs, telephones, and pagers, in addition to a spectrum of set-tops ranging from very simple devices to very sophisticated ones.

Object oriented design also provides for future improvements by shielding application and tool interfaces from any changes that are made as the underlying technology continues to evolve. Network applications, moreover, can be extended simply by adding new types, versions, and implementation for services on a continuing basis.

Object communication is designed to be flexible; the underlying interprocess communications mechanisms and networking protocols can be tailored to fit the needs of the systems being connected.

The object management layer provides a naming service by which objects can identify themselves and locate each other. By obtaining an object reference to a service from the naming service, a client can invoke the service through the IDL-defined APIs without having to know the location of the service or the protocols by which communication is effected. Furthermore, the object management system communications system provides secure communications.

5.1.3 Asset services

Asset Services build upon the Object Management layer to provide the generic services needed to support applications. In addition to the basic function of

constant-bit-rate media delivery, services are provided to manage the media and to distribute service loads across multiple server systems as well as across resources with the systems. Some generic services, such as filing, are also provided for use by set-top applications to manage their own assets.

The prime considerations in the design and implementation of Server System services are:

- Scalability/Capacity
- Service Guarantees
- Reliability/Recovery
- Configurability

Generally, these goals are achieved by providing for distributed operations within the head-end server complex. One of the most obvious advantages of this approach is that it allows for some of the systems in the head-end to be highly specialized. This means, among other things, that third parties and independent service providers can introduce new servers and systems to a working network without disrupting already established services.

5.2 Distribution network

The distribution network carries information between the head-end server complex and the set-tops belonging to network subscribers (see fig. 5).

The FSN system software has been adapted to a number of network distribution architectures. It hides the details of the network from services and applications with a general interface for connection management.

The Full Service Network is based on ATM switching, RF modulation, and frequency multiplexing over fiber optic and coaxial cable. A switch routes information between servers and “MOD/DEMOD” boxes which multiplex, modulate and demodulate signals for each of the neighborhoods served by the Full Service Network. It is not economical to run fiber all the way to the home, so at some point between the MOD/DEMOD and the home, a Neighborhood Area Node (NAN) converts signals between AM light signals carried by the fiber and the AM electromagnetic signals carried by coaxial cable.

Typically, coaxial cable is used to carry signals to and from up to 500 homes in a single neighborhood. Because this last run of cable is rarely longer than one to three miles in length, it’s generally referred to as “the last mile.”

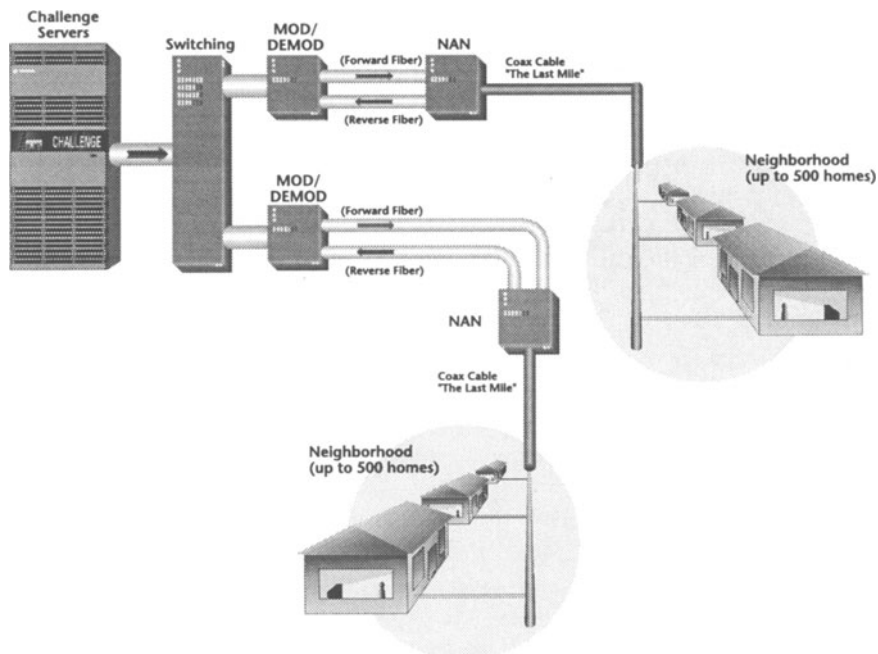


Fig. 5. Distribution network

5.3 Set-top

The set-top is the element of the system that conveys media in both directions between the FSN and the subscriber's television. The set-top is located with the television and is controlled by an infrared remote control device that allows the viewer to make selections on-screen (see fig. 6).

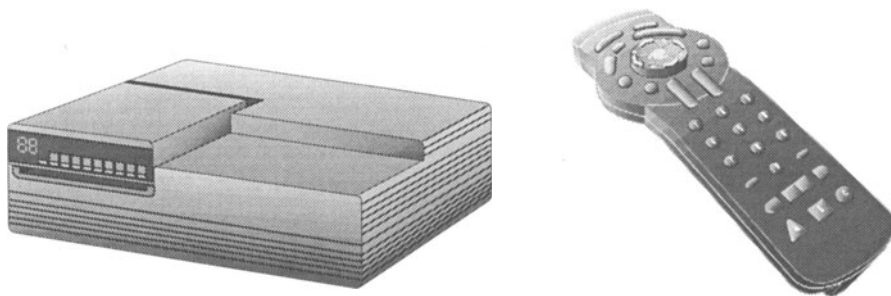


Fig. 6. Set-top equipment

5.3.1 Set-top hardware

The set-top developed for the FSN is an integration of pre-existing and new components from Silicon Graphics and Scientific Atlanta. Through MIPS Technologies, Inc., Silicon Graphics has provided the high performance media microprocessor technology that is at the core of the set-top.

The set-top requires significant compute power to deliver the decoding, rendering, image compositing, decryption, and real-time 2D and 3D graphics - all of which provide a highly intuitive, visually compelling, and responsive viewer environment.

The set-top:

- provides high-bandwidth two-way connectivity with the head-end server complex for reliable delivery of data
- decodes the digital audio and video media sent by the head-end server complex and then re-encodes the signal into an analog form that can be interpreted by the television
- provides "upstream signaling" to the head-end for navigating through the available services
- provides the graphical user interface

In progress is a new media microprocessor design from MIPS Technologies, Inc. that will integrate many of the important functions into silicon making it possible to produce robust, fully functional set-top systems at a very attractive consumer price.

5.3.2 Set-top operating system

A key element of the set-top is the real-time micro-kernel operating system that provides a set of services sufficient to support multimedia applications on a dedicated single processor. The kernel supports drivers that can interface a wide variety of peripherals to the set-top, such as a printer.

5.3.3 Presentation services

The FSN system software multimedia resources include libraries for every media type:

- Audio
- Video
- 3D Graphics
- 2D Graphics
- Animation
- Text

The multimedia resources provide content developers with the tools to seamlessly integrate different media types and include built-in synchronization mechanisms and MPEG support.

The graphics library provides the functionality for constructing, manipulating, and displaying graphics objects. Each element within the presentation services layer is treated as a separate object, meaning that any presentation services that are added - whether developed by Silicon Graphics or by third parties - will be easy to integrate with existing services.

6 Applications, authoring, and content production

Application programs in the FSN are generally implemented as client-server programs. The client executes on the set-top, and makes use of the set-top and server services described above. The application may include a server portion that executes on the IRIX operating system and makes use of Foundation Services to communicate with its client.

Applications in the FSN system software can draw on services available from one or more servers in the head-end complex. Because of the system's object-oriented design, the location of these services can remain transparent to the applications.

To produce compelling applications, developers must have access to affordable platforms supporting a full range of multimedia capabilities and authoring tools. Silicon Graphics has provided FSN content developers with a powerful set of authoring and development tools. These tools enable developers to rapidly prototype media rich interface designs, integrate diverse media, simulate the FSN network environment, and test their applications.

Through Silicon Studio, Inc., Silicon Graphics provides a full digital production environment based on Silicon Graphics workstations, video products, and third party applications. This integrated solution spans the entire content production cycle from storyboards to animation to final post production.

6.1 IRIS Performer

IRIS Performer is a software development environment that provides high-level support for graphics-intensive tasks. It simplifies the process of scene generation and streamlines the use of simulation databases. As an economical and productive starting point for application developers, Performer includes advanced image-generation functions layered above the IRIS GL.

6.2 ImageVision Library

The ImageVision Library toolkit is an object-oriented extensible library for creating, processing, and displaying images. Its robust core set of image processing functions includes color conversion, arithmetic functions, radiometric and geometric transforms, statistics, spatial and non-spatial domain transforms, and edge, line and

spot detection. These functions simplify the extension of standard function sets to suit specific image processing needs.

6.3 CASEVision

CASEVision provides a unique approach to programming by providing tools to visually represent complex development issues. For example, CASEVision includes the Array Visualizer to simplify debugging with a unique 3-D interface; Structure Browser to graphically indicate pointers to linked lists and data structures and highlight dangling or incorrect pointers; Heap View that graphically displays dynamic memory and highlights memory leaks and errors and many others.

7 Summary

The Time Warner Cable Full Service Network architecture and the technologies described in this document represent an ambitious and far-reaching vision for the future (see fig. 7).

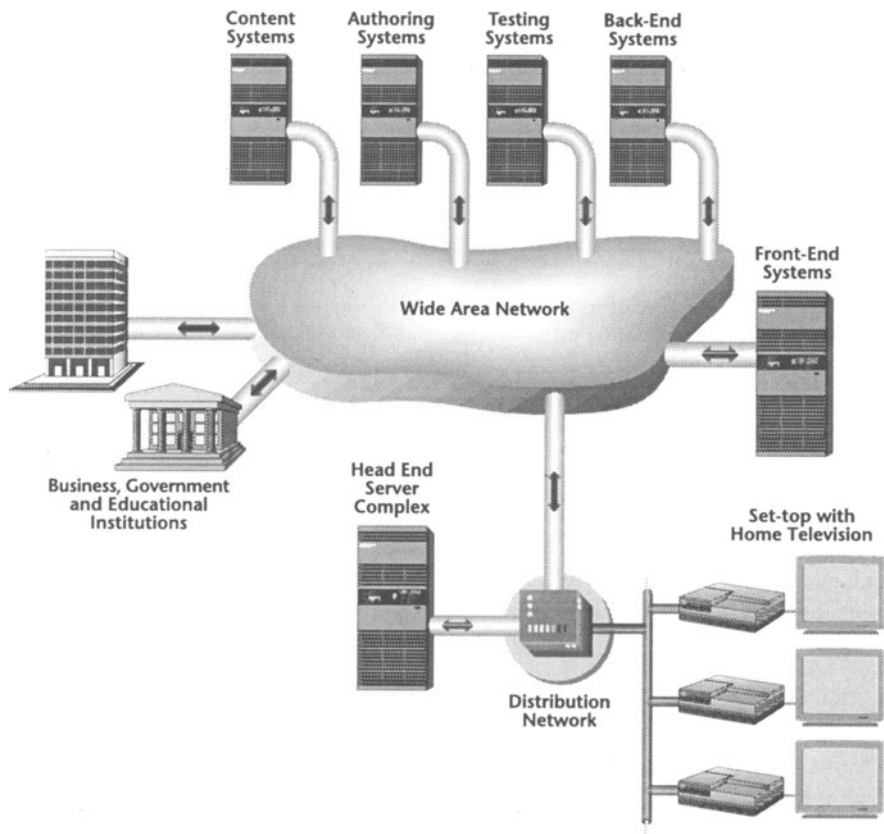


Fig. 7. Growing into the future

Where most other interactive television trials or deployments are satisfied with delivering only movies to the home, the FSN is truly delivering on the promise of interactive television. The FSN architecture and technology is the first to put television viewers in complete control of the information and entertainment they want and need. And it provides the technological headroom that will allow application providers to enhance interactive services over time, making them more compelling and interactive and, ultimately, more valuable.

Time Warner Cable's Full Service Network represents the new standard for interactive television. It is a solid and significant deliverable. But it is only the beginning, both for consumers and for the companies that have invented powerful new interactive technology for the Orlando trial. To maintain this momentum of innovation, two FSN technology partners, Silicon Graphics and AT&T, created a joint venture, Interactive Digital Solutions, based in Mountain View, California. Interactive Digital Solutions was formed to develop and deliver large-scale, fully integrated, interactive video server solutions for telephone company networks and cable TV systems. Interactive Digital Solutions develops middleware and application frameworks and tightly integrates them with hardware and open systems suppliers to provide complete solutions for interactive services.

The achievements of Silicon Graphics, Interactive Digital Solutions, AT&T, Scientific-Atlanta and the other FSN technology partners will allow the creative community and content authors to produce compelling interactive programming services for potentially millions of television households nationwide. In the final analysis, the FSN and its underlying technology provide the infrastructure that enables commercial and educational communities to reinvent themselves, create new opportunities, and thrive in the emerging Interactive Age.

References

MIPS is a registered trademark of MIPS Technologies, Inc.
UNIX is a registered trademark of UNIX System Laboratories Inc.
Full Service Network is trademark of Time Warner Cable
Carousel is a trademark of Time Warner Cable
IRIX is a trademark of Silicon Graphics Inc.
REACT is a trademark of Silicon Graphics Inc.
XFS is a trademark of Silicon Graphics Inc.
IRIS Performer is a trademark of Silicon Graphics Inc.
ImageVision Library is a trademark of Silicon Graphics Inc.
CASEVision is a trademark of Silicon Graphics Inc.
IRIS GL is a trademark of Silicon Graphics Inc.

Acknowledgments

The Full Service Network design and implementation is the integration of many technologies developed by numerous people within Silicon Graphics and at partnering companies. The list of persons who made significant intellectual and personal contributions to the Full Service Network would itself be as long as this overview.