# A Brief Overview of Current TV Set-top Box Developments

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## Abstract

*The integration of computer, communication and consumer-electronics becomes a world wide development trend. One of important and promising developments is TV set-top box which is a crucial part in an interactive TV system. Now more and more leading companies, including media, cable television, telephone, and computer companies, and governments in the world are putting much effort and financial support in the R&D of newly emerging set-top box to own a position in the huge profitable market. This paper briefly introduces an interactive TV system, its main components, and the rapid change of its functional definition; then outlines the latest major players, their products and joint trials in the TV set-top box market; finally analyze the developing and marketing trend, strategies from different views and the technical challenges toward TV set-top box or interactive TV and potential solutions.*

## 1 Introduction

Now nearly everyone is talking about information superhighway, 500 channels of video on demand, information on demand, education on demand, interactive multiplayer games, home shopping, virtual realty, video conference etc. The convergence of TV, computer and telecommunication is invading our lives and will soon be in our offices and homes. We will be able to:

- Search for movie or show what we want in front of TV in our comfortable armchair with a remote controller.
- Order a CD while watching a concert on our TV, which may be downloaded immediately to our home HiFi system.
- Take a stroll through a virtual shopping mall on TV, select items we like from an electronic.
- Browse through some advertisement, or even place our own advertisement onto the screen.
- See how some new clothes or makeup might appear on us by using a virtual body on our TV.
- Play an interactive game on TV with friends while they sit in their own homes.
- Download the latest game to our games console; or be able to look at the type of news that we are interested in when we want to see it.
- Take a class and question/answer interactively with teacher in a university classroom through network and distance learning facility.
- Take part in business video conference in office with other people hundreds miles away from us.

All these and much more are being tested now by many consortia of media, cable, television, telephone and computer companies. In order to provide any of the services mentioned above, one of the key pieces to this revolution in the office and home is needed, that is the set-top box which will be the gateway to interactive services.

## 2 Functional definition about set-top box

Consider an interactive TV system's working process: we use Remote Controller to select a service via the Navigation System. The request is sent via the Return Path to the Control System which locates the required data in the Storage Hierarchy and presents it to the Transmission System which delivers it to the Set Top Box for display on television. The Subscriber Management system is informed so that it can make any relevant charge.

**Content** - any form of source material: movies, games, news, images, sounds, etc..

**Compression Capabilities** - most of the services can only be achieved effectively by using digital technology; systems are required to convert the analogue signals to digital and store them in a highly compressed format. The current compression techniques include Intel/IBM DVI, H261 and ISO/MPEG. To achieve full MPEG quality requires a powerful specialized processors.

**Storage Hierarchy & Control System** - even compressed videos require enormous amounts of storage spaces; the control system must be able to serve all the requests coming in. The video server is the central system on which the data is stored. This is one of the main areas which need extensive development in order to sustain the mass market rather than a limited trial.

**Transmission System** - high speed links are required to deliver the vast amount of information in a timely manner. For video the transmission must not only be at a sufficiently high rate but it must also be delivered isochronously. There are a number of different methods of transmission: twisted pair coaxial cable, fiber optic cable, satellite, microwave, etc.

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**Return Path** - in a fully interactive system there needs to be a signal going from the user to the Control System carrying a user's request. The Return Path for most interactive TV applications does not need to be very fast (64 Kbps is adequate). But this is obviously not sufficient for two way applications such as video conferences which require full video stream capability in both directions.

**Set-top Box** - an addressable communication box is needed to decode the signals as they arrive at the television or PC; depending on the targeted system, it may also need to perform functions such as the decompression of the digital signal or handling of the Return Path.

**Remote Control and Navigation System** - users need a friendly interface to find their way through all the services offered and communicate their requirements to the central Control System.

**Subscriber Management** - sophisticated systems for administration, billing and encryption will be required to ensure that the users pay for the services they use and that copyrights are preserved.

Such interactive TVs will require more intelligence than the current dumb one. A set-top box is needed to achieve these functions. Figure 2-1 is a block diagram of a set-top box.

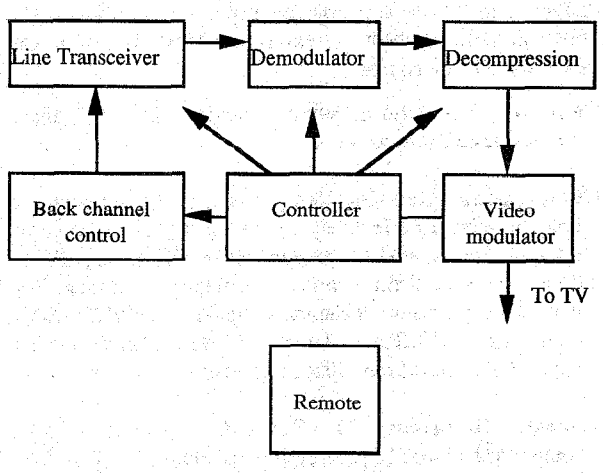


Figure 2-1 Set-top box block diagram

The line transceiver receives the incoming signals and permits the sending of control information back to the video server. The incoming signal is demodulated to baseband to recover the compressed digital video stream that is sent to the video decompression unit where it is converted to analog form and presented to the TV. The set-top box will have a microprocessor to manage the various blocks of hardware including the remote control management, the creation of necessary user-interface interaction on the TV monitor, and protocol exchanges with the VDT (video dial tone) gateway and the service itself.

The earlier definition of set-top box included the transmission of multiple, separate video streams to user's TV for interactive manipulation. It emphasizes the full interactivity. In order to achieve interactive-video-on-demand, where the user can select any movie to start now, the entire system needs a return path and a much more sophisticated control system. It is difficulty for its price to fall in around $300 which is a acceptable price to most users.

Today the fully two-way interactive services might simply have been too much, too expensive and too fast for cable companies and the users. Most companies no longer would define it with full interactivity, which means minimal upstream connectivity. In short, it should be not as interactive as it once was [7]. The direct manipulation or interactivity with an incoming video stream will not be the part of the new definition. It is as the existing pay-per-view, electronic-program-guide application, or near-video-on-demand, for example, a satellite could be using 250 channels to broadcast the top 10 movies, each one being transmitted 50 times with start times staggered by 5 minutes. When you select a movie, the system determines on which channel the movie is about to start on and sets your television to that channel, you will see the beginning of the movie in less than 5 minutes. One benefit of this system is that a user does not need a return path.

In the view of most cable companies, the ideal digital set-top box architecture is one that offers minimal interactivity, or perhaps none at all. But from the video server vendor's view, the set-top box manufacturers should not cut down some necessary functions and leave these matters to video server just for lowering price. In the users' view, an ideal set-top box should be able to offer all the features an interactive TV can achieve with minimal cost. Thus stepwise development of generational set top box products is necessary. These require full consideration of expandability and compatibility with open system standard and technologies.

Below is a wish list of set-top box's features from the major video server vendor Oracle Corp., based on its sophisticated applications running on its MediaServer platform:

**Control/input devices** - minimum requirements would include a remote keypad and cursor, as well as a gamepad. In addition, bar code readers, full keyboards, credit card readers, smart cards and voice recognition would aid the system significantly.

**Color space** - to approach studio quality production value, the set-top box needs to develop a standard way to deal with colors, with a minimum color depth of 16 bits. It also should enable hardware-based, anti-aliasing, which helps smooth the rough edges of text and images.

**Asynchronous time-based objects** - to mask network delays and latencies, the set-top box must be able to generate sound and animation on its own.

**Graphic/video functionality** - the set-top box must be able to handle scaleable video and multiple simultaneous streams of analog and digital video. It also must be able to generate transitions and special effects comparable to those seen on TV today.

**Performance** - the set-top box requires a multitasking operating system and hardware-based decompression for images and sound.

**Graphic engine** - an engine must be able to support multiple animation and sophisticated transitions between graphic/video planes.

**Caching and storage** - a set-top box require more than today's standard 4 Mb of RAM, plus persistent storage, such as flash ROM, CD-ROM or a hard drive.

Although it is impossible for the price of set-top box with these features listed above reaches in a $300 range, it really presents some missing requirements of today's set-top box .

## 3 A glance at current major players

Two years ago, the major providers were General Instrument (GI), Scientific Atlanta (SA), Zenith, AT&T, HP, Philips. But now IBM, Apple, Microsoft etc. are joining in this competition. Europe and Asia are showing great interest in set-top box, and are becoming the next biggest market after the United States. Some concrete and ambitious schedules are put into action. Table 3-1 shows the major schemes in Europe and Asia interactive TV market.

At TeleComm 95, held in Geneva in October 1995, an amazing amount of interactive TV products and technologies were showed. In contrast to the rapidly growing market in Asia and Europe, the appetite of both consumers and system providers to interactive TV in the U. S. is tepid, but they are finding more stable volume markets in overseas. Their enthusiasm to set-top box is not as high as that of two year's ago, they are awaiting more cost/performance-effective products. But in Europe and Asia the situation is not the same as in the U.S., the cable TV is just in the initial stage, and the interactive TV can play an extremely helpful role in the education field. There are great demands for set-top box.

One newly emerging technology trend mentioned here is : on the Western Cable Show held in California in November 1995, a new alliance from all of the top North American cable companies and cable-modem manufacturers including General Instrument, HP, Motorola, Scientific-Atlantic, Zenith and Intel has set an ambitious schedule for tapping the potentially huge cable-modem market. The cable-modem makers pitched the cable modem for providing internet access will be 1,000 times faster than telephone modem. It will be the replacement of current telephone modem used in current set-top box.

**General Instrument** (GI) has about 65% of the set-top box market during the early of 1994, it shipped about 4 million set-top boxes annually. GI had orders for more than 4.5 million digital-based set-top boxes. Each of these boxes can accept a linX module [5]. GI has taped Motorola to manufacture and sell two GI-designed semiconductor circuits for digital compression equipment. Motorola launched the first implementation of "dual-mode" DigiCipher II/MPEG-2 video circuits. This will ensure interoperablity of the products with a wide variety of television, computer and consumer electronic products (Telephony, Mar. 14, 1994, Page 20).

**Scientific-Atlanta** (SA) once took about 25% of market for set-top box. SA won a large volume of orders of set-top boxes from Continental Cablevision, Time Warnere and Cablevision Systems, and is building boxes for Time Warner's Full Service Network trial in Orlando. 4000 homes in Florida used $4000 set-top box based on a Silicon Graphics Workstation. SA is also building a set-top box based on 3DO chipset for a US West trial in Omaha. SA admitted openly that the 3DO technology is too expensive to hit $300 [5]. SA's boxes would support both DigiCipher and MPEG 2 in a single system. DigiCipher enables a cable or satellite system to deliver up to 10 compressed channels in the same amount of space used by a single conventional TV channel.

**Zenith**, number three in the market of set-top box in 1994, provides more than 350,000 set-top boxes for Videotron and Videoway. They have made major inroad with some of the RBOCs (like Ameritech and Nynex) [5].

**Hewlett Packard** is becoming a major set-top box manufacturer. It gets the help from Tele-Communications Inc. (TCI). HP has so far received volume orders from TCI, Comcast and Cox for its Kayak digital/analog set-top box. It is planned to ship Kayak in 1996 [7].

**AT&T** Microelectronics hardwired compatibility for Europe's Digital Video Broadcast (DVB) standard into its latest MPEG-2 system-layer demultiplexer. The chip recently won a design slot in a new digital set-top box from Nokia Satellite Systems, which in turn has lined up an order from Germany's Kirch Group for 1.5 million boxes. Shipments are expected to start from the second quarter of 1996 [7].

**IBM** -manufactured boxes, which will incorporate both IBM and Videoway technology, will include MPEG-2 video compression technology and IBM's PowerPC chip to give them more memory and higher speeds than the set-top boxes that the Canadian cable TV company has used elsewhere. IBM/Videoway boxes will enable users to make banking and purchasing transaction - by swiping credit or smart cards through a scanner - without using their telephones. Subscribers will also get printers so that they can print out copies of all their transactions (Telephony, Mar. 1, 1994, Page 16-17).

**Microware System** Corp. recently announced the David operating system 2.0 for set-top box, which provides an

approach that cuts system memory requirements to 256 Kbytes of ROM at most and less than 128 Kbytes of DRAM. The new OS omits such functions as play from local memory, animation and support of sprites, while reducing graphics capabilities from 16-bit/32-bit down to 4-bit/8-bit graphics. It also dispenses with support for bi-directional control channel and for full-channel, session and download management [7], and has widely been adopted by IBM, Philips, Zenith etc. in many set-top boxes as the operating system.

**Microsoft** has developed an "end-to-end solution" software for TCI's interactive TV network trial in Seattle area. The software will install in video servers, set-top boxes and other control points along TCI's network. The trial will be the first large-scale test of Microsoft software for interactive TV system.

**Bell Atlantic** has announced plans to use DiviCom's MPEG 2 encoder to transmit digital compressed cable programming in the company's New Jersey region. The telephone company also has selected DiviCom to provide set-top boxes for its northern Virginia interactive market trial. Microware will provide its David operating system for the boxes. Bell Atlantic is focusing on the software that will be used in its interactive video network, specifying in its request for quotations to set-top box manufacturers that their systems must be equipped with Apple's QuickTime and Oracle's Media Objects authoring software (*Telephony, Jul. 25, 1994, Page 7*).

**Macromedia and Microware** have joined forces to provide a software tool to help developers create interactive programming to run over telephone and cable TV networks employing set-top boxes with Microware's David operating system. The tool will be based on Macromedia's Director software which is used to create CD-ROM game combining video, graphics, audio and text, and convert existing materials for interactive use. It is the best high-level authoring tool for interactive networks compared with other tools available today. It runs on the idealized machine layer (IML), which maps device-independent instructions for management of image, memory, sound and other functions to the specific instructions that the target device uses. The technology's small code and runtime memory footprint make it particularly well-suited for the memory-constrained environments and low-cost requirements of TV set-top boxes (Telephony, Aug. 15 1994, Page 10).

**In Europe**, Nokia's box is essentially positioned as a multimedia terminal for the home, offering broadband entertainment via satellite or cable; telephony connectivity, to allow e-mail, fax, internet services; and hookups for such PC peripherals as CD-ROMs and printers. The box runs a Nokia-developed real-time operating system on Motorola's 68340 CPU and is equipped with a telephone modem; serial data interfaces, including SCSI and RS-232; and demodulation/decompression capabilities based on Europe's DVB standards and MPEG-2 [7]. Open TV, a platform-independent operating system, was developed by an alliance of Sun Microsystems Inc., and Thomson Multimedia Interactive TV, Paris. The alliance was formed in 1994 to develop end-to-end interactive TV solutions and has been applied in Europe and South Africa.

**Asia** is a potentially huge and rapidly expanding interactive TV market. Nippon Telegraph and Telephone Corp. (NTT) has selected Silicon Graphics to help it to build a trial interactive TV network in Japan which is the first of this kind system in Asia. They worked together to design the set-top boxes. The interactive system trial began in late 1995, providing services include video-on-demand, home shopping, distance learning, remote medical consultation etc. Recently Taiwan Industrial Technology Research Institute launched its set-top box prototype. It is expected to put this mature products into market in one or two years through the cooperation with Acer, Sampu, Tatung and Philips. In addition, a working-closely alliance of more than 20 famous companies, allying computer, domestic appliance, cable TV and IC manufacturers, was announced to be established to aim at the full interactive service. Righttiming Electronics Corp. is developing TV set-top box suitable for Chinese market using its recently purchased Amiga's technologies. Amiga provides a full solution from chipsets to operating system to software tools to authoring workstations to application software, especially its ease to use with TV and low price. All of these features make Amiga considerably suitable for and competitive for Cable TV application [5].

## 4 Discussion

The need to develop standards for interactive TV systems has emerged as one of the important issue in the industry. Set-top boxes must be open and accessible to all programmers and based on standard video signal compression systems. If standards do not emerge, systems will not be interoperable, equipment costs will be higher than necessary and massive commercial deployment will be slowed down. Recently a group called Open Set-top Executive Interest Group sponsored by the Corporation for Open Systems (COS) has initiatively concentrated on defining key technical requirements and architectures for a robust and open set-top box. The group involves many leading companies in this areas such as Bell Atlantic, Ameritech, BellSouth, Nynex, US West, Southern New England Telephone, Bellcore, Computer Sciences Corp., General Instrument, IBM, Northern Telecom, Scientific-Atlanta, Unisys and Zenith Electronics. Another group - known as DAVIC for Digital, Audio, Video, Council - is also dedicated to the standards for video-on-demand. Both COS and DAVIC will play an important role in defining interactive standards. The key requirement to be defined is standardized signaling between video server and set-top box (*Telephony, Jun. 13, 1994, Page 10*). There are many interactive TV trials, but up to now it has not been widely applied, the main cause is lacking standards.

Today there is no single company exists that can tackle all the various technologies of an end-to-end interactive TV system and provide a full solution. From the video server through the ATM switch and down to the set-top boxes,

Table 3-1 Major schemes of interactive TV market in Europe and Asia

| Network provider | Location (subscribers) | Start date | Network type | Operating system | Hardware |
|---|---|---|---|---|---|
| BT | U.K. (2,500) | 1995 | Asynchronous digital subscriber line (ASDL) | MacOS | Apple |
| Cambridge Cable | U.K. (250) | 1994 | Fiber/Coax ATM | — | Online Media |
| Bell/Nynex/ Telewest | U.K. (1,000) | 1996 | — | — | — |
| Deutsche Telekom | Germany (1.5million) | 1996 | Satellite, fiber/coax ASDL/ATM | Nokia | Nokia, IBM, Alcatel, HP |
| France Telecom | France (1,000-2,000) | 1996 | ADSL, Fiber-to-the-home | — | Philips, SEMA |
| Canal Plus | France | 1996 | Satellite | — | Sony,pioneer, Sagem, Philips Thomson |
| Swiss Telecom | Switzerland (800) | 1995 | Coax | — | Philips |
| Svenska Kabel TV | Sweden (500) | 1995 | Fiber/coax | — | Digital, Vela Research |
| Telecom Italia | Italiy (1,000) | 1995 | ADSL (E1) | OS-9/ David | Bell Atlantic |
| Telecom Austria | Australia (2,500) | — | ADSL (E1) | QS-9/ David | CLI |
| Hong Kong Telecom | Hong Kong (65,000) | 1995 | Fiber-to-the-building, ATM | OS-9/ David | NEC |
| Korea Telecom | Korea (100) | 1995 | ADSL (T1) | OS-9/ David | Samsung |
| City TV Nakano | Japan (300) | 1995 | Fiber/coax ATM | OS9/ David | Fujitsu |
| Rightiming | China | 1996 | Fiber/coax | Workbench | Amiga NC |
| Singapore Telecom | Singapore (300) | 1995 | ADSL/ATM | — | — |
| JAST | Japan | 1996 | Satellite | — | — |

Mostly based on the source:: *SAMBA INFORMATION INC. , TELECOMEUROPA , EE TIMES*

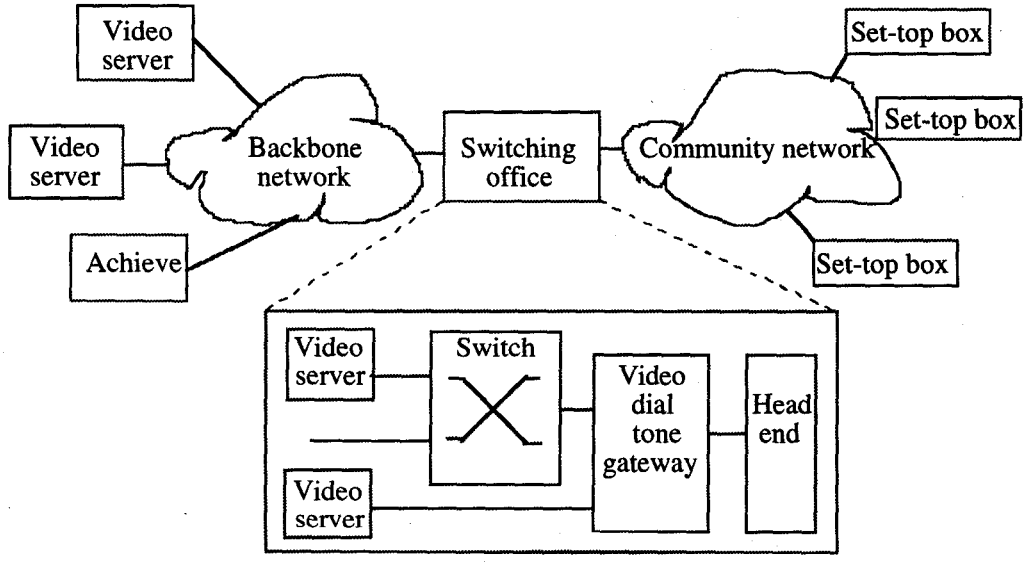


Figure 4.1 Elements of interactive TV systems

there is much hardware integrated software. It needs the close cooperation among network provider, video server vendor, software developer, set-top box maker, IC manufacturer, standards agency etc. to implement interactive TV systems. Alliance will be a trend in near future. Recently AT &T and Silicon Graphics formed a new joint venture company, Interactive Digital Solution, to create software that can integrate AT&T's hybrid fiber/coaxial cable architecture and GlobeView 2000 broadband switch with Silicon Graphics' Challenge video server, and set-top box.

In the fast-moving marketplace, one generation of set-top boxes could become quickly outdated unless the box can be easily upgraded. To increase the flexibility of set-top boxes, it is an effective means to bring PCMCIA support to set-top boxes market. PCMCIA cards can be used to add modem/fax, ethernet interface or additional memory to laptop. PCMCIA technology would enable consumers to extend the life cycle, expend the functionality and simplify the installation of add-in devices to tomorrow's high-powered set-top boxes.

To achieve optimization among price, performance, reliability and ease-to-use in interactive TV systems, we should consider every element from overall and long-term view. Certainly we expect most service providers to want their services accessible by anyone with a set-top box and most users to want access to all services without having multiple set-top boxes. Figure 4-1 is an open system approach from HP. This system will enable servers and set-top boxes to provide different services in a variety of environments. We see the set-top box in the subscriber premises, by which the user interacts with the services. The set-top box, along with TV monitor and the remote control, enables viewers to be connected to video servers and browse through a selection of movie or contents such as news story, software, or games. It is important that the interface specification for set-top box be well designed from the outset because it is more difficult to replace or modify a set-top box and its associated user interface than other elements in the architecture. The services are fed and distributed to individual subscribers by switching office which refers to both central office and a cable company head-end. Within the switching office are video servers, broadband switches with port speeds of one to hundreds of Mb/s, and VDT gateway. Beyond the local switching office, backbone networks provide access to servers that do not reside in the local switching office and to regional, national, or other specialized repositories of information [3]. The current trend also shows that Java engine should be added to the Set-top Box, in order to run any program written in Java or JavaScript on internet.

## 5 Conclusion

There are many kinds of set-top boxes being used in the current trials. The standards do not exist yet and every system is different. The set-top box with full MPEG decompression capabilities is still a little expensive, but by adjusting its definition and massive production it is possible to get the price down below $300. Technical trends for cost-effective set-top box include one chip digitizing solution which can not only reduce the cost, but also escalate the performance and is expected to appear in 1996 based on the report of LSI Logic Corp., [9]; leaner OS and user driver which can be seen in the latest David operating system from Microware System Corp.

Further we expect, through the standardization, the set-top box will become a standard component which can be integrated into the television itself and eventually an open-system solution will emerge. In such systems, all services from different providers will be accessible for anyone with a set-top box, and most users can access all services in the network without having multiple set-top boxes. It needs a great deal of cooperation and effort among the network operators, cable TV companies, equipment providers and content providers to achieve a low-cost, interactive open-system service. We have seen the rapid developing momentum and many rudiments of set-top box recently. We believe, driven by the strong force of entertainment, information, and education service, the set-top box will play an extremely important role in the near future and be bound to have a prosperous days.

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