Dunelm

CABLE MODEMS & SET-TOP BOXES: A MARKET & TECHNOLOGY REVIEW

Course Workbook

A course developed by Dunelm Services Ltd.

Publications History

The publications history for this course workbook is:

Courseware Version	***Date***	***Summary of Amendments***
A	19th March, 2001	The first release of this courseware.

PREFACE

This is the workbook which accompanies the one day Dunelm Services course entitled **Cable Modems & Set-top Boxes: Market & Technology**. It is intended that this course should act as a review of the key markets and technologies for cable networks.

It should always be borne in mind that the field of communications networking is evolving very rapidly, particularly in the case of broadband digital cable networking, and that some of the material covered in this course is accurate only for a short time – particularly that relating to the actual standards and products, etc. This means that when this material is reviewed in future times the reader must take into account this progression of technology. Of course, the fundamentals will never change – or only very rarely !

The main text is split into three sections:

SECTION A. This presents the information about the organisation of the course and its material. It presents the publications history, contents list, syllabus, timetable, symbol set, an extensive list of relevant abbreviations used in cable networks and set-top boxes, and a tutorial paper on cable modems.

SECTION B. A copy of every overhead slide used in the course is presented. There is also space for the delegate to write in their own accompanying comments. The areas covered in the slides are: THE MARKETPLACE – the market context for the roll-out of cable network technologies; CABLE MODEM TECHNOLOGY – a review of cable modem standards, specifications and technology; SET-TOP BOX TECHNOLOGY – a review of the set-top box standards, specifications and technology; ALTERNATIVE TECHNOLOGIES– a review of the alternative access networking technologies; REVIEW– a review of the materials covered in the rest of the course.

APPENDICES. Appendix A contains a bibliography, Appendix B is a glossary of terms, Appendix C contains a white paper on cable modem performance, Appendix D a data-sheet for at simulation software tool that supports accurate prediction of cable network performance and Appendix E which contains the resume of the course presenter.

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Aims & Objectives

The aim of this course is:

> *"To provide an appreciation of the services that will be available through cable modems and set-top boxes."*

The objectives for the fulfilment of this aim are to:

1. Introduce the different competing technologies and to explain the strengths and weaknesses of the services supported by each solution;

2. Describe how the different technologies support quality of service and to explain how this will be perceived by the user;

3. Show how cable modem and set-top box technologies will evolve to provide an extensive set of user services.

It is not the intention of this course to provide an in-depth description of cable networking but to provide a basic understanding of some of the new specifications.

SYLLABUS

1. The Marketplace
- A. An operator's perspective
- B. A technology supplier's perspective
- C. A user perspective
- D. Cable modem and set-top box manufacturers

II. Cable Modem Technology
- A. Cable modem standardisation (inc. DOCSIS, IEEE 802.14 and DVB)
- B. J.83 and J.112 with Annex A and B
- C. DOCSIS specifications (v1.0 and v1.1) – the services
- D. DVB-RCC, ETS200800, EuroModem – the services
- E. EuroDOCSIS and EuroDOCSIS vs. DVB-RCC
- F. Performance comparisons and expectations
- G. End-to-end services and systems

III. Set-top Box Technology
- A. The EuroBOX specifications – relevance, service strengths/weaknesses
- B. The OpenCable specifications – relevance, service strengths/weaknesses
- C. The Multimedia Home Platform
- D. Cable modem and set-top box mixed network architectures and services
- E. End-to-end services and systems

IV. Alternative Technologies
- A. Satellite access (VSAT, DVB-RCS)
- B. Fixed broadband wireless access
- C. x-DSL access (from POTS to NISDN and ADSL)
- D. The killer application and its needs, integration not homogenisation

TIMETABLE

9:30 -10:00	Introductions
10:00 -11:00	The Marketplace
11:00 -11:30	*Coffee Break*
11:30 -1:00	Cable Modem Technologies
1:00 - 2:00	*Lunch Break*
2:00 - 3:15	Set-top Box Technologies
3:15 - 3:45	*Tea Break*
3:45 - 4:30	Alternative Technologies
4:30 - 5:00	Course Review

TUTORIAL PAPER

Choosing the DOCSIS or DVB/DAVIC Return Channel Path for Interactive Services

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Abstract

The development of a standard for interactive multimedia services over Community Antenna Television (CATV) networks is drawing interest from the data communications, telecommunications, broadcasting, consumer electronics and the computer supply industries. Until recently, the solutions available for data transfer over Hybrid Fibre Coax (HFC) CATV networks were based on proprietary random access protocols and consequently they cannot be used in an open system. Also, they are limited when delivering digital audio and video streams. A unified standard is required, that will allow the development of interoperable hardware and drive down the cost of implementation. In Europe the Digital Video Broadcasting (DVB) and the EuroDOCSIS Cable Modem specifications have been adopted whereas the Data Over Cable Service Interface Specification is the choice in North America.

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1. Introduction

The potential of data delivery over Community Antenna Television (CATV) networks was realised as early as the 1960s. The first to benefit were public institutions while the technology was tested by utility companies for telemetry applications. Since then the demand for high bandwidth at the home has risen sharply and before a unified standard could be ratified. The majority of CATV networks in North America are based on the tree and branch architecture. Alternative topologies are the tree and bush, found mainly in Europe, and the rarely used switched star architecture which uses off-premises addressable converters. Fibre has replaced coaxial feeds from the head-end to the initial splitter to create the Hybrid Fibre Coax (HFC) topology. The HFC topology provides immunity from electromagnetic noise and the elements for the transmission over large distances, and the cost efficiency of coax cable for the last mile.

Cable Companies are now exploring new technologies which can be used to support digital interactive multimedia applications over their CATV infrastructures, [Azzam, 97]. Over the last few years much attention has been paid to the development of architectural options for CATV networks that will allow the immediate support of broadband services as the first step toward enhanced communication services for residential users.

These technologies range from the introduction of well established Internet devices to new access mechanisms. The current CATV standards activities, [Tzerefos, 98], are:

- IEEE 802.14 – the IEEE committee producing a broadband Metropolitan Area Network (MAN) Medium Access Control (MAC) and Physical layer protocols and the Advanced High Speed Physical Layer;
- ATM Forum Residential Broadband Working Group (RBWG) – investigating the provision of Asynchronous Transfer Mode (ATM) across different CATV network topologies and for distribution within the home itself;
- Internet Engineering Task Force (IETF) – investigating the use of the Internet Protocol (IP) Over Cable Data Networks (IPCDN). This work is based upon the use of routers to interconnect different logical internet structures;
- Multimedia Cable Networks Systems (MCNS) partners – producing the Data Over Cable Service Interface Specifications (DOCSIS) on behalf of the North American Cable industry and using cable modem technology;
- Digital Audio-Visual Council (DAVIC) – primarily a European driven group, but including many international companies, looking at the standards for complete end-to-end interactive multimedia delivery systems;
- SCTE – an accredited American standards organisation working on compatibility issues for cable telecommunications systems. The SCTE has successfully submitted the MCNS specification for acceptance by the ITU-T;
- The Digital Video Broadcasting (DVB) project – the DVB cable system (DVB-C) was completed in 1995. DVB has adopted the DAVIC recommendations with respect to CATV and has been responsible for the development of the European standard ETS 300800.

The following sections of this paper describe:

- Cable Modem Architectures – a review of pre-standardisation cable modems;
- CATV Data Standardisation:A summary of cable modem standardisation;
- DOCSIS Specifications – a review of the DOCSIS, versions 1.0 and 1.1, cable modem standard;
- DVB/DAVIC Specifications – a review of the DVB/DAVIC cable modem standard;
- DOCSIS/EuroDOCSIS/DVB-RCC Comparison – a review of the capabilities of the DVB-RCC/DAVIC, DOCSIS and EuroDOCSIS cable modems with relevance to the Digital Interactive Retailing business.

2. Cable Modem Architectures

HFC networks were originally designed for analogue audio and video broadcasts. Providing high performance multimedia services to the home over HFC networks presents difficulties due to the inherent problems of these architectures such as long propagation delays, signal attenuation, the high level of noise on the upstream direction and the sharing of bandwidth by all homes in the same loop. Another issue is the integration of the home network, the bearer HFC and the provider's network. The network infrastructure consists of the 'Head-end', the 'Residential' and the 'Home' networks. The Head-end network has to interconnect the servers of the content provider, which need not necessarily be physically located within the same premises, and can be built on upon any of the established MAN and Wide Area Network (WAN) architectures. The Residential network has to provide access to the content provider's servers via the HFC cabling infrastructure. The major limitation of HFC networks is they are broadcast networks with simple or no switching and so the bandwidth is shared among a large number (thousands) of nodes within the same segment. The Home network provides the communications between the cable modem (the gateway) and the appropriate domestic appliances such as television, telephone, PC, etc.

In CATV networks, the spectrum is divided into the forward (also referred to as the downlink, downstream and head-end to user) and return (also referred to as the uplink, upstream and user to head-end) frequencies. Table 1 shows the basic downstream and upstream spectrum allocations and the slight variations in the frequency ranges for Europe, North America and Japan are also shown. The downstream channels support the legacy analogue broadcast television (80-450MHz, the exact value depending on the country) and the multiples of 1-6MHz or 1-8MHz channels in the 450-900Mhz region (the exact value depending on the country). The upstream channels are also divided into 1-6MHz but the high ingress noise means that the data capacity is only 1-10Mbps per channel as opposed to the 28-40Mbps available in each downstream channel. In terms of modulation schemes, most manufacturers have implemented 64 Quadrature Amplitude Modulation (QAM) for the downstream and Quadrature Phase Shift Keying (QPSK) for the upstream channels, thereby creating the difference in data rates between the downstream and upstream.

Table 1 CATV frequency allocations across the world.

Characteristics	**Europe**	**Japan**	**North America**
Upstream (digital)			
Standards	ITU-T J.112-A	ITU-T J.112-C	ITU-T J.112-B
Minimum Frequency (MHz)	5	5	5
Maximum Frequency (MHz)	65	55	42
Channel Bandwidth (MHz)	1-6	1-6	1-6
Downstream (analogue)			
Minimum Frequency (MHz)	110	90	88
Maximum Frequency (MHz)	Operator Specific	Operator Specific	Operator Specific
Channel Bandwidth (MHz)	8	6	6
Downstream (digital)			
Standards	ITU-T J.83-A	ITU-T J.83-C	ITU-T J.83-B
Minimum Frequency (MHz)	110	90	88
Maximum Frequency (MHz)	862	770	860
Channel Bandwidth (MHz)	8	6	6

The downstream cable transmission characteristics in different parts of the world have been defined by the ITU-T as part of the J.83 standard [ITU, 97]. This has three annexes:

- Annex A – derived from the Digital Video Broadcast (DVB) standard originated in Europe. A Motion Picture Encoding Group 2 Transport Stream (MPEG2-TS) is used within an 8MHz channel. DAVIC has selected Annex A;
- Annex B – a transmission format widely accepted in North America. An MPEG2-TS is used within a 6MHz channel;
- Annex C – defined for Japan. An MPEG2-TS is used within an 8MHz channel.

The upstream cable transmission characteristics in different parts of the world have been defined by the ITU as part of the J.122 standard [ITU, 99]. This also has three annexes:

- Annex A – the upstream definition for DVB/DAVIC based architectures;
- Annex B – the upstream definition for the DOCSIS based architectures;
- Annex C – the upstream definition for usage in Japan.

The J.112 standard permits the different upstream systems to be marketed in their 'foreign' environments e.g. J.112 Annex A in the US and J.112 Annex B in Europe.

The cable modem technology originally deployed does not comply with a specific standard. Instead it is based on proprietary interfaces for the cable modem to head-end communications, and interoperability is impossible. The most common interface between the cable modem and the subscriber device is a 10BASET Ethernet connection (USB interfaces are becoming more widely available). Most PCs/workstations are supplied with Ethernet interfaces and so they can be easily connected to a cable modem.

In Figure 1 the key components in a cable modem network are:

- The cable modems/Set-Top Boxes (STB) which are used to supply the subscriber interface capability. In the case of the STB, the cable modem functionality is supplied as part of an integrated consumer device. A 10BASET Ethernet interface is normally used for interconnection to the user's PC/workstation;
- The head-end controller which is responsible for allocating upstream and downstream bandwidth, and for forwarding the data from the upstream onto the downstream. The head-end is also responsible for aggregating multiple upstream channels onto a single downstream channel;
- The CATV data manager which is responsible for management of the data infrastructure. This PC/workstation is responsible for distributing all of the appropriate default control parameters and information;

The router/IP switch which is used to interconnect the head-ends (each head-end will support between 500-2000 cable modems and so most commercial cable plants will require many data head-ends). Head-ends are supplied with a LAN interface and the router/IP switch is used to provide high speed interconnection plus internetworking with other networks e.g. the Internet.

In July, 1999, the Broadband Bob newsletter

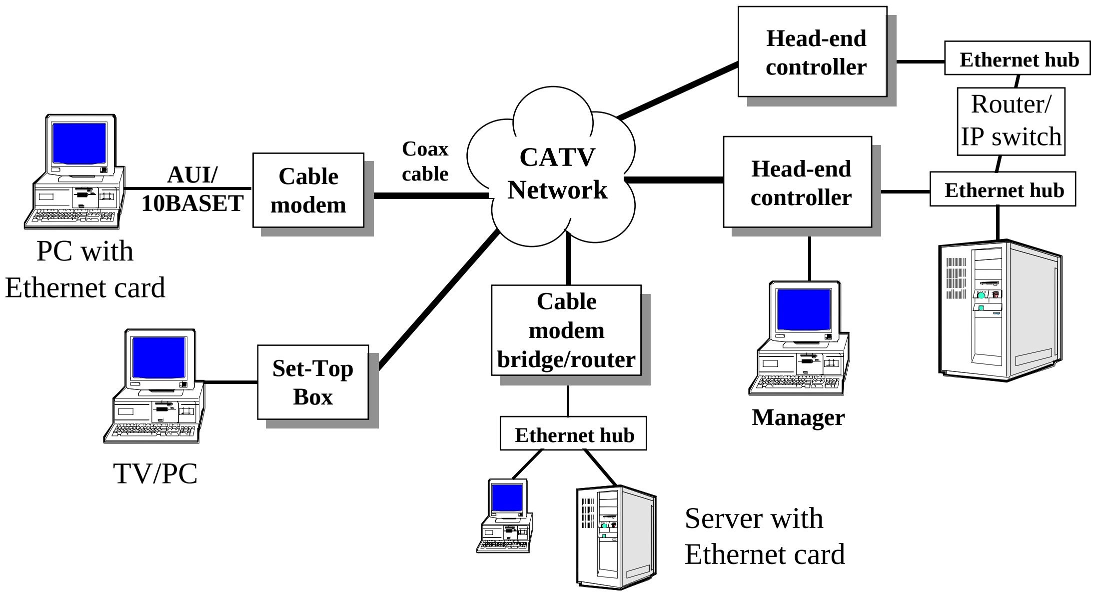

Figure 1 A cable modem architecture.

announced the following cable modem installations market analysis, shown in Table 2. The statistics in Table 2 denote the shipping of all types of cable modem i.e. the inclusion of proprietary solutions from organisation such as Nortel/Arris, Motorola, Com21, etc. CableLabs keep an accurate record of vendors who have certified cable modems and qualified CMTSs.

At present there is very little independently verified information on situation regarding the supply of DVB/DAVIC compliant cable modems. It is however clear that for the next five years the cable modem market will be based upon:

- The provision of DOCSISv1.1 compliant cable modems for usage in North America. It is claimed that some North American operators are evaluating DVB/DAVIC-based solutions however it is clear that DOCSIS will be the only accepted cable modem technology. The success of the CableLabs interoperability testing (resulting in certification and qualification) also provides operators with a confidence is not yet available for the EuroModem solution;
- The UK will be dominated by the usage of DOCSIS and the EuroDOCSIS solutions, in part because most of the UK cable operators now have US ownership. The UK has a long track record of preferring US produced data communications equipment;
- The rest of Europe will be adopt both DVB/DAVIC and the EuroDOCSIS solutions.

Table 2 Cable modem shipments as of July, 1999.

Vendor	Ship ment	Share	Vendor	Ship ment	Share
Motorola	760,000	44%	Samsung	20,000	1%
Nortel/Arris	490,000	28%	Thomson	20,000	1%
Terayon	145,000	9%	NetGame	15,000	1%
Com21	140,000	9%	Toshiba	15,000	1%
Zenith	35,000	2%	Hybrid	15,000	1%
GI	30,000	2%	Phasecom	10,000	0.75%
3Com	25,000	1.5%	Miscellaneous	10,000	0.75%

3. Cable Modem Standardisation

The current CATV standards activities and organisations, [Tzerefos, 98], are the:

- ATM Forum Residential Broadband Working Group (RBWG);
- Internet Engineering Task Force (IETF);
- Multimedia Cable Networks Systems (MCNS) partners;
- IEEE 802.14 subcommittee;
- Digital Audio-Visual Council (DAVIC);
- Society of Cable Telecommunications Engineers (SCTE);
- The Digital Video Broadcasting (DVB);
- International Telecommunications Union for Telecommunications (ITU-T);
- CableLabs;
- EuroCableLabs;
- European Cable Communications Association (ECCA);
- DVB/DAVIC Interoperability Consortium;
- European Cable Modem Consortium.

3.1 ATM Forum Residential Broadband Working Group (ATMF-RBWG)

The RBWG was formed by the ATM Forum in order to promote the deployment of ATM over emerging residential network infrastructures. The efforts of the RBWB focus on the delivery of ATM to the home and ATM within the home. The network topologies considered for delivering ATM down to the last mile are: ATM over HFC, ATM over Fibre To The Curb (FTTC), ATM over Fibre To The Home (FTTH) and ATM over ADSL. ATM-To-The-Home (ATTH) is proposed for the support of new generation of interactive services over CATV networks. ATM is a broadband network technology which features high bandwidth and guaranteed quality of service and the ATM Forum has recently established a group that is standardising the interfaces for the deployment of ATTH over the different network architectures. The major concern when implementing ATM over CATV networks is the definition of the protocols that would allow the deployment of ATM over the different cabling plants (HFC, FTTH, FTTC and ADSL) already in operation i.e. a legacy systems problem. ATM can be implemented over HFC networks by placing an ATM switch within the head-end to interconnect the server with the rest of the cable plant. In turn each port of the ATM switch must be logically connected to each downstream channel. At the subscriber's end the receiver must be tuned to the right frequency before decoding ATM cells. The two basic interfaces under development are the ATM Digital Terminal (ADT) at the head-end and the ATM Interface Unit (AIU) at the subscriber. The ATMF-RBWG specification was ratified in 1998 [ATMF, 98].

3.2 Internet Engineering Task Force (IETF)

The IETF has formed a working group that will produce a framework and requirements document for IP over a CATV infrastructure. Issues to be addressed by the IPCDN WG are the service interface between IP and CATV network, multicast, broadcast, address mapping and resolution (for IPv4), neighbour discovery (for IPv6) and network management.

The deliverables, originally expected from the WG are:

- RFCs covering the framework architecture, requirements and terms of reference for Cable Data Networks;
- IPv4-over-HFC access network document covering the mapping of IP over RF channels, encapsulation and framing of IPv4 packets, IP to modem and/or PC address resolution, multicast and broadcast;
- IPv6-over-HFC access network document covering the mapping of IP over RF channels, encapsulation and framing of IPV6, IP to modem and/or PC address resolution, neighbour discovery, multicast and broadcast;
- A media specific Management Information Base (MIB) for managing the HFC spectrum;
- A MIB for managing the cable data network services including the management of IP over the CATV network itself.

The IPCDN has already released an Internet Draft document presented for discussion purposes only and not for setting any standards. Issues covered are IP service features, IP address assignment using the Dynamic Host Configuration Protocol (DHCP), Address Resolution Protocol (ARP) and other service specific issues relating to IP over CATV. At present the primary focus of the IETF's work is on the adoption and extension of the DOCSIS MIB.

3.3 Multimedia Cable Network Systems (MCNS)

The MCNS partners consist of Comcast, CableLabs, TCI, Cox Communications, Time Warner, Continental Cablevision, Rogers Cablesystems, CableLabs and Arthur D. Little. The task of the Data Over Cable Service Interface Specification (DOCSIS) project was to define, on behalf of the North American cable industry, the required communications and operations support interfaces for cable modems. Originally CableLabs was producing their own standard but this was superseded by the activities of the MCNS. Thus far DOCSISv1.0 and DCSISv1.1 have been produced and there is debate about whether or not to develop DOCSISv1.2. The DOCSIS cable modem solution is discussed in Section 4.

3.4 IEEE 802.14 Subcommittee

The IEEE 802.14 subcommittee's work focused on the definition of a MAC protocol and network access techniques for data communications services over CATV networks. The access techniques originally under consideration were the contention reservation system, polling and a slotted collision system that can be extended to include reserved bandwidth. In the opinion of the IEEE 802.14 subcommittee, the other IEEE 802 LAN/MAN access protocols then available did not meet the requirements for the HFC network:

- FDDI and DQDB could, potentially, have supported the required services but they are based on inappropriate topologies;
- The LAN standards, such as Ethernet, do not support real-time services and are unsuitable for networks covering tens of kilometres;
- The IEEE 802.4 Token Passing bus is based on the same branching coax bus topology as the HFC networks but is designed with the needs of industrial installations in mind and assumes that all nodes are on line at all times.

Three IEEE 802.14 cable modem standards were developed for consideration:

- IEEE 8-2.14a – the original IEEE 802.14 CATV protocol. This will only be ratified if some vendor decides to manufacture IEEE 802.14 cable modems;
- IEEE 8-2.14b – the advanced high speed physical layer specification;
- IEEE 8-2.14c – adoption of the DOCSISv1.0 standard.

The IEEE 802.14 has been made dormant. It will not recommence its work unless at least one major manufacturer decides to adopt the IEEE 802.14a/b specifications.

3.5 Digital Audio-Visual Council (DAVIC)

The Digital Audio-Visual Council (DAVIC), founded in October 1994 and based in Geneva, was a non-profit making Association which has charged itself with the task of promoting broadband digital services. The goals of DAVIC were declared as "... to identify, select, augment, develop and obtain the endorsement by formal standards bodies of specifications of interfaces, protocols and architectures of digital audio-visual applications and services". The applications of particular interest were Video-On-Demand (VOD) and Near VOD (NVOD). DAVIC produced a series of specifications and version 1.5 was made available in June, 1999. The earlier DAVIC specifications define different grades of existing tools or additional tools which provide compatibility with the full range of new Internet facilities e.g. web browsers and Java, [Donnelly, 97]. DAVIC specifications contain normative and informative parts. The normative parts must be implemented as in the specifications in order to claim conformity and the informative parts are included to help clarify the normative parts and to give assistance to those attempting to implement the specifications. The specifications define reference points, i.e. points of particular interest in the system, and these points have a normative value if they are accessible.

A DAVIC delivery system is divided into a core network, an access network and an in-house network. The separation between the core and access network is formed between the Local Exchange (LE) and the Access Node (AN). The separation between the access node and the in-house network is formed by the Network Termination (NT). In the majority of cases the end-service consumer system will contain a STB which can be divided into a network dependant part called the Network Interface Unit (NIU) and the network independent part called the Set Top Unit (STU). The in-house network is contained between the NT and the STB, however, DAVIC 1.0 ignores the in-house network and considers the STB to be connected directly to the NT. DAVIC 1.5 Part 8 is equivalent to the DVB-RCC/ETS300800 specification. DAVIC 1.5 also contains a specification for the in-house LAN. DAVIC was disband in June 2000 because the committee considered that its goals had been achieved.

3.6 Society of Cable Telecommunications Engineers (SCTE)

The SCTE is a non-profit organisation formed in 1969 in order to promote the sharing of technical and operational knowledge for cable TV and broadband communications. As of August 1995 the SCTE became an accredited Standard Developing Organisation of NIST. The Data Standards Subcommittee role is to promote data delivery in the cable industry and define standards for hardware interoperability. In it's charter it is mentioned that the subcommittee will co-ordinate it's efforts with the IEEE 802.14, DAVIC and CableLabs. On August 13 1997, the SCTE submitted the MCNS specification for the transmission of data over cable to the International Telecommunications Union (ITU). DOCSIS, has always been a compromise between the best technological solution and the standard that would allow modem manufacturers to produce interoperable hardware to satisfy the increasing demand for data over cable.

3.7 Digital Video Broadcasting (DVB)

The DVB Project emerged from a group, called the Launching Group, of European broadcasters, consumer electronics manufacturers and radio regulatory bodies in September 1993. It expanded to include public and private interest groups and currently comprises more than 220 members from 30 countries. The main focus of DVB is the delivery of digital TV over satellite, terrestrial and cable links. The DVB-S is satellite specification designed to operate within a range of transponder bandwidths (26MHz to 72MHz, -1dB). The cable network, DVB-C system has the same core as the satellite system, but the modulation system is based on quadrature amplitude modulation (QAM) rather than QPSK, and no forward error-correction is needed. Initially DVB recommendations did not cater for bi-directional communications. However the implementation of interactive TV will require data on the reverse direction. Therefore the DVB group is turning to other standardising bodies in order to produce a specification with a wider range of applications which will span beyond digital TV broadcast such as Internet access, videoconferencing etc. At the initial stages DVB was evaluating which standard would be the most suitable for the delivery of MPEG-2 audio/video streams over CATV networks. At its meeting in July 1997 DVB announced it would adopt the DAVIC 1.2 specification. Both the UK and ECCA announced that they were going to support the DAVIC/DVB standard and this has become a European norm. The ETS 300800 standard has now been produced as the specification of the interaction channel for CATV distribution systems [ETS, 98]. The DVB-RCC solution is described in Section 5.

3.8 ITU Telecommunications Standardisation (ITU-T)

The ITU is one of the United Nations' standing committees responsible for the development of world-wide communications recommendations from the suppliers' perspective (ISO is responsible for the user's perspective). It has three sub-committees: ITU-Telecommunications standards (ITU-T), ITU-Radio standards (ITU-R) and the World Administration Radio Conference (WARC). Originally ITU-T was known as the International Consultative Committee on Telegraph and Telephony (CCITT). It is the ITU-T was has been responsible for the production of the 'J' series recommendations:

- J.83 – downstream CATV-based information transfer [ITU, 97];
- J.112 – upstream CATV-based information transfer [ITU, 99].

3.9 CableLabs

Founded in 1988, Cable Television Laboratories, Inc. (CableLabs®) is a membership organisation consisting of cable television system operators serving cable subscribers in the U.S., Canada, Mexico, and South America. It was established with the goal of ensuring that technology is made practical and accessible to the cable television industry in a timely fashion. Its mission is to plan and to fund research and development projects; to transfer relevant technologies to member companies and industry suppliers; and to serve as a clearinghouse in providing technological information to its members. Membership in CableLabs is available to cable system operators based in North and South America. CableLabs membership is composed of cable television system operators serving more than 85% of the cable subscribers in the U.S.; 80% of the subscribers in Canada; and 12% in Mexico. In November 1997, the Brazil-based cable operator, Globocabo, became the first South American member. Responding to current trends in the cable industry and to its members' interests, CableLabs is focusing on interoperability as its key guiding concept. Cable systems are changing rapidly from islands of service into interconnected regional and even national networks capable of delivering a plethora of services from a variety of sources. Companies must be able to count on interoperability, not only between interconnected cable systems, but also between cable systems and other types of networks ranging from telephone companies to the global Internet. As such CableLabs is responsible for the following projects:

- DOCSIS – the development and certification of DOCSIS compliant cable modems;
- OpenCable – the development and certification of DOCSIS based Set Top Boxes;
- PacketCable – the development of packet-based multimedia services over CATV using a DOCSIS solution. This includes work on Voice over IP (VoIP);
- CableNet – the co-ordination of conference and exhibition activities related to DOCSIS-based solutions.

3.10 EuroCableLabs

The EuroCableLabs was formed by eleven members of ECCA in October 1996. Originally named the ECCA Technical Cell (ETC) it was renamed EuroCableLabs in September 1997 and in March 1998 it was formed as an independent association. EuroCableLabs is responsible for:

- EuroModem – the European cable modem specification that conforms to the ITU-T J.83 Annex A, ITU-T J.112 Annex A, ETS 300800 and ETS 300429 specifications [ECCA, 99];
- EuroBOX – the European STB specification [EuroBOX, 98];
- EuroLoader – the specification that defines the software download functionality within a cable modem or STB;
- EuroPacketCable– the working-group looking at the support of VoIP using EuroModem technology;
- Future STB Applications & Services – this is a working-group looking at future STBs services and applications;
- In-Home Networks (IHN) – a working-group looking at domestic-based networking.

EuroCableLabs is now responsible for validating the self certified interoperability claims made by manufacturers

3.11 European Cable Communications Association (ECCA)

The European Cable Communications Association is the European Association of cable operators and groups European cable operators, as well as their national associations. The main goal of ECCA is to foster co-operation between cable operators, to promote and represent their interests at a European level. ECCA gathers European cable operators who have more than 40 million subscribers. The first informal co-operation between European cable operators started in 1949. As these informal meetings became more frequent, a formal structure for European co-operation was required and on September 2, 1955, AID (Alliance Internationale de la Distribution par câble) was set up by representatives of Switzerland, Belgium and The Netherlands. In 1993, AID was renamed the European Cable Communications Association, thus stressing the communication role of its members as well as the European goals of the Association. ECCA now has 29 members in 17 countries. It also has 5 associate members in Central and Eastern European. ECCA defends the interests of ‘private’ cable operators, of municipalities and utility companies operating cable networks, as well as those of cable operators related to telecom organisations. Eleven members of ECCA were responsible for the creation of the ECCA Technical Cell that eventually became the EuroCableLabs.

3.12 DVB/DAVIC Interoperability Consortium

The DVB/DAVIC Interoperability Consortium was created to develop interoperability among vendors building data over technology based on a DVB-RCCL/DAVIC solution. The participants include Alcatel, COCOM, DiviCom, Hughes Network Systems, Nokia Multimedia Network Terminals, Sagem, Simac Broadband Technologies, Thomson Broadcast Systems (a subsidiary of Thomson Multimedia), and Thomson Multimedia. One of the consortium’s first actions was the release of a white paper comparing

DOCSIS and DVB/DAVIC [DIC, 98].

3.13 European Cable Modem Consortium

The European Cable Modem Consortium, launched at the European Cable Communications '98 show in London, is a group of 11 DOCSIS cable modem vendors and technology suppliers. The consortium consists of 3Com, Broadcom, Cisco, Dassault-AT, DeltaKabel, Elsa, FUBA/GI, Pace, Samsung, Teldat, and Tonna. The solution to promoted to cable operators from this groups consist of a DOCSIS system modified to operate over Europe's cable television systems (DVB-C). This solution is known as EuroDOCSIS.

4. DOCSIS & EuroDOCSIS Specifications

In the DOCSIS system [DOCSIS, 96a] the transmission path over the cable network is controlled by the Cable Modem Termination System (CMTS) at the HE and the Cable Modem (CM) at the customer premises. The reference architecture shown in Figure 2 contains three interface categories:

- Data interfaces which include the CMTS Network Side Interface (CMTS-NSI) between the CMTS and the data network, specified in [DOCSIS, 96b], and the CM to Customer premises equipment Interface (CMCI) between the customer's computer and the CM, specified in [DOCSIS, 97a] for DOCSISv1.0 and [DOCSIS, 98] for DOCSISv1.1;

- Operations support systems and telephone return path interfaces which correspond respectively to network element management layer interfaces between the network elements and the high level Operations Support Systems (OSSs), defined in [DOCSIS, 97b], and the interface between the CM and the telephone return path for the cases where the return path is not available or provided from the cable network, specified in [DOCSIS, 97b];

- The RF interfaces, defined in [DOCSIS, 96b] and [DOCSIS, 98], describe interactions between the CM and the cable network, the CMTS and the cable network (in both the upstream and downstream paths).

The protocol layers for a DOCSIS architecture consist of: the network layer (IP), the data link layer and the physical layer. Specifically, the data link layer is comprised of three sublayers: LLC which conforms to the IEEE 802.2 standard; the link-security sublayer that supports the basic needs of privacy, authorisation and authentication and the MAC which supports variable-length PDUs. The physical layer is comprised of the upstream/downstream transmission convergence (U/D TC) and the physical media dependent (PMD) sublayers. The main features of the MAC protocol are: CMTS-controlled mix of contention and reservation transmission opportunities; a stream of mini-slots (units for upstream transmission opportunities and an integer multiple of 6.25ms increments) in the upstream; bandwidth efficiency through support of variable-length packets; extensions provided for the future support of ATM or other PDUs; support for multiple grades of service and support for a range of data rates.

The CMTS allocates bandwidth via MAC management messages (MAP) which describes the manner in which the upstream mini-slots must be used. Since the upstream channel is modelled as a stream of mini-slots

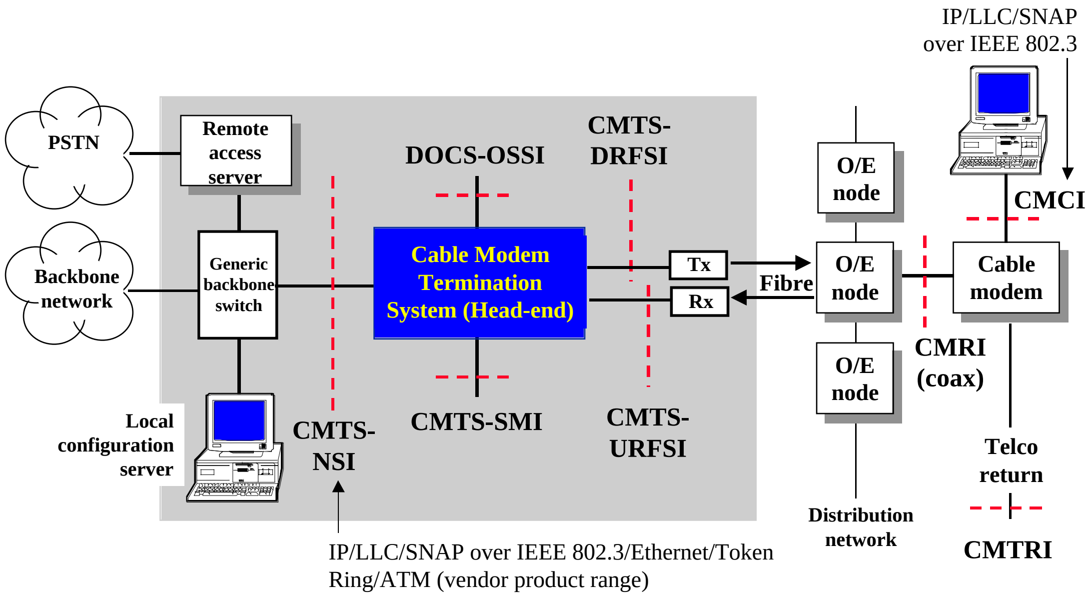

Figure 2 The DOCSIS reference model.

the CMTS must use a scheduling algorithm to determine the order of user access to the network. The basic elements of the band-width allocation scheme are:

- Each CM has one or more Service IDentifications (SIDs), 14 bits, and a 48-bit address. The QoS allocated to the cable modem is directly related to its SID group;

- CMs may issue requests to the CMTS for upstream bandwidth any time that either a request or a data PDU is allowed from a particular station;

- The CMTS schedules all of the trans-fer requests according to priority and the available bandwidth, and then releases the MAP to distribute the mini-slot allocation. The CMTS will also schedule the downstream traffic to take into account the aggregation of multiple upstreams plus loads from traffic sources which are external to the CATV network.

A CM, which has a packet to transmit, must wait until the contention slots, as defined in the last received MAP, arrive. The CM then attempts to request bandwidth by accessing one of the contention mini-slots. If more than one CM attempts to claim any one minislot then the slot information will be corrupted due to the contention. The CM only becomes aware if it has successfully requested bandwidth when the next MAP arrives. If the request was successful then the CMs SID will be identified along with the minislot number in which it can start transmission and the number of minislots assigned to it, otherwise the CM must repeat its request attempt using the next batch of contention minislots. At registration each CM declares its service priority and so in heavily used networks a low priority CM may have access to very little bandwidth.

Within the head-end there are two schedul-ing algorithms: the first is responsible for upstream access scheduling within the MAP and the second multiplexes the upstream channels onto the downstream. In both cases the scheduling algorithm attempts to provide the requested service access and when these exceed capacity to prioritise according to established service priority. In DOCSIS 1.0 the QoS provision is limited to prioritisation and frame concatenation (optional) but in DOCSIS 1.1 there is an extensive QoS definition which is derived from the Internet Protocol QoS [DOCSIS, 98]. Some work on DOCSIS scheduling algorithms has been published recently [Lin, 98], and this has focused on comparisons between IEEE 802.14 and DOCSIS in terms of upstream contention resolution and the interaction with three upstream scheduling algorithms.

5. DVB-RCC/DAVIC Specifications

Figure 3 shows the DVB/DAVIC systems reference model for interactive services [ETS, 98]. In the system model there are two channels established between the service provider and the user:

- Broadcast Channel (BC) – a unidirectional broadband broadcast channel including video, audio and data. The BC is established from the service provider to the users. It may include the Forward Interaction path;

- Interaction Channel (IC) – a bi-directional interaction channel is established between the service provider and the user for interaction purposes. It is formed by:

  – Return interaction path – from the user to the service provider. It is used to make requests to the services provider or to answer questions. It is a narrowband channel, also commonly known as the return channel

  – Forward interaction path –from the service provider to the user. It is used to provide some sort of information by the service provider to the user and any other required communication for the interaction service provision. It may be embedded into the broadcast channel. It is possible that this channel is not required in some simple implementations which make use of the BC for the transmission of data to user.

The user terminal is formed by the NIU and the STU. The NIU consists of the Broadcast Interface Module (BIM) and the Interactive Interface Module (IIM). The user terminal provides an interface to both the broadcast and interaction channels. The interface between the user terminal and the interaction network is via the IIM. The key features of the DVB system are:

- The interactive system consists of the forward and return interaction paths;

- Upstream transmission is based upon a slotted Time Division Multiple Access (TDMA) mechanism. One downstream channel is used to synchronise up to eight upstream channels, all of which are divided into time slots;

- Three major access modes are provided, namely, contention access and two contentionless access schemes;

- Out-of-band (OOB) and in-band (IB) signalling is supported. For OOB a forward interaction path is added. For IB the forward information path is embedded in the MPEG2-TS of a DVB cable channel whereas for OOB a T1-like frame structure is created;

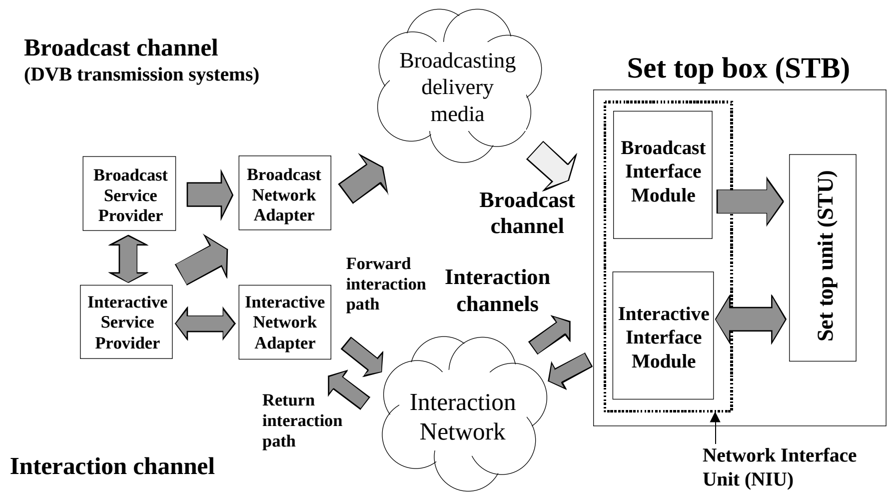

Figure 3 The DVB/DAVIC reference model.

- The spectrum allocation is based upon 70-130MHz and/or 300-862MHz for the forward interaction path (downstream OOB), and 5-65MHz for the return interaction path (upstream);
- The upstream and OOB downstream spectra are divided into separate channels of 1 or 2MHz for downstream and 1MHz or 2MHz or 200kHz for upstream;
- For the interactive downstream OOB channel a rate of 1.544Mbps or 3.088Mbps may be used. For downstream IB channels no constraints other than those specified by ETS 300 429 exist but it is expected that multiples of 8kbps will be used;
- For upstream transmission, there are four data rates namely 6.176kbps, 3.088Mbps, 1.544Mbps or 256kbps;
- Upstream frames consist of packets of 512 bits (256 symbols) which are sent in a bursty mode. The upstream slot rates are 6000 (3Mbps), 3000 (1.5Mbps) and 500 (256kbps) slots per second.

6. DOCSIS/ EuroDOCSIS/DVB-RCC Comparisons

A comparison of the service provision of the different standardised cable modems is shown in Table 3. From this comparison it is clearly seen that DOCSIS is a classical IP data communications protocol whereas both DVB/DAVIC and the IEEE 802.14 solutions support extensive ATM features. However, the answer to question:

“Which cable modem return channel path should be selected to support residential based interactive services ?”

is not determined by the quality of the technology. Instead, it will be based on the pragmatics of which technology can provide a working solution today. Only DOCSISv1.0, EuroDOCSISv1.0 and EuroModem Class A cable modems are available currently.

Table 3 A comparison of cable modem services and features.

Service/Feature	DVB-RCC/DAVIC	DOCSISv1.0/ EuroDOCSIS	DOCSISv1.1/ EuroDOCSIS	IEEE802.14/ HI-PHY
Primary Service	End to end delivery of ATM cells. Voice over IP.	End-to-end delivery of IP packets.	End-to-end delivery of IP packets with guaranteed QoS. Voice over IP.	LLC frame transmission. ATM cell transmission.
Service Modes	Contention access, reserved access, fixed rate access and ranging access. ATM ABR CBR rtVBR nrtVBR UBR.	Best Effort.	Unsolicited Grant; Real-time Polling; Non-real-time Polling; Best Effort; Committed Information Rate.	Best Effort; ATM ABR CBR rtVBR nrtVBR UBR.
Data Modes	Downstream in-band signalling; Downstream out-of-band signalling.	Prioritisation; Concatenation.	Prioritisation; Concatenation; Fragmentation.	Permanent Virtual Circuit; Switched Virtual Circuit.
User (CPE) Interface	10BaseT	10BaseT	10BaseT	Undefined but assumed to be 10BaseT.
Support Services	Main, Quick, Explicit Key Exchange Ethernet MAC bridging; Point-to-point protocol; RADIUS management.	DES encryption; TFTP, DHCP, ARP and Spanning Tree Protocol. SNMP MIB management.	DES encryption; TFTP, DHCP, ARP and Spanning Tree Protocol. SNMP MIB management.	Main and Quick Key Exchange with DES and triple-DES Security. MIB definition.

7. Conclusion

Cable networks are one of the key emerging broadband access technologies. The definition of a networking standard for the delivery of broadband interactive services over Hybrid Fibre Coaxial (HFC) networks is a challenging task due the high bandwidth demands anticipated for the new applications e.g. home-based video-on-demand, and their physical idiosyncrasies (noisy upstream frequencies, tree-based architectures etc.). The three predominant standards for cable modems are: the Data Over Cable Service

Interface Specification (DOCSIS) for North America, the DVB/DAVIC ETS200800 specification for Europe, and the IEEE 802.14 for its Advanced Physical layer specification. Roll-out of these new technologies is currently under way and there are many sites across the world which are evaluating these new systems. At present there is very little informed information about the performance capabilities of these systems and most of the published literature is based on computer simulation.

Recently the EuroDOCSIS specification has been introduced which combines the DVB downstream physical layer protocol within the DOCSIS protocols thereby producing a DOCSIS solution suitable for use within Europe. While there is a significant amount of development and roll-out of the new CATV technologies, the success of this approach is seriously threatened by alternatives such as the Asymmetrical Digital Subscriber Line (ADSL) proposals which as based upon twisted pair cabling. The success, or otherwise, of CATV will be determined by the degree to which the data communications, telecommunications and broadcasting industries and thus far the convergence of technologies by these groups is encouraging.

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The Marketplace

1. The Marketplace

To set the context for cable (CATV) based broadband digital networking before introducing the actual cable modem and set-top box technology.

1.1 Overview

During the last five years the Internet and its associated applications, such as Electronic Mail (E-mail) and the World Wide Web (WWW), have become established as an essential business tool; it is perhaps salutary to realise that research and development on the Internet is about to enter its fourth decade ! Digital data, and its transfer, now accounts for the single largest part of the revenues for the telecommunications industry, recently surpassing the traditional voice services. At the same time the data communications, broadcasting, telecommunications and consumer electronics industries have realised that digital data transport to, and from, the home is an important market. Whilst there are many new technologies under development for home-based data communications, this convergence is most powerfully represented by Cable Modems (CM) and Set-top Boxes (STB) i.e. the devices that enable the delivery of digital data into the home. The cable modem is the device that sits in the user's premises (home) and which is connected to the traditional Community Antenna Television (CATV) infrastructure. Whereas the cable modem delivers a raw data stream, the Set-top box is a more complex and complete device which delivers application services to the user e.g. broadcast television, video-on-demand, radio, audio-on-demand, etc. In most cases the STB will contain a cable modem as its network interface unit.

The focus of this course is on the new standardised, digital versions of CM and STB technology. There are many analogue STBs, some proprietary digital STBs and CMs, and increasing numbers of standards compliant CMs. The new standards for CMs and STBs reflect the complex and functionally rich features that these devices must provide. This in turn is an ideal opportunity for the development and marketing of new products that offer to the user unique capabilities through new combinations of the optional and mandatory features of the CM and STB specifications. This course makes a series of recommendations on the types of new CMs and STBs, which, while conforming to the corresponding standards, have clearly differentiated, necessary and desirable functional capabilities.

1.2 Objectives

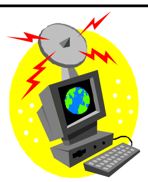
The objectives are to:

1. Describe how the current cable modem and set-top box technology has been developed to respond to the needs of the cable market;

2. Introduce the organisations that have been responsible for the development of the relevant cable modem and set-top box standards and specifications;

3. Describe how the bandwidth allocation for cable networks vary in different regions of the world and to show how these are supported by the different set-top box and cable modem technologies.

1.3 Slides Summary



THE MARKETPLACE

The Marketplace

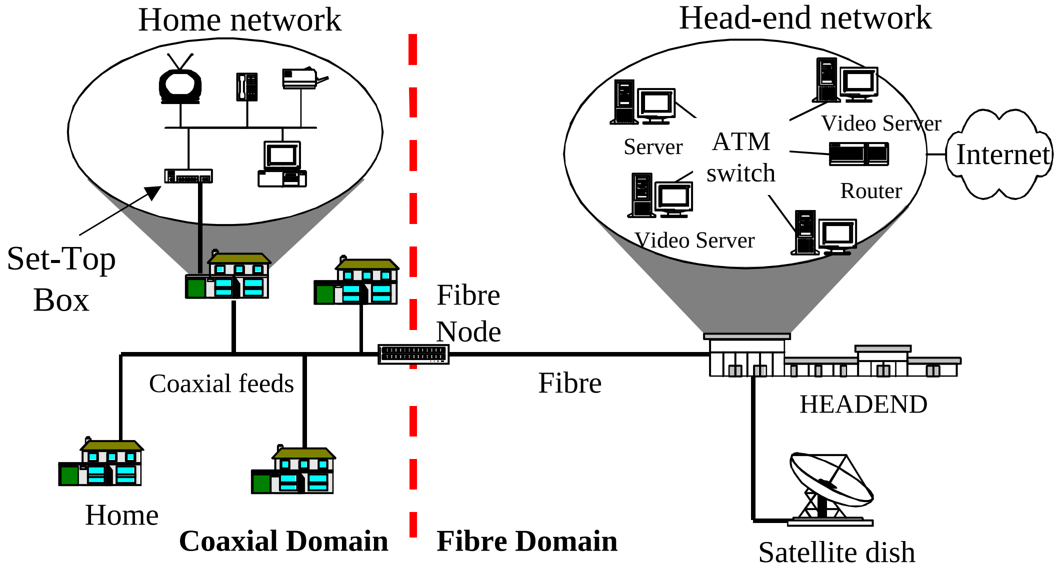
- **Cable network architectures**
- **Digital convergence**
- **Historic perspective**
- **Key issues**

1

DELEGATE NOTES

Access Networking

The Marketplace



Residential/access network

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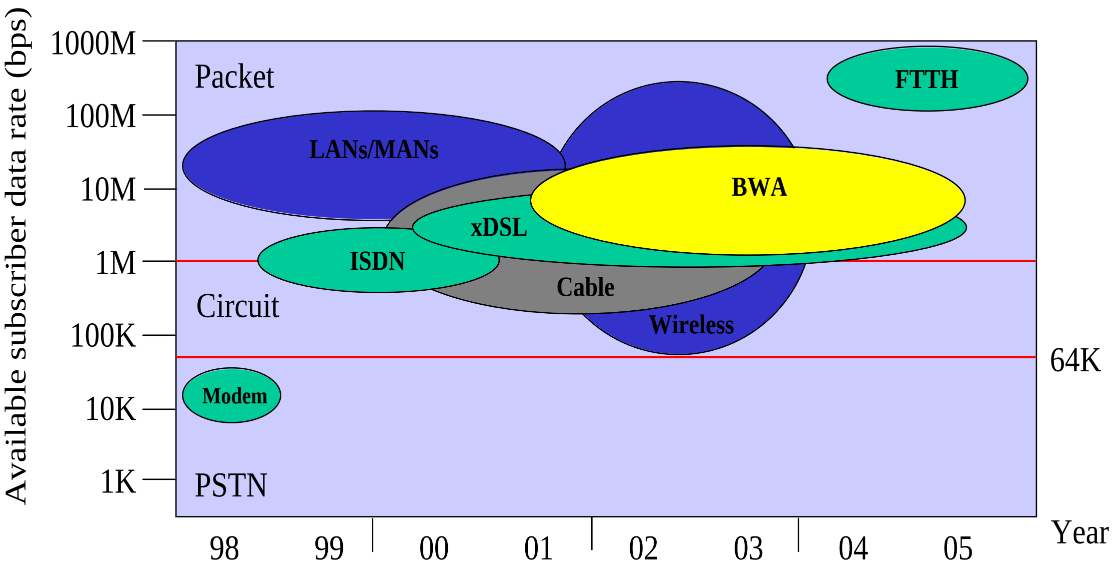
DELEGATE NOTES

TRENDS

The Marketplace



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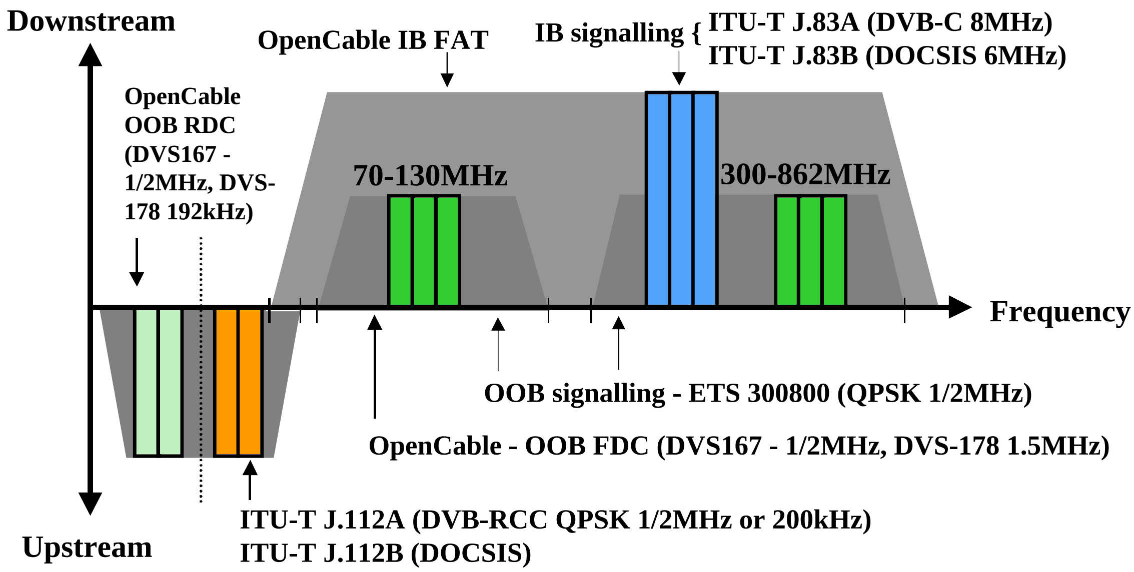
DELEGATE NOTES

The Marketplace

Bandwidth Allocations



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DELEGATE NOTES

The Marketplace

Services & Applications

- **Core service needs**
  - **Best effort IP**
  - **IP with QoS**
  - **Tiered bandwidth allocation**
  - **Remote management**
  - **Support for multiple CPEs**
  - **Secure/private data transfer**
  - **Clear and sustained tariff agreements**
- **Key application needs**
  - **Email**
  - **WWW browsing**
  - **Voice over IP**
  - **Streamed audio**
  - **Streamed video**
  - **Networked games**
  - **On-line support**
  - **Home gateway**
  - **Integrated PC/TV features**

5

DELEGATE NOTES

DIGITAL CONVERGENCE

The Marketplace

Notes:

(a) **'W' denotes that the characteristic is weak within that industry sector**

(b) **'S' denotes that the characteristic is strong within that industry sector**

Characteristic	Data Comms	Telecoms	Broad-casting	Consumer Elecs	Computer Supplier
User understanding	W	W	S	S	W
User support	W	S	W	S	W
To-the-desktop	W	W	W	W	N/A
Data broadcasting	W	W	S	N/A	N/A
Data switch/routing	S	S	W	N/A	N/A
Interactivity	S	S	W	S	S
Int digital services	W	W	W	W	W
Regulation	W	S	S	S	W
Costs	S	W	W	S	S
Tariffing	W	S	S	S	N/A
Quality of service	W	W	W	W	W
Residential access	W	S	S	S	W
Network managem't	W	S	S	W	N/A
Digital infrastructure	S	S	W	W	S

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DELEGATE NOTES

The Marketplace

Legacy Systems

Vendor	Ship ment	Share	Vendor	Ship ment	Share
Motorola	760,000	44%	Samsung	20,000	1%
Nortel/Arris	490,000	28%	Thomson	20,000	1%
Terayon	145,000	9%	NetGame	15,000	1%
Com21	140,000	9%	Toshiba	15,000	1%
Zenith	35,000	2%	Hybrid	15,000	1%
GI	30,000	2%	Phasecom	10,000	0.75%
3Com	25,000	1.5%	Miscellaneous	10,000	0.75%

The sales figures for proprietary cable modem systems as of July 1999.

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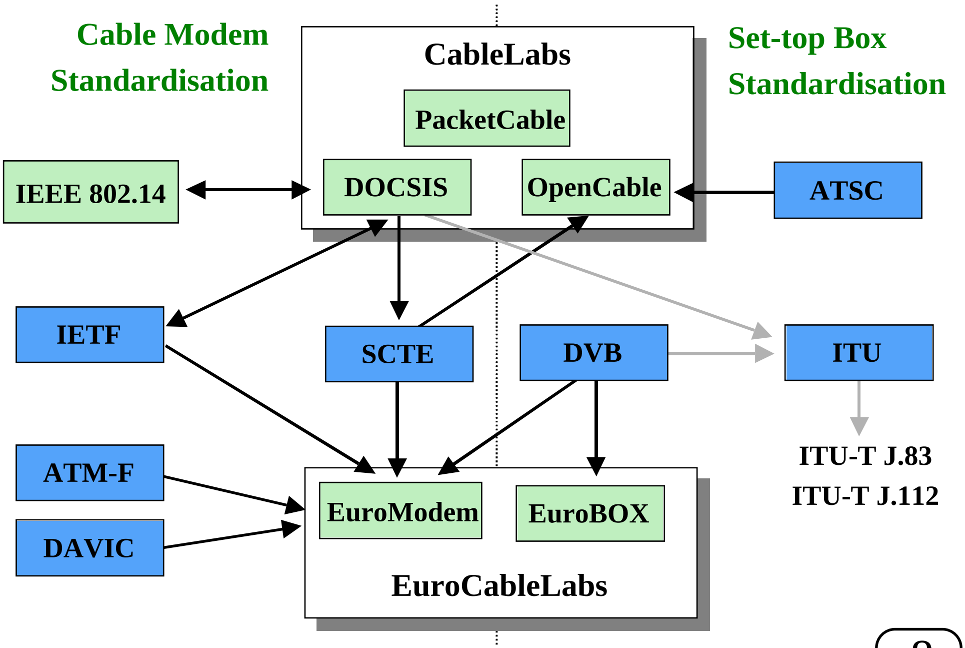
DELEGATE NOTES

The Marketplace

KEY PLAYERS



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DELEGATE NOTES

The Marketplace

HISTORY - I

- Sept, 93 DVB established
- July, 94 IEEE 802.14 established
- Aug, 94 DAVIC established
- Jan, 96 MCNS DOCSIS started
- Mar, 97 DOCSISv1.0 released
- Sept, 97 OpenCable started
  EuroCableLabs established
- Nov, 97 IEEE 802.14 Hi-Phy
  IETF take over DOCSIS MIB
- Mar, 98 ETS300800 approved as J.112A
  DOCSISv1.0 approved as J.112B
  DOCSISv1.1 started
- Jul, 98 ATM-Forum RBB specification
- Oct, 98 DDIC created
  ECMC created

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DELEGATE NOTES

The Marketplace

History - II

- **Nov, 98** — **EuroDOCSIS**
  DOCSISv1.2 started!!
- **Dec, 98** — **PacketCable starts**
  EuroBOXv3.1 released
  EuroModem WG established
- **Mar, 99** — **First DOCSIS head-end qualified**
  DOCSISv1.1 released
  IEEE 802.14b released (Hi-Phy)
- **May, 99** — **EuroModem released**
- **Jun, 99** — **DAVIC 1.5 released**
  PacketCable interop
- **Jul, 99** — **OpenCable planning for interop testing**
- **Aug, 99** — **OpenCable specs release for comment**
- **Sep, 99** — **DAVIC disbanded**
- **Oct, 99** — **EuroDOCSIS certification launched**
- **Jul, 00** — **First EuroModem interop approved**

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DELEGATE NOTES

KEY ISSUES

The Marketplace

- ✦ **Manufacturer/vender**
  - **Cost of manufacture**
  - **Regional bandwidth allocation differences**
  - **Achieving interoperability**
  - **The 'Killer App'**
  - **Scheduling algorithm features**
  - **Alternative technology competition**
- ✦ **Operator/user**
  - **Multiplicity of standards**
  - **Interoperability and technology interworking**
  - **Bandwidth management and tariffing**
  - **Ease of installation**
  - **Services supported**
  - **Home gateway suitability**
  - **Which access technology**
  - **Home integration**

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DELEGATE NOTES

The Marketplace

Review

- Services and application - SOHO needs
- Range of choice
  - Standards & specifications
  - Alternative technologies & range of vendors
- Classical competition
  - Telecomms vs. data comms
  - Broadcast vs. circuit-based
  - North America vs. Europe

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DELEGATE NOTES

1.4 Questions

1. What roles would the Internet Engineering Task Force (IETF) and the ATM Forum (ATM-F) be expected to undertake with respect to the development of standards for cable modems and set-top boxes ?

2. When was version 1.0 of the Data Over Cable Service Interface Specification (DOCSIS) released as a completed specification and when was it formally adopted by the International Telecommunications Union (ITU).

DELEGATE NOTES

Review

5. Review

A review of the all the materials presented thus far on cable modems and set-top boxes.

5.1 Overview

Cable networks are one of the key emerging broadband access technologies. The definition of a networking standard for the delivery of broadband interactive services over Hybrid Fibre Coaxial (HFC) networks is a challenging task due the high bandwidth demands anticipated for the new applications e.g. home-based video-on-demand, and their physical idiosyncrasies (noisy upstream frequencies, tree-based architectures etc.). The two predominant standards for cable modems are: the Data Over Cable Service Interface Specification (DOCSIS) for North America and the DVB/DAVIC ETS200800 specification for Europe; the IEEE 802.14 Advanced Physical layer specification is interesting but development seems to have stopped. Roll-out of these new technologies is currently under way and there are many sites across the world which are evaluating these new systems. At present there is very little informed information about the performance capabilities of these systems and most of the published literature is based on computer simulation. The EuroDOCSIS specification has been introduced which combines the DVB downstream physical layer protocol within the DOCSIS protocols thereby producing a DOCSIS solution suitable for use within Europe.

For set-top boxes there are also two competing specifications: the OpenCable for North America and the EuroBOX for Europe. In both cases there are no commercial products available that comply with these specifications. The OpenCable specification is very feature rich in comparison to the EuroBOX.

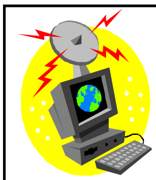
While there is a significant amount of development and roll-out of the new CATV technologies, the success of this approach is seriously threatened by alternatives such as the Asymmetrical Digital Subscriber Line (ADSL) proposals which as based upon twisted pair cabling. The success, or otherwise, of CATV will be determined by the degree to which the data communications, telecommunications and broadcasting industries and thus far the convergence of technologies by these groups is encouraging.

5.2 Aims & Objectives

The objectives are to:

1. Review the information on cable modems;
2. Review the information on set-top boxes;
3. Summarise the key manufacturers of set-top box and cable modem devices.

5.3 Slides Summary



Review

REVIEW

- ✦ **Competition & collaboration**
- ✦ **Device manufacturers**
- ✦ **Future prospects**

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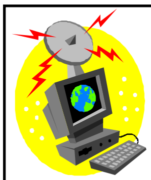
DELEGATE NOTES



Review

Competition & Collaboration

- **Competition**
  - **Device scheduling algorithm capabilities**
  - **North American vs. European technology**
  - **Cheap consumer devices but expensive operator devices**
  - **Manufacturers backing all technologies**
- **Collaboration**
  - **Specification development**
  - **Interoperability testing**
  - **Creating the marketplace**
  - **Commitment to IP-based services**
  - **Making Quality of service work**

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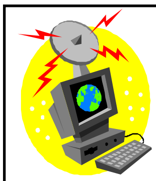
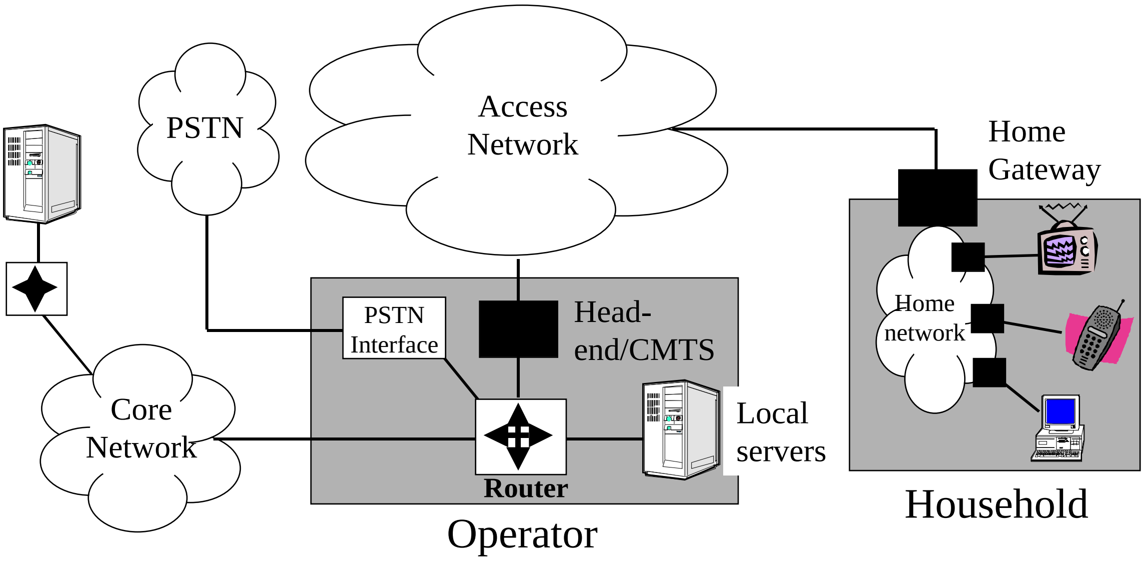
DELEGATE NOTES


Review

END-TO-END SYSTEMS



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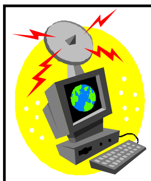
DELEGATE NOTES



Review

MANUFACTURERS (CMS)

- **EuroModem (Class A)**
  - **Cisco (DVB CAR100)***
  - **COM21***
  - **Hughes Network Systems (CS2510/CS2520)**
  - **Terayon (UCM-220)***
  - **The industree (CableJet 900/910)***
  - **Thomson/Alcatel***

* = Interoperability certified

- **DOCSISv1.0 (Certified)**
  - **41 separate manufacturers**
  - **Thomson (first)**
  - **Toshiba (best of breed)**
- **EuroDOCSIS v1.0 (Certified)**
  - **Askey**
  - **Dassault**
  - **Ericsson**
  - **Motorola**
  - **TechnoTrend**
  - **Thomson Multimedia**

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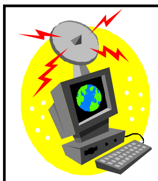
DELEGATE NOTES



Review

MANUFACTURERS (HEAD-ENDS)

- DVB INA (Class A)
  - Cisco (CoCom)
  - Hughes
  - Terayon (DiviCom)
  - Barco (The industree)
  - Alcatel/Thomson
  - COM21
  - Philips Research
- DOCSISv1.0 Qualified CMTS
  - Arris (ex Nortel/LANCity)
  - Motorola, 3COM, Cisco
  - ADC (Broadband Access Systems)
  - RiverDelta, Riverstone, Terayon
- EuroDOCSISv1.0 Qualified CMTS
  - 3COM
  - ADC, Arris
  - Motorola, Terayon

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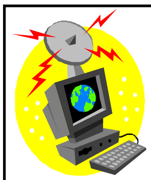
DELEGATE NOTES



Review

Manufacturers (STBs)

- **EuroBOX**
  - **No compliant STBs yet available**
  - **Nokia Mediamaster DVB 9730**
  - **Pace NTL Di4001 Digital Cable Box (recognised market leader)**
  - **Philips Digital Networks**
  - **Sagem**
- **OpenCable**
  - **No compliant STB yet available**
  - **Potential manufacturers**
    - Scientific Atlanta
    - PACE
    - Philips Digital Networks

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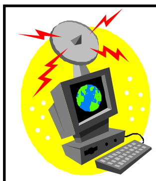
DELEGATE NOTES



Review

CABLE NETWORK FUTURE PROSPECTS

- **Strengths**
  - IP and IP QoS capable
  - High speed services
  - STB integration
  - Integrated to telecoms/data comms infrastructure
- **Weaknesses**
  - Two key standards
  - Unclear service tariffs
  - Slow roll-out
- **Opportunities**
  - Slow ADSL roll-out
  - Depth of penetration of the physical infrastructure
- **Threats**
  - Alternative access technologies
  - Cable company survival
  - Streamed-service overload

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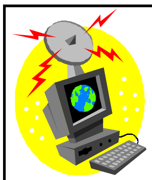
DELEGATE NOTES



Review

CONCLUSION

- North America
  - DOCSIS and OpenCable
- Europe
  - EuroModem and EuroDOCSIS
  - EuroBOX and EuroLoader
- Wide range of devices now available but a lot of development still to be completed
- Cable network solution not guaranteed to be the preferred SOHO data services supplier

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DELEGATE NOTES

5.4 Questions

1. Given the nature of their respective approaches, what problems in interoperability could arise for each of the four specifications ?

2. In what way could the work of the IEEE 802.14 Advanced Physical layer be adopted by the established cable modem specifications ?

DELEGATE NOTES