International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

J.700

(12/2009)

SERIES J: CABLE NETWORKS AND TRANSMISSION OF TELEVISION, SOUND PROGRAMME AND OTHER MULTIMEDIA SIGNALS

Secondary distribution of IPTV services

IPTV service requirements and framework for secondary distribution

Recommendation ITU-T J.700

Recommendation ITU-T J.700

IPTV service requirements and framework for secondary distribution

Summary

The telecommunications industry today is pursuing development of a new generation of television services, typically called IPTV, built upon IP networking technology to deliver integrated triple-play voice, data and video services across a converged network infrastructure. The cable industry has a long history of successfully delivering video services over hybrid fibre/coax (HFC) networks while adding support for data and voice through the DOCSIS and IPCablecom architectures. Recommendation ITU-T J.700 describes the use of the IPTV mechanism, and is intended to support IPTV services over existing cable-based secondary distribution networks and/or other networks to enhance the existing television distribution services.

This revised Recommendation provides a clearer relationship of the IPTV architecture between this Recommendation and Recommendation ITU-T Y.1910, and the relationship to the service provider interface is newly described. In addition, the latest access network technologies for secondary distribution such as radio frequency over glass (RFoG), wavelength-multiplexed video transport over optical fibre, and hybrid use of HFC and optical fibre, are mentioned. This revision is also intended to provide a number of editorial corrections.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T J.700	2007-12-14	9
2.0	ITU-T J.700	2009-12-14	9

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

CONTENTS

Recommendation ITU-T J.700

IPTV service requirements and framework for secondary distribution

1 Scope

This Recommendation describes the service requirements and functional framework architecture for support of IPTV services to provide enhanced broadcasting, where broadcast programmes are delivered over existing cable-based secondary distribution networks composed of HFC or FTTx with some enhancements by applications and/or services provided over IP-enabled networks. It addresses the service requirements, use cases and functional components required to support these requirements. Where possible, this Recommendation utilizes the material already developed, or under development, in ITU-T Recommendations related to video service delivery over secondary networks.

This Recommendation describes the use of an IPTV mechanism based on the general ITU-T IPTV functional architecture [ITU-T Y.1910]. The IPTV applications and services addressed in this Recommendation are intended to be transferred over existing cable-based secondary distribution networks and/or other networks to enhance the existing television distribution services.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T H.222.0] Recommendation ITU-T H.222.0 (2000) | ISO/IEC 13818-1:2000, *Information technology – Generic coding of moving pictures and associated audio information: Systems*.

[ITU-T H.222.0 Amd.3] Recommendation ITU-T H.222.0 Amd.3 (2004) | ISO/IEC 13818-1:2000/Amd3:2004, *Transport of AVC video data over ITU-T Rec. H.222.0 | ISO/IEC 13818-1 streams*.

[ITU-T H.262] Recommendation ITU-T H.262 (2000) | ISO/IEC 13818-2:2000, *Information technology – Generic coding of moving pictures and associated audio information: Video.*

[ITU-T H.264] Recommendation ITU-T H.264 (2005), *Advanced video coding for generic audiovisual services*.

[ITU-T H.770] Recommendation ITU-T H.770 (2009), *Mechanisms for service discovery and selection for IPTV services*.

[ITU-T J.83] Recommendation ITU-T J.83 (1997), *Digital multi-programme systems for television, sound and data services for cable distribution*.

[ITU-T J.112] Recommendation ITU-T J.112 (1998), *Transmission systems for interactive cable television services*.

[ITU-T J.112 Annex B] Recommendation ITU-T J.112 Annex B (2004), *Data-over-cable service interface specifications: Radio-frequency interface specification*.

[ITU-T J.122] Recommendation ITU-T J.122 (2002), *Second-generation transmission systems for interactive cable television services – IP cable modems.*

[ITU-T J.128] Recommendation ITU-T J.128 (2005), *Set-top gateway specification for transmission systems for interactive cable television services*.

[ITU-T J.179] Recommendation ITU-T J.179 (2005), *IPCablecom support for multimedia*.

[ITU-T J.181] Recommendation ITU-T J.181 (2004), *Digital program insertion cueing message for cable television systems*.

[ITU-T J.190] Recommendation ITU-T J.190 (2007), *Architecture of MediaHomeNet*.

[ITU-T J.200] Recommendation ITU-T J.200 (2001), *Worldwide common core – Application environment for digital interactive television services*.

[ITU-T J.201] Recommendation ITU-T J.201 (2004), *Harmonization of declarative content format for interactive TV application*s.

[ITU-T J.202] Recommendation ITU-T J.202 (2003), *Harmonization of procedural content formats for interactive TV applications*.

[ITU-T J.203] Recommendation ITU-T J.203 (2006), *Common core for digital video recorder platform.*

[ITU-T J.280] Recommendation ITU-T J.280 (2005), *Digital Program Insertion: Splicing application program interface*.

[ITU-T J.282] Recommendation ITU-T J.282 (2006), *Architecture of multi-channel video signal distribution over IP-based networks*.

[ITU-T J.290] Recommendation ITU-T J.290 (2006), *Next generation set-top-box core architecture*.

[ITU-T J.291] Recommendation ITU-T J.291 (2006), *Next generation set-top-box cable architecture*.

[ITU-T J.292] Recommendation ITU-T J.292 (2006), *Next generation set-top-box media-independent architecture*.

[ITU-T M.3060] Recommendation ITU-T M.3060/Y.2401 (2006), *Principles for the Management of the Next Generation Networks*.

[ITU-T M.3400] Recommendation ITU-T M.3400 (2000), *TMN management functions*.

[ITU-T Y.1901] Recommendation ITU-T Y.1901 (2009), *Requirements for the support of IPTV services*.

[ITU-T Y.1910] Recommendation ITU-T Y.1910 (2008), *IPTV functional architecture*.

[ITU-T Y.2011] Recommendation ITU-T Y.2011 (2004), *General principles and general reference model for Next Generation Networks*.

[ITU-T Y.2012] Recommendation ITU-T Y.2012 (2006), *Functional requirements and architecture of the NGN release 1*.

[ANSI/SCTE 20] ANSI/SCTE 20 (2004), *Method for Carriage of Closed Captions and Non-Real Time Sampled Video*.

[ANSI/SCTE 21] ANSI/SCTE 21 (2006), *Standard for Carriage of NTSC VBI data in Cable Digital Transport Streams*.

[ANSI/SCTE 26] ANSI/SCTE 26 (2004), *Home Digital Network Interface Specification with Copy Protection*.

[ANSI/SCTE 40] ANSI/SCTE 40 (2004), *Digital Cable Network Interface Standard*.

[ANSI/SCTE 43] ANSI/SCTE 43 (2005), *Digital Video Systems Characteristics Standard for Cable Television*.

[ANSI/SCTE 65] ANSI/SCTE 65 (2002), *Service Information Delivered Out-of-Band for Digital Cable Television*.

[ANSI/SCTE 127] ANSI/SCTE 127 (2007), *Carriage of Vertical Blanking Interval (VBI) Data in North American Digital Television Bitstreams*.

[ANSI/SCTE 128] ANSI/SCTE 128 (2007), *AVC Video Systems and Transport Constraints for Cable Television*.

[ARIB STD-B10] ARIB STD-B10 V4.4 (2007), *Service Information for Digital Broadcasting System*.

[ARIB STD-B32] ARIB STD-B32 V2.1 (2007), *Video Coding, Audio Coding, and Multiplexing Specifications for Digital Broadcasting*.

[ATSC A/65C] ATSC A/65C (2006), *ATSC Standard: Program and System Information Protocol for Terrestrial Broadcast and Cable (Revision C) with Amendment No. 1*.

[CEA-608-C] CEA-608-C (2005), *Line 21 Data Services*.

[CEA-708-C] CEA-708-C (2006), *Digital Television (DTV) Closed Captioning*.

[ETSI EN 300 468] ETSI EN 300 468 V1.7.1 (2006), *Digital Video Broadcasting (DVB); Specification for Service Information (SI) in DVB systems*.

[ETSI EN 301 775] ETSI EN 301 775 V1.2.1 (2003), *Digital Video Broadcasting (DVB); Specification for the carriage of Vertical Blanking Information (VBI) data in DVB bitstreams*.

[ETSI TS 101 154] ETSI TS 101 154 v1.7.1 (2005), *Digital Video Broadcasting (DVB); Implementation guidelines for the use of Video and Audio Coding in Broadcasting Applications based on the MPEG-2 Transport Stream*.

[ETSI TS 102 034] ETSI TS 102 034 v1.3.1 (2007), *Digital Video Broadcasting (DVB); Transport of MPEG-2 TS Based DVB Services over IP Based Networks*.

[ETSI TS 102 543] ETSI TS 102 543 v1.1.1 (2008), *Digital Video Broadcasting (DVB); Globally Executable MHP (GEM) Specification 1.2*.

[IETF RFC 1350] IETF RFC 1350 (1992), *The TFTP Protocol (Revision 2)*.

[IETF RFC 2131] IETF RFC 2131 (1997), *Dynamic Host Configuration Protocol*.

[IETF RFC 2132] IETF RFC 2132 (1997), *DHCP Options and BOOTP Vendor Extensions*.

[IETF RFC 2250] IETF RFC 2250 (1998), *RTP Payload Format for MPEG1/MPEG2 Video*.

[IETF RFC 2326] IETF RFC 2326 (1998), *Real Time Streaming Protocol (RTSP)*.

[IETF RFC 3550] IETF RFC 3550 (2003), *RTP: A Transport Protocol for Real-Time Application*.

[IETF RFC 3551] IETF RFC 3551 (2003), *RTP Profile for Audio and Video Conferences with Minimal Control*.

[IETF RFC 3640] IETF RFC 3640 (2003), *RTP Payload Format for Transport of MPEG-4 Elementary Streams*.

[IETF RFC 3984] IETF RFC 3984 (2005), *RTP Payload Format for H.264 Video*.

[IETF RFC 4184] IETF RFC 4184 (2005), *RTP Payload Format for AC-3 Audio*.

[IETF RFC 4425] IETF RFC 4425 (2006), *RTP Payload Format for Video Codec 1 (VC-1)*.

[IETF RFC 4566] IETF RFC 4566 (2006), *SDP: Session Description Protocol*.

[ISO/IEC 13818-7] ISO/IEC 13818-7 (2006), *Information technology – Generic coding of moving pictures and associated audio information – Part 7: Advanced Audio Coding (AAC)*.

[SMPTE 421M] SMPTE 421M (2006), *VC-1 Compressed Video Bitstream Format and Decoding Process*.

[SMPTE RP 227] SMPTE RP 227 (2006), *VC-1 Bitstream Transport Encodings*.

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 client DVR (cDVR): An instance of a DVR where the end-user terminal device contains the recording capability that can be solicited and operated by end users to record and store video, audio and other associated content locally for subsequent playback.

3.2.2 digital video recorder (DVR): A recording capability that can be solicited and operated by end users to record and store video, audio and other associated content for subsequent playback.

3.2.3 distributed DVR (dDVR): Multiple instances of a DVR where a combination of cDVRs and nDVRs can be used to record and store video, audio and other associated content for subsequent playback. For example, this usually occurs within a home network containing multiple cDVRs in order to distribute storage of video, audio and other content.

3.2.4 DOCSIS-based CPE: A terminal device that contains an embedded DOCSIS cable modem. Hybrid CPEs and IP-only CPEs may be DOCSIS based.

3.2.5 enhanced broadcasting: A system that is capable of delivering broadcast programmes over existing secondary distribution networks composed of HFC or FTTx with enhancements by applications and/or services transferred over IP-enabled networks.

3.2.6 hybrid CPE: A terminal device that is capable of receiving content services over MPEG transport streams and IP.

3.2.7 IP-only CPE: A terminal device that is capable of receiving content services over IP only.

3.2.8 mobile DVR (mDVR): A mobile instance of a DVR where a mobile terminal device can be a cDVR (having the capability to store video, audio and other associated content locally) or contain a means of accessing an nDVR or other cDVR.

3.2.9 MPEG transport CPE: A terminal device that is capable of receiving content services over MPEG-2 transport streams only.

3.2.10 network DVR (nDVR): An instance of a DVR where a network element contains the recording capability that can be solicited and operated by end users to record and store video, audio and other associated content in the network for subsequent playback.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AAC	Advanced Audio Coding
AAC-LC	Advanced Audio Coding – Low Complexity
AC-3	Arc Consistency algorithm #3 (Dolby)
AIT	Application Information Table
API	Application Programming Interface
ASD	Authorized Service Domain
A/V	Audio/Video
AVC	Advanced Video Codec
AVT	Audio/Video Transport
BLT	Bit-block Transfer
BPL	Broadcast over Power Line
BSS	Business Support System
CA	Conditional Access
CAS	Conditional Access System
CDN	Content Delivery Network
cDVR	client Digital Video Recorder
CID	Caller Identity Display
CM	Cable Modem
CMTS	Cable Modem Termination System
CODEC	Coder-Decoder
CPE	Customer Premises Equipment
CSCF	Call Session Control Function
dDVR	distributed Digital Video Recorder
DEPI	DOCSIS External PHY Interface
DHCP	Dynamic Host Configuration Protocol
DLNA	Digital Living Network Alliance
DM	Device Management
DMP	Digital Media Player
DMR	Digital Media Renderer
DNS	Domain Name System
DOCSIS	Data-Over-Cable Service Interface Specification
DPI	Digital Programme Insertion
DRM	Digital Rights Management
DRRP	Dynamic Resource Registration Protocol
DSG	DOCSIS Set-top box Gateway

DSL	Digital Subscriber Line
DSM-CC	Digital Storage Media Command and Control
DTCP	Digital Transmission Content Protection
DVB	Digital Video Broadcasting
DVD	Digital Versatile Disc
DVR	Digital Video Recorder
DVS	Digital Video Service
EAS	Emergency Alert System
eCM	embedded cable modem entity (e.g., STB, router, MTA, etc.)
ECM	Entitlement Control Message
EMM	Entitlement Management Message
eMTA	embedded Multimedia Terminal Adapter
EPG	Electronic Programme Guide
ERM	Edge Resource Manager
ES	Elementary Stream
FCAPS	Fault, Configuration, Accounting, Performance and Security
FG IPTV	ITU-T IPTV Focus Group
FTTx	Fibre-To-The (node, curb, premise or home)
FW	Firewall
GEM	Globally Executable Multimedia home platform
GE-PON	Gigabit Ethernet – Passive Optical Network
GIF	Graphics Interchange Format
GPON	Gigabit-capable Passive Optical Network
GUI	Graphical User Interface
GW	Gateway
HD	High Definition
HDCP	High-bandwidth Digital Content Protection
HDD	Hard Disk Drive
HDMI	High-Definition Multimedia Interface
HDNI	Home Digital Network Interface
HDTV	High-Definition Television
HFC	Hybrid Fibre/Coax
HRC	Harmonically-Related Carriers
HSD	High Speed Data
HSS	Home Subscriber Server
HTTP	HyperText Transfer Protocol
HTTPS	Secure HyperText Transfer Protocol

ICE	Interactive Connectivity Establishment
I-CSCF	Interrogating Call Session Control Function
IGMP	Internet Group Management Protocol
IM	Instant Messaging
IMS	Internet Protocol Multimedia Subsystem
IP	Internet Protocol
IPPV	Impulse Pay Per View
IPTV	Internet Protocol Television
IPv6	Internet Protocol version 6
IRC	Incrementally-Related Carriers
IRT	Integrated Receiver Transcoder
ISDN	Integrated Services Digital Network
ISMS	Information Security Management System
ITV	Interactive Television
JAR	Java Archive
JCE	Java Cryptography Extension
JPEG	Joint Photographic Experts Group
LAN	Local Area Network
LLC	Logical Link Control
LPCM	Linear Pulse Code Modulation
MAC	Media Access Control
M-CMTS	Modular Cable Modem Termination System
MDU	Multi-Dwelling Unit
mDVR	mobile Digital Video Recorder
MHP	Multimedia Home Platform
MLD	Multi-Listener Discovery
MP3	MPEG-1 audio layer 3
MPEG	Moving Picture Experts Group
MPEG-ES	Moving Picture Experts Group Elementary Stream
MPEG-TS	MPEG Transport Stream
MPTS	Multiple Programme Transport Stream
MSO	Multiple System Operator
MTA	Multimedia Terminal Adapter
NACF	Network Attachment Control Function
NAT	Network Address Translation
nDVR	network Digital Video Recorder
NGN	Next Generation Network

NIT	Network Information Table
NPT	Normal Play Time
NTSC	National Television System Committee
NVOD	Near Video on Demand
OCAP	OpenCable Applications Platform
OMA	Open Mobile Alliance
ONU	Optical Network Unit
OOB	Out-Of-Band
OSD	On-Screen Display
OSS	Operational Support System
PAT	Programme Association Table
PBP	Personal Basic Profile
PCM	Pulse Code Modulation
PCMM	PacketCable Multimedia
P-CSCF	Proxy Call Session Control Function
PDU	Packet Data Unit
PEG	Public, Education and Government access
PES	Packetized Elementary Stream
PiP	Picture-in-Picture
PMT	Programme Map Table
PNG	Portable Network Graphics
PON	Passive Optical Network
PPV	Pay Per View
PSI	Programme Specific Information
PSTN	Public Switched Telephone Network
PVR	Personal Video Recorder
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
QPSK	Quadrature Phase-Shift Keying
RACF	Resource and Admission Control Function
RAM	Random Access Memory
RF	Radio Frequency
RFoG	Radio Frequency over Glass
RG	Residential Gateway
RGB	Red Green Blue
RSVP	Resource ReServation Protocol
RTCP	Real-time Transport Control Protocol

RTE	Real-time Encoder
RTP	Real-time Transport Protocol
RTSP	Real-time Streaming Protocol
S-CSCF	Serving Call Session Control Function
SCF	Service Control Function
SD	Standard Definition
SDP	Session Description Protocol
SD&S	Service Discovery and Selection
SDU	Single-Dwelling Unit
SDV	Switched Digital Video
SI	Service Information
SIP	Session Initiation Protocol
SNMP	Simple Network Management Protocol
SOAP	Simple Object Access Protocol
SP	Service Provider
SPI	Service Provider Interface
SPTS	Single Programme Transport Stream
SRM	Session and Resource Manager
SSL	Secure Sockets Layer
SSM	Source-Specific Multicast
STB	Set-Top Box
STT	System Time Table
STUN	Simple Transversal of User datagram protocol through Network address translation
TCP	Transmission Control Protocol
TFTP	Trivial File Transfer Protocol
TMN	Telecommunications Management Network
TURN	Transversal Using Relay Network address translation
UDP	User Datagram Protocol
UPnP	Universal Plug and Play
VBI	Vertical Blanking Interval
VC-1	Video Codec 1
VCR	Video Cassette Recorder
VCT	Virtual Channel Table
VOD	Video On Demand
VoIP	Voice over Internet Protocol
V-ONU	Video Optical Network Unit
VPN	Virtual Private Network

VRN	Video Rich Navigation
WAN	Wide Area Network
WDM	Wavelength Division Multiplexing
WMA	Windows Media Audio
WSDL	Web Services Description Language
XCAP	eXtensible markup language Configuration Access Protocol
xDSL	(symmetric, asymmetric, high bit-rate, very high speed) Digital Subscriber Line
XML	eXtensible Markup Language

5 IPTV reference model, scenarios and requirements

It is helpful to start with a high-level reference model for IPTV over secondary distribution. In this clause, we introduce that model and discuss some scenarios for service delivery. Once this high-level view is set, the service and functional requirements are introduced and discussed.

5.1 Scenarios for IPTV services

Figure 1 shows the basic IPTV reference model derived from the model defined by [ITU-T Y.1910]. Taking the typical cable operators' environments, it has been modified slightly to allow for the network provider and service provider to be the same entity. It has been also modified to show some basic functional relationships.

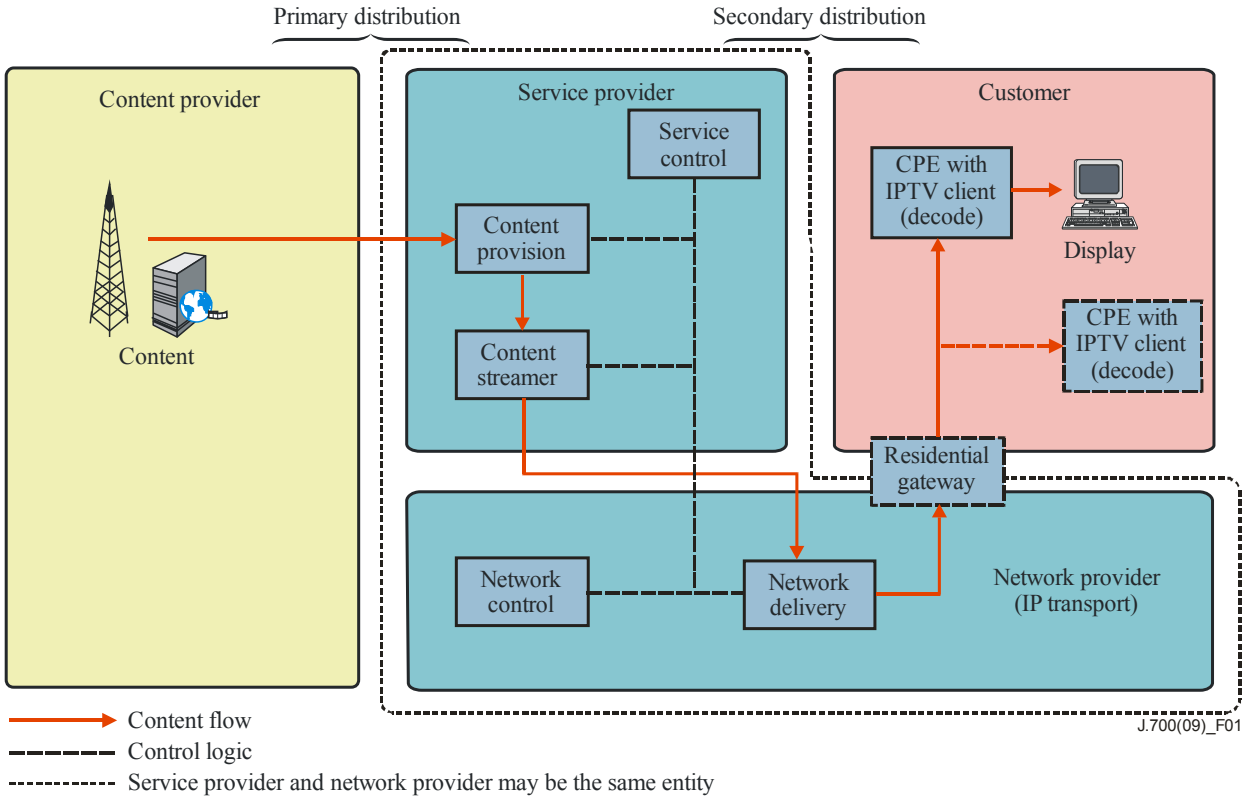


Figure 1 – IPTV reference model

The content provider, service provider and network provider in Figure 1 may be distinct entities; however, there are numerous scenarios where multiple functions may be provided by a single entity. The implementation of the reference model may vary based on whether there are single or multiple entities. The dotted line in Figure 1 above indicates the scenario where the service provider and network provider may be the same entity.

In Figure 1, the interaction between the content provider and the service provider is considered to be "primary distribution". The interaction from service provider to customer is "secondary distribution". The scope of this Recommendation is to provide a framework for secondary distribution only.

In Figure 1 above, the content is received from the content provider at the service provider in the content provision function (primary distribution). The content provision function acquires, manages and provisions content according to service provider requirements (e.g., ad-insertion, logo superimposing, encryption, compression, etc.). Content is then sent to the content streamer function to be streamed and delivered to the customer via the network provider through the network delivery function (secondary distribution). The service control function is used to control interaction with the customer and distribute content via the network provider. The network control and the network delivery functions operate within the network provider entity in order to disseminate and deliver content and data to and from the customer. Each customer entity may contain a residential gateway (owned and/or operated as a CPE by the network provider, service provider or customer), which functions to receive and send content and data to and from the other CPEs within the customer premises network. The CPE may send content to an optional display, which may be used to view and interact with content that is decoded for viewing at the CPE.

The customer premises network may consist of multiple CPEs with IPTV clients, which may or may not have connected or integrated displays. Each CPE, including the residential gateway, communicates upstream, through the network provider, to the network control and service control functions to control the delivery of content and for supporting exchange of data for interactive applications.

For this Recommendation, we derive an IP-enabled secondary distribution system based on the basic reference model and considering existing deployed technology. This secondary distribution system for enhanced broadcast is illustrated in Figure 2.

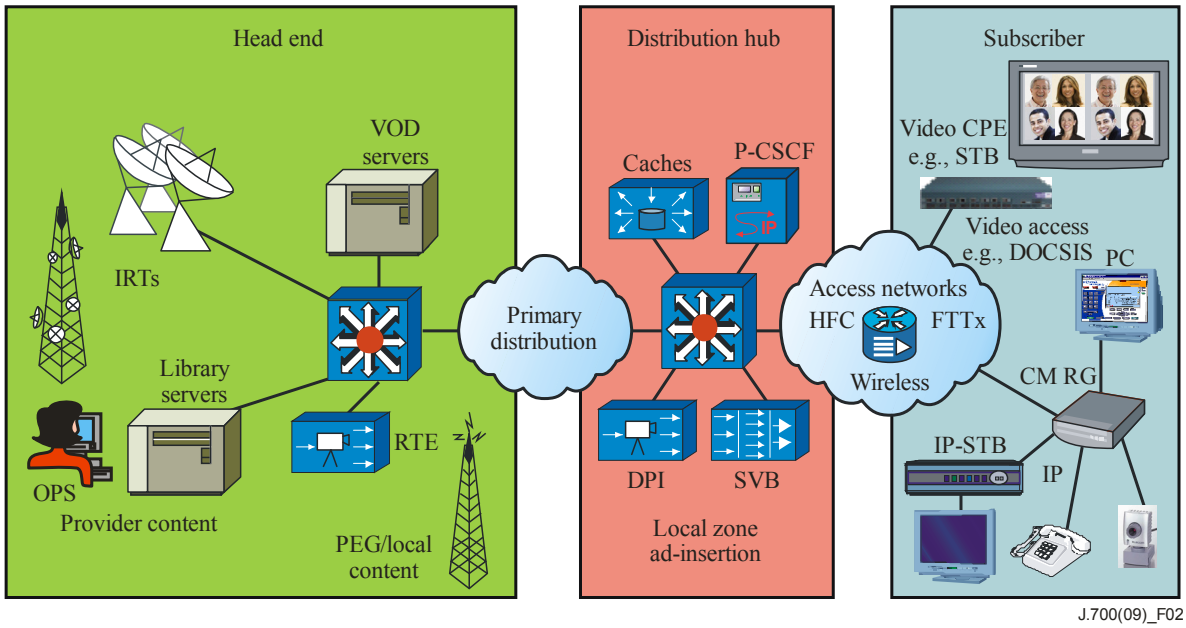


Figure 2 – Example of high level end-to-end physical network for enhanced broadcast

The physical network typically consists of:

- A head end for content acquisition, operations support and subscriber management. The head end allows for content to be made available based on the needs of a particular region served by the cable operator. Often VOD servers reside at the head end, and programming is tailored and branded to the profile of the regional market.
- The distribution hub is the operator's closest location to the subscriber. This is one place where local content can be added (e.g., local programming and ad insertion). Resource management on the access network occurs at the distribution hub, as well as initial termination of signalling for services.
- The subscriber or customer premises is often the demarcation point beyond which the operator may have less control. Leased equipment (owned by the cable operators) is considered trusted, and often other equipment within the customer premises is not considered within the trust boundary. The expanding need to support in-premises networking of content provides a number of challenges in areas such as conditional access (CA), digital rights management (DRM) and network address translation (NAT)/firewall traversal.

The primary focus of this IPTV framework Recommendation is to enable delivery of IP-based video services to end-users in the following ways:

1) Delivering enhanced video and other multimedia capabilities to the TV using IP – This scenario is generally considered to enhance the existing digital television delivery service. The existing video service delivery mechanisms remain intact, but are enhanced to allow for additional service overlays. All of these may also provide an integrated experience with the existing broadcast-based television services.
   a) IP video features – For example, mosaics of video content (e.g., for interactive programme guide or picture-in-picture) require multiple-tuner capabilities using traditional delivery mechanisms. IP gives the ability to deliver multiple video streams for various display purposes efficiently.
   b) Web-based services – Video delivery through standard web-based mechanisms can be used in conjunction with existing digital TV offerings to provide interactivity. For example, enhanced information services related to programming can be displayed through access to web servers over the IP network.
   c) IP-based enhancements – Combining existing broadcast video applications with new interactive IP-based multimedia services. For example, IPCablecom [b-ITU-T J.160] defines a standard architecture for voice over IP (VoIP) and IPCablecom2 [b-ITU-T J.360] defines multimedia services for cable networks. Other IMS-based multimedia services are being defined as well. These new services will be integrated with existing digital television offerings.
2) Delivering video over IP to devices in the home – As IPTV technology matures, operators may realize gains in bandwidth efficiency, lower CPE costs and flexibility in presentation by delivering video in IP to the end devices.
   a) Content may be delivered through traditional RF-modulated MPEG streams to a set-top box-based CPE, and then made available within the home to IP devices through the IP home gateway.
   b) Content may be delivered end-to-end with IP-based streaming. An IP-video home gateway would enable delivering the streams to (potentially multiple) IP devices within the home.

3) Delivering video over IP to devices outside the home – As operators move to provide service to devices beyond the traditional secondary delivery network, many mobile opportunities are presented.

   a) IPCablecom2 provides an IMS-based mechanism for multimedia delivery to mobile devices. Interworking with the IMS delivery subsystem to allow IPTV services to be delivered to the mobile devices is a key component of this architecture.

   b) Innovative mechanisms may allow for content delivery to remote devices outside the home. This capability is often referred to as "place-shifting".

5.2 Service requirements

There are a number of types of services anticipated to be supported by the broadcast enhanced by IPTV defined in this Recommendation. The supported services, described from the CPE perspective, might include the following items.

5.2.1 Digital video and audio content

The CPE should be capable of decoding and processing digital video channels from the network. Examples of digital video include MPEG-2, MPEG-4 AVC and VC-1 based encoding formats. Digital video may include associated digital audio services. Stand-alone audio services may also be offered.

Content may be service-provider or subscriber generated.

See also requirement R 6.5.2-01 of [ITU-T Y.1901].

5.2.2 Navigation and electronic programme guide support

The CPE should support an interactive electronic programme guide (EPG) application selected by the network operator. The interactive EPG runs on top of the middleware and supports all available video and audio services including broadcast, on-demand, time-shifted multimedia services (i.e., DVR) and IP video, and provides utilities that include, but are not limited to:

- Available subscriber and service provider content lists.
- Search and navigation tools of available content.
- Channel and content selection, including last channel recall and favourite channel lists.
- DVR client and on-demand controls, including play, rewind, fast forward and pause.
- DVR client recording control, including reminders.
- Parental control, including block by time, channel, ratings, title and content type.
- Services control, including enabling and disabling access to pay-per-view content.

See also requirements R 6.1-04, R 6.3.6-03, RR 6.3.6-01 and clause 6.6.5 of [ITU-T Y.1901].

5.2.3 Content on demand

The CPE should be able to provide on-demand services and should interoperate with the network and service providers' on-demand infrastructure. On-demand enables television viewers to select from an extensive library of content stored on a video server, and have it delivered over a channel via the cable network. All on-demand services should allow the viewer to pause, fast forward and rewind programming, similar to a VCR or DVD. Other on-demand content such as audio and games should be supported.

On-demand services available using multiple authorization modes that should be supported include, but are not limited to:

- Complimentary on-demand.
- Subscription on-demand.
- Pay-per-view.
- Network-based digital video recorder (DVR) where subscriber specified content is stored at head end-based servers.
- Push on-demand (download-based content distribution services).

From the standpoint of the end user's experience, authorization modes can operate differently depending on the subscriber's relationship with the network and service providers. Each offers play, pause, stop, fast-forward and rewind capabilities. Authorization flexibility allows multiple viewing conditions which include the ability to watch any movie, as often as the customer wishes, for a service provider-defined period of time.

See also requirements R 6.1-03, OR 6.1.1-02 and clause 6.5.1.5 of [ITU-T Y.1901].

5.2.4 Support for digital programme insertion (DPI)

The IPTV framework for the secondary distribution architecture should support the following content insertion services in accordance with [ITU-T J.280], [ITU-T J.181] and Recommendation ITU-T J.189:

- Digital-into-digital advertising includes the capabilities to insert, or splice, one digital programme (the ad) into a second digital programme (the content being viewed). Insertion should include both video and audio content. The insertion may occur in the head end, the hub, the CPE or a combination of any to deliver a particular ad to the viewer. Advertising content can be streamed in real time as part of the transport multiplex for a video service, stored in an on-demand ad insertion system, or available in the hard drive of a DVR-capable CPE and streamed to the CPE across the home network. The CPE should support seamless splicing of ads in all supported formats from any supported source into a video stream as it is being displayed.
- Targeted (geographic grouping) and addressable (demographic grouping) advertising delivers a particular ad to a more targeted audience of viewers. This is normally accomplished by putting multiple ads into the same digital stream multiplex and the CPE selects which ad to present to the viewer based on tagging data on the ads and information present in the CPE.
- Interactive advertising provides the ability for the subscriber to interact with the advertisement using the remote control to, for example, request a coupon or additional information.
- Data collection mechanisms gather information on channel viewing, advertising viewing or other subscriber utilization habits. The CPE should support applications that collect and store data for bulk reporting to a server at scheduled intervals.

See also requirements OR 6.1-03 and OR 6.1.1-09 of [ITU-T Y.1901].

5.2.5 Video game support

Video games may be supported by the CPE at the application layer. CPE models that support video games should provide resource capacity, including processing and memory, to support various gaming applications.

See also requirement R 6.1.1-02 of [ITU-T Y.1901].

5.2.6 Interactive television

The CPE should support interactive television (ITV) applications such as, but not limited to:

- Weather.
- News.
- Sports.
- Investment.
- Local programming.

See also requirements R 6.1.1-02 and OR 6.5.2.9-01 of [ITU-T Y.1901].

5.2.7 Other IP-based applications

The CPE may have the capabilities to utilize the IP access to provide new applications provided by the service provider such as (but not limited to):

- E-commerce including managed content purchases and enhanced shopping channel.
- Textual and video IM.
- E-mail.
- Web-based services/Internet portal access.
- Telephony integration (voicemail, caller ID, etc.).
- Third party call control.
- Video and audio conferencing.
- Real-time text applications.
- Content sharing (video, still images, etc.).
- Audio books.
- Subscriber preferences and parental controls.
- Navigation through a unified messaging application.
- Presence which recognizes the presence of an active user and provides this information to a CPE application.
- Distance learning, telemedicine and other information services.
- Home security monitoring.
- Multi-user online gaming.
- Remote content management.

These services are supported by the CPE at the application layer. The CPE should provide resource capacity, including processing and memory, to provide an interactive user experience.

5.2.8 Managed content and server-based services

Managed content is web-like content, but contained on internal network or service provider servers. This allows the CPE to access this data without the security concerns that comes with full Internet access.

Server-based services are those where processing and rendering of the service or content occurs at the head end and an MPEG stream is sent to the CPE for display.

The CPE should provide the necessary support for managed content and server-based services.

5.2.9 Multi-camera angle programming

Multi-camera angle programming is broadcast programming that has several video streams associated with it. Each video stream can, for example, show a different angle of a sporting event. The user navigates through the different camera angles by using their remote control, which communicates with a CPE application that provides this service, and selecting the desired video stream.

Multi-camera angle programming is supported by the CPE at the application layer. The CPE should provide resource capacity, including processing and memory, to support multi-camera angle programming.

See also requirement RR 6.1-06 of [ITU-T Y.1901].

5.2.10 E-commerce support

The CPE should provide application layer support for e-commerce services including shopping channels. These applications enable direct ordering of featured products and services at the time of display using the remote control. This material will most likely be stored remotely and the CPE should have the ability to communicate with the data repository via secure channels that are analogous to HTTPS protocols.

5.2.11 Digital video recorder (DVR) services

A DVR service is defined as a recording capability that can be solicited and operated by end users to record and store video, audio and other associated content for subsequent playback.

It is recommended that the IPTV CPE be capable of supporting DVR services. The CPE should be capable of supporting four envisioned DVR services:

1) Client DVR (cDVR).
2) Network DVR (nDVR).
3) Distributed DVR (dDVR).
4) Mobile DVR (mDVR).

While each of the envisioned DVR technologies may be unique, the service that is required to be supported by the CPE remains constant to the end user.

In all cases, the end user can interact with a GUI (such as the EPG or DVR on-screen display (OSD)) in order to schedule, modify, playback, erase, etc., recordings.

It is recommended that the DVR service support the ability to:

- Schedule recordings (manually or through the use of an EPG).
- Schedule repeating recordings (manually or through the use of an EPG, e.g., record the whole season of a programme).
- Display a list of already recorded programmes/content and a list of upcoming recordings.
- Modify pre-existing scheduled recordings.
- Rank recordings according to priority (high priority recordings take precedence, when recording, over lower priority recordings).
- Play back recorded programmes/content.
- Erase recorded programmes/content (whether viewed or not).
- Copy recorded programmes/content to removable or external local storage devices, according to copyright privileges.
- Automatically (end user unaware) record content.

See also OR 6.1.1-02 and clause 6.5.1.6 of [ITU-T Y.1901].

5.2.12 Other services

The IPTV system should support needed community and accessibility services, which are additional content components intended to assist people hindered in their ability to perceive an aspect of the main content, as required by the local customer base, for example:

- Emergency alert system (EAS).
- Closed caption, subtitles, audio description and sign language interpretation.
- Real-time text communication between users of the system.

For further information, refer to the accessibility and standardization website [b-ITU-T Accessibility], which includes pointers to the telecommunication accessibility guidelines and telecommunication accessibility checklist.

See also requirements R 6.5.2.10-11, R 6.5.2.10-12 and Appendix I (public interest cross-reference) of [ITU-T Y.1901].

5.3 Functional requirements

This Recommendation specifies how television services may be enhanced by IP-based technology over secondary distribution networks as shown in Figure 2. The enhanced broadcast services will likely support some or all of the following important functional requirements.

5.3.1 Control functions

Most configuration and control parameters are transmitted via IP to the control function of the CPE from a controller in the service provider head end.

The CPE control function should support remote configuration, monitoring, logging, reporting and troubleshooting.

The control interface of the CPE may include many classes of functions. These functions may include service information, emergency alert system, conditional access, configuration and management, software download, and polling and report-back. These classes of functions are further described in the following clauses.

5.3.1.1 Service selection mechanisms

5.3.1.1.1 Service information (SI)

The MPEG transport and hybrid CPE should support the service information (SI) system that describes the programme delivery over MPEG transport including (but not limited to) frequencies, system time, channel maps and services in use on the cable system on which the CPE resides.

- The frequency definition defines the centre frequencies of the carriers used on the network and the indices used to refer to the frequencies, including defining HRC, IRC or standard set-top channel maps.
- System time includes the current time and is used to set the CPE time.
- Channel maps define the relationship between the display channel and the frequency, MPEG service number, source ID (for a linear broadcast channel) and where the service can be found.

The hybrid and IP-only CPE use either the service/system information or other solutions (e.g., solution defined in [ETSI TS 102 034], direct access to a web portal with a browser) in order to find out where on the network to access any content that the user selects. In order to support IP-based CPE (hybrid or IP-only), existing service/system information data need to be updated and modified to provide the data necessary for an IP-based CPE to discover and access digital/analogue services provided on the network. In addition to the existing RF/frequency-related information, the updated SI data must support at least the following (this is not an exhaustive list) in order to allow

for IP transmission: source IP address (to allow for SSM), multicast destination IP address and UDP port, different IP encapsulation methods (e.g., UDP/RTP/MPEG2-TS), stream bandwidth information, etc.

The CPE software should accept the MPEG-2 service information (SI) including programme association table (PAT), programme map table (PMT), network information table (NIT), virtual channel table (VCT) and system time table (STT).

The CPE should use the system time message to synchronize its local clock and should provide a clock signal to the middleware and applications. The CPE should be capable of maintaining a channel map and make it available to middleware and applications.

SI standards are region-specific, and the following are some of the regional standards that apply:

- [ANSI/SCTE 65]/[ATSC A/65C].
- DVB [ETSI EN 300 468].
- [ARIB STD-B10].

5.3.1.1.2 Service discovery and selection (SD&S)

GEM 1.2 [ETSI TS 102 543] defines protocols for the discovery and selection of GEM services and service information (described above in clause 5.3.1.1.1). GEM 1.2 defines an optional "IPTV target" profile (see clause 8.3.1 below).

If the CPE implements the "IPTV target" profile, then the GEM specification requires full conformance with that profile.

[ITU-T H.770] describes another solution for the discovery of IPTV service providers and services offered by these providers.

Access to a web portal operated by the service provider is another solution for the end user to discover services and to make a selection among them.

5.3.2 Emergency alert system (EAS)

The CPE should support the emergency alert system that is used to communicate emergency information to end users, such as severe weather conditions and other local, regional or national emergency alerts. The EAS system in the head end transmits compliant alert messages to the CPE.

The CPE should accept and fully support alerts as detailed in the relevant national standards.

5.3.3 OSS

ITU-T recommended OSS capabilities pertaining to support of IPTV services should be incorporated consistent with the principles for the management of NGN in [ITU-T M.3060] and the management functions in [ITU-T M.3400].

5.3.3.1 Configuration and management

Configuration and management support includes:

- Support for dynamic and static provisioning of CPE (STB, media adaptor, etc.) with such information as an IP address.
- Support for dynamic provisioning changes (such as application-specific configuration) without requiring a CPE reboot unless explicitly indicated via a management interface (for example, critical software download).
- Support for activation and deactivation of clients and application features, such as console interfaces and user guides, setting time zone information, clearing the customer PIN or resetting the CPE.

- Ensuring that real-time provisioning and configuration of software does not adversely affect subscriber service.
- Defining information models for managing customer CPE using an appropriate modelling methodology (for example, the IETF network management approach).

The CPE should support well-established industry standard protocols for configuration and management, such as:

- The IETF protocol suite:
  - SNMPv2/v3 [b-IETF RFC 3417].
  - DHCP [IETF RFC 2131], [IETF RFC 2132].
  - TFTP [IETF RFC 1350].
  - HTTP [b-IETF RFC 2616].
- UPnP [b-UPnP].
- Open Mobile Alliance (OMA) device management [b-OMA DM].
- Web services (e.g., XML) [b-WC3 XML].
- DSL forum TR-069 [b-DSL TR-069].

5.3.3.2 Software download

The CPE should support software download and upgrade capability via the remote download interface using methods such as in-band DSM-CC carousels, multicast IP or TCP/IP.

The software downloaded to the CPE may be classified into three types: firmware, middleware and conditional access software.

In a cable TV network, CPE using DOCSIS software upgrade mechanisms should follow the specification for privacy on the DOCSIS channel and authentication of the software image.

5.3.3.3 Polling and report-back

The CPE should support polling and report-back messages from the head end controller to poll the CPE for purchase information as well as diagnostic and configuration information. Purchases may be retrieved by the controller and passed on to the billing system. The process of collecting CPE report-backs is initiated and managed by the head end controller or may be initiated by the CPE in the form of an "unsolicited report-back".

5.3.3.4 Fault management

Fault management requirements address fault detection, reporting and isolation functions. This also includes diagnostics and testing functions.

5.3.3.4.1 Diagnostics

The CPE should support monitoring capabilities that will provide diagnostic information about its configuration and operation. This information should be made available both locally (for example, by using onscreen display graphics) and over the network. The intent of this capability is to provide information on the CPE's operational and application states such that any CPE issue can be quickly understood and resolved.

Support for the following requirements should be provided by the diagnostics:

1) The CPE software should support remote diagnostics as specified by the network and service providers.
2) The CPE software should provide all requested diagnostic information to the middleware functions and applications.

5.3.3.4.2 Additional fault management requirements

The CPE software should support fault management requirements as specified by the network and service providers. It should support mechanisms such as event notification to report faults.

5.3.3.5 Accounting and metrics requirements

An event-recording mechanism should be supplied to capture event data for transaction-based services. Back-office servers that support delivery of services should report appropriate usage data.

If this function deals with user privacy aspects, it needs to keep privacy protection laws in each region and/or standards such as ISO/IEC 27001, ISO/IEC 27002 (Notes 1 and 2) and the OECD guidelines on the protection of privacy and transborder flows of personal data. This implies the consideration of end user permission when collecting and transferring the user privacy data into a viewership data tracking server.

NOTE 1 – ISO/IEC 27001 is the certification standard against which organizations' ISMS may be certified.

NOTE 2 – ISO/IEC 27002 is the code of practice with good practice advice on ISMS (previously known as ISO 17799 and before that BS 7799 Part 1).

5.3.4 User interface

The user interface defines the input and output control and status mechanisms that interface the CPE with the end user. Beyond interaction with the service applications, customers use the user interface to configure certain parameters and user preferences on the CPE. The primary input mechanism for the user interface to the CPE may be a remote control.

The CPE may provide a web service to enable a user to control its basic features (such as channel selection and EPG browsing) using a standard web browser. This enables users to control the equipment by means other than the traditional remote control and on-screen display.

The user interface should be configurable by network operators for capabilities such as programme selection features and programme guide functionalities.

5.3.5 Signalling and control requirements

Signalling and control includes:

- A preferred signalling architecture for establishing new sessions, modifying existing sessions and tearing down sessions.
- Feature capabilities of the selected signalling protocol(s), including channel change and trick mode (VCR) operation including pause, rewind, fast forward, resume and stop.

5.3.5.1 DOCSIS/DSG in a cable TV network

The DSG [ITU-T J.128] architecture allows the command and control to be based on IP transport over DOCSIS/DSG. The DSG network is designed to be functionally transparent to the head end controller environment from an operations and services standpoint.

The inclusion of a DOCSIS DSG cable modem in the CPE allows and facilitates:

- Transition of the legacy out-of-band (OOB) messaging from its physically separate transport (e.g., legacy quadrature phase-shift keying (QPSK) modulated channels) to DOCSIS transport.
- Transition of interactive application traffic from the legacy OOB transport to DOCSIS transport.

- Definition of a standardized provisioning and operations environment for CPEs which is functionally separate from the conditional access system and is operationally consistent with other IP devices such as cable modems, PCs and IP telephony multimedia telephony adapters (MTAs).

DSG reuses infrastructure from existing HFC networks including the DOCSIS downstream and upstream channels to carry CPE messages in a way that is non-disruptive to other services on those same channels (e.g., high speed data, VoIP, IPCablecom multimedia).

In DSG operation, the CPE includes a DOCSIS cable modem that implements DSG functionality, and a CMTS is used to communicate both one-way and two-way control plane messaging traffic from the head end controller to the CPEs.

In a cable TV network, the DSG cable modem subsystem provides the communication tunnels for command and control of the CPE functionality, some of which are listed below:

- Provisioning of the CPE functionality through the DSG tunnels.
- Delivery of system information (e.g., time and date information).
- Service information including programme association table (PAT), programme map table (PMT), network information table (NIT), virtual channel table (VCT) and system time table (STT).
- Low level device configuration settings and control functions including time zone, virtual channel map ID assignment and CPE reset commands.

In a cable TV network, the CPE DOCSIS DSG cable modem subsystem should continue to operate in the event of failure of any CPE subsystem (except for a power failure) to allow the cable modem in a partially failed CPE to provide status and diagnostic information to local and remote entities (e.g., display and remote monitoring systems).

5.3.5.2 IP-based command and control

The following are standard mechanisms for IP-based command and control of video services:

- *RTSP for on-demand content*

  The IP-based CPE MUST support RTSP for the delivery of unicast on-demand content, and the remote control of a streaming media server. A session ID is used to keep track of sessions, this way no permanent TCP connection is required. RTSP messages such as "setup", "play", "pause", "record" and "teardown" are sent from the CPE to the media server for controlling the delivery of the selected media stream.

- *IGMP/MLD for multicast content*

  Assuming that the IP-based CPE supports IGMPv3 for IPv4 or MLDv2 for IPv6, and that SI information supports IP transmission as described in clause 5.3.1.1.1, the CPE uses the source IP address and multicast destination address in SI to join (using source-specific multicast) the appropriate multicast flow transporting the content requested from the end user.

5.3.6 Media transport functional requirements

Digital media signals enter the CPE via the desired transport, and are demodulated, de-multiplexed, decrypted and decompressed, followed by optional processing such as graphics overlay and image scaling applied to prepare them for viewing by the subscriber.

5.3.6.1 Video

5.3.6.1.1 Video codecs

The CPE should support decoding of MPEG-2 and may support other advanced video codecs, such as MPEG-4 AVC and VC-1. Simultaneous decode of MPEG-2 and one of the two advanced codecs should be supported; however, simultaneous decode of the two advanced codecs need not be supported.

For CPEs that support advanced codecs, it should be possible to switch between MPEG-4 AVC and VC-1 via command from the head end. The switch between MPEG-4 AVC and VC-1 need not be instantaneous and may involve code download and/or remote reconfiguration of the device.

5.3.6.1.2 Video resolutions

The following references detail region-specific source and compression formats that should be supported: [ANSI/SCTE 128], [ANSI/SCTE 43], [ETSI TS 101 154] and [ARIB STD-B32].

5.3.6.1.3 Video processing

The CPE should be capable of converting any specified input decoded picture source format/resolution to the chosen output format/resolution through a combination of video scaling and de-interlacing. CPEs that support high definition outputs should provide native mode video output support so that it automatically changes output resolution formats to match the broadcast format.

The CPE should support the following video processing features:

- Independent horizontal and vertical scaling ranging from 1/32 (down-scaling) to 32 (up-scaling).
- 3:2 pull-down cadence detection.
- Reverse 3:2 pull-down detection and filtering.
- Digital noise filtering.
- Edge enhancements.

Video outputs (RF and baseband) should conform to accepted international standards.

The CPE should support the scaling of a video source for display.

5.3.6.1.4 VBI data processing

The CPE should be capable of passing-through, extracting, decoding and rendering vertical blanking interval (VBI) lines carried in an encoded content stream and should make the VBI data available to the CPE operating system and applications for processing.

The CPE may support closed-captioning standards and VBI capabilities such as: [ANSI/SCTE 20], [ANSI/SCTE 21] and [ETSI EN 301 775] (modified by [ANSI/SCTE 127]), [CEA-608-C] and [CEA-708-C]).

In the event that both [ANSI/SCTE 20] and [ANSI/SCTE 21] closed captions are present simultaneously, the preference is to select [ANSI/SCTE 21] closed-captioning data.

5.3.6.1.5 Video rich navigation – non-overlay

The CPE should support a video rich navigation (VRN) application with decoding and compositing in the video plane, combining with graphics, and display in a non-overlay type configuration of multiple lower resolution full motion video streams (MPEG-2 or advanced codec) onto either SD or HD display outputs. One audio stream is decoded for the video that is highlighted or selected.

5.3.6.1.6 Video rich navigation – overlay

The CPE should support a VRN application with decoding and compositing in the video plane, combining with graphics, and display in a picture-in-picture (PiP) type configuration with one full resolution and multiple lower resolution full motion video streams (MPEG-2 or advanced codec) onto either SD or HD display outputs. One audio stream is decoded for the video that is highlighted or selected.

5.3.6.2 Audio

5.3.6.2.1 Audio decoder

The CPE should support decoding of the following compressed audio bit stream formats:

- MPEG-1 layers 2 and 3 (MP3).
- Dolby Digital (AC-3) up to 5.1 with matrix audio (Pro Logic).
- MPEG-2 AAC (AAC-LC) [ISO/IEC 13818-7].
- Dolby Digital Plus (enhanced AC-3) with matrix audio (Pro Logic).
- MPEG-4 AAC and high efficiency AAC (aacPlus) 2-channel programme.
- Linear pulse code modulation (LPCM) encapsulated in IP over home network interface.
- Non-linear PCM encapsulated in IP over home network interface (for CPE models that support home networking interfaces).
- Windows Media Audio (WMA).

5.3.6.2.2 Audio outputs

The CPE should be capable of responding to user preference for adjusting Dolby Digital audio dynamic range compression. The CPE should be capable of supporting user or network selection among a minimum of three compression characteristics: uncompressed, intermediate and heavy.

Audio signal performance should not degrade over the normal operating volume level range.

5.3.6.3 Still images

The CPE should be capable of displaying MPEG-2 still images received in the transport stream.

The CPE should be capable of displaying MPEG-4 AVC and SMPTE VC-1 still images received in the transport stream.

The CPE should be capable of displaying JPEG, GIF and PNG image formats.

5.3.6.4 Graphics

The CPE should support video graphics display compositing layering functions using a still video layer, the main video programme layer and the graphics layer.

The CPE should implement appropriate graphics scaling filters in order to avoid spatio-temporal aliasing.

The CPE graphics subsystem should support the following two-dimensional acceleration components:

- Colour-space conversion support for all standard video colour spaces (RGB, YCbCr and variants thereof).
- Hardware accelerated per-pixel alpha blitter, line drawing, polygon/rectangle fill, bit masking and panning/scrolling.
- Support for sprites, transparent bit-block transfer (BLT), masked BLT and context chaining.

The CPE should scale graphics to the current output resolution of the given display.

5.3.6.5 Text

The CPE should be capable of handling text output with display features selected by the user, regarding size, colour, background colour and opacity, and position.

The CPE should have support for presenting text in the languages used by the target market.

The CPE may have means for text input, e.g., for use in interactive and conferencing applications.

5.3.7 Resource and policy management

A resource management mechanism should be defined which includes:

- Dynamic resource request mechanisms which utilize the DOCSIS QoS scheduling capabilities.
- Support for unidirectional resource reservations.
- Support for network-initiated resource requests on behalf of the CPE, and means for detecting CPE failure allowing for resource reclamation.
- Support for resource changes during a session.
- Flexible resource commitment (single, multiple phase).
- Theft-of-service protection.
- Protection against denial-of service attacks.
- Admission control mechanisms.
- IP backbone QoS for unicast and multicast traffic.

Policy management may include rules defining resources that are authorized:

- Per-service.
- Per-subscriber.
- Bandwidth (specified using token-bucket parameters).
- Latency guarantees.
- Policy expiration times.
- Policy volume limits.

Policy management may also include:

- Rules defining scarcity/value of bandwidth based on time of day.
- Pre-emption rules.
- Admission control policies.

5.3.8 Security requirements

5.3.8.1 Security architecture

The CPE should include multiple layers of security to protect access to the network, access to content and services, and protection of content. The security architecture for the CPEs should cover the following elements:

- Access to services.
- Access to service provider and subscriber content.
- Access to manufacturing test ports.
- Security of CPE operational functions, including boot sequence and code download.
- Security of access to, and content on, the home network.

- Protection of the various encryption keys used to secure services and infrastructure.
- Protection of user privacy for selection of VOD and impulse pay per view (IPPV) selections.

5.3.8.2 Conditional access

The CPE controls the subscriber's access to content based on entitlements delivered by the conditional access system (CAS). Conditional access provides the functionality to authorize and de-authorize services and resources in a CPE by delivering and managing encryption keys and tiers. Many of the details surrounding conditional access and the messaging used by the conditional access system are securely protected within the removable or renewable security subsystem components.

The CPE should query the conditional access system to determine the subscriber's entitlements.

5.3.8.3 Content protection

Content is defined as any information (including video, audio and application download) that is provided by the network or service provider and available for retrieval by an authenticated and authorized user. Network and service providers are often bound by agreements to their content providers to securely distribute and protect against unauthorized copying and redistribution of content.

Content protection in the CPE may be provided by a CAS client and/or digital rights management client.

The following describes the primary functionality that the authenticated CPE should provide to meet the content protection requirements:

- The CPE should engage the CAS content decryption engine to decrypt all encrypted content that the CPE is authorized to access.
- The CPE should engage the digital rights management content decryption engine to decrypt content that is received from a home network interface for display locally.
- The CPE software should conform to the compliance and robustness rules of relevant licensors of conditional access, copy protection and digital rights management technology.
- The CPE should not provide unencrypted access to compressed content in any components, busses or interfaces.

5.3.8.4 Copy protection

The CPE should support the following copy protection requirements:

- All analogue outputs may be enabled or disabled based on service provider configuration.
- High-bandwidth digital content protection (HDCP) copy protection on the HDMI digital video output.
- DTCP copy protection compliant with [ANSI/SCTE 26] on the 1394 digital video output.

5.3.8.5 Parental control

Parental locks are applied by an application to prevent access to content unless authorized.

5.3.8.6 Code download security

The following describes the primary functionality that the CPE should provide to meet the code download security requirements:

- The CPE should perform secured/trusted code download for the CPE software.
- The CPE should only execute software that has been signed and verified.

- A DOCSIS-based CPE should follow the DOCSIS specification for secure software download.

5.3.8.7 Cryptographic services

The following describes the primary cryptographic services functionality that the CPE must provide to meet security requirements:

- A DOCSIS-based CPE should comply with the requirements of the DOCSIS specification.
- A DOCSIS-based CPE should perform authentication with the CMTS.
- The CPE should provide an SSL cryptographic library.

5.3.8.8 Removable security

The CPE may implement a removable security interface. The interface is a removable device that provides the conditional access and content protection security systems.

In a DOCSIS-based CPE, the DSG communications system should provide the OOB communication path.

5.3.8.9 Digital rights management

The CPE should implement digital rights management content protection for viewing content streamed from other trusted devices through the home network.

5.3.9 Home networking requirements

[ITU-T J.190] describes the ITU standards for home networking.

5.3.9.1 Home networking

The CPE may operate as a device on the home network for applications allowing authorized content and resource sharing from other networked in-home CPEs.

Participation of the CPE in a home network allows the hard disk drive content storage resource to be integrated inside a remote CPE, yet allows stored content to be viewed on a television connected to a diskless CPE.

A high definition version of the CPE should be capable of receiving HDTV content over the home network, decode it, and render it through its video outputs. The CPE should provide sufficient buffer memory for the content streams to provide a freeze-, jitter- and drop-out-free viewing experience.

5.3.9.2 Home networking features

The DLNA home networked device interoperability guidelines [b-IEC 62481-1] and [b-IEC 62481-2] define five device classes that are used in the home network. The CPE should support the following two device class certifications when mated with the appropriate application software:

- Digital media player (DMP).
- Digital media renderer (DMR).

A digital rights management system specified by the service provider should be included to manage the protection of content received through the home network.

The CPE should provide the following services and features when connected to the home network:

- DVR playback including trick play support of stored content as a client to a compatible DVR device.
- Scheduling of programme recording on a compatible DVR device connected to the home network.

- Advertising content can be streamed in real time from the hard drive of a compatible DVR-capable CPE to the diskless CPE across the home network.
- Remote monitoring and diagnostics of the home network.

The CPE should provide the above services when connected to other CPEs as well as legacy devices across the home network.

5.3.9.3 Home networking software support

The CPE should provide the software necessary to support functioning as a client in a compatible home network environment. The compatible home network environment is characterized by a number of interoperable protocols, media formats and software profiles specified by the service provider.

5.3.9.4 Quality of service (QoS)

The goal of QoS is to improve the user experience of the home network's ability to deliver predictable results for sensitive applications such as audio and video. QoS parameters include bandwidth (throughput) and latency (delay) characteristics.

5.3.9.5 Home networking media transport formats

The CPE should support processing of MPEG-2 transport streams, MPEG-4 AVC streams and SMPTE VC-1 ([SMPTE 421M], [SMPTE RP 227]) streams received on any of the home network interfaces.

The transport mechanisms listed are independent of both the codec used to encode the content which is being carried by the transport and the security system used to provide access to that content. All supported codecs and the security system should work with all home network media transport formats.

5.3.10 NAT/Firewall traversal

IPTV services should be able to cross NAT Firewall (FW) boundaries.

5.3.11 Middleware

A set-top-box-based CPE should support broadcast-centric middleware defined by [ITU-T J.200], [ITU-T J.201] and/or [ITU-T J.202] and GEM 1.2 [ETSI TS 102 543] to satisfy the requirements defined in [b-ITU-T J.701].

6 Functional architecture

Now that the IPTV requirements have been discussed, we can define a high-level functional architecture appropriate to meet these requirements.

6.1 General architectural requirements

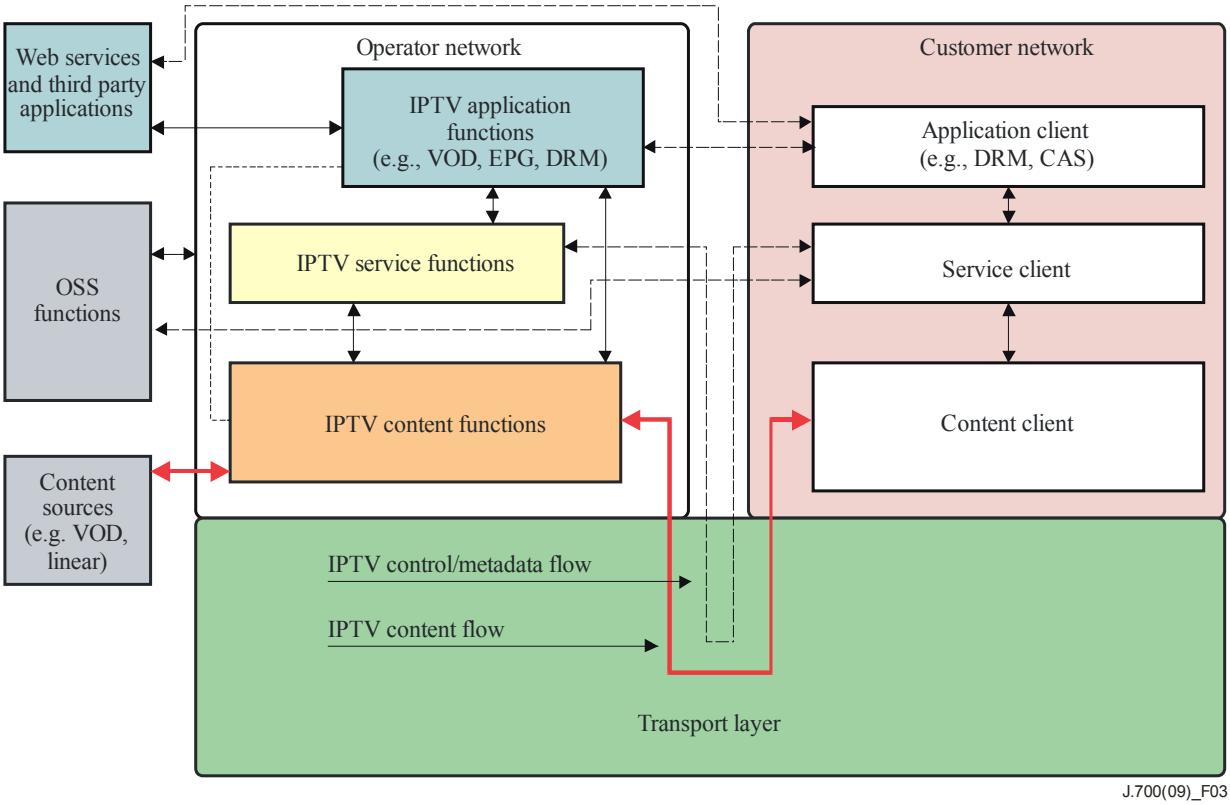
The service and functional requirements have been presented above. This clause revisits some of the general requirements that the functional architecture will satisfy:

- Offer video, voice and data services across a common network infrastructure:
  - This architecture may support the delivery of multiple services over the common IP transport with quality of service (QoS); services may be delivered from multiple service providers or from a single provider.
  - This architecture shall support converged services.

- Access services on a wide variety of subscriber devices:
  - This architecture should allow the delivery of IPTV service to any kind of IPTV-enabled device.
- Support and build upon IPCablecom for signalling QoS support.
- Integrate multiple services together into a common interface customized per device:
  - There are some mature services in the operating network, such as POTS telephone, video conference, etc. It is expected that IPTV services be integrated with the existing services and it is requested that all these services be provided through a unified service platform.
- Easily implement and customize new services.
- Support standards to maximize ability to leverage alternative vendors.
- Support highly available IP-based core and metropolitan networks.
- When using HFC access, all in-home IPTV services can operate over a DOCSIS 1.1-based HFC access network; however, the additional bandwidth enabled by later versions of DOCSIS can increase the number of functions and capabilities.
- The architecture will accommodate interworking with the IMS-based IPCablecom2 systems to allow IPTV services to be delivered to mobile devices, PCs, etc.
- The IPTV architecture should allow the delivery of IPTV services over different access networks (e.g., cable, optical, xDSL, wireless).
- Existing IP-based cable capabilities will be used for delivery of IPTV services over cable networks, including:
  - DSG for IP-based OOB signalling.
  - Delivery of interactive video to unidirectional receivers in conjunction with an IP control mechanism.
  - eDOCSIS for embedded cable modems in the residential gateway or CPE [b-ITU-T J.126] (including eRouter, eSTB, etc.).

6.2 Secondary distribution functional architecture

The IPTV functional architecture shown in Figure 3 is functionally equivalent to the architecture defined in [ITU-T Y.1910] and constitutes a subset of the functions adapted for use over secondary distribution networks.



NOTE – The operator network and the transport layer in Figure 3 are equivalent, respectively, to "service provider" network and "network provider" network specified in [ITU-T Y.1910] "IPTV domains". Also, IPTV application functions, IPTV service functions and IPTV content functions defined in this Recommendation are equivalent to application functions, service control functions and content delivery functions of [ITU-T Y.1910], respectively.

Figure 3 – Functional architecture for IPTV secondary distribution system

Appendix V of [ITU-T Y.1910] identifies mapping of interfaces between this Recommendation and [ITU-T Y.1910]. Detailed correspondence between these two Recommendations can be found in Figures 10-1 to 10-6 and Appendix V of [ITU-T Y.1910].

The following clauses describe the main IPTV functional elements in more detail.

6.2.1 IPTV application functions

The IPTV application functions include the following:

1) Interactive services portal.
2) Web browser capability.
3) Subscriber settings.
4) DVR control.
5) EPG capability and presentation.
6) VOD playback capability.

It is a requirement that the IPTV application functions should be customizable to enable different network operators to configure their own user interfaces in terms of programme selection features and programme guides, etc.

The following are examples of some IPTV services and applications that may fall into the "IPTV application functions" functional block in Figure 3:

1) EAS.
2) EPG.
3) PPV.
4) VOD.

6.2.2 IPTV service functions

The following are examples of IPTV service functions from Figure 3:

1) RTSP handling and processing client functions.
2) Multicast IGMP/MLD processing.
3) System information (SI) acquisition and management.
4) CAS/DRM control processing and client handling.
5) EPG acquisition and management.
6) Content protection.
7) DVR control functions.
8) Diagnostics.
9) SNMP handling/processing.
10) Closed captions processing.
11) Data handling based on DSM-CC data carousel/channel mapping.
12) Session/resource control.
13) Policy management.

Clause 8 expands on these functional components by listing examples of capabilities involved in each area.

6.2.3 IPTV content functions

The following are examples of IPTV content functions from Figure 3:

1) Media/content acquisition.
2) Media/content encoding and encryption.
3) Media/content decoding and decryption.
4) Media/content multiplexing.
5) Media/content modulation.
6) Media/content storage.
7) Media/content rendering and display.
8) Media/content play control interaction.

Clause 8 lists additional IPTV-related capabilities that will be supported by the IPTV service and client functions. These capabilities may be extensions of existing HFC network capabilities or separate platforms interworking with established HFC networks.

6.2.4 Web services and third party applications

The following are examples of some web services and third party applications that may fall into the "web services and third party applications" functional block in Figure 3:

1) third party applications (such as caller ID, web search, etc.).
2) Web services (e.g., Web 2.0 applications).

6.2.5 OSS functions

The OSS functions include the mechanisms for provisioning, activating, controlling and managing the IPTV clients and the operator network (including IPTV services and applications, IPTV server functions, IPTV media/object delivery functions). Included are:

1) Billing and accounting.
2) Subscriber profile databases and services management.
3) Subscriber resource management.
4) CPE management.

6.2.6 Content sources

Content sources for video applications (including VOD) reside outside the operator network, and are acquired by the media/object delivery function within the secondary distribution network.

6.2.7 Transport layer

The transport layer contains the mechanisms for managing network resources, as well as the components of the core network and access network.

7 Relationship to existing secondary distribution networks

As service providers move to providing IPTV services over their networks, the co-existence of the new services with existing architectures and capabilities is of interest. In this clause, we examine the relationships between the IPTV framework and key service delivery and network technologies.

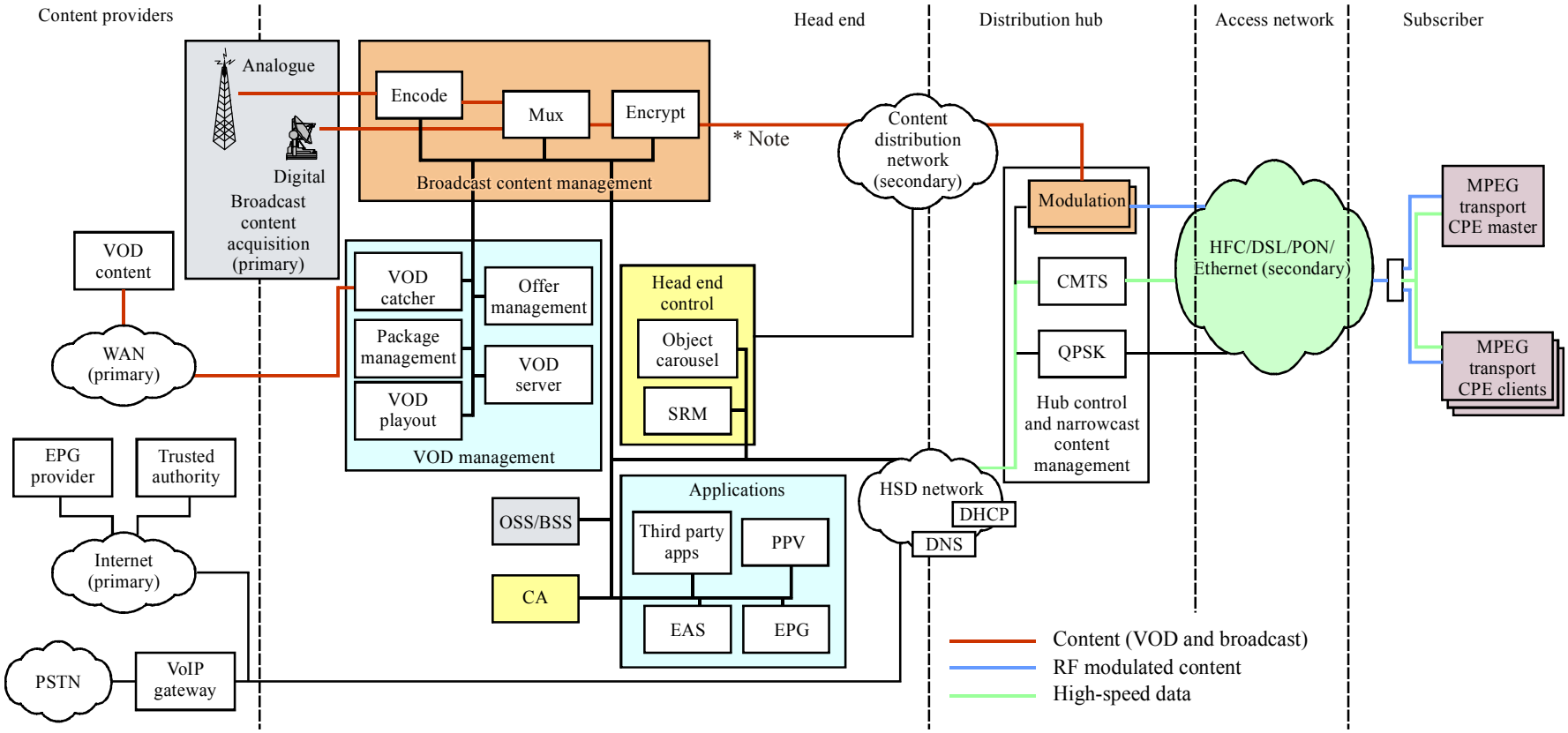
7.1 Relationship to hybrid fibre/coax networks

Of primary importance to cable service providers is the relationship of the new IPTV services to HFC-based technologies. This clause examines several of these relationships.

7.1.1 Relationship to existing video delivery architecture

It is very important to highlight the similarities and differences between existing video delivery architecture implementations (particularly those of HFC networks) to the IPTV framework being defined. The following diagrams and textual descriptions detail how to support IPTV services on existing video delivery architectures.

Figure 4 represents the layout of typical existing video delivery architectures. Analogue or digital broadcast content is received at the head end from a content provider over broadcast content acquisition means and VOD content is received over a WAN (or other content distribution means such as satellite, etc.) from a VOD content provider. The content is then encoded, multiplexed and/or encrypted (if necessary) and distributed to a distribution hub by way of a content distribution network. The modulation functions provide RF content distribution of this content to the subscriber via the access network (HFC/DSL/PON/Ethernet). The subscriber premises contains an MPEG transport CPE which receives, decrypts, de-multiplexes and decodes the content (if necessary). CMTS and QPSK functions are provided by the existing video delivery architecture for bidirectional communication using DOCSIS DSG or similar OOB signalling capabilities.



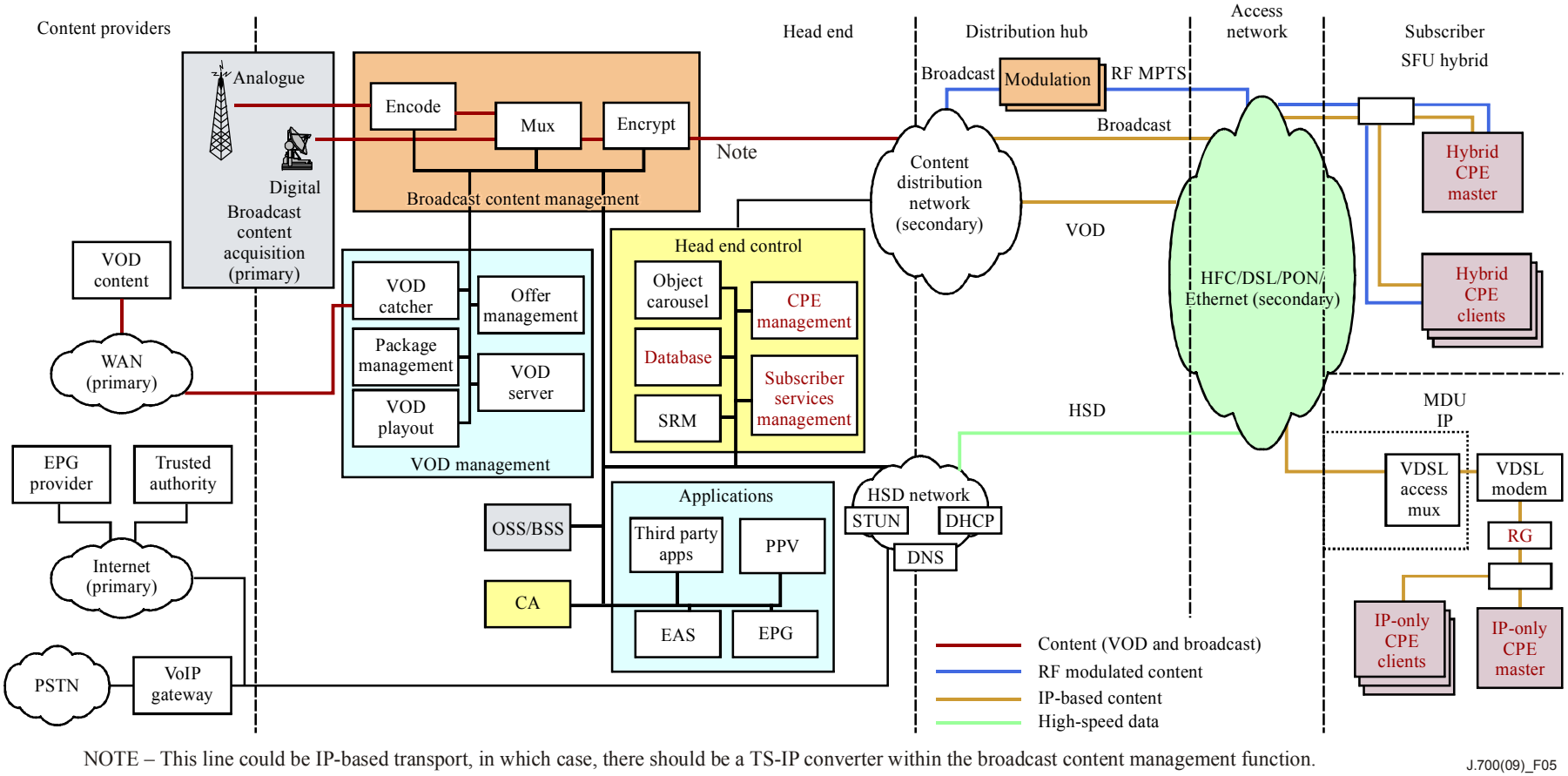
NOTE – This line could be IP-based transport, in which case, there should be a TS-IP converter within the broadcast content management function.

J.700(09)_F04

Figure 4 – Typical existing video delivery architecture

Figure 5 represents typical existing video delivery architecture utilizing IPTV control capabilities to provide IPTV services. Analogue or digital broadcast content and VOD content is received at the head end from a content provider through content acquisition over primary distribution means. The content is then encoded, multiplexed and/or encrypted (if necessary) and distributed to a distribution hub by way of a content delivery network (CDN). The broadcast content is modulated in the modulation functions and carried via RF over the access network and to the subscriber. The broadcast and VOD content is also sent directly from the CDN to the access network and is conveyed to the subscriber via IP. The subscriber premises may contain hybrid CPEs or IP-only CPEs. The hybrid CPEs are capable of decrypting, de-multiplexing and decoding the RF video signals as well as interpreting the IP-based multimedia and content signals. The IP-only CPEs are not capable of viewing RF video signals. In a subscriber premises, a residential gateway (RG) may be required to disseminate content and signals to and from the CPEs in the subscriber premises. Figure 5, which shows a typical existing video delivery architecture with IPTV service, maps to the above Figure 3.

- The block titled "broadcast content acquisition (primary)" maps to the "content sources" shown in Figure 3.
- The blocks titled "broadcast content management" and "modulation" map to the "IPTV content functions" shown in Figure 3.
- The block titled "VOD management" maps to VOD components of the "IPTV applications functions" shown in Figure 3.
- The block titled "applications" maps to "IPTV application functions" shown in Figure 3.
- The block titled "OSS/BSS" maps to the "OSS functions" block shown in Figure 3.
- The "access network" maps to the "transport layer" of Figure 3.
- The blocks titled "CA" and "head end control" map to the "IPTV service functions" of Figure 3.

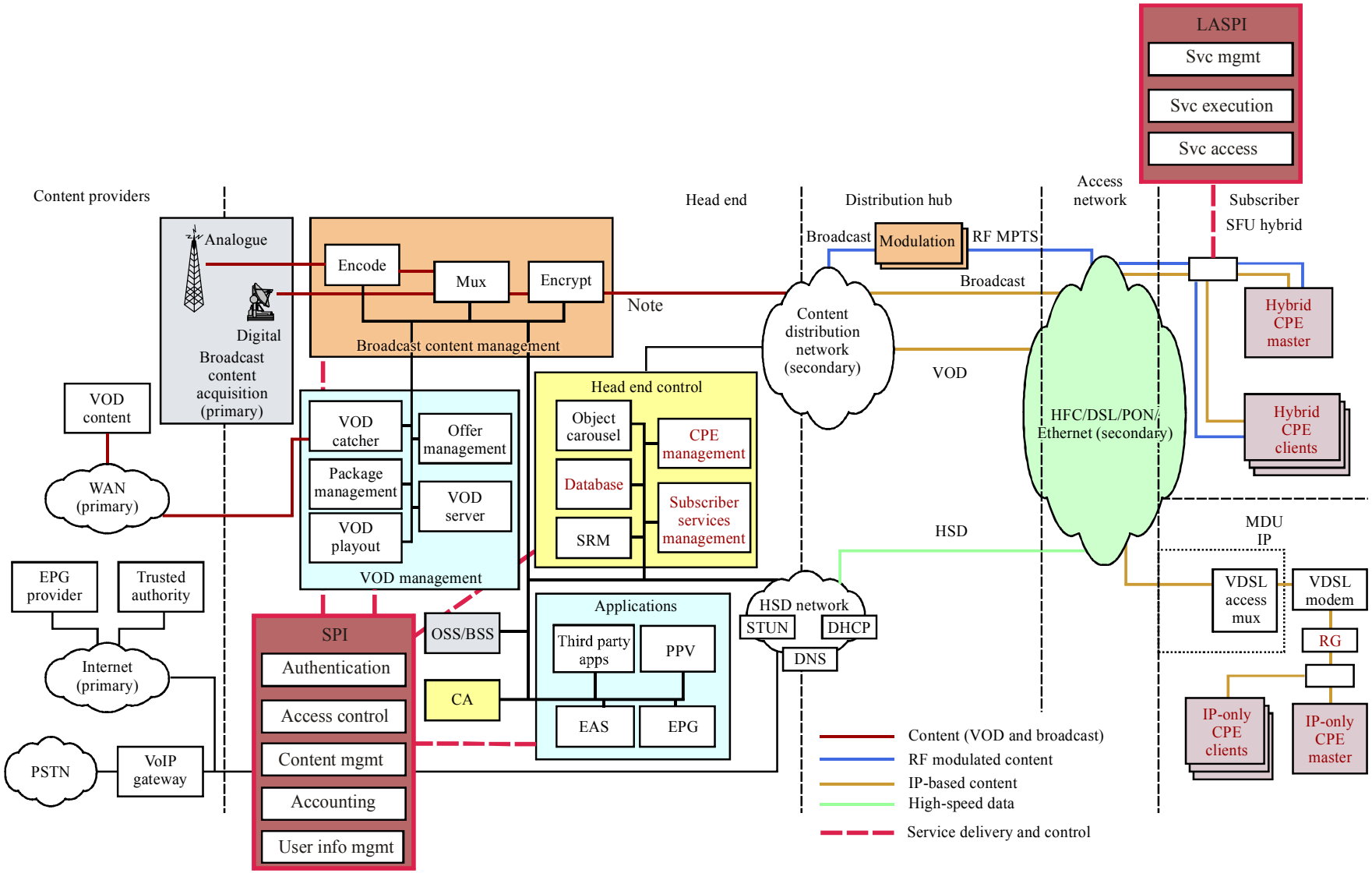


NOTE – This line could be IP-based transport, in which case, there should be a TS-IP converter within the broadcast content management function.

Figure 5 – Typical existing video delivery architecture with IPTV service

The few new items necessary for operating an IPTV service highlighted in Figure 5 above are discussed below:

- *Database, CPE management, subscriber services management* – The new functional blocks are used in the provisioning of services and subscribers within an IPTV system. CPE management manages and provisions the CPEs within the subscriber premises. The subscriber services management function manages the subscribers and the services associated with each. The database is used to manage and control the information required of the CPE management and subscriber services management functions.
- *STUN* – The simple traversal of user datagram protocol (UDP) behind a network address translator (NAT) is a network protocol that allows the CPE located behind the residential gateway (RG) containing a NAT to discover its public address, the type of NAT it is behind and the Internet side port associated by the NAT with a particular local port. This information is used to set up UDP communication between a host in the network and another one behind a NAT router.
- *RG* – The residential gateway is the router that is associated with each subscriber's premises. The RG is used to route information throughout multiple CPEs within the subscriber's home network and to communicate all signals into and out of the premises.
- *Hybrid CPE clients* – A CPE (such as a set-top box, PC, mobile device, etc.) that utilizes IP and RF as reception protocols. Content is delivered to the hybrid CPE by way of RF carriers or IP packets, over the same or different networks. The hybrid CPE clients may contact the hybrid CPE master to obtain content when the hybrid CPE master is the only device capable of recording or rendering content from the network.
- *Hybrid CPE master* – A CPE with master content recording and rendering functionality. The hybrid CPE master may be the only device within the subscriber premises that is capable of recording or rendering content from the network. A hybrid CPE client may then communicate with the hybrid CPE master to receive content.
- *IP-only CPE clients* – The same as the hybrid CPE clients, without the hybrid ability of allowing the CPE to receive and therefore decode and view RF signals. In other words, a CPE that utilizes IP only as reception protocol.
- *IP-only CPE Master* – The same as the hybrid CPE master, without the hybrid ability of allowing the CPE to receive and therefore decode and view RF signals.



NOTE – This line could be IP-based transport, in which case, there should be a TS-IP converter within the broadcast content management function.

J.700(09)_F06

Figure 6 – Relationship between video delivery architecture and service provider interface

Figure 6 represents relationships between the video delivery architecture illustrated in Figure 5 and two types of service provision interfaces, which are the service provider interface at the head end side and the interface in the subscriber environment for local application and services. The service provider interface at the head end will enable service providers to offer their content or services over cable operators' networks through the interface. The interface for local applications and services is also a kind of service delivery platform which resides within a home network to provide programming interfaces and functionalities to enable service providers and third party entities to deliver advanced and innovative applications and services to subscribers over a home network. The interface for local applications and services will communicate and interwork with the functionalities enabled by the service provider interface at the head end to create more value for customers and the service provider.

CPE-specific functionalities over an existing video delivery architecture and an IPTV service on existing video delivery architecture are compared below:

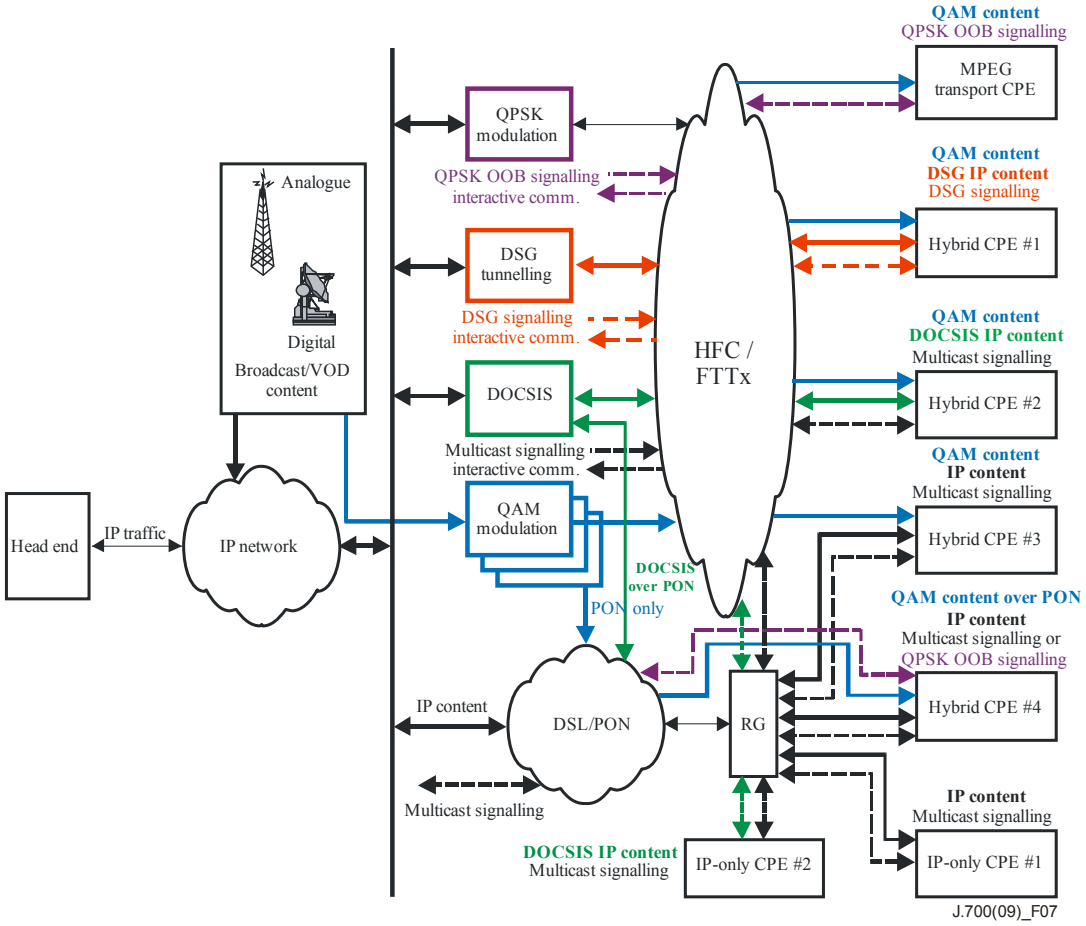


Figure 7 – Client devices in an IPTV-enabled network

In Figure 7, solid, bold lines indicate content or HSD flow. Dotted lines represent signalling and interactive communications paths. For example, notice in hybrid CPE #1, the CPE is receiving content from the QAM and content/HSD from the DSG CMTS; it is also receiving DSG OOB signalling from the DSG CMTS and is interacting two-way with the head end.

- *MPEG transport CPE*

  An MPEG transport CPE is seen in Figures 4 and 7 as the currently deployed technology in many existing video delivery network architectures. This MPEG transport CPE can receive broadcast and on-demand content from a video delivery network that supports the CPE. In

an existing HFC network, the MPEG transport CPE is often represented by a set-top box with a coax connection for receiving MPEG transport video via an HFC network. Many MPEG transport CPEs utilize bidirectional communications to and from the distribution hub by way of DOCSIS or DAVIC communications. The MPEG transport CPE of Figure 7 represents a CPE that uses OOB signalling provided by the QPSK as its signalling path and receives broadcast and VOD content from the QAM modulator. The assumption is that the CPE is not multicast-enabled.

- *IP-only CPE*

  An IP-only CPE is only capable of receiving content in IP form. No reception of RF modulated content is supported and the IP-only CPE must reside in an IP-based network, where it functions much like a network device with the capability of receiving video streams. The IP-only CPEs in Figure 7 represent CPEs behind an RG that receive only IP content and multicast signalling provided by the IP network, whether that network be an HFC network providing IP content over DOCSIS (IP-only CPE #2) or a DSL/PON network providing IP Content (IP-only CPE #1).

- *Hybrid CPE*

  A hybrid CPE should support one of the following access methods:

  1) Dual network access via a video delivery network and a different IP-based network. The video delivery network may consist of any of the following for conveying broadcast media streams:

     a) Hybrid fibre/coax.

     b) Terrestrial.

     c) Satellite.

     d) xDSL.

     e) FTTx.

     f) Wireless.

     This is by no means an exhaustive list, and any network that can be utilized for video delivery may be used as the "video delivery network". An IP-based network is utilized for receiving IP-based video streams and for bidirectional communication.

     Hybrid CPEs #3 and #4 in Figure 7 represent clients equipped with both a QAM tuner and an IP interface. Hybrid CPEs #3 and #4 can receive content (e.g., broadcast content and VOD) through both the QAM tuner (over HFC or a PON network) and an IP interface. It is assumed that these CPEs are multicast-enabled, therefore they are able to receive signalling over multicast via the IP interface. In the case of hybrid CPE #4, instead of signalling over multicast via IP, the CPE can use OOB signalling provided by the QPSK as its signalling path. The assumption is that these CPEs are behind an RG device.

  2) Dual network access via only one video delivery network over one physical interface. The RF and IP traffic is carried on the same network while utilizing different communication protocols. The RF technology of the existing video delivery network in the CPE allows for the reception of modulated content (from the QAM tuners). The IP functionality supported on the CPE allows it to receive IP-encapsulated content, IP signalling and perform interactive communication with the head end.

Hybrid CPE #1 in Figure 7 represents a special case of DSG CPE that could be multicast-enabled. In a scenario such as this, the provider is leveraging an existing video delivery architecture that already supports DSG signalling. In such a case, hybrid CPE #1 would continue to receive its signalling via DSG but is also able to join lightweight content (e.g., gaming, chat, etc.) via multicast over a channel provided by DSG while continuing to receive its broadcast or VOD content via QAMs.

Hybrid CPE #2 in Figure 7 represents a CPE equipped with both a QAM tuner and an embedded cable modem (eCM) that is DOCSIS capable. Hybrid CPEs #2 can receive content through both QAM and DOCSIS. It is assumed that this CPE is multicast-enabled, therefore is able to receive its signalling over multicast.

7.1.2 QoS support by DOCSIS and IPCablecom multimedia

Figure 8 shows how digital video systems would co-exist with IPTV delivery systems. In this figure, IPTV takes the CMTS path to reach the CPE while the existing video delivery takes the native MPEG QAM path. The CMTS can either be an integrated CMTS or a modular CMTS which has CMTS core and DOCSIS QAM in separated devices. The components involved in delivering an IP-based video service should negotiate and establish QoS using IPCablecom multimedia [ITU-T J.179].

IP connectivity through the CMTS to the CPE over the HFC network can be provided by the basic DOCSIS capability as defined in [ITU-T J.112]. However, DOCSIS QoS mechanisms defined in [ITU-T J.112 Annex B] will allow the MSOs to offer a much more robust IPTV service. Therefore, it is recommended that this later version of DOCSIS, also known as DOCSIS 1.1, be used in an HFC IPTV environment. This version of DOCSIS is also required for use with IPCablecom multimedia.

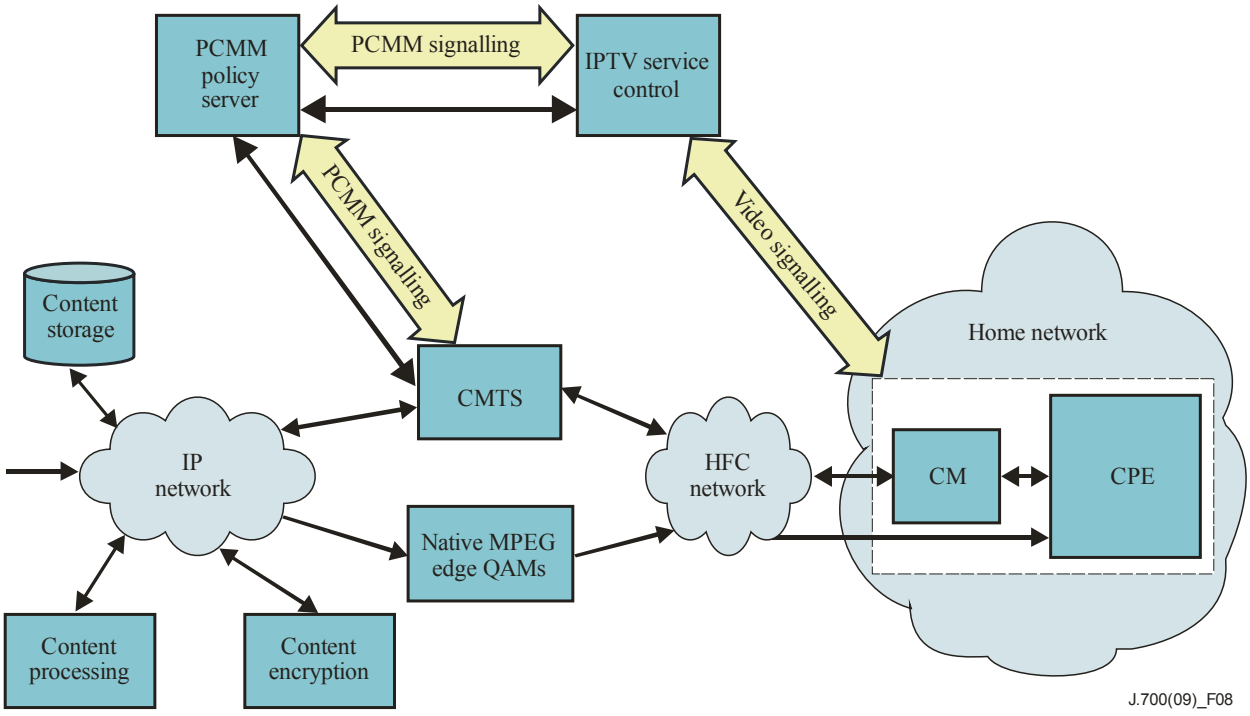


Figure 8 – Interaction with DOCSIS and IPCablecom multimedia

7.1.2.1 Interaction with IPCablecom multimedia

The currently defined mechanism is a push-policy method where the session and resource manager (SRM) would request QoS on behalf of the client using the protocols defined by IPCablecom.

By leveraging IPCablecom multimedia, the network is able to adapt to the resource requirements of not only IPTV, but also other applications which request QoS through the IPCablecom multimedia framework. The IPCablecom framework allows both a policy server and CMTS to make decisions on whether or not to allow a request for QoS. The policy server decisions are based on an extensive rule set provisioned by the operator. These rules can be based on business (e.g., billing), network resources (e.g., acceptable percentage of total bandwidth), time-of-day, etc. The CMTS decisions are based, in real time, on the amount of bandwidth available on the access network and, in some cases, the amount of bandwidth available to the application requesting it.

This authentication and admission control provided by IPCablecom multimedia is necessary to ensure a robust, high quality experience for the end user of IPTV services.

7.1.2.2 DOCSIS support for flexible bandwidth management

Just as hybrid CPEs enable cable operators to migrate from existing video delivery to IPTV, DOCSIS M-CMTS networks ease this migration from the network side. With DOCSIS M-CMTS and universal QAMs (QAMs that can be configured as DOCSIS QAMs or native MPEG QAMs), DOCSIS IPTV and existing video delivery may share the same QAM resource pool. A QAM channel is allocated to either DOCSIS or native MPEG dynamically. The mechanisms for the physical transmission characteristics of the QAM, timing requirements and dynamic channel assignment are defined in [b-ITU-T J.210], [b-ITU-T J.211] and [b-ITU-T J.212]. QAM dynamic sharing decreases the bandwidth requirement on the HFC network to support IPTV and legacy video delivery simultaneously.

To facilitate QAM sharing, a new network entity called edge resource manager (ERM) may be introduced to the architecture. The DOCSIS M-CMTS ERMI specification [b-CableLabs ERMI] defines the functionality of an ERM. The following steps happen for an M-CMTS core to obtain QAM resources for DOCSIS service:

- ERM discovers QAM resources and their capability through CableLabs M-CMTS ERMI DOCSIS resource registration protocol (DRRP) interface automatically.
- The M-CMTS core allocates QAM resources through the ERM via CableLabs M-CMTS ERMI resource allocation interface.
- The M-CMTS core establishes a tunnel to the remote QAM through CableLabs M-CMTS downstream external PHY interface (DEPI).

While a native video session resource manager allocates video session bandwidth directly through ERM, the IPTV video session manager will negotiate QoS for the IPTV session via protocols defined by IPCablecom as described in clause 7.1.2.1.

7.1.2.3 DOCSIS support for channel bonding

A narrow-band DOCSIS channel has a bandwidth limitation of a single QAM. The discrete nature of video session bandwidth in terms of SD, HD and the limited QAM bandwidth causes limited stream packing efficiency. In some cases where the available bandwidth in the service area is adequate for a single HD stream, the HD stream request may still be rejected because no individual QAM channel has the bandwidth to support that HD stream.

DOCSIS 3.0 [b-ITU-T J.222.2] introduces channel bonding, which allows multiple QAM channels to be bonded to serve as a single logical channel. When IPTV is delivered over a bonded channel of 4, 8, 16 and even 24 QAM channels, the bit packing efficiency is improved and denial of service due to insufficient bandwidth will be reduced.

7.1.3 Relationship to IPCablecom2

This clause describes the relationship between the IPTV and IPCablecom2 network architectures.

The relationship between these two architectures is illustrated in Figure 9. The broadband services domain in Figure 9 shows the functional architecture of the IPTV system as described in clause 5. It contains an IPTV application-y which, together with the IPTV service and content functions, provides applications such as electronic programme guide (EPG) or video on demand (VOD) to the video client via signalling control interfaces [2], [4] and [14]. Video content is provided by the IPTV content functions to the client via [3] and [13].

Figure 9 introduces a new entity called the service/control gateway that will handle interworking between the broadband services domain and the IPCablecom2 domain. This service/control gateway provides interworking for application-level interactions as well as control-plane interactions.

The IPCablecom2 domain contains an application-x which utilizes the common service delivery functions of the core network to provide applications such as caller identity display (CID) to the client device via signalling control interfaces [11], [9] and [12]. Video content may be provided directly by application-x to the client via interfaces [10] and [13], or be provided by the IPTV content functions through coordination between application-x and the broadband services domain through the service/control gateway.

Depending on the specific services being delivered, application-x and application-y can operate independently of each other or they can collaborate to provide an integrated service experience to the user. Applications x and y can collaborate through the service/control gateway using interfaces [1] and [15]. Session interworking is provided via the service/control gateway using signalling control interfaces [7] and [6].

The resource management function controls the allocation of QoS resources in the transport layer, based on instructions received via [8] from the P-CSCF in the IPCablecom2 domain, or via [5] from the IPTV service functions in the broadband services domain.

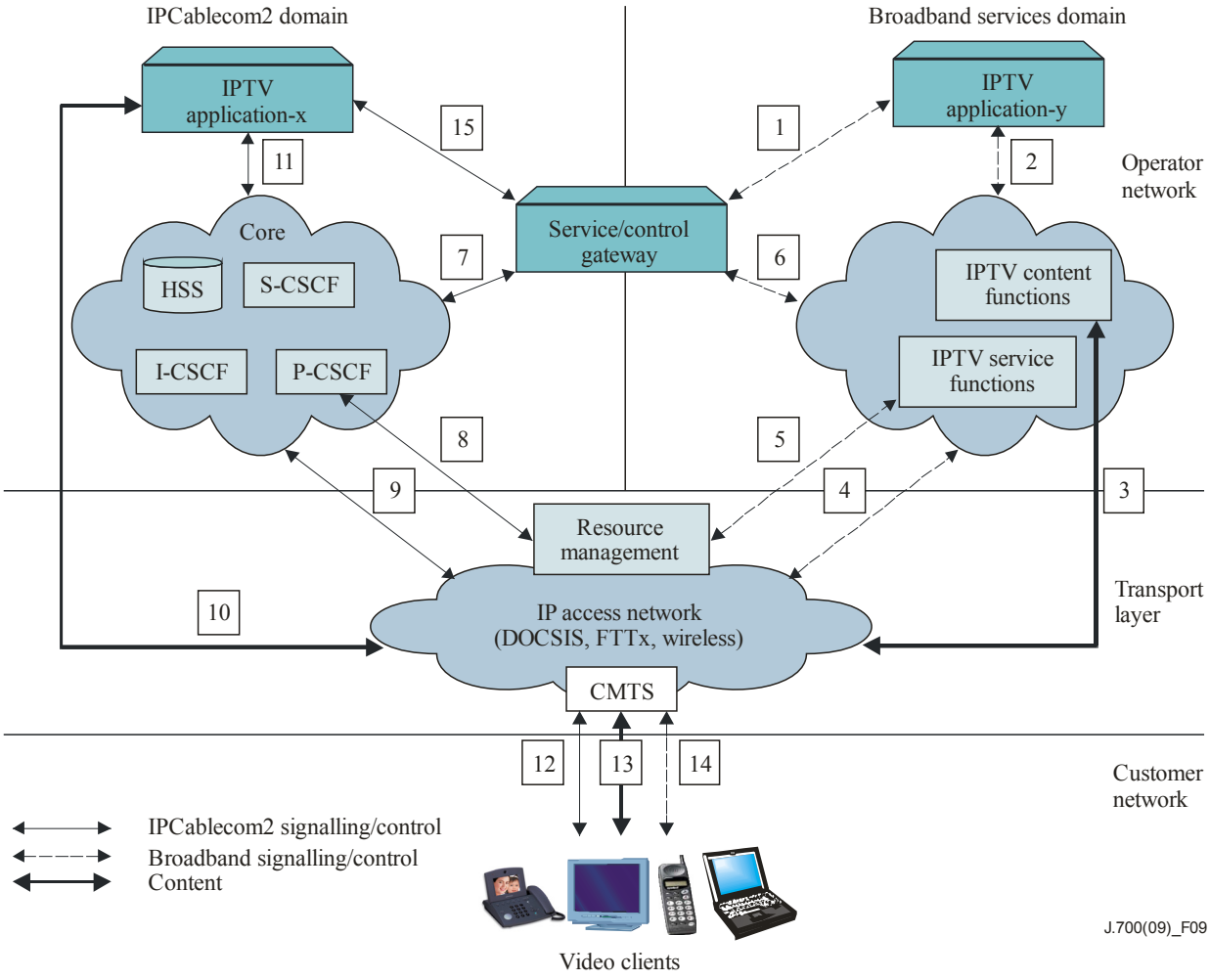
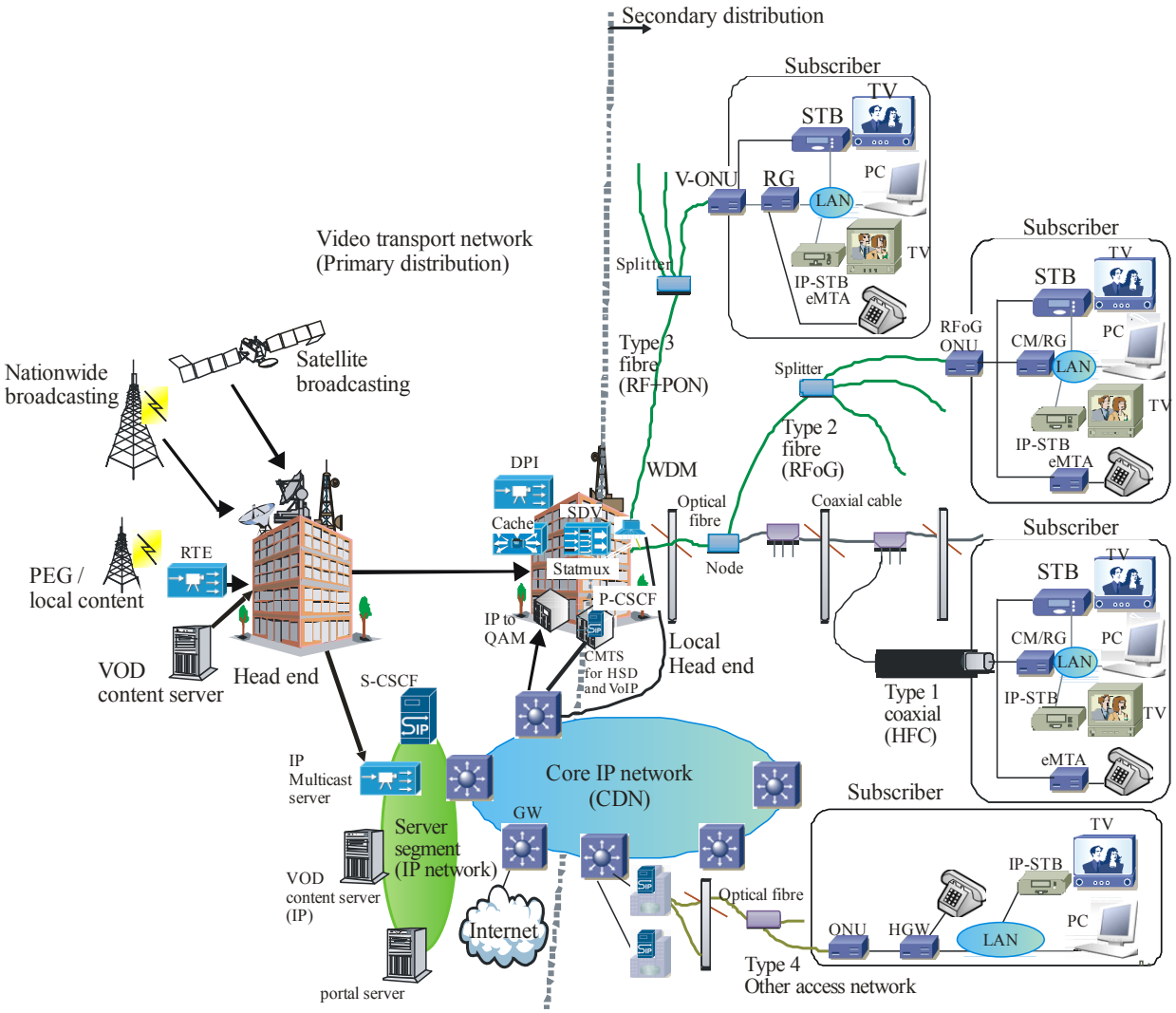


Figure 9 – Relationship with IPCablecom2

7.2 Relationship to optical fibre-based access network configurations

Figure 10 illustrates the way that IP-enhanced broadcasting services may be delivered over several types of access network configurations in comparison to an HFC access network.



NOTE – This drawing exemplifies PON-based IP networks.

J.700(09)_F10

Figure 10 – Variations of optical fibre-based access network configurations for IP-enhanced broadcasting

Type 1 (coaxial): This is the most typical access network configuration for cable television systems referred to as HFC. An optical fibre, within a trunk line from a head end, is connected to a node where an optical signal is converted into an RF electrical signal, and it is forwarded over coaxial cables constituting the last access means to the home. The RF signal may contain video, DOCSIS IP downstream and upstream, OOB, and so on. In the home, a cable modem (with a residential gateway) connected to the coaxial cable handles DOCSIS IP packets to create an Ethernet LAN inside the home, called an IP home network. An STB, which is connected to the coaxial cable, directly receives and plays back RF-modulated video signals transferred from the head end. The STB may also be able to receive IP-based video content and communicate with other devices in the home through the LAN connection. An IP-only STB is connected to the LAN, and receives IP-based video content and communicates with IP-capable devices within the home. An eMTA is also connected to the coaxial cable, and provides telephony capability to subscribers.

Type 2 (fibre): This is one of fibre to the premises (FTTP) or fibre to the home (FTTH) means, also referred to as RF over glass (RFoG), that extends the optical fibre segment of the HFC system to the customer premises. In this system, downstream (RF video and DOCSIS IP downstream) and upstream (DOCSIS IP upstream) RF signals are multiplexed in different wavelengths such as 1550 nm for downstream and 1590 nm (or 1610 nm) for upstream, respectively. The ONU converts the optical traffic to RF signals over the coaxial cable, and vice versa. This system enables cable operators to achieve the bandwidth advantages of optical fibre without changes to the existing equipments in the head end or home.

Type 3 (fibre): This can be considered as a mixed approach of RF over optical fibre and PON. The downstream RF video signals are conveyed over the 1550 nm wavelength. Unlike the RFoG case, PON techniques such as GPON or GEPON transfer RF video signals, IP downstream packets and IP upstream packets over three different wavelengths. The WDM device in the head end combines the video traffic (1550 nm) and IP downstream traffic (1490 nm) to send them in the fibre, and receives IP upstream traffic (1310 nm) from the fibre. The V-ONU (video ONU) at the side of the house converts the 1550 nm optical signal to an RF video signal that is fed to the STB and the 1490 nm signal to downstream Ethernet traffic, and converts the upstream Ethernet traffic from the home devices, including the STB, to 1310 nm wavelength optical signals.

Type 4 (other access network): This is a typical IP access network, e.g., PON-based FTTP/FTTH, media converter FTTH, DSL. In the optical fibre case, IP downstream and upstream are typically multiplexed in 1490 nm and 1310 nm, respectively. This system conveys all kinds of data such as video signals, high speed data, voice and return traffic by IP packets over the IP content delivery network (CDN) and IP-based access networks. Video distribution over this type of network is referred to as pure IPTV, whose architecture is detailed in [ITU-T Y.1910].

A combined approach, for example, of type 1 and type 4 might be possible to provide enhanced broadcasting services to cable television subscribers, where two physical lines, i.e., coaxial cable and optical fibre, are both connected to the home. In this case, a RF-modulated QAM signal is conveyed over the coaxial cable and PON-based IP packets are transported through the fibre, and almost the same configuration of home devices (after V-ONU) as that of type 3 would apply, where coaxial cable is connected to the STB to receive the television signal and Ethernet is connected to the RG to constitute an IP home network.

8 Functional architecture: detailed component descriptions

In this clause, we examine the functionalities of the IPTV framework defined in this Recommendation in more detail.

Figure 11 illustrates the functional components of the IPTV system for cable-based secondary distribution based on the more generic architecture shown in Figure 3. In Figure 11, the most general functional areas are the shaded regions. Some general functional areas have more detailed functional groupings represented by boxes with dotted line notation. The internal boxes drawn with solid lines represent functional blocks. For example, IPTV service functions is a general functional area that includes both functional blocks (e.g., service control) and more detailed function groupings (session/resource/policy control). Each functional block shown is described in detail in subsequent clauses according to their functional groupings.

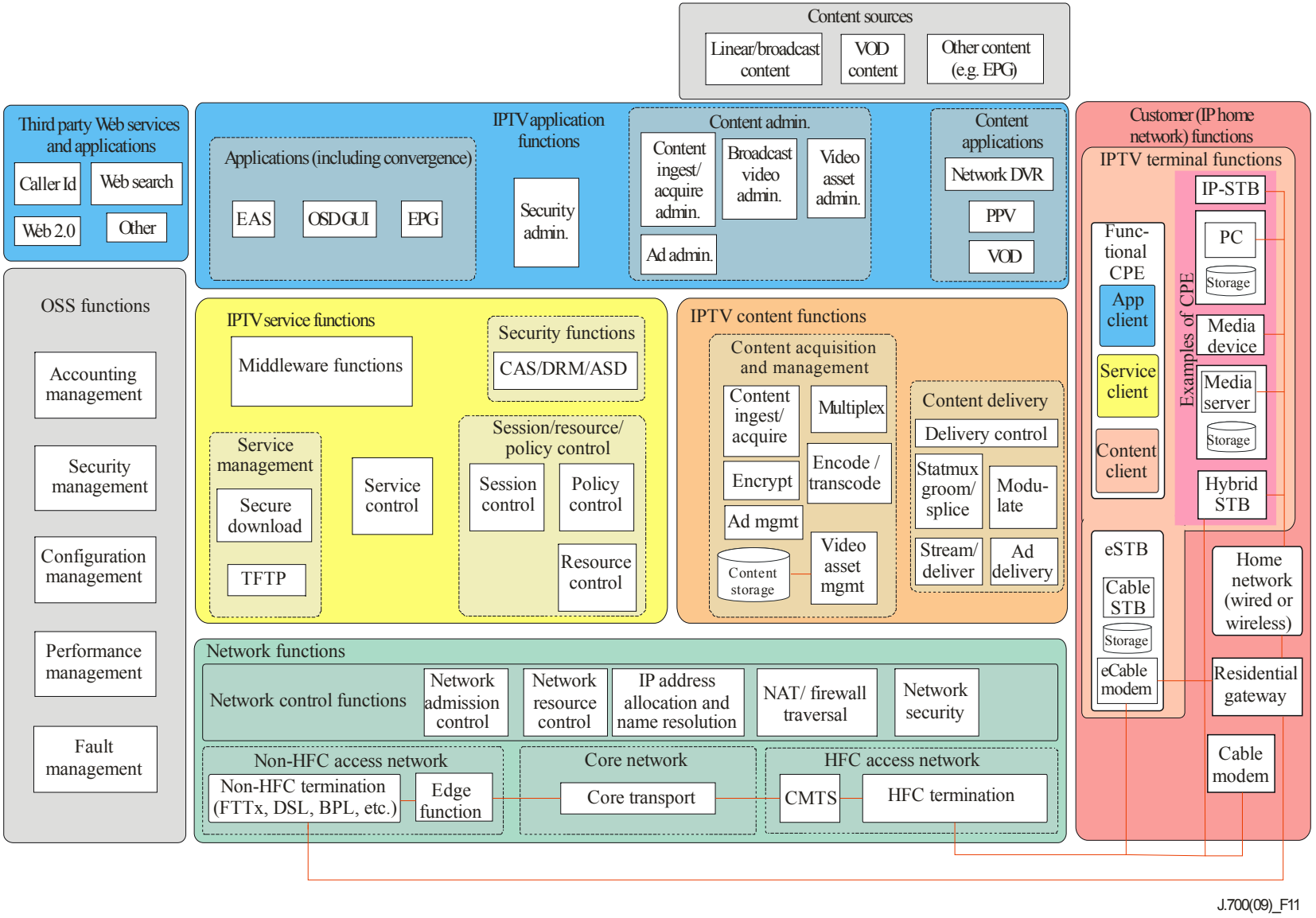


Figure 11 – IPTV functional components

8.1 IPTV application functions

The IPTV application functions include the mechanisms required to define and deliver IPTV services to the subscriber.

8.1.1 Applications

The applications that are grouped within application functions interact with the application client on the CPE to support desired IPTV services including the following shown in Figure 11:

- Electronic programme guide (EPG).
- On-screen display graphical user interface (OSD GUI).
- Emergency alert system (EAS).

Other applications may include converged triple-play (voice, video and data) applications and delivery of web-based applications and content.

8.1.2 Security administration

Mechanisms for IPTV security administration should support authenticating user identity, securing content for distribution, administering digital rights management, providing copy protection and providing distribution control.

This functional block, in conjunction with subscriber management functionality in the service control functional block, administers access to content, administers pre-encryption of content and manages keys for control of real-time access to content.

8.1.3 Content administration

IPTV applications require a functional grouping for administration of content. The functional blocks included in content administration include:

- Content ingest/acquisition administration: This functional block enables the administration and set-up of content ingestion and acquisition. This administration functional block enables the set-up of A/V content ingestion from a variety of sources, including off-air, satellite, file transfer, etc., and interfaces with the "content ingest/acquire" functional block to control the actual ingestion and acquisition of said content.
- Broadcast video administration: This functional block provides capabilities to administer, set up and maintain broadcast video functionality. It interacts with the "content delivery" functional grouping to control the actual delivery of content to the network (including functions such as streaming and channel switching).
- Advertisement administration: This functional block includes the administrative application aspects of implementing targeted and personalized advertisements. All of the functions that are done prior to the real-time delivery and reporting of advertisements are included here.

  Support for ad insertion is covered well in standards such as [ITU-T J.181], [ITU-T J.280] and [b-ANSI/SCTE 118], and these standards apply to IPTV services. These references include the definition of how "avail" inventory sales and management is administered, how ad "spot" metadata is created, and how advertising traffic and billing functions are administered. These functions are included in advertisement administration.
- Video asset administration: This functional block includes administrative functions to prepare VOD content in advance of delivery. This includes capabilities such as tagging, pre-encryption, PiP generation and watermarking.

8.1.4 Content applications

An important category of IPTV applications are those that provide personalized or per-subscriber access to content. These can be categorized into the following functional blocks:

- Video on demand (VOD): VOD applications provide subscribers with the ability to access, through real-time requests, content that they are authorized to access.
- Network digital video recorder (DVR): Network DVR supports the ability of the subscriber to store available content for later viewing. This may be content from the subscriber domain, or broadcast content captured specifically for the subscriber.
- Pay per view (PPV): PPV is similar to VOD, but also requires support for per-access charging.

Applications in this functional group interact with the capabilities in IPTV service functions and content functions. The application presentation is delivered to the application client on the CPE terminal device.

8.2 Third party web services and applications

A separate functional area is defined for applications outside of the IPTV framework defined here. External applications may originate from within or outside of the operator's domain and may interact with the IPTV application functions in addition to the application client of the CPE. Alternatively, the interaction may be just between the CPE's application client and the third party web services and applications servers directly. Such applications may include:

- Voice applications such as caller ID over IPCablecom.
- Standard web-based applications such as web search.
- Advanced interactive web applications.

Although covered in the framework, third party web services and applications may also be used for enhanced IPTV services including programme search and delivery and interactive electronic programme guides (EPGs).

8.3 IPTV service functions

IPTV service functions provide building blocks such as middleware, security and control mechanisms required for IPTV services.

8.3.1 Middleware functions

Middleware Functions provide support for delivery of middleware-based applications (for example, ITU-T J.20x-series-based application services) to the service client functional block of the CPE terminal device. Middleware functions are part of the IPTV service functions. GEM 1.2 is the ITU-T recommended middleware for this functional block where the execution engine approach is used (see [ITU-T J.200] for more information on the execution engine approach). [ITU-T J.201] is appropriate for this functional block where the presentation engine approach is used.

8.3.1.1 GEM overview

Globally executable multimedia home platform (GEM) specifies the common core across OCAP [b-CableLabs OCAP 1.1] and MHP [b-ETSI TS 102 590]. It represents the overlap between the MHP and OCAP standards for interactive television. It is a formally standardized Java-based platform for interactive content and applications. GEM has been standardized by ETSI and ITU, and adopted by DVB, CableLabs, ARIB, ATSC and the Blu-ray Disc Association.

For further information about GEM's role in IPTV support, see the GEM white paper [b-DVB GEM-IPTV].

Figure 12 shows the relationship of GEM to MHP and OCAP at a high level.

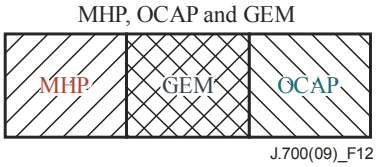


Figure 12 – Relationship of GEM to MHP and OCAP

8.3.1.2 Required features in GEM 1.2

GEM 1.2 [ETSI TS 102 543], a revised version of GEM as referenced in [ITU-T J.202], provides a set of interfaces and semantic guarantees for binary interoperability of applications between different receiver specifications and/or standards. This version of GEM is required for IPTV services. Table 1 shows features added in GEM 1.2 beyond those defined in [ITU-T J.202].

Table 1 – New features in GEM 1.2

Feature	Explanation
Personal basis profile 1.1	Provides up-to-date well-defined profile as well as support for jar not previously available. Includes support for IPv6.
Generic encryption support	This requires the Java cryptography extension (JCE), which is optional in personal basis profile (PBP) 1.1, to be mandatory. JCE provides a simple and common API for encryption/decryption. (J2ME Security (JCE) Optional Package, which is part of JSR-000219 Foundation Profile 1.1)
Plug-in API and infrastructure	Provides the ability to process and render content types other than those defined in MHP and to embed Java TV Xlets within other content types.
Storage of applications in the receiver	Provides the ability to store a service with multiple applications in the persistent memory of a GEM terminal. This reduces start-up time for commonly accessed applications.
Loading of applications via the return channel	Provides the ability to signal and transport the application information table (AIT) and applications over the return channel.
Multiple tuner and video decoder support	Provides the ability to tune via multiple network interfaces (or tuners) and to utilize multiple video decoders.
Persistent storage size requirement increase	Increases the required persistent storage for GEM receivers from 4 kbit/s to 128 kbit/s.
PSI-only services	Provides the ability for an application to tune to video that is not listed in the SI information. These hidden video streams are useful for applications such as "mosaics" and multiple camera angle applications.
JAXP XML parsing API	Provides the most commonly used XML parsing API. Highly useful to most applications due to XML's popularity.
Additional user preference for fine-grained addresses	Provides a more fine-grained user address than was present in MHP 1.0.3 (ETSI ES 201 812 v1.1.2).
Improved persistent storage management	Improved mechanism for managing persistent storage.
Access to removable file systems	New mechanism in MHP 1.1.1 (ETSI TS 102 812 v1.2.2) for accessing removable storage.

Table 1 – New features in GEM 1.2

Feature	Explanation
Synchronized auxiliary data	Preferred alternative mechanism to normal play time (NPT).
IP-based protocol mapping to support IPTV	Protocol-independent mapping of various IP protocols including RTSP, IGMP/MLD, UDP and service discovery and selection (SD&S).
GEM IPTV application	Support VOD, NVOD, network DVR, broadcast TV – all the standard IPTV services.

8.3.2 Service management

This functional grouping contains services needed for maintaining up-to-date CPE software/firmware and configuration, and it interacts with the service client functional block on the CPE terminal device as well as the CPE controller functionality of the service control functional block. This includes:

- TFTP functionality for providing client configuration.
- Secure download functionality for software/firmware downloads and versioning.

8.3.3 Service control

This functional block provides control for the IPTV video processing clients to allow for such functions as:

- Control of video streams (e.g., play, pause, rewind, skip) – this causes actions to be performed by the "delivery control" functional block.
- Control of multicast streaming (e.g., joining and leaving multicast groups) – this causes actions to be performed by the "delivery control" and "stream/deliver" functional blocks.

Delivery of content can be controlled by user interaction with the service client located in the CPE.

Service control includes CPE controller/management functionality, which, for example, manages CPE administrative settings, configuration settings, NAT settings, software downloads and diagnostics/logging. Service control also includes subscriber management functionality, which is capable of managing service provisioning, channel maps, data carousels, SI, messaging and third party applications.

8.3.4 Security functions

This functional block performs real-time authentication, authorization, encryption and key management for protected content delivery, including the capabilities for conditional access systems (CAS), digital rights management (DRM) and authorized service domains (ASDs). For example, it would include generation of an entitlement management message (EMM) and entitlement control message (ECM) for CAS/ASD, or licensing for DRM/ASD. In addition, it may perform functions such as multiplexing, scrambling or encrypting the content to implement and enforce the CAS/DRM/ASD system.

It interacts with the client CAS/DRM/ASD components residing in the service client functional block of the CPE terminal device.

8.3.5 Session/resource/policy control

IPTV services require a functional grouping that controls establishing, maintaining and terminating video sessions and assures sufficient resource allocation.

- Session control is a functional block that performs IPTV session initiation, maintenance and termination. It interacts with the other functional blocks in this group for making session-related decisions.

- Policy control is a functional block that makes decisions on allowing or denying access to services or resources. Policy control often makes admission control decisions, and plays a role in enforcing the permitted use of bandwidth on the network. The bandwidth management functionality of service control allows the IPTV service provider to maintain the expected quality of service (QoS) for the subscriber.
- Resource control is a functional block that takes care of reserving, allocating, maintaining and releasing resources on the network. Examples include managing DOCSIS bandwidth on the access network, and managing QAM resources (using edge resource management interfaces).

8.4 IPTV content functions

IPTV content functions provide the capabilities to acquire, manage and deliver content for IPTV services.

8.4.1 Content acquisition and management

This functional area contains services needed for receiving (access and acquisition), securing, storing, encoding and delivering content. This includes:

- The content ingest/acquisition functional block, which provides functionality to receive and process A/V content from a variety of sources such as satellite, off-air, file transfers and the Internet according to the set-up and processes defined by the "content ingest/acquire administration" functional block.
- Real-time multiplexing, including both broadcast and on-demand content.
- Real-time encryption of content being delivered to the CPE, including both broadcast and on-demand content.
- Real-time encoding and transcoding, including support for different formats and bit rates for both broadcast and on-demand content. In addition to video formats, this can include support for stereo versus. surround sound, multiple languages, closed captioning.
- Ad management, which represents the real-time functions for the selection and delivery of targeted and personalized advertising. Ad management uses subscriber data and data about available advertisement content to determine what to deliver to the subscriber in real time. SCTE has standardized such functionality as part of their digital video services (DVS) initiative [ANSI/SCTE 128].

  Ad management also reports information about advertisements delivered to subscribers.
- Video asset management, which maintains storage of video content. This content storage is typically large in scale. Included in this functional block would be VOD libraries and nDVR content.

8.4.2 Content delivery

The content delivery functional area includes the following functional blocks:

- Delivery control includes functionality for controlling the delivery of content. Examples include following the rules and set-up for switching digital video (as defined in the "broadcast video administration" functional block), and interacting with the service control functional block to control VOD streaming or controlling the delivery of multicast content.
- Statmux/groom/splice maximizes efficiency of network usage by dynamically allocating bandwidth to handle multiple video streams with sufficient quality, and by grooming traffic (grouping content flows into larger units). This functional block also allows for splicing of content into other content flows in order to provide continuous content flows to the network and end user.

- Modulate includes the ability to deliver content over the network. Techniques such as QAM are commonly used to modulate content for delivery.
- Stream/deliver includes centralized versus distributed caching approaches for the streaming and delivery of content throughout the network. For example, this functional block streams VOD content, and also delivers multicast content flows to the client.
- Ad delivery represents parts of the content delivery system involved in the real-time delivery of advertising content. This includes insertion of personalized on-demand advertisements into VOD content and delivering targeted advertising content for broadcast streams. [ITU-T J.181] and [ITU-T J.280] cover the details of ad splicing.

8.4.3 Video transport methods supported by IPTV content functions

The CPE should support the following transport methods to receive digital content from the cable-based secondary distribution network for both broadcast and on-demand applications. These transport mechanisms are documented here to provide general guidance in this framework, and will be further defined in more detailed Recommendations specific to a defined content delivery reference point (see reference point i-5 in clause 9.1).

The transport mechanisms described below are independent of both codecs used to encode the content which is being carried by the transport and the conditional access system used to control access to that content. That is, all supported codecs and the conditional access system should work with all of the media transport methods in this clause.

8.4.3.1 Native MPEG transport

Figure 13 represents the method for providing digital content to the CPE called MPEG-2 multiple programme transport streams (MPTS) over QAM.

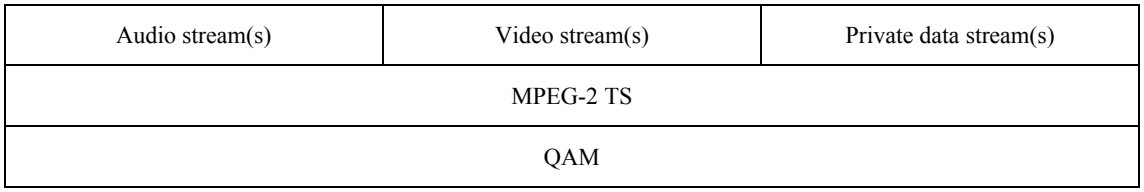


Figure 13 – MPEG-2 MPTS over QAM

MPEG-2 MPTS over QAM is the conventional method used in today's digital cable systems to deliver digital content over the HFC network. The transport stream payload is the audio, video and private data packetized elementary stream (PES) representing an MPEG programme within the MPTS. The CPE should support MPEG-2 MPTS over QAM.

8.4.3.2 MPEG MPTS multiplexed with DOCSIS

Figure 14 represents the method of providing digital content to the CPE called MPEG-2 MPTS multiplexed with DOCSIS.

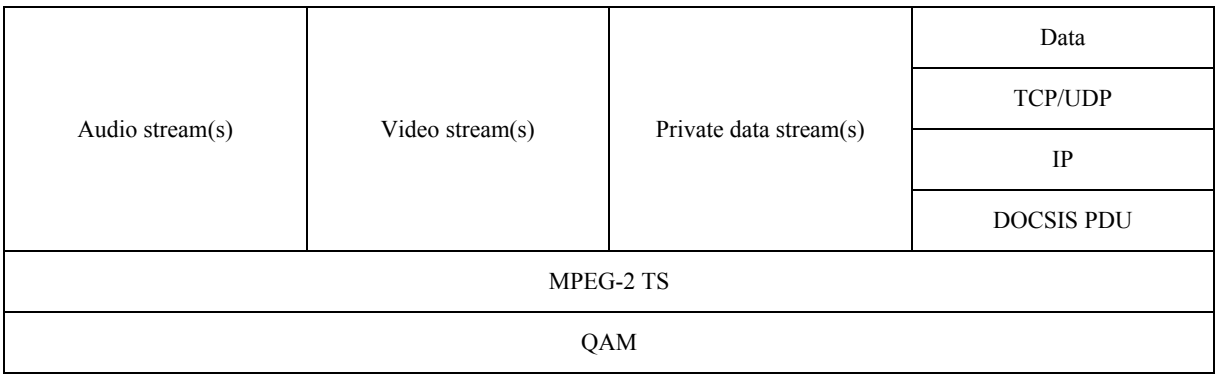


Figure 14 – MPEG-2 MPTS multiplexed with DOCSIS

When MPEG-2 MPTS is multiplexed with DOCSIS, an MPEG-2 transport stream is used to multiplex audio, video and private data programme information with DOCSIS data PDUs. The CPE should support MPEG-2 MPTS multiplexed with DOCSIS.

8.4.3.3 MPEG-2 SPTS/MPTS over UDP/IP

Figure 15 represents the method of providing digital content to the CPE called MPEG-2 SPTS/MPTS over UDP/IP.

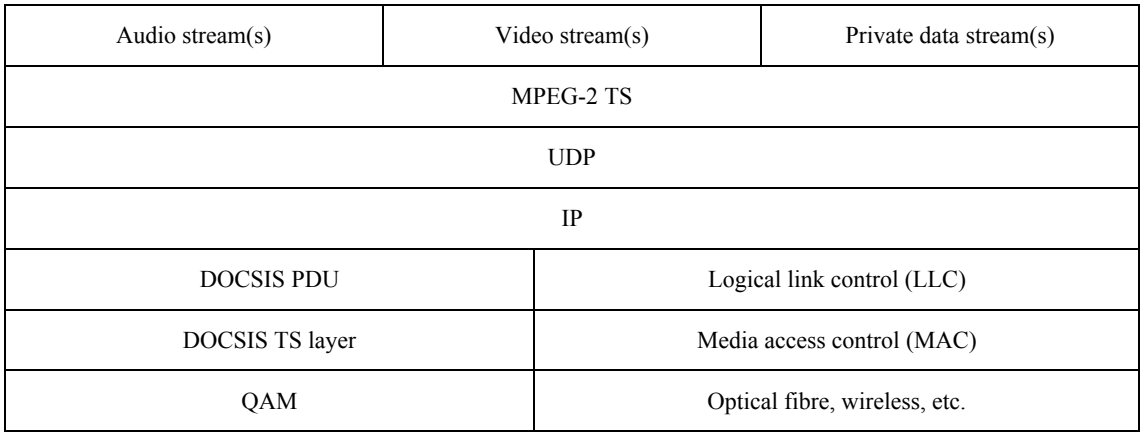


Figure 15 – MPEG-2 SPTS/MPTS over UDP/IP

In this approach, video is carried over UDP/IP and delivered over the DOCSIS connection. The CPE should support MPEG-2 SPTS/MPTS over UDP/IP.

8.4.3.4 MPEG-2 SPTS/MPTS over RTP/UDP/IP

Figure 16 represents the method of providing digital content to the CPE called MPEG-2 over RTP/UDP/IP.

Audio stream(s)	Video stream(s)	Private data stream(s)
MPEG-2 TS		
RTP		
UDP		
IP		
DOCSIS PDU	Logical link control (LLC)	
DOCSIS TS layer	Media access control (MAC)	
QAM	Optical fibre, wireless, etc.	

Figure 16 – MPEG-2 SPTS/MPTS over RTP/UDP/IP

The CPE should support MPEG-2 SPTS/MPTS over RTP/UDP/IP.

8.4.3.5 Elementary streams over RTP/UDP/IP

Figure 17 represents the method of providing digital content to the CPE by transmitting elementary streams (ESs) over RTP/UDP/IP.

Audio stream(s)	Video stream(s)	Private data stream(s)
RTP		
UDP		
IP		
DOCSIS PDU	Logical link control (LLC)	
DOCSIS TS Layer	Media access control (MAC)	
QAM	Optical fibre, wireless, etc.	

Figure 17 – Elementary streams over RTP/UDP/IP

The CPE should support both audio and video elementary streams (ESs) over RTP. For support of MPEG-4 part 2 visual, [IETF RFC 3640] should be used, and for support of MPEG-4 part 10 AVC, [IETF RFC 3984] should be used.

The IETF audio/video transport (AVT) working group is also working on documentation for carrying AC-3 audio over RTP, as defined in [IETF RFC 4184].

8.5 Network functions

Network functions provide the transport of IPTV services.

8.5.1 Network control functions

In the network control functional grouping, there are mechanisms for NAT/firewall traversal, assigning IP addresses and managing domain name systems (DNSs). Functions are required to allow signalling and media to be exchanged with CPE in a home network. Included in this area are:

- Network admission control: This functional block controls whether to allow particular service or application traffic on the network.

- Network resource control: This functional block provides network-level mechanisms to control access to network resources. This function, as well as admission control, is usually done based on interactions with the session/resource/policy control functional block.
- IP address allocation and name resolution: This functional block is often implemented using DHCP and DNS services.
- NAT/firewall traversal: This functional block allows IPTV services to be delivered across NAT and firewall boundaries to CPE terminal devices in the home network. Technologies useful for NAT/Firewall traversal include: ICE methodology (IETF Internet Draft <draft-ietf-mmusic-ice-19.txt>), STUN servers [b-IETF RFC 3489], [IETF RFC 5389], and TURN servers (IETF Internet Draft <draft-ietf-behave-turn-13>).
- Network security: Network control functions include security mechanisms such as IP filtering to aid in the prevention of denial-of-service attacks and VPN tunnelling to protect the privacy of data.

Network control applies to the underlying core network as well as the various access networks supported by this functional architecture.

8.5.2 Core network

The core network includes routing and switching equipment required for the transport of IPTV services. Standard network capabilities will need to be supported for IPTV services (e.g., tunnelling mechanisms and traffic monitoring mechanisms).

8.5.3 HFC-based access networks for cable TV systems

The HFC-based access network is defined as the network between the CMTS and the cable modem. Examples of technologies specific to, and supported by, the HFC-based access network include:

- DOCSIS for the transport of IP over HFC or optical fibre.
- DOCSIS set-top box gateway (DSG) for interactive signalling for video applications.
- Edge QAMs for modulated delivery of video signals.
- Transmission of radio frequency (RF) over optical and coaxial physical distribution.
- Support for embedded cable modems.
- Support for stand-alone cable modems.

8.5.4 Non-HFC access network

Other access networks (transport networks from the service provider's "logical edge" to the consumer premises) which may be supported by the architectural framework defined here could include:

- FTTx (PON- or media converter-based).
- DSL.
- Broadcast over power line (BPL).

8.6 OSS functions

[ITU-T M.3400] defines the OSS functions grouped in terms of five functional areas commonly referred to as fault, configuration, accounting, performance and security (FCAPS). The specific functions, such as diagnostics within fault management, are further specified according to the level of abstraction of the resources and services being managed. The device level management, for example, is defined within network element management. Other abstractions defined are network level, service level and business level management.

Additional functions are required beyond the functions described in [ITU-T M.3400] in the context of IPTV services. The functions that are required for the cable environment will be specified in a future Recommendation. Some examples are included below.

For configuration management, discovery of device capabilities will be required to present suitable contents to the customer by the service provider. Other information to be discovered includes device hardware configuration such as memory, graphic resolution, etc. Configuration functions at the network level include setting transport parameters, installing and initiating routing services and consumer-specific policy management within the provider's network. For IPTV services, discovery and selection mechanisms are required.

In the case of accounting management, some examples of the required functions include different commercial arrangements between the service providers and consumers, inter-carrier support, retail billing and QoS monitoring in support of SLA management.

In the context of IPTV services, security management includes service and content protection, content control and protection mechanisms for content in transit and storage.

Additional fault management requirements to support IPTV services include assuring service reliability to reduce or eliminate packet loss and rerouting due to failure in the network.

8.7 Customer (IP home network) functions

The customer (IP home network) functional area includes the CPE that provides access to IPTV services. In Figure 11, the functional aspects of the IP home network are represented in the functional CPE functional grouping. This functional grouping is also shown grouped into IPTV terminal functions with examples of physical IPTV CPE device configurations. The following functional blocks within the functional CPE interact with the IPTV functions covered in previous clauses:

- The application client: This functional block interacts with functional blocks within IPTV application functions, and includes the ability to present the IPTV applications to the customer.
- The service client: This functional block interacts with IPTV service functions, and includes capabilities to process middleware logic and functions for CAS/DRM/ASD to allow customer access to protected content. It also includes capabilities for remote configuration, the ability to download software, mechanisms for control of the service, the ability to initiate sessions and the ability to request resources.
- The content client: This functional block interacts with IPTV content functions, and includes capabilities to receive and (potentially) transmit video streams, and to process those streams by decrypting and decoding for presentation to the customer.

Also shown in this functional area are examples of physical device configurations that are particularly important to HFC, though other subscriber access technologies are also shown. Devices with IPTV terminal functions, shown in Figure 11, that receive or process video sessions include:

- IP set-top boxes based on [ITU-T J.290], [ITU-T J.291] and [ITU-T J.292].
- Multimedia PCs.
- Rich media devices.
- Home media storage and servers.
- Hybrid STBs.
- eSTBs (STBs with embedded cable modems).

Additional devices that exist in the IP home network, and participate in IPTV service delivery, include:

- Wireless or wired home networking devices.
- IP-based residential gateways.
- Stand-alone cable modems for HFC access.

8.8 Content sources

The IPTV framework is capable of receiving content from a variety of managed sources, such as satellite, off-air, land-line distribution, storage media, file transfers and the Internet. The content can be of any type, such as EPG content (delivered via the Internet), land-line or satellite delivered live-feed video content, or VOD content delivered via land-line, satellite or storage media.

9 Reference points

There are several key interfaces shown in the functional architecture in Figure 3.

IPTV control/metadata flows – the messaging between the server functions and client functions includes:

- Service interaction messaging (request to initiate video services and messages to control video service functions).
- Digital rights management interaction from the client for content access.
- Conditional access interactions for requests to access different video applications.

IPTV media flows – the data sent in the media interface includes:

- Streamed video content.
- Play control signalling.

Application interactions – the interaction between the IPTV services and applications to the application client includes:

- Middleware and metadata delivery and interaction for application functionality.
- Application interactions through higher-level web-based protocols (HTTP, XML, etc.).

OSS interactions – the interaction between the OSS servers and the IPTV client function includes:

- Provisioning of the client device.
- Secure software download.
- Network management using device MIBs.

This clause identifies major reference points to address these interfaces between functional components.

9.1 Reference points definition

For the purposes of this Recommendation, significant reference points are identified between the CPE and the various network functions with which it interfaces, between the session/resource/policy management functions and the IPTV application servers, and between the IP content sources and the content processing, distribution and storage functions. The CPE reference points are meant to address IP interfaces for hybrid and IP CPE. Network interface points for a MPEG CPE and the MPEG portion of a hybrid CPE are of a legacy nature and therefore are not addressed here.

Figure 18 repeats Figure 3 – Functional architecture for IPTV secondary distribution system – with specific reference points marked:

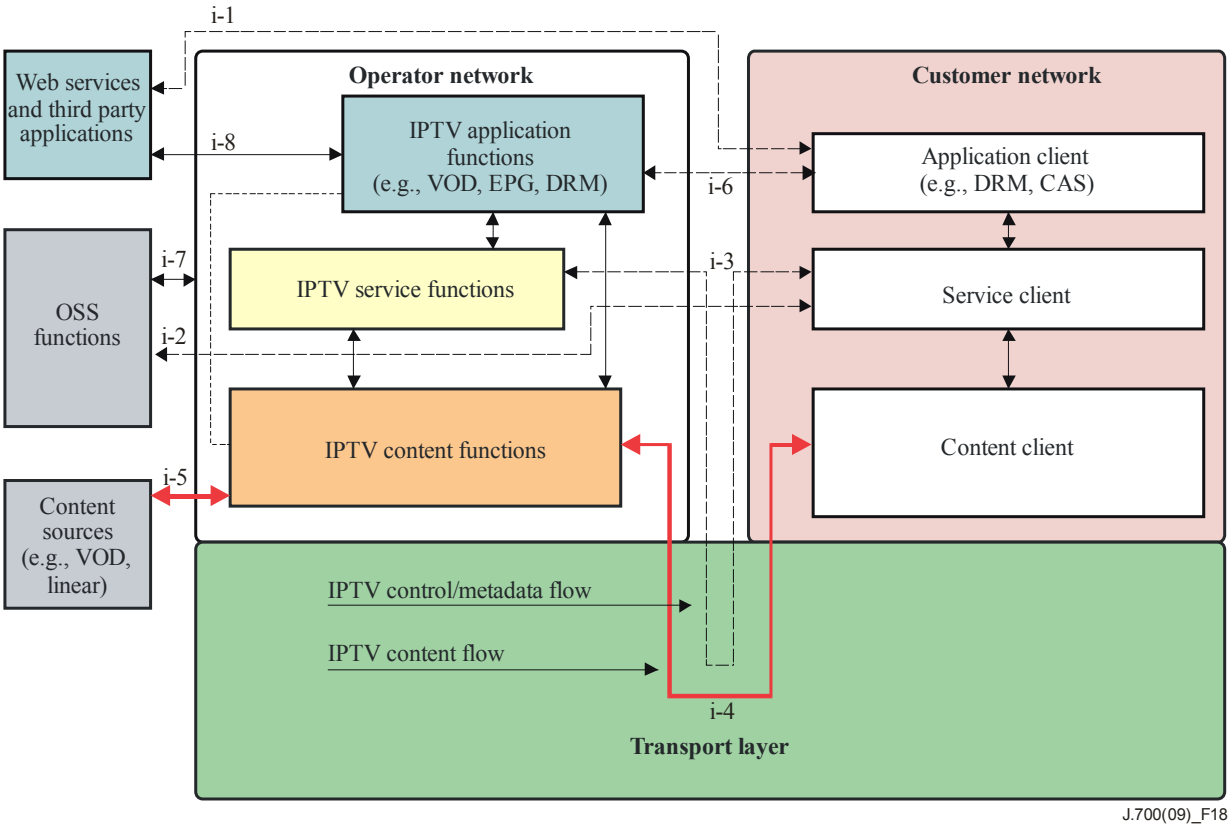


Figure 18 – IPTV network reference points

NOTE – The operator network and the transport layer in Figure 18 are equivalent, respectively, to "service provider network" and "network provider" network specified in [ITU-T Y.1910] "IPTV domains".

Table 2 describes the reference points identified in Figure 18.

Table 2 – IPTV secondary distribution system reference point descriptions

Reference point	IPTV system network elements	Reference point description
i-1	Web services and third party applications – Application client	Enables the web services and third party applications network element to interact and collaborate with the application client in the customer network for the delivery of web-based services and third party applications that utilize a web interface. Potential supporting protocols include HTTP, XML, SOAP and WSDL.
i-2	OSS functions – Service client	Enables the OSS functions to provision and manage the IPTV client functions in the customer network. Potential supporting protocols include XCAP, SIP configuration framework, TFTP and SNMP.
i-3	IPTV service functions – Service client	Enables the service client in the customer network to send requests for IPTV content to the IPTV service functions in the operator network. Examples of IPTV content include digital video and audio programme content, plus the metadata describing the programme content. Examples of IPTV requests include requests for broadcast or VOD content, requests to manipulate VOD content delivery (pause, play, rewind, etc.) and requests to record content for later viewing. Potential supporting protocols include IGMP/MLD, RTSP and SDP.

Table 2 – IPTV secondary distribution system reference point descriptions

Reference point	IPTV system network elements	Reference point description
i-4	IPTV content functions – Content client	Enables the operator network IPTV content functions to send real-time digital video and audio media and associated metadata over IP to the content client in the customer network. Potential supporting protocols include RTP/RTCP containing MPEG encoded audio/video content.
i-5	Content sources – IPTV content functions	Enables the operator network IPTV content functions to access video/audio content and associated metadata from the content sources in the content provider network. This includes requesting video/audio content and associated metadata from the VOD server functions. Supporting protocols for this purpose require further study. CableLabs' metadata specification with an appropriate delivery protocol could be a candidate.
i-6	IPTV application functions – Application client	Enables the delivery of IPTV service application logic and presentation information from the IPTV application functions to the application client. Potential supporting protocols include HTTP and OCAP common download of applications. The application logic can be implemented with such technologies as XML/SOAP, Java/Javascript and GEM middleware.
i-7	OSS functions – Operator network	Enables the OSS network element to provision and manage the Functions within the operator network (including IPTV services and applications, IPTV server functions and IPTV media/object delivery functions). Potential supporting protocols include XCAP, SIP configuration framework, TFTP and SNMP.
i-8	Web services and third party applications – IPTV application functions	Enables IPTV services and applications in the operator network to request web services and other third party applications from the web services and third party applications network element. Potential supporting protocols include HTTP, SOAP and WSDL.

9.2 Internetwork operability

Interconnection of different administrative IPTV networks should be considered. Recommendation ITU-T Y.1911 defines several scenarios for IPTV internetwork operability. Figures 19a to 19c illustrate several patterns of IPTV interconnection, where different administrative IPTV networks are interconnected at the transport layer.

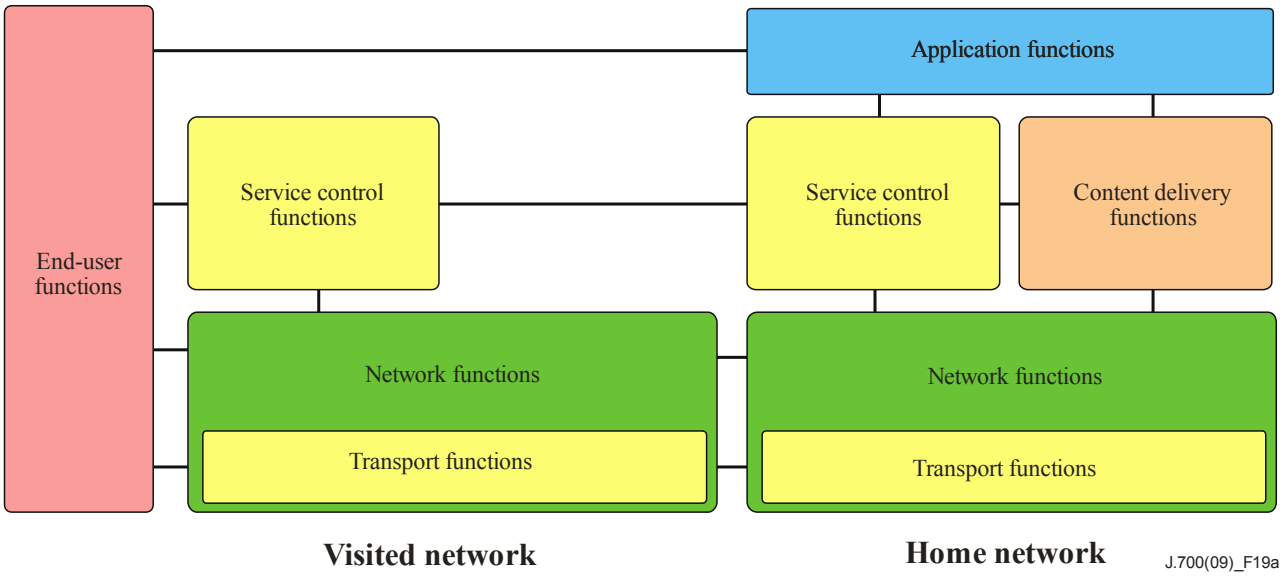


Figure 19a – High-level architecture for interconnection with compatible service control functions between two networks

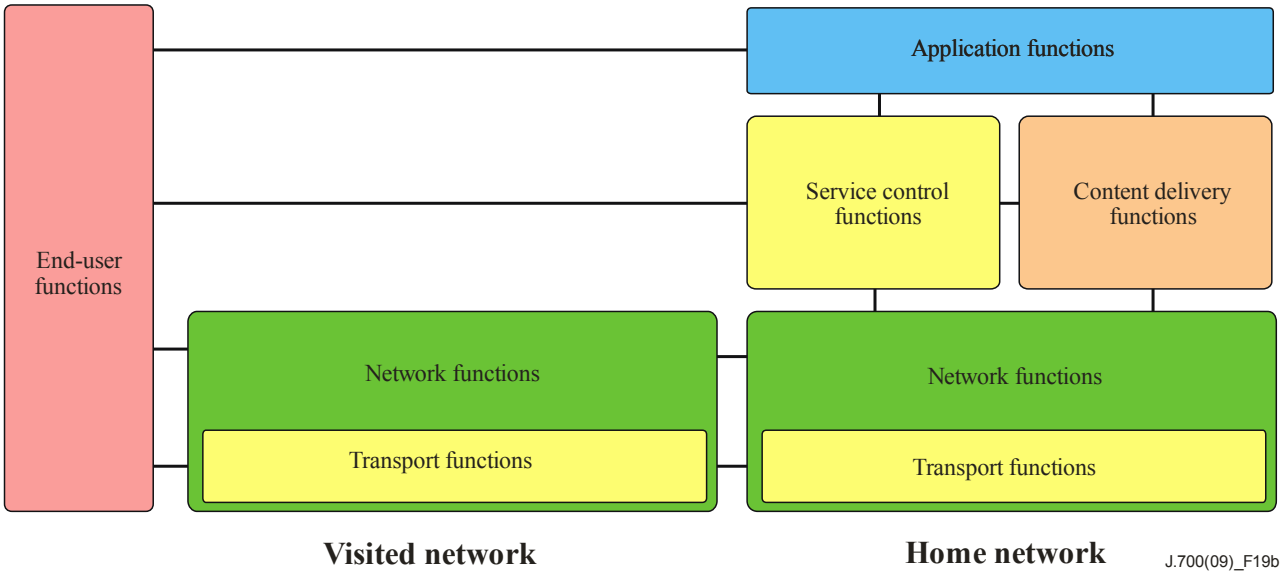


Figure 19b – High-level architecture for interconnection without using service control functions of the visited network

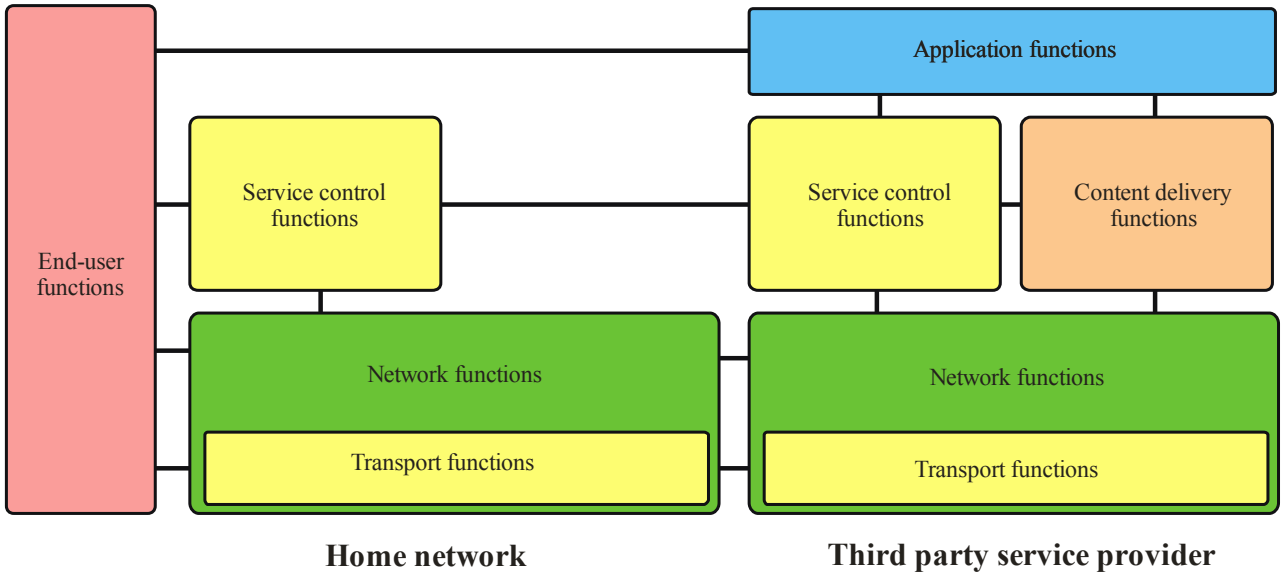


Figure 19c – High-level architecture for interworking with a third party service provider

- Figure 19a shows the case where the service control functions (SCFs) of the home network is compatible with those of visited network. For example, both end-user functions and SCFs of the visited network have IMS-based IPTV capability.
- Figure 19b shows the case where the SCF of the home network is incompatible with those of the visited network. For example, end-user functions have only a non-IMS-based IPTV capability although the SCF of visited network only supports IMS-based IPTV capability.
- Figure 19c depicts interworking with a third party service provider through the interface between the two entities, which can be called a service provider interface (SPI).

Annex A

Relationship to NGN

(This annex forms an integral part of this Recommendation)

IPTV comprises a set of services that fit well into NGN. [ITU-T Y.1910] defines the following architectures:

- Non-NGN-based IPTV architecture.
- Non-IMS-based NGN IPTV architecture.

This clause addresses the IMS-based NGN IPTV architectures and maps functions to the IPTV reference model.

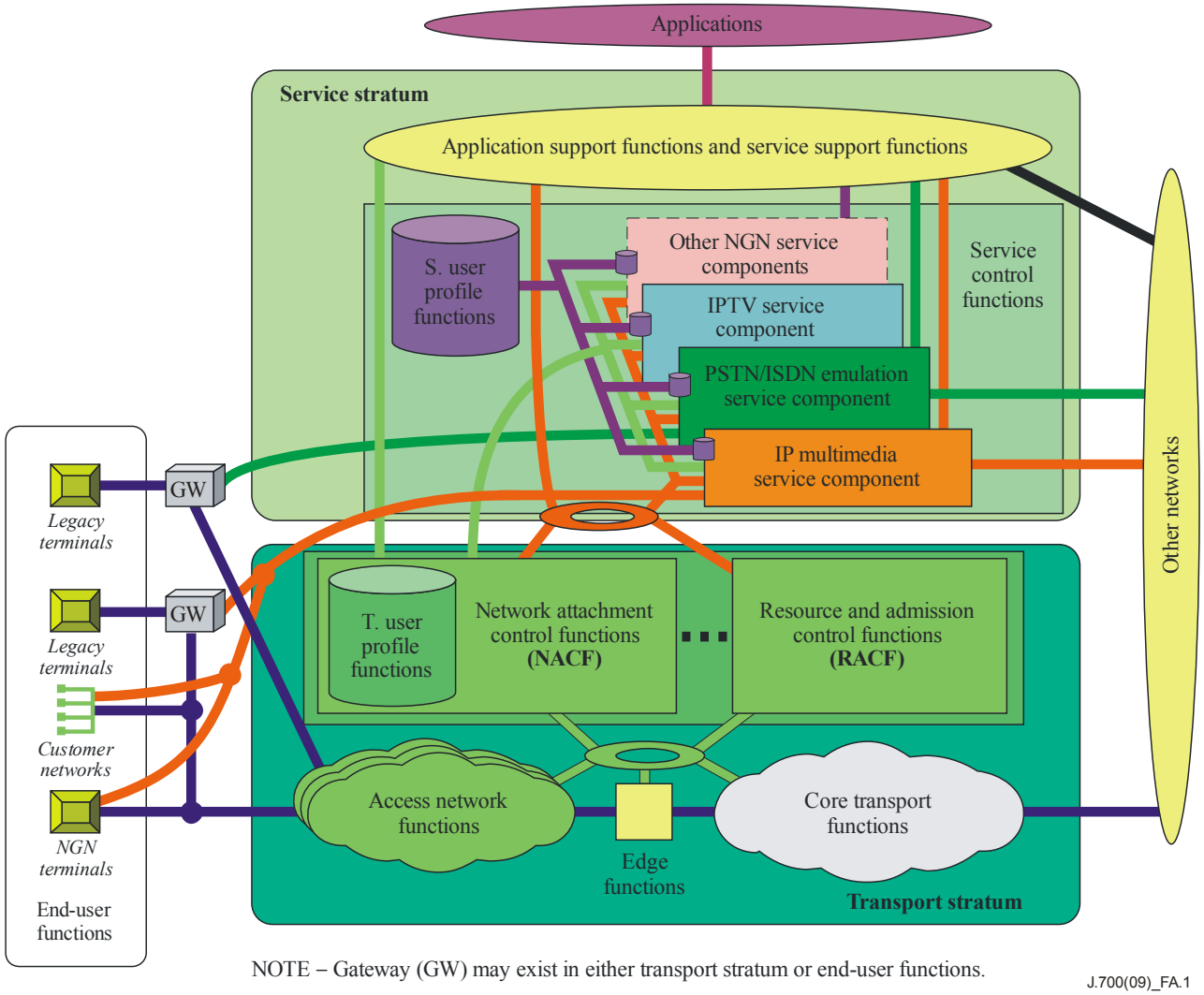


Figure A.1 – Support of IPTV services in the NGN framework architecture

The NGN framework architecture shown in Figure A.1 contains three high-level functional entities, namely, service stratum, transport stratum, and end-user functions. These three high-level functional entities are described in detail in [ITU-T Y.2012] and are described here with reference to Figure 1 (the IPTV reference model).

The functions of the transport layer in Figure 3 correspond to the transport stratum in the NGN framework. These include the related transport control/routing and applicable management functions responsible for the routing of the IPTV packets flows.

The IPTV server and media delivery functions correspond to the IPTV service component in the service stratum of the NGN framework.

The IPTV applications functions, including the third party applications, correspond to the applications layer and application/service support layer in the service stratum of the NGN framework.

The IPTV customer functions correspond to the end-user functions of the NGN framework.

The OSS functions correspond to the NGN management plane functions (not shown in Figure A.1).

Service stratum

The service stratum functional entity encompasses all of the services, user profiles, applications and service support functions that are needed in order to provide IPTV services in an NGN framework. The service stratum acts as the service provider (SP) with connections to external applications and other networks for the acquisition of content, data and external applications. The service stratum is also connected to the transport stratum and ultimately to the end-user functions, as described below.

- *Service control functions*

  The service control functions include resource control, registration, and authorization and authentication functions at the service level for both mediated and non-mediated services. In order to support IPTV services, the service control functions also offer media control resources and functions such as the IP multimedia service component and the IPTV service component.

  The service control functions also provide service user profiles which represent user information and other control data in a single user profile function of the service stratum. The service user profile functions may take the form of a single functional database or multiple, cooperating databases residing in any part of the NGN.

- *Application support functions and service support functions*

  The application support functions and service support functions include functions such as gateway, registration, and authentication and authorization functions at the application level. These functions are available as applications to the "end user" functional groups. The application support functions and service support functions work in conjunction with the service control functions to provide the end users and applications with the NGN services they request.

Transport stratum

The transport stratum provides transport functions and transport control functions per [ITU-T Y.2011]. The transport stratum functions are described here with reference to Figure A.1 above.

- *Access network functions*

  The access network functions take care of end users' access to the network as well as collecting and aggregating the traffic coming from these accesses towards the core network. More details on the access network functions can be found in clause 7.1.1.1 of [ITU-T Y.2012].

- *Edge functions*

  The edge functions are used for media and traffic processing when aggregated traffic coming from the access networks is merged into the core transport network. The functions include support for QoS and traffic control. See clause 7.1.1.2 of [ITU-T Y.2012] for a more detailed description of the edge functions.

- *Core transport functions*

  The core transport functions are responsible for ensuring information transport throughout the core network. They provide the means to differentiate the quality of transport in the core network. The functions include QoS mechanisms dealing with user traffic, buffer management, queuing and scheduling, packet filtering, traffic classification, marking, policing, shaping, gate control and firewall capability.

- *Gateway (GW) functions*

  The gateway functions provide the capability to interwork with end-user functions and/or other networks, including other types of NGN and many existing networks. GW functions can be controlled either directly from the service control functions or through the transport control functions. As noted in Figure 10, the GW functions may exist in either the transport stratum or the end-user functions. See clause 7.1.1.4 of [ITU-T Y.2012] for more details.

- *Resource and admission control functions (RACFs)*

  The RACFs act as the arbitrator between the service control functions and the transport functions for QoS-related transport resource control within access and core networks. The RACFs perform the policy-based transport resource control upon the request of the service control functions, determine the transport resource availability and admission, and apply controls to the transport functions to enforce the policy decisions. See clause 7.1.2.1 of [ITU-T Y.2012] for more details on the RACFs.

- *Network attachment control functions (NACFs)*

  The NACFs provide registration at the access level and initialization of end-user functions for accessing NGN services. These functions provide transport stratum level identification/authentication, manage the IP address space of the access network and authenticate access sessions.

  The NACFs include transport user profile functions which take the form of functional databases representing the combination of a user's information and other control data into a single "user profile" function in the transport stratum. Like the service user profile functions, the transport user profile functions may take the form of a single functional database or multiple, cooperating databases residing in any part of the NGN.

  See clause 7.1.2.2 of [ITU-T Y.2012] for a more detailed description.

End-user functions

End-user interfaces and networks may be extremely diverse and may be connected to the NGN in a multitude of manners. The end user communicates with the service stratum through the transport stratum in order to utilize and interact with the IPTV services offered by the NGN framework. These communications, however, may vary greatly since end-user equipment may be either mobile or fixed and can connect to the NGN in many ways.

Bibliography

[b-ITU-T J.126] Recommendation ITU-T J.126 (2007), *Embedded Cable Modem device specification*.

[b-ITU-T J.160] Recommendation ITU-T J.160 (2005), *Architectural framework for the delivery of time-critical services over cable television networks using cable modems*.

[b-ITU-T J.210] Recommendation ITU-T J.210 (2006), *Downstream RF interface for cable modem termination systems.*

[b-ITU-T J.211] Recommendation ITU-T J.211 (2006), *Timing interface for cable modem termination systems*.

[b-ITU-T J.212] Recommendation ITU-T J.212 (2006), *Downstream external Physical layer interface for modular cable modem termination systems*.

[b-ITU-T J.222.2] Recommendation ITU-T J.222.2 (2007), *Third-generation transmission systems for interactive cable television services – IP cable modems: MAC and Upper Layer protocols*.

[b-ITU-T J.360] Recommendation ITU-T J.360 (2006), *IPCablecom2 architecture framework.*

[b-ITU-T J.701] Recommendation ITU-T J.701 (2008), *Broadcast-centric IPTV terminal middlewave*.

[b-ITU-T Accessibility] ITU-T SG 16 Work on Accessibility, *Accessibility and Standardization*.
<http://www.itu.int/ITU-T/studygroups/com16/accessibility/index.html>

[b-ETSI TS 102 590] ETSI TS 102 590 v1.1.1 (2007), *Digital Video Broadcasting (DVB); Multimedia Home Platform (MHP) Specification 1.2 (including IPTV)*.

NOTE – Currently available as: DVB Document A107 (2007).

[b-IEC 62481-1] IEC 62481-1 Ed. 1.0 (2007), *Digital living network alliance (DLNA) home networked device interoperability guidelines – Part 1: Architecture and protocol*.
<http://webstore.iec.ch/webstore/webstore.nsf/artnum/038283>

[b-IEC 62481-2] IEC 62481-2 Ed. 1.0 (2007), *Digital living network alliance (DLNA) home networked device interoperability guidelines – Part 2: DLNA media formats.*
<http://webstore.iec.ch/webstore/webstore.nsf/artnum/038284>

NOTE – The above two references are equivalent to the combined DLNA Version 1.0 specification.

[b-IETF RFC 2616] IETF RFC 2616 (1999), *Hypertext Transfer Protocol – HTTP/1.1*.

[b-IETF RFC 3261] IETF RFC 3261 (2002), *SIP: Session Initiation Protocol*.

[b-IETF RFC 3417] IETF RFC 3417 (2002), *Transport Mappings for the Simple Network Management Protocol (SNMP)*.

[b-IETF RFC 3489] IETF RFC 3489 (2003), *STUN – Simple Traversal of User Datagram Protocol (UDP) Through Network Address Translators (NATs)*.

[b-IETF RFC 3588] IETF RFC 3588 (2003), *Diameter Base Protocol*.

[b-IETF Draft ICE NAT] IETF RFC 5245 (2010), *Interactive Connectivity Establishment (ICE): A Protocol for Network Address Translator (NAT) Traversal for Offer/Answer Protocols*.

[b-IETF RFC 5389] IETF RFC 5389 (2008), *Session Traversal Utilities for (NAT) (STUN)*.

[b-IETF Draft STUN] IETF Internet Draft <draft-ietf-behave-turn-03> (2007), *Obtaining Relay Addresses from Simple Traversal Underneath NAT (STUN)*.

[b-UPnP] UPnP™ Forum (2006), *UPnP Device Architecture 1.0*.

[b-CableLabs ERMI] CableLabs ERMI Specification (2005), *Edge Resource Manager Interface Specification*.
<http://www.cablemodem.com/downloads/specs/CM-SP-ERMI-I02-051209.pdf>

[b-CableLabs Metadata] CableLabs Metadata Specifications (2005), *VOD MetData 2.0*.
<http://www.cablelabs.com/projects/metadata/specifications/specifications20.html>

[b-CableLabs OCAP 1.1] CableLabs OCAP 1.1 Specifications (2006), *OpenCable Applications Platform Specifications – OCAP 1.1 profile*.
<http://www.opencable.com/downloads/specs/OC-SP-OCAP1.1-I01-061229.pdf>

[b-DSL TR-069] DSL Forum TR-069 (2004), *CPE WAN Management Protocol*.

[b-DVB GEM-IPTV] DVB GEM (2007), *GEM-IPTV white paper*.
<http://www.mhp.org/mhp_technology/gem/tm3749.mug180.GEM-IPTV_white_paper.pdf>

[b-OMA DM] OMA DM (2007), *Open Mobile Alliance Device Management Specifications*.

[b-ANSI/SCTE 118] ANSI/SCTE 118 (2006), *Program-specific Ad Insertion – Data Field Definitions, Functional Overview and Application Guidelines*.

[b-SCTE DVS] SCTE DVS, *Digital Video Subcommittee (DVS)*.
<http://www.scte.org/content/index.cfm?pID=49>

[b-WC3 XML] WC3 XML (2009), *Extensible Markup Language (XML)*.

[b-WC3 SOAP] WC3 SOAP (2007), *Simple Object Access Protocol (SOAP)*.

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series D	General tariff principles
Series E	Overall network operation, telephone service, service operation and human factors
Series F	Non-telephone telecommunication services
Series G	Transmission systems and media, digital systems and networks
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	**Cable networks and transmission of television, sound programme and other multimedia signals**
Series K	Protection against interference
Series L	Construction, installation and protection of cables and other elements of outside plant
Series M	Telecommunication management, including TMN and network maintenance
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Terminals and subjective and objective assessment methods
Series Q	Switching and signalling
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks, open system communications and security
Series Y	Global information infrastructure, Internet protocol aspects and next-generation networks
Series Z	Languages and general software aspects for telecommunication systems

Printed in Switzerland
Geneva, 2010