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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

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IPTV service requirements and framework for secondary distribution

Summary

The telecommunications industry today is pursing 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 HFC networks while adding support for data and voice through the DOCSIS and IPCablecom architectures. This Recommendation defines IPTV service requirements and framework for secondary distribution to deliver advanced video-based and integrated video, voice, and data service applications.

Source

Recommendation ITU-T J.700 was approved on 14 December 2007 by ITU-T Study Group 9 (2005-2008) under Recommendation ITU-T A.8 procedure.

FOREWORD

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1 Scope

This Recommendation describes the service requirements and functional framework architecture for support of IPTV services over secondary distribution (e.g., cable and optical, etc.) 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 a subset of the general ITU-T IPTV functional architecture required for the support of IPTV services delivered over existing secondary distribution networks or NGN, based networks.

The scope of this Recommendation is to provide a framework for IPTV-enhanced broadcast over secondary distribution.

NOTE – The structure and content of this Recommendation have been organized for ease of use by those familiar with the original source material; as such, the usual style of ITU-T Recommendations has not been applied.

2 References

2.1 Normative 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.

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NOTE – Additional Informative References used in this Recommendation are listed in the bibliography.

3 Definitions

This Recommendation uses or defines the following terms:

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

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

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

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations:

AAC Advanced Audio Coding

AAC-LC AAC Low Complexity

AC-3 Arc Consistency Algorithm #3 (Dolby)

AIT Application Information Table

API Application Programming Interface

ASD Authorized Service Domains

ATSC Advanced Television Systems Committee

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

CEA Consumer Electronics Association

CDN Content Delivery Network

CID Caller Identity Display

CM Cable Modem

CMTS Cable Modem Termination System

CODEC Coder-Decoder

CPE Customer Premises Equipment

CSCF Call Session Control Function

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 Program Insertion
DRM	Digital Rights Management
DRRP	Dynamic Resource Registration Protocol
DSG	DOCSIS Set-top Gateway
DSL	Digital Subscriber Loop
DSM-CC	Digital Storage Media Command and Control
DTCP	Digital Transmission Content Protection
DVB	Digital Video Broadcasting
DVD	Digital Video Disc
DVR	Digital Video Recorder
DVS	Digital Video Services
eSAFE	Embedded CM entity (e.g., STB, Router, MTA, etc.)
EAS	Emergency Alert System
ECM	Entitlement Control Message
EMM	Entitlement Management Message
EPG	Electronic Program Guide
ERM	Edge Resource Manager
ES	Elementary Streams
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 MHP
GIF	Graphics Interchange Format
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 HTTP
ICE	Interactive Connectivity Establishment
I-CSCF	Interrogating CSCF
IGMP	Internet Group Management Protocol
IMS	IP 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
ITV	Interactive Television
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
MHP	Multimedia Home Platform
MP3	MPEG-1 Audio Layer 3
MLD	Multi-Listener Discovery
MPEG	Moving Pictures Expert Group
MPEG-TS	MPEG Transport Stream
MPTS	Multiple Program Transport Stream
MSO	Multiple System Operator
MTA	Multimedia Terminal Adapter

NACF	Network Attachment Control Function
NAT	Network Address Translation
NGN	Next Generation Network
NIT	Network Information Table
NPT	Normal Play Time
NTSC	National Television System Committee
OCAP	OpenCable Applications Platform
OMA	Open Mobile Alliance
OOB	Out-of-Band
OSD	On Screen Display
OSS	Operational Support System
PAT	Program Association Table
PBP	Personal Basic Profile
PES	Packetized Elementary Stream
PCM	Pulse Code Modulation
P-CSCF	Proxy CSCF
PDU	Packet Data Unit
PEG	Public, Education and Government access
PiP	Picture-in-Picture
PMT	Program Map Table
PNG	Portable Network Graphics
PON	Passive Optical Network
PPV	Pay Per View
PSI	Program 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
RFC	Request For Comments
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
SD	Standard Definition
SD&S	Service Discovery and Selection
SDP	Session Description Protocol
S-CSCF	Serving CSCF
SI	Service Information
SIP	Session Initiation Protocol
SNMP	Simple Network Management Protocol
SOAP	Simple Object Access Protocol
SP	Service Provider
SPTS	Single Program 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 UDP through NAT
TCP	Transmission Control Protocol
TFTP	Trivial File Transfer Protocol
TMN	Telecommunications Management Network
TURN	Transversal Using Relay NAT
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 IP
VPN	Virtual Private Network
VRN	Video Rich Navigation
WAN	Wide-Area Network
WC3	World Wide Web Consortium
WMA	Windows Media Audio

WWW	World Wide Web
xDSL	(**s**ymmetric, **a**symmetric, **h**igh bit-rate, **v**ery high speed) DSL
xDVR	(**c**lient, **n**etwork, **d**istributed, **m**obile) DVR
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 proposed by the ITU-T IPTV Focus Group (FG IPTV). It has been modified slightly to allow for the Network Provider and Service Provider to be the same entity and to show some basic functional relationships.

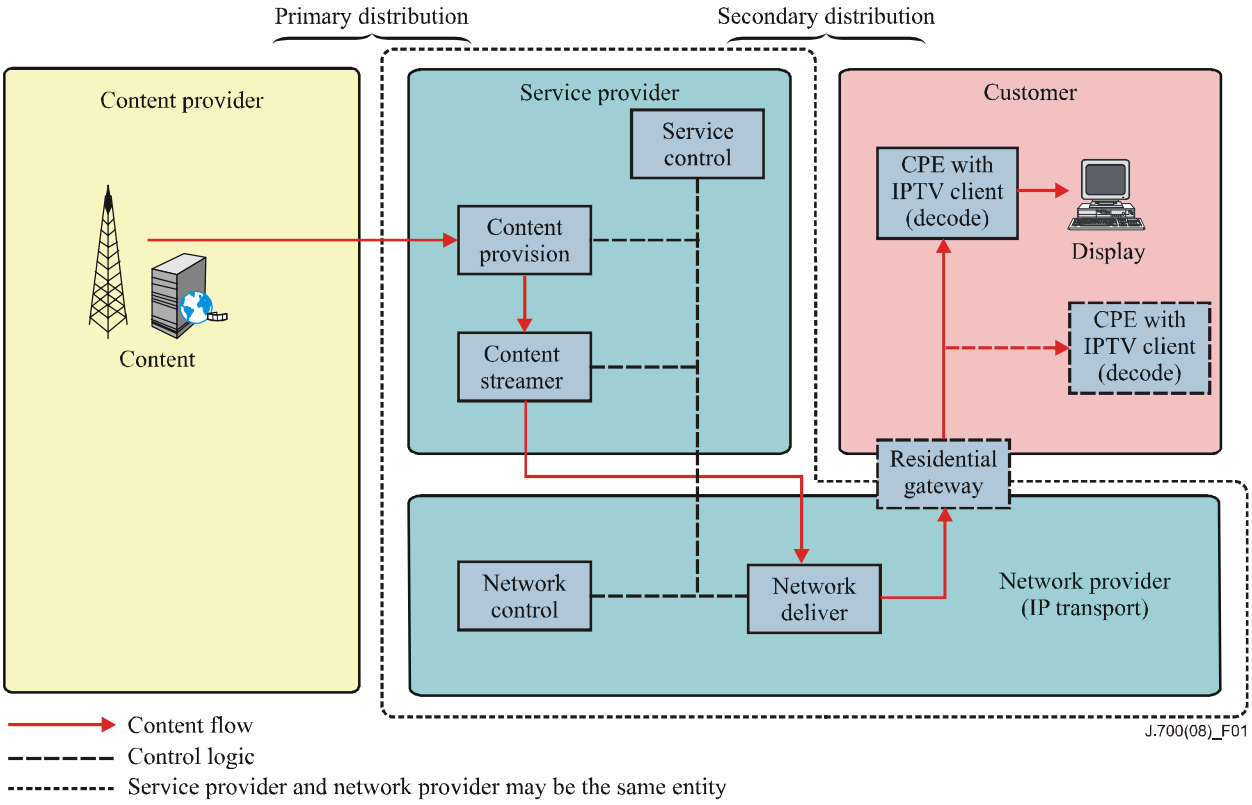


Figure 1 – IPTV Reference Model

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 Deliver 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 Deliver 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's 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's 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 IPTV secondary distribution system based on the basic reference model and considering existing deployed technology. This secondary distribution system is illustrated in Figure 2.

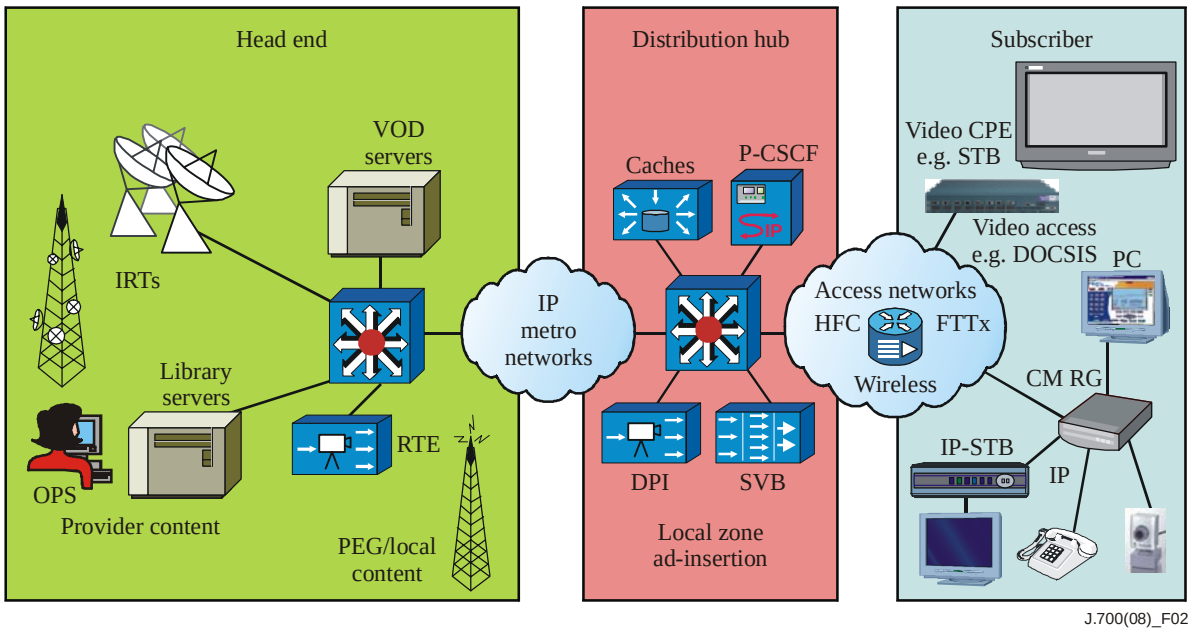


Figure 2 – Example of High Level End-to-End Physical Network

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 premise 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 premise is not considered within the trust boundary. The expanding need to support in-premise 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 multi-media capabilities to the TV using IP – This scenario is generally considered enhancements to 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 also may 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 program 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 [ITU-T J.160] defines a standard architecture for Voice over IP (VoIP) and IPCablecom2 [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 home gateway, and then made available within the home to IP devices from the 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 device 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 service 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 IPTV framework 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.

5.2.2 Navigation and Electronic Program Guide Support

The CPE should support an interactive Electronic Program 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 favorite 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

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 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.

5.2.4 Support for Digital Program 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 [ITU-T J.189]:

- Digital into Digital advertising includes the capabilities to insert, or splice, one digital program (the ad) into a second digital program (the content being viewed). Insertion should include both video and audio content. The insertion may occur in the headend, 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 a 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.

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.

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

5.2.7 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):

- eCommerce including managed content purchases and enhanced shopping channel
- Textual and Video IM
- Email
- Web-based services/Internet Portal Access
- Telephony Integration (Voicemail, Caller ID, etc.)
- 3rd 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 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.

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

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 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 program)
- Display a list of already recorded programs/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 programs/content
- Erase recorded programs/content (whether viewed or not)
- Copy recorded programs/content to removable or external local storage devices according to copyright privileges.
- Automatically (end-user unaware) recording content.

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.

Client DVR (cDVR): An instance of 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.

Network DVR (nDVR): An instance of 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.

Distributed DVR (dDVR): Multiple instances of 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.

Mobile DVR (mDVR): A mobile instance of 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.

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 web-page [*ITU-T SG 16 Work on Accessibility]*, which includes pointers to the Telecommunications Accessibility Guidelines and Telecommunications Accessibility Checklist.

5.3 Functional Requirements

This Recommendation specifies how IP-based television services may be offered over secondary distribution networks including DOCSIS-based Cable Television, FTTH, DSL, etc. IPTV 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, Device Configuration & Control, Code Download, and Polling & 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 program 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 indexes 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 offered available 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 program association table (PAT), program 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:

- SCTE-65/ATSC A/65C
- DVB ETSI EN 300 468
- ARIB-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 9.3.1 below).

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

ETSI TS 102 034 (Digital Video Broadcasting (DVB); Transport of MPEG-2 Based DVB Services over IP-based Networks) 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 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 [IETF STD 62]
  - DHCP [IETF RFC 2131], [IETF RFC 2132]
  - TFTP [IETF RFC 1350]
  - HTTP [IETF RFC 2616]
- UPnP [UPnP Device Architecture 1.0]
- Open Mobile Alliance (OMA) Device Management [OMA DM].

- Web Services (e.g., XML) [WC3].
- DSL Forum TR-069 [DSL TR-069]

5.3.3.2 Software Download

The CPE should support software download and upgrade capability via the remote download interface using method 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.

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.

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 Internet Protocol (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 OOB messaging from its physically separate transport (e.g., legacy 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 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., HSD, 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 Headend 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 program association table (PAT), program 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 info 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 – SSM) 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: [SCTE 128], [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 the following closed captioning standards and VBI capabilities such as: [SCTE-20], [SCTE-21] and [ETSI EN 301 775] (modified by [SCTE-127]), [CEA-608-C], and [CEA-708-C].

In the event both [SCTE-20] and [SCTE-21] closed captions are present simultaneously, the preference is to select [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 Video Rich Navigation (VRN) application with decoding and compositing in the video plane, combining with graphics, and display in a 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 & 3 (MP3)
- Dolby Digital (AC-3) up to 5.1 with matrix audio (ProLogic)
- MPEG-2 AAC (AAC-LC) [ISO/IEC 13818-7]
- Dolby Digital Plus (enhanced AC-3) with matrix audio (ProLogic)
- MPEG-4 AAC and High Efficiency-AAC (aacPlus) 2-channel program
- 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 3 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 program 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 on the target market.

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

5.3.7 Resource & 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 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 resource 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 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 analog outputs may be enabled or disabled based on service provider configuration.
- HDCP copy protection on the HDMI digital video output.
- DTCP copy protection compliant with [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 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 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 communications 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 allowing stored content to be viewed on a television connected to a diskless CPE.

The 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] defines 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 program 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/FW Traversal

IPTV services should be able to cross NAT FW boundaries.

5.3.11 Middleware

The Middleware platform should be based on [ITU-T J.200], [ITU-T J.201], [ITU-T J.202] and GEM 1.2 [ETSI TS 102 543] for set-top box based CPEs.

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:
  - The IPTV 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.
  - The IPTV Architecture shall support converged services.
- Access services on a wide variety of subscriber devices (wired and wireless):
  - IPTV 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 service 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 interaction between the IMS-based IPCablecom2 services and the IPTV services.
- 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 [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 FG IPTV architecture, and constitutes a subset of the functions adapted for use over secondary distribution networks.

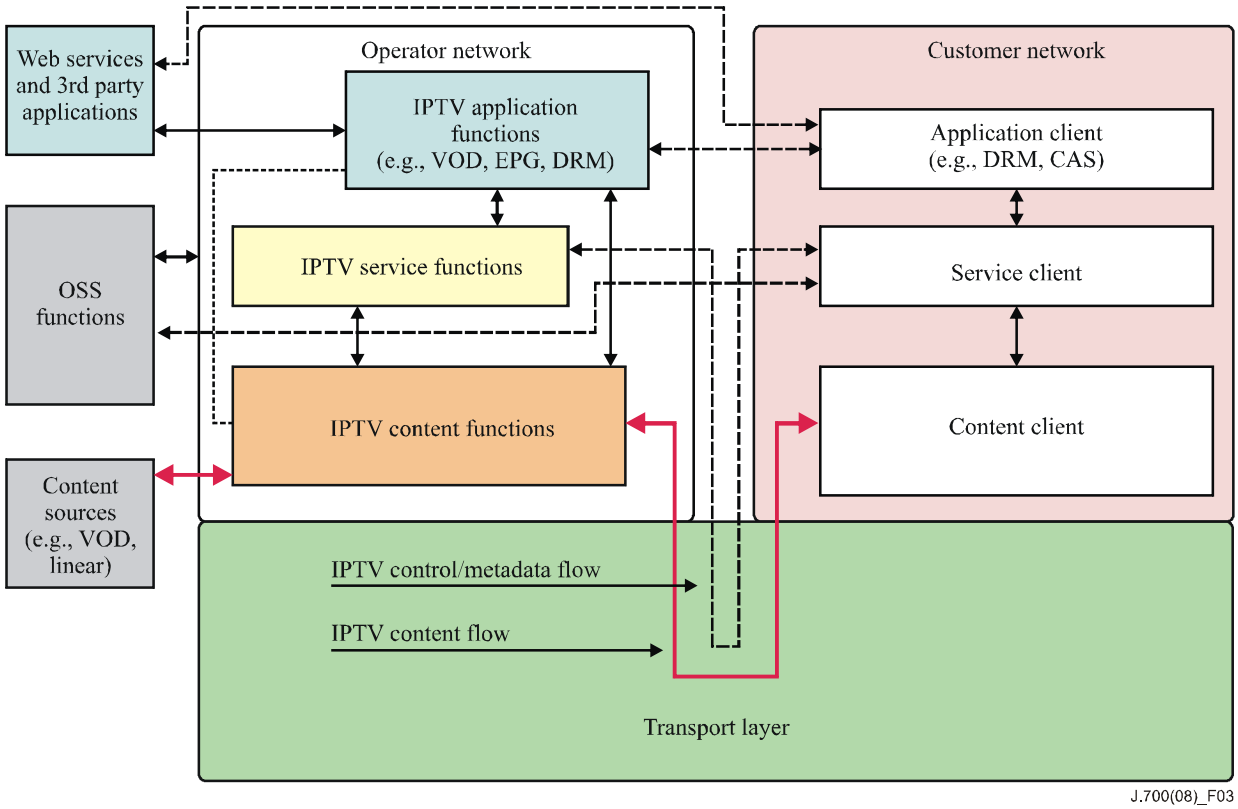


Figure 3 – Functional architecture for IPTV secondary distribution system

NOTE – The Operator Network and the Transport Layer in Figure 3 are equivalent respectively to "Service provider Network" and "Network provider network" specified in the IPTV FG "Functional Architecture".

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 program selection features and program 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 9 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 9 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 3rd Party Applications

The following are examples of some Web Services and 3rd Party Applications that may fall into the "Web Srvcs and 3rd Party Apps" functional block in Figure 3:

1) 3rd 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 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. Analog 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 premise 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.

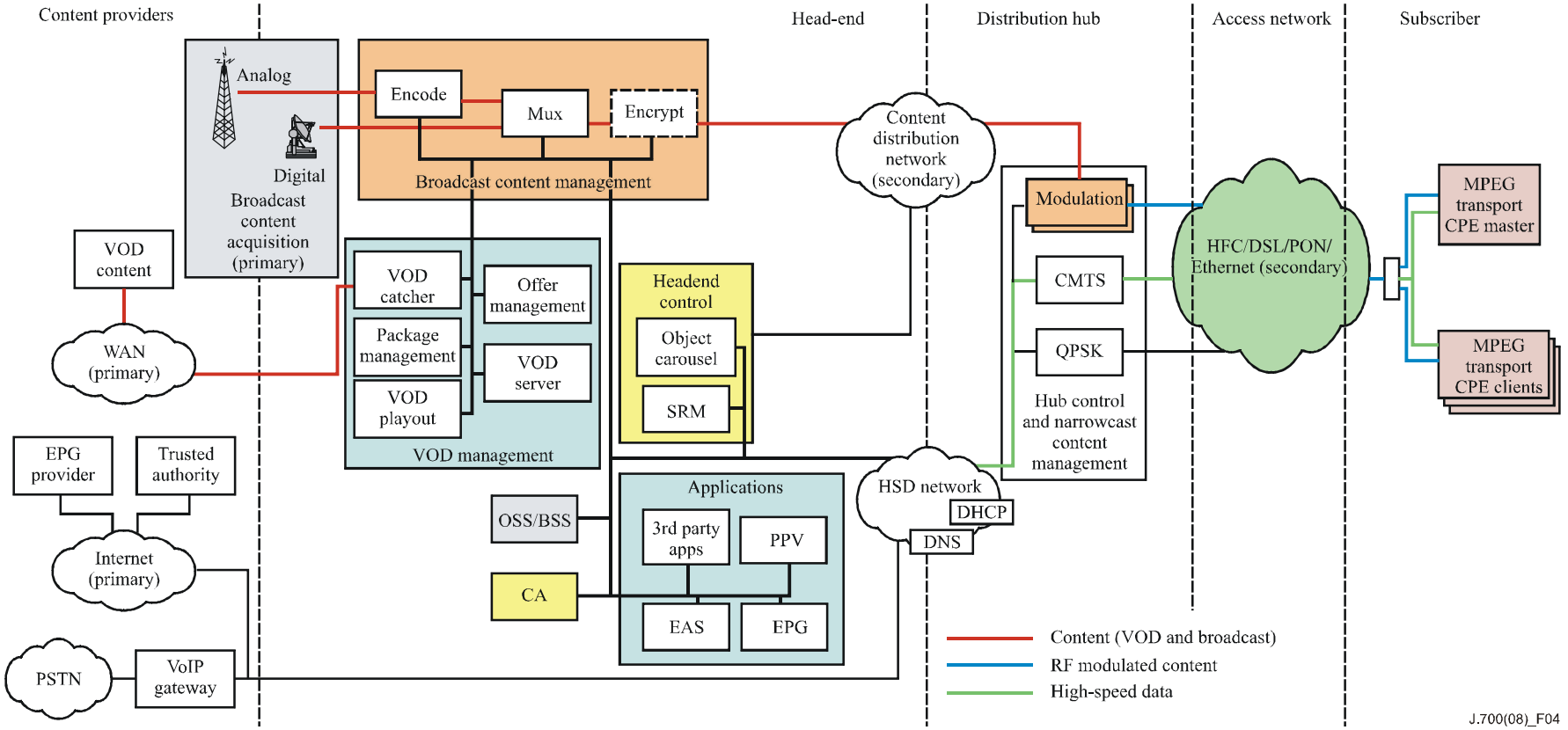


Figure 4 – Typical existing video delivery architecture

Figure 5 represents typical existing video delivery architecture utilizing IPTV control capabilities to provide IPTV services. Analog or Digital Broadcast Content and VOD Content is received at the Headend 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 Distribution 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 Internet Protocol (IP). The Subscriber premise 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 Premise, a Residential Gateway (RG) may be required to disseminate content and signals to and from the CPEs in the Subscriber premise. Figure 5 which shows a typical existing Video Delivery Architecture with IPTV Service maps to the above Figure 3, "Functional architecture for IPTV secondary distribution system".

- 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 blue 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 "Headend Control" map to the "IPTV Service Functions" of Figure 3.

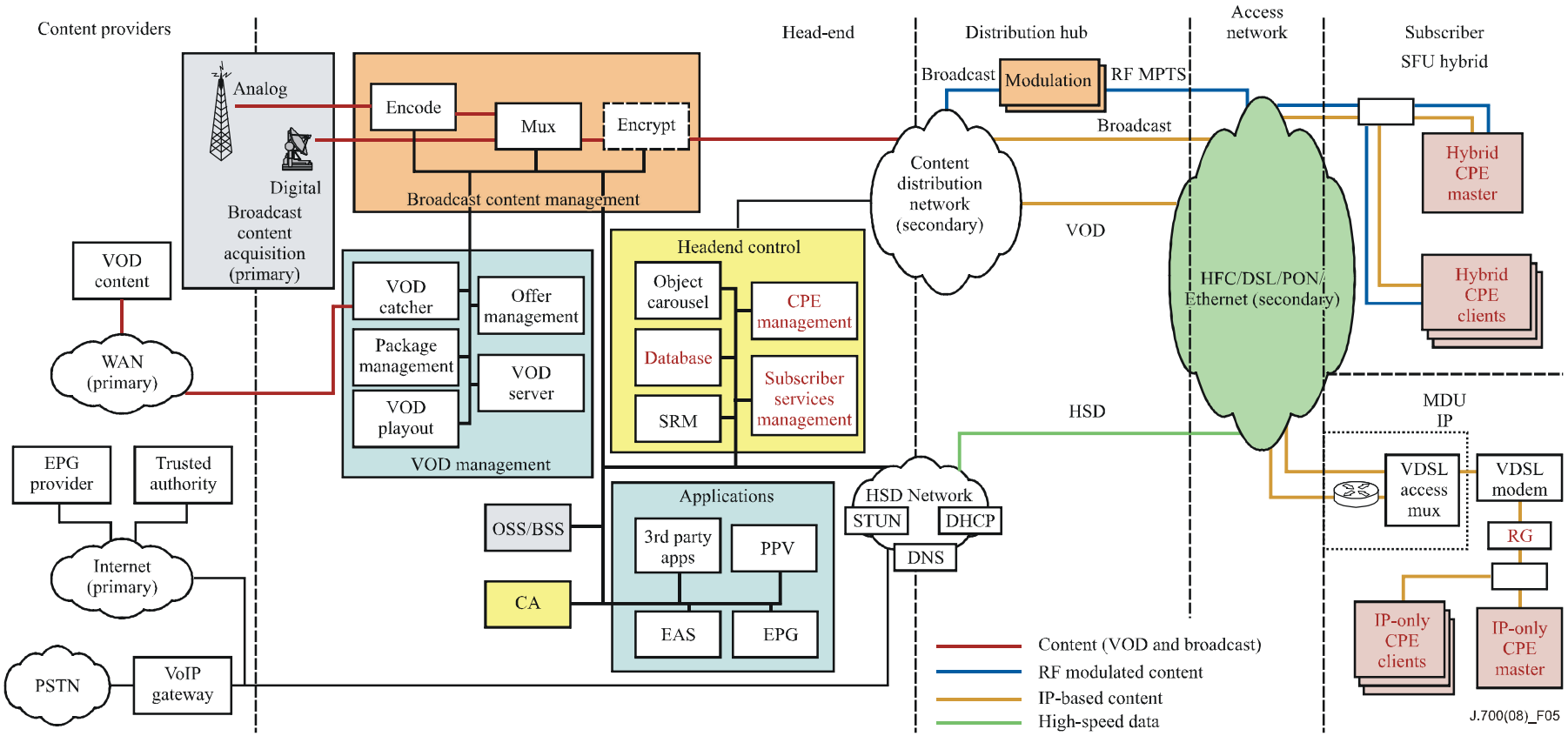


Figure 5 – Typical existing Video Delivery Architecture with IPTV Service

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 UDP (User Datagram Protocol) behind a NAT (Network Address Translators) 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 premise. 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 premise.
- *Hybrid CPE Clients* – A CPE (such as a Set-top, Computer, 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 premise 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.

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

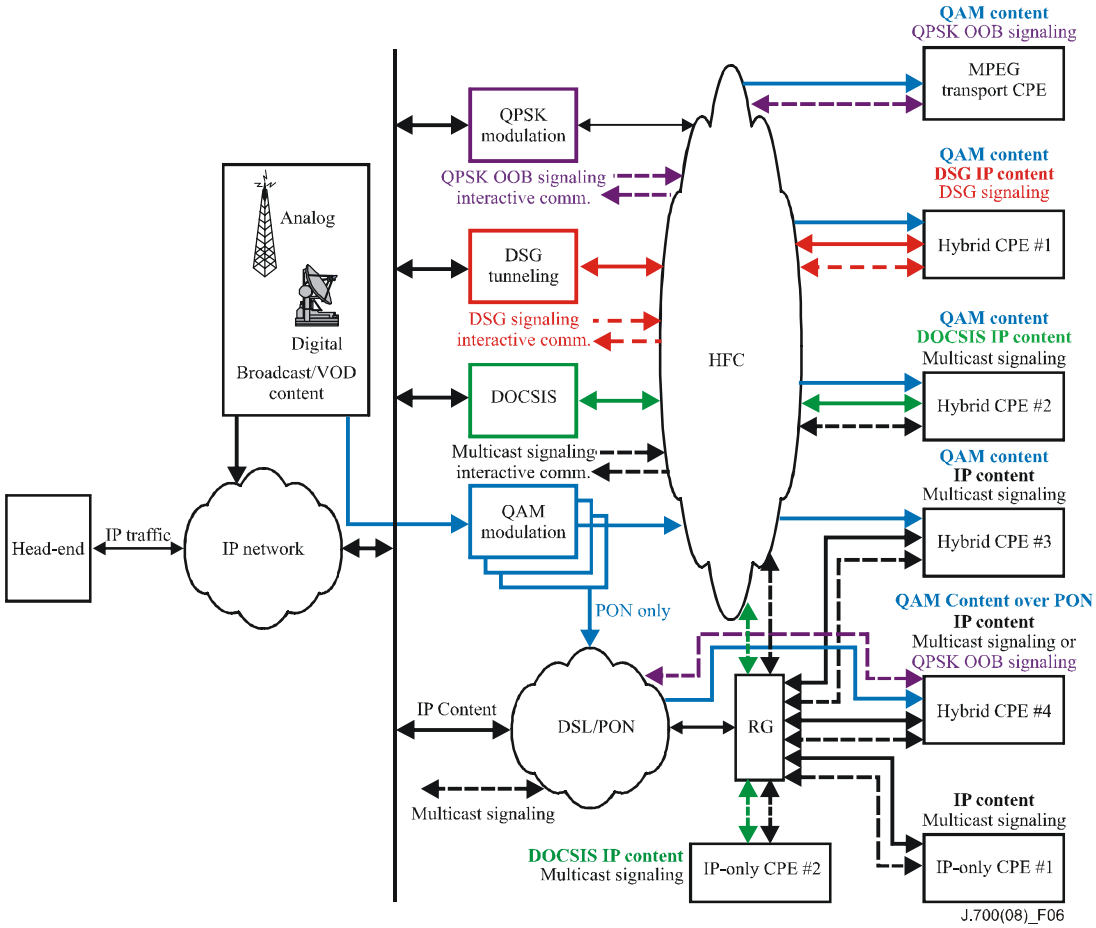


Figure 6 – Client Devices in an IPTV Enabled Network

In the above figure, solid, bold lines indicate Content or HSD (High-Speed Data) 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 6 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 6 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 6 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 6 represent clients equipped with both a QAM tuner and an IP interface. Hybrid CPE #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 6 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 6 represents a CPE equipped with both a QAM tuner and an embedded Cable Modem (eCM) that is DOCSIS capable. Hybrid CPE #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 Relationship to DOCSIS and IPCablecom Support for Multimedia

Figure 7 shows how digital video systems would co-exist with IPTV delivery systems. In this diagram, 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 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 Quality of Service (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.

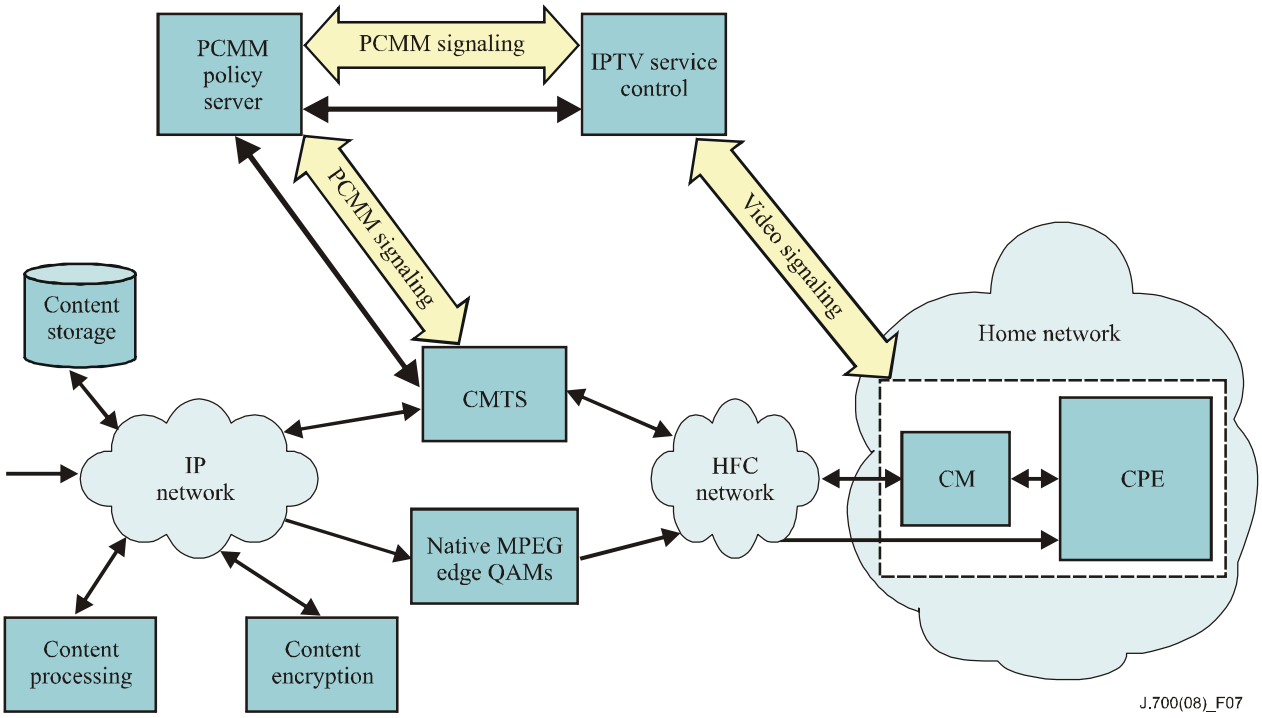


Figure 7 – Interaction with DOCSIS and IPCablecom Multimedia

7.1.2.1 Interaction with IPCablecom Multimedia

The currently defined mechanism is a push-policy method where the SRM (Session and Resource Manager) 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 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 business (e.g., billing) based, network resource based (e.g., acceptable percentage of total bandwidth), time-of-day based, 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 [ITU-T J.210], [ITU-T J.211], and [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 [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 DRRP (DOCSIS Resource Registration Protocol) 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 DEPI (Downstream External PHY Interface).

While 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

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 [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 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 8. The Broadband Services Domain in Figure 8 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 Program 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 8 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.

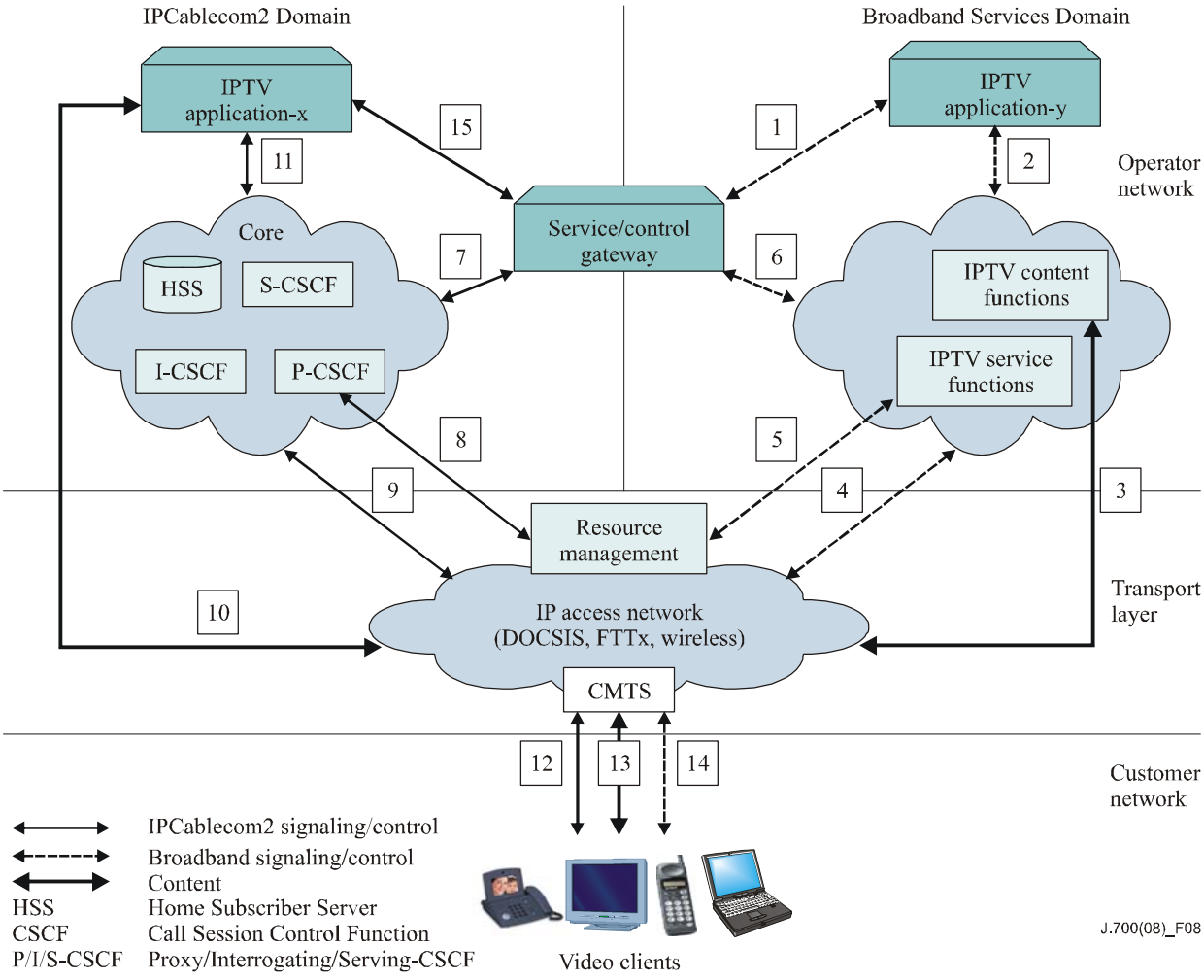


Figure 8 – Relationship with IPCablecom2

7.2 Relationship to FTTH, DSL, Wireless Networks

Figure 9 illustrates the way that video services may be delivered over FTTH-based, DSL-based, and Wireless Access Networks.

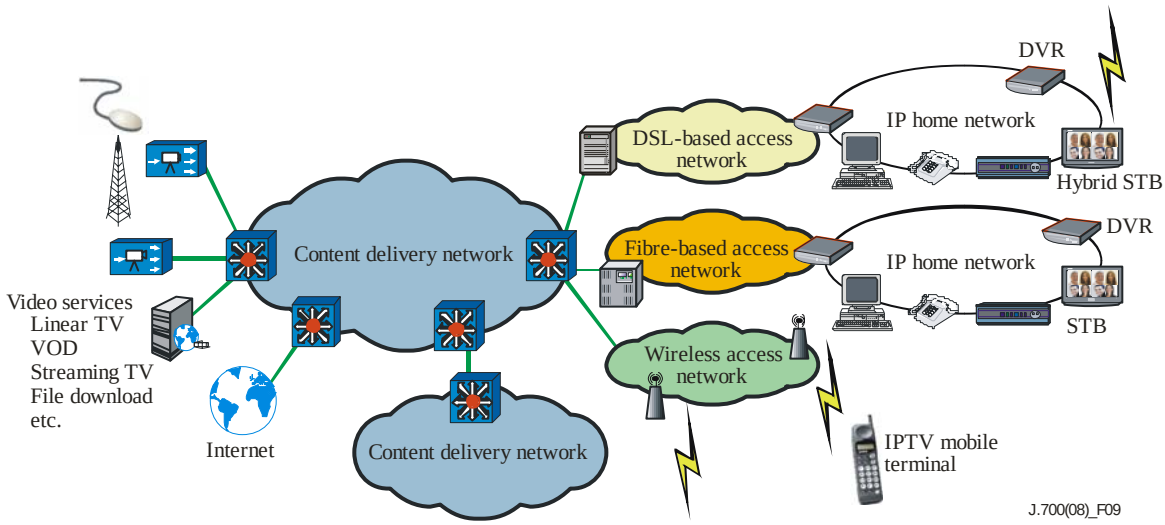


Figure 9 – Relationship to FTTH-based, DSL-based, and Wireless Access Networks

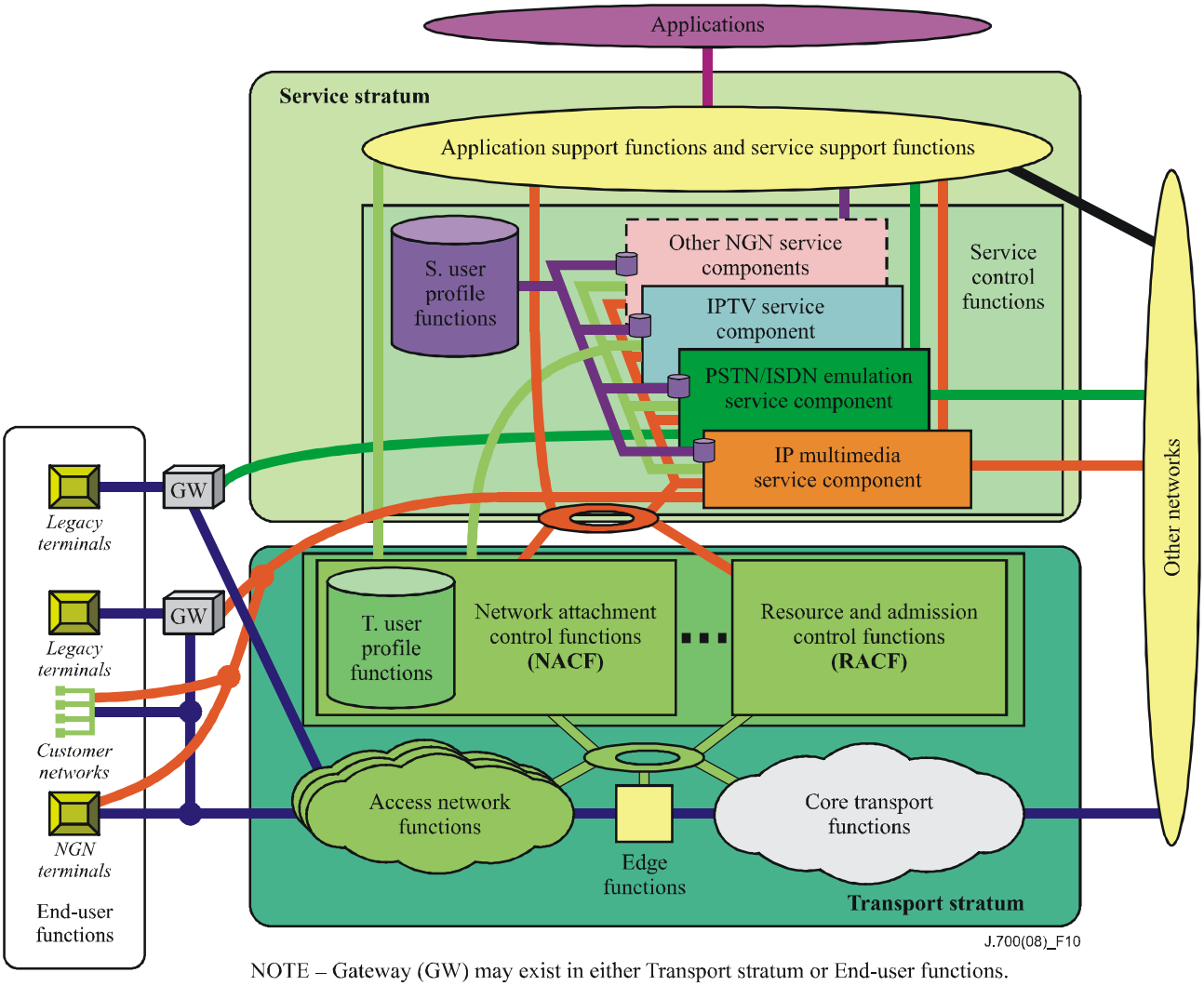
8 Relationship to NGN

IPTV comprises a set of services that will fit nicely into the NGN. The ITU-T FG IPTV has defined 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.



NOTE – Gateway (GW) may exist in either Transport stratum or End-user functions.

Figure 10 – Support of IPTV services in the NGN Framework Architecture

The NGN framework architecture shown in Figure 10 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 3rd 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 10).

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 will be 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 applications 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, as per [ITU-T Y.2011]. The Transport Stratum functions will be described here with reference to Figure 10 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 above, 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 (RACF)*:

The RACF 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 RACF 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 RACF.

– *Network Attachment Control Functions (NACF)*:

The NACF 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 NACF 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 network 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.

9 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 secondary distribution based on the more generic architecture shown in Figure 3. In this figure, 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 function 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.

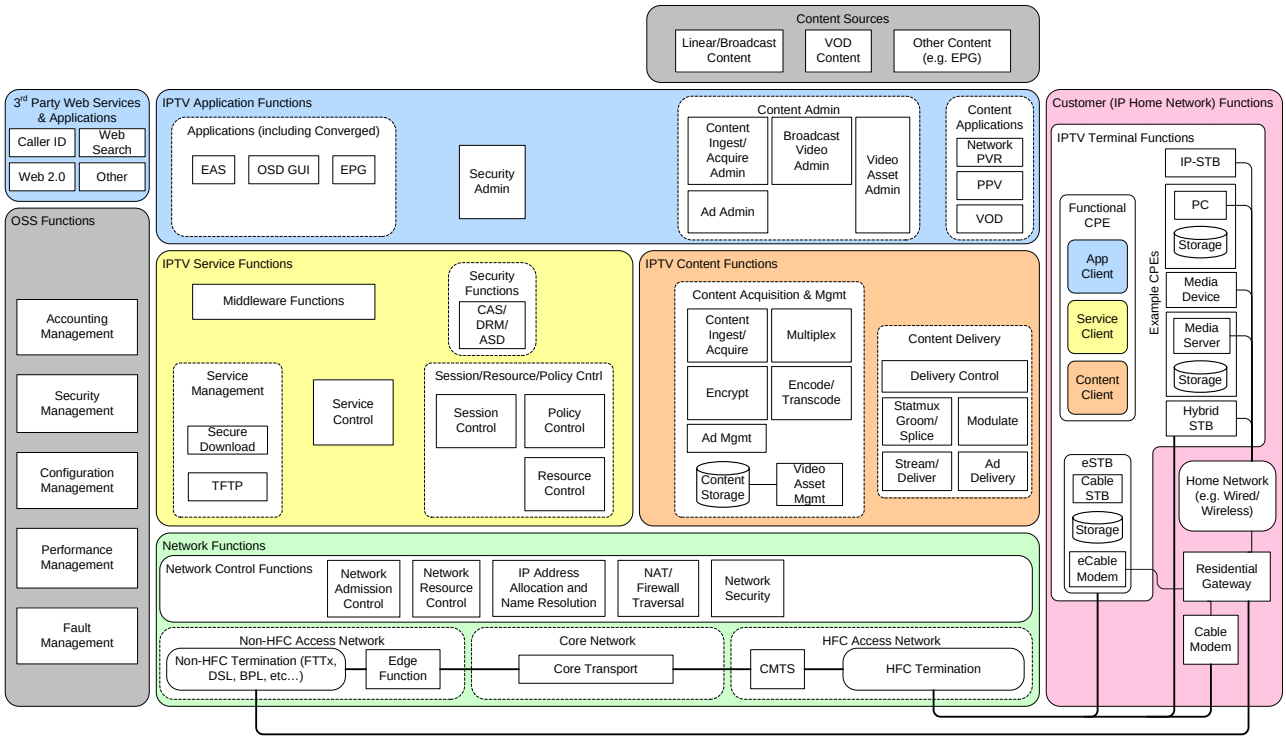


Figure 11 – IPTV Functional Components

9.1 IPTV Application Functions

The IPTV Application Functions include the mechanisms required to define and deliver IPTV services to the subscriber.

9.1.1 Applications (including converged)

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 Programming 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.

9.1.2 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.

9.1.3 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 setup of content ingestion and acquisition. This administration functional block enables the setup 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 like 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 SCTE standards such as [SCTE-30], [SCTE-35], and [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.

9.1.4 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 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.

9.2 3rd 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 3rd Party Web Services and Applications servers directly. Such applications may include:

- Voice applications such as Caller ID

- Standard web-based applications such as web search
- Advanced interactive web applications (Web 2.0)

Though covered in the framework, 3rd Party Web Services and Applications may also be used for enhanced IPTV services including program search and delivery and interactive Electronic Program Guides (EPG).

9.3 IPTV Service Functions

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

9.3.1 Middleware Functions

Middleware Functions provide support for delivery of middleware-based applications (for example, J.200 Series-based Application Services) to the Service Client functional block of the CPE Terminal device. Middleware Functions are part of the IPTV Service Functions 1 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.

9.3.1.1 GEM Overview

Globally Executable Multimedia Home Platform (GEM MHP) specifies the common core across OCAP [OCAP 1.1] and MHP [ETSI TS 102 590 v1.1.1]. 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 the 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 [DVB GEM].

Figure 12 shows the relationship between GEM, OCAP, and MHP at a high level.

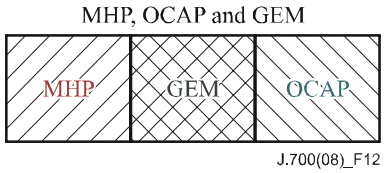


Figure 12 – Relationship of GEM to MHP and OCAP

9.3.1.2 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 Specification v1.0 part of FP 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 receiver	Provides the ability to store a service with multiple applications in the persistent memory of a GEM terminal. This reduces startup time for commonly access 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 finely grained user address than was present in MHP 1.0.
Improved persistent storage management	Improved mechanism for managing persistent storage.
Access to removable file systems	New mechanism in MHP 1.1 for accessing removable storage.
Synchronized Auxiliary Data	Preferred alternative mechanism to NPT (Normal Play Time).
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.

9.3.2 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

9.3.3 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 3rd party applications.

9.3.4 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 (ASD). For example, it would include generation of 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 Service Client functional block of the CPE terminal device.

9.3.5 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 will play 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).

9.4 IPTV Content Functions

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

9.4.1 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 setup and processes defined by the "Content Ingest/Acquire Admin" functional block.
- Real-time Multiplexing, including both broadcast and on-demand content.
- Real-time encryption of content being delivered to CPE, including both broadcast and on-demand content.
- Real-time Encoding and Transcoding, including support for different formats & bit rates for both broadcast and on-demand content. In addition to video formats, this can include support for Stereo vs. 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 real-time. SCTE has standardized such functionality as part of their Digital Video Services (DVS) initiative [SCTE-128].

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

9.4.2 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 setup for switching digital video (as defined in the "Broadcast Video Admin" 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 vs. 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 – This functional block 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. [SCTE-30] and [SCTE-35] cover the details of Ad splicing.

9.4.3 Video Transport Methods supported by IPTV Content Functions

The CPE should support the following transport methods to receive digital content from the HFC 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 10.1).

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 HFC media transport formats in this clause.

9.4.3.1 Native MPEG Transport

Figure 13 represents the method for providing digital content to the CPE called MPEG-2 Multiple Program Transport Streams (MPTS) over QAM.

<table>
<tr><td>Audio stream(s)</td><td>Video stream(s)</td><td>Private-data stream(s)</td></tr>
<tr><td colspan="3">MPEG-2 Transport Stream</td></tr>
<tr><td colspan="3">QAM</td></tr>
</table>

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 audio, video and private data PES representing an MPEG program within the MPTS. The CPE should support MPEG-2 MPTS over QAM.

9.4.3.2 MPEG MPTS Multiplexed with DOCSIS

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

<table>
<tr><td rowspan="4">Audio stream(s)</td><td rowspan="4">Video stream(s)</td><td rowspan="4">Private-data stream(s)</td><td>Data</td></tr>
<tr><td>TCP/UDP</td></tr>
<tr><td>IP</td></tr>
<tr><td>DOCSIS PDU</td></tr>
<tr><td colspan="4">MPEG-2 Transport Stream</td></tr>
<tr><td colspan="4">QAM</td></tr>
</table>

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 program information with DOCSIS data PDUs. The CPE should support MPEG-2 MPTS multiplexed with DOCSIS.

9.4.3.3 MPEG SPTS/MPTS over UDP/IP

Figure 15 represents the method of providing digital content to the CPE called MPEG SPTS (Single Program Transport Streams)/MPTS over UDP/IP.

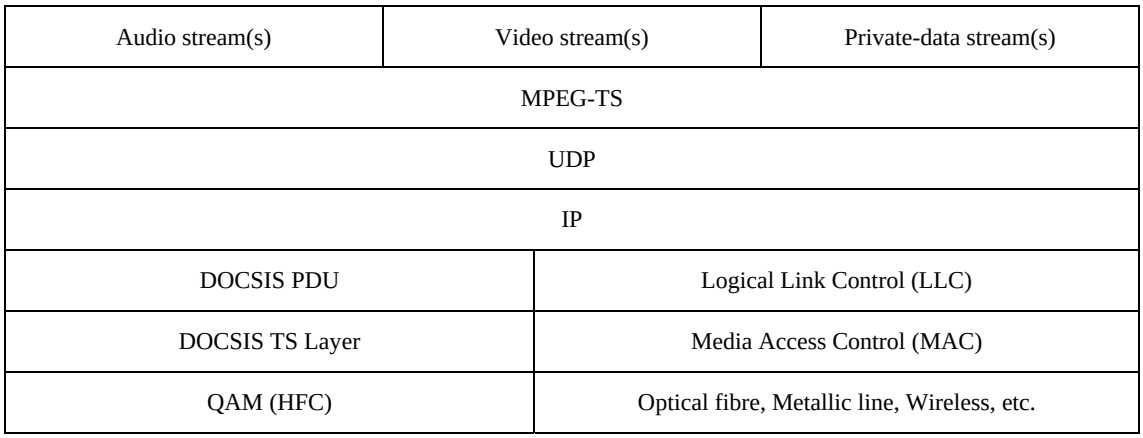


Figure 15 – MPEG-2 SPTS/MPTS over UDP/IP

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

9.4.3.4 MPEG Single Program/Multi-Program over RTP/UDP/IP

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

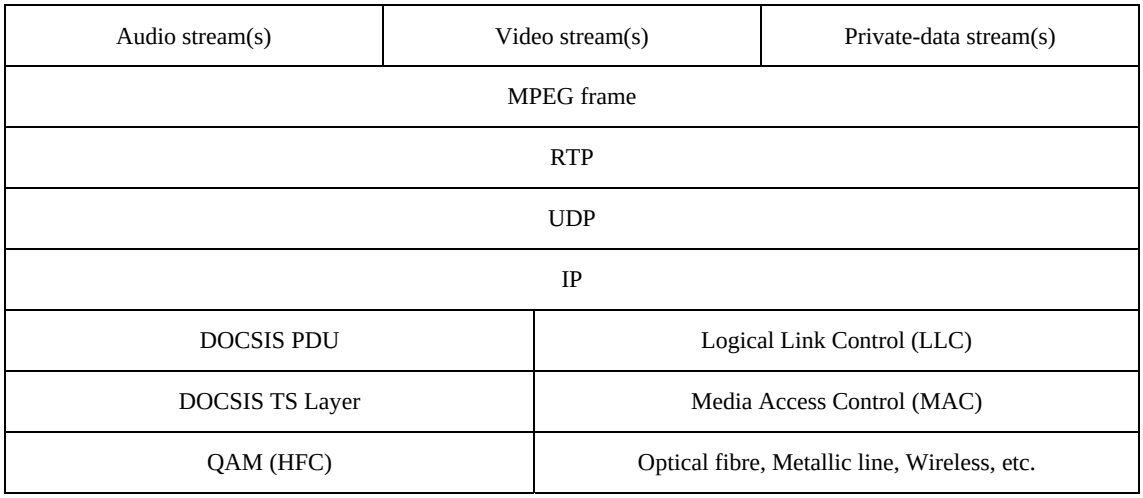


Figure 16 – MPEG-2 Single Program/Multi-Program over RTP/UDP/IP

The CPE should support MPEG Single Program/Multi-Program over RTP/UDP/IP. Either audio/video Elementary Streams (ES) or an MPEG-2 Transport Stream over RTP is allowed.

9.4.3.5 MPEG-4 AVC over RTP/UDP/IP

MPEG-4 AVC over RTP is specified in [RFC 3640] and [RFC 3984] which allow the encapsulation of MPEG-4 AVC video with timing recovered from the RTP layer.

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

9.5 Network Functions

Network functions provide the transport of IPTV services.

9.5.1 Network Control Functions

In the Network Control functional grouping, there are mechanisms for NAT/Firewall Traversal, assigning IP addresses, and managing Domain Name Systems (DNS). 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-15.txt>], STUN Servers [IETF RFC 3489], [IETF Internet Draft <draft-ietf-behave-rfc3489bis-06>], and TURN Servers [IETF Internet Draft <draft-ietf-behave-turn-03>]
- Network Security: Network Control functions include security mechanisms such as IP filtering to aid in the prevention of Denial-of-Service attacks and VPN tunneling 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.

9.5.2 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., tunneling mechanisms and traffic monitoring mechanisms).

9.5.3 HFC Access Network for Cable TV Systems

The HFC access network is defined as the network between the CMTS and the Cable Modem. Examples of technologies specific to, and supported by, the HFC access network include:

- DOCSIS for the transport of IP over HFC
- 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

9.5.4 Non-HFC Access Network

Other access networks (transport network from the service provider "logical edge" to the consumer premise) which may be supported by the Architectural Framework defined here could include:

- FTTx
- DSL
- Broadcast over Power Line (BPL)

9.6 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 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 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 include 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 providers' 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.

9.7 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 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

9.8 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.

10 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.

10.1 IPTV Network Reference Points

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 MPEG CPE and the MPEG portion of Hybrid CPE are of a legacy nature and therefore not addressed here.

Figure 17 repeats Figure 3 – Functional architecture for IPTV secondary distribution system – with specific reference points marked:

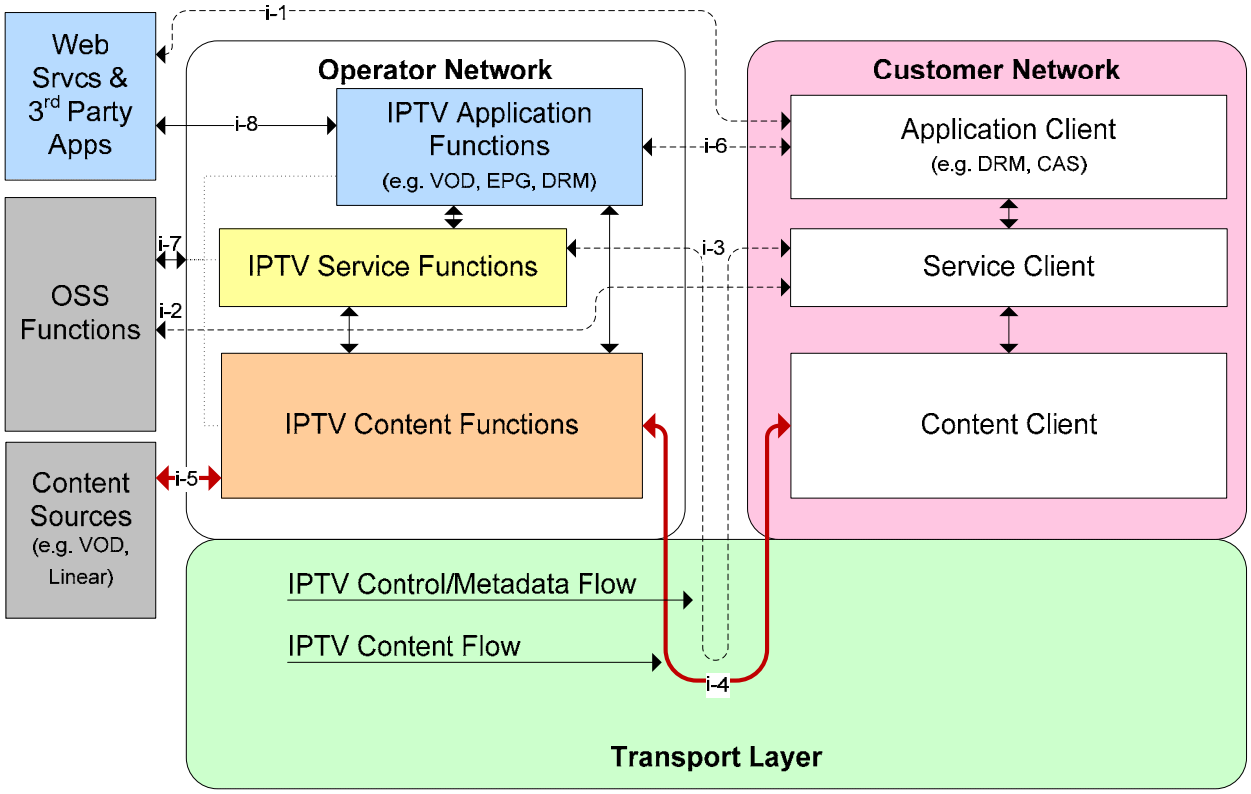


Figure 17 – IPTV Network Reference Points

NOTE – The Operator Network and the Transport Layer in Figure 17 are equivalent respectively to "Service provider Network" and "Network provider network" specified in the IPTV FG "Functional Architecture".

Table 2 describes the reference points identified in Figure 17.

Table 2 – IPTV Secondary Distribution System Reference Point Descriptions

Reference Point	IPTV System Network Elements	Reference Point Description
i-1	Web Services and 3rd Party Apps – Application Client	Enables the Web Services and 3rd Party Applications network element to interact and collaborate with the Application Client in the Customer Network for the delivery of Web-based services and 3rd 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 program content, plus the metadata describing the program 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.
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 3rd Party Apps – IPTV Application Functions	Enables IPTV Services and Applications in the Operator Network to request Web Services and other 3rd Party Applications from the Web Services and 3rd Party Apps network element. Potential supporting protocols include HTTP, SOAP, and WSDL.

10.2 Internetwork Operability

Interconnection of different administrative IPTV networks should be considered. FG IPTV has examined several scenarios for internetwork operability. Figure 18 is one example of the case where different administrative IPTV networks are interconnected at the transport layer. As shown in Figure 18, both IPTV networks should have an equivalent resource control mechanism and they should work based on the same QoS policy and common resource control command.

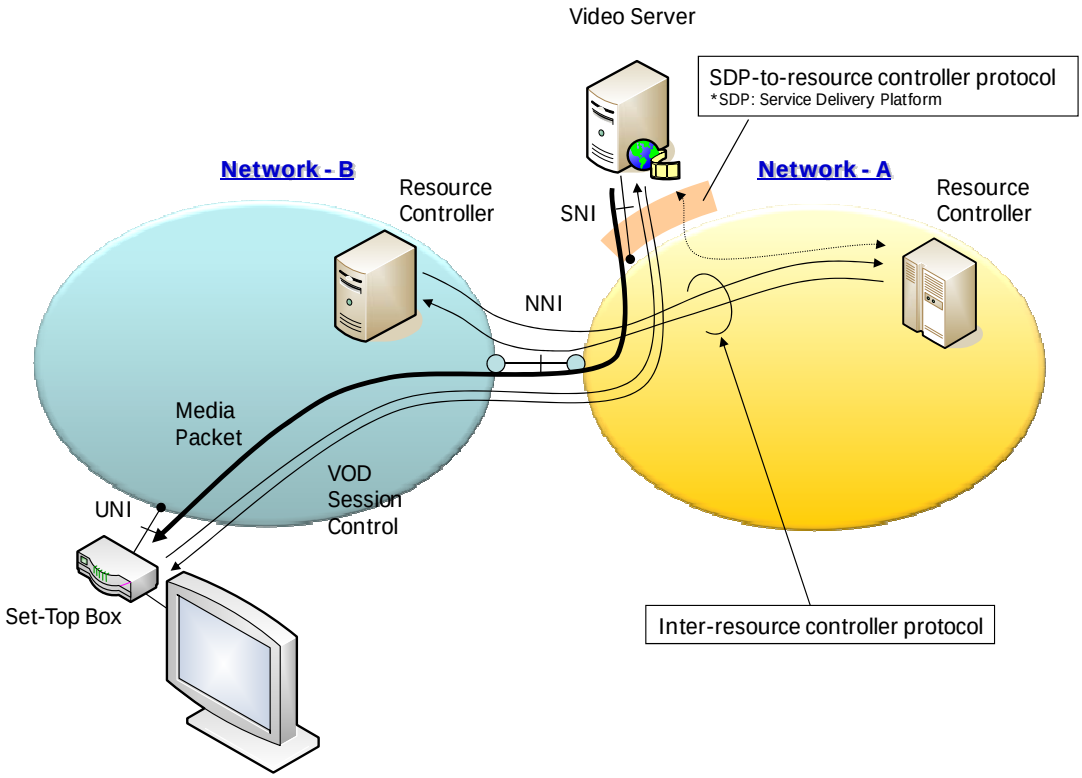


Figure 18 – IPTV network interconnection issue

There would be several kinds of control schemes as follows:

- Interconnection with the visited provider (Network-B) based on the control of IPTV service control function.
- Interconnection with the visited provider (Network-B) without IPTV service control function, where inter-RACF communication controls the network resources.
- Interconnection with the 3rd party provider.

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