International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

J.293

(06/2008)

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

Cable modems

Component definition and interface specification for the next generation set-top box

Recommendation ITU-T J.293

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Component definition and interface specification for the next generation set-top box

Summary

Recommendation ITU-T J.293 defines three categories of STB to support the combination of various kinds of content distribution schemes including RF-based and IP-based networks. It also specifies STB components and interfaces based on the architecture defined in Recommendations ITU-T J.290, J.291 and J.292. This Recommendation further describes a configurable approach in order to support the region-specific content distribution systems. This Recommendation describes interfaces and behaviours of the components that constitute the STB in terms of physical issues, protocols, operating system, software platform, user interfaces, and so on.

Source

Recommendation ITU-T J.293 was approved on 13 June 2008 by ITU-T Study Group 9 (2005-2008) under Recommendation ITU-T A.8 procedure.

FOREWORD

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1 Scope

This Recommendation defines three categories of STB to support the combination of various kinds of content distribution schemes including RF-based and IP-based networks. It also specifies STB components and interfaces based on the architecture defined in [ITU-T J.290], [ITU-T J.291] and [ITU-T J.292]. This Recommendation further describes a configurable approach in order to support the region-specific content distribution systems. This Recommendation describes interfaces and behaviours of the components that constitute the STB in terms of physical issues, protocols, operating system, software platform, user interfaces, and so on.

In addition, this Recommendation is applicable not only to an external independent box implementation (i.e., STB) but also to other approaches such as TV panel-embedded implementation.

NOTE 1 – This Recommendation covers the existing content distribution systems including cable TV and IPTV at the time of publication, is subject to modification when a new content distribution system such as NGN-based IPTV is specified and available.

NOTE 2 – 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.

[ITU-T G.9954] Recommendation ITU-T G.9954 (2007), *Home networking transceivers – Enhanced physical, media access, and link layer specifications*.

[ITU-T H.222.0] Recommendation ITU-T H.222.0 (2006) | ISO/IEC 13818-1:2007, *Information technology – Generic coding of moving pictures and associated audio information: Systems*.

[ITU-T H.SUP1] H-series Recommendations – Supplement 1 (1999), *Application profile – Sign language and lip-reading real-time conversation using low bit rate video communication*.

[ITU-T J.83] Recommendation ITU-T J.83 (2007), *Digital multi-programme systems for television, sound and data services for cable distribution*.

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

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

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

[ITU-T J.202] Recommendation ITU-T J.202 (2008), *Harmonization of procedural content formats for interactive TV applications*.

[ITU-T J.215] Recommendation ITU-T J.215 (2007), *Client digital program insertion API*.

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

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

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

[ITU-T J.700] Recommendation ITU-T J.700 (2007), *IPTV service requirements and framework for secondary distribution*.

[ITU-R BT.1306] Recommendation ITU-R BT.1306 (2006), *Error correction, data framing, modulation and emission methods for digital terrestrial television broadcasting*.

[ITU-R BO.1408] Recommendation ITU-R BO.1408 (2002), *Transmission system for advanced multimedia services provided by integrated services digital broadcasting in a broadcasting-satellite channel*.

[ITU-R BT.1700] Recommendation ITU-R BT.1700 (2005), *Characteristics of composite video signals for conventional analogue television systems*.

[IEC 60958] IEC 60958 (2006), *Digital audio interface*.

[IEC 62360] IEC 62360 (2008), *Baseline specifications of satellite and terrestrial receivers for ISDB (Integrated Service for Digital Broadcast)*.

[IEC 62481-1] IEC 62481-1 Ed. 1.0 (2007), *Digital living network alliance (DLNA) home networked device interoperability guidelines – Part 1: Architecture and protocol*.

[IEC 62481-2] IEC 62481-2 Ed. 1.0 (2007), *Digital living network alliance (DLNA) home networked device interoperability guidelines – Part 2: DLNA media formats*.

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

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

[RFC 3315] IETF RFC 3315 (2003), *Dynamic Host Configuration Protocol for IPv6 (DHCPv6)*.

[RFC 4862] IETF RFC 4862 (2007), *IPv6 Stateless Address Autoconfiguration*.

[DVB-IP] ETSI TS 102 034 V1.3.1 (2007), *Digital Video Broadcasting (DVB); Transport of MPEG-2 TS Based DVB Services over IP Based Networks*.

[TR-069] DSL Forum TR 069 (2007), *CPE WAN Management Protocol v1.1*.

[TR-135] DSL Forum TR 135 (2007), *Data Model for TR-069 Enabled STB*.

[ISO 13818-6] ISO | IEC 13818-6:1998, *Information technology – Generic coding of moving pictures and associated audio information – Part 6: Extensions for DSM-CC*.

2.2 Informative References

[ACC-CHECKLIST] ITU-T Technical Paper (2006), *FSTP-TACL Telecommunications Accessibility Checklist*.

[OC-SP-HOST2.1] OC-SP-HOST2.1-CFR-I01-070720, *OpenCable Host Device 2.1 Core Functional Requirements*.

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 BC-TD: A logical interface defined in 6.1.1 for content reception through a non-IP (RF-based) network.

3.2.2 NW-TD1: A logical interface defined in 6.1.2 for content reception through an IP network.

3.2.3 NW-TD2: A logical interface defined in 6.1.3 for interactive communications to outside of a home network through an IP network.

3.2.4 HN-TD1: A logical interface defined in 6.1.4 for content reception through an IP home network.

3.2.5 HN-TD2: A logical interface defined in 6.1.5 for interactive communications to entities within an IP home network.

3.2.6 TD-PD: A logical interface defined in 6.1.6 for connection between a peripheral device and the STB.

3.2.7 TD-OD: A logical interface defined in 6.1.7 between an output device and the STB.

3.2.8 home network coaxial modem: A modem for IP communications modulated over Coaxial cable for communications within the home, e.g., MOCA, HPNA over Coax.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AOD Approved Output Domain

ASD Authorized Service Domain

BED Best Effort Domain

CA Conditional Access

CAS Conditional Access System

CM Cable Modem

CMTS Cable Modem Termination System

CPE Customer Premises Equipment

CSP Configurable Security Processor

DCAS Downloadable Conditional Access System

DVR Digital Video Recorder

eCM Embedded Cable Modem

ECM	Entitlement Control Message
EMM	Entitlement Management Message
GPU	Graphics Processing Unit
GSD	Guaranteed Service Domain
HDD	Hard Disk Drive
HFC	Hybrid Fibre and Coaxial
HPNA	Home Phoneline Networking Alliance
IP	Internet Protocol
MPEG	Moving Picture Expert Group
OFDM	Orthogonal Frequency Division Multiplexing
PACM	Provisioning, Activation, Configuration, and Maintenance
PES	Packetized Elementary Stream
PSI	Program Specific Information
QAM	Quadrature Amplitude Modulation
RF	Radio Frequency
RG	Residential Gateway
RTP	Real-time Transport Protocol
SAC	Secure Authenticated Channel
SI	Service Information
STB	Set-Top Box
TCP	Transmission Control Protocol
TS	Transport Stream
UDP	User Datagram Protocol
WDM	Wavelength Division Multiplexing

5 System Overview

5.1 Content distribution context

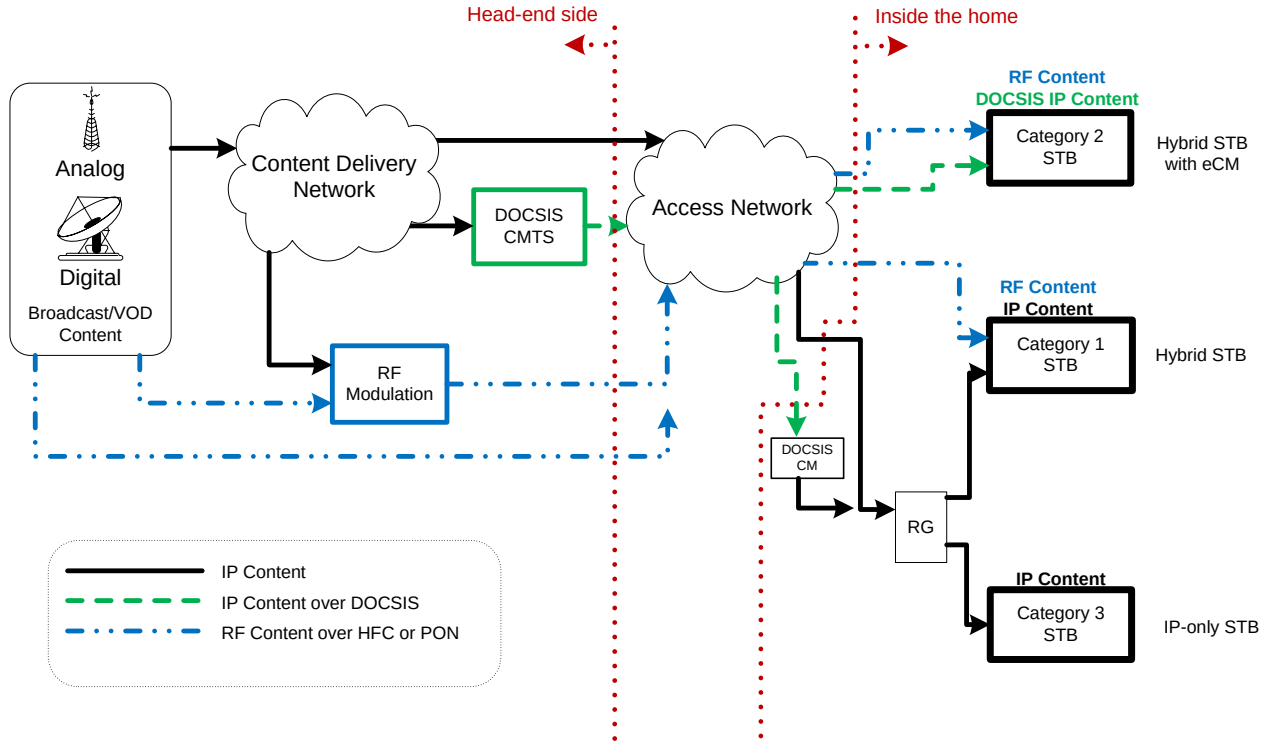


Figure 1 – Client devices in an assumed content distribution network: content flow aspect

Figure 1 shows an assumed distribution network drawn in a content flow aspect. In this Recommendation, the STB receives content signals from the head-end and makes an interactive communication as an in-home equipment (CPE). In Figure 1, there are two cases for content signal distribution, i.e., RF modulated signals such as QAM, OFDM and IP packets such as RTP/UDP/IP. Only IP technology is used for control and interactive communication signal flow in this context. The most applicable access networks are HFC, DSL, or Optical Fibre, but other networks are envisioned. The RF signal can be carried by an HFC or Optical Fibre network. The IP signal may be carried by HFC with DOCSIS, Optical Fibre, DSL or other access networks that support IP transmission, e.g., WiMax. This Recommendation defines three categories of STB as shown in Figure 1.

Category 1 STB (Hybrid STB): This type of STB is required to receive RF-based content signals as well as IP-based ones. The Hybrid STB is applicable to both Optical Fibre where RF signals are multiplexed with IP packets by WDM and HFC where RF modulated content signals and IP packets modulated by DOCSIS are carried. For any cases, a Residential Gateway (RG) is usually used and in-home devices connected to the RG constitute the IP home network. Logically, two kinds of wirings are necessary, i.e., the IP home network and the RF signal wiring. If IP over coaxial cable technology is used, these two wirings can be physically integrated into one coaxial cable.

Category 2 STB (Hybrid STB with embedded CM): This type of STB is required to be a hybrid STB with an embedded DOCSIS cable modem inside the STB. An HFC access network is directly connected to the STB. IP packets received through DOCSIS are terminated by an embedded cable modem.

Category 3 STB (IP-only STB): This type of STB is required to have an IP network interface only. All signals including content reception, controls and interactive communication are carried over IP.

Table 1 summarizes content distribution services, transmission schemes, and access media supported by each type of the above-described STBs. In this Recommendation, STB is required to support both services of content broadcasting and VOD streaming.

Table 1 – Supposed access network, transmission schemes, and supported services for each STB category

	Supposed access network examples	Transmission schemes	Supported services
Category 1 STB	Optical Fibre or HFC with external DOCSIS modem	RF and IP	RF content broadcasting IP content broadcasting RF VOD with IP session control IP VOD with IP session control
Category 2 STB	HFC with embedded DOCSIS modem	RF and IP	RF content broadcasting IP content broadcasting RF VOD with IP session control IP VOD with IP session control
Category 3 STB	Optical Fibre, DSL HFC with external DOCSIS modem	IP	IP content broadcasting IP VOD with IP session control

NOTE – This Recommendation considers a downloading service as one of the services supported by an application platform defined in clause7.9.

5.2 Reference STB Architecture

The reference architecture of STB defined by this Recommendation is based on [ITU-T J.290]. Figure 2 illustrates a functional block diagram of STB that consists of:

- Provisioning, Activation, Configuration, and Maintenance (PACM)
- Signal reception
- Transport stream handling
- Configurable security processing for CAS
- Media (video, audio, text, etc.) decoding
- Rendering (video, audio, graphics processor)
- Signal outputs including copy protection
- Digital Video Recorder (DVR) control including local digital program insertion
- Interactive communication interface
- Application platform (Middleware)
- Microcontroller
- Digital rights management for home network
- Home network connection
- User interfaces including remote control and its receiver
- STB remote management (as a part of PACM)
- Diagnostics (as a part of PACM)
- Mechanical

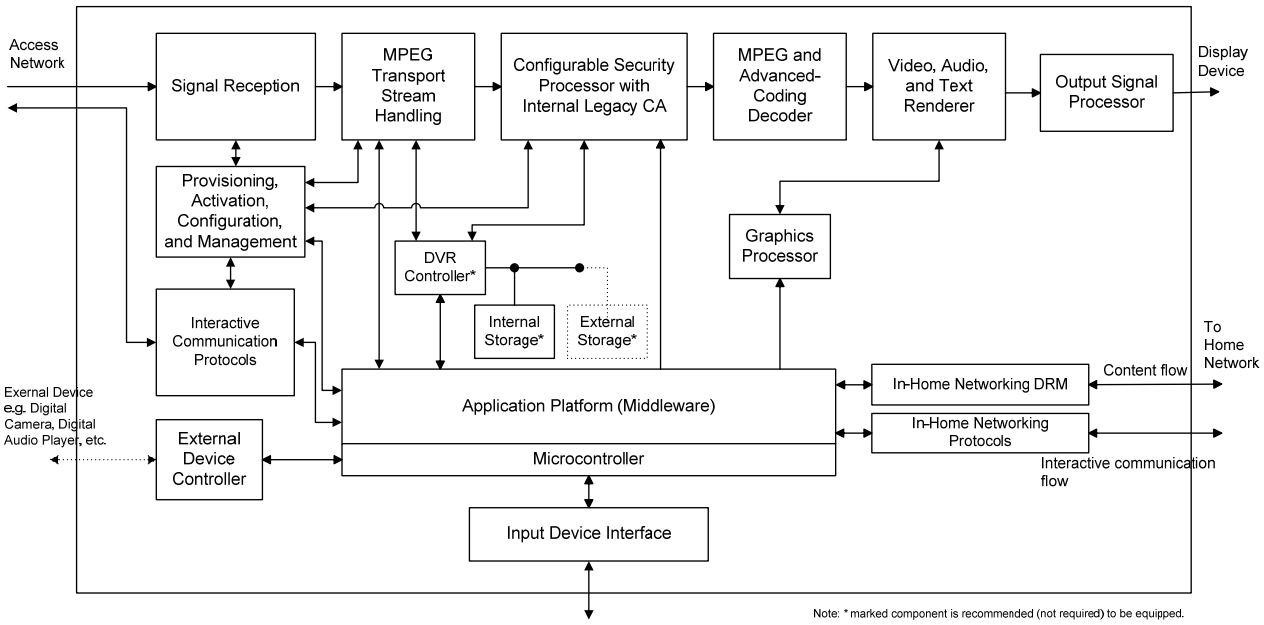


Figure 2 – Functional Block Diagram based on [ITU-T J.290]

Figure 2 shows fundamental components of STB, each of which is defined in this Recommendation. This figure shows a generic diagram in terms of network connections for content signal reception, interactive communication, and home network connection. As described in clause 5.1, there are a variety of STB implementations. Examples are shown in Appendix I according to the three categories defined in clause 5.1.

5.3 Use case scenarios

There are several variations for implementation of interactive communication interface. The interface provides a communication channel with other devices including head-end based on IP-based protocols. There are mainly two types of configurations depending on whether DOCSIS modem is embedded in the STB or not. In addition, there can be several implementation variations in each case.

5.3.1 For category 1 and 3 STB

If the STB is used with IP-based access networks such as Optical Fibre, DSL or with an external DOCSIS modem, the communication signal between outside the home and the STB can be multiplexed with other IP packets communicating with in-home devices. The simplest implementation example is shown in Figure I.5.

If television signal is provided by RF-modulated signal and the communication channel uses IP-based access network or an external DOCSIS modem, the same configuration applies to this case. Examples are shown in Figures I.1 and I.2. The difference between them is that the latter case uses a coaxial modem that multiplexes IP packets on RF television signals in a coaxial cable.

For any implementation configurations, an external residential gateway is required to achieve appropriate routing of IP packets, some of which should communicate with the head-end side, and others should communicate with in-home devices.

5.3.2 For category 2 STB

If the STB equips embedded DOCSIS modem, the communication signal between outside the home and the STB shall be separately handled from other IP packets communicating with in-home

devices as shown in Figure I.3. In this case, a cable interface is used to communicate with the head-end side, whereas 100 Base-T interface is used for in-home communication.

Figure I.4 illustrates other implementation example where a home network coaxial modem is used to multiplex IP packets on RF television signals in a coaxial cable. This means that RF television signals, DOSCIS IP signal, and modulated IP-packets for in-home communications coexist in a coaxial cable.

5.4 Home networking configurations

To clarify signal flows incoming to the STB or outgoing from the STB, several home networking configurations are illustrated in Appendix II.

5.5 Design Concept

STB defined in this Recommendation is designed with a configurable approach in order to support various kinds of content distribution systems such as cable television or IPTV that might be region-specific. Implementations of the following functionalities shall be modularized to be selectable from the corresponding specifications defined in clause 7.

- Signal reception
  - each content distribution system will have to choose one and more alternatives
- Transport stream handling
  - each content distribution system will implement a common part and one or more alternatives
- Security processing
  - each content distribution system will implement a common part and one or more alternatives
- Rendering
  - each content distribution system will implement a common part and one or more alternatives
- Signal output and copy protection
  - each content distribution system will have to choose one or more alternatives
- Application platform
  - each content distribution system will implement one or more of the following:
    a) J.201-based
    b) J.202-based
    c) each content distribution system may implement native application support (outside the scope of this Recommendation)

Figure 3 shows a graphical explanation of the above-described concept. A gray-shaded box denotes a component that depends on each content distribution system listed in clause 7.2 and one or more alternatives should be chosen in accordance with the system that the STB would support. A hatched box denotes a component that also depends on content distribution system selection, but it would be realized with a common basic implementation plus one or more specific portions corresponding to the content distribution system supported by the STB. White box represents a component that can be commonly used for any content distribution system.

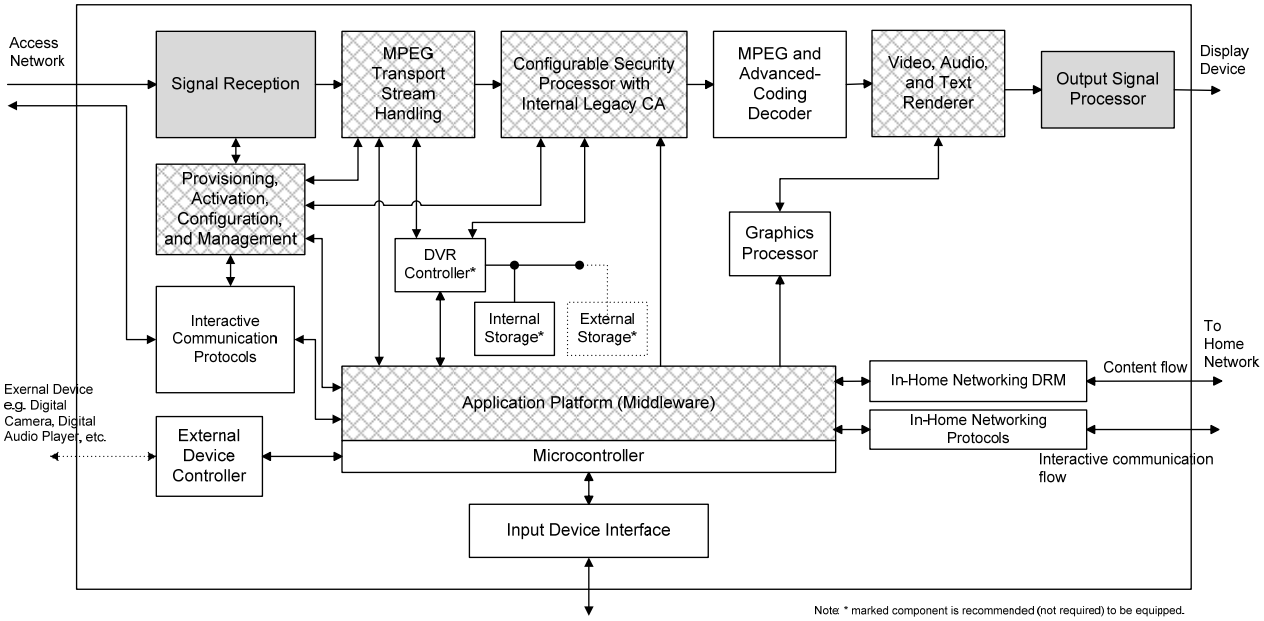


Figure 3 – Graphical Explanation of the Design Concept of a STB defined by this Recommendation

6 STB interfaces

6.1 Logical interfaces

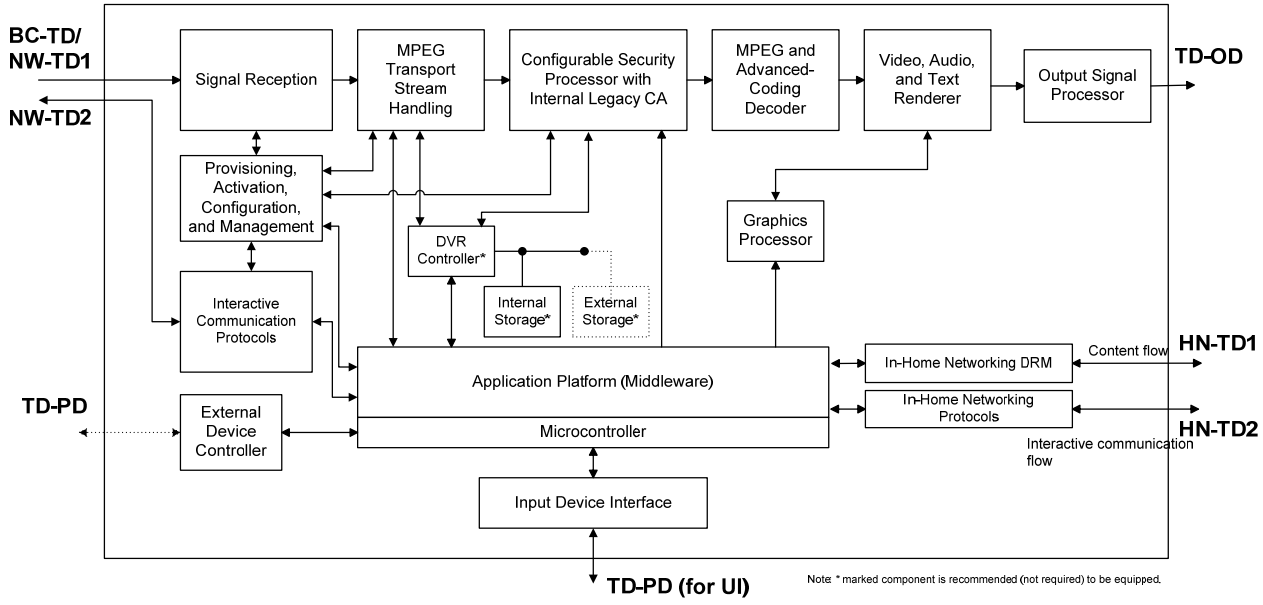


Figure 4 – Logical interface definitions

Figure 4 depicts logical interfaces of the STB.

6.1.1 BC-TD

This interface is used for non-IP content reception over a RF network such as satellite, terrestrial and cable network. This interface facilitates transfer of content and related information by way of RF modulated signals, such as QAM or OFDM.

6.1.2 NW-TD1

This interface is used for content reception through an IP network such as LAN. This interface facilitates transfer of content and related information from outside of a home network by way of an IP streaming method, i.e., RTP over IP multicast or unicast.

6.1.3 NW-TD2

This interface provides interactive communications to outside of a home network over an IP network such as LAN. This interface facilitates transfer of any communication signals other than content transmission including session control by way of IP-based protocols such as RTSP, IGMP, MLD, HTTP, HTTPS, and so on.

6.1.4 HN-TD1

This interface is used for content transfer over an IP home network such as LAN. This interface facilitates transmission of content and related information within a home network by way of an IP streaming method with in-home DRM such as DTCP-IP.

6.1.5 HN-TD2

This interface provides interactive communications to entities within an IP home network such as LAN. This interface facilitates transfer of any communication signals other than content transmission including session control within a home network by way of IP-based protocols such as RTSP, HTTP, HTTPS, UPnP, and so on.

6.1.6 TD-PD

This interface is between a peripheral device and the STB. It allows transfer of information via non-IP based protocols, such as Bluetooth or infrared to facilitate communication between the STB and, for example, a Bluetooth universal serial bus (USB) adaptor or mobile phone headset.

6.1.7 TD-OD

This interface is between an output device (e.g., Display, Home Theatre System) and STB and facilitates transfer of audio and video signals from STB to the output device with copy protection capability.

In this Recommendation, TD-OD shall be capable of video and audio output with an output signal processor component being capable of appropriate copy guard management system as described in clause 7.7.

6.2 Physical interfaces

This subclause defines physical interfaces as follows:

- Coaxial cable interface
- LAN interface
- Peripheral interface
- Output interface

For Category 1 and Category 2 STB, a coaxial cable interface is required to be equipped.

For Category 3 STB, a coaxial cable interface and/or LAN interface is required to be equipped.

For all STBs, a peripheral interface is required to be equipped.

For all STBs, an output interface is recommended to be equipped.

6.2.1 Coaxial cable interface

This physical interface provides electric signal transfer for RF-based content signal reception as well as IP-based signal transfer including DOCSIS IP communication and RF-modulated IP communication.

This interface could be used for BC-TD, NW-TD1, NW-TD2, HN-TD1, or HN-TD2.

For category 2 STB, the STB is required to be equipped with DOCSIS modem for NW-TD1 and NW-TD2. If the category 2 STB uses the coaxial cable physical interface for HN-TD1 and HN-TD2, a home network coaxial modem is required to be equipped.

For category 1 and 3 STB, the STB is required to be equipped with home network coaxial modem if the STB uses the coaxial cable physical interface for NW-TD1/NW-TD2 and/or HN-TD1/HN-TD2.

All STB categories are also required to be equipped with one of the following physical connectors when the coaxial cable physical interface is used:

- F-connector
- PAL-connector

6.2.2 LAN interface

This physical interface provides IP signal transfer for IP-based content transmission and IP interactive communications with entities outside and/or inside the home network.

This interface could be used for NW-TD1, NW-TD2, HN-TD1, or HN-TD2.

All STB categories are required to be equipped with at least one of the following methods when the LAN physical interface is used.

- 100BASE-TX with RJ-45 connector
- 1000Base-T with RJ-45 connector
- IEEE 802.11a/b/g/n wireless LAN

6.2.3 Peripheral interface

The peripheral interface provides a functionality to implement the TD-PD logical interface. In some cases, this physical interface can be also used to implement the TD-OD logical interface, e.g., an USB loud speaker.

All STB categories are required to be equipped with at least one of the following interfaces.

- USB
- IEEE 1394
- Bluetooth
- IR

6.2.4 Output interface

All STB categories are recommended to support at least one for video and one for audio of the following physical interfaces for TD-OD.

- Support of analogue video signal output interface:
  - D connector as per [IEC 62360] or a combination of three RCA pins
    - For 1080p/1080i/720p/480p/480i component output
  - RCA pins
    - For NTSC/PAL/SECAM composite output (as defined in [ITU-R BT.1700])

  - S or S2 Connector
    - For NTSC/PAL/SECAM Y/C output
- Support of digital video signal output interface:
  - DVI (Digital Video Interface)
  - HDMI (High-Definition Multimedia Interface)
- Support of analogue and digital audio signals:
  - RCA pins for analogue
  - S/PDIF as per [IEC 60958]
  - HDMI

Table 2 – Possible combinations of logical interfaces and physical interfaces defined in this Recommendation

	Category 1	Category 1	Category 2	Category 2	Category 3	Category 3
BC-TD	Coaxial	Coaxial	Coaxial	Coaxial	N.A.	N.A.
NW-TD1	LAN	Coaxial (Note)	Coaxial	Coaxial	LAN	Coaxial (Note)
NW-TD2	LAN	Coaxial (Note)	Coaxial	Coaxial	LAN	Coaxial (Note)
HN-TD1	LAN	Coaxial (Note)	LAN	Coaxial (Note)	LAN	Coaxial (Note)
HN-TD2	LAN	Coaxial (Note)	LAN	Coaxial (Note)	LAN	Coaxial (Note)
NOTE – Home network coaxial modem is used.						

This Recommendation defines combinations of logical interfaces and physical interfaces to implement each logical interface with corresponding Categories of STB as shown in Table 2. For example, the second Category 1 STB configuration in Table 2 above equips only one type of the physical interfaces to implement BC-TD, NW-TD1, NW-TD2, HN-TD1 and HN-TD2, where a home network coaxial modem is used for IP communication over coaxial cable.

Table 3 – Possible combinations of TD-PD and TD-OD logical interfaces and physical interfaces defined in this Recommendation

	Category 1, 2, 3	Category 1, 2, 3
TD-PD	Peripheral	Peripheral
TD-OD	Output	Peripheral

This Recommendation defines combinations of TD-PD and TD-OD logical interfaces and physical interfaces as shown in Table 3. This table means that TD-PD can be implemented only by Peripheral physical interface, whereas TD-OD can be implemented by Output physical interface or Peripheral physical interface. These are applicable to any of Category 1, 2, and 3 STBs.

6.3 Implementation examples

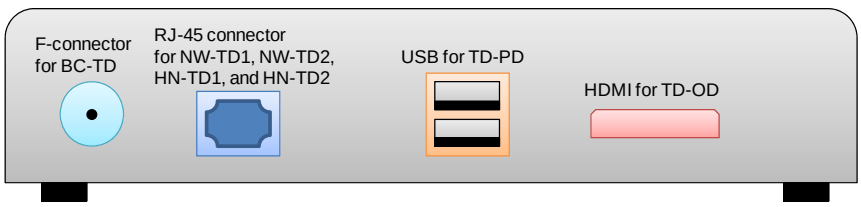


Figure 5 – Example of physical interface implementation (rear view of STB)

Figure 5 illustrates an example of physical interface implementation. This assumes Category 1 STB, which is equipped with F-connector for BC-TD, RJ-45 LAN connector for NW-TD1, NW-TD2, HN-TD1, and HN-TD2, USB for TD-PD, and HDMI for TD-OD. This type of implementation corresponds to the first Category 1 STB configuration in Table 2 and the first STB configuration of Table 3.

Figures I.1, I.3 and I.5 show STB implementation examples that equip 100 Base-T LAN interface for home networking.

Figures I.2 and I.4 show STB implementation examples that equip a coaxial modem, where IP-packets communicating with in-home devices are modulated by a home network coaxial modem, and transferred over one coaxial cable together with television signals or DOCSIS signal. Due to the possibility of frequency interference, [ITU-T G.9954.1] over Coax may not be applicable to cable television home networking scenarios with a DOCSIS modem (see Figure II.3).

6.4 IP-related protocols used for NW-TD1, NW-TD2, HN-TD1, and HN-TD2

The following summarizes IP-related protocols required to be supported by the STB.

- IPv4
- IPv6
- DHCP
- IPv6 Stateless Address Autoconfiguration
- IGMPv2
- MLDv2
- TCP
- UDP
- RTP
- RTSP
- UPnP
- DNS

7 Specifications of components

7.1 Provisioning, Activation, Configuration, and Maintenance (PACM)

The STB defined in this Recommendation is required to support Provisioning, Activation, Configuration, and Maintenance when it is attached to an IP network environment.

During a network attachment process, the STB goes through a number of steps before becoming fully operational on the IP network. The network attachment process comprises three fundamental stages:

1) physical layer initialization,
2) IP initialization, and
3) service discovery.

In the first stage, the STB is required to establish layer-2 level connection when it is connected to a network. When the STB is already physically connected to the network but in an inactive status or a sleep mode, the STB is required to resume the layer-2 level connection by some triggers such as a scheduled timer, remote control key event, and so on.

In the second stage, the STB is required to obtain an IP address with the following procedure:

- Firstly, the STB is required to try to obtain IPv4 and IPv6 addresses because the STB does not know which IPv4 or IPv6 is provided by the network to which the STB is connected.
- For IPv4, the STB is required to use DHCP [RFC 2131] to obtain at least an IPv4 address, a network address, a subnet mask, a DNS server address, and a default gateway address.
- For IPv6, the STB is required to use IPv6 Stateless Address Auto Configuration [RFC 4862] to obtain an IPv6 address, its prefix address, and a default gateway address. The STB is required to obtain a DNS server address for IPv6 connection at least by one of manual setting, DHCPv6 [RFC 3315], or DHCP for IPv4.

In the third stage, the STB is required to obtain providers' information according to a service discovery entry point. The STB is required to support at least one of the following methods to obtain the service discovery entry point:

- The domain names returned by DHCP option 15, and its resolved address by DNS mechanism.
- Pre-defined scheme, domain name and port number specified by the selected content distribution system (e.g., _dvbservdsc.tcp.services.dvb.org and default port #3937 for ETSI TS 102 034 [DVB-IP]), and its resolved address by DNS mechanism. In some cases, an initial file name would be also used (e.g., http://server.example.com/cdn.xml).
- The IANA registered multicast address by the selected content distribution system (e.g., 224.0.23.14 and FF0X:0:0:0:0:0:0:12D are assigned for ETSI TS 102 034 [DVB-IP]).
- Manually entered IP address and port number in the STB.

In this Recommendation, three layered records are defined, i.e., CDN providers discovery record, service providers discovery record, and service discovery record. The formats of the three records are required to be conformant to those defined in the content distribution system selected in the STB, e.g., ETSI DVB 102 304 [DVB-IP].

Discovery record layers	**Description of record**
CDN providers discovery record	Provides network related information (e.g., reference clock) and a list of platforms that aggregates service providers.
Service providers discovery record	Provides a list of initial access information of service providers.
Service discovery record	Provides a list of initial access information of programs or contents.

After the STB completes initialization, it becomes a manageable network element in the IP network. The STB is required to support remote management functionality described in clause 7.12, and is required to respond to queries sent from a service provider.

It is recommended to implement this component as software consisting of a common base with other specific portions dedicated to each content distribution system selected in the STB. This implementation concept is illustrated as a hatched box in Figure 3.

The following specifies interfaces of this component.

Connected from/to:	Description	Direction
RF Signal Reception	Management information communicating with RF Signal Reception component. The data format is RPC messages and parameters defined in clause 7.13 to control the module or collect information from the module.	from/to
from and to IP Signal Reception	Management information communicating with IP Signal Reception component. The data format is RPC messages and parameters defined in clause 7.13 to control the module or collect information from the module.	In/Out
from and to Application Platform	API to this component for controlling it or getting information from it. Refer to clause 7.9 for API details.	In/Out
from and to MPEG Transport Stream Handling	Control signal to the MPEG TS Handling component based on results of PACM processing.	In/Out
from and to Configurable Security Processor	Control signal to the Security component based on PACM processing results.	In/Out

7.2 Signal reception

Implementation of the signal reception functionality shall be modularized. One or more of the following signal reception interface modules shall be supported according to STB's categories defined in clause 5.1. This implementation concept is illustrated as a shaded box in Figure 3.

- RF-based signal reception
  - [ITU-R BT.1306] – Digital television broadcasting systems (DVB-T, ATSC, ISDB-T)
  - [ITU-R BO.1408] – (DVB-S, ISDB-S)
  - [ITU-T J.83] – Digital cable television systems
- IP-based signal reception:
  - IP Multicast – ETSI TS 102 034 [DVB-IP]
  - IP Unicast – ETSI TS 102 034 [DVB-IP]

NOTE – The above list of references is subject to modification when a new content distribution system such as NGN-based IPTV is standardized and publically available.

7.2.1 RF-based signal reception

The following specifies interfaces of this component.

Connected from/to:	Description	Direction
from Coaxial Network	RF-modulated television signal from head-end. The signal format shall be defined by the RF-based television broadcasting standard selected from the above-described list for the STB defined in this Recommendation.	In
to MPEG Transport Stream Handling	Received MPEG Transport Stream packets. The signal format is 188-byte MPEG-2 TS packet. The TS packet timing shall be aligned with its origin. This timing reconstruction shall be performed in the Signal Reception component.	Out

Connected from/to:	Description	Direction
from and to Application Platform	API to this component for controlling it or getting information from it (e.g., channel selection). Refer to clause 7.9 for API details.	In/Out
from and to PACM	Management information communicating with RF Signal Reception component. The signal format is SNMP messages defined in RFC 1157.	In/Out

7.2.2 IP-based signal reception

The following specifies interfaces of this component.

Connected from/to:	Description	Direction
from IP Network	IP-based television signal from head-end or from in-home equipment. The signal format shall be defined by the IP-based content distribution standard selected from the above-described list for the STB defined in this Recommendation.	In
to MPEG Transport Stream Handling	Received MPEG Transport Stream packets. The signal format is 188-byte MPEG-2 TS packet. The TS packet timing shall be aligned with its origin. This timing reconstruction shall be performed in the Signal Reception component.	Out
from and to Application Platform	API to this component for controlling it or getting information from it (e.g., channel selection). Refer to clause 7.9 for API details.	In/Out
from and to PACM	Management information communicating with IP Signal Reception component. The signal format is RPC messages and parameters defined in DSL-Forum [TR-069] with [TR-135].	In/Out

7.2.3 Protocols used for IP-based signal reception

IP-based signal reception module shall support the following protocols:

- IPv4
- IPv6
- TCP
- UDP
- RTP
- IGMPv2
- MLDv2
- RTSP
- RTP payload format for MPEG transport stream [RFC 2250]

7.2.4 IP Multicast

The IP-based signal reception module receives IP-multicast content signals by the following steps:

- channel tuning by IGMPv2 (IPv4) or MLDv2 (IPv6)
- error correction by FEC

- clock recovery
- extraction of MPEG transport stream

The extracted MPEG transport stream data is provided to the transport stream handling component through the interface defined in clause 7.2.2.

7.2.5 IP Unicast

The IP-based signal reception module receives IP-unicast content signals by the following steps:

- session control by RTSP
- error correction by FEC
- clock recovery
- extraction of MPEG transport stream

The extracted MPEG transport stream data is provided to the transport stream handling component through the interface defined in clause 7.2.2.

7.2.6 Channel Tuning by IGMP/MLD

Due to the bandwidth limitation of the IP network such as a home network, an access network, all channels distributed by IP multicast are not always conveyed to a STB in the case of IP signal reception. If there are no IP packets of the desired channel on the network to which the STB is connected, it is necessary to send the Join message to the corresponding IP multicast group address to start IP multicast signal reception. When the STB stops signal reception, it is necessary to send the Leave message to that group address. If there are no other terminals receiving the same channel, the IP multicast packet flow of the channel will disappear.

For this reason, STB defined in this Recommendation is required to equip IP multicast control capability of at least IGMPv2 for IPv4 and/or MLDv2 for IPv6. Support of upper versions of these protocols depends on the content distribution standard that was chosen for the program reception.

7.2.7 Error Correction

Error correction is required to be performed in the Signal Reception component in accordance with the content distribution standard that was chosen for the program reception.

7.2.8 Clock Recovery

Master clock is required to be reconstructed in the TS handling component according to a specific method defined by each content distribution system supported by the STB, e.g., MPEG-TS PCR clock recovery. In case of IP signal reception, the "timestamp" field in RTP header that conveys MPEG-2 Transport Stream is recommended to be used as explained in [RFC 2250]. The reconstructed clock is required to be used as a master clock for those components that require clock synchronization with the program.

7.3 Transport stream handling

This component shall be implemented to support the corresponding content distribution system selected for the signal reception component.

It is recommended to implement this component as a software. It might have a common software base with other software modules dedicated to each broadcasting system as listed in clause 7.2. This implementation concept is illustrated as a hatched box in Figure 3.

The following specifies interfaces of this component.

Connected from/to:	Description	Direction
from Signal Reception	Received MPEG Transport Stream packets. The signal format is 188-byte MPEG-2 TS packet. The TS packet timing shall be aligned with its origin. This timing reconstruction shall be performed in the Signal Reception component.	In
to Configurable Security Processor	TS Packets of the program to be played back and TS Packets for entitlement control such as ECM and EMM.	Out
from and to Application Platform	API to this component for controlling it or getting information from it. (e.g., getting SI) Refer to clause 7.9 for API details.	In/Out
from and to DVR Controller	TS packets necessary for storing or playing back of the program.	In/Out
from and to PACM	Management information communicating with these components.	In/Out

7.3.1 Demultiplexing of transport stream

Implementation of transport stream handling functionality shall be modularized. Transport stream handling module demultiplexes TS packets received by the signal reception module. Demultiplexing is carried out in such a way as PMT is obtained by PAT, and each TS packet is provided to each subsequent processing stage according to its PID written in PMT.

TS packets can be categorized into PES-based media packet, Section-based media packet and PSI/SI. Handling of SI (service information) highly depends on each content distribution system. Therefore, these specific processing shall be implemented in a module, and STB shall be able to equip one or several modularized transport stream handling modules according to the content distribution systems that STB wants to support.

7.3.2 Handling of PSI

The STB is required to correctly handle PSI, i.e., PAT, PMT, NIT, and CAT defined in [ITU-T H.222.0]. In this Recommendation, the following requirements shall apply:

- The number of TS streams means the number of PAT.
- The number of programs in one TS stream means the number of PMT inside the TS stream.
- The number of TS streams that can be simultaneously handled by the TS handling module is recommended to correspond to the number of the signal reception modules. For example, if the STB is equipped with one RF-based signal reception module and one IP-based signal reception module, the transport stream handling module is recommended to receive two transport streams simultaneously.
- The transport stream handling module is required to handle at least one program per transport stream. When this requirement is considered together with the previous one, for example, if the STB equips one RF-based signal reception module and one IP-based signal reception module, the transport stream handling module is recommended to receive one program from RF and another from IP simultaneously. This enables the STB to perform simultaneous multiple program recording.

7.3.3 Handling of SI

Each content distribution system defines its service information tables to be conveyed in MPEG transport stream section. Some of them are used to show an EPG, some of them are used to convey a sort of content providers' information, and so on. The STB is required to handle correctly all the SI tables defined in the content distribution systems that the STB supports.

7.3.4 Handling of PES-based Media Packet

The STB is required to decode and playback PES-based media packet in accordance with its DTS and PTS, respectively [ITU-T H.222.0]. PES is used to convey real-time media such as video, audio, subtitles, captioning, real-time text.

7.3.5 Handling of Section-based Media Packet

The STB is required to handle Section-based media packet [ITU-T H.222.0]. Non-time critical media data such as modules constituting data program, which is usually carried by DSM-CC data carrousel or object carrousel. The STB is required to comply with the timing of presentation of the Section-based media in accordance with the specification defined by the content distribution system selected for the signal reception component.

7.4 Security processing

7.4.1 Conditional access

This component is required to support the establishment of SAC for licence exchange and descrambling of received content signals corresponding to the content distribution system selected for the signal reception component.

It is recommended to implement this component as a separate entity being capable of tamper resistance. It is also recommended to be capable of renewability of security systems, e.g., DCAS.

The following describes basic security functionalities of the STB commonly applicable to the existing content distribution systems:

- SAC establishment
  - Server authentication: The STB authenticates the server with challenge and response mechanism.
  - Client authentication: The server authenticates the STB with challenge and response mechanism issued in response to the first authentication.
  - Session key generation: An authorized session key is also obtained by the STB and the server through the above-described authentication processes. This key is used to encrypt messages communicating through SAC.
- Acquisition of a licence
  - User subscription information is examined and a licence for content will be issued to the STB through SAC established in the previous step. The licence contains a key, which will be a working key (Kw) or a scrambling key (Ks). If the content distribution system uses a time-varying scrambling key, the scrambling key (Ks) is sometimes delivered together with a content signal. In this case, the working key (Kw) is provided by the licence information herein. This licence information is called EMM in some systems.
  - In some legacy systems, EMM is distributed over a typical transmission channel with a content signal rather than via SAC. In this case, a master key (Km), which has almost an equivalent role as the session key, is used to decrypt EMM to obtain the working key (Kw), and SAC mechanism is not used. The Km is usually stored in a physically separated device such as a security card.
- Acquisition of a sublicence
  - If the working key (Kw) is obtained in the previous step, the STB needs to obtain the scrambling key (Ks) from the sublicence information. The sublicence information is usually distributed with a content signal, which is called ECM in some systems.

- Descrambling of content
  - The content signal is descrambled by the scrambling key (Ks) in the STB. The descrambled signal is provided to the decoding modules for playing back.

7.4.2 Protection of received content

Content protection mechanism such as DTCP is required to apply to received content for the purpose of storing, signal output, and transmission through a home network. DVR controller module, Signal Output module, and In-Home Networking DRM module are required to support a content protection method for these purposes. It is also required to apply a compliance rule defined in each content distribution system which the STB claims to support.

7.4.3 Security Module

The security module inside the STB is required to include the following three subsystems:

1) *content and key encryption/decryption*, which is hardware-based but can be remotely re-configured;
2) *key management*, which is partially software-based and thus re-definable by secure conditional access system download;
3) *authentication*, which is partially software-based and thus renewable by the secure CAS download. An STB will include an internal Configurable Security Processor (CSP) for managing security aspects for services. The reference model of CSP is shown in Figure 6.

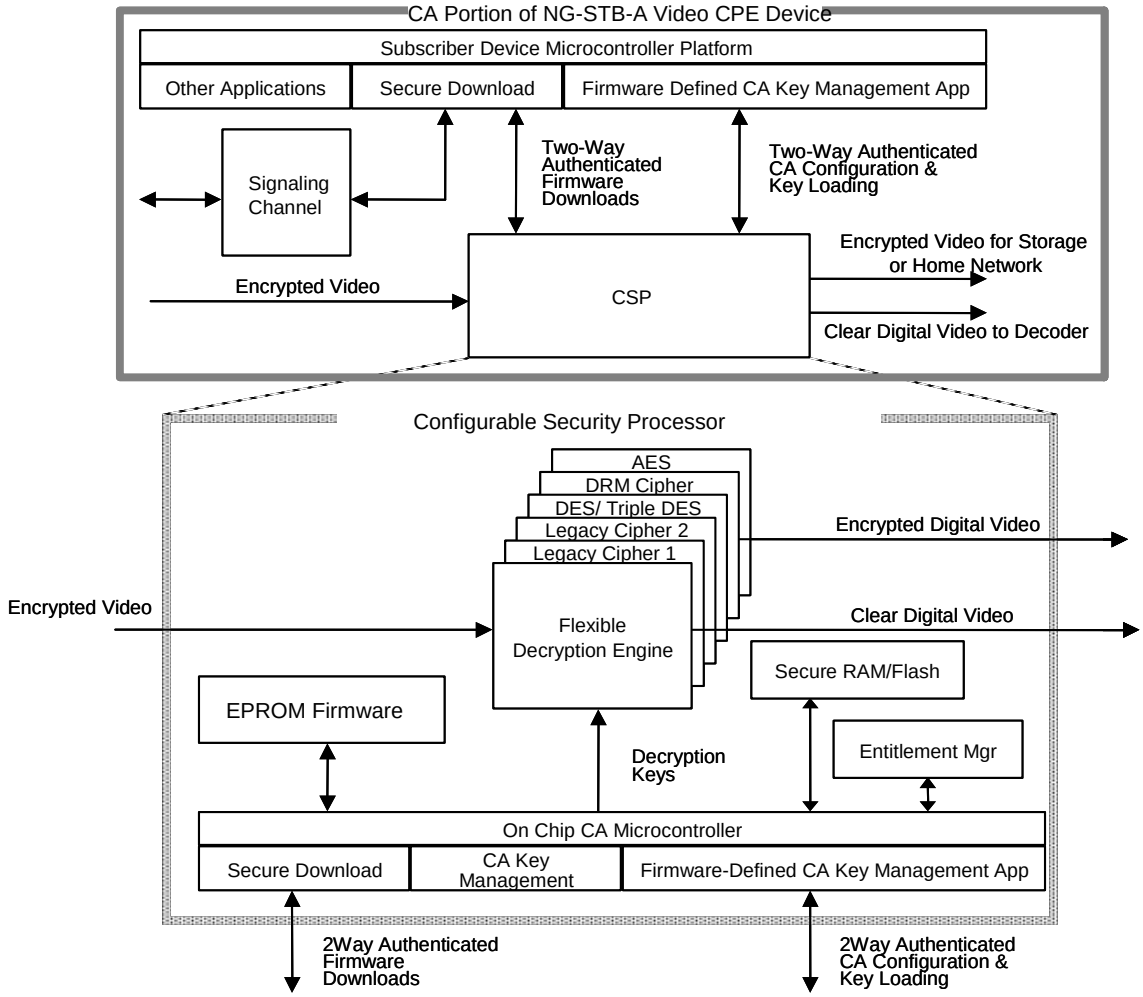


Figure 6 – CSP Reference Model

In the CSP reference model, content may be secured with either an open standard, non-proprietary CA/DRM system and/or a proprietary CA/DRM system (legacy or otherwise).

The "flexible decryption engine" in the CSP is configurable to support multiple algorithms. It is flexible enough to allow configuration by remote command to be compatible with the encryption algorithms used by the CA system as well as the content protection system(s). Entitlement messages and control messages are encoded and distributed over out-of-band and in-band channels to the video CPE such that keys can be securely recovered by the CSP; this is referred to as the firmware-defined conditional access key management application.

The CSP will employ technologies to support the decryption of proprietary or non-proprietary standardized secure transport streams based on such as variants of DES, 3-DES, CSA and, AES and Multi2 encryption algorithms.

Each CSP in a CPE device will be identified with a completely unique ID. For private serialization, each could contain a unique identifier known as a Private Seed ID. This Seed ID is used to generate the unique key to decrypt the entitlements for that specific CPE device. The CPE device will be capable of changing the Seed ID to another unique value upon secure command from the head-end. The encryption key would then be generated using this new Seed ID as a component of the key. An asymmetric key could also be used to decrypt the category key sent in the EMM (entitlement management message).

7.4.4 CA Software Renewability

Certain aspects of algorithms, key exchanges, key management, and cryptographic protocols are implemented in software or renewable firmware on the CSP. Renewability in software is an important aspect of a strong security system and is required to be implemented in the STB. The STB does not support a "software-only" CA in which cryptographic functions are performed on a general purpose processor. Hardware security elements are a required part of an effective security system for high-value content. Software and specialized hardware elements are complementary and may provide additional security over software or hardware-only solutions.

7.4.5 Firmware and/or Software Downloads

The STB is assumed to support three types of secure firmware downloads:

- General control firmware that controls the user interface, device operation, and support for applications (e.g., VOD, EPG, [J.200] Series Recommendations), which is defined in clause 7.12;
- Internal firmware that manages and communicates with the CSP;
- Highly secure messages intended to be passed to the CSP, which reconfigure the hardware engine and/or install CA key management firmware in the CSP.

The secure downloads are encoded for transmission to the STB over a secure channel. All of the secure download signal paths require two-way authenticated exchanges.

7.5 Media (video, audio, text, etc.) decoding

Media decoding component decodes compressed media bitstream. The types of media are video, audio, and text including accessibility features as in captioning and real time text as described in clause 5.2.12 of [ITU-T J.700], and video (e.g., lip reading, sign language) as described in [ITU-T H.SUP1] and [ACC-CHECKLIST].

The STB is required to comply with media decoding schemes defined in the content distribution system selected for the signal reception component.

It is recommended to implement this component as a hardware or by an independent processor. Although software implementation is possible even for H.264, it may require much computational complexity particularly for video decoding of HDTV resolution. Therefore, it is recommended to implement a media decoding component as hardware (e.g., ASIC, FPGA) or software running on an independent processor dedicated to this component.

The following specifies interfaces of this component.

Connected from/to:	Description	Direction
from Configurable Security Processor	Decrypted media transport packets that are accurately reconstructed to represent the original.	In
to Video, Audio, and Text Renderer	Decoded media data such as uncompressed video frames, uncompressed PCM audio signals, or decoded characters.	Out

7.6 Rendering (video, audio, graphics processor)

This component shall be implemented to support the corresponding content distribution system selected for the signal reception component in terms of rendering format. It might have a common base with other modules dedicated to each content distribution system as listed in clause 7.2. This implementation concept is illustrated as a hatched box in Figure 3.

7.6.1 Video, Audio, and Text Renderer

This component synthesizes any kinds of visual data such as video, text, graphics into a video signal taking their perspective relationship (depth information) into account.

It is recommended that the video, audio and text rendering function include accessibility features such as captioning and voice description as clarified in the accessibility definition in clause 5.2.12 of [ITU-T J.700]. It is recommended that [ACC-CHECKLIST] be consulted.

It is recommended to implement this component as hardware or by an independent processor. Although software implementation is possible, it may require much computational complexity particularly for HDTV resolution image processing. Therefore, it is recommended to implement a video rendering component as hardware (e.g., ASIC, FPGA) or software running on an independent processor dedicated to this component (e.g., GPU).

The following specifies interfaces of this component.

Connected from/to:	Description	Direction
from Media Decoding	Decoded media data such as uncompressed video frames, uncompressed PCM audio signals, or decoded characters.	In
to Output Signal Processor	Synthesized image data of each visual media, and processed audio data.	Out
from Graphics Processor	Constructed image data from Graphics Processor. The signal format is three color components such as Y, U, V, transparency (α), and depth information.	In

7.6.2 Graphics Processor

This component generates image data from the output from the microcontroller. This may be application program outputs, browser outputs, or outputs of the internal program of STB.

Graphics processing capability of this component is required to be conformant with the graphics requirements defined in ITU-T J.200 series, e.g., alpha blending.

It is recommended to implement this component as hardware or Graphics Processing Unit (GPU). Although software implementation is possible, it may require much computational complexity particularly for HDTV resolution image processing or 3D image composition. Therefore, it is recommended to implement this component as hardware or GPU.

The following specifies interfaces of this component.

Connected from/to:	Description	Direction
from and to Application Platform	API to this component for controlling of graphics representation or getting information from it (e.g., object drawing, shading effects, etc.) Refer to Clause 7.9 for API details.	In/Out
to Video, Audio, and Text Renderer	Constructed image data from this component. The signal format is three color components such as Y, U, V, transparency (α), and depth information.	Out

7.7 Output signal processor

This component shall be implemented to support the corresponding content distribution system selected for the signal reception component in terms of signal format and required copy protection.

- All analog outputs may be enabled or disabled based on service provider configuration.
- HDCP copy protection on the HDMI digital video output.

This implementation concept is illustrated as a shaded box in Figure 3.

7.8 Digital Video Recorder (DVR) and its control

7.8.1 Device

STB defined in this Recommendation is recommended to be equipped with an internal storage device such as hard disk drive if the DVR functionality is supported.

The STB is also recommended to equip a Serial ATA for external storage devices.

7.8.2 DVR Controller

This component controls the DVR behaviour to store the programs received or play back stored contents. The DVR Controller components shall be capable of preserving a media clock of the program when storing and shall be capable of recovering the media clock when playing back. The reconstructed media clock shall be used as a master clock for those components that require a clock synchronization with the program when the program is being played back. The DVR Controller is also required to support content storing and play back with a content protection mechanism in addition to content scrambling employed in the conditional access system.

The DVR Controller is required to control content storing and play back of accessibility features (e.g., captioning, voice description, sign language interpretation) originally contained in the content. [ACC-CHECKLIST] should be consulted.

It is recommended to implement this component as software.

The following specifies interfaces of this component.

Interface connected to:	Description	Direction
from and to MPEG Transport Stream Handling	MPEG Transport Stream packets with timing information to be stored or played back.	In/Out
from and to Security Processing Module	This interface is used if content is stored or played back with other content protection mechanism than content scrambling employed in the conditional access system.	In/Out
from and to Application Platform	API to this component for controlling it or getting information from it (e.g., DVR playback control). Refer to Clause 7.9 for API details.	In/Out
from and to Hard Disk Drive (HDD)	Data to be stored to the device or to be read from the device. This interface shall be Serial-ATA at the time of publication of this Recommendation.	In/Out

7.8.3 Local digital program insertion

The STB defined in this Recommendation is recommended to be capable of local digital program insertion functionality specified by [ITU-T J.215].

7.9 Application platform (Middleware)

Application platform provides APIs to applications. Applications may be distributed by content signals, obtained through an interactive communication interface, or implemented independently in an STB. This Recommendation defines Common APIs, which is required to be equipped with an STB as a base. This Recommendation also defines specific APIs depending on content distribution schemes that the STB claims to support. The specific APIs are required to be conformant to the content distribution system selected for the signal reception component.

In this Recommendation, APIs are considered as a way to provide a procedural application platform to realize common functionalities of this module. In addition, such APIs also provide another type of the application platforms, for example, an application written in a certain content format, i.e., a declarative application platform.

This application platform module is illustrated as a hatched box in Figure 3, where implementation will have a common base with other modules dedicated to each content distribution system as listed in clause 7.2. In this Recommendation, the functional equivalents for Common APIs are listed as below.

- SI acquisition
- Handling of protocols on MPEG section
- Application signalling
- Application authentication
- Conditional Access
- Content referencing
- Text and graphics rendering

7.9.1 APIs for application programs distributed by content signals

[ITU-T J.200], [ITU-T J.201] and [ITU-T J.202] define APIs for application programs that are conveyed with content signals by means of cyclic data distribution schemes such as DSM-CC data carrousel or object carrousel. In these Recommendations, sets of APIs such as OpenCable-OCAP, DVB-MHP, and ARIB-BML are defined as an application platform dedicated to each content distribution system. The STB that conforms to this Recommendation is required to support a set of APIs and a transport method required by the content distribution systems which the STB claims to support.

7.9.2 APIs for application programs obtained through an interactive communication interface

In some content distribution systems, application programs can be obtained through an interactive communication interface using IP-based protocols such as HTTP. In this case, the STB is also required to comply with a set of APIs based on [ITU-T J.200], [ITU-T J.201] and [ITU-T J.202], series and a transport method defined by each content distribution system.

7.9.3 APIs for application programs independently implemented in STB

In this Recommendation, an application independently implemented in STB is recommended to be built on the common APIs defined in clause 7.9. This enables the STB to manage the software with a common methodology that can apply to the applications defined in the previous subclauses. Utilizing the common APIs would also facilitate cost-effective software development and make online software updating easier.

Native applications might also be implemented in STB. This Recommendation, however, does not define or describe anything about handling of the native applications.

Table 4 shows an implementation example of the application platform module.

Table 4 – Implementation examples of the application platform module

	Example I	Example II	Example III
APIs and protocols for applications distributed with content signals	MHP [ITU-T J.202] DSM-CC object carrousel [ISO 13818-6]	OCAP [ITU-T J.202] DSM-CC object carrousel [ISO 13818-6]	BML [ITU-T J.201] DSM-CC data carrousel [ISO 13818-6]
APIs and protocols for applications transferred on the interactive communication channel	MHP [ITU-T J.202] HTTP and HTTPS	OCAP [ITU-T J.202] HTTP and HTTPS	BML [ITU-T J.201] HTTP and HTTPS
APIs for applications independently implemented in STB	MHP [ITU-T J.202]	OCAP [ITU-T J.202]	ARIB-J [ITU-T J.202]

7.10 Home Networking

The STB defined in this Recommendation is required to support connections to devices located in the home network defined by [ITU-T J.190]. The logical interfaces TD-HN1 and TD-HN2 are used for home networking, where physical transport method would be LAN, home network coaxial modem, wireless LAN, and so on as described in clause 6.2.

In [ITU-T J.190], four logical domains for home networking are defined from service operators' perspectives.

- Guaranteed Service Domain (GSD): GSD is a domain where QoS and UI consistency are guaranteed.
- Authorized Service Domain (ASD): ASD is a domain where the service providers' conditional access and/or content rights management apply to service reception based on authentication and authorization.
- Approved Output Domain (AOD): AOD is a domain where the signal output from terminal devices can be controlled by the service providers.
- Best Effort Domain (BED): BED is a domain where any of QoS guarantee or service providers' management does not apply.

Figure 7 illustrates an overview of in-home network domains defined in [ITU-T J.190].

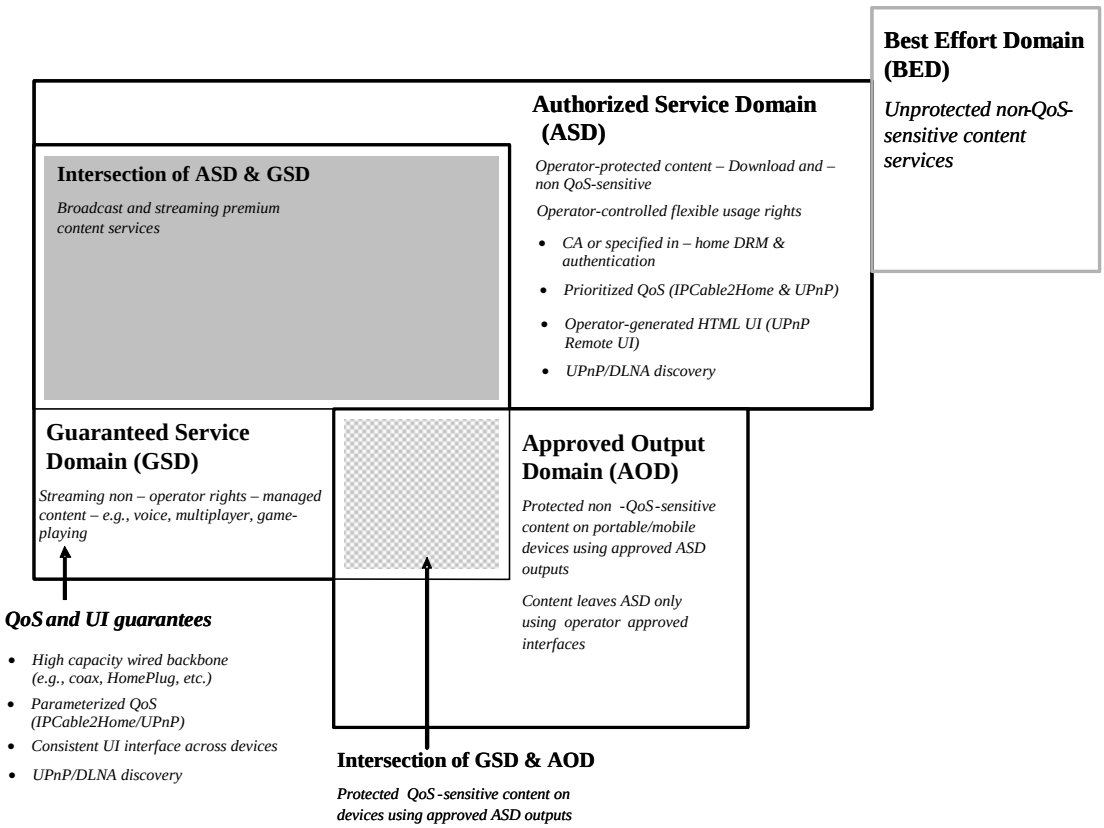


Figure 7 – In-Home Network Domains – Overview

7.10.1 Protocols for Home Networking

The STB that conforms to this Recommendation is required to be capable of DLNA-based home networking protocols.

7.10.2 Digital rights management for home networking

The STB is required to use DTCP-IP as a content protection method for DLNA. This is a way to provide content protection mechanism necessary for ASD and AOD. It is also required to follow the compliance rule defined in each content distribution system when the STB wants to feed the content signal to a device connected in a home network.

7.11 External peripheral devices controller

This module provides control functionalities and necessary protocol stacks to support external peripheral devices connected to the TD-PD interfaces described in clause 6.1.6.

7.12 STB remote management

The STB that conforms to this Recommendation is required to support CPE remote management protocols defined in DSL Forum [TR-069].

The STB should optionally support SNMP-based management mechanism defined in [OC-SP-HOST-2.1].

7.13 Diagnostics

The STB defined in this Recommendation is required to be equipped with diagnostic functionalities that can be performed locally as well as remotely. When the STB is diagnosed remotely, the management protocol defined in clause 7.12 is required to be used.

The following defines diagnostic profiles to be supported by the STB. Details of each profile are defined in DSL Forum [TR-135].

The STB defined in this Recommendation is required to support the following diagnostic profiles defined in [TR-135].

- Baseline
- PVR (if STB is equipped with a storage device)
- IPTVHomeNetwork
- AudienceStats
- AnalogOutput (if STB is equipped with an analog output interface)
- DigitalOutput (if STB is equipped with a digital output interface)
- CA
- DRM

The STB defined in this Recommendation is required to support the following diagnostic profile defined in [TR-135] when the STB is equipped with RF signal reception module.

- DTT

The STB defined in this Recommendation is required to support the following diagnostic profiles defined in [TR-135] when the STB is equipped with IP signal reception module.

- IPTVBaseline
- RTCP
- RTPAVPF
- IGMP

The STB defined in this Recommendation is recommended to support the following diagnostic profiles defined in [TR-135] for monitoring purposes.

- BasicPerfMon
- ECPerfMon
- VideoPerfMon
- AudioPerfMon

Appendix I

Implementation examples of network interface

(This appendix does not form an integral part of this Recommendation)

There are several variations for implementation of network interface. The interface provides content signal reception, an interactive communication with a network-side entity such as head-end, and home networking. There are three types of configurations as described in clause 5.1. The following explains these implementation examples.

I.1 Hybrid STB (Category 1 STB)

If the STB receives RF-modulated television signals in addition to the IP-only STB, a signal reception module is added to the IP-only STB. Regarding the rest of the modules, the same configuration applies to the hybrid STB case. Examples are shown in Figures I.1 and I.2. The difference between them is that the latter case uses an embedded coaxial modem that multiplexes IP packets on RF television signals in a coaxial cable.

For any implementation configurations of hybrid STB, an external residential gateway is also necessary to achieve appropriate routing of IP packets, some of which should communicate with the head-end side, and others should communicate with the in-home devices.

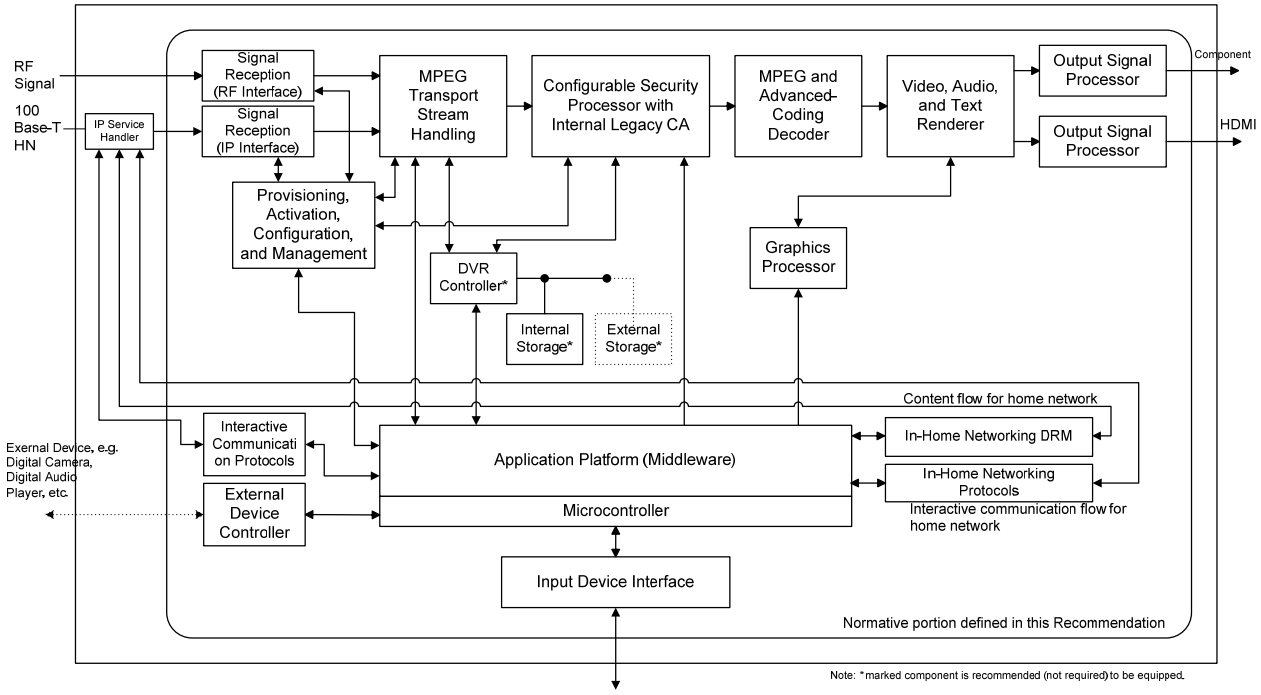


Figure I.1 – Functional block diagram of hybrid STB with a dual network interface

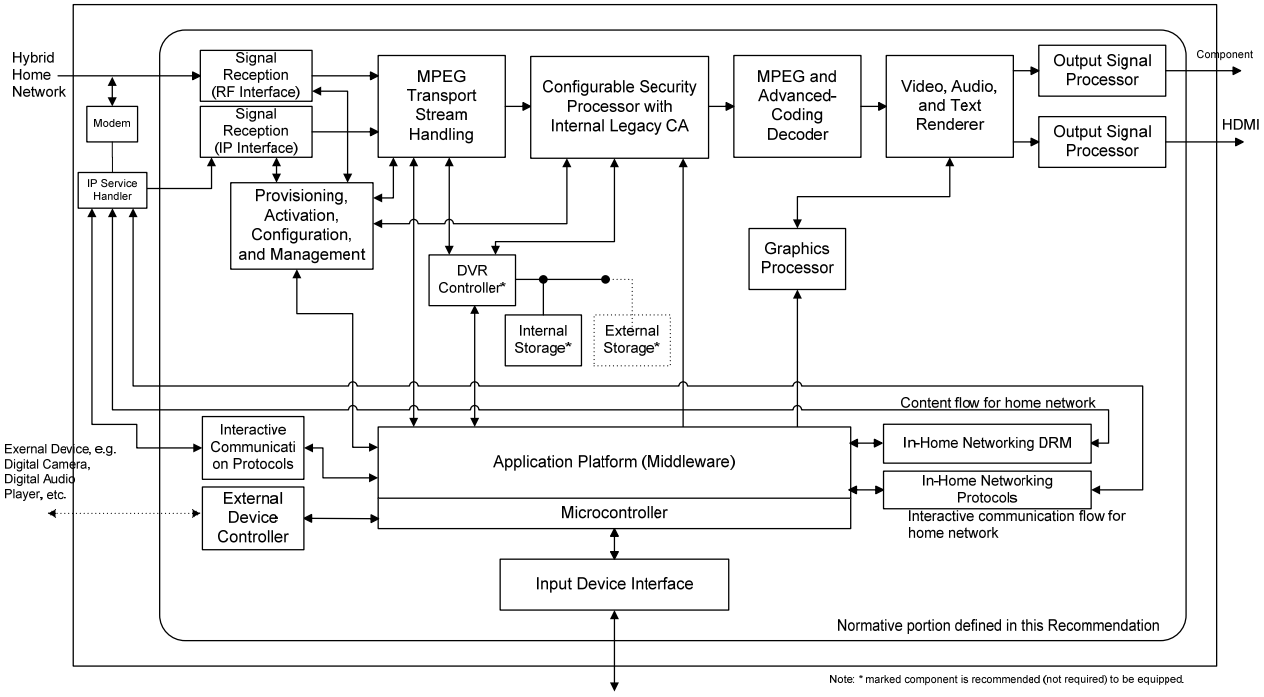


Figure I.2 – Functional block diagram of hybrid STB with a single network interface using a home network coaxial modem

I.2 Hybrid STB with eCM (Category 2 STB)

If the hybrid STB equips embedded DOCSIS modem, the communication signal between outside the home and the STB is required to be physically separated from other IP packets communicating with in-home devices as shown in Figure I.3. In this case, a Cable interface is used to communicate with the head-end side, whereas a 100 Base-T interface is used for in-home communications.

Figure I.4 illustrates other implementation example where a coaxial modem is used to multiplex IP packets on RF television signals in a coaxial cable. This configuration means that RF television signals, DOSCIS IP signal, and modulated IP-packets for in-home communications coexist in a coaxial cable. In this case, DOCSIS IP signal and modulated IP-packets are logically separated even if they are passing through the same physical media.

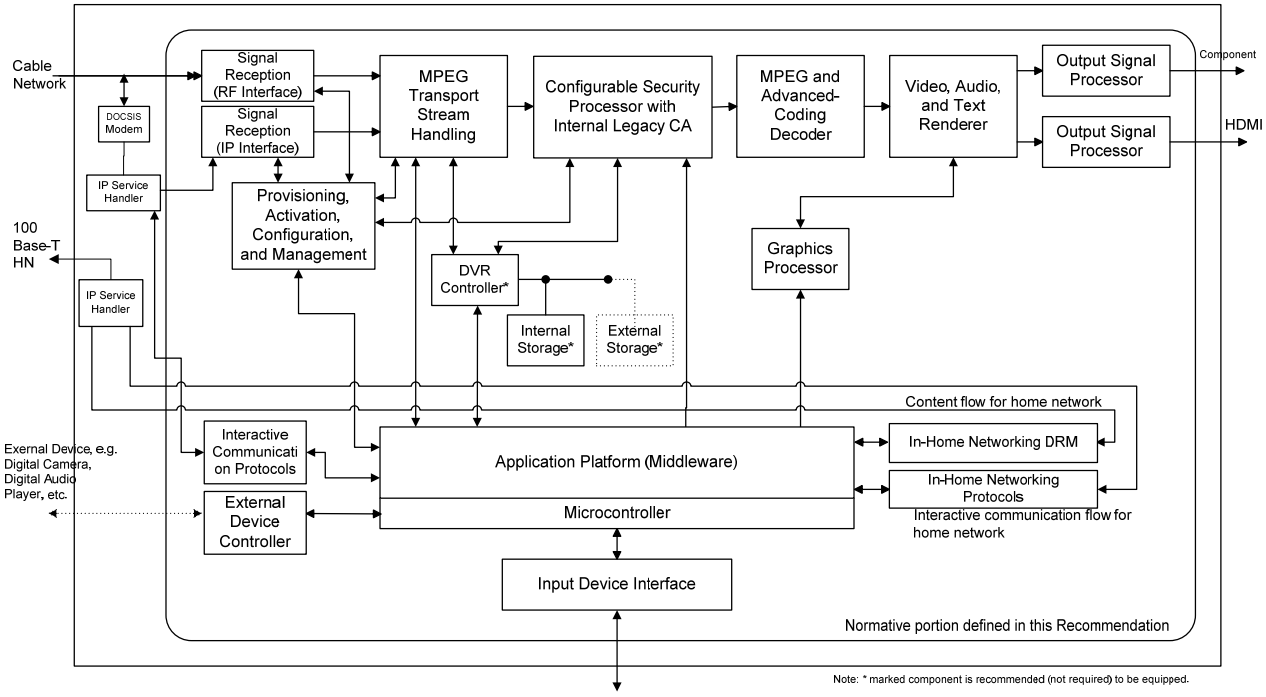


Figure I.3 – Functional block diagram of hybrid STB with an embedded DOCSIS cable modem

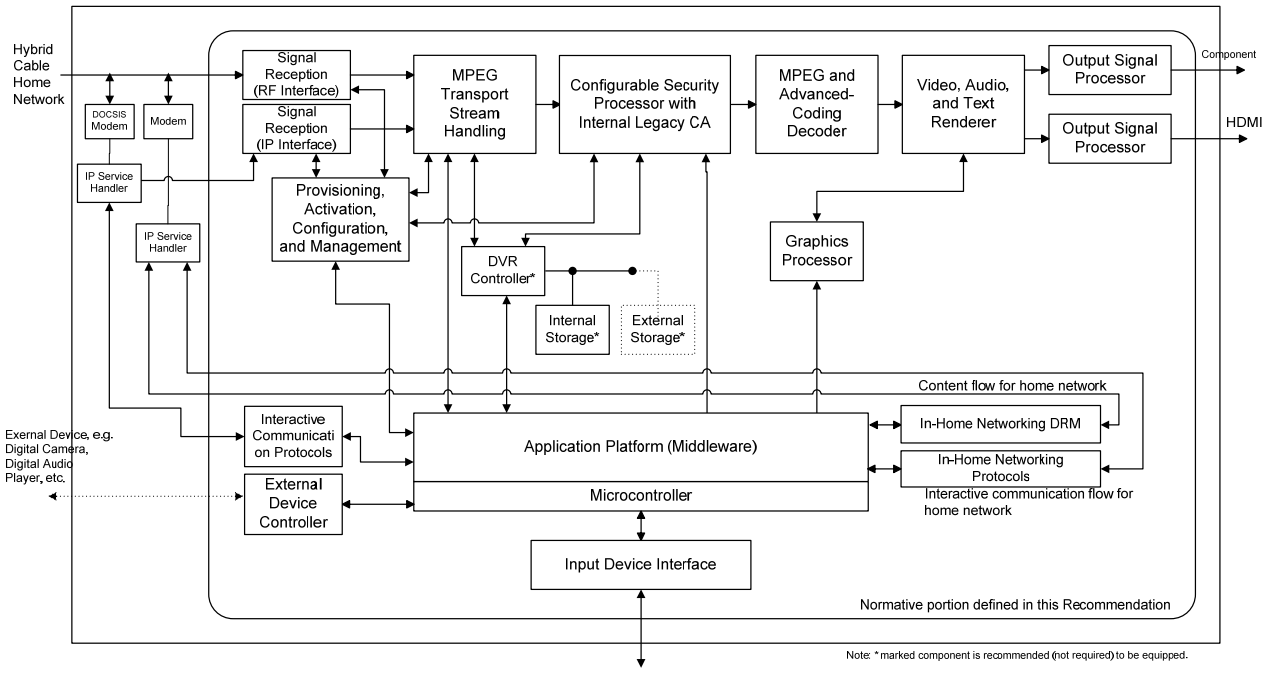


Figure I.4 – Functional block diagram of hybrid STB with an embedded DOCSIS cable modem and an embedded home network coaxial modem for IP home networking

I.3 IP-only STB (Category 3 STB)

If the STB receives television signals and makes interactive communications through an IP access network such as Optical Fibre, DSL or HFC with an external DOCSIS modem, IP packets communicating between outside the home and the STB will be multiplexed with other IP packets for home networking. An implementation example is shown in Figure I.5.

In this configuration, an external residential gateway is necessary to achieve appropriate routing of IP packets, some of which should communicate with the head-end side, and others should communicate with in-home devices.

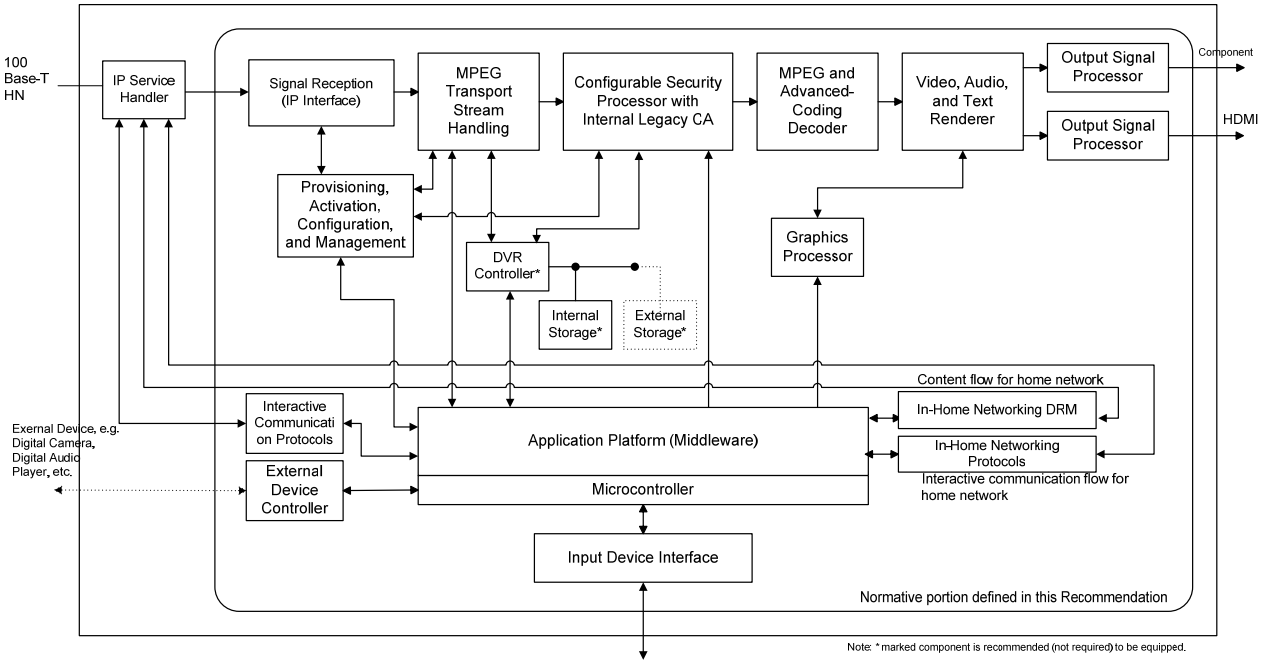


Figure I.5 – Functional block diagram of IP-only STB

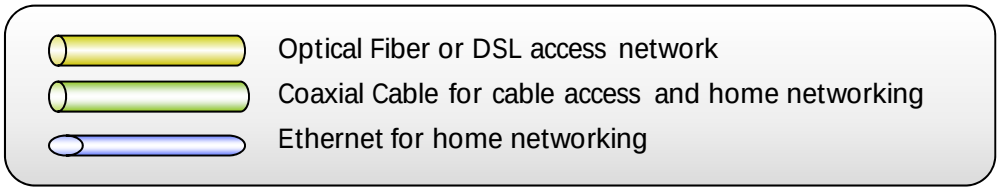
Appendix II

Examples of Home Networking Configurations

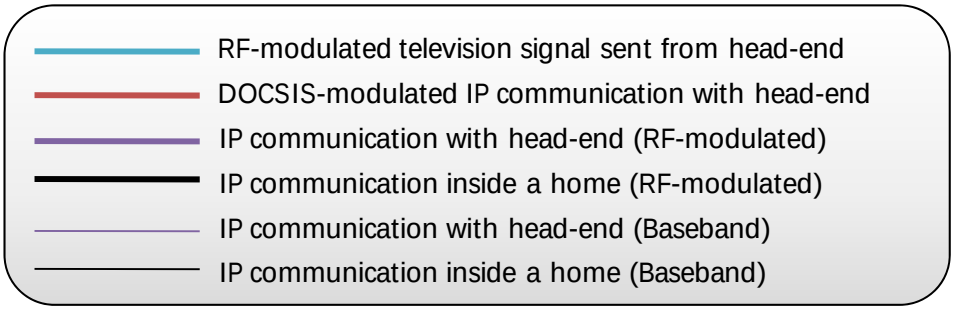
(This appendix does not form an integral part of this Recommendation)

Legend:

for physical wiring



for logical signal flow



II.1 Home networking with IP-based access network

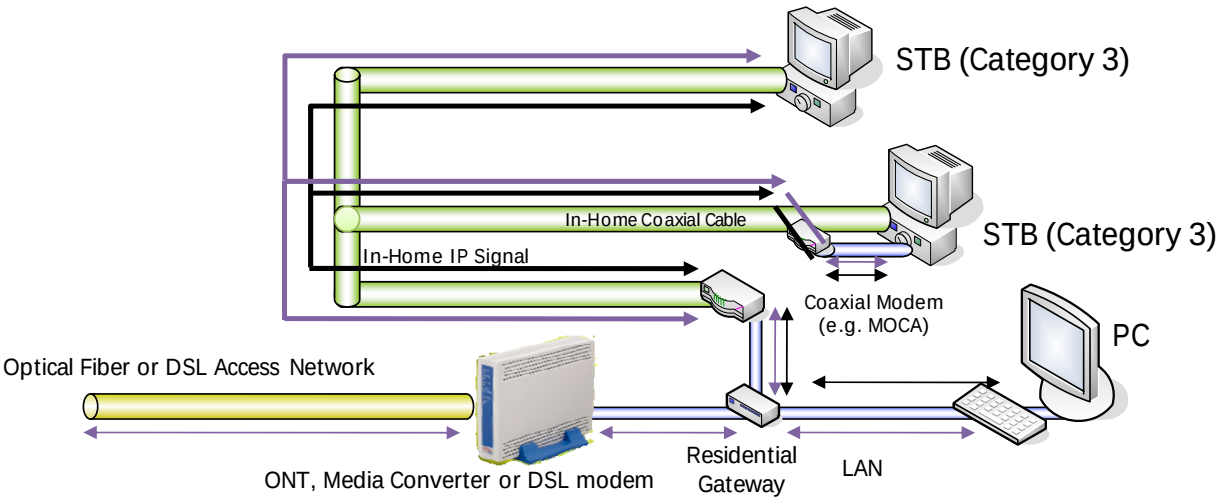


Figure II.1 – Home networking with IP-based access network

In this configuration, all signals including television signals, IP communications with outside the home, and in-home IP communications are multiplexed in a home network, or LAN. IP packets communicating with outside the home are routed by a residential gateway. All devices inside the home are connected through LAN. In Figure II.1, an internal coaxial modem is equipped in the Category 3 STB to make use of a coaxial cable as LAN. This would help solve the in-home wiring problem.

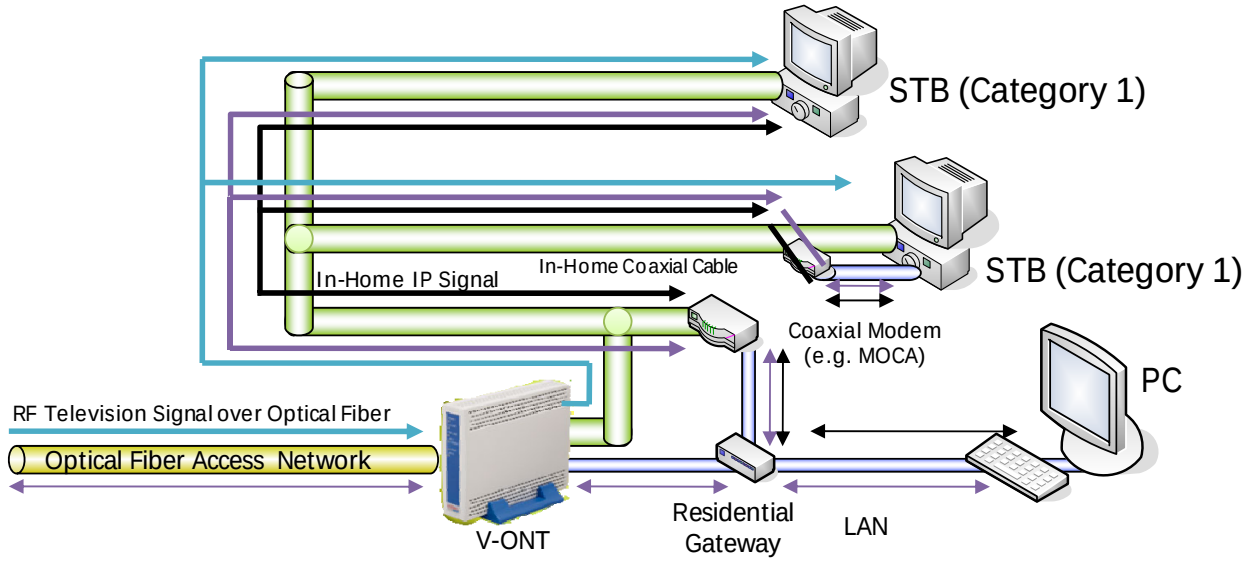


Figure II.2 – Home networking with IP-based access network and RF-based content signal

In this configuration, IP communications with outside the home and with in-home devices, and RF-based content signals are multiplexed in an in-home coaxial cable. IP packets communicating with outside the home are routed by a residential gateway. In Figure II.2, an internal coaxial modem is equipped in the Category 1 STB to make use of a coaxial cable as LAN. This would help solve the in-home wiring problem.

II.2 Home networking with Cable-based access network

II.2.1 With external DOCSIS modem

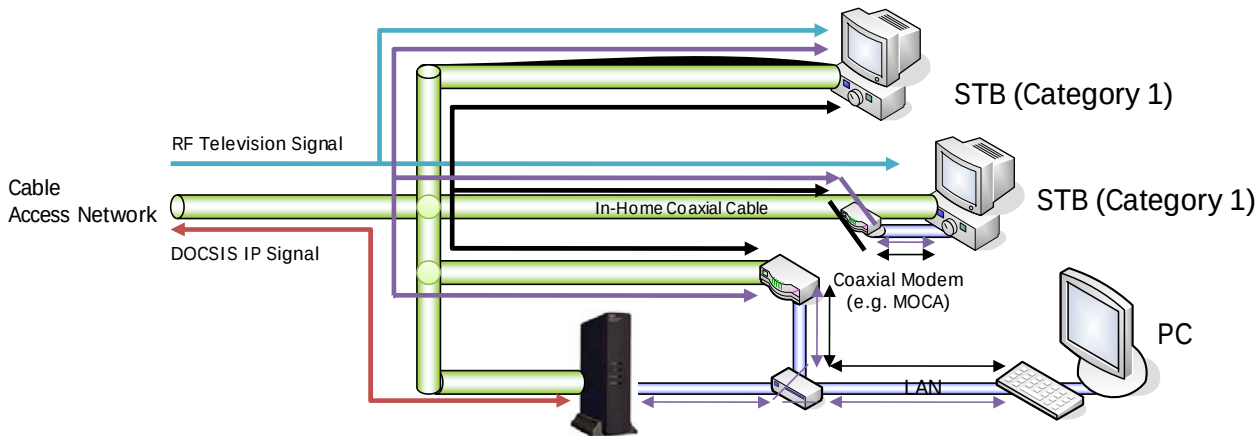


Figure II.3 – Home networking with Cable-based access network and external DOCSIS modem

In this configuration, television signals are RF-modulated, IP communications with outside the home are provided by a DOCSIS modem, and in-home IP communications are multiplexed with the IP packets through the DOCSIS modem in a home network, or LAN. IP packets communicating with outside the home are routed by a residential gateway.

In Figure II.3, a Category 1 STB has two interfaces for coaxial and 100 Base-T. The coaxial interface receives the RF-based television signals and 100 Base-T receives and transmits IP-packets communicating with in-home devices and outside the home networks. Similar to the case of Figure II.1, a coaxial modem is used to make use of a coaxial cable as LAN. This would help solve the in-home wiring problem.

II.2.2 With embedded DOCSIS modem

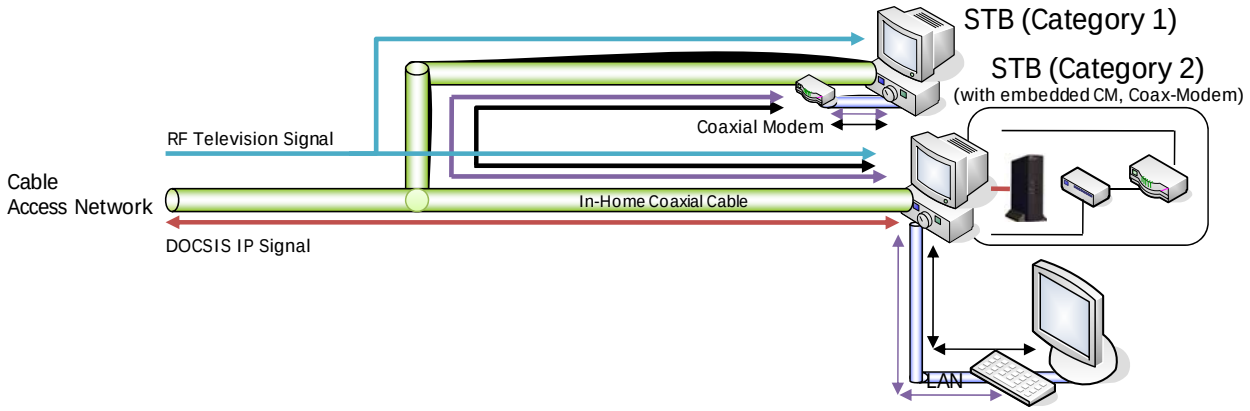


Figure II.4 – Home networking with Cable-based access network and embedded DOCSIS modem

In this configuration, television signals are RF-modulated, IP communications with outside the home are provided by an embedded DOCSIS modem (eCM), and in-home IP communications are received and transmitted through a coaxial modem. All signals are provided to the Category 2 STB with eCM through one coaxial cable. In the Category 2 STB, IP packets communicating with outside the home are separated from in-home IP packets, which might go through a separate LAN interface or the same coaxial cable as a modulated signal by the embedded coaxial modem.

As shown in Figure II.4, the Category 2 STB is allowed to have an additional LAN interface. This is intended to construct a 100 Base-T-based home network. PC and other in-home devices such as a secondary STB (Category 1 STB in this example) are typically connected to this interface. If the PC should have a capability of a coaxial modem, all devices can be connected by a coaxial cable.

Appendix III

Relationship between J.700 and J.293

(This appendix does not form an integral part of this Recommendation)

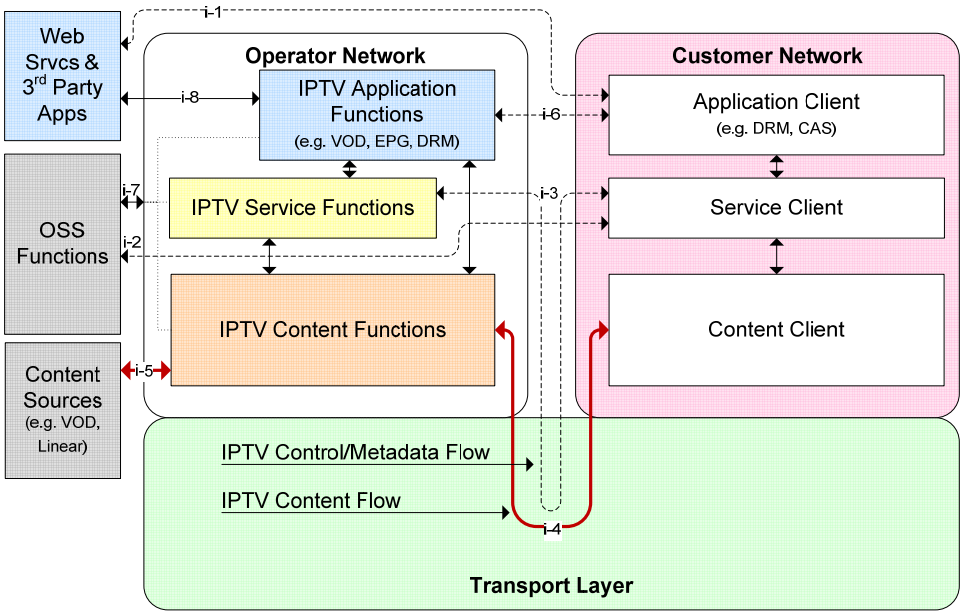


Figure III.1 – IPTV Network Reference Points

[ITU-T J.700] describes the relationship between a terminal device (STB) and an IPTV network. In [ITU-T J.700], STB is divided into three major clients, which are Application Client, Service Client, and Content Client. Each of them is responsible for each corresponding function in the IPTV network architecture defined in [ITU-T J.700]. Figure III.1 shows the relationship between an STB and an IPTV network and defines IPTV network reference points.

Table III.1 describes the relationship between the modules defined in this Recommendation and the three clients identified in Figure III.1.

Note that Figure III.1 focuses only on relationship between IPTV network and the STB. This figure thus does not mention anything about connections to in-home devices.

Table III.1 – Relationship between J.293 modules and J.700 clients

J.700 Clients	J.293 modules	Description of J.293 modules
Application Client	Application Platform	This module is responsible for execution and presentation of applications.
	In-Home Networking DRM	This module is responsible for protection of content controlled by service operators' side.
	Graphics Processor	This module is responsible for composition and drawing output of the application platform module.
Service Client	Provisioning, Activation, Configuration and Management	This module is responsible for initial configuration and management issues of the STB.
	Interactive Communication Protocols	This module is responsible for IP-based interactive communications between entities in a head-end side network and the STB.
Content Client	Signal Reception	This module is responsible for content reception through RF-based or IP-based network.
	MPEG Transport Stream Handling	This module is responsible for MPEG-TS demultiplexing and control of received content.
	Configurable Security Processor	This module is responsible for conditional access and scrambling control of content reception.
	MPEG and Advanced Coding Decoder	This module is responsible for decoding of received content.
	Video, Audio and Text Renderer	This module is responsible for composition and rendering of decoded media.
	Output Signal Processor	This module is responsible for signal output of rendered media.

Appendix IV

Implementation example of J.293

(This appendix does not form an integral part of this Recommendation)

The following provides an implementation example of protocol stack for the Category-1 STB. In this example, hybrid STB with a single network interface using a home network coaxial modem is assumed (see Figure I.2).

Real-time media such as video, audio and text is contained in MPEG transport stream with packetized elementary stream (PES) format. Non-real-time data constituting content such as application (data broadcasting), PSI, SI, ECM, and EMM is held in section-based MPEG transport stream. The multiplexed MPEG transport stream can be transmitted over RF-based distribution network as well as IP-based network with RTP/UDP/IP multicast or IP unicast.

In some IP-based content distribution cases, application (data broadcasting) would be transmitted over TCP/IP logical channel independently from UDP/IP logical channel of the multiplexed MPEG transport stream because such application must be identically received within a certain period regardless of the timing when the reception was initiated. In this case, carousel transmission scheme is not used for application distribution.

In addition, other information relating to each receiver or user can be transmitted also over TCP/IP logical channel independently from the MPEG transport stream UDP/IP logical channel. This is more efficient way to send such kind of dedicated information than sending them in a multicast manner.

For VOD services, RTSP over TCP/IP unicast is always used to control a VOD session.

This Recommendation assumes that details of the above-described issues (as surrounded by bold line in Figure IV.1) are defined in each content distribution system that the STB claims to be conformant to.

Other types of applications can be also implemented in the STB, e.g., browser-based application to be used for Internet applications.

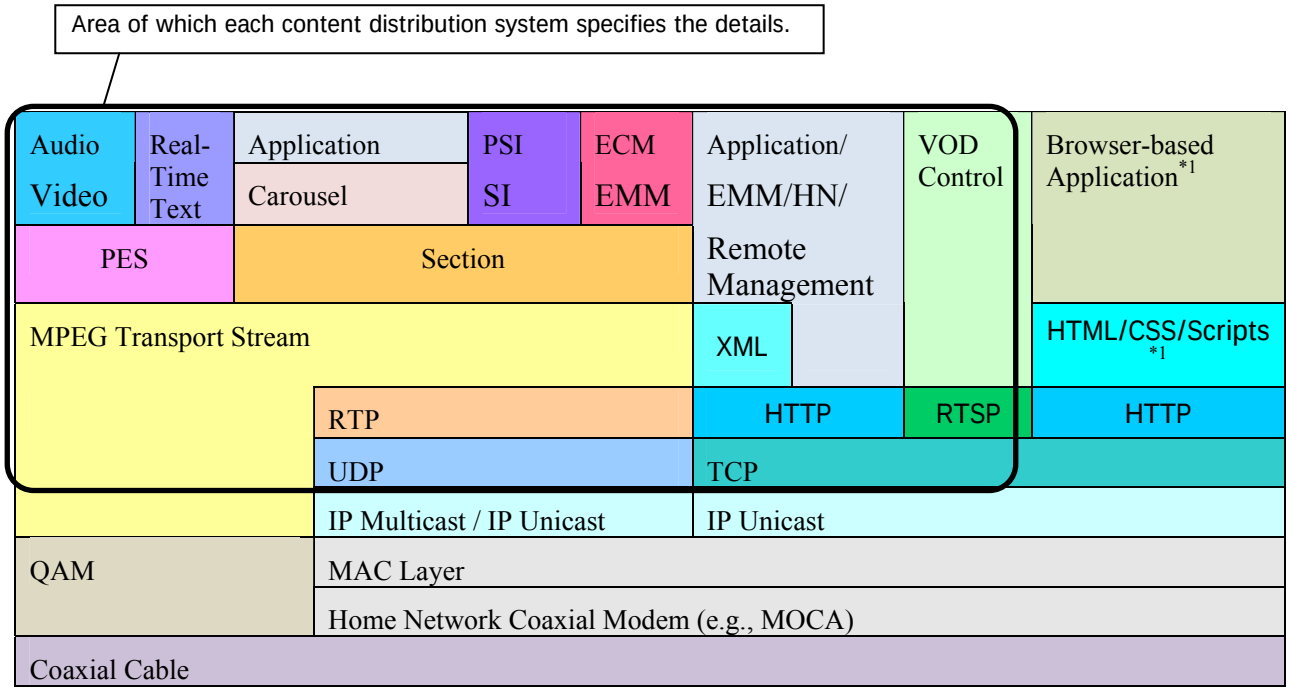


Figure IV.1 – Implementation example of protocol stack of the Category-1 STB

NOTE*1 – Details of this portion is implementation-dependent and outside the scope of this Recommendation.

Appendix V

Relationship between APIs and Bundle Application Programs

(This appendix does not form an integral part of this Recommendation)

A Java-based application management platform, i.e., OSGi framework, is recommended to be implemented in the STB to facilitate management of application programs such as network control, CPE device control over UPnP transaction, log services, permission administration functions and customer services. These software are so called "Bundle Software", which can be easily installed to and removed from the STB by operators' intentions. Every bundled software is able to work independently over the OSGi framework by communicating with OSGi servers located in the IP network. Figure V.1 shows a relationship between STB protocol stacks and Bundle Software.

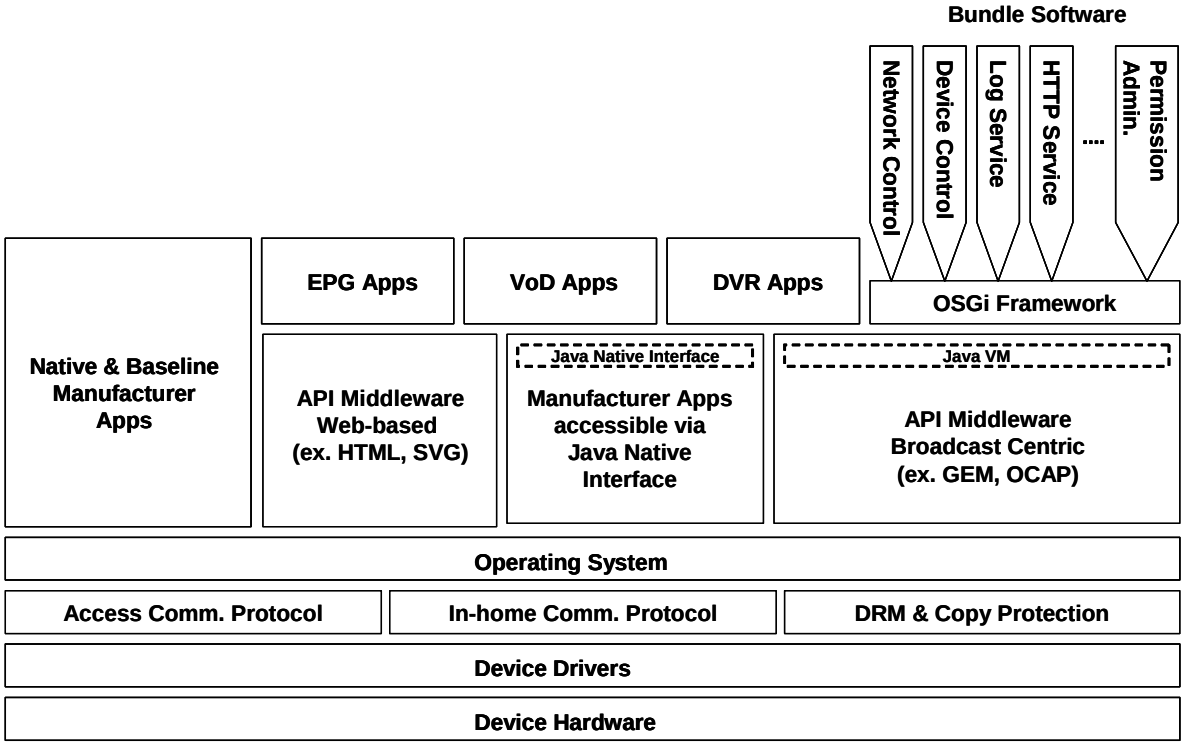


Figure V.1 – A relationship between STB protocol stacks and bundle software

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Printed in Switzerland
Geneva, 2009