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SERIES H: AUDIOVISUAL AND MULTIMEDIA SYSTEMS

IPTV multimedia services and applications for IPTV – IPTV terminal devices

IPTV terminal device: Interworking-enabled model of multiple devices

Recommendation ITU-T H.724

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Recommendation ITU-T H.724

IPTV terminal device: Interworking-enabled model of multiple devices

Summary

Recommendation ITU-T H.724 describes the functional components and features that enable the interworking amongst the Internet Protocol television (IPTV) terminal devices defined in Recommendations ITU-T H.721, ITU-T H.722 and ITU-T H.723. ITU-T H.724 complements the specifications of the basic, full-fledged and mobile terminal device models of those Recommendations by specifying the capabilities and functions needed in an IPTV terminal device to enable services or content consumption over multiple IPTV terminal devices. These capabilities and functions include the interworking models, functional roles, application framework, application programming interfaces (APIs), and physical and logical interfaces. In addition, the appendices describe use cases for the interworking models and various multi-device synchronization schemes.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T H.724	2017-12-14	16	11.1002/1000/13437

Keywords

IPTV, interworking, multiple terminal devices, terminal device.

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FOREWORD

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

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

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

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IPTV terminal device: Interworking-enabled model of multiple devices

1 Scope

This Recommendation describes the features of the terminal device interworking model which enables the service and content to be consumed between/among the multiple Internet Protocol television (IPTV) terminal devices. Those features include interworking enabled terminal functionalities, functional roles, application framework, application programming interfaces (APIs) and physical/logical interfaces among the multiple IPTV terminal devices, which are also specified in this Recommendation.

The expected types of terminal devices are basic terminal devices defined in [ITU-T H.721], as well as full-fledged terminal devices and mobile terminal devices, which are defined in [ITU-T H.722] and [ITU-T H.723], respectively.

2 References

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

[ITU-T H.720] Recommendation ITU-T H.720 (2008), *Overview of IPTV terminal devices and end systems*.

[ITU-T H.721] Recommendation ITU-T H.721 (2015), *IPTV terminal devices: Basic model*.

[ITU-T H.722] Recommendation ITU-T H.722 (2014), *IPTV terminal device: Full-fledged model*.

[ITU-T H.723] Recommendation ITU-T H.723 (2016), *IPTV terminal device: Mobile model*.

[ITU-T H.772] Recommendation ITU-T H.772 (2015), *IPTV terminal device discovery*.

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

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

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 end user [ITU-T Y.1901]: The actual user of the products or services.

NOTE – The end-user consumes the product or service. An end-user can optionally be a subscriber.

3.1.2 Internet Protocol television (IPTV) [ITU-T Y.1901]: Multimedia services such as television/video/audio/text/graphics/data delivered over IP-based networks managed to support the required level of QoS/QoE, security, interactivity and reliability.

3.1.3 interworking [b-ITU-T Y.1401]: The term "interworking" is used to express interactions between networks, between end systems, or between parts thereof, with the aim of providing a functional entity capable of supporting an end-to-end communication.

3.1.4 IPTV terminal device [ITU-T Y.1901]: A terminal device which has ITF functionality, e.g., an STB.

3.1.5 IPTV terminal function (ITF) [ITU-T Y.1901]: The end user function(s) associated with a) receiving and responding to network control channel messages regarding session set-up, maintenance, and teardown, and b) receiving the content of an IP transport from the network and rendering.

3.1.6 linear TV [ITU-T Y.1901]: A television service in which a continuous stream flows in real time from the service provider to the terminal device and where the user cannot control the temporal order in which contents are viewed.

3.1.7 middleware [ITU-T Y.1901]: A layer of software between applications and resources, which consists of a set of service enablers that allow multiple functionalities running on one or more devices in an IPTV system to interact across a network.

3.1.8 service and content protection (SCP) [ITU-T Y.1901]: A combination of service protection and content protection.

3.1.9 terminal device (TD) [ITU-T Y.1901]: An end-user device which typically presents and/or processes the content, such as a personal computer, a computer peripheral, a mobile device, a TV set, a monitor, a VoIP terminal or an audiovisual media player.

3.1.10 time shifting [ITU-T Y.1901]: A function which allows playback of content after its initial transmission.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 multi-device service: An IPTV service for which all related IPTV functions are distributed cooperatively among two or more devices.

NOTE – The term "Multi-screen" is used synonymously with "Multi-device" in this Recommendation.

3.2.2 multi-device interworking: Interworking among multiple terminal devices with the aim of performing a task by working together, where the terminal devices are possibly of different models.

3.2.3 multi-device application: An interworking-enabled application that could add a multi-device service feature into IPTV service.

3.2.4 multi-device enabler: A set of functional components that provides capabilities for device interworking.

3.2.5 interwork instance: A possible configuration of functional roles for a pair or group of IPTV terminal devices for supporting a specific multi-device service scenario.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

API Application Programming Interface

DMC Digital Media Controller

DMP Digital Media Player

DMR Digital Media Renderer

DMS Digital Media Server

DVR	Digital Video Recorder
ECG	Electronic Content Guide
EPG	Electronic Programme Guide
GUI	Graphical User Interface
HN	Home Network
IP	Internet Protocol
IPTV	Internet Protocol Television
IPTV TD	Internet Protocol Television Terminal Device
ITF	IPTV Terminal Function
LAN	Local Area Network
mDNS	Multicast DNS
MDS	Multi-Device Service
OS	Operating System
P2P	Peer to Peer
PDA	Personal Digital Assistant
PVR	Personal Video Recorder
QoE	Quality of Experience
QoS	Quality of Service
RP	Reference Point
RTCP	RTP Control Protocol
RTP	Real-Time Protocol
SADS	Service and Application Discovery and Selection
SCAP	Service, Content and Application Protection
SCP	Service and Content Protection
STB	Set-Top Box
TD	Terminal Device
TDES	Terminal Device and End System
TD-PD	Terminal Device Peripheral Device
UI	User Interface
UPnP	Universal Plug and Play
VoD	Video-on-Demand
Wi-Fi	Wireless Fidelity

5 Conventions

In this Recommendation:

– The keywords "is required to" indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance to this Recommendation is to be claimed.

– The keywords "is prohibited from" indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance to this Recommendation is to be claimed.
– The keywords "is recommended" indicate a requirement which is recommended but which is not absolutely required. Thus this requirement need not be present to claim conformance.
– The keywords "is not recommended" indicate a requirement which is not recommended but which is not specifically prohibited. Thus, conformance with this Recommendation can still be claimed even if this requirement is present.
– The keywords "can optionally" indicate an optional requirement which is permissible, without implying any sense of being recommended. This term is not intended to imply that the vendor's implementation must provide the option and the feature can be optionally enabled by the network operator/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with this Recommendation.

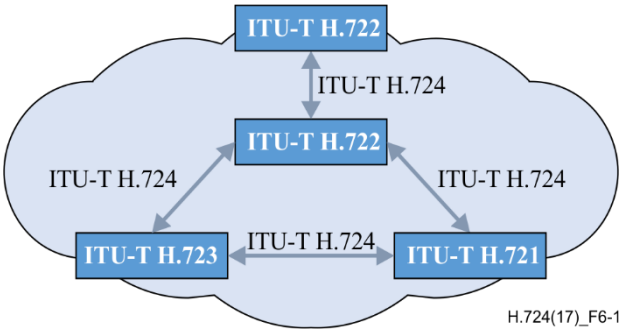
6 Introduction

An IPTV service provider provides the end-to-end solution for distributing content to users via their terminal devices (TDs). IPTV services can also be consumed from terminal devices other than the conventional set-top box (STB). In today's society, more and more people will carry with them more than one TD, such as a laptop or tablet and a mobile phone, at the same time. Each terminal device has its own advantages that help different customers to enjoy their lives in different ways. For example, STB+TV will provide the conventional viewing experience. Mobile phones and tablets will, however, increase the flexibility of watching TV anywhere by taking advantage of their mobility. Personal computers (PCs) provide more powerful computing capacity and a more precisely controlled capability through the use of a mouse and keyboard.

Therefore, there is a tendency for users to enjoy the multimedia service in a more convenient and comfortable manner, adapted to the context of their current experience, by using terminal devices independently or collaboratively.

The overall IPTV functional architecture is defined in [ITU-T Y.1910] and the ITU-T H.720 series of Recommendations (i.e., [ITU-T H.720], [ITU-T H.721], [ITU-T H.722] and [ITU-T H.723]) define the terminal device functions respectively according to the different terminal models. These Recommendations provide the basic hardware and software specifications to support IPTV services consumed over multiple terminal devices. To support multi-device service features in some scenarios, such as streaming, pushing or remote control for any type of terminal device, communication between terminal devices is necessary and should be defined in a standard format.

The relationship between this Recommendation and other ITU-T IPTV terminal device Recommendations is shown in Figure 6-1.



NOTE – Albeit basic model TDs [ITU-T H.721] and mobile model TDs, [ITU-T H.723] could interwork with the same model TD if they implement certain additional non-required features, this is not recommended (see Table 7-1). For this reason, self-interworking is represented in Figure 6-1 only for full-fledged TD models [ITU-T H.722].

Figure 6-1 – Relationship between ITU-T H.724 and other ITU-T IPTV terminal device Recommendations

Based on the general terminal functional architecture defined in the ITU-T H.720 series of Recommendations (i.e., [ITU-T H.720], [ITU-T H.721], [ITU-T H.722] and [ITU-T H.723]), a high-level overview of interworking between terminal devices is shown in Figure 6-2.

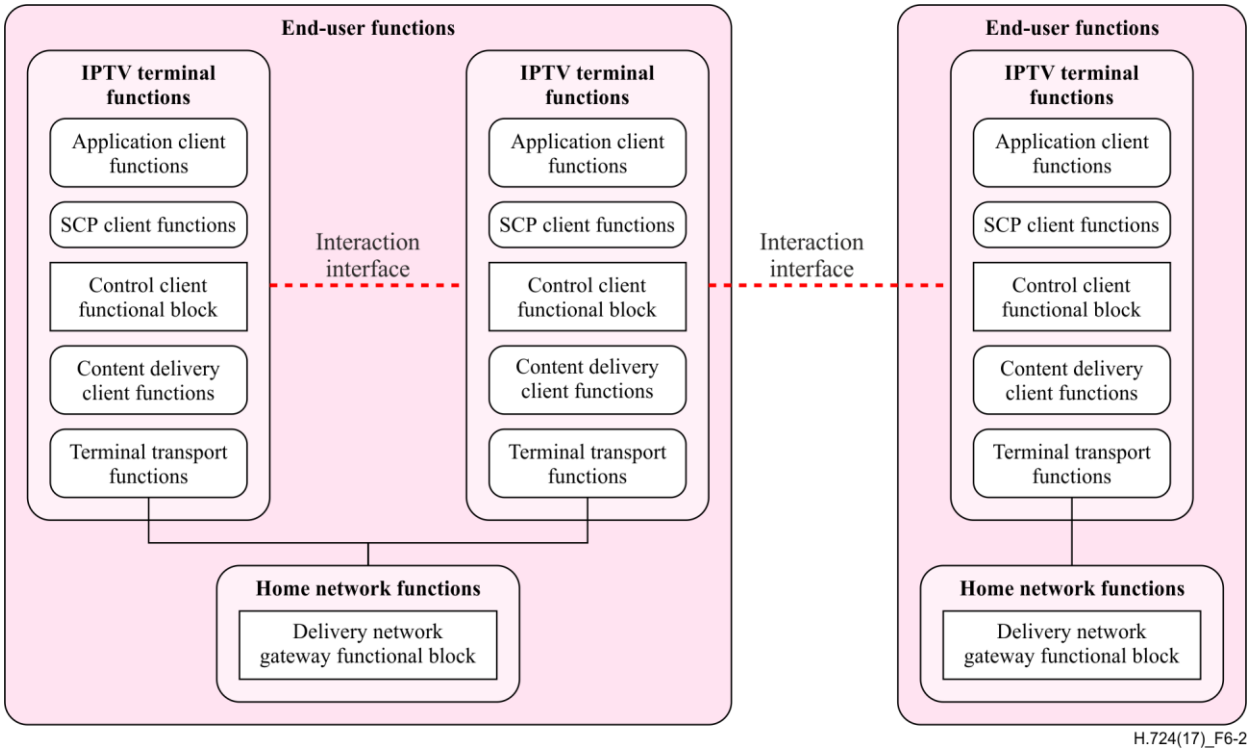


Figure 6-2 – High-level overview of interworking between terminal devices

There are three possible environments for support of interworking between terminal devices:

– All terminals are connected directly, especially for direct connection of two devices

– All terminals are connected together within a home network

– All terminals are connected together via different home networks or transport networks.

With the support of a connection environment, the main functions for implementing multi-device service interworking are listed as follows:

– Terminal device connection establishment

– Terminal device discovery and selection
– Authentication
– Capability discovery
– Content resource discovery and selection
– Service interaction.

It is recommended that the data connection be IP-based and relies on either fixed network connection or wireless or hybrid connection. For example, the digital living network alliance (DLNA) [b-IEC 62481] home networked device interoperability guidelines and the [b-ISO/IEC 29341] universal plug and play (UPnP) specifications are widely used to support the above scenarios, especially in device-to-device connection.

7 Services and key features of interworking among IPTV terminal devices

7.1 IPTV service over multiple terminal devices

The IPTV services listed in clause 6 are able to be consumed not only on each terminal device, but also cooperatively over multiple inter-connected terminal devices. Those terminals can be connected together with various access methods, e.g., wireless fidelity (Wi-Fi), Ethernet cable, Bluetooth, etc. Commonly, they can be connected directly with each other or via a central access point.

A full-fledged ITU-T H.722 IPTV terminal device, which supports multi-device service features, may be able to share the service with other terminal devices. For example, the terminal device may be seen as a media centre in a home network environment. Other ITU-T H.721, ITU-T H.722 and ITU-T H.723 terminal devices can be connected together and are able to be discovered and exchange information with each other. Therefore, any authorized TD is able to share/transfer the IPTV service with/into other TDs.

To support the above features, a full-fledged IPTV terminal device should provide the following capabilities.

– Connection and authentication mechanism for other terminal devices (e.g., a mobile phone or PC)
– Reciprocal discovery across the various device types
– Protocol for communication among the multiple aforementioned TDs
– Media information navigation over the connected TDs
– Media stream from/to another connected TD to play (with optional use of an adaption mechanism). Support of mirror mode, content sharing mode and coordination mode stream transferring
– Remote control over the connected TDs, including legacy remote controller and remote EPG mode, mirror controller
– Transfer of file-based media between the local storage of connected TDs
– Authorization for sending control instructions via full-fledged TD to control another TD (e.g., play, fast forward and rewind).

7.2 Features of multiple interworking terminal devices

7.2.1 Physical devices connection for interworking

The following modes are recommended to be used for supporting multiple interworking terminal devices:

– **Direct connection mode**: the source device can initiate a communication channel directly to another target device, for example via infrared, Bluetooth, cable, wireless ad hoc, etc.

– **Indirect connection mode**: the source device can initiate a communication channel indirectly to another target device. There are variants of indirect connection mode:

  – **Bridged mode**: the source device and target devices exchange information via a bridge device while the devices cannot be physically connected to each other, e.g., both STBs and tablets can connect to a home gateway to exchange control messages by using wire and wireless connections. In bridged mode, the exchanged information does not need to be modified and passes through the bridge device directly. Bridged mode is suitable for home networks. In bridged mode, terminal devices can connect through bridge devices by using level-2 protocol.

  – **Routed mode**: Both source and target devices are connected to a routing-enabled device and exchange information indirectly. For example, STBs can register to a media server. Then the control message from source device can be multicast to a group of target devices via the media server. In routed mode, the exchanged information format can be optionally modified in order to be understood and analysed by a target device. For example, a discovery message could be modified as an mDNS discovery message. Routed mode is suitable for both home network and public network environments. In routed mode, terminal devices can be connected through the network by using level-3 protocol.

Basically, device inter-connection in most home network environments should follow home network configurations and therefore connection mechanisms are out of scope in this Recommendation. Instead, [b-ITU-T H.622] and [b-ITU-T H.622.1] can be referenced.

7.2.2 Basic interworking scenarios for IPTV terminal devices

The basic interworking scenarios for IPTV terminal devices consider two generic arrangements:

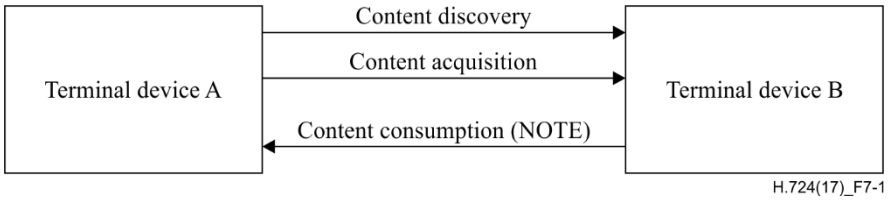
– the IPTV service is transferred between two IPTV terminal devices

– the IPTV service is transferred among three or more IPTV terminal devices.

The two-terminal devices scenario could be further distinguished as push mode and pull mode, see clause 7.2.2.1.

7.2.2.1 Interworking between two devices

a) URL pull mode



NOTE – Arrows denote "initiate" the corresponding process

Figure 7-1 – Interworking between two terminal devices (URL pull mode)

In this mode, Terminal device A discovers the content managed on Terminal device B. Then, Terminal device A acquires the content from Terminal device B and consumes the media locally on Terminal device A.

NOTE – In an optional scenario, if Terminal device A does not have sufficient capability to consume the content locally, it could alternatively consume the content remotely on Terminal device B.

b) URL push mode

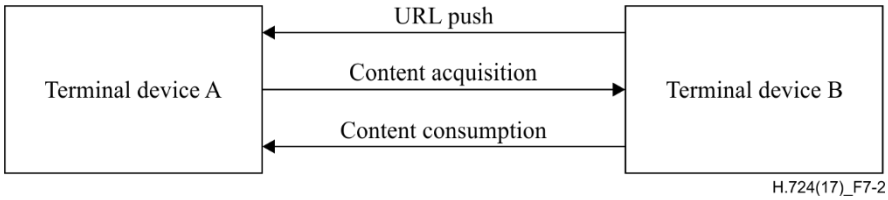


Figure 7-2 – Interworking between two terminal devices (URL push mode)

In this mode, Terminal device B discovers a Terminal device A and pushes a content URL to it. Then, Terminal device A acquires the content from Terminal device B and consumes the media locally on Terminal device A. In this scenario, Terminal device A does not need to discover content on Terminal device B, but only needs to listen to the push request from Terminal device B.

7.2.2.2 Interworking among three devices

a) Interworking with a controller terminal device

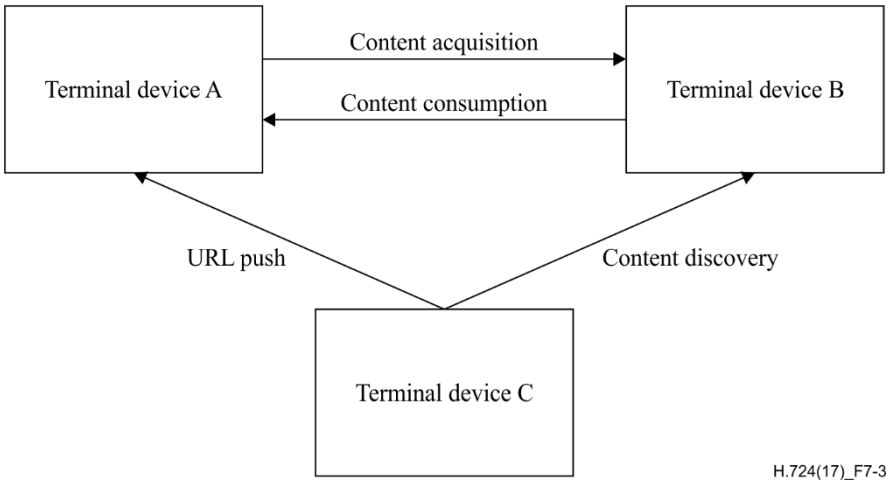


Figure 7-3 – Interworking among three devices

In this model, the control function is separated from Terminal device A or Terminal device B, being held remotely in a third party Terminal device C. As a controller, Terminal device C is responsible for content discovery from Terminal device B and for pushing the URL to Terminal device A. The actual media session connection is still held between Terminal device B and Terminal device A.

7.2.3 Terminal device discovery and selection

Terminal device discovery usually relies on the network infrastructure to which each terminal device connects. Terminal device selection can be implemented by an application graphical user interface (GUI) and can even be atomically implemented based on a pre-defined relationship in the user profile. Terminal device discovery and selection are the first stage in multi-device interworking.

7.2.3.1 Terminal devices within home networks

[b-ITU-T H.622.1] defines the architecture and functional requirements for a home network to support IPTV service. Terminal device discovery and selection are based on the specific device discovery protocol that is used within the home network environment. For example, DLNA is based on UPnP [b-ISO/IEC 29341] and Wi-Fi Miracast is based on Wi-Fi peer-to-peer (P2P) [b-Wifi-P2P]. More terminal device discovery mechanisms can be found in [ITU-T H.772].

7.2.3.2 Terminal devices in public networks

In general, terminal device discovery and selection are based on the IP address when terminal devices are locating in a public network. From the application layer point of view, terminal device discovery and selection can also be implemented based on user ID, account name, device ID and other identifiers. An IPTV service platform can assist one terminal device to locate another terminal device in a public network. In addition, a terminal device can discover another terminal device by searching the terminal device information that may be previously stored locally or remotely in the service platform, such as a friend list or directory database. In a real implementation, the application-based terminal devices discovery and selection are usually designed as slient-server applications. The application server provides the capability to maintain the relationship of terminal devices and users, the current states of a terminal device, message transfer (proxy) and other functions such as security, authentication, etc.

Therefore, the following elements are recommended to be contained in the terminal device discovery message:

– IP address for multicasting from a source device or IP address for a specific target device
– Target user ID
– Target device ID
– User name, user ID
– Other optional elements such as user name, device name, etc.

More terminal discovery mechanisms can be found in [ITU-T H.772].

7.2.4 Media codec

Each terminal device model defined by ITU-T supports variety of audio/video codec formats. All supported formats can be referenced from [ITU-T H.721], [ITU-T H.722] and [ITU-T H.723].

While a terminal device is working as a media server, it can optionally implement media transcoding to provide a suitable media format for other terminal devices.

7.2.5 Media transmission

Media sharing service is a typical multi-device service which is implemented by the assistance of session transfer and media stream transmission and both can be implemented within a home network or public network. In most situations, on-demand service is the ideal service to which a media sharing service can be added on.

Media stream can be directly pushed or pulled from one device to another device. It is determined by whichever device initiates the media transmission request. But in a public network, media stream may not be directly transmitted from one device to another device. Usually the information exchanged between devices is session-related information.

7.2.5.1 Media transmission in home network

Media content can be transmitted directly via connections between devices, or via transport from an intermediate device if they are located in a same local area network (LAN) or home network.

For example, if the terminal devices are DLNA-based devices, then the "2-box push/pull system usage" and the "3-box system usage" can be referenced. By using those modes, the media transmission protocol is required to use HTTP and optionally use real-time protocol (RTP).

Sometimes the transfer of content to another device is prohibited, i.e., the media stream cannot be directly transferred out of the current presenting device. In this situation, the actual content transmitted between devices may be:

– A copy of the original media session

– A new initiated session but with the same content identifier.

In this situation, the actual media stream transmission is very similar to the transmission in a public network. But the difference is, in a home network, the transferring request can be sent from one device to another directly or through a home gateway. In a public network, the request may be sent via a proxy in the IPTV platform.

7.2.5.2 Media transmission in public network

If media content cannot be transmitted directly between terminal devices but only through a public network, such as a dedicated network for IPTV, or even the Internet, the IPTV service platform is expected to manage the session transferring between the source terminal device and the target terminal device. Content delivery function provides the same content stream to multiple target terminal devices.

When registration-based terminal device discovery is applied, see clause 8.1.1 of [ITU-T H.772], terminal devices are usually grouped according to a certain index, e.g., the same user ID, the same group ID, etc. Those terminal devices can be granted the rights of accessing or binding to each other. The relationship could be managed by an IPTV service platform.

In the terminal device discovery stage, see [ITU-T H.772], when a terminal device logs into an IPTV service platform, if the service platform determines that terminal device is bound to another terminal device based on the stored mapping relationship, it sends a transfer permission that contains the location of the bound terminal device.

During the content playing in an on-demand service, such as video-on-demand (VoD), when a terminal device determines to transfer the content playing from one terminal to the other terminal device, it sends a transfer request to the service platform according to the location specified in the transfer permission.

The service platform receives the transfer request which indicates an on-demand service that needs to be transferred form one device to another. That request can be initiated from the source terminal device or the target terminal device. The transfer request message contains at least:

– An identifier of the current playing content

– An identifier of the terminal device in/from which content is to be transferred

– The current playing time if synchronization is required.

With the content identifier, the IPTV service platform can locate the content via the content delivery function. In addition, for content adaptation in a multi-device service, the IPTV service platform will locate an index of the content first. Then, with the target device identifier, the IPTV service platform is able to determine an adaptive content URL for the target device. That information will be forwarded to the target device with the current playing time and then the target device will request the actual media streaming from content delivery function.

7.2.6 Synchronization among terminal devices

In general, a synchronization mechanism is used to guarantee the QoS of an IPTV media service when a media stream is transmitted via an unreliable network. Audio and video packets may be lost because of jitter or delay in the network. Other factors such as the terminal device capability or jitter buffer size, etc., may also be factors that delay the playing of an audio or video packet. Therefore, in general, a synchronization mechanism may be used to cope with these issues. Currently, most media synchronization solutions are based on RTP/RTCP [b-IETF RFC 3550] reports.

It is possible for audio and video streams to be transmitted into two different IPTV terminal devices separately by two network connections. Moreover, if a multi-device service requires displaying the same content on multiple terminal devices at the same time and with the same playing status, a

synchronization mechanism is recommended to be provided to guarantee the quality of experience (QoE) among the multiple end-users.

Basically, the synchronization may be one of the following types:

– **Audio and video synchronization:** In a multi-device service, the video and audio in a movie content may be separated into two different streams and transmitted to two different terminal devices and then played in coordination mode after. Audio and video synchronization is applied for mapping audio packets with the correct video packets.

– **Presentation synchronization** (also known as display synchronization). In general, this situation means the content (or coupled content) being displayed on an IPTV terminal device should be kept at the same progress level with the other terminal devices if it is required. This synchronization mechanism could provide the same viewing experience for two end-users who may be located in different places.

7.3 Application framework

Figure 7-4 presents the application framework for the interworking-enabled model for IPTV terminal devices. The overall architecture is referenced from [ITU-T H.720].

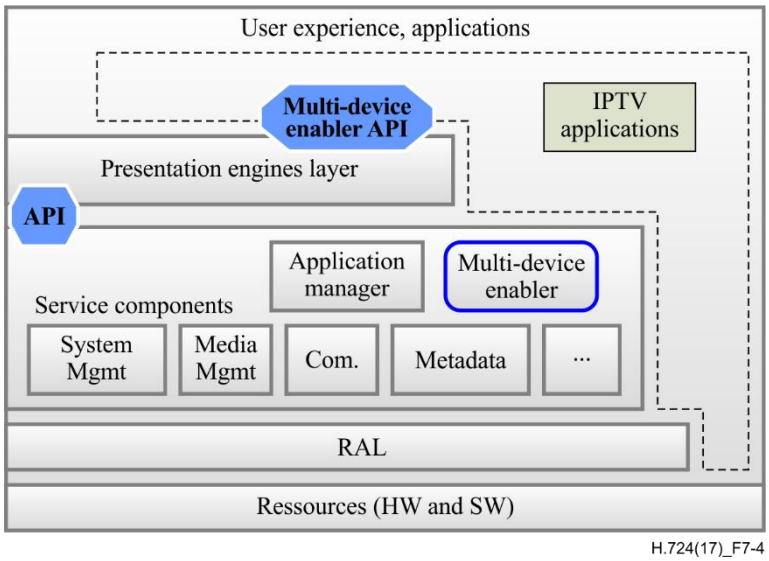


Figure 7-4 – Application framework to support multi-device service

The overall application framework presented in Figure 7-4 is not intended to change the current software architecture defined by [ITU-T H.720]. Instead, it is recommended to add the multi-device features so that the IPTV terminal device becomes able to provide multi-device applications.

Multi-device application is a kind of interworking-enabled application which could enhance IPTV service with multi-device service features. The software architecture is recommended to support install, uninstall, update and run multi-device applications in IPTV terminal devices. The multi-device application may have full or restricted access to other layers in the software architecture. Those service components in the service logic adaptation layer could be used and enriched by application services in order to simplify the development of service components and applications.

A multi-device application could be composed of one or more features. A multi-device application enables an IPTV service with one or more of the following features:

– User interface (UI) for multiple device and content discovery

– IPTV service or content sharing

– Remote control, including its UI.

– Message interchange (pull or push)
– Synchronization control

7.4 Functional roles supported by IPTV terminal devices

The multi-device enabler function provides capabilities for terminal device interworking. The minimum function component is recommended to include (not exhaustively):

– **Functional roles**: Defines what the device module is, such as media server, media player/ media renderer or media controller. Each device module provides different actions. For example, in DLNA, the device may be categorized as a digital media server (DMS), digital media player (DMP), digital media renderer (DMR) or digital media controller (DMC). The digital media server (DMS) provides media server functions and the DMC provides control functions.
– Functional role is not simply a specific application. It is the integration of service features which combine multiple IPTV functional components. Each functional role may cover several IPTV functions. For example, aedia renderer may include media client functions and content delivery client functions. Media client functions provide codec for rendering the media content and content delivery client functions provide the capability of initiating a transport connection with other terminal devices.

Hence, the following functional roles description presents the features for each of them:

– **Media player**: The media player discovers and selects the media content from the media server. It has the capability of consuming the content that is rendered locally on the IPTV terminal device.
– **Media renderer**: The media renderer has the capability of acquiring and consuming the content stream from another media server. It is also able to obtain the control message from the media controller and interpret the control message to be understood by IPTV media control functions.
– **Media server**: The media server stores the media content locally on the IPTV terminal device with a storage device, such as local disk or external hard disk. It also could manage the content with a file system and could be discovered by the media player. As a media server, it also has the capability of media streaming and, optionally, synchronization.
– **Media controller**: The media controller has the capability of discovering the media content in a media server. The media controller is able to select a media renderer and to push the content forward to it by controlling the transport connection between the media server and the media renderer. It controls the media consumption by sending the control message to the media renderer.

Tables 7-1 and 7-2 provide a profile for IPTV terminal device roles in an interworking model. In this Recommendation, two types of interworking models are introduced as the basic interworking model in clause 7.2.2. Each terminal device model, in order to support interworking with other terminal devices, is recommended to be composed of one or more interworking instances. An interworking instance is a possible combination of functional roles for different IPTV terminal devices in a particular service scenario.

Table 7-1 – Minimum sets of functional roles of IPTV terminal devices for interworking between two devices

	Functional roles			
Device model	**Media server**	**Media player**	**Media renderer**	**Media controller**
Interwork instance 1				
ITU-T H.721	Optional	Recommended	Recommended	Optional
ITU-T H.722	Recommended	Optional	Optional	Recommended
Interwork instance 2				
ITU-T H.723	Optional	Optional	Optional	Recommended
ITU-T H.722	Recommended	Recommended	Recommended	Optional
Interwork instance 3				
ITU-T H.723	Optional	Recommended	Recommended	Optional
ITU-T H.722	Recommended	Optional	Optional	Optional
Interwork instance 4				
ITU-T H.721	Optional	Recommended	Optional	Optional
ITU-T H.723	Optional	Optional	Optional	Recommended

Table 7-2 – Minimum sets of functional roles of IPTV terminal devices for interworking among three devices

	Functional roles			
Device model	**Media server**	**Media player**	**Media renderer**	**Media controller**
Interwork instance 5				
ITU-T H.721	Optional	Optional	Recommended	Optional
ITU-T H.722	Recommended	Optional	Optional	Optional
ITU-T H.723	Optional	Optional	Optional	Recommended

An IPTV terminal device could be connected in a public network or a home network. For the different services, each terminal device may play the different roles. The following section presents the functional role and interworking model for each IPTV terminal device defined in ITU-T H.720 series Recommendations (i.e., [ITU-T H.721], [ITU-T H.722] and [ITU-T H.723]).

7.4.1 Functional roles of the ITU-T H.721 IPTV basic-model terminal device

The IPTV basic-model terminal device defined in [ITU-T H.721] is the fundamental device for receiving and decoding the media stream from a media source.

A terminal device as defined in [ITU-T H.721] could be a STB, a chip-set embedded in a TV, etc. The major function of the ITU-T H.721 device is displaying the media content for an end-user. Normally, the media stream is transmitted into an ITU-T H.721 terminal device in a uni-direction.

The basic function of the terminal device as defined in [ITU-T H.721] enables the terminal device to act as a media renderer. In addition, a service navigation application, such as an electronic content guide (ECG), can be redesigned as the GUI for a user to browse and select the content from other interworking devices (e.g., media servers). By combining the codec and GUI, a terminal device as defined in [ITU-T H.721] could act as a media player.

NOTE – An ITU-T H.721 terminal device may be implemented exclusively as a media renderer (scenarios are illustrated in clauses 7.4.2 and 7.4.3).

Figure 7-5 shows the interworking model for an ITU-T H.721 terminal device as a media player and media renderer.

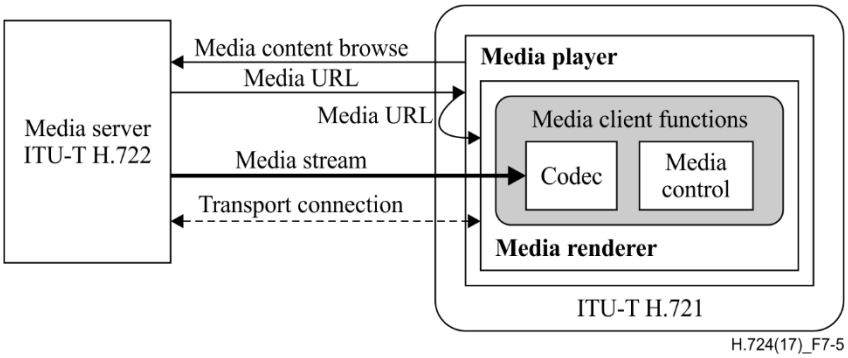


Figure 7-5 – Interworking model for ITU-T H.721 terminal device

7.4.2 Functional roles of the ITU-T H.722 IPTV full-fledged model terminal device

The IPTV full-fledged model terminal device defined in [ITU-T H.722] is the powerful device with the capability of delivering, receiving, coding and decoding the media stream to/from another terminal device. In addition, with a file system and storage equipment, a terminal device as defined in [ITU-T H.721] can also provide the content storing, content managing, content searching and content presentation services, as a media server. If the terminal device is connected to another terminal device, it is also able to control the media playing as a controller while the content stream is received.

So with the function provided by the terminal device, the terminal device is recommended to act as a media renderer, media player, media server and media controller. It is noted that, in media content push mode, the local content browsing is operated by a media controller and then the media URL will be pushed to another appropriate media renderer device.

The terminal device will have many types of product. For example, a terminal device may be an advanced STB, a smart TV, or an application that is running in a PC operating system (OS).

Figure 7-6 shows the interworking model for the ITU-T H.721 terminal device by connecting with other terminal devices.

NOTE – The diagram in Figure 7-5 can also be used to illustrate the use of an ITU-T H.722 TD as media player (replacing ITU-T H.721 with ITU-T H.722).

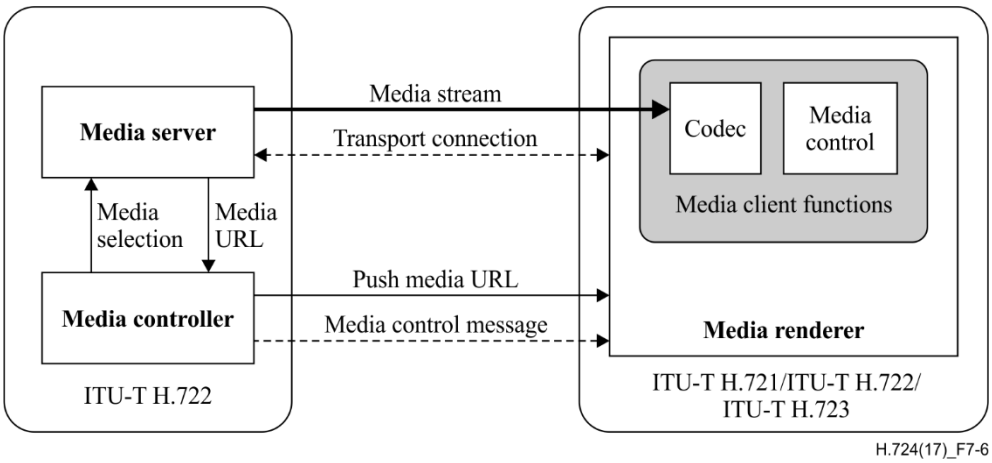


Figure 7-6 – Interworking model for ITU-T H.722 terminal device

7.4.3 Functional roles of the ITU-T H.723 IPTV mobile terminal device

The IPTV mobile terminal device in [ITU-T H.723] is the terminal device with mobile features. In summary, it supports the same functions defined in [ITU-T H.721] and so in essence it supports the role of media player, which is very similar to the mobile terminal device defined in [ITU-T H.723]. In addition, by taking advantage of the portable feature, the mobile terminal device defined in [ITU-T H.723] may easily be used by an end-user as it can be used to control the media playing in another terminal device. Besides media controller, the mobile terminal device defined in [ITU-T H.723] may control the media stream delivery/push from one terminal to the other terminal by controlling them both.

Because of the limited capabilities of the mobile terminal device defined in [ITU-T H.723] such as low codec capability and small screen size, the media controller is mostly used in actual implementation. In the case of media playing control, the playing control command input by a user should be wrapped into the control message and then sent to the media renderer in the other terminal device. The control command is then unwrapped from the message and interpreted by the media renderer in order to be understood by the local media player application.

An ITU-T H.723 mobile terminal device could be a STB with wireless connection, a smart phone, a personal digital assistant (PDA), a laptop, etc.

Figure 7-7 shows the interworking model for the mobile terminal device defined in [ITU-T H.723] connecting with other terminal devices.

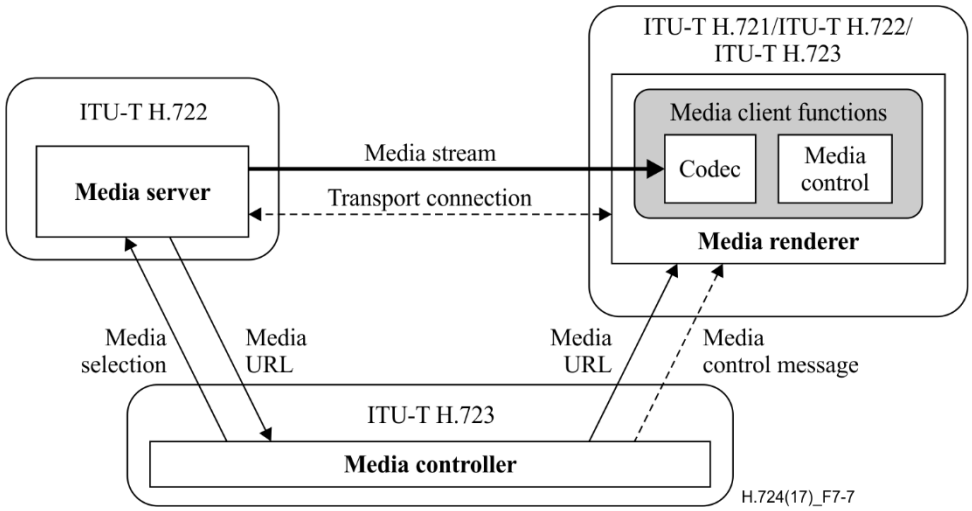


Figure 7-7 – Interworking model for an ITU-T H.723 terminal device

7.5 Multi-device enabler APIs

Multi-device enabler APIs provide the programming interface for IPTV applications to call multi-device enabler components. The multi-device enabler components provide the multi-device functional properties to IPTV applications. With these properties, the IPTV application is able to enhance its capabilities to run its service over multiple terminal devices. For example, a user can share the media content within a STB and mobile device when the VoD service is running.

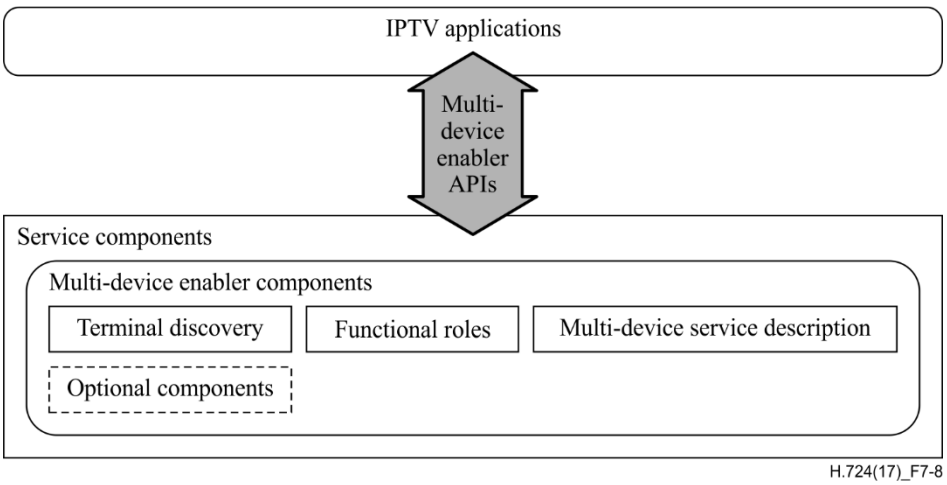


Figure 7-8 – Multi-device enabler APIs

In the IPTV application framework shown in Figure 7-8, multi-device enabler APIs provide an interface for IPTV applications to access the multi-device enabler components for different purposes. Basically, a multi-device enabler provides three types of functional components and their respective APIs.

– API for accessing terminal discovery functions

  With this API, an IPTV application can discover other terminal device information by calling the terminal discovery component in multi-device enabler. Terminal discovery component also manages the communication connection over multiple terminal devices.

– API for configuring functional roles

  With this API, an IPTV application can enable a functional role for the terminal device when a multi-device service is initiating. For example, a terminal device can perform a "media server" role in a future terminal interworking scenario.

– API for retrieving multi-device service description

  With this API, an IPTV application can provide the multi-device service description for other terminal devices to access its service properties. For example, a media server can provide a content list for other terminal devices to discover its contents. With multi-device service description, a media player can require a media stream from the media server by accessing the given location (e.g., URL and port) provided in a multi-device service description.

With these APIs, IPTV applications can be designed to support multi-device service by accessing the provided multi-device enabler components.

8 Functional components for interworking between IPTV terminal devices

The functional components described in this clause are based on [ITU-T H.720], [ITU-T H.721], [ITU-T H.722] and [ITU-T H.723]. As shown in Figure 8-1, the basic functional components architecture supports implementation of various IPTV services. Through the interworking enabled mode, these functional components may provide interworking capabilities to support multi-device services, which may be considered as a kind of additional IPTV service.

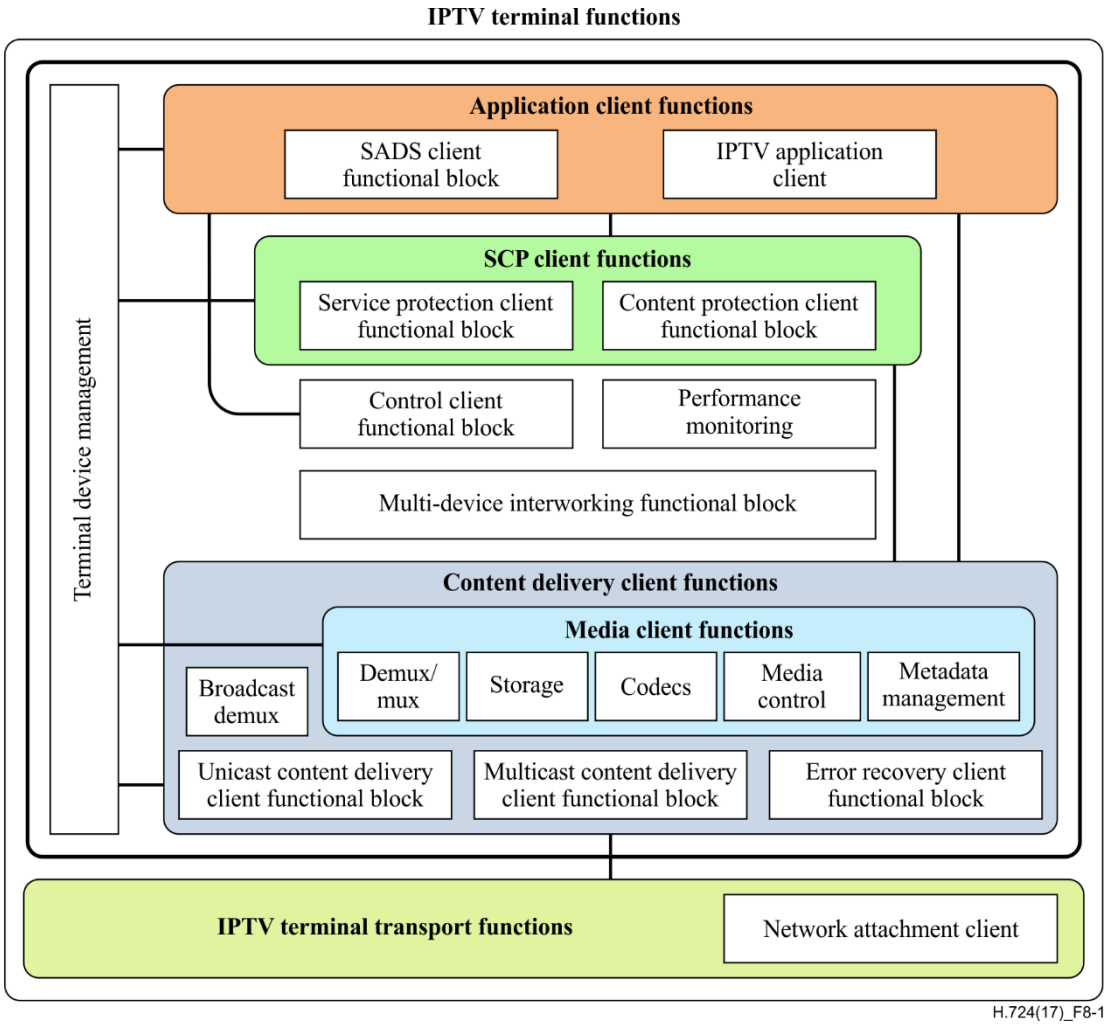


Figure 8-1 – IPTV terminal functions including interworking based on [ITU-T H.720]

The brief explanation of each functional component described here is compliant with the explanations provided in [ITU-T H.721], [ITU-T H.722] and [ITU-T H.723]. The following explanations specifically address each functional component to support the interworking enabled model.

IPTV terminal transport functions

IPTV terminal transport functions are responsible for handling IP-based connections between two or more IPTV terminal devices as well as connections between the fixed network and the mobile IPTV network. Network attachment clients provide connectivity to other terminal devices via wired/wireless networks such as Wi-Fi and 2G, 3G, LTE and WLAN. IPTV terminal transport functions also support NON-IP based connection such as Bluetooth and infrared, but still transmits IP packets over those connections.

Content delivery client functions

Content delivery client functions receive and control the delivery of the content from the content delivery and storage functions. For the interworking enabled model, these functions are also provided to received and control the delivery of content from another terminal device that acts as a media server.

Media client functions

Media client functions are responsible for content processing functionalities such as storage, metadata processing and decoding of audio/video contents. In the case where a terminal device acts as a media server, these functions should provide media transcoding capabilities.

SCP client functions

SCP client functions are responsible for service and content protection aspects of IPTV terminal devices.

Application client functions

Application client functions are responsible for the basic IPTV functions, management functions and service supporting functions. Multi-device service acts mostly as a kind of service supporting function. It could be an IPTV client function or an independent application but needs to be coordinated with IPTV client functions and the service and application discovery and selection (SADS) function to present multi-device service features, such as pushing a VoD streaming to other terminal devices.

Control client functional block

The control client functional block allows the terminal device to initiate service requests to the IPTV service control functional block in order to prepare for the connection to the content delivery functions. In addition, in the interworking model, this functional block may allow service request from other IPTV terminal devices to be initiated.

Terminal device management function

The terminal device management function functional entity provides configuration management and remote management of IPTV terminal devices.

Performance monitoring

The performance monitoring function is responsible for monitoring of performance aspects of IPTV terminal devices.

Multi-device interworking functional block

The multi-device interworking functional block provides the media server and service aggregation capability such as media detection, management, rendering, streaming (push or pull) and synchronization and control functions. For example, a full-fledged IPTV terminal device as defined in [ITU-T H.722] may act like a streamer but with stricter connection authentication and less connections.

9 Interfaces

9.1 Physical interfaces

Figure 9-1 illustrates the physical interfaces that support interworking among multiple IPTV terminal devices.

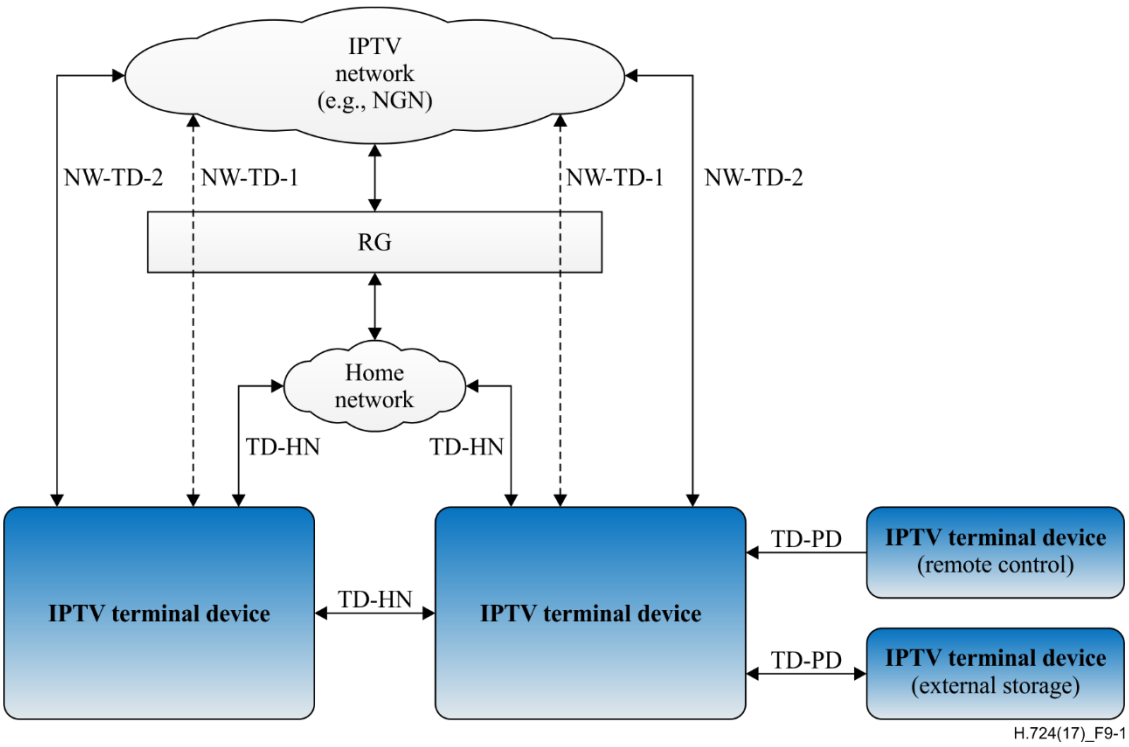


Figure 9-1 – Physical interfaces that support interworking among multiple IPTV terminal devices

Clause 9 mainly describes and specifies the interfaces that support interworking capabilities among the IPTV terminal devices.

The full description of IPTV terminal device interfaces is provided in [ITU-T H.721] and the full-fledged terminal device and mobile terminal device are defined in [ITU-T H.722] and [ITU-T H.723] respectively.

9.1.1 TD-HN interface

TD-HN is an interface that provides a connection to the home network. TD-HN is used for the connection between the IPTV terminal device and other in-home devices such as an external personal video recorder (PVR). In the terminal interworking model, TD-HN is also used for the connections among IPTV terminal devices by direct connections.

9.1.2 NW-TD-1 and NW-TD-2 interfaces

NW-TD-1 and NW-TD-2 are interfaces that provide connection to the IPTV network or the public network. In the terminal interworking model, NW-TD-1 and NW-TD-2 are also used for the connections among IPTV terminal devices through indirect connections.

9.1.3 TD-PD interface

The TD-PD interface is not only between a peripheral device and the IPTV terminal device, but also among the IPTV terminal devices. The TD-PD interface allows transfer of information through a non-IP based connection (e.g., Bluetooth and infrared communication) and an IP-based connection (e.g., UPnP, WiFi).

9.1.4 Input interface

The input interface is responsible for the interactions between user devices and the appropriate applications in the IPTV terminal device. In the terminal interworking model, another IPTV terminal device is able to act as a special user device.

In a remote control scenario, if the IPTV terminal device acts as a device that is controlled by a remote controller, the interface requires a device to receive control signals.

9.1.5 Output interface

In a remote control service, if the IPTV terminal device acts as a remote controller which can control other IPTV terminal device, the interface requires the device to send control signals.

9.2 Logical interface for multi-device application

The logical interface between terminal devices in this Recommendation refers to a pair of logical ports for the multi-device application to build a virtual communication link to exchange information. For example, this Recommendation defines some multi-device functional components as a multi-device enabler and a multi-device application could use those components to implement an actual multi-device action.

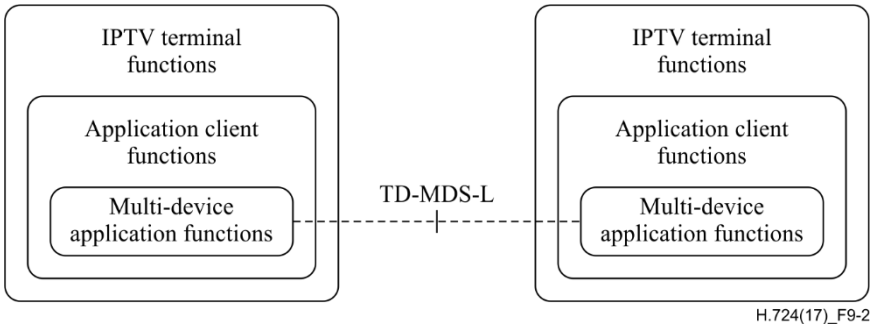


Figure 9-2 – Logical interface between multi-device application functions

The TD-MDS-L logical interface refers to the 'Terminal Device-Multi Device Service-Logical' interface. This logical interface is between multi-device application functions which are located in the different IPTV terminal functions.

This logical interface is used by IPTV terminal functions to send/receive messages which are required to initiate a multi-device application. Those multi-device application related messages may include:

– Messages for terminal discovery.
– Messages for controlling a media session, e.g., to build a communication channel, to control media play, remote control to another terminal device, etc.
– Messages for reporting terminal device status, e.g., to maintain a device online presence, to maintain multiple devices to be synchronized.

In a real implementation, the Logical Interface can be broken down into several reference points (RPs) that specifically handle the related events. For example, the Logical Interface which is used for terminal discovery can be described in terms of the reference points defined in clause 9.1 of [ITU-T H.772].

9.3 Protocols for the logical interface

According to the interface definition in clause 9.2, the multi-device service can be summarized in terms of four types of fundamental service interactions:

– Terminal device discovery
– Media transport
– Media control
– Media synchronization (optional)

9.3.1 Protocols for terminal device discovery

See clause 9.2 of [ITU-T H.772] for protocol details.

9.3.2 Protocols for media transport

Table 9-1 lists the potential protocols that could be used for media transport among IPTV terminal devices.

Table 9-1 – RP protocols used by media transport

RP	Type	Direction	Protocols	Description
TD-MDS-L	Media transport	Media server → Media player or Media server → Media renderer	HTTP/TCP RTP/TCP or RTP/UDP	Content could be transported from a media server to a media player or a media renderer in a different terminal device. According the different media service types, the application could select the appropriate protocol to transport the media stream after the preliminary negotiation.

9.3.3 Protocols for media control

Table 9-2 lists the potential protocols that could be used for media control among IPTV terminal devices.

Table 9-2 – RP protocols used by media control

RP	Type	Direction	Protocols	Description
TD-MDS-L	Media control	Media controller → Media renderer Or Media controller → Media server	HTTP RTSP	A media controller can send a media control command to a media player or a media server. According to the media transport type, the control message also could use a different protocol.

9.3.4 Optional protocols for other media services

Table 9-3 lists the potential protocols that could be used optionally for other media services.

Table 9-3 – RP protocols used by other media services

RP	Type	Direction	Protocols	Description
TD-MDS-L	File download	Media server→ Media server	FTP	Media content could also be downloaded from one media server to another media server.
	Media synchronization*	Media server→ Media player Or Media player ←→ Media player	NTP RTCP	During the media playing, the application may need to adjust the playing time to be synchronized.
	Media	Media server→	HTTP	The media server may need to list the current media content for a media

Table 9-3 – RP protocols used by other media services

RP	Type	Direction	Protocols	Description
	presentation	Media player		player.
* NOTE – Media synchronization may be performed in a higher-level component, for example in a multimedia application framework e.g., [b-ITU-T H.761].				

10 Security module

This clause describes and specifies the security requirements to support interworking capabilities among IPTV terminal devices.

A full description of IPTV terminal device security modules is found in [ITU-T H.721], as well as full-fledged terminal device and mobile terminal device, which are defined in [ITU-T H.722] and [ITU-T H.723] respectively.

Security requirements are described in clause 6.3 of [ITU-T Y.1901] and in [b-ITU-T X.1191].

10.1 Home network security

In a home network, some type of firewall product is recommended to be used, such as a network appliance or a personal firewall software package to prevent intruders from scanning and attacking.

In a wireless network, especially, security guarantee provisioning is recommended to be established, for example, by setting user accounts and passwords with encryption for each allowed terminal device.

10.2 System security

System is recommended to authenticate each terminal device with a user account and password when logging into the service.

System is recommended to have anti-theft security capability to prevent unauthorized terminal devices from entering the page by using the URLs of authorized terminal devices.

Appendix I

Use cases for the interactive model

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

This appendix describes use cases for interactivity among terminal devices.

I.1 Sharing an EPG over multiple terminal devices

A user wants to browse some new content released from an Internet video website. By activating the "multi-screen EPG" service, the user can use his/her tablet device and STB to access the same EPG page, while the tablet and STB could be connected together by the home network. The layout of EPG page may be different according to the display capability of tablet or STB. Furthermore, if the target content was found on the tablet EPG, the user could choose to play it from a TV screen via an STB.

In another application, a user could recommend media content to a friend or make a bookmark. Then the friend could receive the recommendation or browser the bookmark from other terminal devices.

Figure I.1 shows an example of sharing an EPG in different terminal devices.

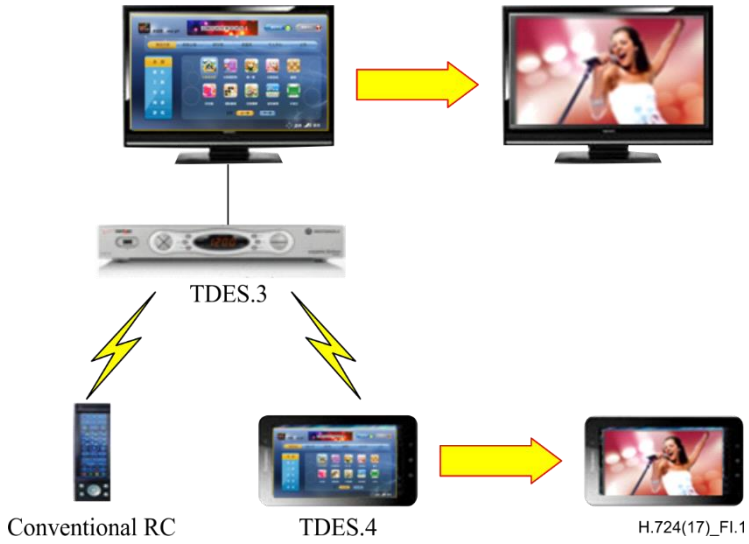


Figure I.1 – EPG and media content sharing over multiple TDs

I.2 Remote control over multiple terminal devices

Using a tablet or other touch-screen enabled device may provide a more convenient remote controller GUI then a conventional remote controller. While a user is watching a programme on a TV screen, the user could use a tablet or smart phone remote controller GUI to control media playback instead of a conventional remote controller with options such as fast forward, stop and record. Figure I.2 shows a remote controller over multiple TDs.

Similar to the above case, any two terminal devices should be first connected together and they could then directly or indirectly communicate with each other (depending on the way they are connected).

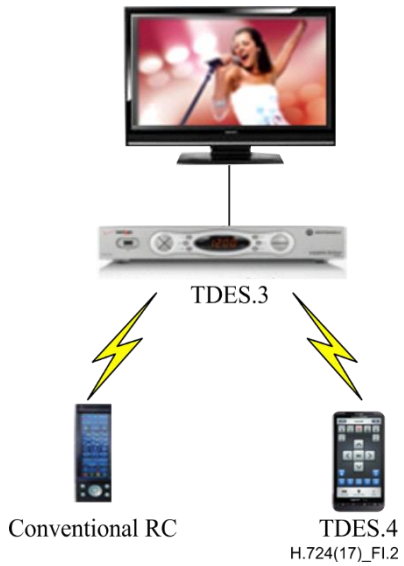


Figure I.2 – Remote controller over multiple TDs

I.3 Sharing media files/streams over multiple terminal devices

A user has his friend visit his home. His friend wants to share some pictures or a short movie with him, which is stored in his mobile phone or tablet. His friend could choose to connect the phone or tablet into the home network. The user can then choose to use his TV set to display the media content list and choose one of his TVs to play the pictures or videos. Such a DLNA scenario is shown in Figure I.3.

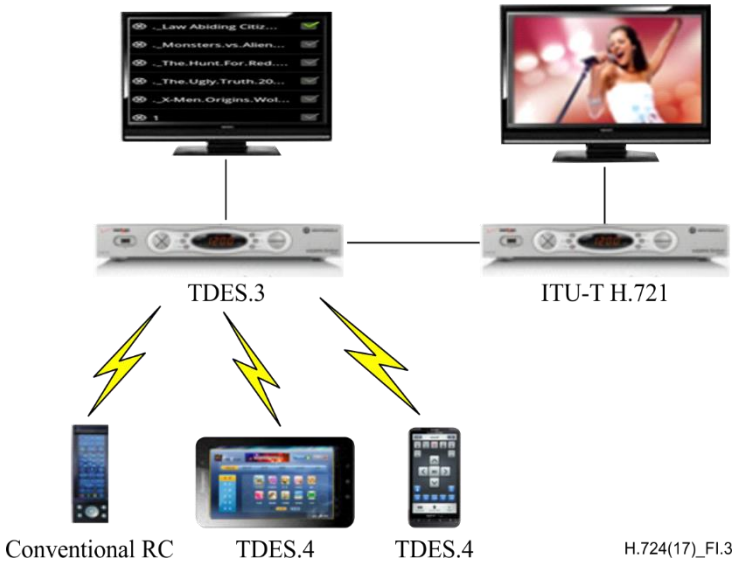


Figure I.3 – Media sharing over multiple TDs (DLNA scenario)

Another case of media sharing is to stop media playing from one terminal device and resuming the media from other terminal device, as shown in Figure I.4. In North America this is called a multi-room digital video recorder (DVR).

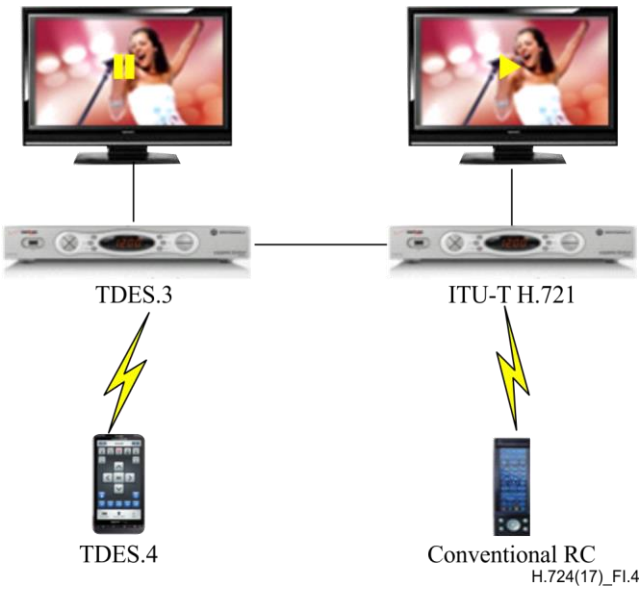


Figure I.4 – Stop and resume media play from different TDs (content migration)

I.4 Consuming extra content on multiple terminal devices

For multi-device services, a content/service provider may attach an extra content or application to the main content, for example, the content/service provider may attach a trailer to a movie, or an advertisement for a football match, etc. The extra content is valid only when the user selects its main programme.

When the user browses the EPG or selects a programme on TV, he can see that a documentary programme about an amazing city may have an extra electronic game or a puzzle related to that city that is attached to this programme. When the user confirms to watch the documentary programme from TV, he can simply ignore the extra electronic game, or he can push the game to another terminal device such as tablet and play the game on the tablet. The expiry time depends on the content or service provider.

Figure I.5 – Consuming coupled content on multiple terminal devices

I.5 Requirements mapping on scenarios

General requirements

1) All terminal devices are recommended to be connected together via an IP or a non-IP network.

2) The IPTV architecture multi-device interworking is recommended to be able to discover terminal devices within the network.

3) The system is recommended to authorize the login request from multi-devices by using legitimate user accounts

4) The system is recommended to be able identify user accounts from multi-devices that are in the same home network and are able to interact with each other.

Specific requirements

1.1 Sharing/interactive an EPG over multiple terminal devices (collaborative EPG)

The system should provide basic video and audio adaptation capability according to the display of a tablet (wireless device) and STB.

1.2 Remote control over multiple terminal devices (multi-screen controller)

The system should provide the related remote controller GUI to the display capability of the tablet (or smart phone).

1.3 Sharing media files/streams over multiple terminal devices (multi-screen media/file sharing)

1) The tablet (wireless device or mobile phone) should provide a file-based download function in offline media sharing mode.

2) The tablet (wireless device or mobile phone) should provide streaming service function in online media sharing mode.

1.4 Consuming extra content on multiple terminal devices for multi-device services (multi-screen content sharing)

The system should provide the extra content related to the main programme.

I.6 Mapping between service scenarios and interwork instances

This clause describes the relationship between service scenarios and interworking instances.

Table I.1 – Mapping between service scenarios and interwork instances

Service scenario	Terminal type/functional roles	Interworking instance option
I.1 Sharing EPG over multiple terminal devices		
Multi-screen EPG	ITU-T H.722/Media server; ITU-T H.723 (or ITU-T H.721) /Media player	Interworking instance (3/4)
I.2 Remote control over multiple terminal devices		
Remote content control	ITU-T H.722/Media server; ITU-T H.723/Media controller	Interworking instance (2)
I.3 Sharing media file/stream over multiple terminal devices		
Remote content discovery & playing locally	ITU-T H.722/Media server; ITU-T H.723/Media player/Media renderer	Interworking instance (1)
Content playing sharing	ITU-T H.722/Media server; ITU-T H.723 (ITU-T H.721)/Media player/Media renderer	Interworking instance (1/3)

Table I.1 – Mapping between service scenarios and interwork instances

Service scenario	Terminal type/functional roles	Interworking instance option
Content migration	ITU-T H.722/Media server; ITU-T H.721/Media player/Media renderer; ITU-T H.723/Media controller	Interworking instance (5)
I.4 Consuming extra content on multiple terminal devices		
Coupled content playing	ITU-T H.722/Media server; ITU-T H.723/Media player/Media renderer	Interworking instance (3)
NOTE – These scenarios may also be implemented as a specific application based on a multimedia application framework, such as [b-ITU-T H.761]. Such an MAFR can make use of the functional roles as defined in this Recommendation to provide higher-level interworking modes.		

Appendix II

Multi-device synchronization schema

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

This appendix describes the several synchronization schemas that could be used for establishing a group of synchronised devices composed of synchronization servers and clients. For different situations, IPTV terminal function (ITF) could be a synchronization server or client, or even the combination of server and client.

II.1 Master-slave control

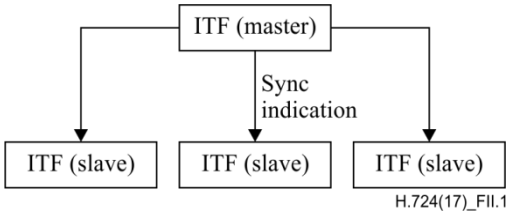


Figure II.1 – Master-slave synchronization schema

This schema consists of one ITF as a synchronization master device and a number of slave devices. All slaves receive the synchronization indications from the master and do not need to send back their status reports. This schema is used when there are a large number of slave devices in which case it would not appropriate to send reports. This schema therefore is appropriate for use in broadcast sessions. The master device here might not be an ITF but an IPTV media server.

II.2 Maestro-based control

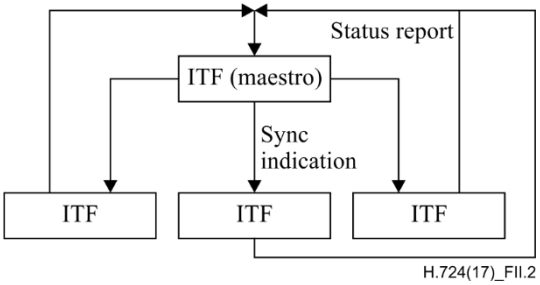


Figure II.2 – Maestro synchronization schema

This schema consists of a number of ITFs. Usually it is used in order to have one device to control other synchronized devices. First, each ITF sends its status report to a maestro device individually by unicast. Then the maestro device summarizes those reports and generates the synchronization indication which is then multicast to all the ITFs.

II.3 Distributed control

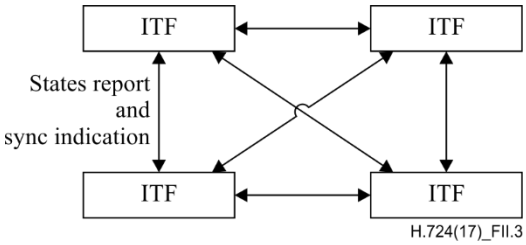


Figure II.3 – Distributed synchronization schema

In a distribution schema, each ITF exchanges status reports with other ITFs. Each ITF calculates the synchronization indication by comparing the report it sent with the other ITF's reports, and then sends (multicast) indications to the other ITFs. This schema is suitable for a small group of devices for synchronization. The synchronization indication could be adaptively changed according to network load and distribution control schema.

II.4 Hierarchical control

This schema introduces the concept of multiple hierarchically arranged application domains. When a child ITF pairs to a parent ITF, they join an application domain and they can be synchronized by the parent ITF. An application domain has a single parent ITF and all of the child ITFs receive the synchronization notifications from this single instance and may or may not send back their status report (it depends of what network protocols are being used, i.e., whether they support unicast or multicast/broadcast connections). A parent device may distribute part of the orchestration duties to other child ITFs. A child ITF may recursively create application subdomains and other ITFs may join as childs. A sub-domain acts as a child in the main application domain and can be composed of a number of ITFs but may use a different synchronization schema. In one sub-domain, an ITF cannot be child and parent at the same time. Moreover, a child ITF in the sub-domain can only receive the synchronization indication from the parent ITF in the same sub-domain.

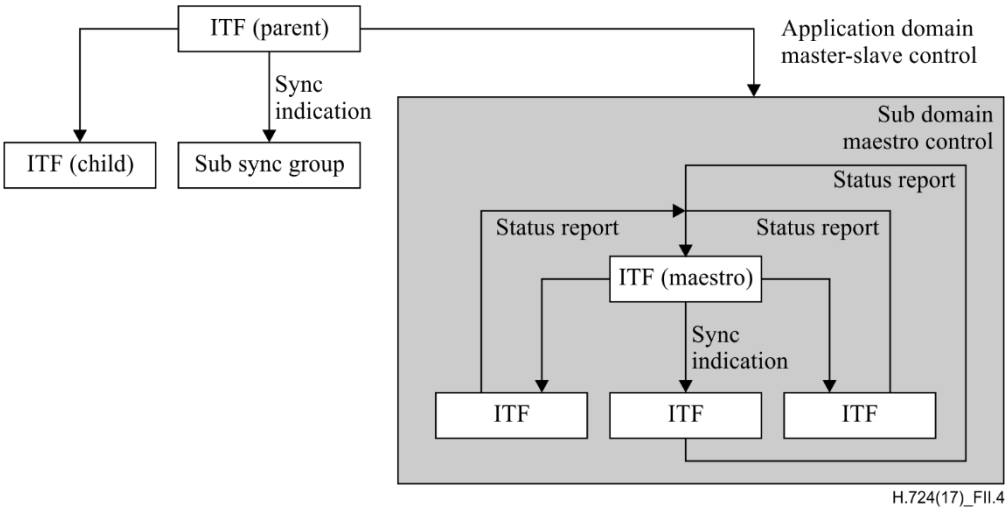


Figure II.4 – An instance of a hierarchical distribution synchronization schema

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