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Multimedia services

Requirements for smart speaker-based intelligent multimedia communication systems

Recommendation ITU-T F.746.13

ITU-T F-SERIES RECOMMENDATIONS

NON-TELEPHONE TELECOMMUNICATION SERVICES

Recommendation ITU-T F.746.13

Requirements for smart speaker-based intelligent multimedia communication systems

Summary

Recommendation ITU-T F.746.13 specifies requirements for intelligent multimedia communication for various types of smart speaker, including those for the reference architecture, smart devices, signalling and platforms, as well as giving a few typical scenario examples. Recommendation ITU-T F.746.13 also specifies requirements for eliminating differences in multimedia communication and access management of heterogeneous devices, to simplify the construction complexity of intelligent multimedia communication systems (IMCSs), to improve the security and reliability of signalling and multimedia data transmission between smart speakers and IMCSs, with a view to finally guaranteeing high-quality multimedia communication service.

History

Edition	Recommendation	Approval	Study Group	Unique ID[*]
1.0	ITU-T F.746.13	2022-03-16	16	11.1002/1000/14960

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Intelligent, multimedia communication system, requirements, smart speaker.

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1   Scope

This Recommendation specifies requirements for smart speaker-based intelligent multimedia communication systems (IMCSs). This Recommendation describes scenarios and requirements for the entire system to support multimedia communication capabilities over smart devices such as smart speakers.

The scope of this Recommendation includes:

–   requirements for smart devices to access IMCSs, including those for multimedia, artificial intelligence (AI) interaction and signalling;

–   requirements for platforms for IMCSs, including those for communications, applications and operations;

–   requirements for security considerations of IMCSs, including those for access control, as well as calling management and transport encryption;

–   typical use cases and application scenarios of IMCSs.

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 G.711]	Recommendation ITU-T G.711 (1988), *Pulse code modulation (PCM) of voice frequencies*.
[ITU-T G.722.2]	Recommendation ITU-T G.722.2 (2003), *Wideband coding of speech at around 16 kbit/s using adaptive multi-rate wideband (AMR-WB)*.
[ITU-T H.264]	Recommendation ITU-T H.264 (2021), *Advanced video coding for generic audiovisual services*.
[ITU-T H.265]	Recommendation ITU-T H.265 (2021), *High efficiency video coding*.
[3GPP TS 24.229]	3GPP TS 24.229 V17.6.1 (2022-03), *3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; IP multimedia call control protocol based on session initiation protocol (SIP) and session description protocol (SDP): Stage 3 (Release 17)*.
[ETSI EN 301 703]	ETSI EN 301 703 V7.0.2 (1999), *Digital cellular telecommunications system (Phase 2+); Adaptive multi-rate (AMR); Speech processing functions; General description (GSM 06.71 Version 7.0.2 Release 1998)*.
[IETF RFC 3550]	IETF RFC 3550 (2003), *RTP: A transport protocol for real-time applications*.
[IETF RFC 4566]	IETF RFC 4566 (2006), *SDP: Session description protocol*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 automatic speech recognition (ASR) [b-ITU-T F.745]: A system that can recognize continuous speech, often having phoneme-sized references, using lexical, syntactic, semantic, and pragmatic knowledge, and reacts appropriately (therefore having interpreted the message and found the corresponding action to be taken). [b-ITU-T P.10]

3.1.2 smart speaker [b-ITU-T Y.4204]: A speaker that is capable of anything beyond just emitting sound.

NOTE – Typically, smart speaker refers to an artificial intelligence speaker that utilizes voice recognition technology and is equipped with Internet connectivity.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 intelligent voice interaction: A technology that is capable of giving appropriate voice feedback according to natural language input by using the speech recognition ability embedded in a terminal or deployed in cloud.

3.2.2 IP multimedia subsystem: An architectural framework for delivering multimedia services over the Internet protocol that is specified in [b-ETSI TS 123 228].

3.2.3 smart display: A smart speaker with a screen to display multimedia information.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AI	Artificial Intelligence
AMR	Adaptive Multi-Rate
AMR-WB	Adaptive Multi-Rate Wideband
ASR	Automatic Speech Recognition
BCLK	Base Clock
IMS	Internet protocol Multimedia Subsystem
ID	Identifier
IP	Internet Protocol
LRCK	Left Right Channel Clock
MCLK	Master Clock
MIC	Microphone
NLP	Natural Language Processing
PBX	Private Branch exchange
PCMA	Pulse Code Modulation A-law algorithm
PCMU	Pulse Code Modulation U-law algorithm
RTCP	Real-time Transport Control Protocol
RTP	Real-time Transport Protocol

| SDK | Software Development Kit |
SDP	Session Description Protocol
SIP	Session Initiation Protocol
SRTP	Secure Real-time Transport Protocol
TV	Television
WLAN	Wireless Local Area Network

5 Conventions

In this Recommendation:

– The phrase "is required to" indicates a requirement that must be strictly followed and from which no deviation is permitted if conformity to this Recommendation is to be claimed.

– The phrase "is recommended" indicates a requirement that is recommended but which is not absolutely required. Thus this requirement need not be present to claim conformity.

6 Overview of intelligent multimedia communication system

Figure 6-1 shows that the system contains an architecture of three layers named: smart device; application; and network. Clauses 7 to 9 provide requirements on three aspects: smart device; multimedia communication platform; and security issues. The network requirement currently lies outside the scope of this Recommendation, it is left for further study. In Appendix I, some typical use cases and scenarios are further described.

The AI interaction module includes:

a) AI capabilities for communication purposes;

b) differentiation calling initiation from home automation control;

c) text or voice-based recognition.
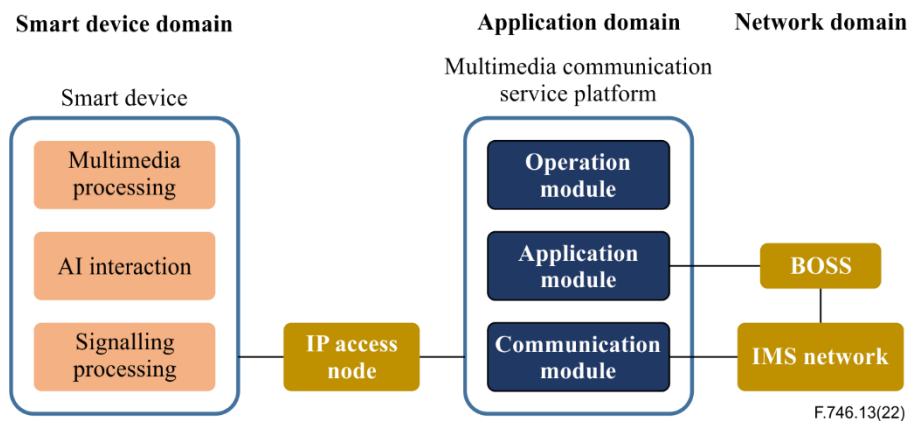
Figure 6-1 – Example of intelligent multimedia communication system architecture

7 Smart device requirement

In general, smart speakers are capable of supporting multimedia communication if they meet the hardware, software and AI interaction requirements in clauses 7.1 to 7.3, which are summarized based on observation of large-scale online services.

7.1 Hardware requirement

For smart speakers, if the operating system is Linux the following requirements are recommended.

a)   The available space of the flash is required to be larger than 20 Mbyte, and the tool chain e.g., compiler GCC 5.0 or above, is required.

b)   The compilation environment is required to support C++ version 11.0, and the underlying audio driver is required to support advanced Linux sound architecture.

For smart speakers with an Android operating system, the following requirements are recommended.

a)   Android version 4.2 or above is required.

b)   The capacity for storing the driver program is recommended to be greater than 9.4 Mbyte.

c)   The flash capacity is recommended to be more than 67 Mbyte.

7.1.1   Requirements of camera and screen for smart display

Table 7-1 lists additional requirements that are recommended for smart display to give a better user experience if multimedia communication is supported.

Table 7-1 – Additional requirements of smart display

Functional blocks		Requirements
Pixels of camera		no less than 2 Mpixels
Display	resolution	800×480 and above
	size	not less than 3.9 inches
	touch mode	multiple types of touch

7.1.2   Requirements of wireless local area network interface

The wireless local area network (WLAN) interface is required to comply with IEEE 802.11 a/b/g/n protocol standards, and the interface of WLAN is recommended to support 802.11ax (WiFi6) protocols [b-IEEE 802.11ax] or 802.11ac protocols [b-IEEE 802.11].

The frequency spectrum is required to support 2.4 GHz (according to requirements for mainstream products in the market), and the frequency spectrum is recommended to support 5 GHz.

It is required to support IPv4, IPv6 protocols.

7.1.3   Additional requirements

Table 7-2 lists requirements for the speaker and microphone (MIC).

Table 7-2 – Additional requirements of speaker and microphone

		Smart Speaker without screen	Smart display
Speaker	Power of single speaker	no less than 2 W	no less than 2 W
	Quantity	no less than one	
	Requirement	full spectrum	
Audio	Frequency response	120-16 kHz (−6 dB)	
	S/N	no less than 75 dB	no less than 75 dB
MIC	Sensitivity	−26 dBFS @94 dB SPL@ 1 kHz −38 dBV/Pa @94 dB SPL@ 1 kHz	
	S/N	no less than 62 dB	
	Material	silicon microphone	
	Quantity	no less than two in home or hotel scenarios	

A list of acoustic requirements for a smart speaker follows.

a)   MIC consistency should be kept within ±3 dB.

b)   The airtightness of the entire MIC is required to meet the requirement that the difference of amplitude frequency response between the blocked case and unblocked case is not less than 15 dB.

c)   The frequency response of the speaker is about 120-16 kHz.

d)   The resonant frequency in the high frequency range should be greater than 8 kHz.

Table 3 lists additional requirements of a MIC array.

Table 7-3 – Additional requirements of microphone array

Category	Requirements
Instruction & calculation	Floating-point computation
	4 500 Dhrystone million instructions executed per second
I2S interface	Left right channel clock (LRCK): 44.1 kHz Base clock (BCLK): 6.144 MHz Master clock (MCLK): 12.288 MHz
	Left alignment, most significant bit
	16 bits, 32-bit wide
	BCLK and MCLK clock synchronization
I2C interface	Bit-rate no greater than 100 kbit/s
	Write operations exceeding 40 bytes
RAM occupied	No more than 50 Mbyte
ROM occupied	No more than 25 Mbyte
Audio re-sampling	Support analogue audio data re-sampling

7.2   Software requirements

Software requirements can be classified into three categories for: a)the smart speaker side; b) access protocols between smart speakers and the platform; c) adaptation between smart speakers and applications.

The software requirements for smart speaker include those for underlying software design, supporting protocols, operating system, security function and management.

The software requirements of access protocols between smart speaker and platform mainly relate to those for service and management.

In order to support communication with the platform, it is required for smart speakers to be able to pre-set a specific software development kit (SDK). With ready-made capability, services such as terminal management, access control and other security control can be achieved.

Manufacturers are required to have the ability to develop embedded software or firmware for their systems to be able to adapt to the SDK and to upgrade and maintain subsequent versions of the software.

7.3   Artificial intelligent interaction requirement

Smart speakers that are capable of supporting multimedia communication are required to support the intelligent interaction requirements, such as voice wake-up and voice recognition, as well as multimedia application interaction requirements, such as quick response and multiple rounds of dialogue (at least two rounds of dialogue and application query).
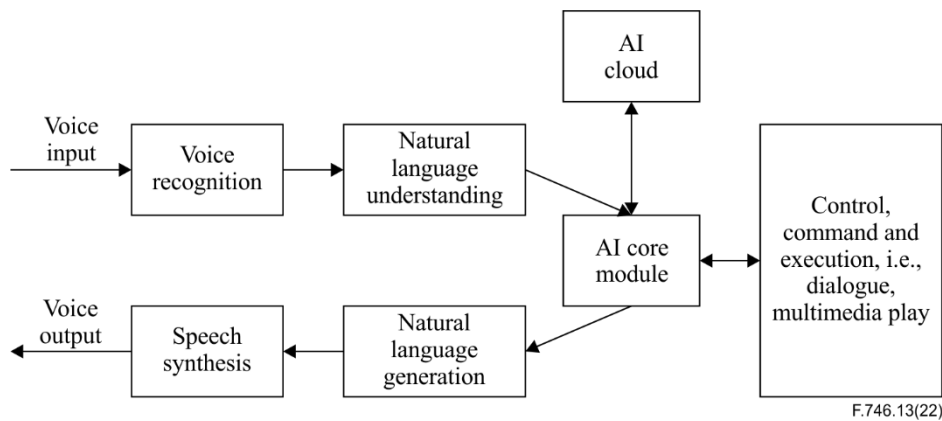
Figure 7-1 – Diagram of intelligent interaction process

To support the functions previously listed, the intelligent interaction process is required to include the following modules or to provide similar functions:

a)   voice recognition: converting voice signals into text signals;

b)   natural language understanding: extracting key information from text signals;

c)   AI core module: being responsible for dialogue management based on key information or completing the execution of corresponding control commands and generating further feedback information;

d)   AI cloud: being used to communicate with the AI core module to deal with AI inference tasks;

e)   natural language generation: generating text signals according to feedback information from the AI core module;

f)   Speech synthesis: converting text signals into speech signals and generating a synthetic voice.

7.3.1   Artificial intelligence-based voice user interaction

A voice trigger that enables users to invoke a speech recognition engine by saying a specific phrase is required.

ASR is required to support basic operation over smart speakers. It is recommended to support far-field ASR [b-Haeb-Umbach] over 3.5 m.

7.3.2   Artificial intelligence-based operation interface

In general, key interaction is supported by most smart speakers. Some smart displays can support multitouch interaction on screens. With the development of AI technologies, it is necessary to support multimedia communication over smart devices. For example, natural language processing (NLP) [b-Guida], used to help understand user voice intention, is required to support multimedia interaction in the data corpus. Here, standard language is recommended, and dialect is not compulsory in the first stage.

7.3.3   Artificial intelligence-based assistance tips

Consideration of advanced intelligent interaction services, such as hand gesture recognition and scene detection, is also recommended to provide a better human-computer interaction experience. With the development of more advanced AI technologies, there can be more mechanisms for users.

8   Signalling requirement

Signalling requirements of smart speakers that have multimedia communication access capability include those for a codec, transmission engine and media streaming.

8.1 Codec requirement

To meet coding and decoding requirements, the following coding and decoding methods, including pulse code modulation A-law algorithm (PCMA) and pulse code modulation U-law algorithm (PCMU) [ITU-T G.711], adaptive multi-rate (AMR) [ETSI EN 301 703] and adaptive multi-rate wideband (AMR-WB) [ITU-T G.722.2] must be supported.

First, to access the Internet protocol (IP) multimedia subsystem (IMS) core network, the corresponding coding methods can be used to complete audio coding, decoding, packaging and disassembling package. Second, support for a variety of video encoding methods, such as VP8 [b-IETF RFC 6386], [ITU-T H.264], [ITU-T H.265] and other video encoding standards, is required. Third, ability to process captured original video in advance to eliminate the effect of ambient light on it is also required. Moreover, adaptation of the code rate to network jitter, delay and packet loss is required to achieve better performance.

8.2 Transmission engine requirement

It is necessary to ensure the safety of transmissions. Commonly used methods are:

a)   solving network traversal issues in peer-to-peer transmissions; and

b)   encryption of audio and video information using SRTP [b-IEFT RFC 3711].

8.3 Media streaming requirement

For media streaming requirements, support for the real-time transport protocol (RTP) and real-time transport control protocol (RTCP) [IETF RFC 3550] is necessary by smart speakers.

8.4 Security requirement

For smart speakers with multimedia communication capability, it is recommended that security requirements include those in clauses 8.1 to 8.3, including encryption of transmission and content. This Recommendation also specifies additional security requirements.

9 Platform requirement

9.1 Communication requirements

The communication module is required to realize the following functions: registration management; business management; calling database management; monitoring management; call management, media agent and IMS agent.

9.1.1 Registration management

The function of registration management is required to support:

a)   allocation of the corresponding phone number according to the pre-allocated unique identifier (ID) for a smart speaker device, such as a mobile equipment identity;

b)   configuration of different formats of phone number for smart speakers, including but not limited to fixed number or mobile phone number;

c)   management of multiple types of smart speakers simultaneously, and conversion of signalling according to operators' requirements;

d)   registration of the corresponding phone number on the IMS for smart speakers, and handling signalling transmission and media stream transmission during a call;

e)   recording of the registration status of pre-allocated ID and telecommunication number, and other information;

f)   initiation of signalling such as session initiation protocol (SIP) and SDP ([b-IETF RFC 3261], [3GPP TS 24.229] and [IETF RFC 4566].

9.1.2 Business management

Deployment of the calling configuration, such as call sequence schedule, simultaneous vibration, sequential vibration and number regulation, should be supported.

9.1.3 Calling database management

The function of calling database management is required to support:

a)   generation of a calling database after each call;

b)   collection of statistics, billing, verification and other calling-related data functions.

9.1.4 Monitoring management

The function of monitoring management is required to support:

a)   recording of the operating status of each component in the communication module;

b)   retrieval, monitoring, alarm and analysis based on the operating status of each component in the communication module.

9.1.5 Signalling controller

The function of signalling controller is required to:

a)   be supported in the IMS system, for which it should use SIP signalling to realize authentication for smart speakers and servers, signalling routing, session control (simultaneous vibration, sequential vibration, session management and control), media control, multiple device control, and other functions;

b)   support SIP and SDP according to [3GPP TS 24.229] and [IETF RFC 4566].

9.1.6 Media agent

The function of media agent is required to support:

a)   establishment of media links between smart speakers and additional functions, including video synthesis, audio mixing, transcoding and data forwarding;

b)   the following codecs: PCMA/PCMU [ITU-T G.711], AMR [ETSI EN 301 703] and AMR-WB [ITU-T G.722.2];

c)   the codec in [ITU-T H.264].

9.1.7 Internet protocol multimedia subsystem agent

The function of an IMS agent is required to support:

a)   the establishment, modification and release of multimedia communication service;

b)   signalling, receiving and forwarding between the signalling controller and the IMS system;

c)   signalling conversion and routing;

d)   signalling interaction using SIP and SDP [3GPP TS 24.229] and [IETF RFC 4566];

e)   RTP and RTCP [IETF RFC 3550] to support multimedia communication.

9.2 Application requirement

The application module is required to manage: accounts; logins; and calling.

9.2.1 Account management

The function of account management is required to support:

a)   storage of phone numbers, authentication passwords and other account-associated information when the service is activated;

b)   enquiries of service plan information;

c)   the maintenance and management of smart speaker information, including device serial number and authentication information.

9.2.2   Login management

The function of login management is required to support:

a)   acquisition of configuration information, including business configuration, account information, authentication account number and authentication password during the login procedure;

b)   synchronously recording of device login operations.

9.2.3   Calling management

The function of call management is required to support:

a)   phone number querying and corresponding name display;

b)   telephone address list management;

c)   the maintenance and management of calling rules, including timeout, calling transfer and calling sequence.

9.3   Operational requirement

The operation module is required to realize the following functions: platform configuration; business configuration; operation and maintenance management.

9.3.1   Platform configuration

The function of platform configuration is required to support:

a)   software management of the platform, including service registration and discovery, configuration centre, service gateway, and service degradation;

b)   the configuration of hardware equipment, including load balancing and message clustering.

9.3.2   Business configuration

The function of business configuration is required to support:

a)   service configuration, including account type, authentication method, account data verification, data synchronization, and some others;

b)   configuration of calling rules, white list for controlling users and other daily operational management.

9.3.3   Operation and maintenance management

Several operation and maintenance functions, including containerized automatic deployment, resource status monitoring, log monitoring management and real-time service alarms should be supported.

Appendix I

Typical use cases and scenarios

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

The typical IMCS has been deployed by China Mobile with AI-based multimedia calls (AIcall), which has now served 5.6 million registered users all over China. The activity ratio of AIcall has improved by over 200% when compared to that of legacy fixed lines.

I.1 Family communication

The smart speaker-based multimedia communication service can be used in family communication scenarios to satisfy a variety of communication demands, such as realizing high-quality audio or video communication on multiform devices with different scene sizes.

It is convenient that the embedded AI speech recognition function helps people realize different interactions, such as intelligent voice interaction, keyless operation as well as wake-up and calling anyone in the family. When people use voice over long-term evolution to call these multiform devices at home, all devices, including television (TV), with smart displays respond with video or audio calls subsequently or simultaneously. People can answer calls on TV to experience the high definition and immersive calling service or directly on smart speakers for easy usage.

I.2 Family and community security

For traditional communities, demands on the ability of audio or video communication are getting urgent for common surveillance devices, such as home pads and peephole video doorbells. A variety of multiform smart devices can easily enjoy services via remote internal upgrade with a specific SDK.

Existing smart devices, such as TVs, speakers and phones, can be used to link with home pads and peephole doorbells to provide high-quality video calls and other interactive services.

I.3 Hotel service

The smart speaker-based multimedia services are suitable for smart hotel scenarios. Use of multiform smart terminals integrated with IMS, cloud private branch exchange (PBX) and AI technologies, can provide users with intelligent customer service, information queries and other special services.

Various smart terminals in hotel rooms can be used to make cross-network and cross-domain calls with the help of intelligent voice interaction. In addition, users can also contact the hotel reception via these smart terminals as well as to receiving some specific services such as wake-up calls, renewal confirmation, cleaning, maintenance and meal delivery.

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[1] Superseded.

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