Recommendation ITU-R BT.2075-5

(05/2023)

BT Series: Broadcasting service (television)

Integrated broadcast-broadband system

Foreword

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Series	Title
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BR	Recording for production, archival and play-out; film for television
BS	Broadcasting service (sound)
BT	**Broadcasting service (television)**
F	Fixed service
M	Mobile, radiodetermination, amateur and related satellite services
P	Radiowave propagation
RA	Radio astronomy
RS	Remote sensing systems
S	Fixed-satellite service
SA	Space applications and meteorology
SF	Frequency sharing and coordination between fixed-satellite and fixed service systems
SM	Spectrum management
SNG	Satellite news gathering
TF	Time signals and frequency standards emissions
V	Vocabulary and related subjects

Note: *This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.*

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RECOMMENDATION ITU-R BT.2075-5[1]

Integrated broadcast-broadband system[2, 3]

(Question ITU-R 131-1/6)

(2015-2017-2019-2020-2022-2023)

Scope

This Recommendation provides guidance in choosing an integrated broadcast-broadband (IBB) system and in harmonizing IBB applications across the multiple systems. The guidance is described in terms of service capabilities and technical elements of the IBB systems as well as harmonization of IBB applications.

Keywords

Integrated Broadcast-Broadband (IBB), HbbTV, Hybridcast, TOPSmedia, Ginga

The ITU Radiocommunication Assembly,

considering

a) that Question ITU-R 131-1/6 has invited the ITU-R to study, *inter alia*, what data structure(s) is(are) most suited to conveying multimedia information to digital broadcast receivers and what application programming interfaces (APIs) should be specified for multimedia applications in broadcasting and webcasting platforms;

b) that Report ITU-R BT.2267 describes several integrated broadcast-broadband (IBB) systems;

c) that Recommendations ITU-R BT.2037 and ITU-R BT.2053 define requirements of IBB systems;

d) that devices with broadband Internet access are becoming widely available and offer multimedia applications;

e) that an ability to provide connected-TV enabled devices with already integrated off-the-shelf applications is of relevance to the end-user;

f) that an addition of content delivery over broadband network to the broadcast channel optimizes the bandwidth usage of the broadcast channel;

g) that common platforms are desirable for production and international exchange of IBB content and applications;

h) that harmonization of applications among IBB systems facilitates deployment of IBB services internationally,

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[1] This Recommendation should be brought to the attention of ITU-T Study Groups 9 and 16.

[2] Integrated broadcast-broadband system is a system in which broadcasting operates in parallel with broadband telecommunication systems and provides an integrated experience of broadcasting and interactivity by combining media content, data and applications from sources authorized by the broadcaster.

[3] This Recommendation is a part of the family of Recommendations and Reports on IBB systems.

recommends

1   that administrations, broadcasters, and related industries wishing to implement an IBB system should consider the service capabilities and technical elements of the IBB systems described in this Recommendation;

2   that the IBB systems listed in the Annex should be considered for the choice of an IBB system and implementation of IBB services.

Annex

1   Introduction

This Recommendation provides guidance information for administrations, broadcasters, and related industries to consider implementing an IBB system. Section 3 describes the IBB systems while §§ 4 and 5 describe the service capabilities and technical elements of the IBB systems. Section 6 describes the harmonization of applications among different IBB systems.

2   Abbreviations

AAC   Advanced audio coding

ABNT   *Associação Brasileira de Normas Técnicas* (Brazilian technical standards association)

ACAP   Advanced common application platform

AIT   Application information table

API   Application programming interface

ARIB   Association of Radio Industries and Businesses

AVC   Advanced video coding

BML   Broadcast markup language

CC   Common core

CE   Consumer electronics

CEA   Consumer Electronics Association[4]

CENC   Common encryption

CORS   Cross-origin resource sharing

DAE   Declarative application environment

DASH   Dynamic adaptive streaming over HTTP

DNS   Domain name system

DNS-SD   DNS-based service discovery

DRM   Digital rights management

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4 In 2015, CEA was renamed CTA (Consumer Technology Association).

DSM-CC   Digital storage media command and control

DTV   Digital Television

DVB   Digital video broadcasting

EBU   European Broadcasting Union

EPG   Electronic programme guide

ETSI   European telecommunications standards institute

HDR   High dynamic range

HE-AAC   High-efficiency advanced audio coding

HEVC   High-efficiency video coding

HFR   High frame rate

HLS   HTTP live streaming

HTML   Hypertext markup language

HTTP   Hypertext transfer protocol

HTTPS   Hypertext transfer protocol secure

IBB   Integrated broadcast-broadband

IMSC   Internet media subtitles and captions

IP   Internet protocol

IPTV   Internet protocol television

IPTVFJ   IPTV forum Japan

ISDB   Integrated services digital broadcasting

JSON   JavaScript object notation

MMT   MPEG media transport

MPEG   Motion picture expert group

NCL   Nested context language

NGA   Next generation audio

OIPF   Open IPTV forum

PVR   Personal video recorder

REST   Representational state transfer

RTP   Real-time transport protocol

RTSP   Real time streaming protocol

SI   Service Information

SSDP   Simple service discovery protocol

SSL   Secure sockets layer

SVC   Scalable video coding

TCP   Transmission control protocol

TLS   Transport layer security

TS	Transport stream
TT	Timed text
TTA	Telecommunications technology association
TTML	Timed text markup language
UDP	User datagram protocol
UHDTV	Ultra-high-definition television
UI	User interface
UPnP	Universal plug and play
URI	Uniform resource identifier
URL	Uniform resource locator
VOD	Video on demand
W3C	World Wide Web Consortium
WebVTT	Web video text tracks
XML	Extensible markup language

3   The IBB Systems

3.1   System definition

The IBB Systems considered in this Recommendation are defined by the following specifications or standards.

HbbTV	For HbbTV1.5: ETSI TS 102 796 V1.2.1 (2012) http://webapp.etsi.org/ewp/copy_file.asp?wki_id=39272
	For HbbTV 2.0.2: ETSI TS 102 796 V1.5.1 (2018) https://www.etsi.org/deliver/etsi_ts/102700_102799/102796/01.05.01_60/ts_102796v010501p.pdf[5]
Hybridcast	IPTVFJ STD-0010 V2.4, STD-0011 V2.7 and STD-0013 V2.10 http://www.iptvforum.jp/en/download/
	ARIB STD-B62 V2.2 https://www.arib.or.jp/english/std_tr/broadcasting/sb_ej.html
TOPSmedia	HTML5 based Smart TV Platform, TTAK.KO-07.0111/R1 http://www.tta.or.kr/eng/new/standardization/eng_ttastddesc.jsp?stdno=TTAK.KO-07.0111/R1

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[5] NOTE – HbbTV 2.0.2 supersedes previous versions of HbbTV 2.0.

Ginga
ABNT NBR 15606 (2018) series
http://forumsbtvd.org.br/legislacao-e-normas-tecnicas/normas-tecnicas-da-tv-digital/english/

Recommendation ITU-T H.761 (2014), Nested Context Language (NCL) and Ginga-NCL
http://www.itu.int/rec/T-REC-H.761

3.2 System summary

3.2.1 Hybrid Broadcast Broadband TV

Hybrid broadcast broadband TV (HbbTV) is an industry standard providing an open and business neutral technology platform that seamlessly combines TV services delivered via broadcast with services delivered via broadband and also enables access to internet only services for consumers using connected TVs and set-top boxes.

The HbbTV specification is based on existing standards and web technologies including OIPF (Open IPTV Forum), CEA, DVB and W3C. The standard provides the features and functionality required to deliver feature rich broadcast and internet services. Utilizing standard Internet technology, it enables rapid application development. It defines minimum requirements simplifying the implementation in devices and leaving room for differentiation, this limits the investment required by CE manufacturers to build compliant devices.

For a Connected TV set that is equipped with the HbbTV function, the consumer just has to push the red button on the TV's remote control to make the HbbTV launch page of the corresponding broadcaster visible. Subsequently, the end-user can select all services (incl. video-on-demand (VOD) and search functions) that are offered by or via this broadcast service specific portal. Example: A user would like to have more information on, say "Napoleon". The result of the search will be a list of all Napoleon-related video clips that are stored and offered by the collaborating broadcasters. Potentially, sound radio programmes and adapted Web-pages (incl. pictures and text files) could also be included in the result list. Viewing of the retrieved content is currently accomplished on the TV set but may in future also happen on a second screen, e.g. on a tablet computer.

HbbTV was developed in 2009 and first standardized by ETSI in 2010. Version 1.5 of the HbbTV specification has been published by the HbbTV Consortium in April 2012. Standardization of HbbTV 1.5 as ETSI TS 102796 v1.2.1 took place by ETSI in November 2012. Amongst other new features, adaptive streaming (in line with MPEG-DASH6) is supported. The latest version is HbbTV 2.0.1, published by ETSI as ETSI TS 102 796 V1.4.1 in August 2016. It includes an HTML browser profile and a number of additional features (many of them in the domain of companion screen integration and stream synchronization). In September 2018, the specification was updated to version 2.0.2 and published by ETSI as ETSI TS 102 796 V1.5.1 (2018-09). HbbTV 2.0.2 adds support for HDR (High Dynamic Range), HFR (Higher Framerates) and NGA (Next Generation Audio).

HbbTV is used for information, education and entertainment (e.g. catch-up TV). It is also used for commercial applications (music download, online shopping, (targeted) advertisement, etc.). HbbTV is very suited to provide access services for people with disabilities: signer video, audio description, spoken subtitles, multi-lingual text subtitles, multi-language sound tracks or additional sound tracks with clear(er) audio dialogues, etc. It was also demonstrated that HbbTV represents a prime means to alert the general public in case of a crisis (automatic popup of alert messages).

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6 The acronym DASH stands for "Dynamic Adaptive Streaming over HTTP", an MPEG standard for adaptive bit-rate media streaming (ISO/IEC 23009).

3.2.2   Hybridcast

Hybridcast, the IBB system that uses HTML5, was standardized in Japan for versions 1.0 and 2.0 in March, 2013 and June, 2014 respectively. The system facilitates the offering of services through a combination of broadcast and broadband telecommunication resources and features. The latest specifications considered most of the requirements in Recommendations ITU-R BT.2053 and ITU-T J.205 including broadcast centric scenario. To achieve the required functionalities, the specifications define system model, application model, application control signals, receiver behaviour, additional APIs, etc. The specifications also define mechanisms and functionalities for companion device collaboration, non-broadcast-oriented managed application, broadcast-independent managed application, application programming interfaces (APIs) for accurately synchronized presentation of video or graphics with broadcast video, application invocation for playing back of VOD or recordings, and support for MPEG-DASH.

In addition, to support interactive ultra-high definition television (UHDTV), ARIB STD-B62, 'the second generation multimedia coding scheme for digital broadcasting', was standardized in July 2014. ARIB STD-B62 defines Hybridcast application environment for UHDTV with MPEG2-TS and MPEG media transport (MMT). When using MPEG2-TS, existing digital broadcasting standards can be used for interactive UHDTV services. When using MMT, ARIB STD-B62 states how Hybridcast application environment works with MMT.

One of the system specifications, IPTVFJ STD-0010, defines system model, application model, application control signals, transport protocols, behaviour for using VOD, monomedia coding, and receiver functions. IPTVFJ STD-0011 defines HTML application structure, behaviour and syntax of elements, and additional objects and APIs. IPTVFJ STD-0013 defines additional details and supplemental information including device discovery protocols, communication protocols between a TV and a companion device, a receiver tune function of the companion device, an application launch function on a TV from the companion device, and MPEG-DASH profiles for on-demand content playback.

In Hybridcast standards, three types of applications are defined to allow flexible and varied IBB services. Broadcast-oriented managed application is an application which is strictly associated to broadcast channels. This type of applications is controlled by an application control signal delivered over broadcast signals to launch and terminate such applications. Non-broadcast-oriented managed application is an application authorized by broadcasters and allowed access to broadcast resources. Non-broadcast-oriented managed applications are allowed to be presented with broadcast programmes simultaneously, and end-users can control the launch and termination of the applications at any time regardless of the selection of broadcast channel. Broadcast-independent managed application is an application that is launched when broadcast services are not selected but still authenticated by broadcasters. This type of applications can be launched or terminated by means other than broadcaster signals. If a broadcast signal is being received before start-up, this type of application can be launched by the instruction of the broadcast signals.

All Hybridcast applications are under control of application control information. To provide service associated IBB services which is tightly combined with broadcasting services and can be provided through broadcast-oriented managed applications, broadcaster's authorization is required. This can be achieved by an Application Information Table (AIT) to be included in the broadcast signal or the service associated IBB services to be authorized by an integrity check server. To provide stand-alone IBB services independent from broadcast channels, non-broadcast-oriented managed applications and broadcast-independent managed applications can be used. For non-broadcast-oriented managed applications, it is assumed that a receiver obtains application control information from repository servers. Application control information for this type notifies broadcast and receiver resources the application accesses. Broadcasters provide application control information that contains information on execution condition and access restriction to broadcast resources. A receiver evaluates application

control information from both application repository and broadcasters, and determines how to manage the application. Formats of application control information are defined in ARIB STD-B24, IPTVFJ STD-0011 and ARIB STD-B60 each of which is used for relevant delivery channels and services. Broadcast-independent managed applications also operate as stand-alone, similar to non-broadcast-oriented managed applications, but operate only when the receiver does not tune a specific broadcast channel. This type of applications can access broadcast resources (such as a list of receiving broadcast channels) and can be tuned to a broadcast channel. In this type of application, authorization is achieved only by the integrity check server.

Hybridcast services were launched in September 2013. Hybridcast is used to offer a variety of information including news, weather, stock market information, Electronic Program Guide (EPG), and VOD as well as program related services for quiz shows. HTML5 allow the provision of rich and useful services by involving existing web servers and thus the number of services that use Hybridcast is increasing rapidly.

3.2.3   TOPSmedia

TOPSmedia (TV Open Platform for Smart media) is an open smart TV platform standard that specifies the web runtime environments for smart TV application based on state-of-the-art HTML5 technologies. (The official title of the standard is "HTML5 based Smart TV Platform, TTAK.KO-07.0111/R1") An application in compliance with this specification can be developed and deployed taking advantage of HTML5 features and interfaces, and will provide the same user experience on smart TV receivers from various broadcasting systems like terrestrial, cable, satellite and IPTV.

This specification suggests four criteria to define smart TV application's types considering smart TV's specific features different from PC or smart phone. They consist of execution method, application packaging, broadcasting resource relation and channel bound.

According to four criteria, application can be divided into signal application, store application and broadband application, or divided into package application and non-package application, or divided into broadcast activated application and broadcast inactivated application, or finally divided into channel bound application and channel unbound application. These kinds of application types define the specific smart TV receiver's behaviour according to these types of requirements.

Furthermore, it defines smart TV extended APIs that is the set of interfaces to support smart TV specific features such as smart TV application, broadcasting resources, smart TV devices and other advanced functionalities.

Through the extended APIs, smart TV application can use interfaces to manage current running application like create, destroy and key/permission control, to control broadcasting video, channel and program, to get information about manufacturer, model and version. Besides, the extended APIs also supports multiscreen interfaces to communicate and work together with companion devices like smart phone or tablet and digital rights management (DRM)7 interfaces to present protected contents.

Finally, to support the application's lifecycle control according to application signal provided by broadcaster, this specification defines an application signal profile based on AIT of ETSI TS 102 809. It defines application package profile for configuration and compression format to support download and install from application repository. Furthermore, it has other features like protocol and contents formats, receiver minimum requirements and own profile definitions. This specification has been developed in continuous relationship with the standardization committee of TTA (Telecommunications Technology Association). The next version will include new features like

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7   The term 'digital rights management' (DRM) refers to the management of user access to protected content and protected services.

content synchronization, remote application control, advanced user input like gesture and voice control, T-commerce and so on. This future version is expected to be completed during the year 2015.

Currently, a few of the cable and IPTV broadcaster in Korea have been developed and tested smart TV receivers compliant with this specification, and it is expected that they will start an official launch of the TOPSmedia during the year 2015.

3.2.4   Ginga

Since its first version, Ginga middleware targets the integration of DTV and broadband services. Ginga was developed in 2006 and firstly standardized by ABNT (Associação Brasileira de Normas Técnicas) in November 2007. The Ginga specifications have continuously evolved ever since through the introduction of new receiver profiles. The first profile introduced is known as profile A (FSA_09 for full-seg or OSA_09 for one-seg) and the latest profile is known as profile D (FSD_09 for full-seg or OSD_09 for one-seg). IBB support in Ginga is provided by functional components and APIs defined throughout its subsystems, which include the Ginga Common-Core, Ginga-NCL (mandatory in all interactive receiver profiles – A to D), Ginga-J (optional in receiver profiles A to C, not applicable in receiver profile D) and Ginga-HTML5 (mandatory in receiver profile D). Their current specifications, standardized under the ABNT NBR 15606 (2018) series, fully address IBB requirements as specified in Recommendation ITU-R BT.2053.

In Ginga, application signalling and life-cycle control is delivered by using application information table (AIT), in accordance with ABNT NBR 15606-3. The AIT can signal applications bounded to the DTV Service or Service Associated Applications (delivered via broadcast or broadband). The signalling and life-cycle control are managed by selected broadcaster.

Additionally, applications can be launched by Stream Event editing commands, user selection among the available applications (installed or signalled) via Application Catalogue UI, via Ginga CC WebServices app control API or via Ginga CC WebServices deep link API.

DSMCC Object Carousel is used as transport protocol for applications delivered within the DTV Signal. Alternatively, applications can be retrieved through a broadband channel by using the HTTP protocol. The transport protocol mechanism is signalled in the AIT by using the transport protocol descriptor in accordance to ABNT NBR 15606-3.

Once the application is being executed in the receiver, it can use protocols such as HTTP, HTTPS, or more basic IP-based protocols such as TCP sockets and UDP, to communicate with servers or retrieve additional resources (code, images, video, audio, etc.) through a broadband channel.

Ginga-CC delivers applications with their associated media content that can come from broadcast channels or broadband IP services to Ginga-NCL (nested context language), Ginga-J or Ginga-HTML5, depending on the type of application. Ginga-CC includes a remote API that allows for the access and certain degree of control over the broadcast services, based on the REST architectural style. Ginga-CC WebServices (ABNT NBR 15606-11) provides this remote API to broadcaster-authorized Ginga and non-Ginga applications. In this way, any application running on devices in the home network (TV, SmartTV, SmartPhone etc) may be authorized to be part of the IBB experience.

Ginga-NCL is tasked with running NCL applications. NCL applications are collected inside a data structure known as private base. Ginga associates at least one private base with each TV channel (set of services) in which service associated applications are stored. Stand-alone applications are managed in specific private bases: one for resident applications and another for installed applications. Applications in a private base may be edited, started, paused, resumed, aborted, stopped, saved and may refer to each other.

A private base manager component is tasked with supporting signalling mechanism (NCL editing commands and control delivered using AIT table control code field) used to control when and how the application must be active/inactive, installed/removed, available/unavailable, visible/hidden, etc.,

or even if control must be left completely to the end-user. The AppCatUI is an extension of the Ginga middleware that must be provided by the IBB receiver, intended for listing the available applications in the private base data structure that can be launched by the end user, adding, moving and removing applications, in agreement with Recommendation ITU-T J.205.

NCL is the declarative language of Ginga. Its characteristics make it a sound declarative solution for IBB services: the language flexibility; its reuse facility; multi-device support (companion device collaboration); presentation and application content adaptability; API for building and modifying applications on-the-fly; and, mainly, its intrinsic high-level ability for easily defining spatiotemporal synchronisation among media assets (including viewer interactions). For particular procedural needs, e.g. when more complex dynamic content generation is required, NCL provides support to the Lua scripting language. NCL applications have a stricter separation between its content and its structure. NCL does not define itself any media content. Instead, it defines the glue that holds media objects together in multimedia presentations. An NCL document (NCL application code) only defines how media objects are structured and related, in time and space. Each media object of NCL specifies the URI Scheme used to retrieve its content. Depending on the specified scheme, Ginga-NCL knows if it has to get the content from the broadcast signal, from the IP network or from local storage. Ginga-NCL is mandatory in all interactive receiver profiles as defined in ABNT NBR 15606-1.

Ginga-J is an optional procedural environment, based on the Java language. Its stack includes the core API from Recommendation ITU-T J.202 and Recommendation ITU-R BT.1722 (specifically, CDC 1.1, FP 1.1, PBP 1.1.2 and JavaTV 1.1), the JavaDTV set of API as defined in ABNT NBR 15606-6, and a set of system-specific API defined in the ABNT NBR 15606-4.

Ginga-HTML5 (ABNT NBR 15606-10) has been incorporated as another presentation engine into Ginga, starting with receiver profile D. It supports an HTML5 language profile that is a subset of W3C specifications with no extensions for IBB-specific functionalities. The HTML5 profile seeks equivalency with the W3C-specific definitions found in HbbTV 2.0.1. For IBB features, Ginga-HTML5 applications rely on Ginga-CC WebServices to access and control broadcast services, in conjunction with its intrinsic broadband capabilities. In fact, any Ginga (NCL and HTML5) application can make use of Ginga-CC WebServices. This is a possibility also extended to any application running on devices in the home network, if authorized by the user and by the broadcaster.

The first commercial Ginga implementations appeared in 2008. In 2009, NCL 3.0 and its presentation environment Ginga-NCL became part of Recommendation ITU-T H.761 for IPTV services and Recommendation ITU-R BT.1699 and the Ginga-J environment became part of Recommendations ITU-T J.202 and ITU-R BT.1722. Since then, many countries, particularly in South America, have adopted Ginga as the middleware of their terrestrial DTV standards, based on the ISDB-Tb International Standard. More recently (2014), the latest version of Recommendation ITU-T H.761 for IPTV services defines NCL 3.1 and its presentation environment Ginga-NCL which introduces new features to better support IBB DTV services. Currently, work is underway towards NCL Version 4.0.

At the present time, consumer equipment manufacturers offer a large number of models of Ginga-enabled TV sets, set-top boxes and smartphones. There are open source implementations for Linux, Windows, MAC OS, and Android platforms which can be embedded in desktop computers, tablets, smartphones, etc. Some consumer equipment manufacturers offer these open source implementations in their products. Ginga-based applications have been used for information, education, entertainment, online shopping, advertisement, government services, early warning services, etc.

4   Service capabilities of the IBB systems

This clause describes what service capabilities are provided in each system. It has to be noted, however, that this list is not exhaustive and the systems may incorporate more technical elements and that they may differ in which additional elements they provide.

4.1 Items to be considered

Recommendation ITU-R BT.2053 – Technical requirements for integrated broadcast-broadband systems, defines requirements for IBB applications and their environments. From technical perspective, some important requirements to characterize the system are chosen. Furthermore, other items are added from the view point of service provisioning.

– Relationship with interactive TVs

   If the IBB system works with digital TV services which already provide interactive services from other systems, it is important to manage IBB application and interactive content. For example, interactive Digital TV (DTV) service launches first then interactive content switches to the IBB application, or vice-versa. This item describes the capability of managing both services for the system.

– Support various types of IBB services

   IBB services are provided by functions of IBB applications and there are some application types. As described in Recommendations ITU-R BT.2053 and ITU-T J.205, service associated applications are those applications that are part of IBB DTV service. They are delivered or listed as a component part of the DTV service. In addition, within service associated applications, there are two types of applications.

   • Service exclusive applications

      Execution of service exclusive applications (service bounded) must be terminated when the service exhibition is stopped.

   • Service shared applications

      Service shared applications (service unbounded) execution should continue in case the same application is also signalled in the service that is selected next.

   Stand-alone applications are those applications that are not part of IBB DTV service. Stand-alone applications can be launched and terminated at any time through end-users instructions regardless of the broadcast service that is selected.

   Third-party applications are those applications delivered by service providers other than broadcasters. Such applications may or may not have relationship with broadcast programs.

   The type of services, such as programme-related services by service associated applications that are supported conditionally should be described in these items.

– Application lifecycle control

   Lifecycle control is the control of when to start and terminate an application. Lifecycle should be controlled properly in accordance with application context and IBB services. Some applications should be controlled by broadcasters, while others can be controlled by end users.

– Service integrity and security

   Broadcasting content is a subject of rights management. Unintended presentation should be avoided. At minimum, content presentation should be distinguished from other presentation material of applications that are outside the control of broadcasters.

– End user privacy protection

   Applications can be accessed by certain areas in a receiver where personal information is stored. Unauthorized access to such areas should be prohibited.

– Content protection

   A mechanism to protect broadcast content against malicious activity of the applications, including piracy.

– Companion device collaboration

Companion devices are those devices used with an IBB receiver for presentation, interaction and receiver control. Collaboration between the receiver and companion devices is an effective method for these functionalities.

– VOD playback

This describes possible user experience for VOD playback, such as the capability of offering the same or equivalent user experience as that for live broadcasting.

– Applicability to UHDTV

This describes applicability of IBB services with UHDTV broadcasting.

4.2 Comparison of service capabilities

TABLE 1

Comparison of service capabilities

	Hybridcast	HbbTV	TOPSmedia	Ginga
Relationship with interactive TV	Hybridcast can work as an interactive TV environment by delivering of applications and required resources over broadcast signals. In addition, Hybridcast can switch to another interactive TV environment such as broadcast markup language (BML), thus a service can be built by using both. A broadcaster can choose which one should be used first.	HbbTV can work as interactive TV environment with and without broadband connection. Interactive content can be program associated or stand-alone application. HbbTV is usually activated via RED button on a remote control.	It can work as interactive TV environment by running various types of smart TV applications. However, it does not consider to work with another interactive system like ACAP. They work exclusively by the policy of broadcaster.	Ginga can work as interactive TV environment with and without broadband connection. Service associated applications and stand-alone applications are supported. The type of application is signalled by broadcasters and thus identifies if IBB functions will be needed or not.
Support of service associated IBB services	Supported by using broadcast-oriented managed application.	Supported by using broadcast related applications.	Supported by using broadcast activated application.	Supported by using broadcast managed (signalled) applications.

TABLE 1 (*continued*)

	Hybridcast	HbbTV	TOPSmedia	Ginga
Support of stand-alone IBB services	Supported by non-broadcast-oriented managed applications and broadcast-independent managed applications which can be started and stopped by end-users at any time. Execution of and access to broadcast resource by non-broadcast-oriented managed applications are required to be permitted by broadcasters for simultaneous presentation. Broadcast-independent managed applications are not allowed simultaneous presentation, but can access some broadcast-related functions.	Supported A broadcast-independent application is not associated to any broadcast channels. A broadcast-independent application is not allowed to access to broadcast resources.	Supported by using broadcast inactivated application. While the application is running, broadcasting resources like demultiplexer and decoder are suspended and access to them is not allowed.	Supported. Stand-alone applications can be signalled as broadcast managed applications, by using the UNBOUNDED control code in the AIT. Broadcast-independent applications may be authorized to access broadcast resources. Unauthorized broadcast-independent applications are not allowed to access to broadcast resources.
Support of third-party provided IBB services	By using service associated IBB applications, broadcasters or associated service provider can switch to or involve third-party provided IBB services. Third-parties can offer their own services by stand-alone applications as far as broadcasters permit for execution by giving execution and presentation condition to them.	Third-party can provide any application and broadcaster can authorize it by signalling. Under these circumstances, broadcasters signal that application's lifecycle by using AIT.	Third-party can make smart TV application compliant with this standard. To obtain a broadcaster's authorization to access broadcasting resources, a broadcaster can define a policy for the permission of broadcast activated applications.	Service-associated IBB applications can involve third-party IBB services, when signalled by the broadcaster. Third-parties can also offer their own services by stand-alone applications (via Application Catalogue UI) or broadcast-independent applications as long as broadcasters allow their execution, by giving them execution and presentation permissions.

TABLE 1 (*continued*)

	Hybridcast	HbbTV	TOPSmedia	Ginga
Application lifecycle control by provider	Supported	Supported	Supported	Supported
Application lifecycle control by end-user	Stand-alone applications by non-broadcast-oriented managed applications and broadcast-independent managed applications allow control application lifecycle by end-users.	Stand-alone applications can be controlled by end-users.	End-users can download and install applications from an application repository ("app store"). End-users can control the lifecycle for such applications.	Service associated applications can be signalled with specific AIT control codes that enable lifecycle control by the end user. Stand-alone applications can be controlled by end-users. User controls application lifecycle via the Application Catalogue UI.
Service integrity and security	Service associated applications by broadcast-oriented managed applications are considered as under the control of signals provided by broadcasters at all times. For stand-alone applications by non-broadcast-oriented managed applications and broadcast-independent managed applications, broadcasters can grant permission and conditions for execution of each application.	Service associated applications by broadcast related applications are considered as under the control of signals given by broadcasters at all times.	Service associated applications by signal applications and broadcast activated applications are considered as under the control by broadcasters at all times. On the other hand, service associated applications downloaded from a store and broadcast activated applications are considered as under the permission and control of broadcasters.	Service associated applications and some stand-alone applications are under control of signals issued by broadcasters. For broadcast-independent applications, broadcasters can grant permission and conditions for execution.

TABLE 1 (*continued*)

	Hybridcast	HbbTV	TOPSmedia	Ginga
End-user privacy protection	Same as typical web browsers, i.e. local resource access from an application is prohibited.	Same as typical web browsers, For object carousel's resources, original domain definition using DVB schema is specified for CORS.	Same as typical web browsers.	Same as typical in the Web. In the case of Ginga-J applications, they are executed in a sandboxed environment with limited and controlled access to the file system and user properties. Ginga applications can use TLS/SSL Sockets for server authentication and securing user communication.
Content protection	Audio and video content are protected by (DRM). In addition, a dedicated object to access to broadcast video images is defined to avoid image capture by an application.	Using DRM (MPEG CENC) Actual DRM system is defined by each service provider.	DRM-protected contents can be presented by applications using DRM APIs.	Ginga supports DRM methods using MPEG CENC. The actual DRM system is defined by each service provider. Ginga also relies on ABNT NBR 15605-1, which specifies content protection for broadcast A/V.

TABLE 1 (*continued*)

	Hybridcast	HbbTV	TOPSmedia	Ginga
Companion device collaboration	Supported. APIs for communication between applications on a receiver and a companion device allow the creation of a basic service that uses companion devices. In addition, models for communication between many functional entities in a receiver and a companion device such as built-in functions will allow more useful services. A receiver and companion devices can be paired by a device discovery function. The paired companion device can control a receiver for tuning a broadcast channel and launching IBB applications.	Supported from V2.0.	Supported. The smart TV application using multiscreen APIs can discover companion devices like smart phone or tablet and communicate with them.	Supported. Different abstraction levels are supported. In Ginga-NCL, an optional multi-device API allows for easy device collaboration by identifying devices as classes (groups) that can be used to render synchronized media transparently for the programmer. Ginga applications can use available network APIs to implement discovery and communication protocols between DTV receiver and user devices. Ginga-CC WebServices allows for companion device collaboration with Ginga applications and broadcast content.
VOD playback	The application bundled with VOD content can be started by 'tuning to' the content. It is the same for the recordings.	Supported	Supported	Supported

TABLE 1 (*end*)

	Hybridcast	HbbTV	TOPSmedia	Ginga
Applicability to UHDTV	Maximum resolution for Hybridcast is not determined thus UHDTV is supported. ARIB STD-B62 defines how the Hybridcast application environment works with MMT or MPEG2-TS based UHDTV signals.	Supported for the broadcast part. Supported for the broadband part from V2.0 (ITU-T H.265, HDR and HFR (for HEVC via DASH), 4K resolution, NGA)	Not supported yet.	Maximum resolution for main broadcast video is not determined by Ginga. UHDTV formats are supported for broadband and alternative broadcast content (ITU-T H.265, HDR, HFR, 4K resolution, NGA).

5   Technical elements of the IBB systems

This section describes how technical elements are designed in each system. It has to be noted, however, that this list is not exhaustive, and the systems may incorporate more technical elements and that they may differ in which additional elements they provide.

5.1   Items to be considered

a)   Coexistence with interactive TV systems

As described in § 3.1, an IBB system can be built over existing digital broadcasting systems. In some cases, an IBB system is required to coexist with interactive TV systems already deployed. For such cases, information on whether an IBB system is designed with such considerations, and how to do it, is required.

b)   Transport related items

These items describe the delivery channels that are available for service components, i.e. application, content, metadata, and application control signals, on each system. There may be some conditions for combination.

c)   Supported application types

In Recommendations ITU-R BT.2053 and ITU-T J.205, several application types are defined. Supported application types are fundamental system designs of the IBB systems. Hence, describing supported application types to characterize IBB systems is useful.

d)   Application format

Application format is that format used for creating applications such as HTML or Java. Selection of application format affects the capability of IBB systems, ease of deployment and implementation, etc. Future work will identify a common core of the application formats of the IBB systems described in this Recommendation.

e)   Application authentication

Authentication of an application is to ensure execution of a proper application. In IBB systems, this mechanism contributes to mitigate the risk of inconsistent simultaneous presentation of applications and broadcast programmes. Inconsistent presentation may lead to misunderstanding the intention of broadcast programmes. In addition, this mechanism contributes to mitigate the risk of malicious applications. There are several methods for authenticating applications, such as authentication based on the trust chain using delivery channel combinations, or using cryptography. Whereas there are various approaches and mechanisms, having information on a mechanism and/or concept of application authentication in each IBB system is useful.

f)   Security and permission control to access resources

An IBB application requires the access of various resources, including those provided through broadcast channels. An appropriate access control should be essential to maintain copyright, privacy of end users, presentation consistency, etc. Conditions to access control may vary by application, broadcaster, or service provider. This item is to describe mechanisms or related information of each IBB system in order to achieve appropriate security and access control.

g)   Protocols available for broadband access

In IBB systems, various types of information are delivered over broadband channels. This item describes the protocols used over broadband channels for both downward and upward directions.

h) Protocols for broadcast channel, including delivery of application data

This item describes the protocols for broadcast channels for various data and applications.

i) Available delivery channels for application triggering and messaging

The use of application triggering and messaging to notify and/or update information processed by IBB applications is an important aspect for IBB services. This item describes how the signal is delivered to applications.

j) Supported video formats and encoding

This describes supported video formats and their encoding schemes. When an IBB system is capable of video streaming over broadband channels, usable bandwidth consideration may be a factor for selection video formats and their encoding scheme.

k) Supported audio formats and encoding

Similar to supported video formats and encoding, supported audio formats and their encoding scheme should be described.

l) Subtitle control and formats

Subtitle or closed caption is an important component and service for broadcast services. This item describes how an IBB system supports this feature.

m) Storage access and management

Some IBB applications may require local storage in a receiver. When using local storage, functions to access it are required for applications. In addition, storage management mechanisms are required regardless of the required capacity for local storage or IBB services. This item describes how to access and manage local storage by IBB applications or IBB receiver functions.

n) Signalling format and delivery

In general, application signalling is used to advertise the existence of applications, control of application lifecycle, to provide metadata or property information of an application, etc. Describing the information contained in signalling and its delivery method to characterize an IBB system is useful.

o) Synchronization between applications and broadcast programmes

For applications that make progress in accordance with the progress of broadcast programmes, synchronizing with such broadcast programmes is important. In addition, if an application that manages multiple time-constrained materials, such as broadcast stream and streaming content over broadband network, controlling the synchronization between such materials might be required. In device integration, it is important to maintain synchronization between a broadcast programme, an application on a broadcast receiver, and an application on a second screen device in order to provide an integrated user experience to viewers. This item describes the mechanism and purpose of synchronization features of each IBB system.

p) Protocol for device integration

Device link is achieved through communication between devices and/or applications. Protocol for such communication is the subject for standardization in some cases. This item describes information on this.

q) Device discovery protocol for device integration

Device discovery is one of the most important functions for device integration. Device discovery is normally performed in an early stage of the establishment of device integration to find a device or application with which to communicate. There may be various mechanisms for it. The entity, such as an application or preinstalled function in a receiver,

that is responsible for device discovery affects the application behaviour and structure of the APIs of IBB systems.

r)   VOD Playback

Playing back VOD content controlled by an IBB application is natural behaviour. However, time shift for watching a TV programme by using VOD playback instead of selection of a broadcast channel is different, because normally, the IBB application does not start at the moment playback starts. If an IBB system can offer the same user experience for time shift watching as that for live watching, there might be a need for mechanisms that allow to start the same or equivalent application as that for live events. In addition, consideration for 'trick' play is also required.

5.2 Comparison of technical elements

TABLE 2

Comparison of technical elements

	Hybridcast	HbbTV	TOPSmedia	Ginga
Coexistence with interactive TV systems	An API to switch to other interactive TV environment(s) is defined. Application control signals can provide prioritization information that designates what should start first.	To be developed by broadcasters or with associated service provider	It is assumed not to work together with another interactive system like ACAP. They work exclusively by the policy of broadcaster.	Ginga IBB-enabled receivers are capable of presenting interactive content from conventional Ginga DTV services. Application signalling defines the type of application (IBB or DTV)
Available delivery channels for application	Broadcast and/or broadband.	Broadcast and/or broadband.	Broadband only.	Broadcast and/or broadband.
Available delivery channels for content (See Note below)	Broadcast and/or broadband.	Broadcast and/or broadband.	Broadcast and/or broadband	Broadcast and/or broadband.
Available delivery channels for metadata	Broadcast and/or broadband.	Broadcast and/or broadband.	Broadcast and/or broadband	Broadcast and/or broadband.
Available delivery channels for application control signal	Broadcast and/or broadband. Delivery of application control signals over broadband is for cases of application invocation call by another application, including that of other interactive TV standards, such as broadcast markup language, and stand-alone applications	Broadcast and/or broadband. Acquisition of AIT through broadband channel is used for starting broadcast-independent applications. For broadcast-related applications, AIT will be received through broadcast interface.	Broadcast only An application can be signalled and launched via AIT information provided by broadcast.	Broadcast and/or broadband (Rec. ITU-T H.761 specifically). Delivery of application control signals uses (broadcast and broadband) mechanisms available through the AIT and through NCL Editing Commands.

TABLE 2 (*continued*)

	Hybridcast	HbbTV	TOPSmedia	Ginga
Support of service associated application	Supported This type of application can be started by an application control signal transmitted over a specific broadcast channel to which the application belongs.	Supported This type of application can be started by an application control signal transmitted over a specific broadcast channel to which the application belongs.	Supported This type of application can be started by an application control signal transmitted over a specific broadcast channel to which the application belongs. An application downloaded from a store can also be started by end-users as an application that is configured to broadcast activated application (access to broadcast resources are limited by application permission).	Supported. This type of application can be started by an application control signal transmitted over a specific broadcast channel to which the application belongs.

TABLE 2 (*continued*)

	Hybridcast	HbbTV	TOPSmedia	Ginga
Support of stand-alone application	Supported Non-broadcast-oriented managed applications and broadcast-independent managed applications can be used for this type. Application control signals for both applications can include additional information for resources and functions that the applications use. For non-broadcast-oriented managed applications, broadcasters can provide information for execution conditions and access to broadcast resources over broadcast channels. A receiver evaluates information both with the application and from the broadcaster, and controls execution of the application and display management. In some cases, the application may be suspended. Evaluation is performed at every channel change.	Supported A broadcast-independent application can be used for this type. A broadcast-related application can transition or invoke a broadcast-independent application, and can go back to a broadcast-related application in some cases.	Supported A broadcast inactivated application can be used for this type. It can be invoked by a broadcast activated application or be launched by end-users as a downloaded application and broadcast inactivated application.	Supported by using broadcast managed applications, signalled with the UNBOUNDED control code in the AIT. Broadcast-independent applications may be authorized to access broadcast resources. Unauthorized broadcast-independent applications are not allowed to access broadcast resources.

TABLE 2 (*continued*)

	Hybridcast	HbbTV	TOPSmedia	Ginga
Support of third-party application	Supported Non-broadcast-oriented managed applications and broadcast-independent managed applications can be provided by the third-party. An execution control mechanism for the case of third-party application is the same as stand-alone application, i.e. the mechanism is developed with consideration for this case.	Supported A broadcast-independent application can be provided by the third-party, which can be started via an Internet TV portal or transition from a broadcast-related application.	Supported A broadcast inactivated application can be provided by a third-party. If a third-party gets permission from broadcasters, downloaded applications and broadcast activated applications may be provided.	Supported Service-associated IBB applications can involve third-party IBB services, when signalled by the broadcaster. Third-parties can offer their own services by stand-alone applications (via Application Catalogue UI) or broadcast-independent applications as long as broadcasters allow their execution, by giving them execution and presentation permissions.
Application format	HTML5	HTML4/OIPF-DAE in V1.5 and HTML5 from V2.0	HTML5	– NCL 3.0/3.1 NCL applications can embed HTML5, Lua and other NCL child applications – Java – HTML5
Application authentication	Authentication for service-associated applications is achieved by the fact that application control signals are provided by broadcasters. For stand-alone applications, three authentication methods are defined by the difference of the origin of trust chains, application repository, application control signal, or an application.	Authentication for service-associated applications is achieved by the fact that application control signals are provided by broadcasters.	Authentication for signal application and broadcast activated application is achieved by application control signals provided by broadcasters.	Authentication for service-associated applications is achieved by the fact that application control signals are provided by broadcasters. For broadcast-independent or stand-alone applications, a process of application pairing, user and broadcaster authorization is performed.

	Hybridcast	**HbbTV**	**TOPSmedia**	**Ginga**
Security and permission control to access resources	Broadcasters can deliver permission information for access control over broadcast channels.	Broadcast-related applications are considered as trusted applications, and broadcast-independent applications are untrusted applications.	All applications have permission information to access broadcast resources	Broadcast-related applications are considered as trusted applications, and broadcast-independent applications are untrusted applications. Broadcasters can deliver permission information for access control over broadcast channels.
Protocols available for broadband access	HTTP, HTTPS, RTP and MPEG-DASH When MMT is used for broadcast channels, the use of MMT on broadband channels is also available.	HTTP, HTTPs and MPEG-DASH	HTTP, HTTPs, RTSP and MPEG-DASH	TCP sockets, UDP, HTTP, HTTPS, RTSP, RTP, MPEG-DASH or HLS
Protocols for broadcast channel including delivery of application data	MPEG2-TS and MMT	MPEG2-TS	MPEG2-TS	MPEG2-TS
Available delivery channels of application triggering and messaging signals	When MPEG2-TS is used for broadcast channels, DSM-CC stream event is used for this purpose. When MMT is used for broadcast channels, the Event Message Table defined in ARIB STD-B60 is used. For broadband channels, HTTP, HTTPS, and web socket defined in RFC 6455 can be used.	DSM-CC stream event can be used to deliver triggering and message information.	W3C web socket or server-sent event can be used for this purpose.	– DSM-CC stream event – MPEG2 private data sections – any other wrapping to transport NCL Editing Commands in IP networks (Rec. ITU-T H.761 specifically)

TABLE 2 (*continued*)

	Hybridcast	HbbTV	TOPSmedia	Ginga
Supported video formats and encoding	MPEG-2 video, MPEG-4 AVC and HEVC	For broadcast channels, no specifications for video encoding are defined, i.e. video encoding are defined by appropriate specifications for each market. (typically DVB systems) For broadband, MPEG-4 AVC and MPEG-4 SVC are used.	For the broadcast channel, no specification is defined for video encoding, i.e. it complies with the requirements of broadcast system being applied for. For the broadband delivery, MPEG-2 video and MPEG-4 AVC are supported.	Encoding is defined by appropriate specifications of each DTV system. As an example, ISDB-Tb International standard defines H.264 (MPEG-4 AVC) for main broadcasted video. For broadband and alternative broadcast content, ITU-T H.264 and H.265 are supported.
Supported audio formats and encoding	MPEG-2 AAC, MPEG-4 AAC, and AIFF-C	For broadcast channels, no specifications for audio encoding are defined, i.e. audio encoding are defined by appropriate specifications for each market. (typically DVB systems) For broadband, MPEG4 HE-AAC and E-AC3 are used.	For broadcast channel, no specification is defined for audio encoding, i.e. it complies with the requirements of broadcast system being applied for. For the broadband delivery, MPEG-1 Layer 3, MPEG-2 AAC, AC-3 and MPEG-4 HE AAC are supported.	Encoding is defined by appropriate specifications of each DTV system. As an example, ISDB-Tb International standard defines MPEG-4 AAC for main broadcasted audio. For broadband and alternative broadcast content, MPEG4 AAC, AC-3 and E-AC3 are supported. Optionally, AC-4 and MPEG-H 3D Audio can also be supported.
Subtitle control and formats	APIs to control subtitle presentation and to acquire subtitle data are defined. These APIs are designed to be applicable to both ARIB STD-B24 based subtitle format and ARIB-TTML defined in ARIB STD-B62.	A subtitling system which is used for broadcast is also available for broadband if TS container is used. HbbTV V 2.0 (and higher) supports EBU-TT.	APIs to control subtitle presentation and to acquire subtitle data are defined. Subtitle format specifications are defined by the broadcasting system being applied for.	Main subtitle format specifications are defined by appropriate specifications of each DTV system. For broadband and alternative broadcast content, IMSC1 TTML or WebVTT must be supported.

TABLE 2 (*continued*)

	Hybridcast	**HbbTV**	**TOPSmedia**	**Ginga**
Storage access and management	APIs to access non-volatile memory visible only through applications are defined.	Mass storage optionally available locally to the terminal – this is referred to as the "PVR feature".	W3C web storage API can be used for this purpose.	APIs to access non-volatile memory visible only through applications are defined. End-users can also access and manage the storage system through the AppCatUI.
Signalling format and delivery	Application control signals are described in the MPEG-2 private section, MMT-SI format, or XML. Information syntax is defined in ARIB STD-B24, STD-B60, and IPTVFJ STD-0011. MPEG-2 private section format and MMT-SI format are used for delivery of the information over broadcast channels. XML format is used for both broadcast and broadband delivery of the information.	AIT defined by ETSI TS 102 809 V1.1.1 is used.	AIT profiles are defined based on ETSI TS 102 809 V1.1.1.	AIT as defined by ABNT NBR 15606 and NCL Editing Commands are used.

TABLE 2 (*continued*)

	Hybridcast	HbbTV	TOPSmedia	Ginga
Synchronization between applications and broadcast programme	Protocols for application triggering and messaging are used to synchronize applications and broadcast programmes. APIs to detect the time position in the programme for both live and VOD/recordings are available for applications. In addition, APIs for accurate synchronization of multiple streams are also available. The combination of these APIs allows an application developer or service provider to offer extremely flexible time dependent services.	Protocols for application triggering and messaging are used to synchronize applications and broadcast programmes.	To be developed in the next version of the specification.	Supported. Different abstraction levels are supported. Ginga provides access to DSMCC stream events and MPEG2 private data section filtering. NCL Editing Commands can be also used for synchronization. But mainly, an NCL document itself (NCL application code) defines how media objects (including broadcast programme) are structured and related, in time and space.

	Hybridcast	**HbbTV**	**TOPSmedia**	**Ginga**
Protocol for device integration	When using communication between applications on a receiver and a companion device, both standardised protocols in the Hybridcast specifications and proprietary protocols implemented by receiver manufacturers can be used. The communication APIs for using proprietary protocols are defined so that the protocols actually used are invisible to applications. APIs, which originate from a companion device, use standardized protocols to receive requests through HTTP/HTTPS and return information in a structured JSON format.	Direct device-to-device communication is part of HbbTV from V2.0. For integration over the Internet, existing web-based communications and relay servers enable for device integration as application level implementation.	When smart TV applications communicate with a companion device, W3C web socket can be used. Message are encoded according to the JSON format. The actual JSON message is defined in accordance with the multiscreen service providers.	When using communication between applications on a receiver and a companion device only, proprietary protocols implemented by receiver manufacturers are mostly used. The communication APIs for this case are defined so that the protocols actually used are invisible to applications. Ginga-CC WebServices rely mostly on HTTPS for device integration. It also provides discovery mechanisms based on SSDP. Actual protocols for communication between other functional entities will be decided in consideration of the protection of users' interest and business schemes.

TABLE 2 (*end*)

	Hybridcast	HbbTV	TOPSmedia	Ginga
Device discovery protocol for device integration	When using communication between applications on a receiver and a companion device, both standardised protocols in the Hybridcast specifications and proprietary protocols implemented by receiver manufacturers can be used. In the case of standardised protocol for device discovery, Discovery and Launch (DIAL) is supported.	Supported by HbbTV from V2.0	Various zero conf. network like UPnP and mDNS can be used. And then, companion device shall use same network to communicate with smart TV application.	When using communication between applications on a receiver and a companion device only, the proprietary protocols implemented by receiver manufacturers can be used. SSDP is supported for the functionalities provided by Ginga-CC WebServices.
VOD Playback	By sending application control information from a VOD server, a receiver can start the application indicated in the information. A mechanism to detect the playing back position in time by the application is also defined to support trick-play. If a recorder provides similar functions to provide application control information, the same mechanism can be applied to recordings.	By using the streaming API (the CEA-2014 AV Control object)	Basic VOD playback including play control and trick play is supported by HTML5 video element. For VOD playback, MPEG-DASH is also supported.	Supported By using the media-related APIs which by definition includes support for streaming and media control.

NOTE – Content means elements of IBB services of which presentation is controlled by applications, such as video, audio, graphics, either in a form of a file or stream.

6 Harmonization of applications among different IBB systems

All the IBB systems are HTML-based systems. However, applications in these systems are not compatible, and therefore, it is required to build individual application(s) for the same services in each system. To exchange the IBB services and to deploy these services in an area where other systems are used, it is important to harmonize the IBB systems to ensure compatibility with the IBB applications and interoperability across systems.

This section describes and analyses commonality among the IBB systems and equivalency of their functions for achieving harmonization of applications among the IBB systems.

6.1 Comparison of additional objects, properties, and methods

As Hybridcast, HbbTV 2.0, TOPSmedia and Ginga-HTML5 are based on HTML5, functions provided by APIs, elements, attributes, etc. defined in HTML5 and other related Recommendations of World Wide Web Consortium are considered common between these systems.

On the other hand, each system defines additional objects and their properties and methods [8], elements [9], attributes, etc. to provide functionalities needed for IBB systems. Those additions are not common between the systems. However, considering similarity of behaviours of service-associated applications in these systems, there may be similarity or equivalency in those additions in the systems. Table 3 shows equivalent additional objects, properties and methods that have been identified by detailed analysis of the systems. Note that Table 3 does not consider combination of additional methods to provide the equivalent function among the systems and that properties and methods specific to a system in the object are not listed in Table 3. For example, identification of StreamEvent is incompatible between the systems because it is strongly tied to multiplexing scheme, i.e. ARIB data carousel and DVB object carousel.

In the case of Ginga-HTML5, the needed IBB functionalities are enabled by remote APIs based on the REST architectural style, provided by 'Ginga Common Core Web Services' (ABNT NBR 15606-11). Therefore, instead of JavaScript objects' methods and/or properties, Ginga-HTML5 applications access functions and data via HTTP requests and get the returned values mostly in JSON format. Ginga-CC WebServices provides these remote HTTP APIs to broadcaster-authorized Ginga and non-Ginga applications. In this way, any application running on devices in the home network (TV, SmartTV, SmartPhone etc.) may be authorized to be part of the IBB experience. Ginga-NCL (ABNT NBR 15606-2) applications may also access this remote API, if needed, although most IBB functionalities can also be found in its NCLua API.

If considering the conversion of applications, the process of harmonization to convert APIs from one IBB system to another should be based on the equivalency described in Table 3.

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[8] In this context, property and method are the terms used in object-oriented programming. Property represents data or event relevant to an object. Method is a function to give a behaviour of an object.

[9] In this context, the term 'element' is a technical term used in XML. Elements can behave as containers to hold text, elements, attributes, media objects or all of them.

TABLE 3

Equivalent additional objects, properties and methods

	Hybridcast		HbbTV 2.0		TOPSmedia		Ginga
	Object	**Property or method**	**Object**	**Property or method**	**Object**	**Property or method**	**REST API (HTTP request)**
Reference to a broadcasting service	ISDBResourceReference	original_network_id transport_stream_id service_id	Channel	onid tsid sid	Channel	number type	http(s)://<host>/dtv/current-service GET { serviceContextId, serviceName, transportStreamId, originalNetworkId, serviceId }
Interface for an available channel list	List of available channels can be obtained by query to a server.		ChannelList	getChannel()	ChannelList	item()	http(s)://<host>/dtv/service-list GET { { serviceContextId, serviceName, transportStreamId, originalNetworkId, serviceId }, ...}
Application execution control	NavigatorApplicatonManager	getOwnerApplication()	oipfApplicationManager	getOwnerApplication()	ApplicationManager	tvExt.application.appmgr	http(s)://<host>/dtv/<service-context-id>/apps GET { { appid, name, type, controlCode, state, entryPoint }, ... }
	Application	replaceApplication() destroyApplication()	oipfApplication	createApplication() destroyApplication()	ApplicationManager	createApplication() destroyApplication()	http(s)://<host>/dtv/current-service/apps/<appid> POST { action: start/stop }
		visibility and/or display of style property of visible elements	Application	show() hide()	ApplicationManager	showApplication() hideApplication()	

TABLE 3 (*continued*)

	Hybridcast		HbbTV 2.0		TOPSmedia		Ginga
	Object	**Property or method**	**Object**	**Property or method**	**Object**	**Property or method**	**REST API (HTTP request)**
Key control	KeySet	RED GREEN YELLOW BLUE NAVIGATION VCR NUMERIC value	KeySet	RED GREEN YELLOW BLUE NAVIGATION VCR NUMERIC value	ApplicationMa nager	keySetValue (it defines constant values: KEY_RED, KEY_GREEN, KEY_YELLOW, KEY_BLUE, KEY_NAVIGATI ON, KEY_VCR, KEY_NUMERIC, KEY_OTHER)	http://<host>/dtv/current-service/ginga/keyset GET numeric_keys, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 interactive_keys, colored_keys, RED, GREEN, YELLOW, BLUE, selection_keys, ENTER, BACK, EXIT, cursor_keys, CURSOR_LEFT, CURSOR_RIGHT, CURSOR_DOWN, CURSOR_UP
		setValue()		setValue()		setKeySet()	http://<host>/dtv/current-service/ginga/keyset POST
Interface for receiver's functional capabilities	Capabilities	hasCapability()	oipfObjectFactory	isObjectSupported()	DeviceStatus	xmlCapabilities	http(s)://<host>/dtv/platform-capabilities GET
Interface for receiver's functions	ReceiverDevice	tuneTo()	video/broadcast object	setChannel() prevChannel() nextChannel()	HTML5 video element	src	http(s)://<host>/dtv/<service-context-id> POST
		getCurrentEventInformation()	oipfApplicationPrivat eData	currentChannel	ChannelManag er	getCurrentChannel ()	http(s)://<host>/dtv/current-service GET
			ChannelConfig	currentChannel			
Interface for broadcast events	StreamEventTarg et	addGeneralEventMessageListener()	video/broadcast object	addStreamEventListe ner()	Not support StreamEvent though the DSMCC (it can be substituted by W3C WebSocket or Server-Sent event on the broadband network)		http(s)://<host>/dtv/current-service/dsmcc/stream-events/<component-tag>/<carrousel-id> GET
		removeGeneralEventMessageListener ()		removeStreamEvent Listener()			http(s)://<host>/dtv/current-service/dsmcc/stream-events/<handle> DELETE

TABLE 3 (*continued*)

	Hybridcast		HbbTV 2.0		TOPSmedia		Ginga
	Object	**Property or method**	**Object**	**Property or method**	**Object**	**Property or method**	**REST API (HTTP request)**
Broadcast audio and video control	Broadcast audio/video object	enableFullScreen()	A/V Control Object	setFullScreen()	HTML5 video/audio element	requestFullScreen()	http(s)://<host>/dtv/current-service/<comp-tag> POST { action, pos, vol }
			video/broadcast object	setFullScreen()			
		disableFullScreen()	A/V Control Object	setFullScreen()		exitFullScreen()	
			video/broadcast object	setFullScreen()			
		enableAudioMute()	A/V Control Object	setVolume()		muted	
			video/broadcast object	setVolume()		volume	
		disableAudioMute()	A/V Control Object	setVolume()			
			video/broadcast object	setVolume()			
		isAudioMute()	video/broadcast object	getVolume()			http(s)://<host>/dtv/current-service/<comp-tag> GET
Interface for broadcast programme schedule information	EITSchedule [1]	name description start_time duration service_id transportstream_id original_network_id	Programme	name description startTime duration channelID	Programme	name description startTime duration channel audioInfoArray videoInfo captionInfoArray	http(s)://<host>/dtv/<service-context-id>/info/epg GET Current programme is identified in the 'present' field in the returned JSON structure
	RecordedContentInformation [2]	start_time duration					
	ReceiverDevice [2]	getRecordedContenInformation()		selectComponent() unselectComponent() getComponents()			

TABLE 3 (*end*)

	Hybridcast		HbbTV 2.0		TOPSmedia		Ginga
	Object	**Property or method**	**Object**	**Property or method**	**Object**	**Property or method**	**REST API (HTTP request)**
Interface for broadcast programme schedule information (cont.)	EITSearchManager	onEITScheduleUpdate() onEITSearch()	oipfSearchManager	onMetadataUpdate() onMetadataSearch()	Not support metadata search and query mechanism		http(s)://\<host>/dtv/\<service-context-id>/info/epg GET or http(s)://\<host>/dtv/all_services/info/epg GET
		createSearch()		createSearch()			
	EITSearch	result setQuery() createQuery()	MetadataSearch	result setQuery() createQuery()			Metadata search must be implemented by the application, based on the returned JSON structure
	Query	and() not()	Query	and() not()			
	SearchResults	length offset totalSize	SearchResults	length offset totalSize			
		item() getResults() abort()		item() getResults() abort()			

[1] Since this object is a part of the results of EITSearch, no constructor is defined. However, information contained in this object is equivalent to corresponding object(s) of other systems.

[2] These objects are applicable only to recorded content.

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