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Usage scenarios, requirements and technical elements of a global platform for the broadcasting service

BT Series

Broadcasting service
(television)

International Telecommunication Union

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Note*: This ITU-R Report was approved in English by the Study Group under the procedure detailed in Resolution ITU-R 1.*

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REPORT ITU-R BT.2400-4

Usage scenarios, requirements and technical elements of a global platform[1] for the broadcasting service

(Question ITU-R 140/6)

(2017-04/2018-10/2018-2019-2021)

1 Introduction

A conceptual block diagram of the global platform is shown in Fig. 1.

As shown in the left-hand box in Fig. 1, broadcasters are producing a wide range of content and services for distribution not only as traditional linear radio and television programming but also as time-shifted, on-demand, hybrid content and data services. 'Hybrid content' refers to content for which a part is provided over non-broadcasting networks in parallel with broadcasting platforms.

The audience has an increasing range of devices at its disposal. Typical user devices are shown in the right-hand box in Fig. 1. Television receivers for consumer use are now larger and more capable; this in turn feeds user expectations for increased picture quality and functionality.

Annex 2 of this Report provides an example of how media could be created in a flexible way using Componentized Content Creation Workflows, that enable the wide range of versions or localized options the global platform would require for international and local content exchange and delivery.

Personal computers, smartphones and tablets are increasingly used to access media services. These devices are used either as a second screen to supplement the main television set, or as a secondary receiver or even as the main media device, in particular for out-of-the-home use.

The audience thus enjoys a wide choice of content and services, both linear and on-demand, which are increasingly available at any time and at any location. The audience increasingly expects, from a technical perspective, to be able to watch linear and non-linear broadcast content anytime, anywhere and on any audio-visual device, both stationary and in motion.

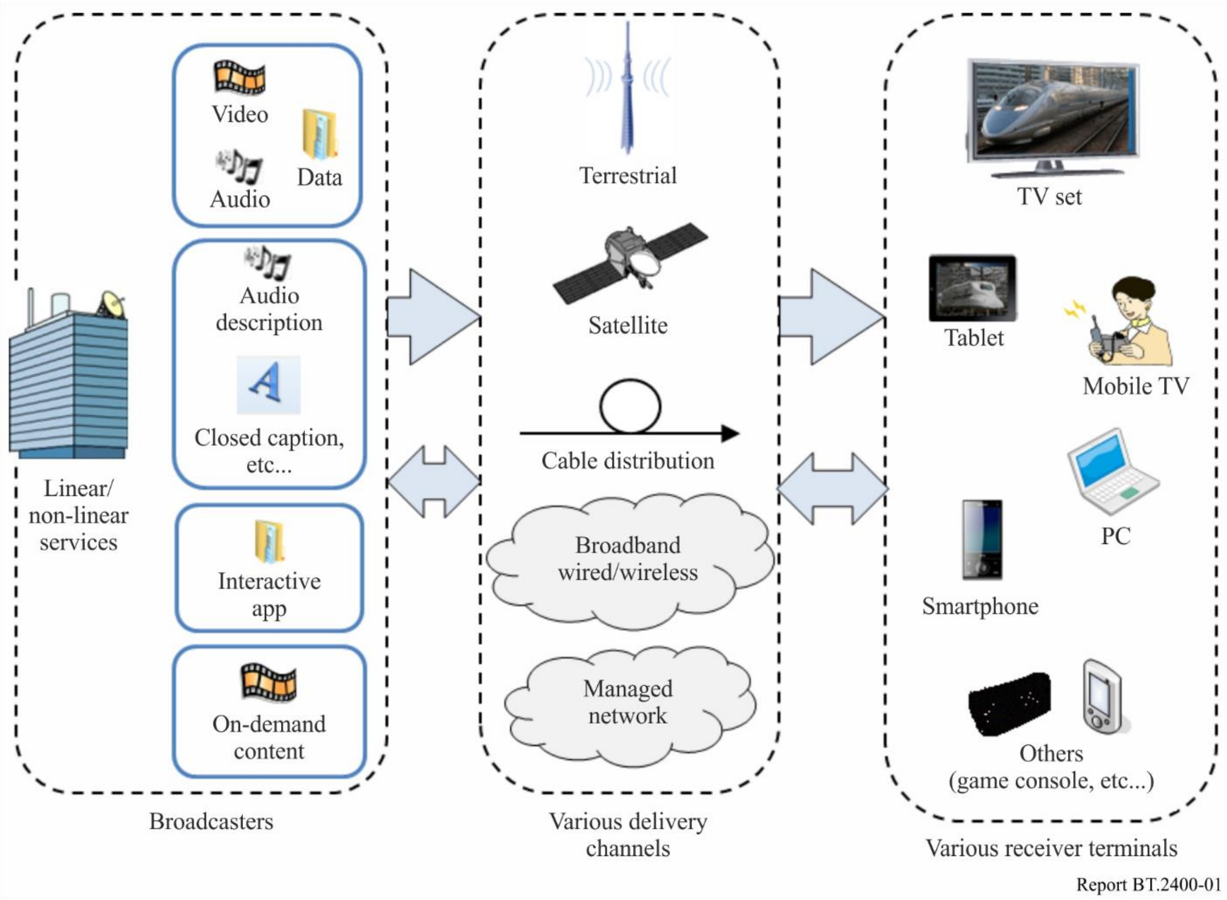
This trend is fully recognized and supported – to the extent possible – by today's broadcasters, who naturally seek to deliver their range of content and services to all interested users on a device of their choice and in their preferred environment. This is the reason ITU-R Study Group 6 studies a global platform, which is a delivery platform to facilitate distribution of broadcast content to end-users with various receiving devices in multiple reception environments, implemented by using both broadcasting and non-broadcasting (e.g. broadband) technologies. This Report provides examples of broadcast systems such as ATSC 3.0, DVB-T2 and ISDB-S3 that were developed as next generation digital television systems and envisioned to leverage the type of global platform considered in this Report to deliver content to end users.

As shown in the centre box in Fig. 1, this requires the use of a number of different means of distribution, including traditional broadcasting platforms, such as terrestrial, cable and satellite, as well as broadband networks, both stationary and mobile. Although the global platform is intended to take advantage of non-broadcast networks, ITU-R SG 6 studies how the technical specifications of non-broadcast networks may be utilized in the global platform from the perspective of assembling and accessing broadcast content.

[1] The global platform is defined as a delivery platform to facilitate distribution of broadcast content to end-users with various receiving devices in multiple reception environments, implemented by using both broadcasting and non-broadcasting (e.g. broadband) technologies.

FIGURE 1

Conceptual block diagram of global platform



2 The envisioned global platform for the broadcasting service

This ITU-R Report resulted from initial work of ITU-R Study Group 6 on the high-level user and technical requirements and possible wrapper techniques to address a new multifunctional, Global Platform for the broadcasting service (TV, sound and multimedia), and now includes examples of digital television systems that represent implementations of the Global Platform.

It considers the following elements:

– Modern requirements for digital TV and multimedia broadcasting are radically different from the current ones, and traditional requirements do not reflect the latest international decisions as well as the current and future technological progress.

– Thanks to interactive "info-communication", the users can take an active part in the way programmes are received on the basis of personal preferences and convenient viewing time. These possibilities of the consumers influence television and multimedia broadcasting strategies and the associated info-communication services as never before.

– The intensive development of broadband access and the wide penetration of the Internet and its applications significantly enhance the users' possibilities to receive and consume various types of audiovisual content.

– The development of video information systems, in addition to home and mobile reception, allows for the delivery of broadcasting to all audiences in private and public places, a variant of "always and everywhere".

– The logical result of the considerations above is the introduction of a new integrated, multifunctional, global platform for the broadcasting service that includes all broadcasting media and means, as well as the associated info-communication services.
– There is now a demand for a new global platform for the broadcasting service and there is also a demand for a new model of the information society.

The high-level conclusions of this ITU-R Report are the following:

– Broadcasters require a new multifunctional global platform for the broadcasting service, in order to integrate modern and prospective media and means for the creation, delivery and presentation of broadcasting content with the highest possible quality through terrestrial, satellite and cable TV broadcasting as well as multimedia broadcasting in other networks: a new global platform for the broadcasting service should be conceived to respond to modern requirements for digital broadcasting, which are radically different from the traditional ones.
– Consumers require a new global platform for the broadcasting service, in order to facilitate access to the desired content in the most convenient form at any time and any place, on stationary or mobile receivers.

The new global platform would use those radiofrequency channels that are currently used for the delivery of broadcasting content, which are currently available and provide an optimal balance for the user between quality of service and cost of the service.

Specifically, the global platform would be able to serve the delivery channels below or combinations thereof:

– Terrestrial broadcasting.
– Satellite broadcasting.
– Cable television.
– Fixed broadband access.
– Mobile broadband access.

These delivery channels include integrated broadcast broadband (IBB).

These may include linear and non-linear transmission mechanisms, such as the “pre-service push” option, e.g. transmission during the night for later selection by the end-user.

Interactivity should also be provided using user-friendly ways: through fixed and mobile networks, the reverse channel of the cable and satellite systems, etc.

3 Usage scenarios for the global platform

This section considers the distribution options currently available to broadcasters and identifies the distribution means that may be required in the future. It is based on studies of the BBC reflected in full detail in EBU Technical Report TR 026 – Assessment of available options for the distribution of broadcasting services – June 2014 [2].

It assumes that broadcast content encompasses the entire range of content that broadcasters offer to the audience irrespective of the technical platform across which it is distributed. (In this context, the term “broadcast service” is used to indicate broadcast content deliberately selected for that purpose).

In order to address the current and anticipated future audience behaviour, this section uses the concept of use cases. A use case is defined as a combination of a broadcast service, a user environment in which the service is used, and a user device.

Two distinct user environments are considered: a permanent one where a user spends considerable amount of time in the same place and where the vast majority of media use takes place (e.g. home or office), and a transient one (e.g. public place or when travelling) which is becoming increasingly important, in particular on portable devices.

A set of representative types of user devices has been identified without considering their respective functionalities and features in any great detail. These device categories reflect how services are consumed by the viewers and listeners and not necessarily the technical means of their delivery.

Individual use cases have been evaluated in terms of their relevance to broadcasters. In reality, different use cases coexist and are strongly influenced by their context. The following assumptions have been made:

– Linear viewing is the primary way of watching TV content and there is currently no indication that this will change in the foreseeable future.
– Time-shifted and on-demand viewing will continue to grow, but this will not significantly erode the overall amount of linear viewing.
– Migration of TV services from SDTV to HDTV will continue. More content will be offered as well, in particular with the introduction of new HDTV services.
– Ultra-HDTV will be introduced and may become the mainstream format in the medium to long-term future on all TV platforms.
– Portable and mobile devices are increasingly used to access media services. Nevertheless, most of the TV viewing will remain on the large screen.
– Majority of the TV viewing, both linear and nonlinear, will continue to occur in the home. Usage in transient environments will become increasingly significant.
– Innovative media services embrace active audience participation, in particular through social networks such as Facebook, Twitter, etc.
– Hybrid broadcast-broadband services are becoming commonplace based on broadcast platforms and fixed broadband infrastructure. In the future they may also make use of wireless broadband.

Not all identified use cases are equally relevant from a broadcaster's perspective. The relevance is determined taking into account the current situation as well as the short to mid-term future (e.g. next 5-10 years). For instance, a use case is considered highly relevant if it is currently important or if it is foreseen to become important in the future. Elements to be considered may include the size of audience, availability of suitable devices or the programme offer.

Once a relevant use case has been identified the question becomes by which distribution options this use case can be enabled. For the purpose of analysis of distribution options only the highly relevant use cases have been considered. A distribution option refers to any technical possibility available to a broadcaster to distribute its services to the audience. This report dealt with terrestrial, satellite, cable, fixed broadband and mobile broadband as distribution options.

For every use case a set of requirements has been defined that needs to be fulfilled by a viable distribution option. The requirements are service focused, i.e. defined in such a way as to ensure desired availability and quality of service. Two types of requirements have been defined:

– general requirements which are common to all use cases, and
– specific requirements for each use case.

The distribution options are assessed in terms of their ability to satisfy the requirements. The following are the main conclusions:

– The use cases that include linear services are sufficiently well served by broadcast networks except those that target portable devices such as tablets and smartphones.
– Broadband networks are not suitable to support use cases containing linear TV services because they typically provide only best-effort quality and are, in general, not able to serve large concurrent audiences. This limitation is more pronounced on mobile networks than on fixed.
– The use cases that include on-demand services are supported only by broadband networks as they provide the required return channel which is not available on broadcast networks, except in the case of integrated broadcast broadband services in which the broadband network can serve as the return channel.
– A number of use cases are supported by more than one distribution option.
– No single distribution option can support all relevant use cases. Therefore, in order to enable the whole range of relevant use cases multiple distribution options need to be employed in a complementary manner.
– Some distribution options may be able to support multiple use cases simultaneously. For example, broadband networks can be used to watch linear TV and access on-demand services at the same time. However, broadband networks may not be able to serve peak demands of all supported use cases simultaneously, even though they may in principle satisfy them individually at different times.
– Some use cases have been identified that are considered highly relevant but cannot be fully supported by any of the currently available distribution options. For these cases further technical and market developments are necessary.

The above-mentioned analysis focused on individual use cases. However, it is important to recognize that individual use cases taken in isolation do not cover all situations that occur in reality. Combinations of use cases, i.e. simultaneous use of different devices and services or consecutive use over time and space, sometimes even including a switch of device, are becoming increasingly important. This kind of user behaviour is described by the term ‘usage pattern’.

Only a brief analysis of usage patterns was performed. It revealed that most usage patterns cannot be enabled by a single distribution option. Combination or even cooperation of different options would be required.

Furthermore, this study touched upon some of the ongoing technical developments, noting that all distribution options are evolving and may in the future overcome some of their current limitations. However, it remains to be seen which of the proposed innovative technical solutions will be successful on the market. Full details of the study providing global platform usage scenarios are given in [2].

The results of the analysis clearly indicate that there will be no ‘one-fits-all’ solution.

4 Broadcasters' general requirements for a global platform

4.1 General requirements

General requirements address not only technical issues but also regulatory, market and business-related aspects relevant for broadcasters and apply across all distribution options.

The general requirements are:

– Ability to provide content free-to-air (no additional cost for viewers/listeners).

– Deliver public content to the public without blocking or filtering the service offer (i.e. no gate keeping).

– Content and service integrity: No modification of the content or service by third parties. For example, TV content and additional services (e.g. subtitles, etc.) must be displayed on screen, unaltered and without unauthorised overlays.

– Broadcast content should be protected from unauthorized access.

– Quality of service (QoS) to be defined by the broadcaster, including availability of a network, robustness, up-time, and reliability.

– QoS for each user should be independent of the size of the audience.

– Geographical availability of the service (e.g. national, regional, local) is to be defined by the broadcaster.

– A distribution method needs to support an attractive breadth of programmes as offered by the broadcaster.

– Broadcast content should be given prominence and be straightforward to access.

– Low barrier for access to content and services for people with disabilities (e.g. subtitles, audio description and signing).

– Ability to reach audiences in emergency situations.

– No limitation in the number of concurrent users.

– Option for anonymous reception of free-to-air content.

4.2 Specific requirements

In addition, depending on the service, user device, reception environment, and distribution method, technical parameters would need to be adapted to the particular delivery mechanism. These should take account of the following requirements:

– The original quality of the broadcast content should generally be capable of being maintained irrespective of the delivery channel selection, network loading, etc.

– Latency for delivering broadcast content should be predictable and small.

– Broadcast functions in terrestrial communications networks should allow fixed and mobile reception over large service areas.

5 High-level end-to-end user requirements for a global platform

This section succinctly lists the main requirements with which the Global Platform should comply, in order to meet the main needs of broadcasters. The identification, development and validation of the Global Platform should be based on these end-to-end requirements.

5.1 Reception/consumption situation for TV/radio/data broadcast services

– Stationary (including within home-networks).
– Portable (including personal body-worn displays).
– Transient/On the move, e.g. in a vehicle (including in-car networks).

5.2 Terminals used

– On a conventional TV/radio set.
– On a desktop/laptop or tablet computer.
– On a smart phone.

5.3 Broadcast services offered as linear TV/radio/data broadcasts via broadcast networks

– As linear TV/radio/data broadcasts via broadband networks.
– On demand TV/radio/data broadcasts (normally retrieved over broadband networks).
– In hybrid form (IBB, i.e. simultaneous access over broadcast and broadband networks).
– Via pre-service push (e.g. during the night for later viewing/listening by the end-user).

6 Deployment examples of global platforms

6.1 General

This section introduces two deployment examples of global platforms. Delivery of content such as described in the two examples below is currently achievable through systems such as ATSC 3.0, DVB-T2, and ISDB-S3.

6.2 4K broadband service

SKY Perfect JSAT Corporation provides a broadband service by using fibre to the home (FTTH) in which service identical to that of satellite broadcasts, including three 4K services, is provided simultaneously. This service is intended to be received with TV sets or STBs.

All of the satellite broadcast signals are delivered over optical fibres separately from data signals delivered for Internet service by using wavelength division multiplexing (WDM) technology. This usage of WDM technology is specified in Recommendation ITU-T J.185 – Transmission equipment for transferring multi-channel television signals over optical access networks by frequency modulation conversion. A video-optical network unit (V-ONU) equipped at each receiving home and apartment outputs the same signals as those received by a parabolic antenna.

This service has many advantages. Because it does not require an antenna, the quality of the broadcast service does not deteriorate even when there is rain, and the service is easily introduced in apartments in which equipping an antenna is not allowed. The broadcast signals are delivered separately from the data signals, so the quality of the broadcast service remains high even when end users use the Internet service. The high-quality 4K services can be received with several TVs and STBs simultaneously. Further, the Internet service is not affected even when a lot of broadcast programmes are being watched.

Existing Over-The-Top (OTT) services in the Republic of Korea provide broadband services including video on demand (VOD) service as well as live streaming in 4K. Terrestrial broadcasters provide multiple 4K live content feeds simultaneously by over-the-air (OTA) transmission using the ATSC 3.0 standard.

6.3 Internet radio services

In Japan, internet radio services simultaneously provide most of the radio programmes available on AM or FM radios . The services are intended to be received by PCs, smartphones, and similar devices.

In these services, audio signals encoded at 48 kbit/s per channel are provided with Flash and HTTP live streaming (HLS) formats though a Content Delivery Network (CDN). Any devices connected to the Internet are able to receive the services, although the reception areas are restricted to Japan. Neither time signals nor emergency warning systems are offered because the internet radio services are behind the original radio services by a few to a few tens of seconds.

An electronic programme guide (EPG) is provided on web pages and dedicated applications. End users see the information together with thumbnails about on-air programmes and then choose the programme to receive. In the services, both live radio programmes and programmes requested by end users are provided. End users can listen to a programme they missed by requesting it. The internet radio services provide convenient functions that are not provided by the original radio services.

7 Technical elements

In order to establish broadcasting services on the global platform, many different technical elements are required. Annex 1 of this Report contains some examples.

The second "*decides*" of Question ITU-R 140/6 describes:

> What means and measures could be recommended, that would allow broadcast content to be flexibly delivered to the end-users via the widest possible range of terminal devices?

The technical elements described in Annex 1 would provide some answers to this aspect of the Question.

8 Related ITU texts

1) Integrated Broadcast-Broadband systems

   – Recommendation ITU-R BT.2075 – Integrated broadcast-broadband system

   – Report ITU-R BT.2267 – Integrated broadcast-broadband systems

   IBB applications may work as service enablers on various kinds of terminals via various kinds of delivery networks, and seamlessly integrate the final delivery to the end users.

2) International Mobile Telecommunications (IMT) networks

   – Report ITU-R M.2373 – Audio-visual capabilities and applications supported by terrestrial IMT systems

   Concerning delivery over IMT networks, Report ITU-R M.2373 describes the capabilities of IMT systems to deliver audio-visual services. It also examines user requirements as well as some of the requirements from the audio-visual content providers.

3) Access network transport

   – http://www.itu.int/en/ITU-T/studygroups/com15/Pages/ant.aspx

   "Access network transport standards overview" is found on the above URL. Some of the networks listed in the overview are effective means of delivery for the global platform.

9 Bibliography

[1] EBU Technology Fact Sheet – Public Service Media Requirements in Distribution – December 2014.

[2] EBU Technical Report TR 026 – Assessment of available options for the distribution of broadcasting services – June 2014.

[3] A/300 – ATSC Standard: ATSC 3.0 System – October 2017.

Annex 1

Technical elements of a global platform

1 Introduction

This Annex contains examples of some of the technical elements of a global platform.

2 Delivery of IP-based broadcasting services over broadband networks

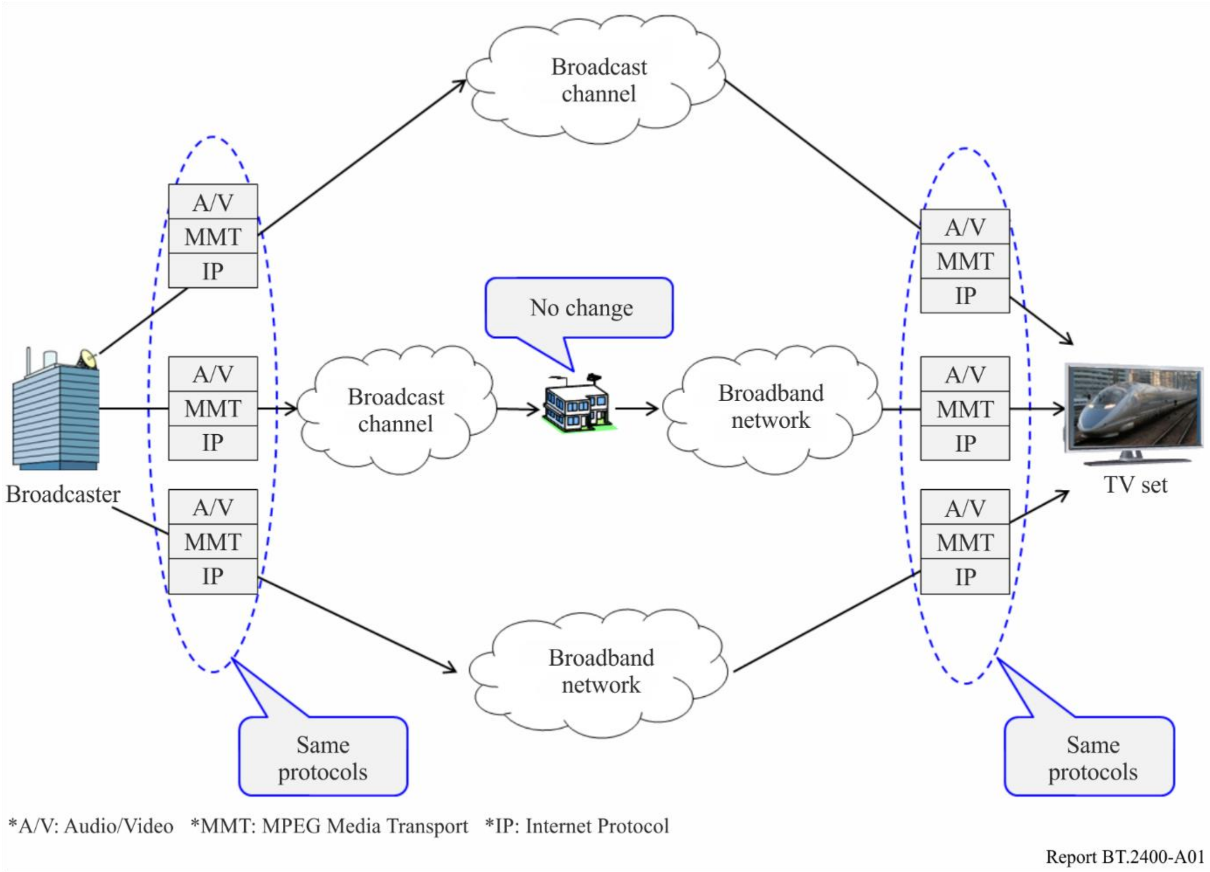
2.1 Overview

Internet Protocol (IP)-based broadcasting systems such as ISDB-S3 and ATSC 3.0 have been developed. In these systems, broadcasting services are transmitted as IP packets, which are used in broadband networks. Since IP packets are a common interface between broadcast and broadband, broadcast channels can be used to deliver broadcasting services to broadband networks without making any changes to these services, such as by transcoding, replacing encryption for Conditional Access System (CAS) or Digital Rights Managements (DRM), or converting the protocol.

Figure A1-1 illustrates the protocols used in IP-based broadcasting and broadband. A broadcaster is able to transmit its services by using the same protocols for broadcast channels as for broadband networks. A TV set can receive these broadcast services with the same protocols even though they are transmitted along different paths.

FIGURE A1-1

Protocols in IP-based broadcasting and broadband



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2.2 Differences between broadcast channels and broadband networks

The ISDB-S3 system uses MPEG Media Transport (MMT), a media transport protocol on top of IP, to transmit broadcasting services including audio, video, and other signals. In ATSC 3.0, either MMT or ROUTE/DASH on top of IP is used to transmit broadcasting services. In any of these systems, IP packets carry the broadcasting services through the broadcast channel.

In the case of a broadcast channel, broadcast services are transmitted by multicasting UDP/IP packets to any receiver, as the channel is a unidirectional path. The broadcast channel for fixed reception provides quasi-error-free transmissions, because broadcast systems have a robust error correction mechanism in their physical layer. In the case of ATSC 3.0, both physical layer error correction and Application Layer-Forward Error Correction (AL-FEC) are specified. In the case of DVB-T2, in addition to the defined physical layer FEC, an application layer FEC can be used in combination with the DVB defined Generic Streaming Encapsulation (GSE) protocol. MMT also supports AL-FEC as specified in ISO/IEC 23308-10 “MPEG Media Transport Forward Error Correction (FEC) codes”.

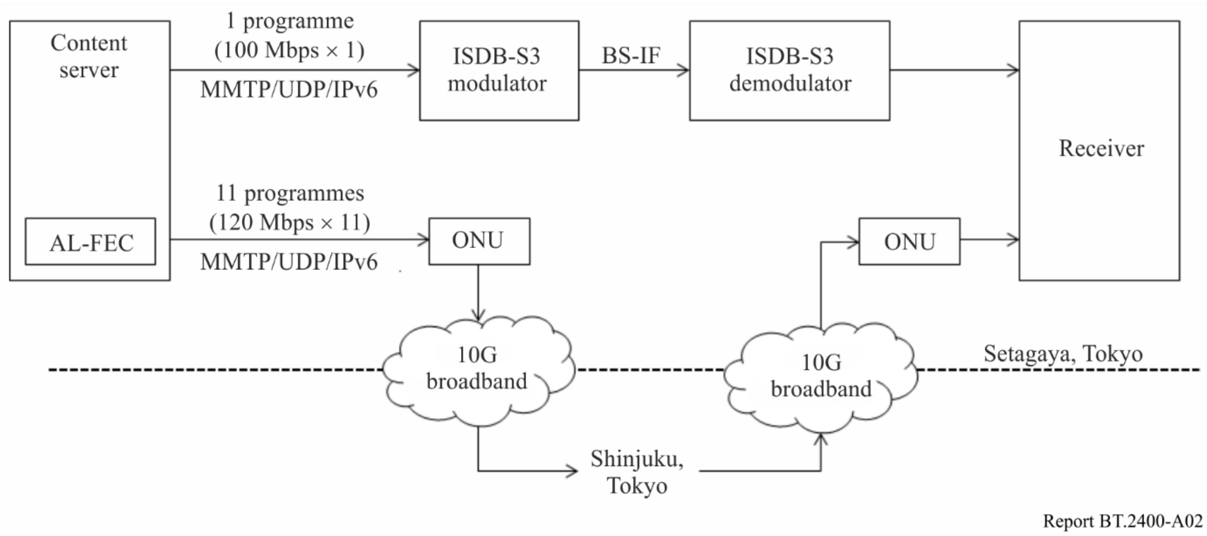
In the case of broadband, both bidirectional transmission in the form of TCP/IP packets and unidirectional transmission with the form of UDP/IP packets are possible. However, packet losses could result from buffer overflows at routers on the transmission path, even if there are no packet losses over the broadband lines themselves. Re-transmission of packets with the TCP mechanism or AL-FEC in combination with UDP is often used to keep transmission quality high when packet losses occur.

2.3 Experiment on delivery of 8K programmes over broadcast and broadband

NHK conducted an experiment in May 2016 in order to confirm that the protocol of ISDB-S3 works through an actual broadband network without any modifications. Figure A1-2 shows the experimental system.

FIGURE A1-2

Experimental system using actual broadband network



*ONU: Optical Network Unit.

The content server and receiver were located in Setagaya, Tokyo in Japan. The ISDB-S3 modulator and demodulator are connected back-to-back as the broadcast channel. A 10G-EPON was used as the broadband network. The server transmitted one programme through an ISDB-S3 modulator and demodulator and eleven programmes through broadband.

Each programme consisted of encoded 8K video and two-channel audio signals. It was transmitted in real-time in accordance with their presentation time by using MMTP/UDP/IPv6 packets, whose bitrates were approximately 100 Mbit/s. Table A1-1 lists the signals transmitted in the experiment.

TABLE A1-1

Signals transmitted in experiment

Item	Configuration
IP version	IPv6
Transport protocol	MMTP/UDP
IP packet size	Max. 1.5 KB
Audio format	Two channels
coding	MPEG-4 AAC LC
Video format	7680×4320/59.94/P
coding	HEVC Main 10 profile

Eleven programmes were transmitted from the server to Shinjuku, Tokyo, about 25 km away from Setagaya, Tokyo, at which point they were returned to the receiver in Setagaya. At this time, 10-Gbit/s services are available in limited areas of the Tokyo metropolitan region. Such service areas will spread throughout Japan in the near future.

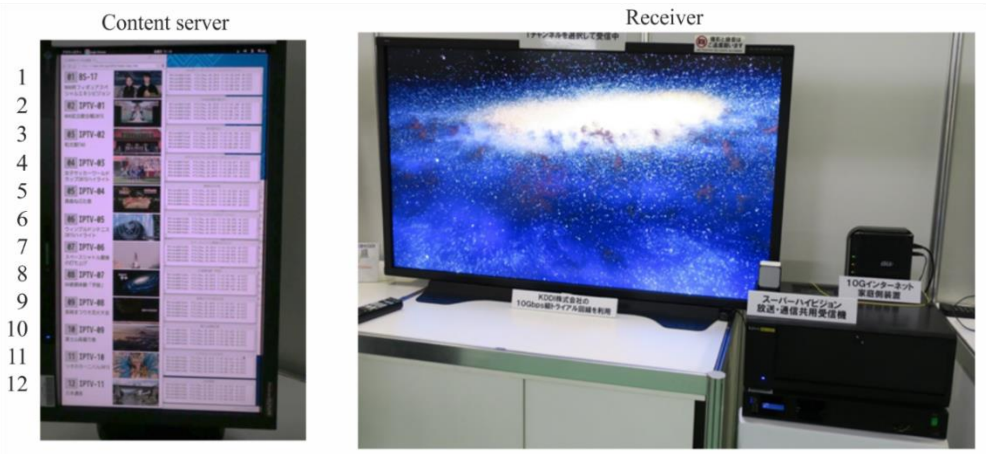
In order to maintain error resiliency, the packet flows through broadband included repair packets generated by AL-FEC. The source packets through broadband were identical to those through the broadcast channel. The bitrate of one programme with repair packets was approximately 120 Mbit/s.

The receiver chose one of the twelve programmes from either broadcast or broadband and displayed it after extracting the AAC/HEVC streams from the received MMT packets and decoding them.

Figure A1-3 shows the content server and receiver. The monitor on the left shows the status of the content server that transmitted the twelve programmes in real time: one for broadcast and eleven for broadband. The monitor on the right shows the received 8K programme that a user selected.

FIGURE A1-3

Content server and receiver



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During this experiment, the receiver stably presented the 8K programme selected by the user. The user could choose the programme he wanted to watch without having to worry about its delivery path.

A receiver that did not support the AL-FEC function received IP packets including the repair packets. In this case, the receiver could ignore the repair packets and processed only the source packets. There was no packet loss during the 24-hour period in which the eleven 8K programmes were delivered.

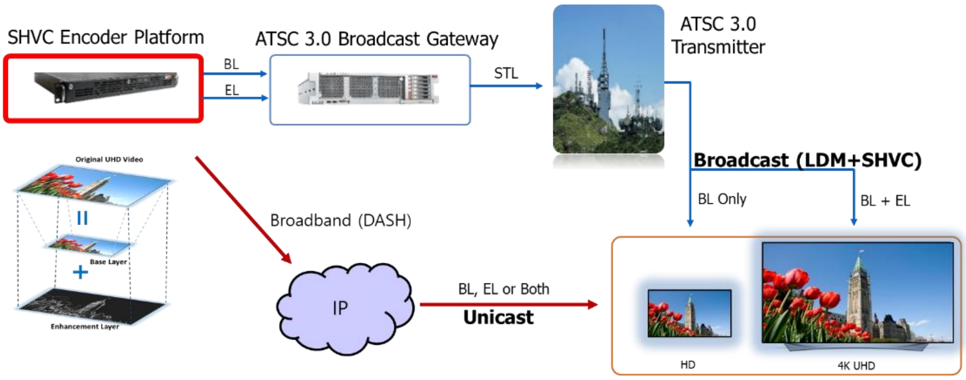
This experiment confirmed that the protocol of ISDB-S3 on top of IP correctly worked through broadband.

2.4 Experiment on convergence of broadcast and broadband using ATSC 3.0

In October 2018, Electronics and Telecommunications Research Institute, Republic of Korea (ETRI), conducted a field trial demonstrating IP convergence of broadcast and broadband based on the ATSC 3.0 standard. In an ATSC 3.0 broadcast network, the combination of Layered Division Multiplexing (LDM) of the physical layer and Scalable High Efficiency Video Codec (SHVC) of the presentation layer was used to deliver spectral-efficient mobile and fixed broadcast services together in a single RF channel. For a broadband network, the 4th generation (4G) Long-Term Evolution (LTE) network was used to deliver an alternative service to cooperate with the broadcast network. Figure A1-4 shows the ATSC 3.0 system configuration for the field trial including SHVC encoder platform, broadband server, transmitter and receiver delivering signals from broadcast and broadband networks.

FIGURE A1-4

Experimental systems of ATSC 3.0 LDM/SHVC based broadcast and broadband convergence platform



A service was SHVC encoded to consist of Base Layer (BL) of a 720p High Definition (HD) stream and Enhancement Layer (EL) of a 4K-UHD stream. For all IP transmission, MMT or ROUTE were implemented in a broadcast path and DASH was used in a broadband path. In the physical layer, LDM was configured such that Core Layer Physical Layer Pipe (PLP) of LDM carried BL of SHVC and Enhanced Layer PLP of LDM carried EL of SHVC.

For the field trial, the ATSC 3.0 transmission systems were installed at the Jeju Technopark facility located in Jeju, Republic of Korea, and deployed 4G LTE networks in the Jeju city area were used for broadband signal transmission. The tested service scenarios were as follows:

– Switching between BL and EL depending on channel conditions in the broadcast coverage;
– Hybrid service that received BL from the broadcast network and EL from the 4G LTE networks;
– Switching between the broadcast and broadband networks for the BL signal depending on the broadcast signal availability.

This field trial confirmed that the convergence service scenarios correctly worked while taking benefits from both the broadcast and broadband networks, and it is expected that such convergence service scenarios will enable a future broadcast service model.

FIGURE A1-5

Receiving equipment inside the field test vehicle for ATSC 3.0 broadcast and broadband reception

2.5 Conclusion

This section described an experiment on delivering 8K programmes through an actual high-speed broadband network by utilizing a media transport protocol on top of IP identical to that of an IP-based broadcasting system, ISDB-S3. The receiver stably presented the 8K programmes during the experiment. The experimental results showed that the IP-based protocol of ISDB-S3 also worked well through a high-speed broadband network using IP. A demonstration of 8K programmes was also presented at the 2019 National Association of Broadcasters Show by ETRI under ATSC 3.0 channel bonding technology, which utilizes two RF channels for large data transmission over the air.

This section also described an experiment on convergence of broadcast and broadband using the ATSC 3.0 standard. The all IP transmission of ATSC 3.0 facilitated the combined use of broadcast and broadband networks for better multimedia services.

3 Content delivery model using a distribution status management server

3.1 Overview

Broadcasters have begun distributing TV programmes via Internet simulcast and video on demand (VOD) as well as broadcasting. End users watch TV programmes provided by broadcasters with various devices such as smartphones, tablets, and Integrated Broadcast and Broadband (IBB) receivers.

It is important for audiences to be able to obtain the content they desire regardless of the delivery channel. For broadcasters, it is important to provide content to audiences through inexpensive channels.

The following server and end-user device are required to achieve such content delivery:

– A server that manages the status of content distribution; that is, indication of availability on each delivery channel, and provides the status to each end-user device.

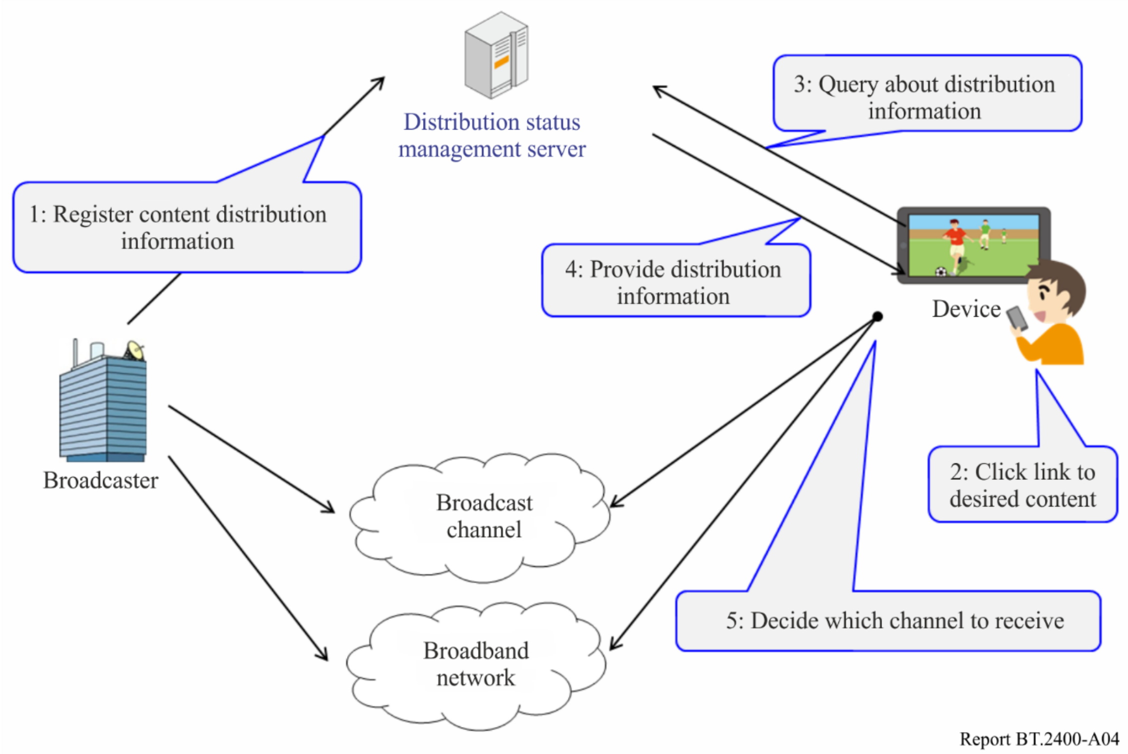
– An end-user device that decides an appropriate delivery channel for end users to obtain the desired content on the basis of the status of content distribution.

3.2 Distribution status management server

When there is a server that manages the status of content distribution on each delivery channel, a device can obtain the desired content on an appropriate delivery channel depending on the situation. This mechanism also enables broadcasters to guide end users to broadcast channels in which the delivery cost is lower than that of broadband networks. Figure A1-6 illustrates the content delivery model including the server that has such functionality.

FIGURE A1-6

Distribution status management server and content delivery model



The distribution status management server stores information on how content is distributed.

Before distributing their content, broadcasters register the distribution information of the content, including broadcast channel information, Internet simulcast URLs, or VOD services URLs on the server (Step 1 in Fig. A1-6). Additional information such as video resolution and transmission latency from a live broadcast service, which is used to determine an appropriate distribution channel for a device, is also registered.

When an end user wants to view content, they simply click a URL link to the content (Step 2 in Fig. A1-6). The URL is described independently of the distribution channels.

Then, the device queries the server for the distribution information of the content (Step 3 in Fig. A1-6). In response to the inquiry, the server provides the device with the distribution information, including available channels, video resolution, transmission latency, and so on (Step 4 in Fig. A1-6).

On the basis of this information, the device decides an appropriate channel to obtain the content (Step 5 in Fig. A1-6); then, it presents the content. It is assumed that an appropriate channel can be determined by examining various parameters including those describing the device capabilities.

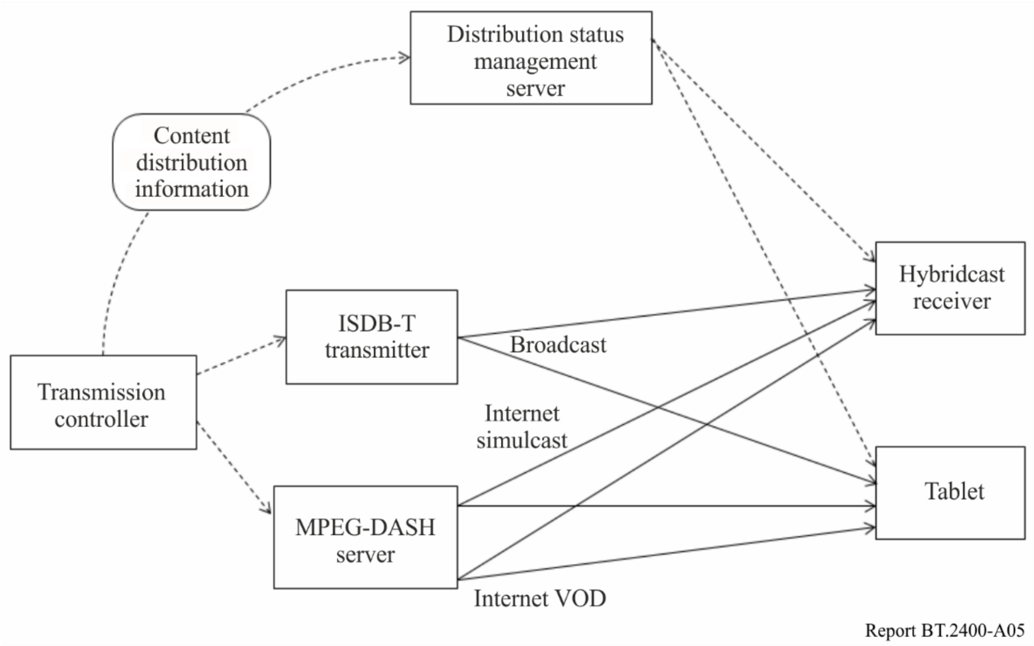
In this content delivery model, content is identified by a URL that is independent from the delivery channel. The device decides an appropriate channel from the distribution information provided by the server and dynamically resolves the link. Owing to this mechanism, end users can watch a TV programme without caring about its delivery channel.

3.3 Implementation of the content delivery model

To verify the content delivery model described above, NHK implemented a server, receiver, and transmitter. Figure A1-7 shows the implementation overview.

FIGURE A1-7

Implementation overview



A hybridcast receiver and an Android tablet were used as the end users' devices.

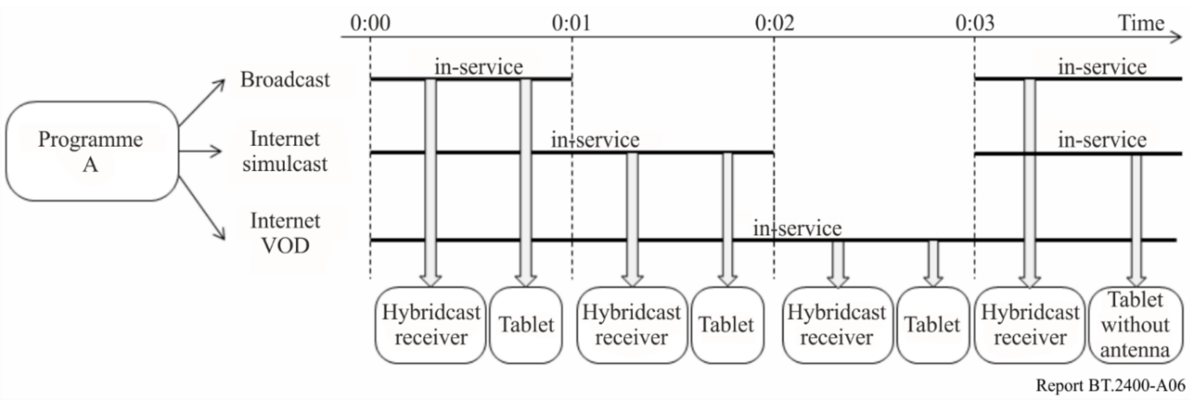
A programme was distributed from ISDB-T transmitter (through broadcast), MPEG-DASH server for live streaming (through Internet simulcast), and MPEG-DASH server for on-demand (through Internet VOD). In this implementation, the Internet VOD offered 'start-over' service that enabled end users to watch a programme from the beginning anytime, while it was delayed more than several minutes from real time.

The transmission controller informed the distribution status management server about the distribution status; then, the server stored them. For simplicity, each device decided an appropriate delivery channel by prioritizing real-time availability and video resolution in that order.

The verification experiment was conducted with one programme, Programme A. The distribution methods were updated every minute, and the end user clicked the link for Programme A after each update. Figure A1-8 illustrates the change in available distribution channels. This Figure also illustrates the channels selected by each device.

FIGURE A1-8

Registered schedule of each delivery channel and channel selected by each device



During the interval 0:00 to 0:01, Programme A was distributed via broadcast, Internet simulcast, and VOD. The devices selected broadcast to receive Programme A, since broadcast provided Programme A in real-time and at the highest resolution.

During the interval 0:01 to 0:02, the Programme A was distributed only via Internet simulcast and VOD. The devices selected Internet simulcast, since it was a real-time delivery method.

During the interval 0:02 to 0:03, the devices selected VOD, since it was the only available delivery channel to receive Programme A.

In addition, after 0:03, the broadcast antenna cable was unplugged from the tablet in order to simulate a bad receiving condition. At that time, the tablet selected Internet simulcast, since it could not receive broadcast signals.

From this experiment, it was confirmed that the devices determined an appropriate delivery channel by using the distribution status management server.

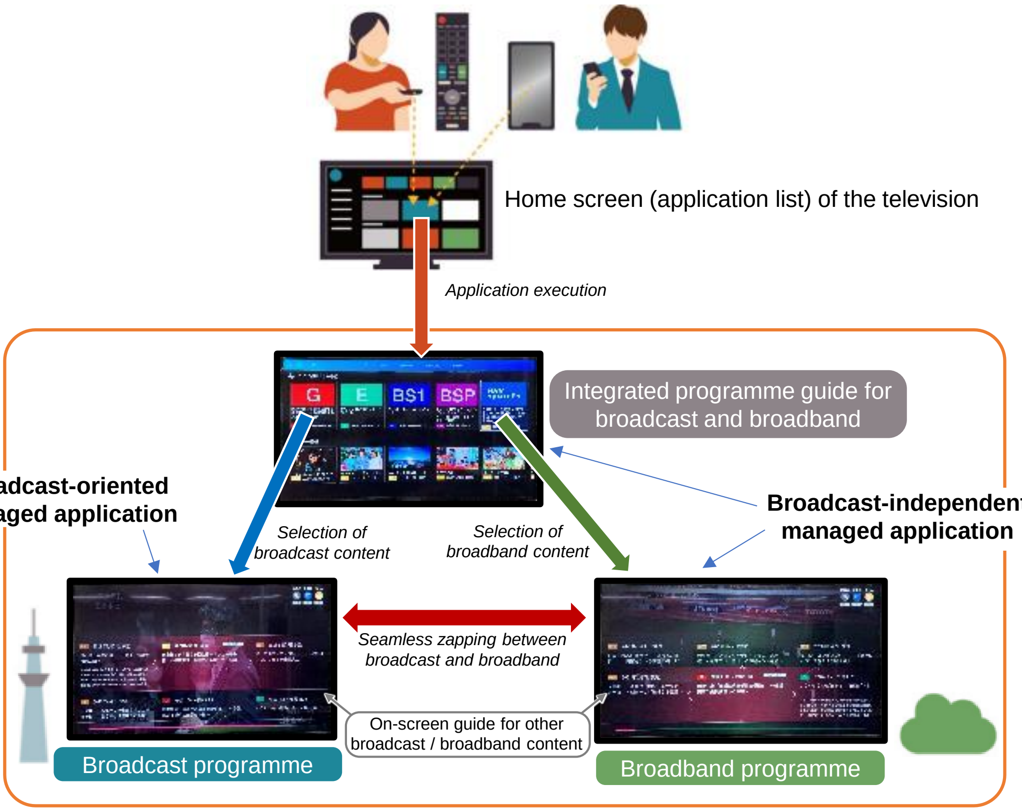
3.4 Receiver system with an application control technology

A content distribution platform with a distribution status management server enables end-user devices to automatically select an appropriate delivery path for each content in accordance with the user's reception situation including the availability of delivery paths and device capabilities. The user can watch the content without being aware of which delivery path is actually used. For a responsive content selection and zapping through broadcast and broadband in such a distribution platform, a receiver system should support prompt switching between broadcast channels and broadband networks.

An experimental receiver system was developed by NHK to verify seamless switching between broadcasting and broadband. The receiver is capable of executing two types of HTML application defined in the Hybridcast standards, a broadcast-oriented managed application and a broadcast-independent managed application. The broadcast-oriented managed application is associated with a specific broadcast channel and used for presenting broadcast programmes with an on-screen guide for other broadcast/broadband content. The broadcast-independent managed application runs as a stand-alone application and is used for a broadcast-broadband integrated programme guide and for presenting content delivered via the broadband network. Extended JavaScript APIs are used to transit between the two application types, allowing for a simple and smooth operation in going back and forth between broadcasting and broadband content. Figure A1-9 shows a navigation path for viewing broadcast and broadband content using the experimental receiver system.

FIGURE A1-9

Navigation of broadcast and broadband content and corresponding application types on experimental receiver



This receiver system linked to a distribution status management server enables users to navigate through broadcasting and broadband content with easy and responsive operations as they do with the conventional television reception without being conscious of the actual transmission paths.

4 Measuring reception quality of broadcast and mobile broadband in the field

4.1 Measuring reception quality

To investigate the potential of using both broadcast and mobile broadband to deliver broadcast content, the reception quality was measured in actual mobile reception environments that simulated real-life situations such as walking or riding on a train or bus.

Measurements were conducted for two round-trip routes (Routes A and B) in October and November 2016, as shown in Table A1-2 and Fig. A1-10. Route A included underground sections on the way.

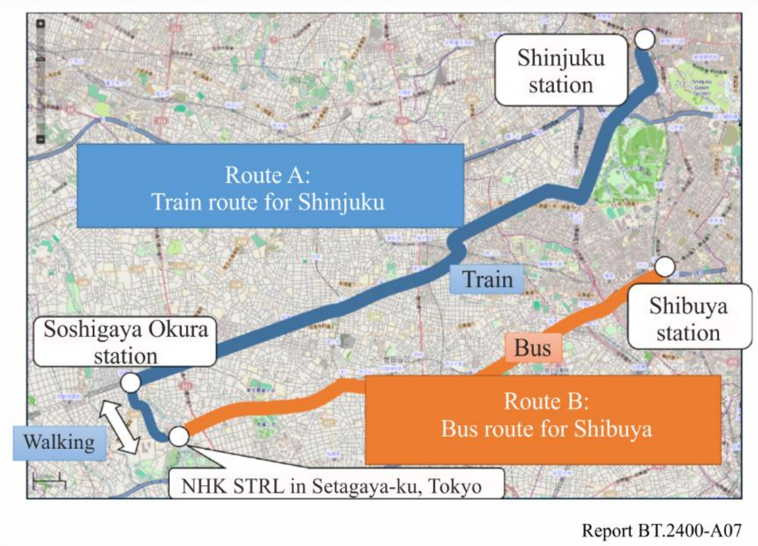
TABLE A1-2

Two routes for measuring reception quality

Route A	NHK STRL – (walking) – Soshigaya Okura station – (train) – Shinjuku station (staying in neighbourhood for approx. 15 minutes)
Route B	NHK STRL – (bus) – Shibuya station (staying in neighbourhood for approx. 15 minutes)

FIGURE A1-10

Two routes for measuring reception quality



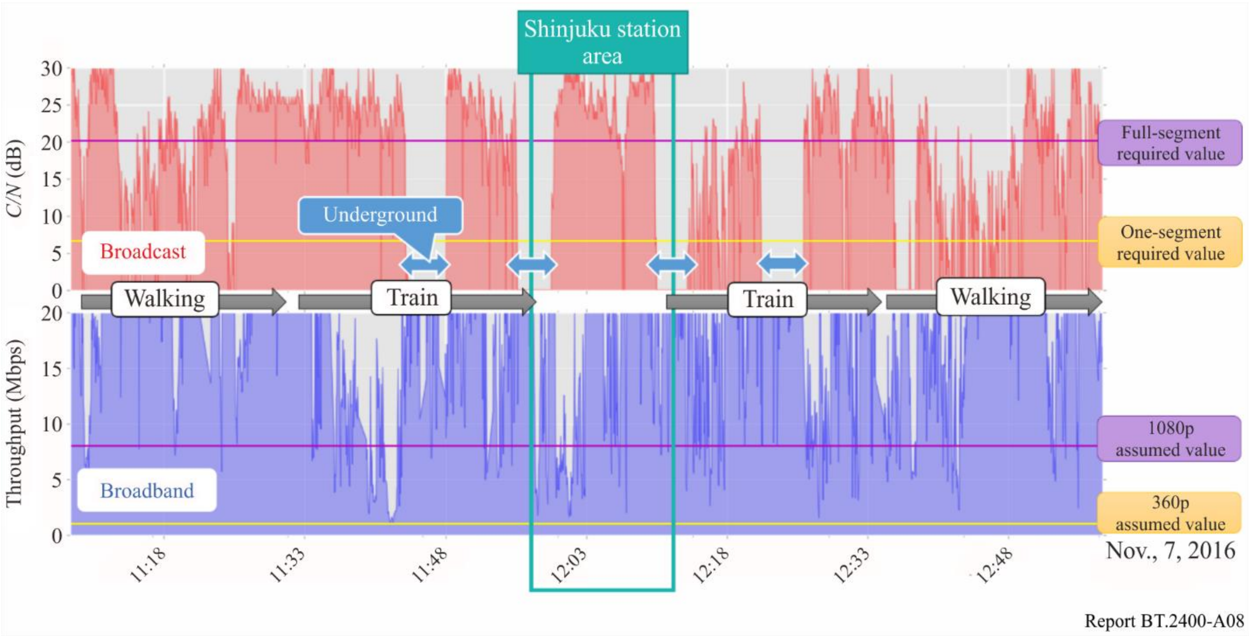
Report BT.2400-A07

Figures A1-11 and A1-12 show the measured *C*/*N* (dB) of the broadcast signals and the throughput (Mbit/s) of the broadband on Routes A and B, respectively.

On Route A, shown in Fig. A1-11, the throughput of mobile broadband did not decrease even in the underground sections, although the broadcast quality deteriorated. On Route B, shown in Fig. A1-12, the broadcast quality remained high in the neighbourhood of Shibuya station, while the throughput of mobile broadband frequently decreased, which was supposed to be due to congestion.

FIGURE A1-11

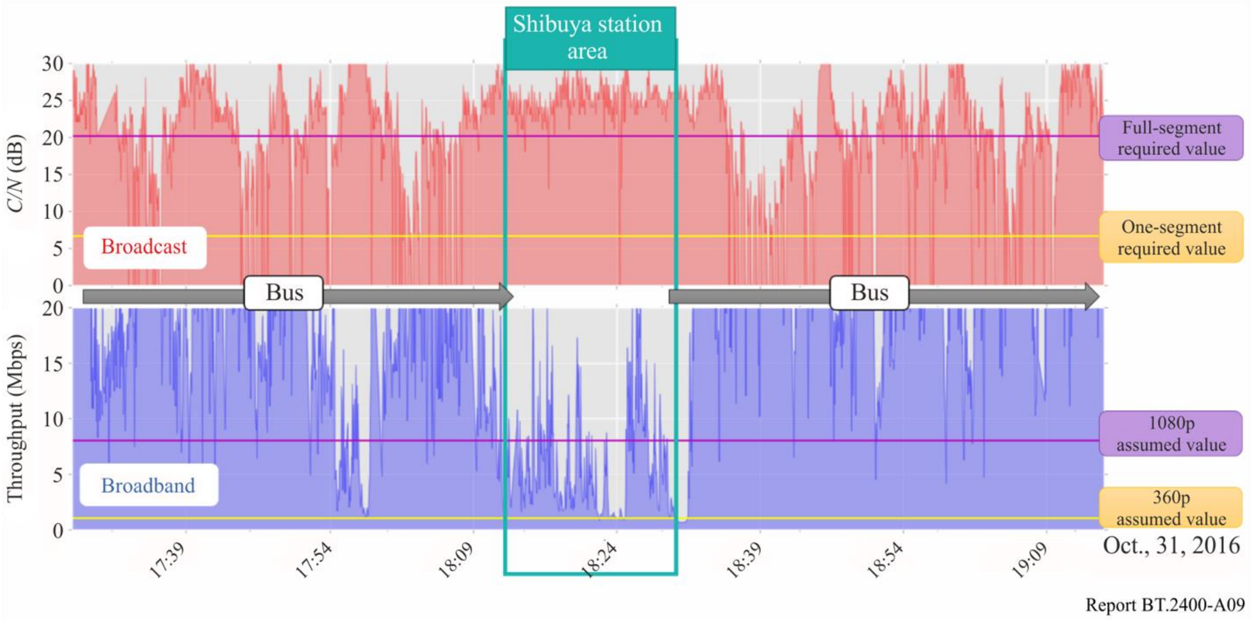
Measured reception quality on Route A



Report BT.2400-A08

FIGURE A1-12

Measured reception quality on Route B



Report BT.2400-A09

4.2 Improved service availability by combined use of broadcast and broadband

Table A1-3 shows the service availability for different reception scenarios, that is, broadcast only, broadband only (low or high data rate), and a combination of both, on Routes A and B.

TABLE A1-3

Service availability on basis of measured reception quality

Reception scenario	Assumed reception condition		Service availability	
	via broadcast	via broadband	Route A	Route B
One-segment broadcast only(1)	$C/N \geq 6.6$ dB(3)	N/A	75.0%	92.0%
Full-segment broadcast only(2)	$C/N \geq 20.1$ dB(3)	N/A	50.9%	64.3%
Broadband only (low data rate)	N/A	Throughput ≥ 1 Mbit/s(4)	99.7%	98.3%
Broadband only (high data rate)	N/A	Throughput ≥ 8 Mbit/s(5)	91.7%	82.8%
One-segment broadcast and low-data-rate broadband	$C/N \geq 6.6$ dB (3)	Throughput ≥ 1 Mbit/s(4)	100.0%	100.0%
Full-segment broadcast and high-data-rate broadband	$C/N \geq 20.1$ dB (3)	Throughput ≥ 8 Mbit/s(5)	99.8%	100.0%

(1) Data rate of 416.0 kbit/s for 320 × 240/15/P video encoded with ITU-T H.264|MPEG-4 AVC and stereo sound.

(2) Data rate of 18.2 Mbit/s for 1440 × 1080/59.94/I video encoded with MPEG-2 Video and 5.1-channel sound.

(3) Required C/N is defined by standard.

(4) Assuming 640 × 360/30/P video encoded with ITU-T H.264|MPEG-4 AVC.

(5) Assuming equivalent quality of full-segment.

The service availability was improved when the combination of broadcast and broadband was used.

4.3 Improved video quality by use of broadcast

The video quality of full-segment broadcasting is higher than that of video streaming via broadband with less than 8 Mbit/s. There were some time periods when a full-segment broadcast could be received while the throughput on broadband was less than 8 Mbit/s; they were 5.3% and 16.4% on Routes A and B, respectively. In this situation, receiving a full-segment broadcast rather than a broadband improves received video quality without decreasing service availability.

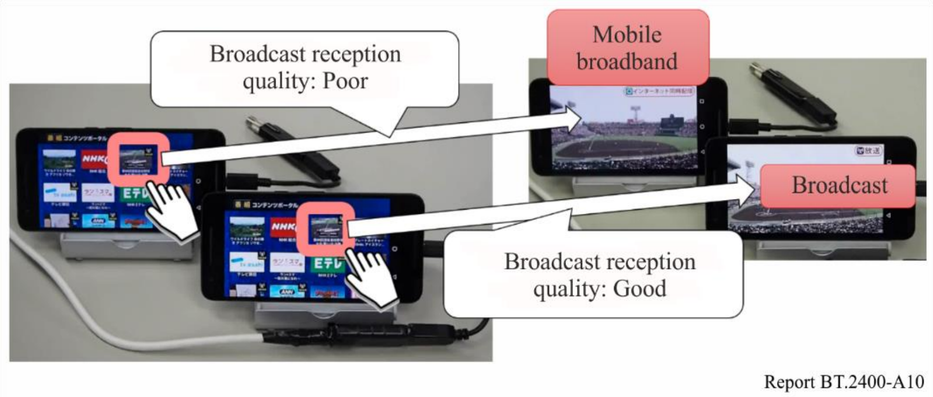
4.4 Summary of advantages of using broadcast and broadband based on measured reception quality

The measured mobile reception quality of broadcast and broadband assuming real-life situations shows that using both improves service availability and video quality.

Owing to the distribution status management server described in § 3, end users are able to receive their desired content without caring about its delivery channel, as shown in Fig. A1-13. The distribution status management server is applicable to any broadcasting systems and any protocols over broadband networks.

FIGURE A1-13

Operation examples based on broadcast reception quality

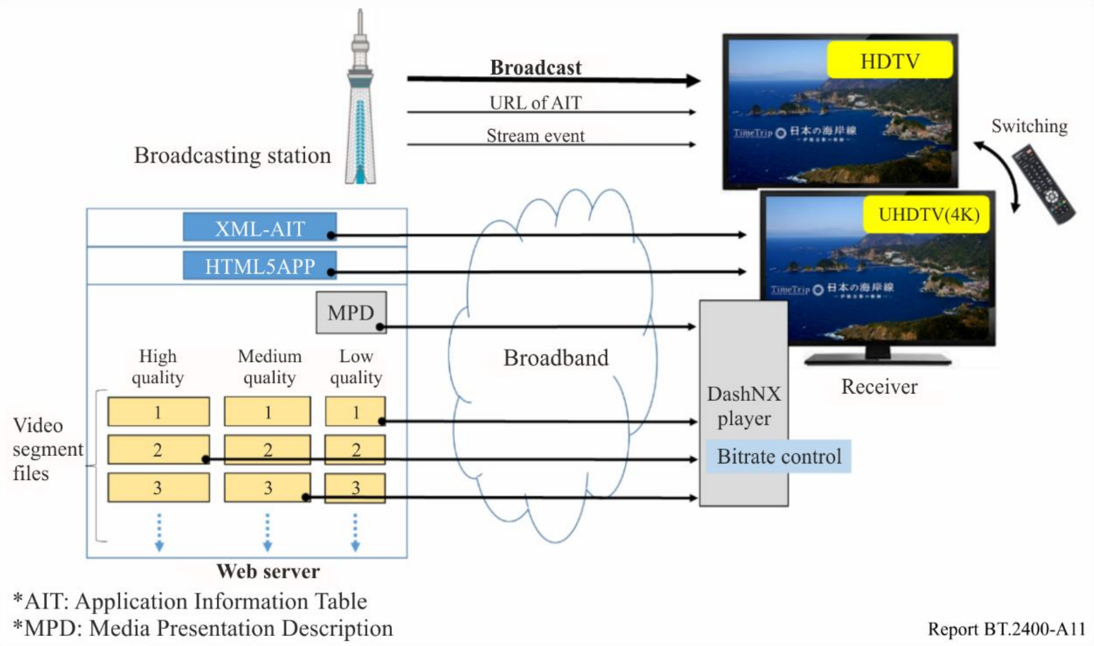


5 Simultaneous delivery of broadcast content using integrated broadcast-broadband (IBB) systems

Integrated broadcast-broadband (IBB) systems enable simultaneous transmission of broadcast content, one through broadcasting networks and the other through broadband networks. Even when UHDTV programmes are not available in terrestrial or satellite broadcasting, they can be delivered through broadband networks. IBB systems can also provide VOD catch-up services. Figure A1-14 shows a system configuration for a multi-resolution video service by means of an IBB system.

FIGURE A1-14

System configuration for multi-resolution video service by means of IBB system



Another example of simultaneous, or hybrid, delivery of content is multiple audio language delivery within a broadcast programme. For instance, in ATSC 3.0 system, ROUTE/DASH and MMTP support delivery of two or more audio components in different languages via different paths, one via broadcast and another via broadband. In the case of ROUTE/DASH, the Service-based Transport Session Instance Description (S-TSID) defines all the broadcast components so that the ROUTE client can retrieve the desired components. Moreover, the User Service Description (USD) contains URL patterns for broadband and URL patterns for broadcast, so that when a DASH Client issues a request for a Segment, the receiver middleware can describe which Segments will be delivered through which path. The middleware will then know which Segments to request from a remote broadband server, and which ones to look for in the broadcast.

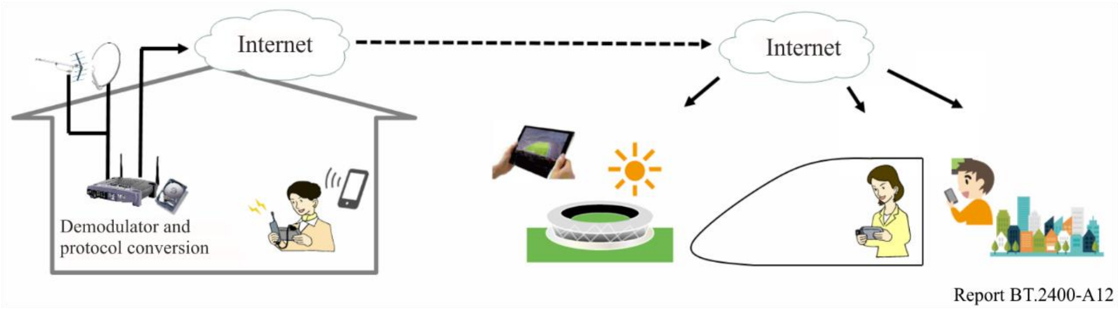
6 Retransmission of received broadcast content to home or private network

Broadcast content received at a home may be retransmitted to a home network or a private network at the discretion of a user so that the user can watch the content on any Internet-connected viewing devices at any location, and even at any time if a server functionality is available (Fig. A1-15). When broadcast content is transferred from the broadcast receiver to the network, the protocol may be converted and encryption may also be needed for content protection.

One demonstrated method of delivering retransmission of received broadcast content to the home is through the use of a ‘home gateway’ device that is capable of tuning and demodulating broadcast content and then forwarding the content to other devices on the home network. In the case of ATSC 3.0, the received broadcast signal is IP-based, and so the content can be forwarded to other IP-enabled devices on the home network without any additional processing in the home gateway device other than tuning and demodulating the signal.

FIGURE A1-15

Retransmission of received broadcast content by the user



7 Broadcast offload use case

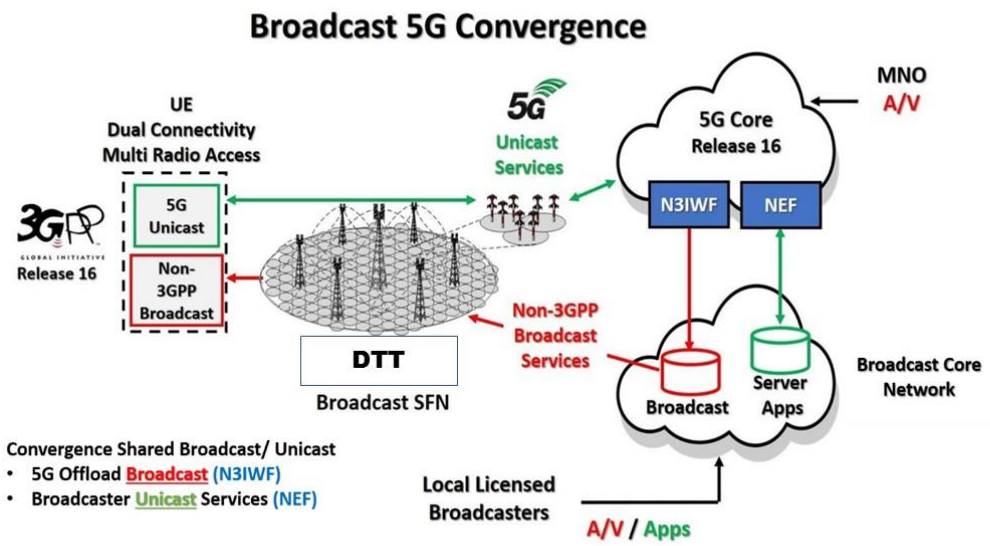
'Broadcast Offload' offers LTE and future 5G service providers an effective way to lower cost per bit when delivering the same content simultaneously to multiple end users. 'Broadcast Offload' allows content (multimedia and other) to be sent once and received by many end users. This "one-to-many" distribution mode can be a valuable alternative to unicast when a large number of users are interested in the same content. Analytics at the core network level (Evolved Packet Core or 5G New Core) define optimal use across the available networks (unicast and broadcast). For example, during live streaming of major sports or news events, unicast must send the same video to every user individually. But 'Broadcast Offload' takes advantage of the inherent broadcast qualities of wireless broadcast networks to send the content (in this case video) only once to reach an equal number of end users. This is also true of file delivery, such as operating system upgrades, where the same file is delivered to a large number of end user devices.

In these types of scenarios, 'Broadcast Offload' makes more efficient use of the available spectrum and reduces cost per bit. The most common uses for 'Broadcast Offload' are likely to include distributing video, music, software, news, weather, ads and other data to a mass audience. The content can be live or preloaded for later usage, which has the potential for additional cost savings.

With the 'Broadcast Offload' scenario, the data is only delivered via one of the two networks (unicast or broadcast). This conserves spectrum bandwidth by only delivering the content via one path. The cellular network is used when the number of end-devices is low, and the broadcast network is used when the number of end-devices is high, taking advantage of the limitless scalability of the broadcast one-to-many delivery network. Figure A1-16 provides an illustration of this type of scenario.

FIGURE A1-16

Broadcast offload example



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[1] Recommendation ITU-R BT.2074-1 – Service configuration, media transport protocol, and signalling information for MMT-based broadcasting systems

[2] Recommendation ITU-R BO.2098-0 – Transmission system for UHDTV satellite broadcasting

[3] ISO/IEC 23008-1:2017: Information technology – High efficiency coding and media delivery in heterogeneous environments – Part 1: MPEG media transport (MMT)

[4] ISO/IEC 23008-13:2017: Information technology – High efficiency coding and media delivery in heterogeneous environments – Part 13: MMT implementation guidelines

Annex 2

Componentized content versioning and packaging for a global platform

1 Introduction

This Annex describes a potential content exchange format that is capable of supplying multiple versions of non-live programmes to a global platform for broadcasting. It describes both generic componentized content workflows and the Society of Motion Picture and Television Engineers (SMPTE) Interoperable Media Format (IMF).

2 Purpose of a componentized content system

Broadcasters and programme makers are producing a wide range of content and services for distribution not only as traditional linear radio and television programming but also as time-shifted, on-demand, hybrid content etc. plus many additional data services. To accommodate the delivery of non-live content to this rapidly changing broadcasting environment, an efficient, flexible system is required for Programme Production and International Exchange. Such a system has been described in the SMPTE IMF.

3 Background

It should be noted that due to territorial, regulatory and rights requirements, multiple versions of a programme are often required and that that different platforms may require technical variants to accommodate a variety of display formats and capabilities (screen size and shape, display colour and dynamic range capability etc.).

In addition, the introduction and use of Ultra High-Definition content (as described in Recommendation ITU-R BT.2100) has dramatically increased the amount of data storage required for programme files and the associated versions. It is therefore desirable that programme making systems minimise the storage and processing requirements during the production and exchange of content for global distribution.

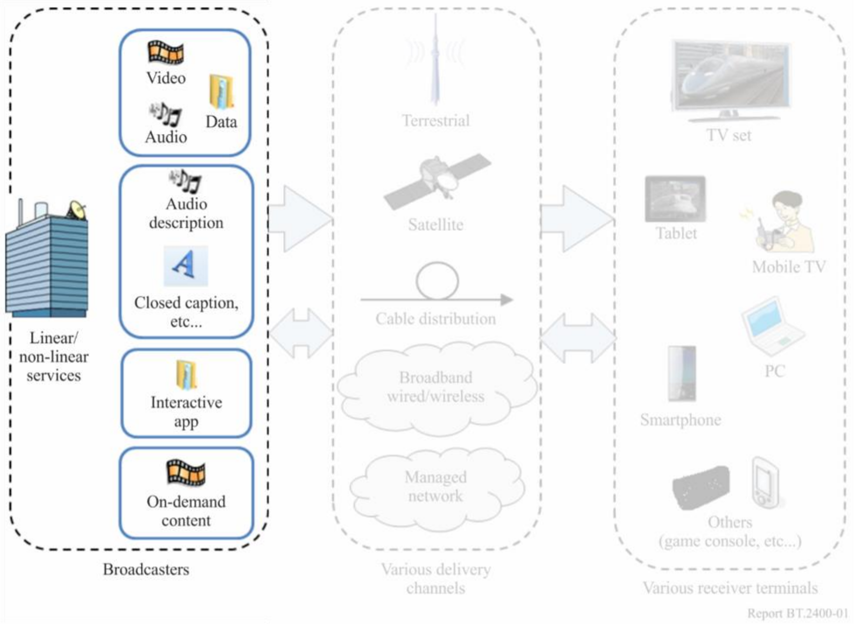
Television programmes often require new versions to be made even after the initial distribution, where local or international regulations are revised or when events such as legal, or local issues require changes that must be applied to some or all versions. Currently this usually requires a completely new file must be created and re-distributed for each version of the programme originally made.

4 The need for componentized content

The left-hand block of Fig. A2-1 highlights the suggested content creation component options that would be required for delivery to a Global Platform. The range of content required will dramatically increase due to territorial, local and personalization options a Global Platform might offer.

FIGURE A2-1

Global Platform Overview



Inevitably content for delivery via a Global Platform will not be simple territorial versions and it is highly unlikely to be just regional within territories. Current technology already enables personalization of content by surrounding more traditional programming with targeted content and experimentation with personalized programming is beginning – that is unique versions targeted or created by the viewer[2]. The Figure above includes and assumes a return data path from the consumer of the content back to the content distributor and inevitably eventually the content creator. Adding Artificial Intelligence (AI) to the content creation and distribution process will exponentially increase the need for content to be made in a componentized form.

5 The Interoperable Media Format (IMF)

As part of its work on content creation for cinema distribution, the SMPTE developed a format that could minimise the processing and storage requirements of content that has multiple versions where much of the material is duplicated in each version.

5.1 IMF overview

It is a logical evolution of the AMWA AS-02 format and has been designed to be a flexible and extendable framework for fully file-based systems using established and mature techniques from the Digital Cinema Package (DCP) and Extensible Mark-up Language (XML).

IMF is described in a family of SMPTE documents with a Core framework (core constraints) and a group of incremental constraints or “Applications” that are specific to particular use cases.

A typical IMF Application will specify video codecs and image characteristics, audio options and tracks plus any additional (optional) descriptive and technical metadata required. It includes detail of the tracks containing MXF wrapped video and audio essence and any time or content dependent data (e.g. timed text subtitles), basic descriptive metadata, complex playlists, and delivery or output options.

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[2] https://arstechnica.com/gaming/2018/10/report-netflix-to-offer-choose-your-own-adventure-tv-series

A componentized content format provides the foundation for a business-oriented workflow enabling multiple versions to be created from a common set of audio-visual components (audio, video. timed text…). Each of these content versions can be transformed into multiple deliverables, tailored for different target platforms and audiences facilitating the distribution of unique versions of programmes between content owners, service providers and distributors.

It is a Core framework together with the Applications structure that makes componentized content formats an interesting option to anyone buying, selling or making content for local and international exchange.

Componentized workflows are becoming more attractive to an increasing number of content producers because:

– More OTT parties are appearing in the market and a common exchange format will gain importance, especially for broadcasters delivering to multiple parties.
– The fact that the creation of different versions of the same content for online services is increasing for national broadcasters (e.g. different online version for mobile watching, in signage applications in public transport, etc.). This fits the overall trend towards a more ‘object-based’ production and delivery chain.
– Many companies are using higher quality post-production codecs for allowing IMF to be used with existing content workflows and libraries.
– The increasing understanding of IMF, thanks to various activities (open-source implementations, educational work by the EBU, SMPTE, HPA, IRT, etc.).
– Componentised workflows allow a high level of automated processing and there is growing need to avoid multiple re-encoding, to maximise storage/transport efficiency, to automate audio track assignment and labelling and the increasing need for version management.

The media industry, as a whole, is making the transition towards completely file-based workflows and at the same time, formats are becoming more flexible, allowing content to be ‘rendered’ into different versions by sending collections of component parts of the content instead of creating multiple finished and flattened files.

This trend is related to the emergence of powerful rendering devices that are more and more heterogenic. They can adapt content to different screen sizes, resolutions, technical capabilities, audio arrangements, etc. They are also able to adapt content to enable personal preferences, that is rendering in the end-device (subtitles being packaged as text instead of preformatted characters, object-based audio…).

Componentized content workflows can exploit new tools to combine audio-visual and data objects into different content versions using XML instruction sets (known in IMF as “CPL”s) without the need to continually duplicate content. It would therefore seem natural for broadcasters to prepare for a completely componentized content chain instead of continually duplicating content as flattened files. Unfortunately, ‘going file-based’ for many broadcasters has simply meant taking a relatively traditional approach by replacing a linear tape workflow with a linear file workflow.

5.2 Concepts

Componentized means the content is not a single file but is a collection of files orchestrated by a “*Composition*”

The Composition defines a specific version of a title. In IMF, the media essence needed for a Composition to be stored as individual ‘Track Files’ which only have to come together at time of final delivery processing. In IMF, the components of a Composition can be ‘bundled’ for transport using Interoperable Media Packages (IMP).

The key support concepts supports are:

– internal and business-to-business media exchange;
– content with multiple audio, video and data components;
– Access Service provision in multiple languages;
– descriptive and dynamic metadata, used by or synchronized with the essence;
– creation of multiple distribution formats from the same editorial version;
– creation of multiple editorial versions from a common set of essence and data files;
– delivery of content in phases, without having to resend already available material;
– identifier-rich metadata for ‘robust’ automation and auditing.

A traditional versioning process will create a full-length file for each version of a programme. Much of the content will be identical in each of these versions. This is an unnecessary and inefficient use of local and cloud storage and requires excessive and unnecessary QC, file transfer, compliance checks and repeat processing.

IMF for example, eliminates the need for multiple copies of content by separating it into specific Components which can be combined to produce different versions.

5.3 Compositions

Each composition defines a specific version of a programme by bringing all the required content and metadata together. In IMF ach version of a programme therefore needs a Composition Play List (CPL). Each CPL calls the required component parts into a timeline that forms that particular version of the programme.

5.4 The Composition Play List

A Composition Play List (CPL) is a small XML file similar to a complex Edit Decision List (EDL). The CPL contains the instructions to identify and position all the associated essence components (track files) that are needed to compile it into a programme.

This allows multiple CPLs (versions of a programme), to refer to content common to each version and to any content unique to each version.

In many workflows, multiple child versions called VF (version file) compositions are generated from an original version called the OV (original version) composition.

– A CPL defines the playback timeline for a composition. It also includes or calls any metadata applicable to the composition.
– Each version of the content has a unique CPL which combines the essence components and data required to complete the version.
– The CPL cannot define the output format of the composition. For this type of transformation, an Output Profile List (OPL) needs to be used. It is a good idea to define the Output Format when any programme is commissioned.

5.5 Track Files

A composition is the combination of a CPL and all the track files it references. A track file is an MXF file that contains a single essence track such as:

– Video essence: Applications currently include the ProRes, J2K and MPEG-4 Studio Profile codecs;
– Audio essence: usually 24-bit baseband PCM;

– Timed text (subtitles and captions): IMSC1 profile of the Timed Text Markup Language (TTML);

– Alternate essence for audio description and signing;

– Dynamic metadata tracks (metadata that changes with programme running time).

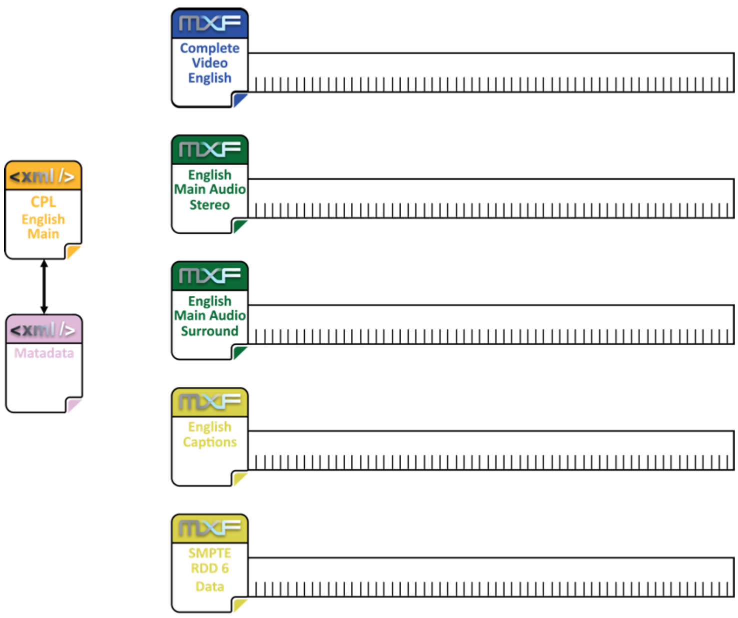
5.6 How Compositions Work

In a traditional workflow, every one of these different versions would have been individually created and stored. A componentized format usually has a primary version and the additional components for each known version. Additional components and CPLs can be added if different versions are required. For example, a programme may include a localised language track, which is only needed in one specific country. This makes processing very storage efficient and is one of the major advantages componentized content workflows.

Figure A2-2 is an example of an English Version CPL – Main Programme made in English with Stereo and 5.1 Audio and Subtitles. The 5.1 audio also has an audio metadata track.

FIGURE A2-2

Compositions



To make the French version the French Version CPL is used to replace the English audio, Subtitles and various video elements that contained English burnt-in text.

Each content version defined by a CPL (XML) file that describes the make-up of the version and ‘calls’ all the associated essence Track Files that are needed to compile the Components it into a finished version.

This allows multiple versions of the same content, each embodied by a CPL, to reuse shared essence components. In many workflows, multiple child versions (called VF compositions) are generated from an original version (called OV composition):

– A CPL defines the playback timeline for a Composition. It also includes or calls any metadata applicable to the Composition.

– Each Version of the content has a unique CPL which combines the essence components and data required to complete the version.

A Composition is the combination of a CPL and all the Track Files it references. A Track File is an MXF file that contains a single essence track such as:

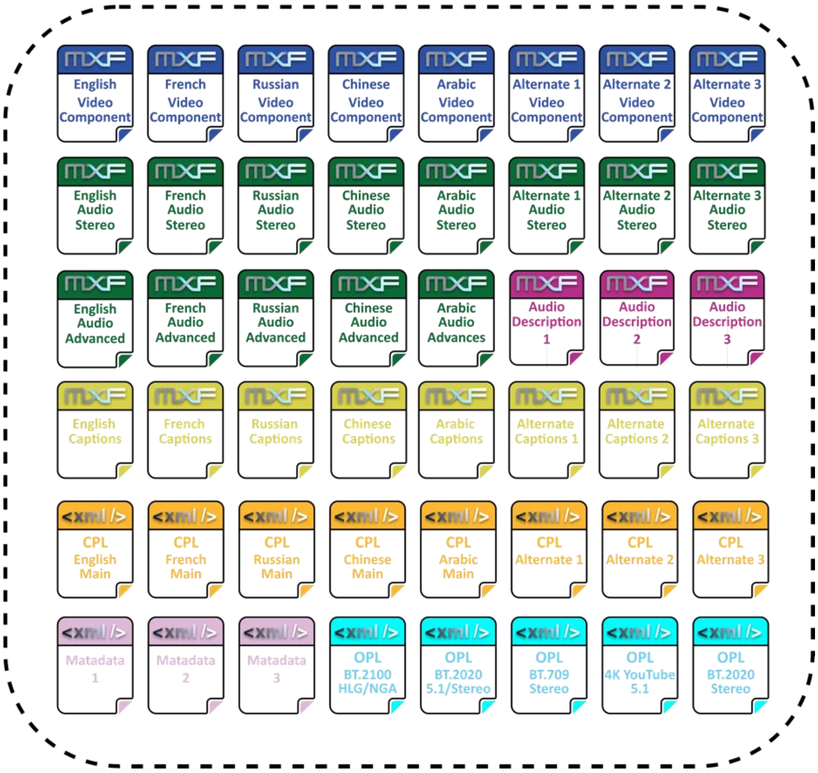
– Video essence: currently there are applications for ProRes, J2K and MPEG-4 Studio Profile
– Audio essence: 24-bit baseband PCM
– Timed text (subtitles captions): IMSC1 profile of the Timed Text Markup Language (TTML)
– Alternate essence for Audio Description and Signing
– Dynamic metadata tracks (metadata that changes during the version).

6 Packaging

In IMF, the elements can be grouped together as an Interoperable Media Package (IMP). It is the IMP that "bundles" all the separate components together. Figure A2-3 is an example of the possible content of an Interoperable Media Package.

FIGURE A2-3

Interoperable Media Package (IMP)



This arrangement allows a high level of automation, reduces redundancy - duplicated content - and thereby minimises storage. A single primary version needs only additional essence containing the differences between versions to be stored making IMF an efficient option for the three main television use cases identified:

– Outgoing – programmes for sale or distribution to others where there is more than one version.
– Incoming – programmes bought from distributors or other broadcasters.
– Archiving – programmes with multiple versions that require archiving.

Increasingly, broadcasters make some of their content available to other distributors and alternate platforms (OTT, package media, streaming services) where alternate editorial versions are needed. Similarly, broadcasters receiving content from others now need to re-package it for their linear and non-linear services.

Although the concept of IMF is now better understood and exploited technically, operationally, it is far more difficult to appreciate IMF's potential and to understand what changes are required to move from a traditional flattened file "linear" and versioning workflow to a componentized unflatten one.

Understanding that IMF exploits the relationship between different content elements required to make different versions is as large a leap as the move from simple stand-alone linear editing to fully networked, shared resource, non-linear post-production.

6.1 Package options

An IMP can be **Complete** or **Partial**:

– A **Complete IMP** contains the complete set of assets for one or more Compositions.

– A **Partial IMP** does not contain the complete set of assets for one or more Compositions.

In addition to the packing list there should also be some or all of the following:

– CPL file(s) (XML);

– Track Files;

– Sidecar files (QC reports, production metadata…).

6.2 Componentized Media

Components make Compositions. IMF uses two file wrappers/formats. MXF is used for media essence assets or any temporarily based data. XML is used documents for descriptive information – metadata.

Essence data (video, audio data, subtitles and dynamic composition-specific metadata) are wrapped into individual MXF data track-files which can be addressed by one or more compositions. Rather than modifying the essence to create different versions, IMF uses an XML file instruction set to combine and order the essence and data needed for each version.

To better understand how this works, the relationship between the components of an IMF package needs to be examined – it is this relationship that make Compositions work.

7 Timecode and file names

IMF has two fundamental concepts that break broadcaster's traditional thinking:

– IMF does not use Timecode.

– IMF has no user generated File Names.

7.1 Timecode

Timecode is a historic artefact of existing linear workflows. It can introduce conflicts that produce errors and complexities that inhibit efficient automated.

Componentized content workflows do not use timecode in same the way a traditional linear workflow does. In IMF, the duration of the essence and any positional offsets are measured and expressed as *Edit Units*. An Edit Unit is the smallest unit of time that can be used to measure an asset. A more useful unit however is the *Edit Rate* which is the *inverse* of the Edit Unit (see Fig. A2-4):

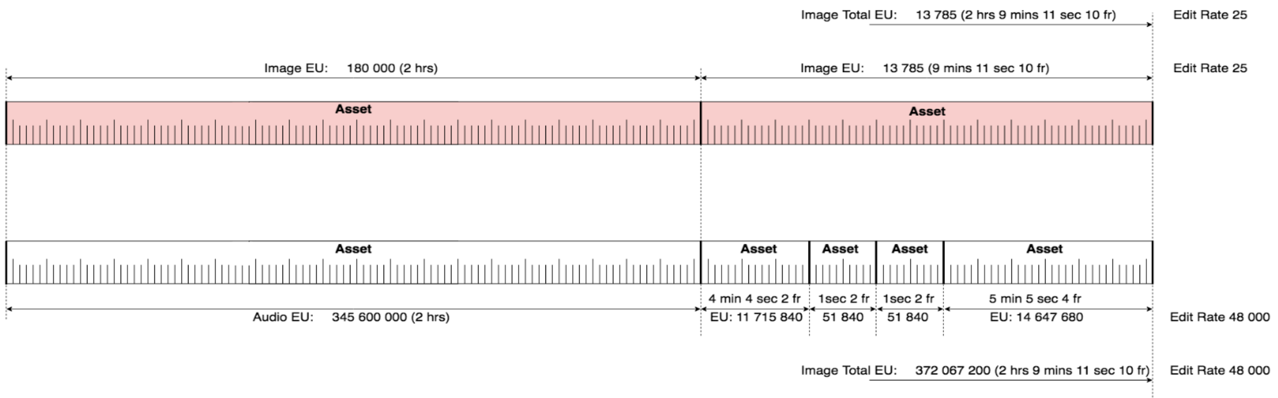
– The Edit Rate for Video would normally be the frame rate.

– The Edit Rate for Audio would normally be the sample rate.

Edit Rates and Edit Units can be defined independently for a Composition and each Resource. A Composition Edit Rate will generally be the video frame rate.

FIGURE A2-4

Edit unit and edit rate



IMF defines the duration of a Sequence as “the sum of the duration of its Resources and shall be an integer number of Composition Edit Units”.

An important fact to remember is that *ALL* tracks in a Composition must be *exactly the same length*.

7.2 File Names

Filenames are also an historic artefact of existing workflows. They often are wrong, forever changing, mistyped or simply misleading. They frequently introduce conflicts that produce errors and complexities that inhibit efficient workflow automation.

In IMF there is no need to know what the name of a file in an IMP is. A Universal Unique Identifier (UUID) for each Asset (see Fig. A2-5).

FIGURE A2-5

File naming

To map the IDs to files, an abstraction layer called the ASSET MAP is used. When delivered there must be an Asset Map which contains all the asset identifiers and which specifies the locations of the required files. Files can be on a local file system or they may be accessed from HTTP/HTTPS addresses.

An IMP can contain any combination of assets. However, it does not need to contain all the assets required for a composition. Also, an asset can be in multiple IMPs.

8 IMF Applications

IMF essence is defined in an *Application* which specifies the allowed codec types, frame rates, resolutions and resolution. The current published Applications are:

– **Application 2E** (SMPTE ST 2067-21). Features and episodic content. Lossy and lossless image coding using JPEG 2000 from SD SDR to 4K (4096×3112) HDR. Defines use of PQ and HLG (amendment 1:2020) as described on Report ITU-R BT.2100.

– **Application 3** (SMPTE ST 2067-30) is for essence encoded as MPEG-4 Visual Simple Studio Profile for images up to 4 096 × 2 160, 12-bit 4:4:4.

– **Application 4** (SMPTE ST 2067-40 is a Cinema Mezzanine specification for essence encoded a JPEG 2000 for images up to 8 192 × 6 224, 16-bit.

– **Application 5** (SMPTE ST 2067-50) ACES, targets archival applications where a TV or movie title is to be archived as a single, high-quality set of files.

– **Application ProRes** (SMPTE RDD 45) is for essence encoded as ProRes for SD, HD and UHD (3 840 × 2 160).

– **Application DPP (ProRes)** (SMPTE Public Committee Draft PCD RDD 59-1) specifies an Application Constrain of Application 2E and Application ProRes for video format described in ITU-R BT.2100 (1 920 × 1 080 and 3 840 × 2 160) defines the use of both PQ and HLG.

– **Application DPP (JPEG2000)** (SMPTE Public Committee Draft PCD RDD 59-2) specifies an Application Constraint of SMPTE ST 2067 – the Interoperable Media Format Application #2E.

– **Application 6** (SMPTE Public Committee Draft PCD ST 2067-60) specifies an Application that targets UHDTV formats (720p, 1080p, 2160p and 4320p) encoded a AVC as used, but not limited to, Japanese broadcasters.

Other Applications are being considered.

8.1 Technical specifications

Applications can be added based on particular criteria such as:

– business requirements;

– the industry at large;

– groups with a common interest;

– a single organisation.

Providing the proposers have the resources to support the process of creating and maintaining a Specification.

9 Using Componentized Content Workflows

As seen from the IMF Applications, component content formats are "living" which can and will evolve over time to meet current and future needs of broadcasters.

As the volume of component-based packages exchanged grows, the need for systems that can import, manage and understand the structure. Also, the ability to retain the relationships between the components and export the content as either flattened files or intermediate component packages, becomes critical. To get the real benefits of scale, it is important that Media Asset Management (MAM) systems support componentized workflows. This currently is not always the case.

The following gives example workflows for Incoming (Acquisitions), Outgoing (Sales) and a potential workflow for an Archiving process.

9.1 Versioning and Selling content

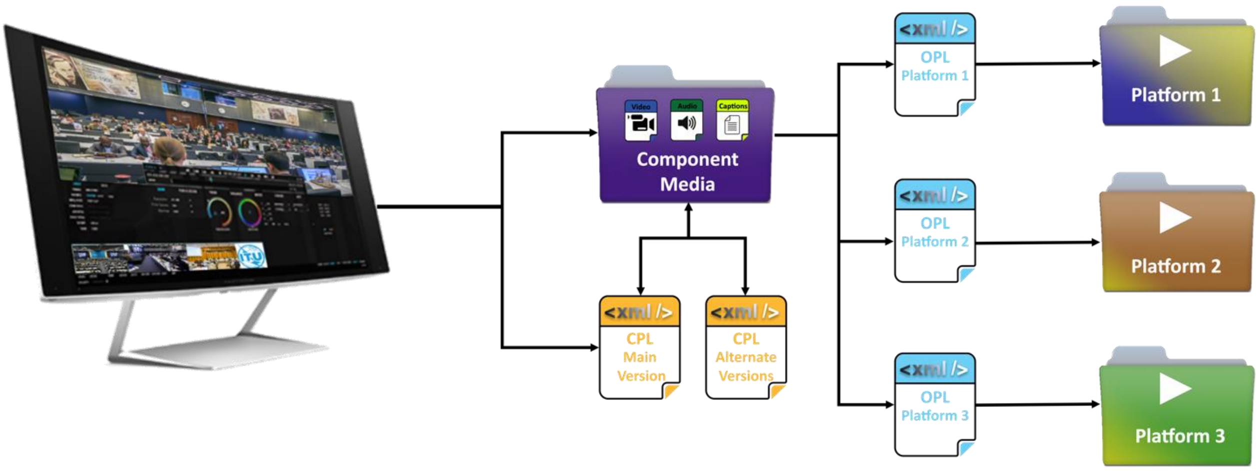
Broadcasters who sell content internationally need to consider versioning as well as international exchange. Sales versions of programmes can be both editorially and technically different to the broadcaster's playout copy. The broadcaster or content owner has to hold many variants of the same core content or keep going back to the original material or production for additional material when orders arrive.

In some cases, the cost of providing multiple formats, specifications and standards can be more than the value of the original content. It can also easily be beyond the capability of the content owner, especially in the case of smaller independent production companies that would require the use of expensive and repetitive versioning.

Due to limitations in most broadcasters' infrastructure (file size, data rate, image resolution…), it may not be possible to create an linear service playout copy of a suitable quality for sales and international exchange.

FIGURE A2-6

IMF use case – Content Sales



A high-quality sub version with the capability to automate the versioning process is an attractive solution. It allows:

– Production of content at a quality high enough to satisfy all outputs.

– On-demand creation of versions.

– Additional material to be held within the same wrapper (clean backgrounds, etc.).

Here, the programme maker produces an IMF (see Fig. A2-6) with all the options required for the commission and any known sales. The broadcaster can make linear service playout version from the delivered IMF and the distributors can make the required sales versions. Should more material be required in for future sales or broadcaster deliverables, the content owner need only supply the deltas.

9.2 IMF for Acquired content

Virtually all broadcasters buy content from international distributors. There are two potential routes options for Acquired content – Linear Playout Files and Component Content Packages.

9.2.1 Linear Playout Files

Definition: *Linear Playout Files (LPF) describes a single version flattened file. It usually has a lower data rate than an international or sales version and only contains the content for a particular platform or "broadcast".*

A very common method for buying content is to simply acquire an LPF which is pre-prepared and "ready to go".

Providing the required file is available in an internationally recognised format (e.g. AS-10, AS-11 H.264 or MPEG2), there is the potential for cost savings, and guaranteed high quality and reliability of the delivered file.

FIGURE A2-7

IMF use case – Linear playout file

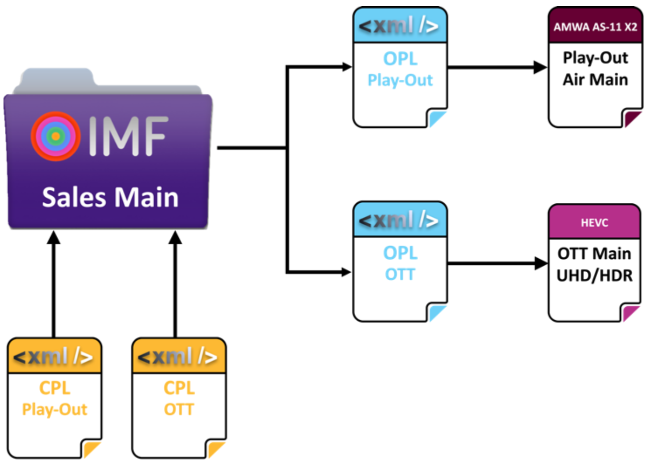


Figure A2-7 illustrates a typical scenario, the broadcaster orders two versions of the content. The Play-out file is formatted for the broadcasters play-out infrastructure (codec, frame size, frame rate, audio options, subtitles etc.) and is editorially hard-parted formatted for commercial breaks. The second delivery is for the On-Demand services and is formatted for the broadcaster OTT services as a single (no break) version in UHD. All parameters of the delivered files are 'fixed' at the time of delivery and no additional material is delivered.

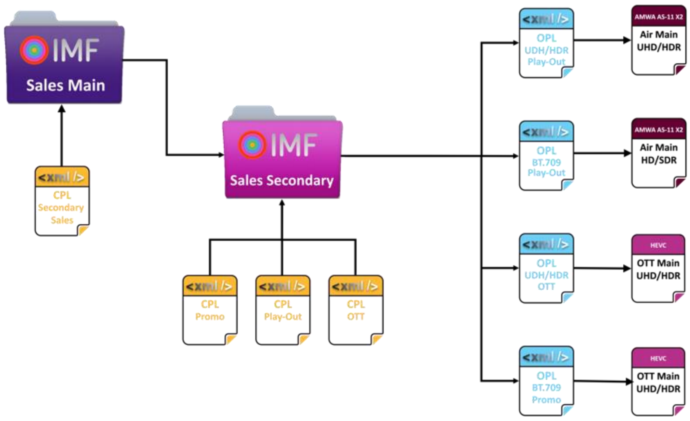
9.2.2 Component Content Packages

Definition: Component Content Packages *(sometimes knows as Library or Archive packages) is a term used to describe high quality set of files that contain all the information and content needed for an individual content buyers licence agreement.*

Broadcasters can also acquire content as a component content packages (see Fig. A2-8) which is in a format that can be post processed in order to comply with local territorial language, editorial and technical requirements. This is not a simple operation for the distributors unless the broadcaster can receive and process the available options from the studio. There is always significant extra cost incurred unless an internationally agreed format is used, and this is a scenario is where a standardized component content format such as IMF becomes valuable.

FIGURE A2-8

IMF based Components Content Packages



Quality can be managed during post-production and processing costs kept to a minimum. Assuming the component content packages is at a higher quality than the buyer's current requirements, it can be used to generate higher quality versions when needed e.g., in future after upgrading from HD to UHD and HDR or from stereo to surround to the Advances Sound Systems described in Recommendation ITU-R BS.2051.

9.3 Componentized Content for Archives

It is very important to remember that componentized content formats are not "a file". For Archival purposes, it is not necessary to keep all the elements of an IMP in a fixed location or group.

Most Archives already have systems to handle media and data. A main requirement for efficient archives with multiple versions will be object-based storage. This does not mean archives have to store 'IMF' itself. Specifically, an archive can adopt an object model compatible with that of IMF, but store and represent content internally as it wishes and use IMF strictly for interchange with other systems. As has been explained, IMF is a set of standards that define an interoperability format. The IMP (Interoperable Media Package) is the actual incarnation of the format as a structured package. Storing an IMP might be a solution for certain Archives[5], but it would need a mechanism to keep track of the compositions and asset relationships it contains at a higher level (a MAM).

One thing is clear: transcoding archive content to benefit from IMF is a nonsense. Most broadcasters have large archives containing multiple legacy codec assets that were made and stored using multiple legacy production workflows. The conversion of these assets to a single codec would not just be time consuming; it would inevitably and unnecessarily degrade the quality of content and use far more storage than is actually needed.

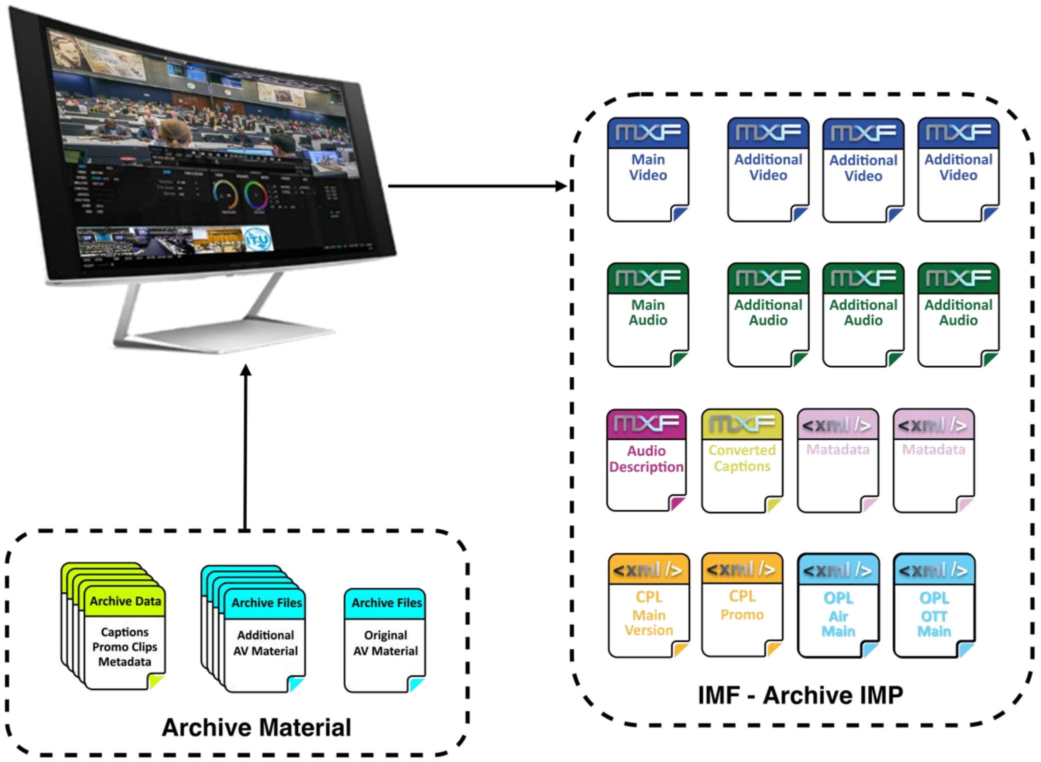
With a (currently imaginary) codec-agnostic Application, it would be possible to transition to an IMF-based workflow over time without damaging the content quality. Such an Application would not break the ethos of the interoperability of the format[6]. Archive content will always be processed before export unless the files just happen to be in a broadcaster's 'current' codec (which will change several times in the lifetime of many assets). Even then, hybrid content workflows that process componentized and flat assets will be needed for a considerable period. Further work would be needed to minimise this workflow overhead.

Archiving programme essence, additional content and associated metadata is a key operation for any broadcaster. A format that allows storing multiple versions of the same content and related metadata in an efficient way can be an attractive proposition. However, this does not mean IMF must sit in the archive.

The key feature for Archives is the way the workflow handles componentized content (see Fig. A2-9). Television programmes 'grow' as they age. Regulation changes add Access Service options that must be applied to repeat transmissions. Circumstances, changes in the law and international events sometimes mean further editing must be carried out before repeat transmission. This leads to multiple flattened versions being stored where the majority of the content is repeated across all versions. Eliminating this was one of the primary reasons IMF was developed.

FIGURE A2-9

Componentized archives



Here, additional material and updated versions can be combined into an IMF Archive package.

10 Componentized content workflows and access services

10.1 IMF subtitles/captioning

IMF supports the W3C TTML's IMSC 1 (Internet Media Subtitles and Captions 1.0) subtitling format. This provides a good international harmonization point for subtitling, even though it currently does not support some of the Japanese/Asian language requirements.

Tests so far have demonstrated IMSC 1 implementations seem to be at a relatively early stage of maturity; the interoperability of IMSC 1 implementations is expected to improve over time.

The EBU-TT family is based on the same W3C TTML specification. EBU-TT-D can be seen as a subset of IMSC 1.

For broadcasters wanting to use IMF, converting legacy subtitling formats (e.g. EBU STL) into IMSC 1 may be required.

10.2 Audio description/described video service

Audio Description (AD) files can processed in two ways in a componentized package.

10.2.1 Using fully rendered audio

Fully rendered audio is simple the contents audio premixed with the audio description dialogue as a new audio track or tracks. This can be called by a CPL and rendered into a distribution version through an OPL.

10.2.2 Using separate dialogue and a control signal

It is also possible to include Audio Description as a dialogue channel and control signal channel in a virtual track. SMPTE Multi Channel Audio tags and UUIDs have already been defined for the dialogue channel and the control signal channel as well as the Soundfield Groups containing Audio Description with dialogue and control signal.

10.3 Signing services

Currently there is no provision for signing services. It would be possible to reference a fully rendered signed version of an asset as a virtual track, but this seems a cumbersome method and goes against the ethos of IMF as it would create an additional asset containing repeated material.

11 Tools

From the start it must be understood the versioning is not editing. Traditional editing tools were adequate when a versioning workflow created a separate and complete asset for each version. Non-Linear Edit systems are storytelling tools that treat each shot and audio element as discrete items whose relationship is set by the storyteller's intent. Componentized Content Creation is a skilled craft role that is very different to Editing.

Componentized Content Creation is about:

– Manipulation of finished and complete segments of essence.
– Creating and editing metadata related to the assets and version(s).
– Creating and maintaining the relationship between the assets in an IMP.
– Identifying and reporting the presence or absence of assets against metadata.
– Creating the required CPL(s) for each version in an IMP from a timeline representation.
– Creating and/or importing output profiles as required for each version.
– Adding and combining additional materials or security (e.g. watermarking, etc.).
– Play-back of versions from created or imported CPLs.
– Creating and applying traceable asset names.

The tools required will need to be capable of managing media and metadata components and the skills required will require a deep understanding of componentized workflow management and multiple output content creation.

12 Global platform use case examples

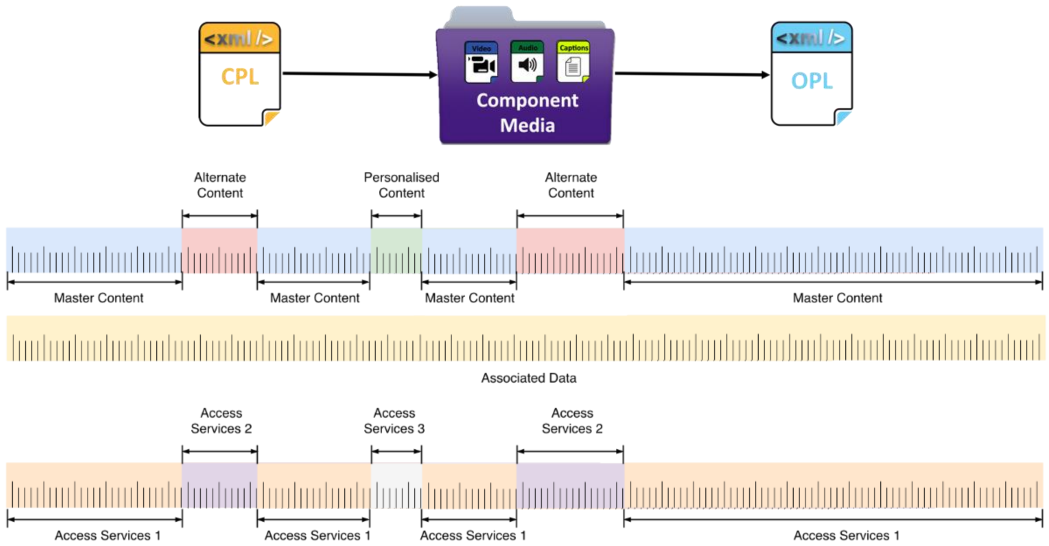
There are many different combinations and options that can be used to illustrate how IMF can supply a Global Platform with content targeted at devices, territories or even individuals. Currently IMF is used to "push" pre-prepared versions via pre-made CPLs between broadcasters or between content creators and distributors. These versions can be tailored to meet regulatory, editorial and/or technical requirements. Additional versions can be made at any time (assuming any additional components are available or can be made). There are many different combinations and options that can be used to illustrate how IMF could be used to supply a Global Platform with content targeted at devices, territories or even individuals. Currently IMF can *only* push pre-prepared version via pre-made CPLs between broadcasters or distributors.

The versions can be tailored to deal with regulatory, editorial and technical requirements provided all details are known in advance. Additional versions can be made at any time (assuming any additional components are available or can be made).

Figure A2-10 is an example of the Composition Play List (CPL) used to select a given set of assets to build a timeline that is relevant to the distributors target audience.

FIGURE A2-10

CPL Process Example



These assets could also contain "personalized" asset markers that could be inserted locally or even via assets already pushed to individual subscribers receiving devices

It is not unreasonable to expect that future models of a Global Platform could sent personalized date back to the distributor who could produce a CPL and render a version "on the fly" to be sent to a subscriber.

12.1 BBC Studios documentary use case example – Perfect Planet

A Perfect Planet, in a unique fusion of blue-chip natural history and earth sciences, explains how the living planet operates. The five-part series shows how the forces of nature – weather, ocean currents, solar energy and volcanoes – drive, shape and support Earth's great diversity of life. In doing so, it will reveal how animals are perfectly adapted to whatever the environment throws at them.

A Perfect Planet is a Silverback Films Production for BBC and Discovery. And co-produced with Tencent Penguin Pictures, ZDF, China Media Group CCTV9 and France Televisions. A BBC Open University Partnership.

12.1.1 Versioning

Editorial versions

The series consists of five episodes with each episode having a 50' and a 60' version plus a single 50-minute "making of" or diary programme containing additional behind the scenes content.

Episode one to four 60-minute versions were made from the 50-minute version main body with a 10-minute diary section added between the programme end and the closing credits

Episode five did not contain the diary at the end making the difference between two versions editorially different.

Because episode five did not have a Diary section, the single making programme contained 10 minutes if new material.

Additionality the programmes also had a presenter in-vision and presenter not in-vision version.

– Presenter-led (A-list presenter in vision, usually 60 min).
– Presenter-less (A-list presenter is not in vision, usually 50 min).
– Presenter-less with presenter's VO (presenter is not in vision but presenter narrates).
– Presenter-less with generic VO (presenter is not in vision and generic VO is used instead).

BBC Studios also has a single 90-minute programme made from all five episodes.

Branding Versions

Branding requirements that create new versions in addition to the different editorial versions, each programme could have one of several different branding options at the beginning, just before the end credits and an 'end-board'. Each branding option leads to an additional set of versions.

Upfront branding with audio stings (BBC Sting, BBC Planet franchise sting. Tencent stings) changes the durations of the main programme.

– CCTV – branding removed – shorter duration.
– Tencent – additional branding added at the beginning – longer duration.
– DCI – BBC earth branding replaced with BBC white blocks.
– AS11 UK files – no upfront branding shorter duration.
– BBC Planet franchise sting is inserted in the body of the programme.

Technical Versions

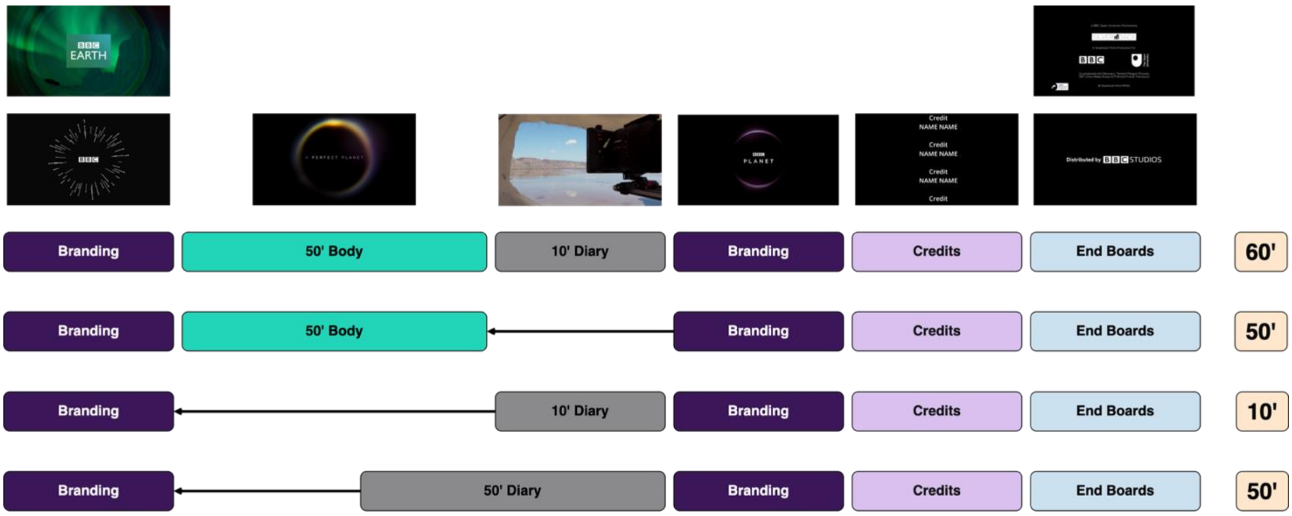
Video	**Audio**
HD ProRes 25P	Stereo
UHD HDR HLG ProRes 25P	Dolby 5.1
HD AS11 25i (psf format)	Dolby Atmos - ADM for Distribution
TIFF 23.98P	Dolby Atmos - DAMFs for Consumer
DCP 24P	
Large Screen 24P	

12.1.2 Versioning content

Versions (see Fig. A2-11) can be created for various reasons such as music or other content clearance issues. It can also be specific and title dependant. Frame rate conversions can make the programme longer or shorter. Where USA co-production is involved a version for them with imperial voice over is required (Fahrenheit instead of Celsius etc.).

FIGURE A2-11

Content version options



12.1.3 Versioning map

Table A2-1 shows the different duration, branding and technical versions for each primary co-producer.

TABLE A2-1

Version Map for BBC Studios Perfect Planet

Company	No. of episodes	Duration	Format		Content
BBC Studios	5	50	UHD HDR	HD	Core
Tencent	5	60	UHD HDR	HD	Branding
BBC Studios	5	50	UHD HDR	HD	Core
CCTV	5	50	UHD HDR	HD	Branding
DCI	5	50	-	HD	Branding
BBC Studios	4	10	-	HD	Core
Tencent	4	10	-	HD	Branding
DCI	4	10	-	HD	Branding
BBC Studios	1	50	-	HD	Core
Tencent	1	50	-	HD	Branding
CCTV	1	50	-	HD	Branding
DCI	1	50	-	HD	Branding

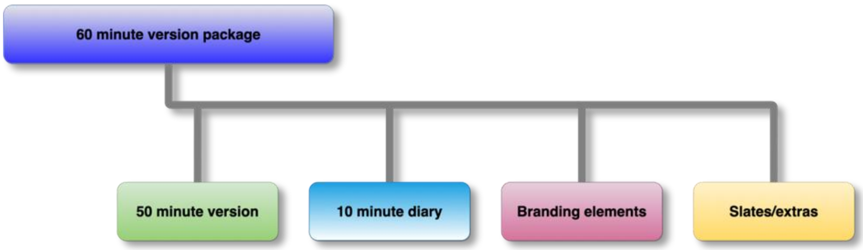
12.1.4 IMF Workflows

To create the IMF package an Original Version is created first (see Fig. A2-12). This contains all the media necessary and known *at the point of creating* an IMF package per episode.

Supplemental packages (see Fig. A2-13) that contain material not available at the time the Original Version is created. Supplemental packages also include any production fixes/corrections to the Original Version. These packages usually only contain the media for the ident, any fix material or branding, as these are the only assets that differ for a particular version that are not already contained within the Original Version IMF package.

FIGURE A2-12

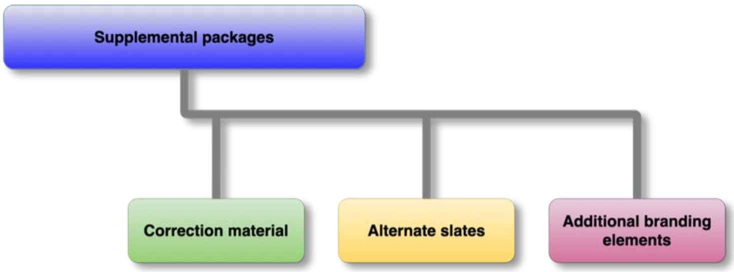
Package example



Each Supplemental Version contains a CPL that instructs the IMF player which assets to play in which order and whether an asset is in the Original Version or the Supplemental package

FIGURE A2-13

Supplemental package example



At the beginning of the process, the post production company would have sent the core content as an Original Version package then all the necessary branding and extra elements as supplements even if they were available at that time. This was changed later so that branding elements and the required versions known at the point of packaging, were delivered as a single ‘super’ IMF package and not drip feeding the branding as supplements.

It should be noted that feeding elements as supplements outside of the main Original Version package although requiring more energy and costs while managing media, this method can be faster, requiring less time to completer time critical deliveries as processing could start ahead of receiving supplements for other versions.

Currently not all the processing areas used for programme deliverables can handle IMF packages. To overcome this, flattened versions had to made but it is hoped this will continue to move down the processing chain to as late as possible.

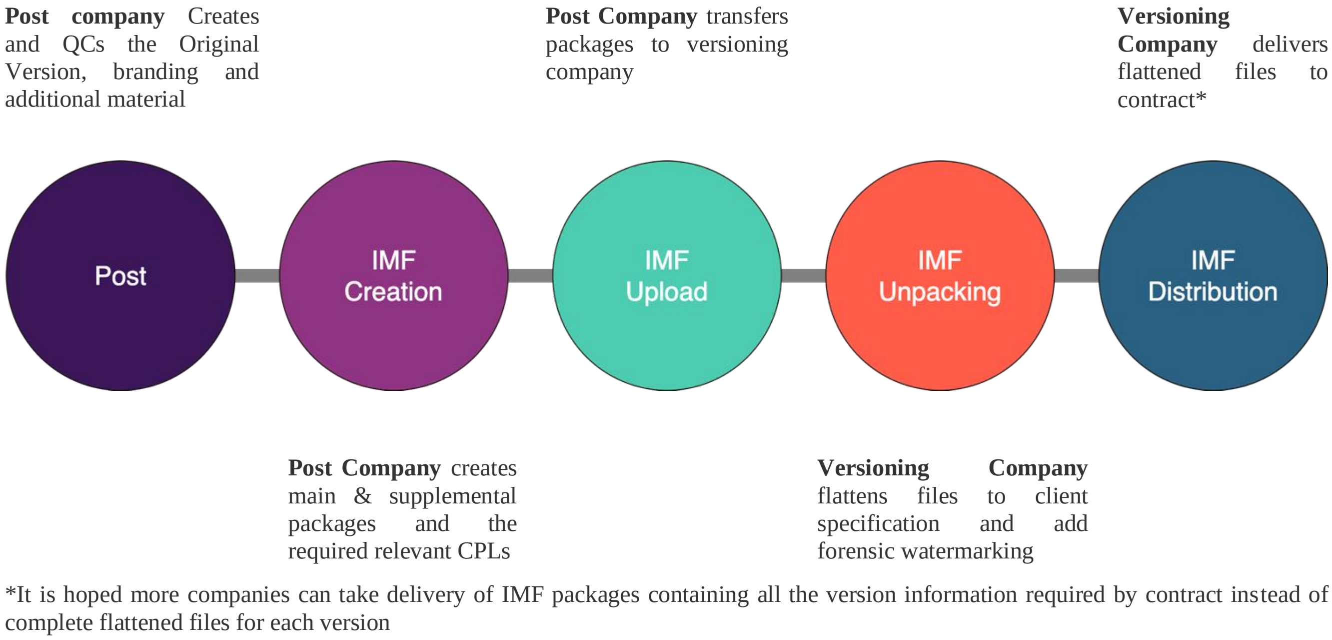
– BBC Studios 60’ and 50’ versions been exported as UHD files using Da Vinci Resolve.

– 60’ package took 1 hour 53 minutes to export.

– 50’ package took 1 hour 33 minutes to export.

– File sizes were 309 Gb and 256 Gb respectively.

A package is ALL versions of an episode with a main Original Version plus branding and extra elements in component form.



12.1.5 IMF Supplemental packages for production re-calls

Supplements were used for rectifying mistakes/production errors without the need to remake the complete programme file. Each production recall is classified as either compliance or editorial edits.

– Compliance Edits may have a serious implication if BBC Studios continues to distribute the content. These instances include, but are not limited to:
  - Regulatory complaints;
  - music clearances;
  - archive clearances;
  - contributor sensitivities;
  - uncleared telephone numbers (in vision).

– Editorial edits are issues that production would prefer to fix in order to maintain production values. Examples may be, but are not limited to:

– updating video FX:
  - credit changes;
  - contributor misspellings.

Any updates via a supplemental will need processing to the relevant formats and go through the validation process. As the Versioning Company has already validated the main package, any supplemental packages/fixes are faster to process.

12.1.6 Quality Assessment Review (QAR)

One of the current concerns during the delivery of IMF packages referring a flattened version back to the Original Version. The addition of different duration branding or commercial back changes the position of the content relative to the start of the Original Version programme body.

Ideally, a single document would list all elements within the Original Version package giving a QC report for each especially where some material may not meet the highest quality standards (e.g. up converted material, specialist miniature camera shoots etc.).

12.1.7 Wish List (at the time on production)

Dolby ATMOS Audio in IMF packages

At the time of production, Dolby ATMOS audio had to be delivered alongside the IMF packages and not within. Since then, developments may have reached a suitable point for insertion of ATMOS into the IMF packages. Delivering ATMOS within IMF packages is the preferred option for BBC Studios and further investigation and testing will be carried out.

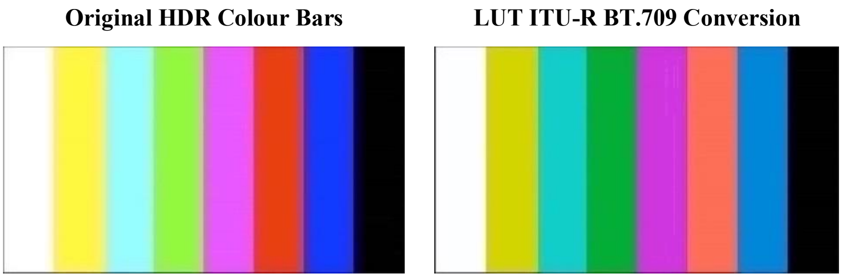
Automated LUT Conversion HDR to SDR[3]

Automated LUT conversion from UHD HDR to HD SDR has been used on a BBC Studios commissioned programme however the Perfect Planet production company wanted to create the HD version manually which meant a second package needed to be produced.

Also, it was noticed that colour distortion was seen on the Colour Bar test signal when colour space converting via the LUT (see Fig. A2-14).

FIGURE A2-14

Conversion



However, the programme was made prior to the revision on ITU-R BT.2111 which explain the reason converted bars generally look a bit de-saturated in SDR and would exhibit incorrect levels on video waveform monitor scopes[4].

QC Issue Tracking

Natural History programmes with the making ofs/diaries often have a less polished feel - on purpose, and some material is not of the expected high quality of the body of the programme. Although many technical issues and errors would be fixed and graded to the best abilities at the time (and signed off by production), n the *flattened file* world, these shots may not technically *ideal* would be listed on the QAR report and as 'best endeavours'. This allows BBC Studios as a distributor, to refer to the programme timecoded list if any clients in the future raise concerns.

A method of tracking the position of individually identified issues across multiple versions (in the flattened delivered files) is desirable.

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[3] Note: This programme was made and finished while some ITU-R Reports and Recommendations were still in development. It is expected more automation will be used on future series.

[4] Future programme for BBC Studios will be required to use the test signal described in EBU TECH 3373 which is based on the HLG Colour Bars in ITU-R BT.2111.

12.2 ITV drama pilot use case example – Vanity Fair

To begin our implementation journey we set about organising delivery of a pilot IMF package for a high profile ITV drama. Delivery of the landmark Sunday evening drama, Vanity Fair, happened to coincide with publication of the new IMF specification. Vanity Fair was also shot in UHD which made it an ideal fit for the IMF specification.

Anyone who has been involved in delivering technological innovations will be painfully aware that successful implementation is wholly dependent on excellent change management and communication skills. Successful technology change is about winning the hearts and minds of key stakeholders and that is what we have set out to achieve within ITV with a major business change programme underway to run in parallel with our technical implementation.

The production company, Mammoth Productions (the company behind Poldark and Victoria), and the post-production house Technicolor were fantastically supportive and helpful delivering our first IMF pilot deliverable using the UK Digital Production Partnership specification for the componentized content creation and international exchange of content for broadcast and online (SMPTE Public Committee Draft PCD RDD 59-1).

As part of the pilot IMF project, ITV took delivery of one episode of Vanity Fair in UHD with the essence being supplied as ProRes 422 HQ MXF and 5.1 audio. This was then used to create an IMF Package (IMP). The IMP contained one simple Composition Playlist (CPL), a subtitle file and a foreign language track.

The Italian and French language audio files were delivered later as 24-bit WAV files. These were added as a supplemental package. The metadata included the minimum common metadata set to support broadcast and online as defined in Phase 1 by the DPP Metadata Working Group. During Phase 1 this metadata will be carried in an XML sidecar.

To help evaluate the potential for version and localisation, we also created a second CPL within the package, containing localised opening and closing credits. This helped us understand the benefits and also the challenges of creating multiple downstream deliverables from a single package of audio-visual content.

It is still very early days, but the IMF pilot is an important step on the road to full adoption by ITV of the SMPTE/DPP Specification for Broadcast and Online. Going forward, it is intended to implement at least two more pilot IMF deliverable for the dramas Snowpiercer and Brassic. Snowpiercer is set in a future where a failed climate change experiment kills all life on the planet, sparing only the lucky few that managed to board the Snowpiercer train.

12.3 Creation and package verification worked example

Tools have been and continue to be, developed to create and verify that IMF packages are compliant with either the standards directly or meet a particular organisations delivery requirements. CPL Player tools are also becoming available that can be used wither locally or via Cloud Applications to review the original version or alternate versions or corrections as appropriate.

12.3.1 Package Creation Example

Figure A2-15 is an example of the timeline used to create the BBC Studios Perfect Planet programme. The finished Original Version can be exported as a series of MXF wrapped files. The process separates the video and audio into components parts with each audio MXF file containing the relevant SoundField groups.

FIGURE A2-15

Programme Timeline

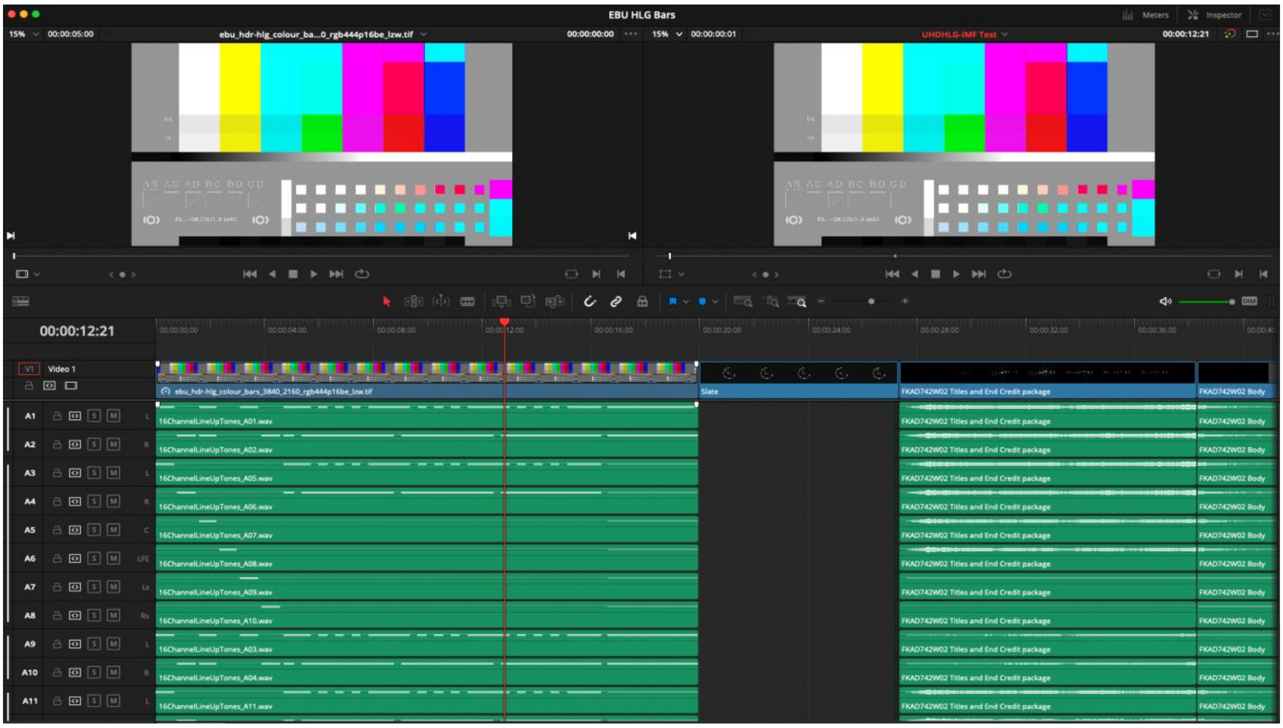
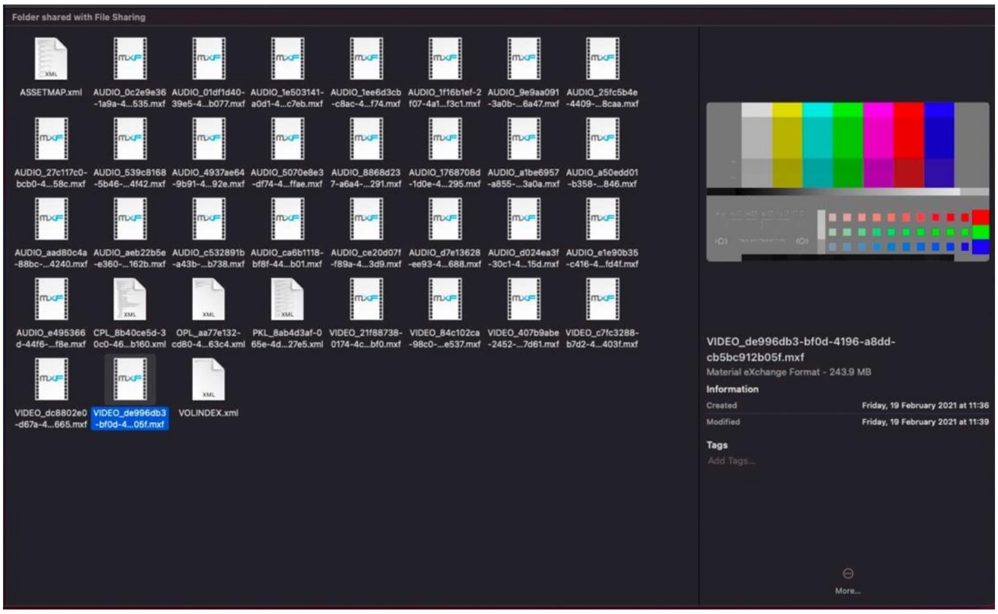


Figure A2-16 shows the package containing the MXF essence components and the XML descriptive or instructional metadata. The package must contains at least one CPL but can contain as one for each version of the content that is known at the time of packaging.

FIGURE A2-16

Conversion



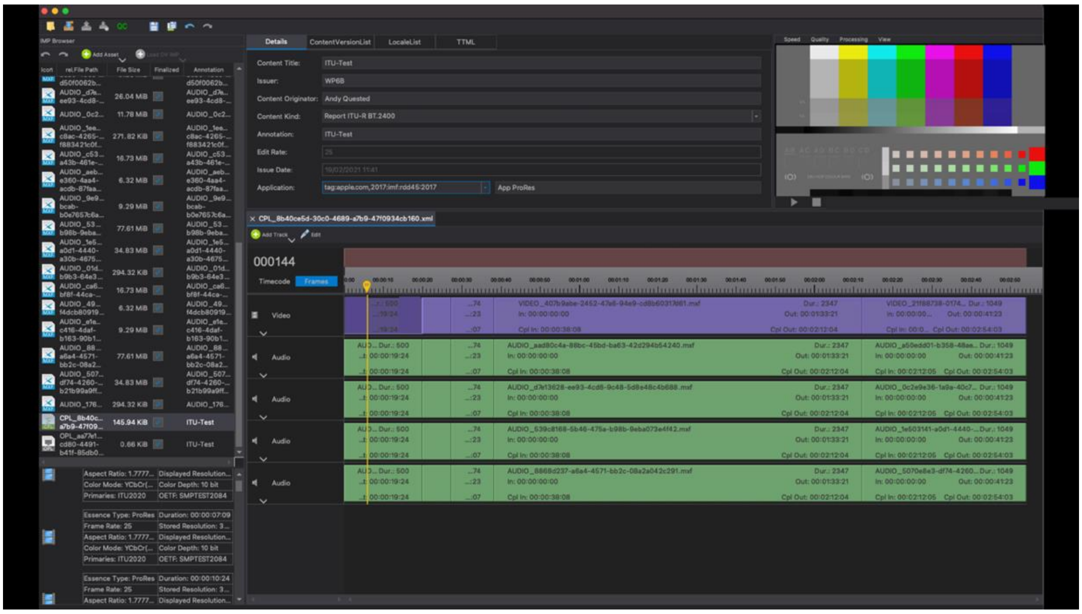
12.3.2 Compliance tools

A compliance tool loads the MXF media assets and the XLM data assets. The tool organises the assets, which are displayed as a timeline, as instructed by the CPL9s). The tool usually includes an AV player to reply the loaded version of the programme.

Figure A2-17 is an example of a package loaded into a compliance tool.

FIGURE A2-17

Compliance Tool



13 IMF documents

IMF documents are continuously being developed and reviewed. Table A2-2 is a snapshot of current documents available at the end of 2018. IMF is a mix of several different types of SMPTE document including Standards, Technical Specifications and Registered Disclosure documents.

TABLE A2-2

SMPTE IMF documents as of 2021

Core Documents	
SMPTE document number	**Title**
ST 2067-2	IMF – Core Constraints
ST 2067-3	IMF – Composition Playlist
ST 2067-5	IMF – Essence Component
ST 2067-5: Am 1	IMF – Essence Component (Amendment)
ST 2067-8	IMF – Common Audio Labels
ST 2067-9	IMF – Sidecar Composition Map
ST 2067-100	IMF – Output Profile List
ST 2067-101	IMF – Output Profile List – Common Image Definitions and Macros
ST 2067-102	IMF – Output Profile List – Common Image Pixel Color Schemes
ST 2067-103	IMF – Output Profile List – Common Audio Definition and Macros
ST 2067-200	IMF – Dynamic Metadata for Color Volume Transform – Plug In
ST 2067-201	IMF – Immersive Audio Bitstream Level 0 – Plug-in
RDD 47	IMF – Isochronous Stream of XML Documents – Plug In

TABLE A2-2 (*end*)

Application Documents	
SMPTE application document number	**Title**
ST 2067-20	IMF – Application #2 (JPEG2000 HD)
ST 2067-21	IMF – Application #2E (JPEG2000 adding UHD)
ST 2067-30	IMF – Application #3 (MPEG 4 Simple Studio Profile)
ST 2067-40	IMF – Application #5 (Cinema Mezzanine)
ST 2067-50	IMF – Application #5 (ACES)
ST 2067-60 (public committee draft)	IMF – Application #6 (UHDTV program workflow - AVC)
RDD 45	IMF – Application ProRes
RDD 59-1 (public committee draft)	IMF – Application DPP (ProRes based on ITU-R BT.2100)
RDD 59-2 (public committee draft)	IMF – Application DPP (JPEG2000 constraints Application #2E

NOTE – This Table omits the SMPTE document year from the name. The intention is to show how the suite of documents interact. The latest version applies to actual use of IMF.

14 Conclusion

Componentized Content Creation and Workflows are rapidly developing to incorporate many more use cases than envisioned when it was first developed. Currently it may not meet all the options a Global Platform might require but this is not necessarily a problem as the strength of IMF for example, lies in the flexibility of its structured which allows continual development though new Applications and plug-in which are built on stable core documents.

The value of componentized content used to supply non-live content to a Global Platform ultimately depends on the platform’s final requirements. With additional features, either via new Applications or Plug-Ins, IMF does meet many of the use scenarios, requirements and the technical elements required for non-live content being supplied for distribution via a Global Platform.