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DVB-I SERVICE DELIVERY OVER 5G SYSTEMS

R. Bradbury[1], F. Gabin[2] and T. Stockhammer[3]

[1] British Broadcasting Corporation, UK, [2] Dolby Labs, France,
and [4] Qualcomm, Germany

ABSTRACT

The convergence of Internet-based media delivery and traditional broadcasting presents an opportunity to separate the way services are described and discovered from the technologies used to deliver them. At the same time, recent 5G standards published by 3GPP allow linear television and radio services to be delivered over unidirectional and bidirectional 5G mobile networks. This paper examines how services described and packaged for delivery according to DVB standards can be carried over LTE- and NR-based 5G networks.

The combination of DVB-I service discovery metadata with DVB-DASH service delivery is described in the context of three key service scenarios: standalone delivery over 5G Broadcast, unicast delivery assisted by 5G Media Streaming and hybrid scenarios where broadcast and unicast delivery are combined in different ways. A generic reference architecture to support these service scenarios is also presented.

INTRODUCTION

As well as defining Service Information for describing linear services available over digital broadcast networks and for populating Electronic Programme Guides (EPGs), the DVB Project has more recently specified an XML-based format for discovering linear and related on-demand services available via broadcast and/or IP-based networks, as well as accompanying programme metadata [0]. These are referred to as DVB-I services.

In July 2021, the DVB Project approved Commercial Requirements for supporting the carriage and description of DVB-I services over 5G networks and systems [1]. The document not only provides a set of 70 technical and procedural requirements, but also introduces key elements of 5G networks and systems related to media distribution including 5G Broadcast, 5G Media Streaming and other ongoing standards activities in 3GPP. LTE-based 5G Broadcast (as defined in ETSI TS 103 720 [2]) provides all functionalities to operate classical TV services, including receive-only mode, free-to-air, and high-power high-tower network infrastructures.

5G-based technologies enable content and service providers to access mobile devices, typically interfacing with installable apps. 5G-based distribution to other types of receivers, such as moving vehicles, devices connected to roof-top mounted antennas or 5G-based home gateways, is also enabled. A particular benefit of DVB-I services over 5G is the ability to support integrated DVB-I hybrid services, i.e., services for which the basic broadcast distribution is augmented with unicast for extended service coverage, lower distribution costs, improved quality, and additional user experiences.

In January 2022, the DVB and 5G-MAG (5G Media Action Group) approved the formation of a joint Task Force on DVB-I over 5G with the goal to develop a Technical Report (TR)

documenting deployment guidelines for DVB-I service delivery over 5G Systems. This paper provides an overview of the Technical Report which, at the time of writing, is due for publication mid-2023 as ETSI TR 103 972 [3].

COMMERCIAL REQUIREMENTS

Over the last decade, the previously separate broadcast and cellular mobile ecosystems have started to collaborate. A few trends accelerated this collaboration:

1. A standalone broadcast system to mobile devices, developed by a TV-standards setting organization, has not achieved commercial traction for multiple reasons, but primarily due to the lack of suitable receiver functionality in mainstream mobile devices. Reasons for this include the lack of a globally and universally available standard and the need for specific silicon parts.
2. Television services managed by mobile operators, possibly using efficient radio technologies such as MBMS to support broadcast and multicast, were similarly unsuccessful. Reasons for this are manifold but include for example the lack of the ability to easily support third-party services with a well-established TV service layer or app, or the lack of being to share radio resources with other Mobile Network Operators (MNOs).
3. Traction to separate the TV service layer from the distribution network. The DVB Project has historically worked to harmonise the service layer across terrestrial, satellite, cable and managed IPTV distribution networks. Motivated by a need to distribute and discover Internet-based television and radio services, a further simplification and separation of the service layer from the distribution network has been achieved with the DVB-DASH and DVB-I specifications.
4. Meanwhile, with the expansion of 3GPP standardisation to industry verticals and the continued migration to 5G, a flexible distribution platform for mobile networks is now available using combinations of 5G Broadcast, unicast 5G mobile broadband with extensions such as 5G Media Streaming and MBS services. These generic building blocks support different services without specifying the user service layer separately for each different industry vertical.

Based on these trends, a natural next step is the combination of a DVB-specified service layer with a distribution system that enables efficient access by mobile TV service receivers such as smartphones, automotive entertainment systems, as well as a plethora of portable or stationary devices. The application of DVB-I on top of the flexible 5G distribution platform for advanced TV services is therefore an attractive opportunity.

In order to progress these ideas, the DVB Project convened a Task Force of experts to collect more detailed use cases and Commercial Requirements for “DVB-I over 5G” and produced DVB Bluebook C100 (1) providing the description of key use cases to realize DVB-I services over 5G Broadcast and unicast:

- Standalone DVB-I Service using 5G Broadcast.
- DVB-I Service using 5G Media Streaming.
- DVB-I services offering simultaneously over broadcast and unicast.

From the commercial requirements it was obvious that a more detailed technical evaluation was needed before embarking on specification work in 3GPP. Because 5G-MAG had gained significant experience in the implementation of 5G-based technologies as part of the 5G-MAG Reference Tools initiative [7], it was an obvious partner for DVB to collaborate with as a proxy for 3GPP on the development of a technical analysis and deployment guidelines.

To that end, a joint task force was created in 2022 by DVB and 5G-MAG to carry out this work and it was quickly agreed to produce a joint Technical Report providing deployment guidelines for delivering DVB-I services over 5G, initially addressing the three most relevant commercial use cases identified above as guiding scenarios.

BUILDING BLOCK TECHNOLOGIES – PUZZLE PIECES

In order to systematically approach the monolithic use cases and requirements, the JTF decided to formalize the existing technical building blocks available from 3GPP and DVB, primarily by describing the network and client functions, the logical interfaces between these functions as well as the APIs to make use of these functions. This was done under the hope and expectation that these building blocks would be well-specified and complementary. Assembling them in a proper way should facilitate a technical realisation of the use cases without requiring substantial new specification work. An overview of the puzzle pieces from 3GPP and DVB identified in the first version of the Technical Report can be found in Figure 1.

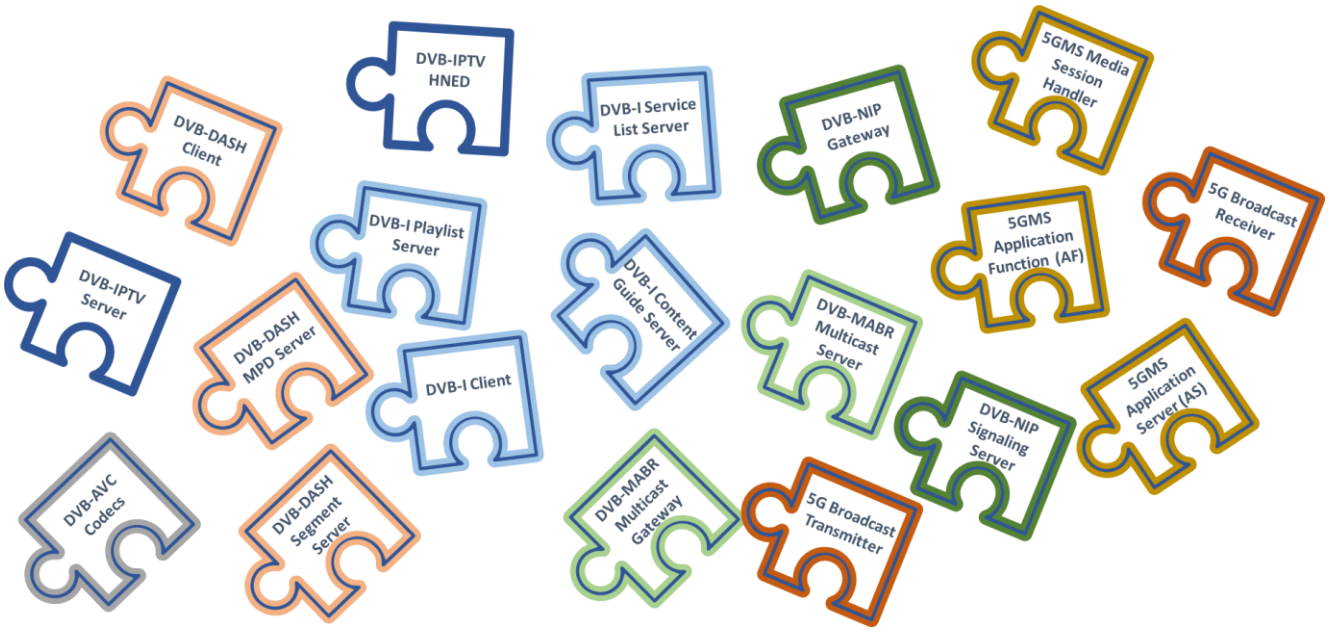

Figure 1 The DVB-I over 5G puzzle pieces

The Joint Task Force documented the key aspects of the each of the building block puzzle pieces to realize these use cases as summarised in the following.

DVB technologies

The DVB Project is well known for specifying conformance profiles of codecs for use on digital broadcasting systems. The DVB-DASH specification [4] additionally profiles MPEG-DASH segment-based packaging to support Adaptive Bit Rate streaming over HTTP with a high degree of compatibility. DVB-MABR [5] builds on this, specifying how linear DVB-DASH services can be carried simultaneously to large audiences using multicast packet replication in IP routers.

DVB-I service discovery [0] specifies the means to describe and discover both broadcast- and IP-delivered instances of linear services by means of a common XML metadata format. It also profiles the XML-based TV-Anytime metadata description in order to provide a content guide for these services as well as related on-demand content.

In combination with DVB-MABR, DVB-I provides the foundation for service discovery on IP-based broadcasting platforms as part of the DVB Native IP (DVB-NIP) specification [6].

3GPP technologies

As part of its Long-Term Evolution (LTE) System, 3GPP specified Multimedia Broadcast Multicast Services to support a variety of scalable media distribution use cases including linear television and radio services. A number of enhancements were made to 3GPP specifications to better support broadcast (as opposed to cellular radio) transmission modes, including longer cyclic prefixes (permitting larger gaps between the high-power transmitter sites more common in broadcast network topologies) and additional signalling to support Receive-Only Mode in SIM-free reception equipment. This "enhanced TV" system is described in 3GPP specifications. These are summarised and profiled by ETSI as the LTE-based 5G Broadcast System [2].

A reference implementation of the LTE-based 5G Broadcast System has been undertaken by 5G-MAG.

When it defined the 5G System, 3GPP took the opportunity to decompose the control plane into a modular set of Network Functions called the 5G Core that can be scaled horizontally to meet the demands of a particular network deployment. These Network Functions communicate using a service-based architecture that is realized as a set of well-defined RESTful HTTP service operations exposed by each Network Function over secure HTTP/2.

The New Radio (NR) cellular access network for 5G interfaces with the 5G Core to provide basic unicast mobile broadband services at higher bit rates than was possible with LTE-based modulation. In addition, 5G NR defines modes for ultra-reliable, low-latency cellular radio communication. 5G networks based 5G NR have been deployed in many countries, and an increasing fraction of these deployments are now being migrated from a legacy core (so-called "non-standalone" deployment) to a 5G Core ("standalone" deployment).

The 5G Media Streaming architecture recognizes the need for greater cooperation between content providers and mobile networks. Taking advantage of service-based interactions with the Policy and Charging Function (PCF) in the 5G Core, an application is able to safely manipulate the network Quality of Service of a media streaming session via an Application Function for 5G Media Streaming (5GMS AF) by means of a standardized set of client and network APIs:

1. The application can enquire about the bit rate that the network is able to reliably sustain at the current location, allowing it to select the most appropriate ABR representation of the media.
2. The application can negotiate a service operation point with the network from a set previously negotiated between the content provider and the network provider.
3. The application can request a temporary increase in bit rate, for example to quickly replenish a starved playback buffer after a period of network congestion or signal loss.

The cooperation enabled by the 5G Media Streaming architecture leads to better outcomes for media streaming sessions with the dual goal of marshalling of scarce network resources while achieving the best possible Quality of Experience for the end user.

A reference implementation of the 5G Media Streaming System is being undertaken by 5G-MAG and is described in [7].

DVB-I OVER 5G REFERENCE ARCHITECTURE

The Joint Task Force detailed a proposed DVB-I over 5G Reference architecture to support all service scenarios and requirements. The architecture references existing architecture specifications and leverages standard interfaces.

Figure 2 illustrates the principal system approach for running DVB-I services over 5G Systems. The approach is to leverage existing and well-defined interfaces, reference points and APIs defined in DVB and 5G to connect and establish services.

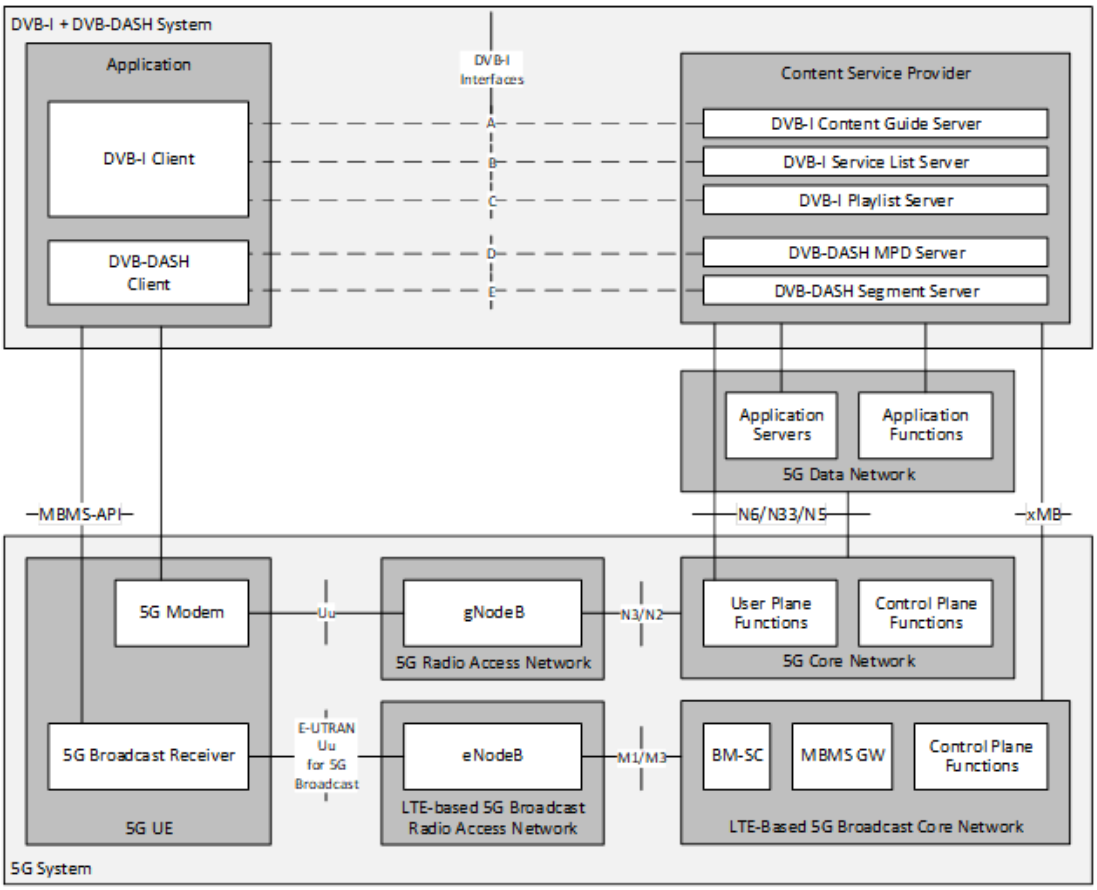

Figure 2: DVB-I over 5G reference architecture [3]

The top part describes the DVB-I and DVB-DASH system that comprises an Application running on a 5G-connected device (left) and the Content Service Provider's back-end servers in the network (right) that support the Application. The Application includes a DVB-I Client (for discovering DVB-I services), a DVB-DASH Client (for consuming DVB-I services). In the general case depicted in the reference architecture, the Application can consume DVB-DASH content via the 5G mobile broadband and/or from an LTE-based 5G Broadcast. In the latter role, it acts as a Broadcast TV/Radio Service application as defined in [2]. The client is connected via DVB-I logical interfaces to the Content Service Provider's DVB-I and DVB-DASH servers. The logical interfaces are carried over the 5G System which is depicted in the bottom part of the figure.

The DVB-I Client and DVB-DASH Client are connected via client APIs to the broadcast-capable 5G UE (User Equipment a.k.a. 5G device). The UE interfaces to the 5G Core network via the 5G Radio Access Network and to the LTE-based 5G Broadcast Core Network via the LTE-Based 5G Broadcast Radio Access Network.

The Core Network functions interfaces towards the Content Service Provider's DVB-I and DVB-DASH servers via two reference points whose interfaces are defined by 3GPP:

- xMB API for LTE-Based 5G Broadcast.
- N6 for direct user plane IP Connectivity, or via Application Functions and Application Servers for 5G Media Streaming.

The 5G Media Streaming Application Function (5GMS AF) interfaces towards the 5G Core's Control Plane Functions (PCF and NEF) via reference points N33 and N5.

SERVICE SCENARIOS

Overview

Based on the reference architecture, the Technical Report [3] details workflows for the following service scenarios identified in the Commercial Requirements [1]:

- DVB-I over 5G broadcast,
- DVB-I over 3GPP 5G Media Streaming, and
- DVB-I services offered simultaneously over broadcast and unicast.

Each of the workflows includes references to relevant specifications to assist implementation. Recommended configurations are documented. Gaps identified in existing specifications are documented as recommended changes to the relevant specifications under the control of DVB, 3GPP or ETSI, as appropriate.

Each scenario includes workflows with guidance in reference to relevant specifications.

Standalone DVB-I Service using 5G Broadcast

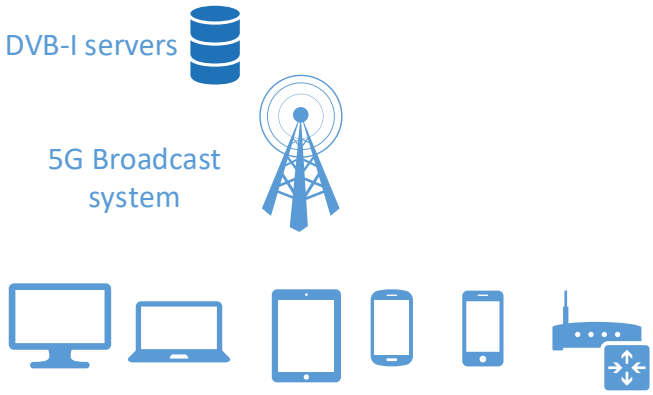

Figure 3: 5G Broadcast to any device

This is the case where DVB-I services are provided through 5G Broadcast only. However, it is expected that 5G Broadcast receivers will typically be capable of connecting to a mobile network through unicast as well. Therefore, this pure 5G Broadcast service may not be the primary deployment choice. However, it is beneficial to provide at least a basic self-contained DVB-I service via 5G Broadcast, for example to address receivers that are not connected through a unicast network, are temporarily out of cellular coverage, lack the necessary subscription, or due to overload of the unicast system.

As well as a detailed architecture for this case, the Technical Report includes detailed procedures for service provisioning, service transmission, service discovery and service (re)selection. Alternative scenarios are also described for DVB-MABR carried over 5G Broadcast, DVB-NIP over 5G Broadcast and DVB-IPTV (IP Television) over 5G Broadcast. The analysis led the task force to suggest improvements to 3GPP, ETSI and DVB specifications.

DVB-I Service using 5G Media Streaming

DVB-I service discovery can also be used by an Application to discover streaming services that are delivered over unicast with the assistance of a 5G Media Streaming (5GMS) System. The Technical Report includes detailed procedures for service provisioning, service discovery and service (re)selection.

In this case, the DVB-I service metadata needs to convey not only the entry point for the media presentation, such as a DVB-DASH Media Presentation Description, but also needs to include sufficient service announcement information to launch media session handling in the 5G UE, unlocking the features described earlier. Work is underway in 3GPP to standardise a Service URL for 5G Media Streaming that combines all of these components into a single launch URL that can be processed by the operating system to launch a media streaming session implicitly.

DVB-I service offerings simultaneously over broadcast and unicast

An innovative step forward when using 5G-based delivery systems is the expected simple ability to operate and receive DVB-I Services over broadcast and unicast in parallel – also referred to as Hybrid Services. Based on the commercial requirements, the technical report details different flavours of unicast and broadcast mixed services exist. A subset of potential use cases is documented in more details in the following:

- *DVB-I via unicast and DVB-DASH via 5G Broadcast:* DVB-I Service metadata is retrieved via unicast and DVB-DASH content is transmitted via 5G Broadcast. Such a setup would for example allow creating a DVB-I compatible service offering, but only popular channels are delivered over broadcast, whereas long-tail or on-demand channels are provided via unicast. It may also be the case that the content service is provisioned at the same time over 5G Broadcast and regular unicast, modelled as two different DVB-I service instances. Based on the capabilities of the device, the Application Client may decide to select one or the other service instance using information provided in the DVB-I service list.
- *Hybrid broadcast–unicast services with session continuity:* The same DVB-DASH service may be available via both unicast and 5G Broadcast delivery networks, but only one Representation of each Adaptation Set in DVB-DASH is provided via 5G Broadcast. When the receiver is in 5G Broadcast reception, it consumes the broadcast content. When out of coverage, it uses unicast with DASH adaptive streaming. The Technical Report describes different options on handling this case, also shown in Figure 4, namely: 1) the unicast-broadcast switch it is managed by the 5G Broadcast receiver that proxies also unicast requests from the DVB-DASH client to the network, 2) the DVB-DASH client smartly selects the delivery network, possibly supported by information provided from the 5G Broadcast receiver or 3) the DVB-I client provides information on two equivalent and time-aligned service instances and transition between service instances is supported on DVB-I level.
- *Hybrid broadcast–unicast services for time-shifted viewing:* The service is made available via both unicast and 5G Broadcast delivery networks. The content is retained on unicast for a period of time to support time shifted access. Hence, if content is consumed at the live edge, broadcast reception may be chosen, whereas in case of time-shifted viewing, the content is accessed via unicast.
- *Hybrid broadcast–unicast services with content or component replacement:* The service is made available via both unicast and 5G Broadcast delivery networks. However, some content components are only available via unicast, for example an

alternative language, an enhanced video version in HDR, or a subtitle. In another case, two or more content alternatives may exist for a period of time, but only one alternative is provided over 5G Broadcast. This may for example address cases for which a common advertisement provided in the broadcast stream is replaced by a targeted ad received over unicast. Based on the selection of the client, the receiver collects the content from broadcast, if available or otherwise from unicast.

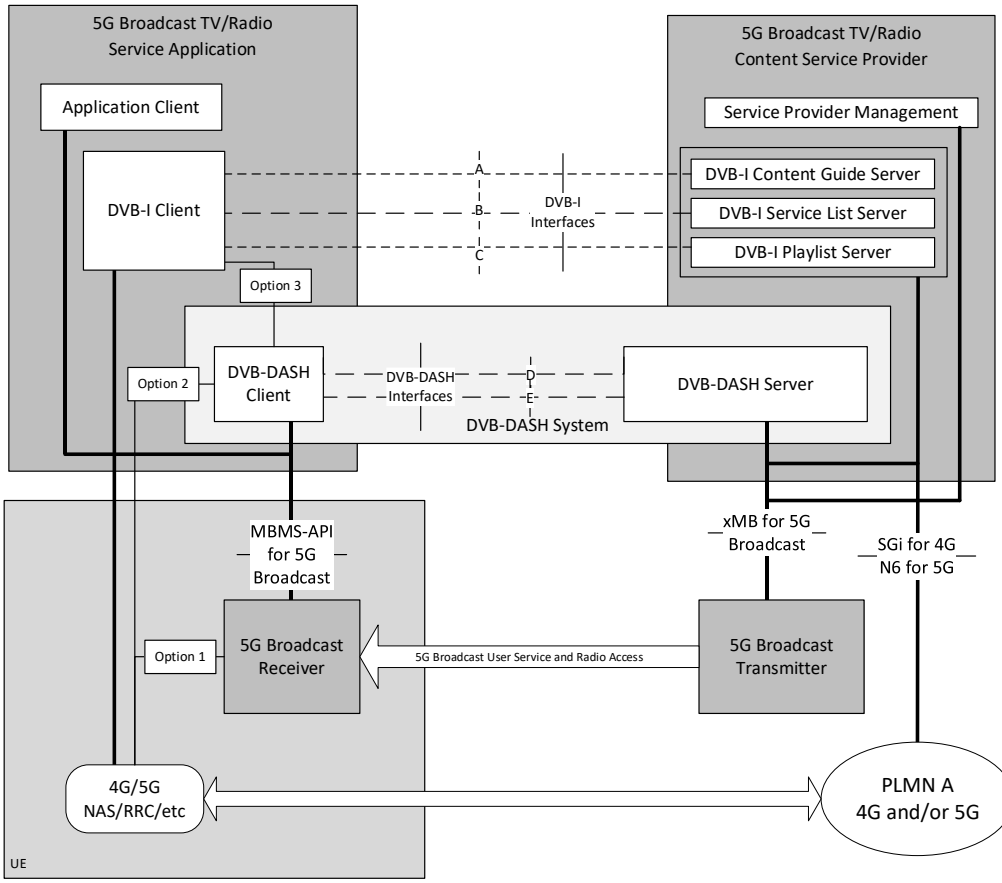

Figure 4 DVB-DASH based service continuity using unicast and broadcast [3]

For the scenarios documented in this case, basically no functional gaps have been identified in any of the 3GPP or DVB specifications – as it was expected. However, small extensions to 3GPP and DVB specs may be needed to optimize operation and fully support all scenarios, for example:

- the 5G Broadcast Client (in hybrid option 1) or the DVB-DASH Client, possibly in collaboration with the Application needs to define which network resources are selected at a certain point in time. The DVB-DASH Client needs to be able to receive content from at least two different networks and needs to be actively steered towards selecting one or the other network, possibly using additional signalling in the MPD. Such an extension may be considered in DVB-DASH.
- For hybrid Option 3, two separate MPDs are provided, each one describing an instance of the same DVB-I service. New signalling is required in the DVB-I Service List to indicate that the content distributed on these two service instances is both identical and time-aligned, and that the content can therefore be combined into a single hybrid presentation to the user.

CONCLUSIONS

While DVB-I services deployments are currently moving into commercial experimentation and 5G subscriptions forecast to account for 1.8 billion subscribers at the end of 2023 and 4.2 billion subscribers by 2026 (source: GSA.com), DVB and 5G-MAG jointly progressed guidelines for the deployment of DVB-I services over 5G networks. This paper presented an overview of the ETSI Technical Report on deployment guidelines for DVB-I service delivery over 5G Systems [3]. The guidelines are meant to be considered by network and terminal vendors as well network and broadcast operators for future deployments. It is also used by members of organizations such as 3GPP, ETSI, DVB and 5G-MAG to consider improvements to their specifications.

The Technical Report drafted by the Joint Task Force was endorsed by both DVB and 5G-MAG and has been published as ETSI TR 103 972, which is freely available. The Technical Report identifies several gaps in existing standards in order to address the scenarios studied – notably in DVB-I and in 3GPP's specifications for MBMS – and the next step is to propose normative work items to relevant bodies aiming to close these gaps.

TERMS AND ABBREVIATIONS

3GPP	Third Generation Partnership Project
5G-MAG	5G Media Action Group
API	Application Programming Interface
BM-SC	Broadcast Multicast Service Centre
DVB	Digital Video Broadcasting
DVB-DASH	DVB- Dynamic and Adaptive Streaming over HTTP
DVB-I	Digital Video Broadcasting over Internet
DVB-MABR	DVB-Multicast Adaptive Bit Rate
DVB-NIP	DVB-Native IP
ETSI	European Telecommunication Standards Institute
HDR	High Dynamic Range
IPTV	Internet Protocol TeleVision
JTF	Joint Task Force
LTE	Long-Term Evolution
MBMS	Multicast Broadcast Media Service
MPD	Media Presentation Description
NEF	Network Exposure Function
NIP	Native IP
SIM	Subscriber Identity Module

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ACKNOWLEDGEMENTS

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