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Network Operator-Provided 5G Streaming Media and Future Broadcast Services

By Christophe Burdinat, Thomas Stockhammer, Mickaël Raulet, and Thibaud Biatek

Introdução:

Com a publicação do Digital Video Broadcast-I (DVB-I) em 2020, que permite a entrega de serviços de televisão linear para dispositivos conectados à internet através de banda larga e redes de transmissão, o DVB-I tornou-se um forte candidato para fornecer uma camada de serviço convergente para 5G. Este artigo explora exatamente os recursos oferecidos pelo 5GMSA. Um verdadeiro tutorial de como os recursos multicast/broadcast serão integrados e como isso permitirá a entrega de serviços DVB-I. Leitura obrigatória para todos os que querem entender melhor essa integração, que inclusive poderá fazer parte da futura TV 3.0 que o Brasil está desenvolvendo. Boa leitura e sintam-se a vontade para debater mais este tema enviando os seus comentários para: tvdigitalbr@gmail.com!

Tom Jones Moreira

Abstract

Beyond the spectral efficiency and throughput improvement for enhanced mobile broadband (eMBB), 5G brings many new features targeting vertical applications. To leverage the new 5G features and capabilities for media distribution, 5G offers the 5G Media Streaming Architecture (5GMSA), which supports a full set of collaboration scenarios between third-party content providers and mobile network operators (MNOs) with various degrees of integration adapted to the over-the-top (OTT) ecosystem. While the first version of 5GMSA focuses on media delivery over unicast, multicast/broadcast in 5G is one of the key new features currently specified by 3GPP and expected for Release 17. Integration of 5G multicast/broadcast capabilities within 5GMSA is essential to scale up the network capacity for linear contents. With the publication of Digital Video Broadcast-I (DVB-I) in 2020, DVB allows for the delivery of linear television services to internet-connected devices over broadband and broadcast networks. As an access-independent service layer, DVB-I becomes a strong candidate for providing a converging service layer for 5G. This article explores the growing capabilities offered by the 5GMSA, how the multicast/broadcast capabilities will be integrated, and how it will enable the delivery of DVB-I services.

Keywords

5G Media Streaming (5GMS), 5G Multicast/Broadcast Services (5MBS), Digital Video Broadcast-I (DVB-I), DVB-MABR, Dynamic Adaptive Streaming over HTTP (DASH), HTTP Live Streaming (HLS), LTE-based 5G Broadcast

Introduction

The first version of the 5G Media Streaming (5GMS) architecture has been specified by Third Generation Partnership Project (3GPP) in Release 16 (July 2020). It succeeds in the packet-switched streaming (PSS) architecture[1] specified for 3G and 4G. PSS was designed for the delivery of streaming services managed by the mobile network operator (MNO), including transport protocols, codecs, and analytics. 5GMS offers a significantly more flexible framework, adapted to the evolving media streaming ecosystem, where the majority of video content is provided by over-the-top (OTT) service providers. 5GMS takes advantage of the new 5G features and capabilities to increase the quality of service (QoS) and quality of experience (QoE) for video delivery, going beyond "best efforts" for resource allocation when streaming IP-based OTT content. Further details on these objectives, and how they are addressed, are presented in the "Optimizing OTT Service Delivery with 5GMS" section.

An important component for media distribution over 5G is the service layer, which specifies the protocol stack in charge of distributing Dynamic Adaptive Streaming over HTTP (DASH) and/or HTTP Live Streaming (HLS) content, as well as additional procedures for discovery, announcement, reporting, and loss recovery.

This first version of 5GMS focuses on media delivery over 5G unicast. Integration of new 5G multicast/broadcast capabilities in 5GMS is targeted for Release 17 at 3GPP (July 2022) and is expected to provide a major upgrade for 5GMS-based media distribution. Details will be introduced in the "5G Multicast and Broadcast Capabilities" section.

An important component for media distribution over 5G is the service layer, which specifies the protocol stack in charge of distributing Dynamic Adaptive Streaming over HTTP (DASH) and/or HTTP Live Streaming (HLS) content, as well as additional procedures for discovery, announcement, reporting, and loss recovery. While the legacy service layer from previous releases is considered, enhancements are necessary to tackle new challenging requirements such as low-latency delivery. Alternatively, the Digital Video Broadcast (DVB) project brings new specifications for content delivery under the name DVB-I, which could provide a converging service layer for delivery over 5G and other networks. We discuss these aspects in the "DVB-I: An Access Independent Service Layer for 5G" section.

Optimizing OTT Service Delivery With 5GMS

5GMS, specified in Refs. 2–5, provides a large framework for the optimization of the delivery of OTT service over 5G. The architecture for the 5G unicast downlink, referenced as 5GMS downlink (5GMSd), is depicted in **Fig. 1**.

5G distinguishes the trusted data network (DN) in which network functions can directly interact with the functions of the operator's 5G core, and the external DNs, in which network functions can only interact with the 5G Network Exposure Function (NEF).

The architecture includes the 5GMS Client for downlink (5GSMd Client), with the user equipment (UE) being the receiver of the streaming services and accessible to the 5GMSd Aware Application through well-defined APIs.

Following the Control and User Plane Separation (CUPS) design principle, two entities are specified network side: 5GSMd Application Function (AF) for the control plane and the 5GSMd Application Server (AS). These functions are provisioned by a third-party actor referred to as the 5GMS Application Provider, which is an OTT service provider in this case.

The 5GSMd AS is a very large function envisioned to include many subfunctions of the media distribution chain: an adaptive bitrate (ABR) encoder, a segment packager, and manifest/media playlists generator, an origin server and content delivery network (CDN) (e.g., edge) server, a replacement content server (for ad insertion/substitution), a Content Guide Server, and Service Discovery. This modular design principle of 5GMS architecture (5GMSA) allows for many different collaboration scenarios and business arrangements between a service provider and an operator. Hence, these subfunctions may or may not be instantiated/used/realized within the 5GSMd AS, and the 5GSMd AS may be located by the operator in its trusted domain, or can be implemented and hosted by a third-party service provider. The following key collaborative scenarios can be implemented with the 5GMS:

- The operator may expose its caching infrastructure—ordinarily used for the distribution of its own media services—to a third-party provider as a CDN. While the content provider keeps control of the codecs, the ABR ladder, and the DRM, it benefits from the delivery optimization provided by the operator.
- The operator may transcode a live video stream provider by a third party, apply DRM, and redistribute it with codecs supported by 5GMSd clients.

With the emergence of new media services such as virtual reality (VR)/augmented reality (AR)/mixed reality (MR) where latency requirements are essential, QoS service requirements will vary greatly.

5GMS allows the leveraging of existing 5G capabilities with respect to QoS management:

- **Dynamic Policy Selection:** The 5GSMd client can ask for a specific QoS policy and the 5GMSd AF interacts with the Policy Control Function (PCF, providing policy rules to other control plane functions to enforce them). Thus, operators can offer specific services associated with a data plan subscription and charge differently for service consumption when a certain policy is applied. For instance, to avoid

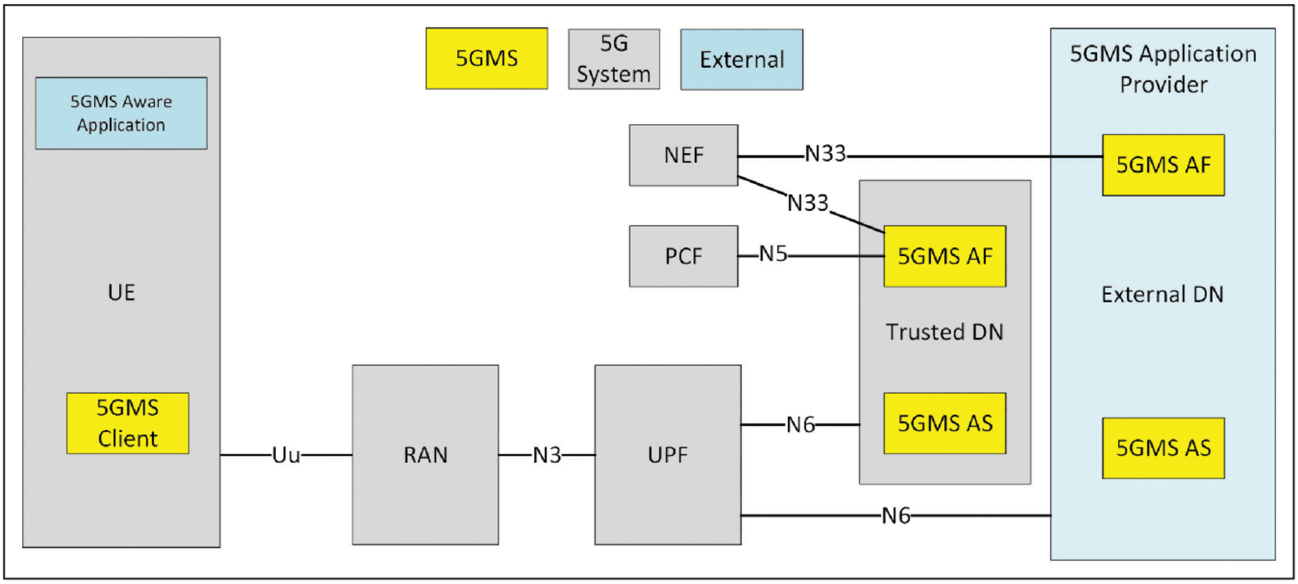

FIGURE 1. 5G Downlink Media Streaming within 5G System (from Ref. 2, **Fig. 4.2.1-1**).

congestion, a zero rating policy could be proposed to subscribers who agree not to consume the largest service renditions.

- **Network Slicing Instantiation:** 5GMS facilitates the creation of dedicated network slices satisfying the service level requirements (bandwidth, latency, reliability, mobility, etc.) for the service distribution of a given service provider.
- **Network Assistance (by the 5GSMd AF):** Assisting functions provided by the 5GSMd AF to the 5GMSd Client and Media Player in the form of bit rate recommendation (or throughput estimation), to be used for the media player's selection of media representations to avoid interruption and rebuffering. The 5GMSd Client may request a temporary delivery boost from the AF.
- **ANBR-Based Network Assistance:** The 5GMSd Client accesses the radio access network (RAN) modem driver to acquire the access network bitrate recommendation (ANBR) provided by the MAC layer of 5G New Radio (NR).

5G Multicast and Broadcast Capabilities

The 5GMSA in Release 16 is focused to deliver services over unicast. The integration of two complementary capabilities are scheduled for Release 17: LTE-based 5G broadcast, focusing on broadcast on a dedicated spectrum, and 5G multicast/broadcast services (5MBS), targeting the coexistence of multicast/broadcast and unicast within the same carrier.

Why This Is Important

Service streaming delivery over multicast/broadcast allows scaling up the network capacity for linear contents. Integrating these capabilities with the 5GMS framework also creates new opportunities beyond regular broadcast, for the delivery of hybrid services.

Hybrid services can be services simultaneously available over multicast/broadcast and unicast. The client can decide which delivery mode to use depending on the reception quality and its capabilities. They can allow, in particular, a fast service acquisition at a startup. They can be enriched by auxiliary components over unicast, such as alternative languages, and can include unicast-based ad insertion or substitution (targeted to users, geographical areas, and so on).

Hybrid services would naturally benefit from the integration of multicast/broadcast capabilities depending on the collaboration model and the target use case: if the 5GMSd AS is in charge of encoding and packaging, the 5GMSd AS should integrate multicast capabilities to make the service available over multicast as well. By aggregating QoE and consumption reports, 5GMSd AF could also trigger the activation or deactivation of delivery over multicast/broadcast.

Emergence of LTE-Based 5G Broadcast

3GPP specified in Release 9 Evolved Multimedia Broadcast Multicast Services (eMBMS,[6,7] also known as LTE broadcast). eMBMS is a point-to-multipoint LTE interface used for mobile services, designed to improve the efficiency in the delivery of broadcast services, using the LTE infrastructure and targeting mobile TV. To extend the coverage at a cell's edge, eMBMS radio transmissions are done in a single frequency network (SFN), where synchronized cells send the same signal simultaneously.

Significant improvements were done in Release 14 and 16 under the work item "enTV" (enhanced TV). enTV addressed some major limitations of eMBMS and key broadcaster requirements: the ability to allocate the full band for eMBMS, free-to-air delivery to SIM-less devices, optimization of the physical layer to allow deployments on high power high tower (HPHT), with an intersite distance (ISD) up to 100 km.

Last but not least, enTV standardized two APIs: (1) xMB[8] and (2) MBMS API.[9] xMB is a northbound interface exposed to content services providers for provisioning and ingestion. The MBMS API is exposed by the MBMS client to the UE for service discovery and consumption.

The service layer specified for eMBMS and continuously enhanced is reused.[10] It includes the discovery and announcement procedures and a set of delivery methods defining the protocol stack over UDP multicast and associated procedures for reporting or loss recovery. The download delivery method, based on the FLUTE protocol, supports the delivery of live ABR services such as DASH or HLS. Delivery can also be made with the transparent delivery method, which can forward any IP packet streams received from the service provider, allowing the distribution of any other IP multicast services. It was added to not restrict TV formats and to support the transport of external content formats specified by broadcasting organizations such as DVB or the Advanced Television Systems Committee (ATSC), without the need of transcoding, facilitating the reuse of existing TV receivers.

This set of features addresses all the requirements of a 5G Broadcast System, formulated in Ref. 11, and is profiled by the European Telecommunications Standards Institute (ETSI) in TS 103 720[12] for 5G dedicated broadcast networks. This profile, referred to as LTE-based 5G broadcast, could be used for rooftop reception, car entertainment systems, or even smartphones to complement unicast delivery over mobile networks.

Mixed Mode in 5G NR: 5G Multicast/Broadcast Services

NR is the new radio access technology (RAT) specified in 5G. While bringing a large number of improvements for point-to-point (PTP) transmissions, no point-to-multipoint transmissions are currently supported in

NR, which is the objective of the current 3GPP work item named "5MBS."[13]

5MBS, which allows the coexistence of unicast and multicast/broadcast, corresponds to the mixed-mode track. It is particularly suitable for use cases where broadcast/multicast services are expected to be delivered to a limited number of cells due to user interests and the concerned cells may dynamically change due to user movement. It can address, in particular, public safety use cases, for group communications when a large number of first responders are concentrated in a few cells, and vehicle-to-network (V2N) use cases, for delivery of local traffic information. 5MBS also covers media delivery scenarios to optimize the utilization of the operator's radio resources. Reusing the operator's infrastructure, 5MBS will not require the deployment of a new dedicated network. Mixed mode targets a high commonality with unicast, that is, a common physical layer. 5MBS could be used to preserve network resources for popular linear services delivered over fixed wireless access (FWA).

Integration of Multicast and Broadcast in 5GMSA: More and More Collaboration Models for OTT Delivery?

The first part of this article introduced the different collaboration models proposed by the 5GMSA: the 5GMSd AS/AF functions can be in the trusted domain or not and can provide various elements of the media distribution chain. This second part describes the two 5G multicast/broadcast capabilities. For both these capabilities, the application can directly provide the IP multicast streams to be delivered, or a pointer toward the origin server hosting the OTT content. While this can lead to a multiplication of architectural and collaboration variants, two main deployment options can be distinguished.

Option 1: Multicast/Broadcast Used by the Operator, Transparent to the Application

In this option, depicted in **Fig. 2**, the service provider only interacts with the 5GMS APIs M1d and M2d for provision and ingestion. For capacity enhancement purposes, the 5GMS system can decide to distribute the content over multicast/broadcast. Usage of multicast/broadcast capabilities is made transparently to the service provider. The 5GMS AS and AF interact directly with the eMBMS entity, namely the Broadcast Multicast Service Center (BM-SC) to offload traffic to 5G broadcast. Similarly, the 5GMS can offload traffic to 5MBS. Client-side, the 5GMSd client needs to be integrated with the 5MBS client and MBMS client.

Option 2: Multicast/Broadcast Used by the Service Provider as Another Delivery Options

In this option, depicted in **Fig. 3**, the service provider uses separately three distinct pipes within 5GMS for unicast and multicast/broadcast capabilities. It leverages the existing northbound APIs and interfaces and their client-side counterparts. One immediate advantage relies on the fact that two of these pipes—LTE-based broadcast and 5GMS—are already fully specified in Release 16, and the third one—5G MBS—will be

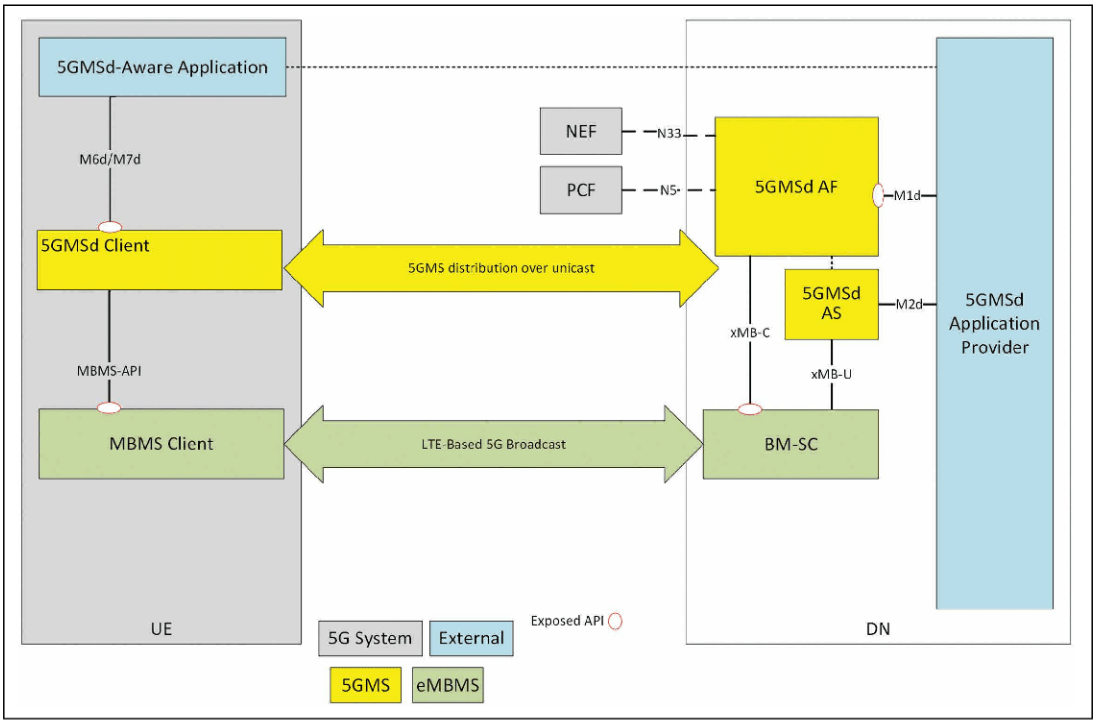

FIGURE 2. Option 1: 5G Broadcast capabilities used by 5GSM.

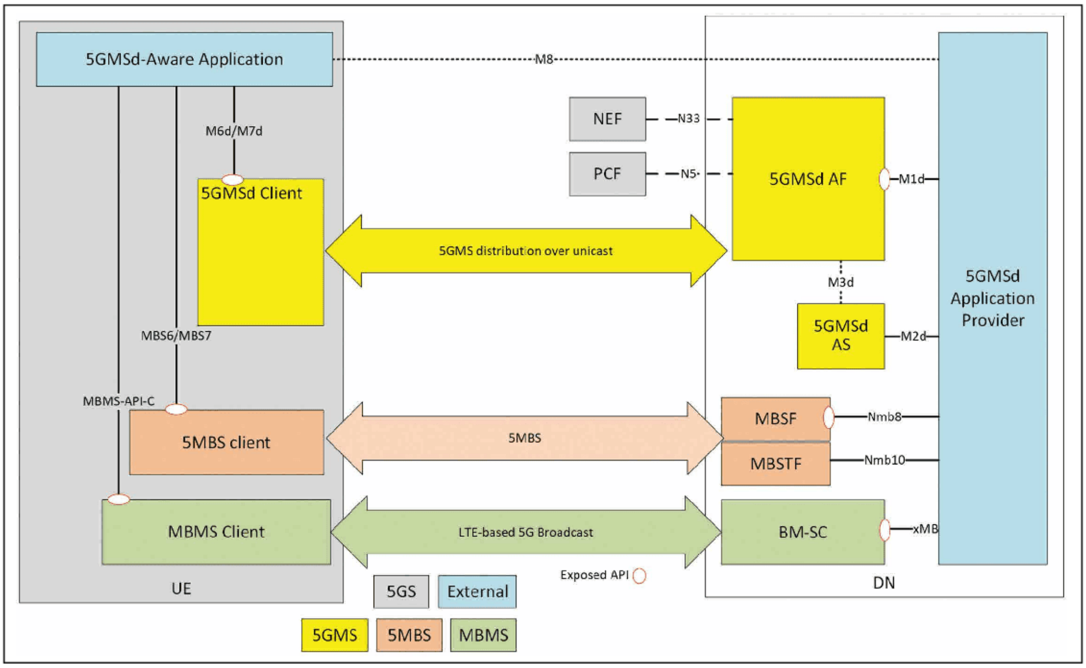

FIGURE 3. Option 2: 5MBS capabilities used by 5GMS.

available soon. However, service providers need to integrate as many APIs and interfaces as targeted pipes. This option matches the vision of DVB-I, as an access-independent service layer for 5G.

DVB-I: An Access-Independent Service Layer for 5G

The DVB-I specifications are designed by DVB to bring the standard of linear TV delivered over IP networks up to the user experience level for traditional broadcast. This includes delivery over unmanaged networks ("OTT") and over managed networks, with operator support and targets any devices with internet access, whatever the nature of the physical medium (e.g., satellite, fiber, cable, mobile, and so on). The objective of DVB-I is to signal and distribute services in a standardized manner, without the need for a specific application.

DVB-I specifications include:

- **DVB-I Service Discovery and Program Metadata:**[14] Defines discovery and signaling of linear TV services available over broadband; distribution of the Electronic Program Guide (EPG) and provides a method for national TV operators to offer a list of trusted/regulated services.
- **DVB Multicast ABR (DVB-MABR):**[15] Specifies how ABR segment-based services such as DASH or HLS can be delivered over IP multicast.

A study of the distribution of DVB-I services over 5G[16] and the specification phase is now under way. High-level vision of DVB consists of adding 5G delivery systems as new alternative silos for DVB-I services as illustrated in **Fig. 4**.

Each silo or pipe is characterized by the provisioning and ingestion API, the internal API toward the application exposed by a client. The client can be a middleware component provided with the modem or part of an Original Equipment Manufacturer (OEM)-customized engine or can be available as a downloadable app.

At the end of a multicast transmission (5MBS, MBMS-API), a DVB-I MABR GW receives the segment delivered with DVB-MABR and acts as a CDN edge by caching them toward the application. Each application includes a DVB-I client, which implements the service discovery procedures, the support of DVB-DASH, and the DVB profiles for audio-video codecs.

This access-independent service layer benefits also from the latest enhancements brought by DVB-MABR. In particular, DVB-MABR provides solutions for the distribution of low-latency DASH (LL-DASH) over multicast, which is not supported yet by the 3GPP service layer.

To achieve end-to-end latency for DASH/HLS services as low as traditional TV, the first step is to shorten the duration of the media segments. Then, to reduce the latency to a point where short segments become inefficient, segments consisting of multiple chunks, as described in clause 6.6.5 of ISO/IEC 23000-19,[17] may be delivered progressively through the distribution chain. DVB-MABR specifies how these chunks can be delivered over multicast and made available to the player by a multicast gateway.

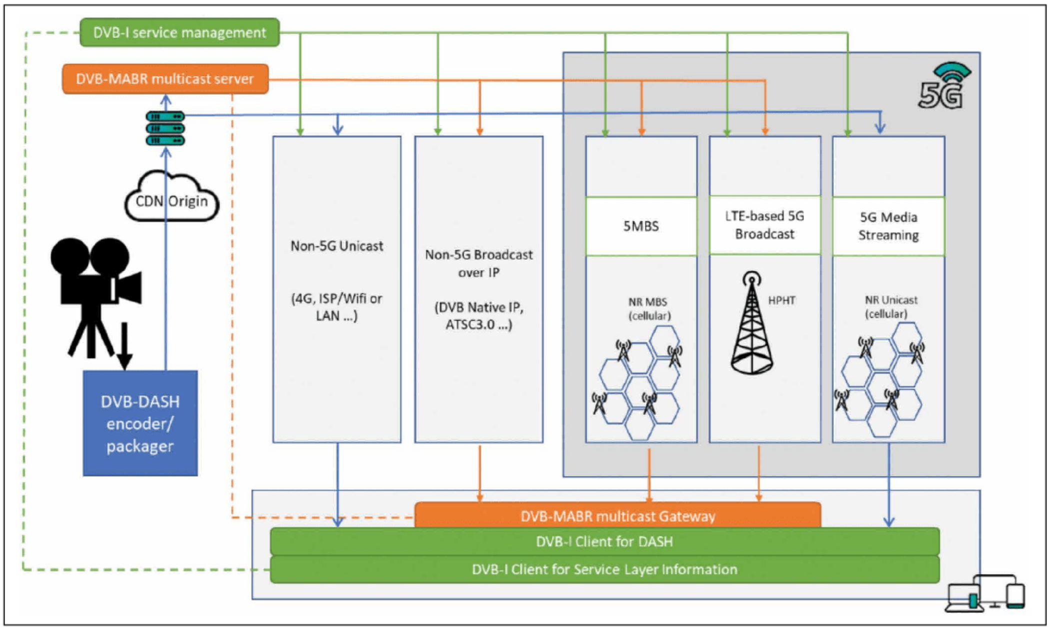

FIGURE 4. DVB-I services distribution over 5MBS, LTE-based 5G Broadcast, and 5GMS.

Conclusion

5GMS represents an important effort by 3GPP to enable the distribution of media streaming services over 5G, taking into account the complexity of the ecosystem, through a complete list of collaboration models. 5GMS allows leveraging the latest 5G features and capabilities with a set of dedicated northbound and client-side APIs.

5MBS is a key capability in the coming Release 17. To allow the delivery of enriched hybrid services, two main options are considered for integrating multicast/broadcast with 5GMS: one where the usage of multicast/broadcast is made transparently to the service provider and a second where the service provider selects the best network according to its needs.

DVB-I as an access-independent server layer is a promising candidate to implement these hybrid services in a wide range of delivery broadband/broadcast networks, including soon the capabilities of 5G mobile networks.

This set of standards is very recent or still being written. They cover a wide list of distribution scenarios over 5G and need to be profiled. This highlights the need for cross-industry collaboration between operators, broadcasters, and manufacturers as targeted by the 5G Media Action Group (5G-MAG).[18]

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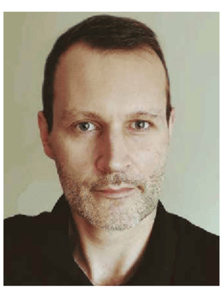
About the Authors



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