**3GPP TSG- Meeting # *r01***

**, , - revision of S4-242261**

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| *For* [***HE******LP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* | | | | | | | | |
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| ***Proposed change affects:*** | UICC apps |  | ME | **X** | Radio Access Network |  | Core Network | **X** |

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| ***Category:*** |  |  | | | | | ***Release:*** | | |  |
|  | *Use one of the following categories:* ***F*** *(correction)* ***A*** *(mirror corresponding to a change in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)*  Detailed explanations of the above categories can be found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | | | | | | | | *Use one of the following releases: Rel-8 (Release 8) Rel-9 (Release 9) Rel-10 (Release 10) Rel-11 (Release 11) … Rel-17 (Release 17) Rel-18 (Release 18) Rel-19 (Release 19)  Rel-20 (Release 20)* | |
|  |  | | | | | | | | | |
| ***Reason for change:*** | | 1. **In-session Unicast Repair for MBS Object Distribution**: For live and low-latency live services using the Object Distribution Method in MBS, in certain cases the transmission of an object is not successful. In this case, unicast repair for individual MBS Clients can improve the service quality. However, the timing of such requests needs to be carefully studied in order to avoid network overloads or significant latencies in the delivery. A study to extend MBS User Services and object streaming to address in-session repair is of relevance. For details refer to S4-242128, 26802-0001rev5. 2. **MBS User Service and Delivery Protocols for eMBMS:** The MBS User Service architecture and protocol follows the modern design philosophies of the 5G System with separation of user services from transport, a service-based architecture and RESTful APIs. At the same time, eMBMS and enTV as used for LTE-based 5G Broadcast support a transparent delivery mode. While interworking in between MBMS and MBS is addressed in TS 23.247, interworking between these two systems at the User Service level is not addressed. In order for MBMS and LTE-based 5G broadcast to leverage MBS User Service technologies, a study is warranted to identify the gaps to fully support this functionality. For details refer to S4-242258, 26802-0002rev9. 3. **Selected MBMS Functionalities not supported in MBS:** In completing TS 26.502 and TS 26.517, it is obvious that only a subset of the MBMS functionalities is supported in Rel-17. While many MBMS functionalities are likely not important to be supported for MBS, a systematic analysis of MBMS User Services features and their potential relevance for MBS should be completed and recommendations made on which ones to migrate to MBS User Services specifications and how best to achieve this. For details refer to S4-242129, 26802-0003rev6. 4. Conclusions are needed to identify normative work. For details refer to S4-242244, 26802-0004rev1. 5. Editorial Updates and corrections | | | | | | | | |
|  | |  | | | | | | | | |
| ***Summary of change:*** | | Addresses the work item objectives for this key issue   * Documents the key issue in more detail, in particular how they relate to the 3GPP Media Delivery architecture and/or the MBS User Service architecture * Studies collaboration scenarios between the Application Service Provider and the 5G System and for each of the key topics. * Based on existing architectures, provides one or more deployment architectures that address the key topics and the collaboration models. * Maps the key topics to basic functions and develop high-level call flows. * Identifies the issues that need to be solved. * Provides candidate solutions including call flows, protocols and APIs for each of the identified issues.   Identifies gaps and recommend potential normative work for stage-2 and stage-3, including which existing specifications would be impacted and/or if any new specifications would preferably be developed. | | | | | | | | |
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| ***Consequences if not approved:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
| ***Clauses affected:*** | | 1, 2, 3.2, 4.2.2.5, 4.3.1, 4.4.5.2, 5.2.1, 5.2.5, 5.3.1.6, 5.9 (new), 5.10 (new), 5.11 (new), 7.2.1.4, 7.2.2.2, 8.3, 8.4 (new) | | | | | | | | |
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|  | | **Y** | **N** |  | | | |  | | |
| ***Other specs*** | |  | **X** | Other core specifications | | | | TS/TR ... CR ... | | |
| ***affected:*** | |  | **X** | Test specifications | | | | TS/TR ... CR ... | | |
| ***(show related CRs)*** | |  | **X** | O&M Specifications | | | | TS/TR ... CR ... | | |
|  | |  | | | | | | | | |
| ***Other comments:*** | | This CR merges the agreed CRs   * S4-242128, 26802-0001rev5 * S4-242258, 26802-0002rev9 * S4-242129, 26802-0003rev6 * S4-242244, 26802-0004rev1 | | | | | | | | |
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| ***This CR's revision history:*** | |  | | | | | | | | |

## ===== CHANGE =====

# 1 Scope

The present document identifies and evaluates potential enhancements to the 5G Media Streaming (5GMS) [1] in order to provide multicast-broadcast media streaming services. It has the following objectives:

- Define scenarios where multicast ingestion or multicast distribution might be used, including potential IGMP termination options [2], [3], and [4]. Examples for such collaboration scenarios are transparent multicast delivery, multicast linear IPTV delivery, hybrid unicast/multicast (e.g. MooD or service continuity), and multicast Adaptive Bit Rate (ABR) for Over the Top (OTT) live streaming.

- Identify the relevant key issues and gaps in 5GMS to support the above scenarios based on the existing 5GS multicast architecture.

- Document architecture extensions and procedures to support the above-defined scenarios.

- Identify protocols to support the above extensions and procedures in 5GMS.

- Identify Procedures for managing downlink multicast streaming and session lifecycle.

- Select a subset of relevant scenarios that should be supported in extensions to 5G Media Streaming.

A revision of the present document identifies and evaluates a set of potential improvements and extensions, referred to as Key Issues:

- In-session Unicast Repair for MBS Object Distribution.

- MBS User Service and Delivery Protocols for eMBMS.

- Selected MBMS Functionalities not supported in MBS.

For each of the above key topics, the following objectives are identified:

1. Document the key topics in more detail, in particular how they relate to the 3GPP Media Delivery architecture and/or the MBS User Service architecture.

2. Study collaboration scenarios between the Application Service Provider and the 5G System and for each of the key topics.

3. Based on existing architectures, develop one or more deployment architectures that address the key topics and the collaboration models.

4. Map the key topics to basic functions and develop high-level call flows.

5. Identify the issues that need to be solved.

6. Provide candidate solutions including call flows, protocols and APIs for each of the identified issues.

7. Coordinate work with other 3GPP groups e.g. SA2, SA3, SA5, SA6 and others as needed.

8. Coordinate work with external organizations such as DASH-IF, CTA WAVE, ISO/IEC JTC29 WG3 (MPEG Systems), 5G-MAG, DVB or IETF, as needed.

9. Identify gaps and recommend potential normative work for stage-2 and stage-3, including which existing specifications would be impacted and/or if any new specifications would preferably be developed.

## ===== CHANGE =====

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TS 26.501: "5G Media  Streaming (5GMS); General description and architecture”".

[2] IETF RFC 2236: "Internet Group Management Protocol, Version 2".

[3] IETF RFC 4604: "Using Internet Group Management Protocol Version 3 (IGMPv3) and Multicast Listener Discovery Protocol Version 2 (MLDv2) for Source-Specific Multicast".

[4] IETF RFC 3376: "Internet Group Management Protocol, Version 3".

[5] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[6] 3GPP TS 23.246: "MBMS Architecture and functional description".

[7] 3GPP TR 23.757: "Study on architecture enhancements for 5G multicast-broadcast services".

[8] 3GPP TS 23.316: "Wireless and wireline convergence access support for the 5G system".

[9] 3GPP TS 23.501: "System architecture for the 5G System (5GS)".

[10] 3GPP TS 23.502: "System architecture for the 5G System (5GS)".

[11] 3GPP TS 23.503: "System architecture for the 5G System (5GS)".

[12] ETSI TS 103 769: "Digital Video Broadcasting (DVB); Adaptive media streaming over IP multicast", v1.1.1, November 2020.

[13] CableLabs OC-TR-IP-MULTI-ARCH-C01: "IP Multicast Adaptive Bit Rate Architecture Technical Report", October 2016. Internet Available https://www.cablelabs.com/specifications/ip-multicast-adaptive-bit-rate-architecture-technical-report

[14] ETSI TS 103 285: "Digital Video Broadcasting (DVB); MPEG-DASH Profile for Transport of ISO BMFF Based DVB Services over IP Based Networks".

[15] 3GPP TS 26.348: "Northbound Application Programming Interface (API) for Multimedia Broadcast/Multicast Service (MBMS) at the xMB reference point".

[16] 3GPP TS 26.346: "Multimedia Broadcast/Multicast Service (MBMS); Protocols and Codecs".

[17] ATSC A/331: "ATSC Standard: Signaling, Delivery, Synchronization, and Error Protection".

[18] 3GPP TS 29.468: "Group Communication System Enablers for LTE (GCSE\_LTE); MB2 Reference Point; Stage 3".

[19] 3GPP TS 23.468: "Group Communication System Enablers for LTE (GCSE\_LTE); Stage 2".

[20] RFC 6733: "Diameter Base Protocol", October 2012.

[21] 3GPP TS 26.347: "Multimedia Broadcast/Multicast Service (MBMS); Application Programming Interface and URL", Release 16.

[22] 3GPP TS 22.146: "Multimedia Broadcast/Multicast Service (MBMS); Stage 1", Release 16.

[23] RFC 5053: “Raptor Forward Error Correction Scheme for Object Delivery”, October 2007.

[24] RFC 5445: “Basic Forward Error Correction (FEC) Schemes”, March 2009.

[25] RFC 3695: “Compact Forward Error Correction (FEC) Schemes”, February 2004.

[26] 3GPP TS 23.247: "Architectural enhancements for 5G multicast-broadcast services; Stage 2;" Release 17.

[27] 3GPP TS 26.511: "5G Media Streaming (5GMS); Profiles, codecs and formats".

[28] 3GPP TS 26.512: "5G Media Streaming (5GMS); Protocols".

[29] 3GPP TS 26.502: "5G multicast-broadcast services; User service architecture".

[30] 3GPP TS 26.517: "5G Multicast-Broadcast User Services; Protocols and Formats".

[31] ETSI TS 103 720: "LTE-based 5G Broadcast System".

[32] 3GPP TS 23.479: "UE MBMS APIs for Mission Critical Services".

[33] 3GPP TS 23.247: "Architectural enhancements for 5G multicast-broadcast services".

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## 3.2 Abbreviations

For the present document, the abbreviations given in TR 21.905 [5] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905.

5G-MAG 5G Media Action Group

5MBS 5G Multicast/Broadcast Service

5GMS 5G Media Streaming.

ABR Adaptive Bit Rate.

AL‑FEC Application-Level Forward Error Correction

ATSC Advanced Television Systems Committee

BM-SC Broadcast-Multicast - Service Centre

CDN Content Delivery Network

CMAF Common Media Application Format

DASH Dynamic Adaptive Streaming over HTTP

DNS Domain Name Service

DVB Digital Video Broadcasting

EPC Enhanced Packet Core

EPS Enhanced Packet System

FDT File Delivery Table

FEC Forward Error Correction

FFS For Further Study

FLUTE File deLivery over Unidirectional Transport

FQDN Fully-Qualified Domain Name

GCS Group Communication Service

GCSE Group Communication Service Enabler

HLS HTTP Live Streaming

HPHT High Power High Tower

HTTP HyperText Transfer Protocol

IGMP Internet Group Management Protocol

IPTV Internet Protocol Television

ISO BMFF International Standardization Organization Base Media File Format

LCT Layered Coding Transport

MAA MBMS-Aware Application

MABR Multicast ABR

MBMS Multimedia Broadcast/Multicast Service

MBS Multicast/Broadcast Service

MBSF Multicast/Broadcast Service Function

MBSTF Multicast/Broadcast Service Transport Function

MCPTT Mission Critical Push-To-Talk over LTE

MLD Multicast Listener Discovery

MPEG Moving Picture Experts Group

NAS Non-Access Spectrum

NEF Network Exposure Function

OTT Over-The-Top

PCC Policy and Charging Control

PCF Policy and Charging Function

PDU Protocol Data Unit

PTM Point-To-Multipoint

RoHC Robust Header Compression

ROUTE Real-time transport Object delivery over Unidirectional Transport

RTP Real-time Transport Protocol

RTSP Real-time Streaming Protocol

SACH Service Access CHannel

SCTP Stream Control Transmission Protocol

SDP Session Description Protocol

SFN Single-Frequency Network

SMF Session Management Function

SNTP Simple Network Time Protocol

STB Set-Top Box

TMGI Temporary Mobile Group Identity

TOI Transport Object Identifier

UPF User Plane Function

XML Extensible Markup Language

## ===== CHANGE =====

#### 4.2.2.5 MB2 reference point

MB2 reference point, specified in TS 29.468 [18] and TS 23.468 [19], is used when the MBMS network provides Group Communication Services (such as MCPTT) delivery to the UE [16], as shown in Figure 4.2.2.5-1.



Figure 4.2.2.5-1: MBMS network architecture model for GCS Delivery

NOTE: For services other than Group Communications, the standard reference point between the content provider and the BM-SC is defined in TS 26.348, and reviewed in clause 4.2.2.4.

The MB2 interface carries both control and user plane data, and provides a standardized way for an external entity, e.g. GCS AS to connect to BM-SC. A high-level reference model of the architectural elements relevant to understand the MB2 reference point is shown in Figure 4.2.2.5-2, reproduced from [18]. More complete reference models for GCS are contained in TS 23.468 [19].



Figure 4.2.2.5-2: Reference model for MB2 reference point

For MBMS delivery, the MB2 interface provides:

- MB2‑C procedures defined in TS 23.468 [19], for requesting the BM‑SC to activate, deactivate, modify an MBMS bearer, allocate/deallocate TMGI, and apply FEC and RoHC

- Forwarding of data to be delivered via an MBMS bearer to the BM‑SC via the MB2‑U reference point.

The MBMS session is identified by TMGI and Flow Identifier, which are assigned by TMGI upon request of the AS function.

The MB2-U Protocol stack is specified in clause 7 of TS 29.468 [18], as reproduced in Figure 4.2.2.5-3:



Figure 4.2.2.5-3: The user plane protocol stack

MB2-C protocol is a Diameter-based protocol as defined in RFC 6733 [20] and TS 29.468 Annex B [18]. BM-SC is the Diameter server in the sense that it is the network element that handles action requests and sends notifications. The AS function acts as the Diameter client in the sense it is the network element requesting actions and handles notification from the BM-SC. Transport protocol of Diameter messages over MB2-C interfaces make use of SCTP or TCP.

## ===== CHANGE =====

4.3.1 Introduction

This clause provides a review of related multicast and broadcast streaming standardization efforts outside 3GPP.

NOTE: This clause focusses on streaming-related work to understand their implications on 5GMS.

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#### 4.4.5.2 Standalone 5MBS client architecture

Figure 4.4.5.2-1 provides an architecture for which 5MBS is used independently of 5GMS. Note that the network part may have different instantations and implementation models, and is hence is not fully documented.



Figure 4.4.5.2-1: 5MBS architecture independent of 5GMS

The key aspects of the client architecture are:

1. The existence of a 5MBS client on the UE. This client is expected to have similar functionalities of an MBMS client as defined in TS 26.346 [21].

2. An API from the 5MBS client to the MBSF for the purpose of 5MBS control plane and service handling referred to as interface MBS-5. It is expected that this API has similar functionalities to those of the User Service Description as defined in TS 26.346 [21].

3. An interface between the 5MBS Client and the MBSTF for the purpose of 5MBS user data exchange at MBS‑4. This interface includes:

- MBS-4-MC dealing with unidirectional and multicast delivery from the MBSTF to the 5MBS client. It is expected that this interface has similar functionalities as defined in the delivery methods defined in TS 26.346 [21].

NOTE: Whether or not the architecture requires an interface MBS-4-UC for bidirectional and unicast-based delivery between the 5MBS AS and the 5MBS Client, and how the 5MBS AS is configured, is for further study.

4. An interface MBS‑8 between the 5MBS Application Provider and the 5MBS Aware-Application in order to announce 5MBS services.

5. An API-based interface MBS‑6 exposed by the 5MBS Client and used by the 5MBS-Aware Application to manage and control 5MBS services. It is expected that this API has similar functionalities to the control interfaces defined in clause 6 of TS 26.347 [21].

6. An API-based interface MBS‑7 exposed by the 5MBS Client and used by the 5MBS-Aware Application to receive user data information about 5MBS services. It is expected that this API has similar functionalities as the data interfaces defined in clause 7 of TS 26.347 [21].

NOTE: In the case where the 5MBS Client is deployed in a 5G Residential Gateway and the 5MBS-Aware Application is deployed in a separate end device, reference points MBS‑6 and MBS‑7 span the network interface between these devices.

A further decomposition of the above client architecture is provided in Figure 4.4.5.2-2 for which the 5MBS Client is separated into two components, namely:

*-* An **MBSF Client** communicating with the MBSF function and predominantly dealing with user service description aspects. This function exposes the aforementioned MBS-6 API.

*-* An **MBSTF Client** communicating with the MBSTF function for delivery functions. This function exposes the aforementioned MBS-7 API.



Figure 4.4.5.2-2: Extended 5MBS architecture independent of 5GMS

Two new APIs are introduced, namely:

*-* MBS-6′ that predominantly provides an API to control and manage the delivery functions of the MBSTF Client.

*-* MBS-7′ that provides information logically assigned to MBS-5 delivery (user service information) through MBS-7′.

Some open question remain on details (see also clause 5.6 key issues):

*-* Are there deployments that do not require an MBSF Client and hence, MBS‑6′ is directly exposed to the 5MBS defined application.

*-* Are there deployments for which no unicast is used? In this case MBS‑5 is completely served through MBS‑7′.

*-* Is it useful to separate the MBSTF Client into a multicast delivery and a unicast delivery component?

*-* On the MBS‑4‑UC requests, which unicast requests are proxied through 5MBS, for example to detect consumption, and which are served through M8?

NOTE: The 5MBS-Aware Application itself may be a media function and may include a media player, independently of the 5GMS architecture.

## ===== CHANGE =====

### 5.2.1 Description

It has been observed that a small number of popular live linear TV channels account for large viewership in over-the-top media service deployment. It is expected that multicast could be used to deliver ABR-packaged media segments in 5G Media Streaming so that a shared multicast/broadcast packet stream can be delivered to the RAN nodes, without having the capacity costs associated with unicast video delivery.

Some relevant features of a generic MABR functional architecture are described below in terms of the DVB‑MABR architecture reproduced in Figure 4.3.1.1‑1:

- Media objects (e.g. presentation manifests, media segments) can be made available by the *Multicast server* on different multicast transport sessions (i.e. IP multicast groups) at reference point M, with the *Multicast gateway* function selecting between them using standard multicast join/leave procedures under the influence of requests from the *Content playback* function at reference point L.

- In the case where there is more than one set of media object streams encoded from the same source media stream (e.g. DASH adaptation set) in a presentation, an additional set of multicast transport sessions can be provided for each such set of media object streams.

- The *Content playback* function is an unmodified ABR media player (e.g. a DASH player). However, specific APIs may additionally be provided to support player operation.

- The *Multicast gateway* may be a media-aware HTTP(S) proxy or may be media-unaware.

NOTE: Bit rate adaptation by a *Multicast gateway* is for future study.

- The purpose of the *Multicast rendezvous service* is to maintain records of managed *Multicast gateway* instances, and to handle the initial request from the *Content playback* function for a presentation manifest. The *Multicast rendezvous service* redirects the *Content playback* function to use a *Multicast gateway* for a particular media presentation, when this is appropriate. This HTTP-level redirection is “sticky” and therefore is only needed in the case of the *Content playback* function’s initial request for a presentation manifest at the start of the presentation session. Subsequent requests for the presentation manifest in the same presentation session go straight to the *Multicast gateway*.

- Once the *Content playback* function has decided to use the *Multicast gateway* for a given media presentation, the request for the presentation manifest is proxied through the *Multicast gateway*. This gives the *Multicast gateway* the opportunity to modify the presentation manifest. Notably, the *Multicast gateway* can arrange for the *Content playback* function to direct certain media segment requests to the *Multicast gateway* at reference point L by selectively changing the origin in some of the URL base paths.

- The same media segments made available via multicast at reference point M are also available via unicast at reference point A. This enables a *Multicast gateway* to offer transparent unicast-based repair of media not received intact at reference point M and irreparable using AL‑FEC (if available). Unicast retrieval of media segments is also useful for supporting fast presentation start-up and for patching gaps when switching between multicast transport sessions.

NOTE: Other relevant features may be identified and added at a later point during the course of the study.

In the CableLabs IP Multicast ABR architecture Technical Report [13], similar to DVB‑MABR, the term “Multicast Adaptive Bit Rate” is also used to refer to the multicast delivery of video segment files to a gateway or proxy which subsequently delivers these segments via HTTP when they are requested by a streaming video Player. As with DVB‑MABR, each multicast stream typically carries a single bit rate (e.g. a single DASH representation).

This key issue is aimed at studying how to provide support two scenarios:

1. For a 5G Media Streaming Service provider to implement “Multicast ABR” like functionalities in 5G Media Streaming leveraging 5G MBS functionalities. For details see clause 5.2.3.

2. For an external Multicast ABR provider to interface with 5G Media Streaming and 5G MBS to distributed data over 5G System. For details see clause 5.2.4.

Where appropriate, solutions addressing this Key Issue may include the reuse of existing concepts, functions and/or interfaces from Release 16, including the 5G Media Streaming architecture and the MBMS Service Layer.

NOTE: DASH-over-MBMS and the generic Application Service specified in TS 26.346 already supports many of the required functions.

## ===== CHANGE =====

### 5.2.5 Scope of study

For Scenario #1, the following is expected to be studied:

1. A mapping of relevant Multicast ABR logical functions into the 5G Multicast/Broadcast Service architecture and the 5G Media Streaming architecture, including which reference points and protocols are required to support Multicast ABR functionality.

2. Outline procedures for configuring the Multicast ABR features relevant to the scenario in the 5MBS System and/or in the (extended) 5GMS System.

3. Outline procedures for discovering and establishing a Multicast ABR session, for switching dynamically between multicast transport sessions, for recovering from multicast packet loss and for reporting usage statistics and Quality of Experience metrics for the purpose of optimal service management.

4. Identifying network provisioning of different Representations, for example using different QoS, different FEC settings etc.

Any gaps identified during the analysis will also be documented.

It is noted that Scenario #2 is primarily about wrapping the DVB-MABR architecture around SA2's 5MBS architecture and interfacing it with a 5MBS-extended 5G Media Streaming architecture. The problems relevant to 5G Media Streaming for which solutions need to be studied are:

1. How to realise the DVB *Multicast gateway* function in a 5GMS UE and how best to interface with the 5GMS Client. This includes studying options for bit stream compatibility between DVB-MABR multicast transport sessions and 5MBS.

2. How best to provide DVB-MABR multicast session configuration to a *Multicast gateway* using either native DVB-MABR mechanisms, 5MBS Service Announcements or a blend of the two.

3. How best to realise the DVB-MABR unicast repair mechanism. This could be over-the-top repair requests via the unicast PDU Session, mediated through the 5GMS AS at M4, or a blend of the two.

4. How best to integrate the *Multicast gateway* with the DVB‑MABR reporting mechanism. This could use native reporting over unicast PDU Session, or an extension of the existing reporting mechanisms between the Media Session Handler and 5GMS AF, or a blend of the two.

NOTE: Whereas Scenario #2 is possibly interesting to enable such external services, it is more the duty of DVB as an example to make use of 5GS capabilities than new definitions in 3GPP. Scenario #2 is more of relevance for external organizations being users or 5GS technologies. It is thus proposed to prioritize scenario #1.

## ===== CHANGE =====

#### 5.3.1.6 Model of a BM-SC User-Plane Function for Group Communication Delivery

The model in Figure 5.3.1.6-1 below assumes that the BM-SC FEC encoding function according to Group Communication Delivery Method (Clause 8A in TS 26.346 [16]) is mapped into the MBSTF. According to TR 23.757 [7], the MBSTF exposes an MB2-U interface, which should be used (only?) when FEC needs to be added to Group Communication. When no FEC is needed, the GCS AS may directly send the traffic to the MB-UPF using N6.

The purpose of this simplified model is to help identify the MB2-C parameters needed to configure an MBSTF at Nmb2. The function “FEC Payload creation” generates a new RTP flow carrying the FEC redundancy information to protect one or more RTP media flows.

A diagram of a process flow

Description automatically generated

Figure 5.3.1.6-1: Simplified User Plane model for Group Communication Delivery with FEC  
(as an MBSTF function)

The model depicts some key functions from an MB2-U ingest to an MB-UPF ingest (N6). In the case of Group Communication Delivery the MBSTF operates as follows:

1. The **MB2-U Receiver** is responsible for receiving the MB2-U packets. The IP multicast user plane packets are encapsulated into the MB2-U packets. The MB2-U receiver may duplicate the packets so that the original packet can be passed through to the output and the copy remains in the Packet Cache for FEC source block creation.

2. The **RTP Passthrough** passesthe source packets directly to the output.

NOTE: It is for further study whether the RTP Passthrough function appends FEC information (like a source block id), without modifying the original parts.

3. **FEC Payload Creation** calculates the FEC redundancy information which is then carried as a separate RTP flow to the receiver.

4. **RTP packet creation** prepends RTP header fields to the payloads of the FEC flow.

5. The **Streamer & Pacer** ensures a smooth output bit rate according to the configured Guaranteed Bit Rate.

NOTE: Since FEC redundancy is added to the stream, the output bit rate is higher than the input bit rate.

When a GCS AS activates an MB2 session with FEC, the GCS AS provides the following information to the BM‑SC:

- **FEC configuration information** (see clause 6.4.27 of TS 29.468 [18]). A list of the FEC Framework configuration information according to clause 8A.5 of TS 26.346 [16] is depicted in Figure 5.3.1.5-2 below.

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Description automatically generated

Figure 5.3.1.6-2: FEC Framework configuration information according to TS 26.346 Clause 8A.5

As response, the GCS AS receives the MB2-U tunnel endpoint information (i.e. the BM‑SC Address AVP and BM‑SC Port AVP).

When the BM‑SC is split into MBSF and MBSTF, the MBSF interacts with the MB-SMF in order to obtain the N6 ingest parameters for the MB-UPF. The MBSF provides the FEC framework configuration information together with the MB-UPF N6 ingest information to the MBSTF via Nmb2. The MBSTF allocates the MB2-U tunnel endpoint information and passes the MB2-U ingest information back to the MBSF.

The MBSF may pass the FEC Framework configuration information to the MBSTF as an Octet Stream (see clause 6.4.27 of TS 29.468 [18]) so that the MBSTF parses the SDP information.

## ===== CHANGE =====

5.9 Key Issue #8: In-session unicast repair for MBS Object Distribution

5.9.1 Description

Clause 4.2.6 of TS 26.502 [29] defines object repair. However, only a post-session repair procedure is defined up to and including Release 18; in-session object repair procedures are declared as being for further study. Accordingly, clause 6.2.4 of TS 26.517 [30] defines an object repair mechanism for FLUTE, but only a post-session repair procedure is defined in clause 6.2.4.2; in-session object repair procedures in clause 6.2.4.3 are for further study.

However, for live and low-latency live services using the Object Distribution Method in MBS, in certain cases the transmission of an object is not completely successful. In this case, unicast repair for individual MBS Clients can improve the service quality. However, the timing of such requests needs to be carefully studied in order to avoid network overloads or significant latencies in the delivery. A study to extend MBS User Services and object streaming to address in-session repair is of relevance.

5.9.2 Collaboration scenarios

Different high-level collaboration scenarios may apply:

1) Based on the collaborations in clauses A.3 and A.4 of TS 26.502 [29], objects ingested by the MBSTF at reference point Nmb8 are made available to the MBS AS within the Trusted DN. The MBS AS may, for example, be co-located with a 5GMSd AS.

2) Based on the collaboration in clause A.5 of TS 26.502 [29], the MBS Application Provider provides the delivery functions, i.e. the MBS Application Provider (AF/AS) uses an MBSTF-like function to produce packet data compliant with reference point MBS-4-MC and the MBS Application Provider (AF/AS) makes object repair available from an MBS AS-like function that is compliant with reference point MBS-4-UC. The MBS AS-like function may, for example, be co-located with a 5GMSd AS-like function.

3) A mixture of 1 and 2 not yet documented in annex A of TS 26.502 [29], for which:

- An MBS AS-like function that is compliant with reference point MBS-4-UC is provided by the MBS Application Provider (AS/AF). Objects published to the MBSTF at reference point Nmb8 are also ingested by the MBS AS-like function.

- the MBS Application Provider (AF/AS) makes object repair available from an MBS AS-like function that is compliant with reference point MBS 4 UC. The MBS AS-like function may, for example, be co-located with a 5GMSd AS-like function.

5.9.3 Architecture mappings

The MBS User Services network architecture in clause 4.2.2 of TS 26.502 [29] and the MBS User Service reference architecture in clause 4.3.1.1 of [29] apply to all collaboration scenarios described in clause 5.9.2 above.

For scenario 1, a mapping to a deployment architecture is provided in clause A.4 of [29]. It is noted that while figure 4.2.2-1 of [29] depicts a reference point between the MBSTF and the MBS AS, it is marked out of scope up to and including Release 18. This reference point may be more formally defined as indicated in figure 5.9.3-1.

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**Figure 5.9.3-1: MBS User Services network architecture highlighting the potential need for a new reference point between MBSTF and MBS AS**

For scenario 2, a mapping to a deployment architecture is provided in clause A.5 of TS 26.502 [29].

For scenario 3, a mapping to a deployment architecture is provided is provided in figure 5.9.3-2.

****

**Figure 5.9.3-2: Deployment with MBS Application Provider (AF/AS) hosting MBS AS in External DN**

In this collaboration:

- The MBS AS-like entity is not configured by the MBSF, and hence reference point MBS-9 is not instantiated.

- An equivalent of the considered MBS-NEW reference point is also not required between the MBS AS-like entity and the MBSTF.

This new collaboration scenario is not considered in the prime focus of this key issue and is not further studied.

5.9.4 High-level call flows

5.9.4.1 Existing call flow for post-session object repair

Up to and including Release 18, TS 26.502 [29] does not include any procedural call flows for object repair.

Clause 6.2.4.2 of TS 26.517 [30] includes a detailed procedure for post-session object repair from which the sequence diagram in figure 5.9.4.1-1 has been synthesised.

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NOTE: In a normative specification the call flow is preferably extended with provisioning and ingest.

**Figure 5.9.4.1-1 Call flow for post-session object repair  
as specified in TS 26.517 [30], clause 6.2.4.2**

5.9.4.2 In-session object repair call flow

Figure 5.9.4.2-1 provides a modified version of the post-session repair call flow from figure 5.9.4.1-1 that describes a call flow for in-session repair. In this case, MBS object delivery and repair of objects typically runs in parallel.

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NOTE 1: In a normative specification the call flow is preferably extended with provisioning and ingest.

NOTE 2: Distribution and repair transactions may be interleaved in time or may occur in parallel, no longer sequentially.

**Figure 5.9.4.2-1 Call flow for in-session object repair**

One of the crucial parts in the above call flow is the timing of when the delivery of the object is declared complete, and repair procedures are initiated. If the delivery is considered to be complete too early, all participants in the MBS User Services session may initiate a repair request. If it is too late, then the recovery of the object is delayed for the application and may arrive too late to be useful, especially in the case of segmented media presentations.

Secondly, parallel execution of object distribution and in-session object repair may be achieved using broadcast distribution of objects concurrently with unicast uplink repair requests and downlink reception of the requested repair data. In case the MBS User Service is made available via a Receive-Only Mode (ROM) system (for example MBMS-ROM or via broadcast mode in a Non-Terrestrial Network), the MBS Client may even require use of multiple Radio Access Networks at the same time.

5.9.5 Gap analysis and requirements

The following aspects are identified to be missing:

1) Formal definition of a named reference point between the MBSTF and the MBS AS in order to publish objects to the MBS AS for the purpose of object repair.

2) Reliable signalling from the MBSTF to the MBS Client via reference point MBS-4 of when the delivery of an object is completed.

3) Signalling from MBSTF to the MBS Client via reference point MBS-4 when the object needs to be released to the application.

4) The execution of parallel MBS object delivery and in-session object repair.

5) In order to ensure that the timing in FDTs is synchronized with the UE’s view of time, an accurate time synchronisation between the MBSTF and the UE is needed.

5.9.6 Candidate solutions

On gap #1 identified in clause 5.9.5:

- Define a named reference point between the MBSTF and the MBS AS in order to publish objects to the MBS AS for the purpose of object repair.

- Document a call flow for procedures including post session repair and in session repair.

On gap #2 identified in clause 5.9.5, the following signalling options exist:

- using the FLUTE File Delivery Table (FDT) parameters to signal the time when repairs can be requested (e.g. Expires attribute).

- Using LCT header information to signal the time when repairs can be requested (e.g., B-Flag).

On gap #3 identified in clause 5.9.5, the following signalling options exist in the FLUTE File Delivery Table (FDT):

- Using FDT parameters to signal the availability time when the object needs to be released.

On gap #4 identified in clause 5.9.5, the execution of MBS object delivery and in-session unicast repair can run in parallel in the MBS Client.

On gap #5 identified in clause 5.9.5, time synchronization can reuse functionalities defined in TS 26.346 [16], but tighter synchronization that 1 second.

5.9.7 Summary and conclusions

Clause 4.2.6 of TS 26.502 [29] defines object repair. However, only a post-session repair procedure is defined up to and including Release 18; in-session object repair procedures are declared as being for further study. Accordingly, clause 6.2.4 of TS 26.517 [30] defines an object repair mechanism for FLUTE, but only a post-session repair procedure is defined in clause 6.2.4.2; in-session object repair procedures in clause 6.2.4.3 are for further study.

For live and low-latency live services using the Object Distribution Method in MBS, in certain cases the transmission of an object is not completely successful. In this case, unicast repair for individual MBS Clients can improve the service quality.

It is recommended to support in-session unicast repair in a future version of MBS User Services. For this purpose, the candidate solutions documented in clause 5.9.6 are recommended to be implemented.

For stage-2 impact:

- Gap#1 in clause 5.9.5 is expected to be addressed by the candidate solution in clause 5.9.6:

a. Defining a new reference point in TS 26.502 [29].

b. Documenting call flows and procedures for both post-session and in-session unicast repair.

Stage-3 impact is expected to address gaps #2, #3 and #5 in clause 5.9.5 in TS 26.346 [16] and TS 26.517 [30] based on the candidate solutions in clause 5.9.6.

- On gap #2 identified in clause 5.9.5, both of the following signalling options are expected to be supported:

- Using FDT parameters to signal the time when repairs can be requested using the Expires attribute).

- Using LCT header information to signal the time when repairs can be requested using the B-Flag.

- On gap #3 identified in clause 5.9.5, the following signalling options exist in the FLUTE File Delivery Table (FDT):

- Defining an new FDT extensions parameter to signal the availability time when the object needs to be released.

- On gap #4 identified in clause 5.9.5, the execution of MBS object delivery and in-session unicast repair can run in parallel in the MBS Client. However, this should be validated if there are cases this is not the case and whether these cases need to be explicitly stated, for example reduced capability (RedCaP) UEs.

- On gap #5 identified in clause 5.9.5, time synchronization can reuse functionalities defined in TS 26.346 [16], but tighter synchronization than 1 second. This work is aligned with the findings and work in clause 5.11.3.6.

## ===== CHANGE =====

5.10 Key Issue #9: MBS User Service and Delivery Protocols for eMBMS

5.10.1 Description

The MBS User Service architecture and protocol follows the modern design philosophies of the 5G System with separation of user services from transport, a service-based architecture and RESTful APIs. At the same time, eMBMS and enTV (as used for LTE-based 5G Broadcast) support transparent delivery mode and group communication. While interworking between MBMS and MBS is addressed in clause 5.2 of TS 23.247 [26] and clause 4.9 of TS 26.502 [29], interworking between these two systems at the User Service level is not addressed. In order for MBMS and LTE-based 5G broadcast as defined in ETSI TS 103 720 [31] to leverage MBS User Service technologies, a study is warranted to identify the gaps to fully support this functionality.

Figure 5.10.1-1 reproduces the MBS–eMBMS interworking system architecture as documented in figure 4.9-1 of TS 26.502 [29]. The functional elements that fall within the scope of [29] are highlighted in green.

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**Figure 5.10.1‑1: MBS–eMBMS interworking system architecture (see TS 26.502 [29], figure 4.9-1)**

The interworking architecture defined in clause 4.9 of [29] addresses the following functionalities:

1. Using MBS northbound interfaces at reference point Nmb10 for MBS, and using eMBMS northbound interfaces at reference point xMB-C or MB2-C for eMBMS.

2. Potential dynamic switching between MBS and eMBMS reception, if a UE implements both an MBS Client and an eMBMS Client.

3. Common ingest of content through reference point Nmb8/xMB-U, if these reference points are compatible.

4. Common MBS User Services distribution and eMBMS delivery methods such that the same ingested content can be delivered to an MBS Client and to an eMBMS Client. UEs supporting only eMBMS are served by this architecture as well.

However, there is no guarantee that items 3 and 4 can generally be achieved in practice.

5.10.2 Collaboration scenarios and architecture mappings

5.10.2.1 Joint BM-SC + MBSF functionality

A more common interest is the ability to deploy a system for which MBS User Services are distributed via eMBMS. This would allow a single, common User Service specification for MBS and eMBMS/5G Broadcast to be maintained going forward. A modification of the architecture is shown in figure 5.10.2-1 in which:

- Only the MBS northbound reference points Nmb10 and Nmb8 are exposed respectively by the MBSF and MBSTF. These are extended as required to support eMBMS transport (as those are extended, they are marked with an asterisk).

- The UE in the 5G System is extended to support eMBMS reception, for example an LTE-based 5G Broadcast profile as defined in ETSI TS 103 720 [31]. Such an approach permits a single middleware client with unified APIs, etc. to be deployed in the UE that is capable of both MBS User Service reception and eMBMS User Service reception.



**Figure 5.10.2‑1: MBS User Services on top of eMBMS**

5.10.2.2 MBS User Services feeding only eMBMS

A further variant of the architecture is shown in figure 5.10.2-2, in which case MBS radio delivery is not even in scope, but the MBS User Service is used to deliver only eMBMS traffic.



**Figure 5.10.2‑2: MBS User Services on top of eMBMS**

5.10.2.3 MBS User Services on top of eMBMS using Group Communication

Another possible implementation architecture is shown in figure 5.10.2.3-1 where a subset of MB2 procedures and protocols is used southbound of the MBSF and MBSTF to communicate with the EPS via a function implementing the Group Communication functionality of a BM-SC. Such a deployment architecture may be of interest in order to address a combination of MBS User services with eMBMS radio delivery.

According to TS 26.346 [16], the Group Communication Service (GCS) AS as defined by TS 23.468 [19] uses the MBMS Group Communication delivery method on top of MBMS bearers for MBMS delivery. However, in general, the MBMS Group Communication delivery method is available for any application. In this case, the application interfaces to the BM-SC at reference point MB2. This carries control plane signalling (via reference point MB2-C) and user plane data (via reference point MB2-U) between the Application Server for Group Communication (GCS AS) and the BM-SC.

The data transferred via MBMS bearer(s) is delivered from the BM-SC using the Group Communication delivery method as defined in TS 26.346 [16]. Stage 2 procedures between the GCS AS and the BM-SC at reference point MB2 are defined in TS 23.468 [19]. The stage 3 specification of the MB2 procedures and the protocol aspects of MB2-C and MB2-U are specified in TS 29.468 [18].



**Figure 5.10.2.3-1: MBS User Services on top of eMBMS using Group Communication**

In this deployment scenario, with reference to the interworking architecture defined in annex C of TS 23.247 [26], the MBS User Service is treated as an application on top of the Group Communication delivery method:

- The MBSF additionally implements the relevant subset of GCS AS control plane functionality, including MB2-C provisioning operations at a new reference point MB2′-C, allowing it to control a separate BM-SC that implements at least Group Communication functionality.

- The MBSTF additionally implements the relevant subset of GCS AS user plane functionality, including MB2-U protocols at a new reference point MB2′-U to exchange user plane data with a separate BM-SC that implements at least Group Communication functionality.

- A UE connecting to the E-UTRAN implements the relevant MBS User Service functionalities above suitable eMBMS middleware (MBMS Client) to support the reception of MBS User Services via the Group Communicaton API as defined in TS 23.479 [32].

The MBMS Client only includes the Access Stratum as well as the functionality to establish the group communication API.

Figure 5.10.2.3-2 provides an MBS/eMBMS interworking reference architecture for this purpose including the client architecture based on what is available in figure 4.9-2 of TS 26.502 [29].



NOTE: This figure is slightly modified compared with figure 4.9-2 of TS 26.502 [29] to terminate MBMS northbound reference points at the joint functionality, and not the MBS functions.

**Figure 5.10.2.3-2: MBS–eMBMS interworking reference architecture on top of eMBMS  
using Group Communication**

In this case, the application only needs to have knowledge of MBS, but can use MBMS/GCS delivery. There is a *Joint MBS Client + MBMS-Aware Application* that can use GCS API to connect to MBMS delivery.

5.10.2.4 MBS User Services on top of eMBMS using Transparent Delivery

Yet another possible architecture is shown in figure 5.10.2.4-1 where a subset of xMB provisioning procedures and protocols are used southbound of the MBSF and MBSTF to communicate with the EPS via a function implementing the Transparent Delivery functionality of the BM-SC.



**Figure 5.10.24-1: MBS User Services on top of eMBMS using Transparent Delivery**

In this scenario, with reference to the interworking architecture defined in annex C of TS 23.247 [26]:

- The MBSF additionally implements the relevant subset of Content Provider control plane functionality, including xMB-C provisioning operations at a new reference point xMB′-C, allowing it to control a separate BM-SC that implements at least Transparent Delivery functionality.

- The MBSTF additionally implements the relevant subset of Content Provider user plane functionality, including xMB-U protocols at a new reference point xMB′-U to exchange user plane data with a separate BM-SC that implements at least Transparent Delivery functionality.

- A UE connecting to the E-UTRAN would implement the relevant MBS User Service functionalities above suitable eMBMS middleware (MBMS Client) to support the reception of the MBS User Services via the transparent delivery mode API as defined in TS 26.347 [21].

Figure 5.10.2.4-2 provides an MBS/eMBMS interworking reference architecture for this purpose including the client architecture based on what is available in figure 4.9-2 of TS 26.502 [29].



NOTE: This figure is slightly modified compared with figure 4.9-2 of TS 26.502 [29] to terminate MBMS northbound reference points at the joint functionality, and not the MBS functions.

Figure 5.10.2.4-2: MBS–eMBMS interworking reference architecture on top of eMBMS  
using Transparent Mode

In this case, the application only needs to have knowledge of MBS, but can use MBMS transparent delivery. There is a *Joint MBS Client + MBMS-Aware Application* that can use MBMS-API to connect to MBMS delivery.

5.10.3 High-level call flows

5.10.3.1 Joint BM-SC and MBSF Functionality

The extended high-level baseline procedures for MBS User Services for the architecture showing in figure 5.10.2-2 are shown in figure 5.10.3.1-1, highlighting in **boldface** the extensions to the call flow in clause 5.2.1 of TS 26.502[29].



**Figure 5.10.3.1-1: MBS User Service high-level baseline procedures  
with Joint BM-SC and MBSF Functionality**

The same procedures as defined in clause 5.2 of TS 26.502 [29], apply, but the distribution of content in steps 9 and 11 is via eMBMS. However, the detailed procedures documented in the remainder of clause 5 in TS 26.502 need further consideration to support eMBMS distribution.

In clauses 5.3, 5.3A, and 5.5 of TS 26.502, the communication with the MB-SMF to allocate TMGIs, create sessions, update sessions, or delete sessions is extended with a communication with the MBMS-GW at reference point SGmb, and the procedures defined in clause 8 of TS 23.246 [6] apply instead. In particular:

- The BM-SC sends a Session Start Request message to MBMS-GW to indicate the impending start of the transmission and to provide the session attributes (TMGI, Flow Identifier, QoS, MBMS service Area, list of cell IDs if available, Session identifier, estimated session duration, list of MBMS control plane nodes (MMEs, SGSNs) for MBMS GW, time to MBMS data transfer, MBMS data transfer start, access indicator, ...).

- The MBMS-GW responds with a Session Start Response message with information for BM-SC to send MBMS data to the MBMS-GW.

According to TS 23.247 [33], a common TMGI for MBS and eMBMS is used towards the AF/AS and the TMGI is also used as identifier for transport over E-UTRAN/EPC.

In the user plane, the MBSTF distributes the received data to the MB-UPF at reference point Nmb9 and/or to the MBMS-GW at reference point SGi-mb, when supported by operator network configuration.

The session description document specified in clause 5.2.5 of TS 26.517 [30] describes the parameters of the MBS distribution session using either:

- The session description for the MBS Object Distribution Method, as specified in clause 6.2.2 of TS 26.517, or

- The session description for the MBS Packet Distribution Method, as specified in clause 7.2.3 of TS 26.517.

In either case, the service type is restricted to Multicast MBS and Broadcast MBS as shown in clause 6.2.2.2 of TS 26.517. The use of the *mbms-mode* as defined in TS 26.346 [16] is not currently permitted in TS 26.517.

5.10.3.2 MBSF/MBSTF southbound interface to BM-SC via MB2′

According to TS 23.468 [19], reference point MB2 offers access to the MBMS bearer service from an application. MB2 carries control plane signalling (MB2-C) and user plane traffic (MB2-U) between a Group Communication Application Server (GCS AS) and a BM-SC. Some relevant properties of MB2 are summarized as follows:

- MB2 is a standardized secured interface between a GCS AS and a BM‑SC.

- MB2 is used by the GCS AS to interact with the BM-SC for MBMS bearer management.

- The application data transferred via MBMS bearer(s) by the GCS AS is transparent to the BM-SC.

- The GCS AS needs to be configured with the IP addresses or a FQDN of the MB2-C endpoint on the BM‑SC. A separate MB2-C endpoint needs to be exposed by the BM‑SC per PLMN ID.

- The user plane transport information (e.g. IP address/UDP port) for delivering a Group Communication application data flow from the GCS AS to the BM-SC over reference point MB2-U is exchanged over reference point MB2-C.

Reference point MB2 provides the ability for the application to use the functionality of the MBMS System to deliver data to group members over MBMS. The procedures supported include:

- allocation of a set of TMGIs (TS 23.246 [3]) by the BM-SC at the request of the GCS AS (see clause 5.1.2.2.2 of TS 23.468 [19]),

- deallocation of a set of TMGIs by the BM-SC at the request of the GCS AS (see clause 5.1.2.2.3 of TS 23.468),

- activating an MBMS bearer in the BM-SC (see clause 5.1.2.3.2 of TS 23.468):

NOTE: This may include configuration requesting the BM-SC to apply Application Layer Forward Error Correction (AL-FEC) or Robust Header Compression (RoHC), or both, to the MBMS bearer.

- deactivating an active MBMS bearer in the BM-SC (see clause 5.1.2.3.3 of TS 23.468),

- modifying the characteristics of an active MBMS bearer in the BM-SC (see clause 5.1.2.4 of TS 23.468), and

- reporting of MBMS delivery status by the BM-SC to the GCS AS (see clause 5.1.2.5 of TS 23.468).

A session at reference point MB2 is established between the GCS AS function of the MBSTF and the downstream BM‑SC before any MB2 messages are exchanged between these two entities, and this session carries all MB2 messages between them for all MBMS bearers provisioned and used by the GCS AS. The TMGI/FlowID is the unique identifier used by the GCS AS and BM-SC to refer to the MBMS bearer.

The extended high-level baseline procedures for the MBS User Services architecture using Group Communication depicted in figure 5.10.2-3 are shown in figure 5.10.3.2-1, highlighting in **boldface** the extensions to the call flow compared with that in clause 5.2.1 of TS 26.502 [29].

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**Figure 5.10.3.2-1: MBS User Service high-level baseline procedures using Group Communication enablers and APIs**

The core extensions are:

- The Distribution Session provisioning, TMGI allocation and MBMS bearer allocation in steps 2, 3 and 4 are extended to address the allocation of the bearers on the MBMS distribution. The variant shown in the figure allows the MBSF to handle the communicaton with the MBSTF and BM-SC.

- In step 10, the MBSF Client provides information to the MBMS Client using the MC-MBMS-API in order to establish the MBMS bearer, involving also the MBSTF Client.

- In step 11, the MBMS Client activates the MBMS session to receive Group Communication data and the MBSTF Client activates the MBS User Services session to receive MBS data conveyed in the MBMS session.

- In step 13, MBS User Services session data is received through the MBMS bearer and directly provided to the MBSTF Client for relevant processing, for example FEC decoding, unicast repair determination and so on.

5.10.3.3 MBSF/MBSTF southbound interface with xMB to BM-SC

The call flow is similar to clause 5.10.3.2.

5.10.4 Gap analysis and requirements

5.10.4.1 Joint BM-SC and MBSF Functionality

For the Joint BM-SC/MBSF Functionality, no specific architectural gaps are identified. However, additional stage-2 procedures are required to support communication with the MBMS-GW at reference point SGmb, and consequent additions to the domain model and baseline parameters may also be needed.

The following stage-3 gaps are identified:

- The session description for the *MBS Object Distribution Method* in TS 26.517 [30] is restricted to describing MBS Sessions.

- The session description for the *MBS Packet Distribution Method* in TS 26.517 [30] is restricted to describing MBS Sessions.

To support the Joint BM-SC/MBSF Functionality, the removal of the above restrictions is needed.

5.10.4.2 MBSF/MBSTF southbound interface to BM-SC via MB2

In order to support the extended implementation in clause 5.10.3.2, in addition to the extensions documented in clause 5.10.4.1, the following extensions are needed:

- The MBSF and MBSTF need to be able to communicate with BM-SC using southbound instances of reference points MB2′-C and MB2′-U respectively based on what is presented in clause 5.10.3.2, figure 5.10.3.2-1, steps 2, 3 and 4.

Analysis of gaps in the MBS User Services client architecture is for future study.

5.10.4.3 MBSF/MBSTF southbound interface to BM-SC via xMB

The gaps are similar to those documented in clause 5.10.4.2.

5.10.5 Candidate solutions

As a minimum change, full support of the Joint BM-SC and MBSF Functionality is expected. For this purpose, the gaps documented clause 5.10.4.1 needs to be addressed by:

1. Documenting additional procedures in TS 26.502 [29], adding baseline parameters to the domain model as needed.

2. Permitting the signalling of MBMS sessions.

In an extended change:

3. It would be valuable to document in TS 26.502 [29] the deployment architectures to run MBS User Services over Group Communication Services (GCS) or MBMS Transparent Delivery by interfacing with an externally deployed BM-SC at new reference points MB2′ and xMB′ respectively. As part of this, the client architectures in figures 5.10.2.3-2 and 5.10.2.4-2 would also need to be documented as well as corresponding call flows.

The normative addition of these reference points to the MBS reference architecture would require an extension to TS 23.247 [26]. This may also have consequences to northbound interfaces Nmb8 and Nmb10. This may be too impactful, and more study is needed.

In an alternative approach, the architectures in clauses 5.10.2.3 and 5.10.2.4 may be documented informatively as potential deployment architectures in TS 26.502 [29], for example in an informative annex, without specifying the reference points.

5.10.6 Summary and conclusions

The MBS User Service architecture and protocol follows the modern design philosophies of the 5G System with separation of user services from transport, a service-based architecture and RESTful APIs. At the same time, eMBMS and enTV (as used for LTE-based 5G Broadcast) support transparent delivery mode and group communication. Clause 5.2 of TS 23.247 [26] and clause 4.9 of TS 26.502 [29] define interworking between these two systems. However, the architecture does not address deeper integration on User Service level. In this Key Issue, different deployment architectures are shown that allow the user services of MBMS and MBS to beneficially converge. In particular:

- A service provider can use MBS northbound reference points Nmb8 and Nmb10 to interface with both MBS and eMBMS delivery,

- In the network, a common MBSTF supports user plane delivery for both MBS and eMBMS. In the latter system, either the group communication or transparent delivery mode is used.

- In the UE, a common eMBMS-aware MBSTF Client can take advantage of User Service delivery via either MBS or eMBMS. This aspect is important also for future deployments and enhancements harmonisation between the MBMS and MBS delivery methods.

- Rather than requiring the application to be both MBMS and MBS aware, an application that is only MBS-aware may be implemented while still being able to leverage eMBMS delivery at the radio layer.

Based on this summary, it is recommended to:

- Fully specify support for the *Joint BM-SC and MBSF Functionality*. For this purpose, the gap identified in clause 5.10.4.1 of the present document needs to be addressed by documenting additional procedures and baseline parameters as required in TS 26.502 [29] and permitting the signalling of MBMS sessions.

- Document in an informative annex to TS 26.502 [29] the deployment architectures, client architectures and high-level call flows in clauses 5.10.2.3 and 5.10.2.4.

- Validate the approaches by implementation, for example in 5G-MAG Reference Tools, and identify if the functionality is fully supported or any further specification updates are needed.

NOTE: whether the TMGI allocation in the MBS US Announcement is achievable via MB-SMF is FFS.

- Going forward, ensure that enhancements to the MBSTF and delivery methods in MBS can also be leveraged and deployed for eMBMS.

## ===== CHANGE =====

5.11 Key Issue #10: Selected MBMS Functionalities not supported in MBS

5.11.1 Description

In completing TS 26.502 [29] and TS 26.517 [30], it is obvious that only a subset of the MBMS functionalities is supported in Release 18. While many MBMS functionalities are likely not important to be supported for MBS, a systematic analysis of MBMS User Services features and their potential relevance for MBS should be completed and recommendations made on which ones to migrate to MBS User Services specifications and how best to achieve this.

5.11.2 Gap analysis and requirements

5.11.2.1 Feature Comparison of MBMS and MBS User Services

In order to address the Key Issue as documented in clause 5.11.1, table 5.11.2.1-1 below provides an overview of the MBMS features as documented in clause 5.11.2, equivalent functionality in MBS. The final column identifies related gaps, provides comments and suggests potential next steps.

**Table 5.11.2.1-1: Overview of the MBMS features, equivalent functionality in MBS and related gaps as well as comments and potential next steps.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **MBMS feature and sub-feature** | | **TS 26.346 [16] clause** | **Equivalent MBS Feature** | **Gaps, Comments and next steps** |
| User Service Announcement and Discovery Metadata Fragments | | 4, 11 | Announcement of MBS User Services.  See clauses 4.5.7 and 4.5.8 of TS 26.502 and clause 5 of TS 26.517. | No gaps identified. |
| Download delivery | Basic protocol | 7.2, 7.3 | Object Distribution Method, see clause 6.2 of TS 26.517. | No gaps identified. |
| OMA Push | 7.4 | Not supported in TS 26.517 Release 18. | Not considered relevant for MBS User Services. |
|  | RTSP session setup | 7.5 | Not supported in TS 26.517 Release 18. | Not considered relevant for MBS User Services. |
|  | Generic Application Service | 7.6 | Partially supported in clause 5.2.6 of TS 26.517. | Gaps: Metadata lacks the ability to assign URLs to different distribution sessions, including unicast.  Next Steps: Define the association of URLs to distribution sessions – for more details see clause 5.11.3.2. |
|  | Keep-updated Service | 7.7 | Supported through object manifest as specified in clause 6.1.2 of TS 26.517. | No gaps identified. |
|  | Location-specific delivery method | 7.8 | Not supported in TS 26.517 Release 18. | For further study |
|  | Partial file handling | 7.9 | Not supported in TS 26.517 Release 18. | Gaps: Lack of support of the feature results in unnecessary loss of correctly received information  Next steps: define the support of partial file handling for MBS – for more details see clause 5.11.3.3. |
|  | QoE metrics | 8.4 | Not supported in TS 26.517 Release 18. | Gaps: Reporting mechanisms for MBS are minimally supported  Comment: It is expected that some functionalities can be covered by the application, but an analysis of reporting for MBS is needed.  Next steps: analyse reporting options for MBS in the 5G context. |
| Streaming delivery | Basic protocol | 8.2 | Not explicitely supported in TS 26.517, but covered in clause 7.2 of TS 26.517 as part of the packet distribution method. | Gaps: None identified  Comment: more details on RTP based delivery may be checked, but are only considered as potential optimizations.  Next steps: Nothing for now. |
|  | QoE metrics | 8.3, 8.4 | Not supported in TS 26.517 Release 18. | Gaps: Reporting mechanisms for MBS are minimally supported  Comment: It is expected that some functionalities can be covered by the application, but an analysis of reporting for MBS is needed.  Next steps: Analyse reporting options for MBS in the 5G context – for more details see clause 5.11.3.4. |
|  | Unicast | 8.5 | Not supported in TS 26.517 Release 18. | Not considered relevant for MBS User Services. |
|  | Group Communi­cation delivery | 8A | Not explicitely supported in TS 26.517, but covered in clause 7.2 of TS 26.517 as part of the packet distribution method. | No gaps identified. |
|  | Transparent delivery | 8B | Not explicitely supported in TS 26.517, but covered in clause 7.2 of TS 26.517 as part of the packet distribution method. | No gaps identified. |
|  | Key management | 4.4.2 | Supported in clause 5.2.10 of TS 26.517. | No gaps identified. |
| Associated delivery functions | File repair | 9.3 | Post-session Object Repair mechanism for FLUTE as specified in clause 6.2.4 of TS 26.517. | No gaps identified. |
| Reception reporting | 9.4 | Not supported in TS 26.517 Release 18. | Gaps: Reporting mechanisms for MBS are minimally supported  Comment: It is expected that some functionalities can be covered by the application, but an analysis of reporting for MBS is needed.  Next steps: Analyse reporting options for MBS in the 5G context – for more details see clause 5.11.3.4. |
|  | Consumption Reporting | 9.4A | Not supported in TS 26.517 Release 18. | Gaps: Reporting mechanisms for MBS are minimally supported  Comment: It is expected that some functionalities can be covered by the application, but an analysis of reporting for MBS is needed.  Next steps: Analyse reporting options for MBS in the 5G context – for more details see clause 5.11.3.4. |
|  | Media codecs | 10 | Not supported in TS 26.517. MBS is not considered to operate as a full service and hence codecs are excluded. With the combination with 5GMS, the codecs from 5G Media streaming are relevant for MBS. | No gaps identified. |
|  | MBMS Operation on Demand (MooD) | 11 | Not explicitely supported in TS 26.517. However, in combination with 5G Media Streaming, and 5G Media Streaming consumption reporting, an operation on On-demand may be implemented | Gaps: MooD not supported  Comment: It is expected that some functionalities can be covered by the application or by 5G Media Streaming, but an analysis of MooD for MBS is encouraged.  Next steps: Analyse MBS on demand operation in combination with 5G Media Streaming – for more details see clause 5.11.3.5. |
| Time synchronization | | 4.6 | Not supported in TS 26.517. | Gaps: Time synchronization not supported.  Next steps: Analyse time synchronization requirements and add functionality if needed – for more details see clause 5.11.3.6. |
| Guidelines for DASH | | K | Not explicitly documented in TS 26.517. | No immediate actions needed, but may be combined with Application Service extension – for more details see clause 5.11.3.2. |
| Profiles | MBMS Profile 1a | L.2 | For further study | For further study |
|  | MBMS Profile 1b | L.3 | For further study | For further study |
|  | MBMS Profile 1c | L.3A | For further study | For further study |
|  | MBMS Profile: Download | L.4 | For further study | For further study |
|  | MBMS Profile: UA for Transparent delivery | L.5 | For further study | For further study |
|  | FLUTE Profile | L.6 | Developed for TS 26.517, so no gaps. | No actions needed. |
| Guidelines for HLS | | M | Not explicitely documented in TS 26.517. | No immediate actions needed, but may be combined with Application Service extension – for more details see clause 5.11.3.2. |

5.11.3 Candidate solutions

5.11.3.1 Introduction

Candidate solutions for the gaps identified in clause 5.11.2 are advanced in the following clauses.

5.11.3.2 Application Services – MBS and hybrid

The generic Application Service as defined in clause 7.6 of TS 26.346 [16] may be supported fully in clause 5.2.6 of TS 26.517 [30] by extending the ability to signal application resources that are available on unicast, resource available via MBS User Services, as well as those that are available on both.

It is recommended to address this functionality in normative specifications in stage-2 and stage-3 by mapping the existing MBMS functionality to the MBS User Services.

5.11.3.3 Partial file handling

Partial file handling as defined in clause 7.9 of TS 26.346 [16] may be fully supported in TS 26.517 [30] by referencing the required functionality in TS 26.346 [16].

It is recommended to address this functionality in normative specifications in stage-2 and stage-3 by mapping the existing MBMS functionality to the MBS User Services.

5.11.3.4 Reporting and metrics

Reporting of metrics is preferably supported by the MBS Client collecting and aggregating application metrics and providing those as an aggregated record to an appropriate network function, for example, the MBS AF.

It is recommended to address this functionality in normative specifications in stage-2 and stage-3 by mapping the existing MBMS functionality to the MBS User Services.

5.11.3.5 MBS-on-demand

This topic is for further study.

5.11.3.6 Time synchronization

Time Synchronization may be fully supported in TS 26.517 [30] by referencing the required functionality in TS 26.346 [16] in clause 4.6.

This would require updates to the MBS architecture as well as stage-3 extensions, unless the functionality is supported in existing MBS network functions.

Candidate solutions to support the network functionalities (i.e. the SNTP server) for this feature may include:

- the addition of a function in the MBSTF, or

- the addition of a function in the MBSF, or

- a new network entity shared between all functions requiring time synchronization.

It is recommended to address this functionality in normative specifications.

5.11.4 Summary and conclusions

It is recommended to address the following functionalities that are available in MBMS for MBS User Services:

1. The generic Application Service as defined in clause 7.6 of TS 26.346 [16] based on the discussion in clause 5.11.3.2.

2. Partial file handling as defined in clause 7.9 of TS 26.346 [16] based on the discussion in clause 5.11.3.3,

3. Reporting of metrics based on the discussion in clause 5.11.3.4,

4. Time Synchronization as defined in TS 26.346 [16] in clause 4.6 based on the discussion in clause 5.11.3.6.

Other aspects identified in clause 5.11.2 for aligning MBS and MBMS are for further study.

## ===== CHANGE =====

#### 7.2.1.4 Mapping to Collaboration B0

Figure 7.2.1.4‑1 below shows how the DVB‑MABR reference model (blue functions and reference points) maps onto the 5MBS reference model proposed in the present document (green functions and reference points) and the 5MBS reference model for 5GC (grey functions and reference points) in the case of **Collaboration B0**.



Figure 7.2.1.4‑1: Mapping of the DVB‑MABR reference model onto the 5MBS reference model (Collaboration B0)

In this mapping:

1. The *Multicast server* function is realised by the MBSTF.

- Configuration at DVB‑MABR reference point **CMS** is achieved using xMB-C (Rel-17) MBS session provisioning procedures with the MBSF rather than using the DVB‑MABR multicast transport configuration. This results in configuration of the MBSTF via Nx2.

NOTE: xMB-C (Rel‑17) may be redesignated Nmbsf or Nx4 following consultation with SA2.

- The Object delivery method is provisioned.

- Pull-based content ingest at reference point **Oin** is realised by provisioning xMB-U pull mode procedures.

- Push-based content at reference point **Pin′** is realised by provisioning xMB-U push mode procedures.

NOTE: xMB-U may be redesignated Nmbstf or Nx5 following consultation with SA2.

2. Reference point **M** is realised by MBS‑4‑MC.

- The MBSTF generates a bitstream according to the specification of the Object delivery method.

3. The MBS session is announced to the 5MBS Client at MBS-5.

- The session descripion may be delivered via a 5MBS session announcement channel generated by the MBSTF at MBS‑4‑MC. This realises the DVB‑MABR multicast gateway configuration transport session.

- Alternatively, the 5MBS Client may retrieve the session description from the 5MBS AS via MBS‑4‑UC. This realises reference point **CMR** in the DVB‑MABR reference model.

In the UE:

3. The *Content playback* function and the *Multicast rendezvous service* are realised as a 5MBS-Aware Application.

4. The *Multicast gateway* function is realised by the 5MBS Client.

- New sessions are notified to the *Multicast rendezvous service* via MBS‑6 so that it can configure its redirect behaviour.

- The 5BMS Client provides object reassembly and repair functions in line with the 5MBS Object delivery method.

- The 5MBS Client implements dynamic adaptation between multicast transport sessions corresponding to different representations of the same adaptation set.

5. HTTP-based object repair at reference point **A** is realised by MBS‑4‑UC.

- The 5MBS AS may act as a unicast proxy for the external *Content hosting* function.

- Alternatively, the associated delivery procedures described in the 5MBS session announcement may direct the 5MBS Client to use the *Content hosting* function directly for HTTP-based object repair.

6. Reference point **L** is realised by MBS‑7.

- Intact playback delivery objects are exposed to the *Content playback* function, as required.

The following potential gaps merit study in relation to Collaboration B0:

1. What interface is used by the MBSF to publish session descriptions to the 5MBS AS?

2. How are multicast delivery sessions corresponding to different representations of the same adaptation set configured as part of a single 5MBS session description at xMB‑C (Rel‑17), Nx2 and MBS‑5?

NOTE: xMB-C (Rel‑17) may be redesignated Nmbsf/Nx4 following consultation with SA2.

3. How is dynamic adaptation achieved in the 5MBS Client between multicast transport sessions corresponding to different representations of the same adaptation set?

## ===== CHANGE =====

## 8.3 Recommended normative work arising from version 17

To document the potential standardization areas identified in clause 8.2 above, it is expected that several new specifications are produced and several existing specifications are extended.

In particular, the following normative specification work is recommended for immediate action:

1. A new architecture specification (as an example, TS 26.502) to define a 5MBS User Service architecture, including the following reference points/interfaces and entities:

a. New entities MBSF, MBSTF, 5MBS Client, and 5MBS AS.

b. The northbound reference points Nmb6 and Nmb4.

c. The reference point Nmb2 between the MBSF and the MBSTF.

d. The interfaces between the 5MBS Client and 5MBS network functions: MBS-4-UC, MBS-4-MC and MBS‑5.

e. the 5MBS Client reference points MBS-6 and MBS-7.

NOTE: at the time of drafting there was a dependency on SA2’s work on Rel-17 TS 23.247 [26].

This specification also includes:

f. Relevant call flows and procedures to support 5GMS over 5MBS.

g. Relevant call flows and procedures to support 5GMS hybrid services.

h. Relevant call flows and procedures for 5GMS independent usage of 5MBS.

2. In combination with the new 5MBS User Service Architecture specification (e.g. TS 26.502) above, extend TS 26.501 by providing a general description and architecture of:

a. 5GMS via 5MBS.

b. 5GMS hybrid services.

c. 5GMS via eMBMS.

d. Multicast ABR with 5GMS and 5MBS.

The following normative work is expected subsequently:

3. A new specification (as an example TS 26.513) to define the 5MBS User Service transport/application protocols and Delivery Methods for the interfaces defined in the 5MBS User Service Architecture specification (e.g. TS 26.502) above. This specification will take into consideration the need to maximize the reuse of components of already specified MBMS.

4. Extend TS 26.347 to provide Client APIs for 5MBS User Services, as defined in the 5MBS User Service Architecture specification (e.g. TS 26.502) above.

5. Extend relevant clauses in TS 26.512 [28] to realise the procedures defined in the 5MBS User Service Architecture specification (e.g. TS 26.502) above for 5GMS via 5MBS, 5GMS hybrid services, 5GMS via eMBMS, and Multicast ABR with 5GMS and 5MBS, as needed.

6. Extend relevant clauses in TS 26.346 [16] to define protocols and codecs for 5GMS via 5MBS, 5GMS hybrid services, 5GMS via eMBMS, and Multicast ABR with 5GMS and 5MBS, as needed.

8.4 Recommended follow-up work arising from version 19

### 8.4.1 Introduction

In a second phase of this feasibility study, additional Key Issues have been documented.

Based on the study of these, the following next steps are recommended.

### 8.4.2 Recommendations for stage 2 normative work arising from version 19

It is recommended to provide relevant extensions to TS 26.502 [29] to extend the MBS User Service architecture based on the updated conclusions in clause 5. Candidates for these extensions are:

1. For *Key Issue #8: In-session unicast repair for MBS Object Distribution* as introduced in clause 5.9 and based on the conclusions in clause 5.9.7:

- Address Gap #1 identified in clause 5.9.5 by the candidate solution described in clause 5.9.6:

i. Define a new reference point in TS 26.502 [29] between the MBSTF and the MBS AS.

ii. Document call flows and procedures for both post-session and in-session unicast repair.

2. For *Key Issue #9: MBS User Service and Delivery Protocols for eMBMS* as introduced in clause 5.10 and based on the conclusions in clause 5.10.6:

a. Fully specify support for the Joint BM-SC and MBSF Functionality. For this purpose, the gap identified in clause 5.10.4.1 of the present document needs to be addressed by documenting additional procedures and baseline parameters as required in TS 26.502 [29] and permitting the signalling of MBMS sessions.

b. Document in an informative annex to TS 26.502 [29] the deployment architectures, client architectures and high-level call flows in clauses 5.10.2.3 and 5.10.2.4.

3. For *Key Issue #10: Selected MBMS Functionalities not supported in MBS* as introduced in clause 5.11 and based on the conclusions in clause 5.11.4:

a. Add the necessary functional extensions and call flows to support the generic Application Service as defined in clause 7.6 of TS 26.346 [16] based on the discussion in clause 5.11.3.2,

b. Add the necessary functional extensions and call flows to support partial file handling as defined in clause 7.9 of TS 26.346 [16] based on the discussion in clause 5.11.3.3,

c. Add the necessary functional extensions and call flows to support reporting of metrics based on the discussion in clause 5.11.3.4,

d. Add the necessary functional extensions and call flows to support time Synchronization as defined in TS 26.346 [16] in clause 4.6 based on the discussion in clause 5.11.3.6.

### 8.4.3 Recommendations for stage 3 normative work arising from version 19

It is recommended to provide relevant extensions to MBS User service protocols and formats specified in TS 26.517 [30] based on the conclusions in clause 5 and the stage-2 extensions above, if applicable. Candidates for these extensions are:

1. For *Key Issue #8: In-session unicast repair for MBS Object Distribution* as introduced in clause 5.9 and based on the conclusions in clause 5.9.7:

- Address Gaps #2, #3, #4, and #5 in clause 5.9.5 by the candidate solution in clause 5.9.6:

i. On gap #2 identified in clause 5.9.5, both of the following signalling options are expected to be supported:

- Using FDT parameters to signal the time when repairs can be requested using the Expires attribute).

- Using LCT header information to signal the time when repairs can be requested using the B-Flag.

ii. On Gap #3 identified in clause 5.9.5, the following signalling options exist in the FLUTE File Delivery Table (FDT):

- Defining a new FDT extensions parameter to signal the availability time when the object needs to be released.

iii. On gap #4 identified in clause 5.9.5, the execution of MBS object delivery and in-session unicast repair can run in parallel in the MBS Client. However, this should be validated if there are cases this is not the case and whether these cases need to be explicitly stated, for example reduced capability (RedCaP) UEs.

iv. On gap #5 identified in clause 5.9.5, time synchronization can reuse functionalities defined in TS 26.346 [16], but tighter synchronization that 1 second. This work is aligned with the findings and work in clause 5.11.3.6.

2. for *Key Issue #9: MBS User Service and Delivery Protocols for eMBMS* as introduced in clause 5.10 and based on the conclusions in clause 5.10.6:

- Address the relevant stage-3 aspects based on stage-2 work.

3. For *Key Issue #10: Selected MBMS Functionalities not supported in MBS* as introduced in clause 5.11 and based on the conclusions in clause 5.11.4:

a. Address the relevant stage-3 aspects based on stage-2 work.

b. Adapt the generic Application Service as defined in clause 7.6 of TS 26.346 [16] to MBS User Services,

c. Adapt partial file handling as defined in clause 7.9 of TS 26.346 [16] to MBS User Services

d. Adapt time synchronization as defined in clause 4.6 of TS 26.346 [16] to MBS User Services.

### 8.4.4 Recommendations for further study arising from version 19

It is recommended to continue the study of additional extensions to MBS User Services. Candidate topics based on the present document are:

1. For *Key Issue #9: MBS User Service and Delivery Protocols for eMBMS* as introduced in clause 5.10 and based on the conclusions in clause 5.10.6:

a. Validate the approaches by implementation, for example in 5G-MAG Reference Tools, and identify if the functionality is fully supported or any further specification updates are needed.

b. Going forward, ensure that enhancements to the MBSTF and delivery methods in MBS can also be leveraged and deployed for eMBMS.

2. For *Key Issue #10: Selected MBMS Functionalities not supported in MBS* as introduced in clause 5.11 based on the conclusions in clause 5.11.4:

- Further study MBMS features that are not yet supported in based on the analysis in clause 5.11.2.

### 8.4.4 Recommendations for coordination arising from version 19

It is recommended to coordinate work with other working groups and organizations as follows:

1. For *Key Issue #9: MBS User Service and Delivery Protocols for eMBMS* as introduced in clause 5.10 and based on the conclusions in clause 5.10.6:

a. Validate the approaches by implementation, for example in 5G-MAG Reference Tools.

b. Validate with other working groups whether the TMGI allocation in the MBS User Service Announcement is achievable via MB-SMF.

2. For *Key Issue #10: Selected MBMS Functionalities not supported in MBS* as introduced in clause 5.11 and based on the conclusions in clause 5.11.4:

- Validate the approaches by implementation, for example in 5G-MAG Reference Tools.

## ===== END OF CHANGES =====