|  |  |
| --- | --- |
| 3GPP TR 23.700-47 V18.0.0 (2022-12) | |
| Technical Report | |
| 3rd Generation Partnership Project;  Technical Specification Group Services and System Aspects;  Study on architectural enhancements for  5G multicast-broadcast services;  Phase 2  (Release 18) | |
|  | |
|  |  |
|  | |
| The present document has been developed within the 3rd Generation Partnership Project (3GPP TM) and may be further elaborated for the purposes of 3GPP. The present document has not been subject to any approval process by the 3GPPOrganizational Partners and shall not be implemented. This Specification is provided for future development work within 3GPPonly. The Organizational Partners accept no liability for any use of this Specification. Specifications and Reports for implementation of the 3GPP TM system should be obtained via the 3GPP Organizational Partners' Publications Offices. | |

|  |
| --- |
|  |
| ***3GPP***  Postal address  3GPP support office address  650 Route des Lucioles - Sophia Antipolis  Valbonne - FRANCE  Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16  Internet  http://www.3gpp.org |
| ***Copyright Notification***  No part may be reproduced except as authorized by written permission. The copyright and the foregoing restriction extend to reproduction in all media.  © 2022, 3GPP Organizational Partners (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC).  All rights reserved.  UMTS™ is a Trade Mark of ETSI registered for the benefit of its members  3GPP™ is a Trade Mark of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners LTE™ is a Trade Mark of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners  GSM® and the GSM logo are registered and owned by the GSM Association |

Contents

Foreword 8

1 Scope 10

2 References 10

3 Definitions of terms and abbreviations 11

3.1 Terms 11

3.2 Abbreviations 11

4 Architectural Assumptions and Principles 12

4.1 Common architectural requirements and principles 12

4.2 Specific architectural requirements and principles for public safety service in a cell with large number of UEs 12

5 Key Issues 13

5.1 Key Issue #1: Multicast MBS data reception in RRC Inactive state 13

5.1.1 Description 13

5.2 Key Issue #2: 5MBS MOCN Network Sharing 13

5.2.1 Description 13

5.3 Key Issue #3: On demand multicast MBS session 13

5.3.1 Description 13

5.4 Key Issue #4: Group message delivery 14

5.4.1 Description 14

5.5 Key Issue #5: Coexistence with existing power saving mechanisms for capability-limited devices 14

5.5.1 Description 14

5.6 Key Issue #6: Improvement for potential performance issues related to high numbers of public safety UEs 15

5.6.1 Description 15

6 Solutions 15

6.0 Mapping of Solutions to Key Issues 15

6.1 Solution #1: Procedures for RRC Inactive MBS data reception 16

6.1.1 Introduction 16

6.1.2 Functional description 16

6.1.3 Procedures 18

6.1.3.1 General 18

6.1.3.2 MBS session creation, multicast session join and session establishment procedure 19

6.1.3.3 Moving a UE to RRC Inactive state 20

6.1.3.4 Moving a UE to RRC-CONNECTED from RRC Inactive state 21

6.1.4 Impacts on services, entities and interfaces. 21

6.2 Solution #2: Procedures for MOCN network sharing 22

6.2.1 Introduction 22

6.2.2 Functional description 22

6.2.2.1 General 22

6.2.2.2 Identifier of the broadcast MBS service 23

6.2.2.3 Reception of the broadcast data by the UE 23

6.2.3 Procedures 24

6.2.3.1 General 24

6.2.3.2 Broadcast Session Establishment 24

6.2.3.3 Broadcast Session Release 25

6.2.4 Impacts on services, entities and interfaces 25

6.3 Solution #3: AF providing assistance information 26

6.3.1 Introduction 26

6.3.2 Functional description 26

6.3.3 Procedures 26

6.3.4 Impacts on services, entities and interfaces. 27

6.4 Solution #4: MBS session management for RRC Inactive MBS data receiving UE 27

6.4.1 Introduction 27

6.4.2 Functional description 27

6.4.3 Procedures 28

6.4.4 Impacts on services, entities, and interfaces 29

6.5 Solution #5: Mobility Procedures for UE supporting RRC Inactive MBS data reception 29

6.5.1 Introduction 29

6.5.2 Functional description 29

6.5.3 Procedures 30

6.5.3.1 RRC-inactive multicast group member moves within RNA 30

6.5.3.2 RRC-inactive multicast group member UE move out of RNA and within RA 30

6.5.3.3 RRC-connected multicast group member UE move to RRC-inactive MBS reception supporting NG-RAN 31

6.5.4 Impacts on services, entities, and interfaces 31

6.6 Solution #6: Reusing the existing assistance info and Qos for RRC Inactive MBS data reception decision 32

6.6.1 Introduction 32

6.6.2 Functional description 32

6.6.3 Procedures 33

6.6.4 Impacts on services, entities and interfaces. 33

6.7 Solution #7: MOCN RAN Sharing 33

6.7.1 Introduction 33

6.7.2 Functional description 33

6.7.3 Procedures 33

6.7.3.1 General 33

6.7.3.2 MBS Session Creation 34

6.7.3.3 MBS Session Start for Broadcast 35

6.7.3.4 MBS Session Release for Broadcast 36

6.7.3.5 Broadcast MBS Session Transport Request 36

6.7.4 Impacts on services, entities and interfaces 37

6.8 Solution #8: Allocating and using MOCN TMGI 38

6.8.1 Introduction 38

6.8.2 Functional description 38

6.8.3 Procedures 39

6.8.3.1 Procedure for Broadcast using MOCN TMGI 39

6.8.4 Impacts on services, entities and interfaces 41

6.9 Solution #9: Broadcast services considering MOCN RAN 41

6.9.1 Introduction 41

6.9.2 Functional description 41

6.9.3 Procedures 41

6.9.3.1 General 41

6.9.3.2 Broadcast Session Start procedure 42

6.9.3.3 Broadcast Session update and release procedure 43

6.9.4 Impacts on services, entities and interfaces 44

6.10 Solution #10: AF triggered MBS session management 44

6.10.1 Introduction 44

6.10.2 Functional description 44

6.10.3 Procedures 45

6.10.3.1 General 45

6.10.3.2 AF triggered MBS Session management procedures with PCC 46

6.10.3.3 AF triggered MBS Session management procedures without PCC 48

6.10.4 Impacts on services, entities and interfaces. 49

6.11 Solution #11: Solution on enabling the on-demand multicast MBS session management 50

6.11.1 Introduction 50

6.11.2 Functional description 50

6.11.2.1 Use cases 50

6.11.3 Procedures 51

6.11.3.1 on-demand multicast MBS session management 51

6.11.4 Impacts on services, entities and interfaces. 52

6.12 Solution #12: Group Message Delivery 52

6.12.1 Introduction 52

6.12.2 Functional description 52

6.12.3 Procedures 52

6.12.3.1 General 52

6.12.3.2 Group Message Delivery via MBS Broadcast 53

6.12.3.3 Modification of previously submitted Group message 55

6.12.4 Impacts on services, entities and interfaces 56

6.13 Solution #13: Group message delivery for broadcast 57

6.13.1 Introduction 57

6.13.2 Functional description 57

6.13.3 Procedures 57

6.13.3.1 General 57

6.13.3.2 Broadcast Session Establishment 58

6.13.3.3 Modification of previously submitted group message 59

6.13.4 Impacts on services, entities and interfaces 60

6.14 Solution #14: MBS coexistence with power saving mechanisms of 5GS 60

6.14.1 Introduction 60

6.14.2 Functional description 60

6.14.3 Procedures 61

6.14.4 Impacts on services, entities and interfaces. 62

6.15 Solution #15: Solution for coexistence of MBS delivery and power saving mechanisms 62

6.15.1 Functional description 62

6.15.2 Procedures 63

6.15.3 Impacts Analysis 63

6.16 Solution #16: Public Safety services offered over both Broadcast and Multicast transport 63

6.16.1 Description 63

6.16.1.1 General 63

6.16.1.2 Functional description 64

6.16.2 Procedures 65

6.16.2.1 GCS AS configuration of both Broadcast and Multicast Services 65

6.16.2.2 UE switching from Broadcast Reception to Multicast Reception 66

6.16.2.3 UE switching from Multicast Reception to Broadcast Reception (UE based) 66

6.16.2.3b UE switching from Multicast Reception to Broadcast Reception (NG-RAN based) 66

6.16.3 Impacts on services, entities and interfaces. 67

6.17 Solution #17: Performance Improvements for Public Safety 68

6.17.1 Introduction 68

6.17.2 Functional description 68

6.17.3 Procedures 69

6.17.3.1 General 69

6.17.3.2 UE join multicast MBS session 70

6.17.3.3 UE leave multicast MBS session 71

6.17.3.4 Multicast session leave requested by the network or MBS session release 72

6.17.3.5 MBS Session Activation 73

6.17.3.6 N2 based Handover and IDLE Mobility 74

6.17.4 Impacts on services, entities and interfaces. 74

6.18 Solution #18: MBS session management for RRC Inactive MBS data receiving UE 75

6.18.1 Introduction 75

6.18.2 Functional description 75

6.18.3 Procedures 76

6.18.4 Impacts on services, entities, and interfaces 77

6.19 Solution #19: Procedures for Transmission mode tor inactive data reception 77

6.19.1 Introduction 77

6.19.2 Functional description 77

6.19.3 Procedures 78

6.19.3.1 Moving a UE to RRC Inactive state and providing assistance information to additional RAN nodes (Option A) 78

6.19.3.2 MBS service activation 79

6.19.3.3 Triggering MBS service announcement by MB-SMF (Option B) 80

6.19.3.4 MBS session release (Option A and B) 81

6.19.4 Impacts on services, entities and interfaces. 81

6.20 Solution #20: Registration procedure enhancements for multicast reception 82

6.20.1 Introduction 82

6.20.2 Functional description 82

6.20.3 Procedures 82

6.20.3.1 Registration procedures 82

6.20.4 Impacts on services, entities and interfaces 83

6.21 Solution #21: Mobility Procedures for UE supporting RRC Inactive MBS data reception with the MBS session container 84

6.21.1 Introduction 84

6.21.2 Functional description 84

6.21.3 Procedures 84

6.21.3.1 RRC-inactive multicast group member UE move out of RNA and within RA 84

6.21.4 Impacts on services, entities, and interfaces 84

6.22 Solution #22: Session management for RRC Inactive MBS data receiving UE 85

6.22.1 Introduction 85

6.22.2 Functional description 85

6.22.3 Procedures 85

6.22.3.1 Modification to the MBS session de-activation procedure 85

6.22.3.2 Modification to the MBS session (re-)activation procedure 86

6.22.4 Impacts on services, entities, and interfaces 86

6.23 Solution #23: MBS session activation for RRC Inactive MBS data receiving UE 86

6.23.1 Introduction 86

6.23.2 Functional description 87

6.23.3 Procedures 88

6.23.4 Impacts on services, entities, and interfaces 89

6.24 Solution #24: Solution based on configuration in RAN to support MOCN RAN Sharing 89

6.24.1 Introduction 89

6.24.2 Functional description 89

6.24.3 Procedures 89

6.24.3.1 General 89

6.24.3.2 MBS Session Creation 89

6.24.3.3 MBS Session Start for Broadcast 90

6.24.3.4 MBS Session Release for Broadcast 91

6.24.4 Impacts on services, entities and interfaces. 91

6.25 Solution #25: Triggering capability limited devices to receive MBS data 92

6.25.1 Introduction 92

6.25.2 Description 92

6.25.3 Procedures 93

6.25.3.1 Periodic or one time transmission of MBS data to capability-limited devices 93

6.25.3.2 Deferred activation for aperiodic transmission of MBS data to capability-limited devices 94

6.25.4 Impacts on services, entities and interfaces. 94

6.26 Solution #26: AF selects UEs to be kept in connected mode 95

6.26.1 Introduction 95

6.26.2 Description 95

6.26.3 Procedures 96

6.26.4 Impacts on services, entities and interfaces. 96

6.27 Solution #27: AF providing list of prioritized UEs when creating multicast MBS Session 97

6.27.1 Introduction 97

6.27.2 Functional description 97

6.27.3 Procedures 98

6.27.4 Impacts on services, entities and interfaces. 99

6.28 Solution #28: Session management and Mobility for RRC Inactive MBS data reception 100

6.28.1 Introduction 100

6.28.2 Functional description 100

6.28.3 Procedures 101

6.28.3.1 Moving the UE to RRC Inactive mode 101

6.28.3.2 Mobility within/out of RNA area. 101

6.28.4 Impacts on services, entities, and interfaces 103

6.29 Solution #29: MOCN network sharing with a single TMGI 103

6.29.1 Introduction 103

6.29.2 Description 104

6.29.3 Procedures 104

6.29.4 Impacts on services, entities and interfaces 106

6.30 Solution #30: On demand multicast MBS session set up by MB-SMF 107

6.30.1 Introduction 107

6.30.2 Description 108

6.30.3 Procedures 110

6.30.4 Impacts on services, entities and interfaces. 112

6.31 Solution #31: Multicast access control for high number of public safety UEs 113

6.31.1 Introduction 113

6.31.2 Functional description 113

6.31.3 Procedures 113

6.31.4 Impacts on services, entities, and interfaces 114

7 Evaluation 114

7.1 Key Issue #1: MBS session reception in RRC Inactive 114

7.1.1 Overview over available solutions 114

7.1.2 Assistance Information 117

7.1.3 Activation of MBS multicast session 119

7.1.4 Mobility for RRC\_Inactive UEs receiving MBS data 120

7.2 Key Issue #2: 5MBS MOCN RAN Sharing 121

7.3 Key Issue #3: On demand multicast MBS session 125

7.4 Key Issue #4: Group message delivery 126

7.5 Key Issue #5: Coexistence with existing power saving mechanisms for capability-limited devices 126

7.6 Key Issue #6: Improvement for potential performance issues related to high numbers of public safety UEs 128

8 Conclusions 130

8.1 Key Issue #1: MBS session reception in RRC Inactive 130

8.1.1 Conclusions 130

8.2 Key Issue #2: MOCN network sharing 131

8.3 Key Issue #3: On demand multicast MBS session 132

8.4 Key Issue #4: Group message delivery 132

8.5 Key Issue #5: Coexistence with existing power saving mechanisms for capability-limited devices 132

8.6 Key Issue #6: Improvement for potential performance issues related to high numbers of public safety UEs 132

Annex A: Public Safety use cases of large number of UEs in a single cell 134

Annex B: Change history 135

# Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

In the present document, modal verbs have the following meanings:

**shall** indicates a mandatory requirement to do something

**shall not** indicates an interdiction (prohibition) to do something

The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

**should** indicates a recommendation to do something

**should not** indicates a recommendation not to do something

**may** indicates permission to do something

**need not** indicates permission not to do something

The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

**can** indicates that something is possible

**cannot** indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

**will** indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**will not** indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**might** indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

**might not** indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

**is** (or any other verb in the indicative mood) indicates a statement of fact

**is not** (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

# 1 Scope

This Technical Report studies and evaluates further enhancements to the 5G Multicast/Broadcast Architecture in order to provide the following features.

- Enabling UE's receiving Multicast MBS Session data in RRC Inactive state.

- Study feasible and efficient resource utilization for the same broadcast content to be provided to 5G MOCN network sharing scenarios (i.e. multiple CNs are connected to the same NG-RAN).

- Study whether and how to support on demand multicast MBS session triggered by AF, and efficient resource utilization via 5GC choosing multicast and/or unicast delivery for a certain service.

- Study whether and how to support group message delivery for capability-limited devices, including NEF enhancement, coexistence of existing power saving mechanisms and MBS.

- Study whether there are any identified performance issues for high number of public safety UEs, and if yes study necessary enhancements to 5MBS for that scenario.

# 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 TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 23.501: "System Architecture for the 5G System; Stage 2".

[3] 3GPP TS 23.502: "Procedures for the 5G system; Stage 2".

[4] 3GPP TS 23.247: "Architectural enhancements for 5G multicast-broadcast services; Stage 2".

[5] 3GPP TR 26.850: "MBMS for Internet of Things (IoT)".

[6] 3GPP TS 23.682: "Architecture enhancements to facilitate communications with packet data networks and applications".

[7] 3GPP TS 23.280: "Common functional architecture to support mission critical services; Stage 2".

[8] 3GPP TS 24.379: "Mission Critical Push To Talk (MCPTT) call control; Protocol specification".

[9] 3GPP TS 22.179: "Mission Critical Push To Talk (MCPTT); Stage 1".

[10] 3GPP TS 23.288: "Architecture enhancements for 5G System (5GS) to support network data analytics services".

[11] 3GPP TS 26.502: "5G Multicast-Broadcast User Service Architecture".

[12] 3GPP TS 23.468: "Group Communication System Enablers for LTE (GCSE\_LTE); Stage 2".

[13] 3GPP TS 38.300: "NR; Overall description; Stage-2".

[14] 3GPP TS 33.501: "Security architecture and procedures for 5G system".

[15] 3GPP TS 36.300: "Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access (E-UTRAN); Overall description; Stage 2".

[16] 3GPP TS 36.321: "Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification".

[17] 3GPP TS 29.532: "5G System; 5G Multicast-Broadcast Session Management Services; Stage 3".

[18] 3GPP TS 29.522: "5G System; Network Exposure Function Northbound APIs; Stage 3".

# 3 Definitions of terms and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1] and TS 23.247 [4].

## 3.2 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] 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 [1] and TS 23.247 [4].

# 4 Architectural Assumptions and Principles

## 4.1 Common architectural requirements and principles

Editor's note: This clause will document any architectural assumptions and principles for the study.

- Solutions shall build on the 5G System architectural principles as in TS 23.501 [2], including flexibility and modularity for newly introduced functionalities.

- The system shall provide an efficient transport for a variety of multicast and broadcast services.

- Only NR of NG-RAN connected to 5GC is considered as RAT.

- Architecture reference models defined in clause 5.1 of TS 23.247 [4] are used as the baseline architecture for this study. Enhanced Architecture and Solutions in this study shall enable UEs with Rel-17 MBS capability to receive MBS data from Rel-18 architecture/solutions.

Editor's note: The impact on RAN is to be analysed by and coordinated with the relevant RAN WGs.

Editor's note: This study may also include the potential enhancements identified by other WGs or other SIDs (e.g. FS\_ 5GSAT\_ARCH\_Ph2) in their MBS work that need SA WG2 cooperation.

## 4.2 Specific architectural requirements and principles for public safety service in a cell with large number of UEs

Public Safety specific architectural requirements and principles:

- Solutions shall enable simultaneous reception of MBS session data for a higher number of UEs in a cell than can be operating in RRC\_CONNECTED state, to participate in public safety group calls using MBS-based service.

- Solutions shall ensure that the pre-emption and admission control mechanisms result in public safety UEs being able to complete the setup of the MBS services and then operate according to regulation and operator policy, when a mix of UEs participating in one or more services and/or one or more sessions within each service is present in the cell.

NOTE 1: This issue, which involves other Working Groups, deals with aspects like recognizing which UEs may be moved to RRC\_INACTIVE (service continues via MBS) vs. moved to RRC\_IDLE (service may fail), not impacting the UE while the UE is setting up connections or waiting for the floor (permission to talk), ability to override user settings in order to be able to pre-empt, if necessary, etc.

- Solutions shall enable provision of assistance information to NG-RAN from the application function (AF) via 5GC, if required/needed.

Editor's note: Solutions may require information to NG-RAN and application function (AF) to enable proper provisioning. This includes, e.g. the SA6 and RAN WGs deciding on, what information to be provided on, which members of a public safety group should stay in RRC\_CONNECTED and which one(s) are candidates for being transitioned to RRC\_INACTIVE.

- If MBS sessions are temporarily deactivated and are subject to subsequent (re)activation, resulting in UEs in e.g. RRC\_INACTIVE state which need to be (re)-awakened to receive MBS service, solutions may enable simultaneously wake up (for MBS reception) for all the UEs associated with the session.

NOTE 2: For active MBS Session, it is assumed that public safety applications (under the remit of SA6) will initiate minimum number and frequency of requests to transition to RRC\_CONNECTED state to perform uplink transmissions, while Public Safety UEs are in RRC\_INACTIVE state.

- Whether there is a need for additional solutions to minimize packet loss during MBS reception, this should be addressed together with RAN WGs.

# 5 Key Issues

## 5.1 Key Issue #1: Multicast MBS data reception in RRC Inactive state

### 5.1.1 Description

In order to provide MBS service to more UEs in a cell, NG RAN could enable UEs within an MBS multicast session to receive MBS session data while in CM-CONNECTED with RRC Inactive state.

The following aspect will be studied for multicast:

- Whether, how and what MBS assistance information to provide from 5GC to RAN for an MBS session allowing UEs in CM-CONNECTED with RRC Inactive state to receive MBS content, including the aspect which 5GC NF(s) determine the MBS assistance information and how they do so;

- Whether and how to enhance the current procedures (including mobility related procedures) for MBS session with member UEs in RRC Inactive state.

NOTE 1: During the study of this key issue, coordination with RAN WGs is needed before final conclusion.

NOTE 2: RAN WG will determine how the switching for the UEs belonging to MBS session from CM-CONNECTED state to CM-CONNECTED with RRC Inactive state (and vice versa) is performed by the RAN node.

## 5.2 Key Issue #2: 5MBS MOCN Network Sharing

### 5.2.1 Description

According to clause 5.18 of TS 23.501 [2], in a 5G Multi-Operator Core Network (5G MOCN), multiple CNs are connected to the same NG-RAN.

When the same broadcast content is to be delivered to multiple CNs, the AF will set up multiple broadcast MBS sessions towards those CNs, each CN delivering the same content towards the same shared NG-RAN node. Therefore, for a broadcast MBS Session, the consumed radio resource will be (N-1) times more than needed, where N is the number of CNs involved.

To investigate the feasibility of avoiding allocating more radio resource than needed, the following aspects need to be considered:

- Whether and how to assist NG-RAN node to determine the same content is delivered by broadcast MBS Sessions from different 5G CNs?

- Whether and how to assist NG-RAN node to determine which PLMN is used to broadcast the MBS session data?

- Which entity (e.g. AF or other NFs) could provide the assistance parameters to the shared NG-RAN if needed?

- Whether and how to enable the UE to receive the broadcast content from the broadcast PLMN when the UE camps on cells of other PLMNs?

NOTE 1: The feasibility of radio resource utilization optimization will be determined by RAN WGs.

NOTE 2: Collaboration with SA3 is required regarding the security issue.

## 5.3 Key Issue #3: On demand multicast MBS session

### 5.3.1 Description

For services shared by a group of users, e.g. background audio/video streams, status/warning update during the game, shared streaming of collaborative interactive application, enabling temporary multicast group for the service would be beneficial for operators to be more flexible to provide services with resource efficiency, i.e. dynamically creating multicast session when required by the service, and releasing them when not required.

Based on the triggers provided by the AF, e.g. information or request provided by the AF which allows multicast transport for a specific service, and other factors, on demand multicast MBS session may be created by the 5GS for the service. A similiar example in eMBMS is MBMS operation on Demand (MooD) defined by SA4.

The following aspects are to be studied:

- Use cases for on demand MBS multicast sessions and related requirements and potential gaps in Rel-17 MBS multicast procedures.

- Whether and how to enhance the Release-17 MBS procedures to enable the on-demand multicast MBS session management. If needed, what information can be exposed by the 5GC to the AF or be provided by the AF, to enable on demand multicast MBS session management by AF.

NOTE: Coordination with SA4 is needed for study of this KI.

## 5.4 Key Issue #4: Group message delivery

### 5.4.1 Description

In previous Releases, group-based enhancements were introduced to enable an optimised handling of groups of UEs/subscriptions. In clause 5.5 of TS 23.682 [6], the group message delivery is specified via MB2 and xMB interfaces over eMBMS. This key issue will study whether and how to support Group Message Delivery over MBS for feature parity.

For this key issue, the following aspects will be studied:

- Whether and how to enhance the MBS functionality to provide a similar group message delivery as available in eMBMS.

- Whether group message delivery applies to MBS broadcast, MBS multicast, or both.

- Whether and how to provide a unified group message delivery applicable to both 5GS using MBS and EPS using eMBMS.

NOTE 1: Collaboration with SA4 is needed.

NOTE 2: Control plane cell broadcast is not included.

## 5.5 Key Issue #5: Coexistence with existing power saving mechanisms for capability-limited devices

### 5.5.1 Description

Capability-limited devices may use power-saving mechanisms to extend their battery live. Existing power saving mechanisms include MICO (Mobile Initiated Connection Only) mode, DRX (Discontinuous Reception), eDRX (Extended Discontinuous Reception).

MBS content should be transmitted to all devices at the same time to save transmission resources. However, the existing power saving mechanisms may prevent devices from receiving MBS content (for instance group messages).

This KI will study the following issue:

- Whether and how to support MBS content (for instance group message) delivery for capability-limited devices by considering coexistence of existing power saving mechanisms and MBS.

NOTE: In SA WG4, co-existence between power saving mechanism and eMBMS has been studied in TR 26.850 [5]. The study result in TR 26.850 [5] could be taken into consideration during the solution study of this KI.

## 5.6 Key Issue #6: Improvement for potential performance issues related to high numbers of public safety UEs

### 5.6.1 Description

Public safety requirements are documented in TS 22.179 [9] and related procedures are documented in TS 23.280 [7] and TS 24.379 [8].

Specific 5MBS requirements for public safety are documented in clause 4.2.

Based on the 5MBS requirements for public safety documented in clause 4.2, this Key issue will study whether there are any performance issues for high number of public safety UEs, and for identified performance issues related enhancements to 5MBS.

NOTE: Coordination with RAN WGs and SA6 WG will be required.

# 6 Solutions

## 6.0 Mapping of Solutions to Key Issues

Editor's note: This clause describes the mapping between solutions and key issues.

Table 6.0-1: Mapping of Solutions to Key Issues

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Key Issues | | | | | |
| Solutions | 1  MBS session reception in RRC Inactive | 2  MOCN network sharing | 3  On demand multicast MBS session | 4  Group Message Delivery | 5  Coexistence with existing power saving mechanisms for capability-limited devices | 6  Improvement on performance issues for public safety UEs |
| 1 | X |  |  |  |  |  |
| 2 |  | X |  |  |  |  |
| 3 | X |  |  |  |  | X |
| 4 | X |  |  |  |  |  |
| 5 | X |  |  |  |  |  |
| 6 | X |  |  |  |  |  |
| 7 |  | X |  |  |  |  |
| 8 |  | X |  |  |  |  |
| 9 |  | X |  |  |  |  |
| 10 |  |  | X |  |  |  |
| 11 |  |  | X |  |  |  |
| 12 |  |  |  | X |  |  |
| 13 |  |  |  | X |  |  |
| 14 |  |  |  |  | X |  |
| 15 |  |  |  |  | X |  |
| 16 |  |  |  |  |  | X |
| 17 |  |  |  |  |  | X |
| 18 | X |  |  |  |  |  |
| 19 | X |  |  |  |  |  |
| 20 | X |  |  |  |  | X |
| 21 | X |  |  |  |  |  |
| 22 | X |  |  |  |  |  |
| 23 | X |  |  |  |  |  |
| 24 |  | X |  |  |  |  |
| 25 |  |  |  |  | X |  |
| 26 | X |  |  |  |  | X |
| 27 | X |  |  |  |  |  |
| 28 | X |  |  |  |  |  |
| 29 |  | X |  |  |  |  |
| 30 |  |  | X |  |  |  |
| 31 |  |  |  |  |  | X |

## 6.1 Solution #1: Procedures for RRC Inactive MBS data reception

### 6.1.1 Introduction

This solution addresses Key Issue #1.

### 6.1.2 Functional description

It is assumed to reuse the current architecture defined in Rel-17 MBS work (see TS 23.247 [4]). In other words, MB-SMF is used to handle MBS session-level management while SMF performs per-UE MBS session management, e.g. authorization, multicast session information provisioning, managing 5GC Individual MBS traffic delivery.

An AF creating a multicast session should be able to influence the service quality (more UEs vs. higher reliability) talking into consideration the specific needs of the service it offers. Thus the AF can provide assistance information to help the PLMN to enable or disable the transmission to UEs in RRC-INACTIVE state. The AF may also, based on local configuration or triggered by e.g. event report from the NEF (e.g. "Number of UEs present in a geographical area" as specified in clause 4.15.3.1 of TS 23.502 [3]), subscribe to or requests network analytics information (e.g. Observed Service Experience analytics, NF load analytics, Network Performance analytics, User Data Congestion analytics) from the NWDAF as specified in TS 23.288 [10], and decide to enable or disable the transmission to UEs in RRC-INACTIVE state based on the analytics information. For example, if the User Data Congestion analytics information indicates that the congestion level of the network is (predicted to be) high, then the AF can enable the transmission to UEs in RRC-INACTIVE state (i.e. instructing the NG-RAN to switch the UE in RRC-CONNECTED state to RRC-INACTIVE state); and later on when the analytics information indicates that the congestion is relieved, the AF can disable the transmission to UEs in RRC-INACTIVE state (i.e. instructing the NG-RAN to switch the UE in RRC-INACTIVE state back to RRC-CONNECTED state). The AF provides the indication of enabling or disabling the transmission to UEs in RRC-INACTIVE state (i.e. an indication whether NG-RAN nodes may deliver the MBS session to UEs in the inactive state) as part of the assistance information to the NG-RAN. However, the decision whether to apply transmission to UEs in RRC-INACTIVE state remains in the RAN nodes if transmission to UE in RRC-INACTIVE state is enabled.

NOTE: If the AF provides assistance information to disable reception in RRC-INACTIVE state, the number UEs in a cell that can receive the MBS session will be more limited but the transmission will be more reliable.

Editor's note: Whether such behaviour is intended is FFS.

Procedures in the following clauses focus on the following functionalities:

- 5GC provisioning necessary parameters to NG-RAN node(s).

- Switching between RRC Connected and RRC Inactive modes.

There are two levels of priority as a part of 5GC-provided parameters, namely:

- MBS session priority: the MBS session priority denotes the priority level of an MBS session, and the priority level defines the relative importance of an MBS session. This allows the NG-RAN nodes deciding (the members of) which MBS session can be switched to RRC Inactive state, to free up resources of NG-RAN node upon e.g. congestion. NG-RAN node may also use it to decide (the members of) which MBS session can be switched to RRC Connected state, once the resources are regarded as sufficient.

The details of how the 5GC provides MBS session priority to NG-RAN node are further described in clause 6.1.3.2.

Editor's note: Whether the existing QoS parameters (e.g. ARP, 5QI) of the MBS QoS Flow(s) can be used for the MBS Session priority is FFS.

- UE session priority: the UE session priority denotes the priority level of a certain UE within a certain MBS session, and the priority level defines the relative importance of a UE for an MBS session. This allows the NG-RAN nodes deciding if the UE of an MBS session can be switched to RRC Inactive state, to free up resources of NG-RAN node upon e.g. congestion. NG-RAN node may also use it to decide if the UE of an MBS session can be switched to RRC Connected state, once the resources are regarded as sufficient.

The details of how the 5GC provides UE session priority to NG-RAN node are further described in clause 6.1.3.2.

Editor's note Whether and how the NG-RAN use the assistant information will be determined by RAN WGs.

Whether the transmission mode for inactive reception is applied depends on multiple factors and determined by the NG-RAN node:

- Backward compatibility with UEs supporting Rel-17 MBS but not capable of receiving 5MBS data while in RRC-inactive state. If such UEs that joined a MBS multicast session are in a cell, MBS data need to be transmitted using the Rel-17 transmission mode for RRC-connected reception.

- UE preferences: UEs could prefer to receive MBS data in RRC inactive state to reduce their battery consumption, or in RRC connected state to increase the service quality.

NOTE: If the UE indicates reception in RRC-INACTIVE state is not preferred and if NG-RAN follows the UE preference, the number UEs in a cell that can receive the MBS session will be more limited but the transmission will be more reliable.

Editor's note: Whether such behaviour is intended is FFS.

- MBS session priority.

Editor's note: How MBS Session priority could assist the NG-RAN in determining whether to apply transmission for inactive reception is FFS.

- UE session priority.

Editor's note: Detailed usage of combining UE priority and MBS session priority requires more study.

- Whether the transmission for inactive reception is allowed for specific multicast MBS service(s).

- Ongoing session of the UEs (e.g. UE has other PDU session activated).

Editor's note: Those assumptions need to be confirmed by RAN WGs.

AF provides the following information, and MB-SMF stores this information as a part of Multicast MBS Session context, during MBS Session Creation procedures defined in clauses 7.1.1.2 or 7.1.1.3 of TS 23.247 [4] and clause 6.1.3.2:

- MBS session priority.

- Whether the transmission for inactive reception is allowed for specific multicast MBS service(s).

AF provides the following information, and UDM stores this information as a part of MBS subscription data, during External Parameter Provisioning procedures as defined in clause 6.4.2 of TS 23.247 [4]:

- UE session priority.

### 6.1.3 Procedures

#### 6.1.3.1 General

NOTE: The message names in the procedures below are descriptive. It is assumed that the names are updated with corresponding SBI based names where applicable during the normative phase.

#### 6.1.3.2 MBS session creation, multicast session join and session establishment procedure



Figure 6.1.3.2-1: Enhancement to current MBS procedures for session creation and join

0. When UE registers, it indicates its capability to receive MBS multicast using the transmission mode for RRC inactive. It may also indicate a preference regarding the connectivity state in which it wishes to receive MBS session(s). If UE's preference changes (e.g. due to UE state change such as power level etc.), then the UE performs registration update. This information is propagated to NG-RAN via AMF.

1-2. When an AF requests the creation of a multicast MBS session, it indicates whether inactive reception of multicast shall be enabled for that session. AF also provides the MBS session priority to MB-SMF, optionally via NEF or MBSF.

Editor's note: Whether the existing QoS parameters (e.g. ARP, 5QI) of the MBS QoS Flow(s) can be used for the MBS Session priority is FFS.

3. The AF may also indicate in the service announcement towards the UE whether inactive/idle reception of multicast is enabled.

4.-14 The information whether the inactive transmission mode is enabled for an MBS session is propagated from MB-SMF towards NG-RAN, via PDU session and/or via shared delivery of a multicast session.

SMF provides the UE session priority to NG-RAN node: In step 7, SMF includes UE session priority as a part of N2 SM information in Nsmf\_PDUSession\_UpdateSMContext response to AMF. In step 8, AMF sends the N2 SM information received from SMF to NG-RAN node during the shared tunnel establishment procedure. AF provides the UE session priority, and UDM stores this information as a part of MBS subscription data, during External Parameter Provisioning procedures as defined in clause 6.4.2 of TS 23.247 [4]. During PDU session establishment procedure, SMF fetches UE session priority from UDM.

MB-SMF provides the MBS session priority to NG-RAN node: In step 13, since MB-SMF receives the MBS session priority in step 2, MB-SMF includes MBS session priority in the N2 SM information of Nmbsmf\_MBSSession\_ContextUpdate response message. And AMF sends N2 MBS Session response message to NG-RAN node in step 14.

15. The NG-RAN decides the transmission mode to apply for the MBS multicast session in a cell.

#### 6.1.3.3 Moving a UE to RRC Inactive state



Figure 6.1.3.3-1: NG-RAN node moves a UE to CM-CONNECTED with RRC Inactive state

0. 5GC provides assistance information of RRC Inactive multicast MBS data reception to NG-RAN node, details see clause 6.1.3.2. UE receives multicast MBS data in CM-CONNECTED mode.

Editor's note: Whether/what assistance information is needed is to be coordinated with RAN WGs. It is ffs if some UEs in the same cell can receive MBS data in RRC Inactive reception mode and other UEs can receive MBS data in Rel-17 reception mode.

1. RAN determines to move UE in multicast MBS session to RRC Inactive state and the transmission mode to apply for the MBS multicast session in a cell taking the assistance information into consideration.

Editor's note: Determination of switching to RRC Inactive will be confirmed by the RAN WGs.

2. NG-RAN node releases the RRC connection and moves the UE to CM-CONNECTED with RRC Inactive state.

Editor's note: How to release the UEs belongs to multicast MBS session will be determined by RAN WGs.

3. UE receives multicast MBS data in CM-CONNECTED with RRC Inactive mode.

Editor's note: RAN WGs will determine the configuration of UE receiving multicast MBS data in RRC Inactive.

#### 6.1.3.4 Moving a UE to RRC-CONNECTED from RRC Inactive state



Figure 6.1.3.4-1: NG-RAN node moves a UE to RRC-CONNECTED state

0. 5GC provides assistance information of RRC Inactive multicast MBS data reception to NG-RAN node, details see clause 6.1.3.2. UE receives multicast MBS data in CM-CONNECTED with RRC Inactive mode.

Editor's note: Whether/what assistance information is needed is to be coordinated with RAN WGs.

1. RAN determines to move UE in multicast MBS session to RRC-CONNECTED state based on the assistance information as described in clause 6.1.2.

Editor's note: Determination of switching to RRC Inactive will be confirmed by the RAN WGs.

2. NG-RAN node informs related UEs to RRC-CONNECTED state.

Editor's note: How to inform the related UEs belonging to multicast MBS session will be determined by RAN WGs.

3. UE receives multicast MBS data in RRC-CONNECTED mode.

Editor's note: RAN WGs will determine the configuration of UE receiving multicast MBS data in RRC-CONNECTED mode.

### 6.1.4 Impacts on services, entities and interfaces.

Editor's note: This clause describes impacts to existing services, entities and interfaces.

Functional entities defined in clause 5.3.2 of TS 23.247 [4] is reused.

AF:

- The AF includes the MBS session priority and information whether the transmission for inactive reception is enabled in the message sent to MB-SMF.

- The AF includes the UE session priority during External Parameter Provisioning procedure.

MB-SMF:

- The MB-SMF stores MBS session priority and information whether the transmission mode for inactive reception is enabled as a part of multicast context, and provides MBS session priority and information whether the transmission mode for inactive reception is enabled to the NG-RAN node.

SMF:

- SMF fetches the UE MBS priority and provide to the NG-RAN node during PDU Session modification/establishment procedure.

NG-RAN:

- Determine the transmission mode for an MBS session in a cell and which UE can be switched RRC Inactive/Connected mode based on the UE MBS priority and MBS session priority from SMF/MB-SMF, respectively.

UDM:

- Storing the UE session priority of a certain MBS session.

UE:

- Indicate capability and preference for multicast reception in RRC inactive state.

## 6.2 Solution #2: Procedures for MOCN network sharing

### 6.2.1 Introduction

This solution addresses Key Issue #2.

### 6.2.2 Functional description

#### 6.2.2.1 General

It is assumed to reuse the current architecture and TMGI definition in Rel-17 MBS work (see TS 23.247 [4]). In other words, MB-SMF is used to handle MBS session-level management while SMF performs per-UE MBS session management, e.g. authorization, multicast session information provisioning, managing 5GC Individual MBS traffic delivery.

In general the proposal is based on the additional identifier (i.e. identifier of the broadcast MBS service) provided by AF during MBS session Create procedure. The identifier of the broadcast MBS service is non-PLMN specific, which would be included and the same when AF sends requests for establishing the broadcast MBS session for the same broadcast MBS service to different PLMNs. The MB-SMF includes the received identifier in the N2 MB-SM container, and provided to NG-RAN node. Figure 6.2.2.1-1 demonstrates an example of the proposal.



Figure 6.2.2.1-1: MOCN network sharing using additional identifier

It is assumed that for the MBS sessions identified by the same "identifier of the broadcast MBS service", the NG-RAN node will use the same radio resources, but still broadcast the TMGIs for different PLMNs. In other words:

- UE: UEs of different PLMNs behave the same as Rel-17, i.e. listen to the control channel of the TMGIs broadcasted by the NG-RAN node and receive the broadcast data.

- NG-RAN node: NG-RAN node behave the same as Rel-17, i.e. broadcasts the TMGIs of different PLMNs, but the NG-RAN node also use the same radio resources for transmitting the MBS data of different TMGIs but with the same "identifier of the broadcast MBS service".

#### 6.2.2.2 Identifier of the broadcast MBS service

The Identifier of the broadcast MBS service is used to denote the broadcast communication service. When creating the MBS session, the AF may additionally include the Identifier in the MBS session create request message. For the same broadcast communication service but transmitted in different PLMNs, the Identifier will be the same.

The Identifier of the broadcast MBS service is non-PLMN specific, it is used for globally identify the broadcast service data at the NG-RAN node. The Identifier is in the form of IP addresses, which is the target IP address and optionally includes the source IP address. The source IP address is the source IP address of the data provider, e.g. the address of the AS, and the target IP address can be the destination IP address of the broadcast data, which might be the IP multicast address.

Editor´s note: It is ffs how a unique identifier can be provided if different AFs act as data source against different core networks.

#### 6.2.2.3 Reception of the broadcast data by the UE

It is proposed to not change the Uu interface for the MOCN scenario, i.e. MCCH/MTCH mechanisms defined by Rel-17 are reused. The sharing NG-RAN node uses the same radio resources for the data transmission, since the data service will be the same between/among different PLMNs.

NOTE: The above-mentioned parts needs confirmation by the RAN WGs.

### 6.2.3 Procedures

#### 6.2.3.1 General

NOTE: The message names in the procedures below are descriptive. It is assumed that the names are updated with corresponding SBI based names where applicable during the normative phase.

Editor's note: It will be confirmed by the RAN WG that whether the additional identifier is needed.

Editor's note: Support of the encrypted content reception is FFS.

#### 6.2.3.2 Broadcast Session Establishment



Figure 6.2.3.2-1: Broadcast Session Establishment for MOCN network sharing

The following additions apply compared to clause 7.3.1 of TS 23.247 [4]:

1. AF performs TMGI allocation and MBS session creation as specified in clause 7.1.1.2 or clause 7.1.1.3 of TS 23.247 [4]. The AF further includes the identifier of the broadcast MBS service in MBS session creation request.

2. MB-SMF invokes Namf\_MBSBroadcast\_ContextCreate Request with further including identifier of the broadcast MBS service in the N2 SM container received in step 1.

4. NG-RAN node creates a Broadcast MBS Session Context, stores the TMGI, the QoS Profile and the identifier of the broadcast MBS service in the MBS Session Context, if the Broadcast MBS Session Context does not exist (i.e. the other PLMN network sharing the NG-RAN node has not requested for the same broadcast MBS service to be established at the NG-RAN node).

If the NG-RAN node already exists, i.e. NG-RAN nodes stores the same "identifier of the broadcast MBS service" in the MBS Session Context of other MBS session, then the NG-RAN node reuses the previously allocated radio resources of the MBS session identified by the same "identifier of the broadcast MBS service", as the one for the newly requested MBS session. In other words, all MBS sessions having the same "identifier of the broadcast MBS service" shares the radio resources. When the NG-RAN node receives the DL MBS data of the requested MBS session afterwards, it will not send the received data in the air interface.

9. NG-RAN broadcasts the TMGI representing the MBS service over radio interface.

NOTE: This step is same as the session start procedure in TS 23.247 [4]; it is included here for the sake of clarity.

Editor's note: Details will be confirmed by the RAN WGs.

#### 6.2.3.3 Broadcast Session Release



Figure 6.2.3.3-1: Broadcast Session Release for MOCN network sharing

The following additions apply compared to clause 7.3.2 of TS 23.247 [4]:

4. After NG-RAN node receives multiple N2 message to release the MBS Session for the TMGI (e.g. from several AMFs the NG-RAN is connected to), if there is no other PLMN requesting to the broadcast MBS service, the NG-RAN node performs step 5 and step 6.

If the MBS session is about to be released, and 1) the NG-RAN nodes uses its MBS data as the one sending in the air interface, and 2) there are other MBS sessions identified by the same "identifier of the broadcast MBS service", then the NG-RAN node will select DL data of one other MBS session of the same "identifier of the broadcast MBS service" and send its data using the previous allocated radio resources.

Editor's note: Details will be confirmed by the RAN WGs.

### 6.2.4 Impacts on services, entities and interfaces

Functional entities defined in clause 5.3.2 of TS 23.247 [4] is reused exception for the following additions:

AF, NEF:

- Support to provide/process the identifier of the broadcast MBS service during broadcast session establishment procedure.

MB-SMF:

- Include the identifier of the broadcast MBS service to the N2 SM container sent to NG-RAN node.

NG-RAN:

- Support to identify the broadcast MBS service from 5GC and use the same resources for the same broadcast MBS service.

- Support to configure radio bearer of the MBS sessions with the same "identifier of the broadcast MBS service" with the same radio resources.

- Refrain from sending the data of the subsequently established MBS session with the same "identifier of the broadcast MBS service" to the UEs.

## 6.3 Solution #3: AF providing assistance information

### 6.3.1 Introduction

This solution addresses the following bullet in Key Issue #1.

- Whether, how and what MBS assistance information to provide from 5GC to RAN for an MBS session allowing UEs in CM-CONNECTED with RRC Inactive state to receive MBS content, including the aspect which 5GC NF(s) determine the MBS assistance information and how they do so.

### 6.3.2 Functional description

After the multicast MBS session is created, the AF may provide to the 5GC the group member information (e.g. whether a member belongs to a "privileged" category in a multicast group) so that the group members' UEs are not sent to RRC\_INACTIVE state and those members get the best possible service (e.g. voice quality, response time, assurance of not getting pre-empted, etc.).

The 5GC then forward this information to NG-RAN to assist the RAN in the decision which UEs can be sent to RRC\_INACTIVE when needed.

The group member information consists of the following:

- MBS Session ID;

- group member category (e.g. privileged, non-privileged).

### 6.3.3 Procedures

The following existing procedures specified in TS 23.502 [3] are reused for the AF to provide assistant information, i.e. group member information (e.g. whether a member belongs to a "privileged" category in a multicast group):

- 4.15.6.6 AF session with required QoS Create procedure.

- 4.15.6.6a AF session with required QoS update procedure.

- 4.16.5.2 PCF initiated SM Policy Association Modification.

- 4.3.3.2 UE or network requested PDU Session Modification (non-roaming and roaming with local breakout).

Compared to clause 4.15.6.6 AF session with required QoS Create procedure of TS 23.502 [3], the additional group member information may be included in the following service operations:

- Step 1: Nnef\_AFsessionWithQoS\_Create request.

- Step 3: Npcf\_PolicyAuthorization\_Create request.

Compared to clause 4.15.6.6a AF session with required QoS Update procedure of TS 23.502 [3], the additional group member information may be included in the following service operations:

- Step 1: Nnef\_AFsessionWithQoS\_Update request.

- Step 3: Npcf\_PolicyAuthorization\_Update request.

Compared to clause 4.16.5.2 PCF initiated SM Policy Association Modification, there is following addition:

- Step 4: In Npcf\_SMPolicyControl\_UpdateNotify service operation may include group member information.

Compared to clause 4.3.3.2 UE or network requested PDU Session Modification (non-roaming and roaming with local breakout), there are following additions:

- Step 3b: PCF initiated SM Policy Association Modification, same as step 4 of clause 4.16.5.2.

- If the UE has joined the MBS Session and the PDU Session UP activated, the SMF provides the group member information via PDU Session Modification towards the NG-RAN.

If the UE has not joined the MBS Session or the UE has joined the MBS Session but does not have PDU Session UP activated, the SMF stores the group member information. The SMF sends the information to NG-RAN next time when PDU Session UP is activated for UE that has joined the MBS Session.

### 6.3.4 Impacts on services, entities and interfaces.

AF:

- See clause 6.3.3.

NEF

- See clause 6.3.3.

PCF:

- See clause 6.3.3.

SMF:

- See clause 6.3.3.

UPF:

- No impact. The new parameter of MBS member priority is only used in NG-RAN.

NG-RAN:

- The NG-RAN receives the group member information in PDU Session setup or modification.

Editor's note: How the group member information is used by NG-RAN requires collaboration with RAN WGs.

## 6.4 Solution #4: MBS session management for RRC Inactive MBS data receiving UE

### 6.4.1 Introduction

This solution addresses Key Issue #1, especially on the enhancement of MBS session management for RRC Inactive MBS data receiving UE.

### 6.4.2 Functional description

This solution builds on top of solution 1. The multicast session management include following procedures:

- MBS session activation, the group-based CN paging may be executed. If a UE in RRC-INACTIVE state is allowed to receive multicast data in that state, a paging reaction is not always needed due to it may not need to resume the RRC connection for receiving the MBS data. But paging reaction for other group member UE, which are in RRC-IDLE state or which need to receive the MBS data in the RRC connected state, is still needed.

- Multicast session deactivation/multicast session update, no impact to the existing procedure as defined in TS 23.247 [4]. If the UE is in the CM-IDLE state and need be notified, the paging is per UE paging.

- Multicast session release, the group-based paging may be executed. As defined in TS 23.247 [4] Paging reaction is needed for all UE as they all need go back to CM-CONNECTED with RRC-CONNECTED state.

Per above consideration, it is suggested to focus on how to page UE due to the MBS session activation and MBS session release. The intention is to avoid RRC-INACTIVE group member UE, which supports receiving multicast service in RRC-inactive state, always resume the RRC connection blindly if the paging event is for activation and MBS session data can be received in RRC-INACTIVE state.

Editor's note: Paging procedures are under remit of the RAN groups and any related enhancements need to be confirmed by RAN groups.

### 6.4.3 Procedures



Figure 6.4.3.1-1: Multicast Session Activation/Release Procedure.

1. UE joins the multicast MBS session via the procedure as defined in clause 7.2.1.3 of TS 23.247 [4].

2. In some cases, e.g. due to radio resource congestion, NG-RAN could move one or multiple multicast group member UEs to RRC-INACTIVE state and those UEs are still able to received multicast MBS data.

3. The multicast MBS session becomes inactive via the procedure as defined in clause 7.2.5.3 of TS 23.247 [4]. The group member UE can be moved to CM-IDLE or CM-Connected with RRC Connected/Inactive state.

4. After some time, MB-SMF triggers the multicast session activation or multicast session release.

5. MB-SMF sends Nmbsmf\_MBSSession\_ContextStatusNotify to SMF(s), same as step 2 of clause 7.2.5.2 or step 1a of clause 7.2.2.3 of TS 23.247 [4], which also includes the MBS session status, i.e. activation or release, as event information. In addition the RRC-inactive reception assistance information, which assist NG-RAN to determine whether the MBS session is allowed to be received in RRC-inactive state, is also included.

NOTE 1: Steps 1, 3-5 are same as the one defined in TS 23.247 [4].

6. The SMF includes the event information and RRC-inactive reception assistance information (if it is received) in Namf\_MT\_EnableGroupReachability Request to AMF. Other parameters in the Namf\_MT\_EnableGroupReachability Request to AMF are same as specified in TS 23.247 [4].

7. If AMF determines that there are UEs in CM-IDLE state among the UEs provided by the SMF in step 6, based on the event information received from SMF, the AMF includes the MBS session ID and a paging cause in the paging message sent to NG-RAN, the paging case is used to indicate the paging is for the received MBS event, e.g. MBS session activation and RRC-inactive state reception assistance information.

8. The NG-RAN performs the group paging by sending the MBS session ID and paging cause. If paging is for MBS session activation and allowed to be received in RRC-inactive state, the NG-RAN node determines for each cell whether transmission for RRC INACTIVE UE is enabled and includes a paging cause if RRC INACTIVE UE do not need go back to the RRC-CONNECTED state.

For RRC-inactive UE(s) that joined the MBS session and receive multicast service in RRC-INACTIVE state, if the UE(s) receives the group paging with the paging cause indicating that the paging is for MBS session activation for MBS session they are receiving and allowed to be received in RRC-inactive state, those UE(s) may remain in RRC-INACTIVE state and do not perform RRC connection resumption. Otherwise, e.g. group paging does not contain a paging cause, this UE sends RRC connection resumption message to NG-RAN.

For the UE(s) joined the MBS session and need receive multicast service in RRC-Connected state, the UE initiates the Service Request as usual.

9. For MBS session activation, steps 6-15 of clause 7.2.5.2 of TS 23.247 [4] is executed with the following difference:

- For the UE(s) joined the MBS session and allowed to receive multicast service in RRC-INACTIVE state, step 6-10 are skipped.

NOTE 2: It is to be decided by RAN WG on whether RAN initiated paging is needed or not. If the RAN initiated paging is needed, different paging cause can be included in the paging message for MBS session activation.

For MBS session release, steps 3-9 of clause 7.2.2.3 of TS 23.247 [4] is executed.

### 6.4.4 Impacts on services, entities, and interfaces

UE:

- Aware whether the group paging is for multicast session activation and allowed to be received in RRC-inactive state.

AMF:

- Support receive the event information from SMF and generate the corresponding paging cause.

SMF:

- Includes the event information and RRC-inactive reception assistance information parameter sent to AMF.

MB-SMF

- Notify the RRC-inactive reception assistance information to SMF.

NG-RAN:

- Support adding paging cause for group paging per receiving paging cause and whether the UE need go back to the RRC CONNECTED state.

## 6.5 Solution #5: Mobility Procedures for UE supporting RRC Inactive MBS data reception

### 6.5.1 Introduction

This solution addresses Key Issue #1, especially on the mobility handling for UE supporting RRC Inactive state MBS data receiving.

### 6.5.2 Functional description

The procedures in clause 6.5.3.1 and 6.5.3.2 are used for the UE receiving the MBS data in RRC-inactive state, under the following mobility cases:

- Moving within the RA.

NOTE 1: It is assumed that the NG-RAN node(s) within the same RNA have the same MBS capability, i.e. all the NG-RAN nodes within the RNA are RRC-inactive MBS data reception supporting.

- Moving out of RNA and within the RA.

NOTE 2: The procedure includes a UE initiated service request handling, which can also be used for the case without mobility.

- Moving out of the RA.

NOTE 3: The target NG-RAN node could be either RRC-inactive MBS data reception supporting NG-RAN or non RRC-inactive MBS data reception supporting Node.

The procedures in clause 6.5.3.3 is used for RRC-connected multicast group member UE moves to RRC-inactive MBS reception supporting NG-RAN.

### 6.5.3 Procedures

#### 6.5.3.1 RRC-inactive multicast group member moves within RNA

Editor's note: The procedure of the mobility within RNA is under the responsibility of RAN WG. It need be confirmed and defined by RAN WGs.

This clause describes the mobility procedure for the UE, which joined the MBS session and is allowed to receive the multicast service in RRC-inactive state, moves within RNA.

NOTE 1: It is assumed all the NG-RAN nodes within the same RNA have same RRC-inactive MBS data reception supporting capability.

Editor's note: If this assumption is realistic needs to be confirmed by RAN WGs

Editor's note: It is ffs how to deal with situations where the transmission for inactive reception is nor applied everywhere, e.g. to support Rel-17 UEs in some cells



Figure 6.5.3.1-1: Mobility procedure for multicast service received in RRC-inactive

The UE(s) joined the multicast MBS session and is allowed to receive the multicast service in RRC-inactive state.

1. If due to mobility the UE finds NG-RAN is changed and no multicast data received at the camping cell, the UE sends RRC message to target NG-RAN node.

NOTE 2: The details of what is contained in the RRC message will be decided by RAN WG2.

Editor's note: How the UE determines no multicast data at the camping cell is to be determined by RAN WGs.

Editor's note: Whether the target RAN node needs to obtain any information about the MBS session and needs to broadcast any information about the multicast session to aid the UE with the determination is ffs. How to deal with transmission pauses is FFS.

2. The target NG-RAN send Xn message to the source NG-RAN to get the related multicast MBS session information. The source NG-RAN provides the related MBS session information to target NG-RAN node.

3. Based on the message in step 2, if the target NG-RAN has not established the shared delivery for the indicated MBS session, the target NG-RAN trigger to establish the shared delivery to MB-UPF as defined in clause 7.2.1.4 of TS 23.247 [4].

Editor's note: How to stop the MBS data transmission at the cell if there are no RRC connected state UE and RRC inactive UE camp at that cell.

#### 6.5.3.2 RRC-inactive multicast group member UE move out of RNA and within RA

RNA update procedures for UE in RRC\_INACTIVE state are specified in TS 38.300 [13].

Editor's note: In this clause, the NG-RAN behaviour (e.g. interaction with UE) is to be determined by RAN WGs, e.g. for the UE joined the multicast MBS session and allowed receiving MBS data in RRC-inactive state, if the UE moves out its RNA and within RA, whether the RNA update procedure is performed in the same way as in Rel-17 is FFS.

For the UE joined the multicast MBS session and allowed receiving MBS data in RRC-inactive state, if the UE moves out its RNA and within RA, it triggers the RNA update procedure as specified in TS 38.300 [13]. Based on that procedure, the UE may still in RRC Inactive state or enter RRC IDLE state per whether the UE context can be retrieved successfully or not.

- If the UE is in the RRC Inactive state and the network indicate support RRC Inactive MBS data reception, the UE is aware that the multicast service can be received in RRC Inactive state and not need perform Service Request.

Editor's note: How the RRC Inactive UE determines that network support RRC Inactive reception is to be determined by RAN WGs.

- If the UE is in the RRC Inactive state and the network does not support RRC Inactive state MBS data reception, or in RRC Idle state, the UE invokes the Service Request to activate the user plane of the associated PDU session ID. During the user plane activation procedure, the SMF notifies the MBS session ID UE joined and the RRC inactive assistance information for MBS data receiving parameter in the N2SM Info to the NG-RAN. Per the received information, the individual or shared delivery path between the NG-RAN node and MB-UPF is established if needed. Later per NG-RAN configuration, the UE may be changed to RRC Inactive state to receive the MBS data.

Editor's note: How the RRC Inactive UE determines that network does not support RRC Inactive reception is to be determined by RAN WGs.

#### 6.5.3.3 RRC-connected multicast group member UE move to RRC-inactive MBS reception supporting NG-RAN

For the UE joined the multicast MBS session and in RRC-connected state to receive the MBS data, if the UE moves to a RRC inactive MBS reception supporting NG-RAN, the following additions applies compared to clause 7.2.3 of TS 23.247 [4]:

- For Xn handover, after the SMF receives the path switch request transfer information from target NG-RAN via AMF, the SMF includes the RRC inactive assistance information for MBS data receiving parameter in path switch request ACK (i.e. the N2SM Info) and sent to target NG-RAN.

- For N2 handover, after the SMF receives the Handover Required information from the source NG-RAN via the AMF, the SMF includes the RRC inactive assistance information for MBS data receiving parameter in the N2SM Info and sent to target NG-RAN within the Handover Request message via the AMF.

- After the handover procedure, based on the received RRC inactive assistance information for MBS data receiving parameter, the UE may be configured to RRC inactive state to receive the multicast MBS data same as defined in solution 1.

### 6.5.4 Impacts on services, entities, and interfaces

UE:

- When the UE receives the MBS data in RRC Inactive state and move to a new cell but not receive the MBS data, the UE need activate the associated PDU session via the service request or registration procedure.

SMF:

- Include the RRC inactive assistance parameter in N2 SM Info and sent to target NG-RAN during handover procedure.

Editor's note: Other impact will be determined by (and/or by collaboration with) RAN WGs.

NG-RAN:

Editor's note: The impact of NG-RAN is to support the mobility within RNA. It need be confirmed by RAN WGs.

- Support trigger to establish the 5GC Shared MBS traffic delivery per the received MBS session information.

Support provide the MBS session related information from source NG-RAN to target NG-RAN.

## 6.6 Solution #6: Reusing the existing assistance info and Qos for RRC Inactive MBS data reception decision

### 6.6.1 Introduction

This solution it to address the Key Issue #1: Multicast MBS data reception in RRC Inactive state.

### 6.6.2 Functional description

Clause 5.3.3.2.5 of TS 23.501 [2] defines "RRC Inactive Assistance Information" sent by AMF to NG-RAN. It includes DRX, eDRX, RA, Periodic Registration Update timer, MICO mode, Information from the UE identifier, Paging Cause Indication for Voice, PEIPS Assistance Information.

From the above Assistance information, there is no service related parameters except voice. In this solution, it keeps the same principle, i.e. there is no service related parameters added to the exist "RRC Inactive Assistance Information".

NOTE 1: The transfer of a UE capability to receive the multicast MBS data in RRC\_INACTIVE state from UE to NG RAN is are assumed to be defined by RAN WGs. When the UE receives the multicast data in the RRC inactive, the major impact is the NG-RAN cannot receive the feedback, i.e. HARQ. It may cause the higher PER. And ARP of MBS QoS flow also be used by NG-RAN to determine whether or which MBS session can be put into RRC inactive, i.e. the member of multicast MBS session can be moved to RRC inactive state to receive the MBS data.

Editor's note: Whether/how ARP of MBS Session QoS Flow can be used by NG-RAN in determining what UEs can be moved to RRC\_INACTIVE is to be determined by NG-RAN.

So in addition to "RRC Inactive Assistance Information", the QoS parameters, e.g. PER and ARP in the 5QI of MBS QoS flow can be used by NG-RAN to determine whether the MBS session can be sent to RRC Inactive state to receives the multicast MBS session data.

NOTE 2: The QoS parameters of MBS QoS flow is received by NG-RAN from MB-SMF during establishment of shared delivery.

To support differentiate the UEs involving in one multicast MBS sessions, the same mechanism can be used. During or after the UE join the multicast MBS session, the AF may provide the PER to SMF which can be used for the associated Qos flow. After the SMF receives the PER for the associated Qos flow, it replaces the PER in the mapped Qos parameters of the associated Qos flow. The PER in the 5QI and ARP of associated QoS flow can be used by NG-RAN to determine whether the UE can be sent to RRC Inactive state to receives the multicast MBS session data. There are two possible method to provide the PER/ARP of associated QoS flow to SMF:

- via PCF, in the R17, the associated QoS flow is not visible in PCF. But for this feature, the AF need to provides the flow description (e. g, SSM), PER to PCF, and PCF provides the rule to SMF. According to flow information (e.g. SSM), the SMF know this is related to the associated Qos flow.

- similar with UDM/UDR based solution, the AF provides the (PER/ARP and related UE list) for the MBS session to UDM/UDM. The SMF obtain these information.

NOTE 3: In the R18 SID FS\_TRS\_URLLC, the KI#4 "How to enable an AF to explicitly provide PER to NEF/PCF" enable the AF provides the PER to PCF.

NOTE 4: The UDM/UDR based solution can refer to solution 1. AF provides the PER, MBS session id, UE list, and UDM stores this information as a part of MBS subscription data, during External Parameter Provisioning procedures as defined in clause 6.4.2 of TS 23.247 [4].

NOTE 5: The NG-RAN can use the physical channel status load of the cell, or any other logic to determine whether the UE can be sent to RRC Inactive state meanwhile meeting the QoS requirement of the multicast service. Decision based on the channel status is out of SA WG2 scope.

Editor's note: RAN WGs need to confirm the proposed NG RAN node behaviour.

### 6.6.3 Procedures

None.

### 6.6.4 Impacts on services, entities and interfaces.

AF:

- Request PER for QoS.

PCF:

- Map Requested PER to PCC Rule with a 5QI that reflects the Requested PER.

## 6.7 Solution #7: MOCN RAN Sharing

### 6.7.1 Introduction

This solution addresses Key Issue #2.

### 6.7.2 Functional description

This solution utilizes the associated session identifier (e.g. SSM used by AF) to be the identifier to associate broadcast MBS sessions from different CNs which transmitting the same content.

The AF provides the associated session ID when creating broadcast MBS sessions with the same broadcast content. In all CNs, MB-SMF provides the associated session ID to the NG-RAN via the AMF. And then, the NG-RAN can utilize the associated session ID to associate those broadcast MBS sessions.

NG-RAN establishes the user planes for the first broadcast MBS session it receives. The NG-RAN delivers the packets received from the established user plane over the air. For the other broadcast MBS sessions which are associated with the broadcast MBS session, the NG-RAN creates the broadcast MBS session contexts, advertises the TMGIs, but does not establish the user planes.

In case there is a failure in the established user plane, the NG-RAN selects another associated broadcast MBS session to establish the user plane and continue to deliver the packets received from the newly established user plane over the air.

Another option is to let AF select one allocated TMGI as the associated session identifier when creating MBS sessions towards all CNs. In this case, the NG-RAN includes only this selected TMGI in radio interface which points to the configuration, regardless of whether the NG-RAN is dedicated or MOCN shared. AF also includes only this selected TMGI in the service announcement, so that UE use it to receive the broadcast MBS session data.

NOTE: The security mechanism for MBS traffic transmission specified in clause W.4 of TS 33.501 [14] is not applicable, while the content protection in AF can be applied for the content encryption and decryption.

### 6.7.3 Procedures

#### 6.7.3.1 General

NOTE: The message names in the procedures below are descriptive. It is assumed that the names are updated with corresponding SBI based names where applicable during the normative phase.

#### 6.7.3.2 MBS Session Creation



Figure 6.7.3.2-1: MBS Session Creation for MOCN RAN sharing

The following additions apply compared to clause 7.1.1.2 of TS 23.247 [4]:

8. The AF provides the associated session ID (e.g. SSM used by AF or one TMGI selected by AF) to the NEF/MBSF when invoking Nnef\_MBSSession\_Create Request. If AF determines to use TMGI as associated session ID, it needs to select one from those TMGIs which are to be used to create MBS sessions transmitting the same content. The AF also uses this TMGI in the service announcement.

11. The NEF/MBSF provides the associated session ID to the MB-SMF when invoking Nmbsmf\_MBSSession\_Create Request. The MB-SMF stores the associated session ID as a part of the MBS session context to be further distributed to NG-RAN in clause 6.7.3.3.

The same updates apply to clause 7.1.1.3 of TS 23.247 [4].

#### 6.7.3.3 MBS Session Start for Broadcast



Figure 6.7.3.3-1: MBS Session Start for Broadcast for MOCN RAN sharing

The following additions apply compared to clause 7.3.1 of TS 23.247 [4]:

2-3. The MB-SMF provides the associated session ID in the N2 SM container to the NG-RAN via AMF.

4. The NG-RAN creates the Broadcast MBS Session context including the associated session ID. If the NG-RAN determines there is already established user plane of another broadcast MBS session which is associated (identified by same associated session ID), the NG-RAN skips the user plane establishment of this broadcast MBS session.

If multicast transport of N3mb applies, the NG-RAN skips step 5.

If unicast transport of N3mb applies, the NG-RAN does not allocate N3mb DL Tunnel Info in step 6, and not include it in the N2 message towards MB-SMF in step 6-7 or step 10-11, so that step 8 or step 12 can also be skipped.

9. If the NG-RAN determines the radio resource of another broadcast MBS Session is allocated which is associated (identified by the same associated session ID), and if the associated session ID is SSM, the NG-RAN advertises the TMGI of the broadcast MBS session and link the TMGI to the existing radio resources.

If the associated session ID is TMGI, the NG-RAN uses the TMGI indicated in the associated session ID in radio interface, instead of the TMGI of broadcast MBS session.

14-15. In case the user plane of the broadcast MBS session is not established, the NG-RAN will not receive the packets from the MB-UPF.

Editor's note: Details will be confirmed by the RAN WGs.

#### 6.7.3.4 MBS Session Release for Broadcast



Figure 6.7.3.4-1: MBS Session Release for Broadcast for MOCN RAN sharing

The following additions apply compared to clause 7.3.2 of TS 23.247 [4]:

5. If the user plane of the broadcast MBS session has not been established, the NG-RAN simply stops the advertisement of the TMGI without releasing the user plane which hasn't been established. That is, step 6 is skipped for multicast transport of N3mb, and for unicast transport of N3mb DL Tunnel Info is not provided in steps 7-8.

If the user plane of the broadcast MBS session has been established, the NG-RAN checks whether there are other associated broadcast MBS sessions. If there are, the NG-RAN may trigger Broadcast MBS Session Transport Request as specified in clause 6.7.3.5.

Editor's note: Details will be confirmed by the RAN WGs.

#### 6.7.3.5 Broadcast MBS Session Transport Request

When NG-RAN detects there is a failure in the user plane which causes the NG-RAN cannot deliver the contents, the NG-RAN select another CN to trigger Broadcast MBS Session Transport Request procedure to establish the user plane. The selecting of CN can be up to NG-RAN implementation.

It may apply to the scenario when the broadcast MBS session is released in that CN, whose user plane is used to content transmission, while there are some other broadcast MBS sessions not released.



Figure 6.7.3.5-1: Broadcast MBS Session Transport Request

1. NG-RAN select a CN to establish user plane, utilizing the broadcast MBS session context stored in the NG-RAN.

2. If multicast transport of N3mb applies, the NG-RAN performs join the multicast group towards the LL SSM provided by the CN, and skip step 2 to step 5.

3. If unicast transport of N3mb applies, the NG-RAN allocates N3mb DL Tunnel Info, and sends N2 message (e.g. BROADCAST SESSION TRANSPORT REQUEST) to AMF, including the MBS Session ID and the N3mb DL Tunnel Info.

4. The AMF transfers the Namf\_MBSBroadcast\_ContextStatusNotify request to the MB-SMF, which contains the N2 message.

5. If unicast transport of N3mb applies, the MB-SMF sends an N4mb Session Modification Request to the MB-UPF to allocate the N3mb point-to-point transport tunnel for a replicated MBS stream for the MBS Session. The MB-UPF sends N4mb Session Modification Response to the MB-SMF.

6. The MB-SMF sends Namf\_MBSBroadcast\_ContextStatusNotify response to the AMF, which contains the N2 information.

7. The AMF forwards the received N2 information in N2 message (e.g. BROADCAST SESSION TRANSPORT RESPONSE) to the NG-RAN

8. The MB-UPF transmits the media stream to NG-RAN via N3mb multicast transport or unicast transport.

9. The NG-RAN brings the packets received over the air, reusing the existing radio resource.

### 6.7.4 Impacts on services, entities and interfaces

Functional entities defined in clause 5.3.2 of TS 23.247 [4] are reused exception for the following additions:

AF:

- Provide the associated session ID (e.g. SSM used by AF or one TMGI selected by AF) to 5GC when creating MBS session. If AF determines to use TMGI as associated session ID, it needs to use this TMGI in the service announcement.

NEF:

- Provides the associated session ID to the MB-SMF if received in MBS Session Creation.

MB-SMF:

- Provides the associated session ID to the NG-RAN if received in MBS Session Start for Broadcast.

NG-RAN:

- Support the associated session ID and understand the association among those broadcast MBS sessions which delivers the same content. If the associated session ID is TMGI, the NG-RAN uses the TMGI indicated in associated session ID in radio interface, instead of the TMGI of broadcast MBS session.

- When broadcast MBS session start, if there is already established user plane of associated broadcast MBS session, the NG-RAN skips the user plane establishment of the broadcast MBS session.

- When broadcast MBS session release, if the user plane hasn't been established, the NG-RAN skips the user plane release of the broadcast MBS session. If the user plane has been established and there are some other associated broadcast MBS sessions, the NG-RAN may trigger Broadcast MBS Session Release Require procedure for each associated broadcast MBS session or trigger Broadcast MBS Session Transport Request procedure.

- When NG-RAN detects there is a failure in the CN which causes the NG-RAN cannot deliver the contents, the NG-RAN select another CN to trigger Broadcast MBS Session Transport Request procedure to establish the user plane.

## 6.8 Solution #8: Allocating and using MOCN TMGI

### 6.8.1 Introduction

This solution addresses key issue #2 "5MBS MOCN Network Sharing".

### 6.8.2 Functional description

The proposed solution introduces a MOCN TMGI used for MBS session when the related MBS service needs to be provided over PLMNs sharing NG-RANs. The MOCN TMGI is identified by a shared PLMN ID it includes. A MOCN TMGI is allocated by one of the PLMNs and the MBS session identified by the MOCN TMGI is established only with the PLMN that has allocated the MOCN TMGI. The AF transmits the DL media stream to the PLMN that the MBS session was established. Therefore, the NG-RAN shared by the multiple PLMNs receives the DL media stream only from the 5GC of the PLMN that the MBS session was established and transmits the media stream by using the MOCN TMGI.

For the MOCN TMGI, a Shared PLMN ID needs to be created and used by the PLMNs sharing NG-RANs. All the MB-SMFs in the PLMNs sharing NG-RANs are configured with the Shared PLMN ID so that the MB-SMFs can allocate the MOCN TMGIs. The MB-SMF understands whether a TAI is for shared NG-RAN or not by local configuration.

Figure 6.8.2-1 shows an MBS example scenario including MOCN network sharing, specifically:

- The AF wants to provide MBS service over PLMN-A, PLMN-B, PLMN-C and PLMN-D, i.e. to the UEs that are served by these PLMNs.

- UE-A, UE-B, UE-C and UE-D are served by PLMN-A, PLMN-B, PLMN-C and PLMN-D, respectively.

- NG-RAN#1 is shared by PLMN-A, PLMN-B and PLMN-C while NG-RAN#2 belongs only to PLMN-D.

- NG-RAN#1 and NG-RAN#2 covers the MBS service area for the MBS service provided by the AF.

- The AF is configured about which PLMNs share the NG-RAN, i.e. PLMN-A, PLMN-B and PLMN-C based on service level agreements with the PLMNs.



Figure 6.8.2-1: MBS example scenario including MOCN network sharing

The outline of the proposed solution for allocating and using MOCN TMGI is as below:

- The AF performs TMGI allocation with only one PLMN among PLMNs sharing the NG-RANs to obtain a TMGI to identify new MBS session by indicating that MOCN TMGI allocation is requested (e.g. with PLMN-A in Figure 6.8.2-1).

- The MB-SMF allocates a MOCN TMGI and returns it to the AF.

- The AF performs MBS session establishment with the PLMN that has allocated the MOCN TMGI.

- The AF transmits the DL media stream to the PLMN that the MBS session was established.

### 6.8.3 Procedures

#### 6.8.3.1 Procedure for Broadcast using MOCN TMGI

Figure 6.8.3.1-1 shows the procedure for Broadcast using MOCN TMGI. This procedure is based on the MBS example scenario depicted in Figure 6.8.2-1.



Figure 6.8.3.1-1: Procedure for Broadcast using MOCN TMGI

1. The AF requests TMGI allocation with one of PLMNs that it wants to provide broadcast service over. In this figure, the AF performs TMGI allocation with PLMN-A to obtain a TMGI to identify new MBS session.

Steps 1 to 6 in clause 7.1.1.2 or clause 7.1.1.3 of TS 23.247 [4] are performed with the following differences:

- In step 1, the following information is provided by the AF when requesting TMGI allocation.

a) A list of PLMNs that the AF wants to provide MBS service (i.e. PLMN-A, PLMN-B, PLMN-C in this figure).

b) Indication that MOCN TMGI allocation is requested.

NOTE 1: In Rel-17, the MBS service area is provided by the AF to indicate the possible service area for those TMGI(s) to be allocated, which may be needed for local MBS. In this solution, the MBS service area from the AF can be used for the MB-SMF to check whether all the MBS service area's NG-RANs are shared by the PLMNs that the AF wants to provide MBS service.

- In step 5, the MB-SMF allocates a MOCN TMGI based on the information provided by the AF and local configuration related to MOCN network sharing. In this figure, the local configuration related to MOCN network sharing is that PLMN-A, PLMN-B and PLMN-C share NG-RANs. If some of the NG-RANs in the MBS service area provided by the AF are not shared by all the PLMNs that the AF wants to provide MBS service (i.e. some of the NG-RANs in the MBS service area provided by the AF are dedicated to specific PLMN), the MB-SMF allocates a MOCN TMGI only for the MBS service area served by the NG-RANs that are shared by those PLMNs.

- In step 5, the following information is provided by the MB-SMF when returning the TMGI.

i) Indication that MOCN TMGI is allocated.

ii) MBS service area that the allocated MOCN TMGI applies, if the MOCN TMGI does not apply to all the MBS service area that the AF provided when requesting TMGI allocation.

If the MOCN TMGI allocated by the MB-SMF does not apply to all the MBS service area that the AF wants to provide MBS service, the AF performs TMGI allocation and MBS session creation with each PLMN for the MBS service area that the MOCN TMGI does not apply. The AF also may perform a Service Announcement including the TMGI dedicated to the PLMN to the UE in the PLMN.

2. The AF may perform a Service Announcement including the MOCN TMGI towards UE-A, UE-B and UE-C.

NOTE 2: When the UE receives Service Announcement including MOCN TMGI for shared NG-RAN(s) and Service Announcement including non-MOCN TMGI for dedicated NG-RAN(s) (i.e. TMGI dedicated to the PLMN) for same service from the AF, the service layer (e.g. 5MBS client, MC service client) or the application layer of the UE needs to understand these two TMGIs are for same service based on the information in the Service Announcements, e.g. SDP info with IP multicast address and port#, Service ID.

3. The AF performs TMGI allocation with PLMN-D to obtain a TMGI to identify new MBS session as specified in steps 1 to 6 in clause 7.1.1.2 or clause 7.1.1.3 of TS 23.247 [4].

The MBS session identified by the MOCN TMGI allocated in step 1 and the MBS session identified by the TMGI allocated in this step are for the same broadcast service.

Step 1 and step 3 can be performed in parallel.

4. The AF may perform a Service Announcement towards UE-D.

5. The AF performs MBS session creation with PLMN-A by providing description for the MBS session for a previously allocated MOCN TMGI in step 1, as specified in step 8 in clause 7.1.1.2 or clause 7.1.1.3 of TS 23.247 [4].

6-7. The MBS session is established in PLMN-A as specified in steps 9 to 20 in clause 7.1.1.2 or steps 9 to 33 in clause 7.1.1.3 of TS 23.247 [4].

The AF may also perform a Service Announcement towards UE-A, UE-B and UE-C at this stage.

8. The AF performs MBS session creation with PLMN-D by providing description for the MBS session for a previously allocated TMGI in step 3, as specified in step 8 in clause 7.1.1.2 or clause 7.1.1.3 of TS 23.247 [4].

9-10. The MBS session is established in PLMN-D as specified in steps 9 to 20 in clause 7.1.1.2 or steps 9 to 33 in clause 7.1.1.3 of TS 23.247 [4].

The AF may also perform a Service Announcement towards UE-D at this stage.

11. The AF starts transmitting the DL media stream to PLMN-A as specified in step 13 in clause 7.3.1 of TS 23.247 [4].

12. The MB-UPF of PLMN-A transmits the media stream to NG-RAN via N3mb multicast transport or point-to-point transport.

13. NG-RAN#1 shared by PLMN-A, PLMN-B and PLMN-C transmits the received DL media stream using DL PTM resources.

UE-A, UE-B and UE-C can receive the media stream.

14. The AF starts transmitting the DL media stream to PLMN-D as specified in step 13 in clause 7.3.1 of TS 23.247 [4]. The DL media stream is same to that in step 11 which means the AF transmits the same DL media stream to PLMN-A and PLMN-D.

Step 11 and step 14 can be performed in parallel.

15. The MB-UPF of PLMN-D transmits the media stream to NG-RAN via N3mb multicast transport or point-to-point transport.

16. NG-RAN#2 of PLMN-D transmits the received DL media stream using DL PTM resources.

UE-D can receive the media stream.

### 6.8.4 Impacts on services, entities and interfaces

AF:

- supports MOCN TMGI allocation request.

MB-SMF:

- supports MOCN TMGI allocation.

NEF:

- Nnef\_MBSTMGI\_Allocate service operation supports additional parameters related to MOCN TMGI allocation.

UE:

- supports MOCN TMGI.

NG-RAN:

- supports MOCN TMGI.

## 6.9 Solution #9: Broadcast services considering MOCN RAN

### 6.9.1 Introduction

This solution addresses Key Issue #2.

### 6.9.2 Functional description

It is assumed to reuse the current architecture in Rel-17 MBS specification (see TS 23.247 [4]).

A TMGI is assigned and used for a broadcast service in an operator's network. However, if an NG-RAN is shared among operators, a primary TMGI may be selected and used instead of the TMGI in the shared NG-RAN if MOCN operators share a same broadcast service.

### 6.9.3 Procedures

#### 6.9.3.1 General

When a broadcast service is shared among operator's networks, the contents provider may recognize the using TMGI for each operator. So that if the operators share some NG-RAN(s) (call MOCN NG-RAN), AF/ contents provider may provide the TMGI list for the broadcast service to 5GS.

Then, the MOCN NG-RAN decides to use a primary TMGI out of the TMGI list, and the primary TMGI and its usage area (i.e. NG-RAN location or Cell IDs) is notified to AF so that such information can be announced to the UEs.

NOTE: Security (i.e. en/decryption of content) is assumed to be not supported in 5GS, but possible by application layer.

#### 6.9.3.2 Broadcast Session Start procedure



Figure 6.9.3.2-1: Broadcast Session start for MOCN NG-RAN

The following additions apply compared to clause 7.3.1 of TS 23.247 [4]:

0-3. AF performs TMGI allocation and MBS session creation as specified in clause 7.1.1.2 or clause 7.1.1.3 of TS 23.247 [4]. The AF provides additionally the TMGI list for the broadcast service which each operator uses in MBS session creation request.

5-6. MB-SMF invokes Namf\_MBSBroadcast\_ContextCreate Request including AF may provide the TMGI list for the broadcast service which each operator uses in the N2 SM container.

7. NG-RAN node creates a Broadcast MBS Session Context. If the NG-RAN is MOCN NG-RAN, it selects a primary TMGI out of the TMGI list.

NOTE 1: How to select a primary TMGI follows local policy or NG-RAN implementation.

8-12. NG-RAN responds additionally the primary TMGI and its location(e.g. Cell ID(s)) if the NG-RAN is MOCN NG-RAN, where such information is delivered to AF. At step 10 MB-SMF lets MB-UPF block and not deliver Broadcast service media stream to the NG-RAN if TMGI is different from the primary TMGI.

13. MOCN NG-RAN advertises the primary TMGI for the broadcast service instead of using the TMGI for operator's network.

Editor's note: Details will be confirmed by the RAN WGs.

14. Service announcement to UEs includes the primary TMGI and its usage area (i.e. NG-RAN location or Cell IDs) as well as the TMGI for operator's network.

Editor's note: Whether it is possible to prevent that each NG-RAN node selects a different primary TMGI and a number of TMGIs with potentially complicated location areas thus needs to be included in the service announcement is FFS.

15. Broadcast service media stream is delivered to MOCN NG-RAN.

NOTE 2: Broadcast service media stream is not delivered to MOCN NG-RAN via each operator's TMGI which is different from the primary TMGI.

16. MOCN NG-RAN uses the primary TMGI only instead of TMGI for the same broadcast service.

17. UE receives the broadcast service via the primary TMGI when it is in the MOCN NG-RAN.

#### 6.9.3.3 Broadcast Session update and release procedure

The clause 7.3.3 of TS 23.247 [4] is used when the broadcast MBS session is updated, which is triggered from AF or contents provider.

However, when the primary TMGI can not be used longer in the NG-RAN e.g. due to the TMGI's PLMN becomes not to share the NG-RAN, NG-RAN should select another valid TMGI as a primary TMGI and update the broadcast MBS session with the new primary TMGI for the other PLMNs than the old primary TMGIs as in the following figure.



Figure 6.9.3.3-1: NG-RAN triggered primary TMGI update procedure

0. Broadcast service media stream is delivered to MOCN NG-RAN via the primary TMGI.

1-2. When the primary TMGI is not valid any more, it selects a new primary TMGI.

3. For the old primary TMGI, NG-RAN performs the broadcast release require(the clause 7.3.6 of TS 23.247 [4]) for the old primary TMGI.

For the other TMGIs than the old primary TMGI, steps 4 ~13 are applied.

4-5. The new primary TMGI is updated in the MBS Broadcast context in AMF and MB-SMF.

6. In case that the new primary TMGI only is used for broadcast traffic delivery among the shared PLMNs, MB-SMF may update the forwarding rules in the MB-UPF(e.g. for other PLMN than the primary TMGI, MB-UPF is allowed to block the broadcast traffics to NG-RAN, which are duplicated with the primary TMGI)

9. MOCN NG-RAN advertises the new primary TMGI for the broadcast service instead of using the old primary TMGI.

10-11. Information on the primary TMGI update is notified to AF.

12-13. AF updates the primary TMGI and announces the UEs.

Editor's note: It is FFS whether there can be service interruptions until the UEs receive the updated service announcement.

14-15. via the new primary TMGI the broadcast service is performed in the MONC NG-RAN.

The following additions apply compared to clause 7.3.2 of TS 23.247 [4] when the broadcast MBS session is released:

- If the broadcast MBS session is used as the primary TMGI in the NG-RAN, NG-RAN should select another valid TMGI as a primary TMGI, and for the other PLMNs than the old primary TMGIs the broadcast MBS session should be updated as above procedure.

### 6.9.4 Impacts on services, entities and interfaces

Editor's note: This clause describes impacts to existing services, entities and interfaces.

Functional entities defined in clause 5.3.2 of TS 23.247 [4] is reused exception for the following additions:

AF, NEF:

- Support to provide the TMGI list for the broadcast service which each operator uses in MBS session creation request only when there exists a MOCN NG-RAN among operators.

- Obtain a primary TMGI which will be used in the MOCN NG-RAN and announce to UEs the primary TMGI and its usage area.

MB-SMF:

- Send TMGI list of other networks for a same broadcast service to NG-RAN node.

- Let MB-UPF block and not deliver Broadcast service media stream to the NG-RAN node if TMGI is different from the primary TMGI.

NG-RAN:

- In the case of MOCN NG-RAN, decide the primary TMGI for a same broadcast service, which will be used for the broadcast service in the MOCN NG-RAN.

- NG-RAN does not receive broadcast service media stream for the TMGI of MBS session establishment if TMGI is different from the primary TMGI.

UE:

- Receive the broadcast service via the primary TMGI in the MOCN NG-RAN.

Editor's note: other additional impacts are FFS.

## 6.10 Solution #10: AF triggered MBS session management

### 6.10.1 Introduction

This solution addresses Key Issue #3.

This solution addresses the case that AF dynamically demands 5GC to use multicast transport for the content delivery, e.g. due to publisher dynamically provides the service and APP in UE interacts with AF for content fetching of the service, and according to the response from 5GC to select unicast mode for content delivery, e.g. UE does not support multicast transport (out of the scope of this study). The service may contain multiple media streams but only part of the media streams is demanded to use multicast transport.

### 6.10.2 Functional description

It is most popular today that content provider provides video to users via APP in UE, but in unicast transport style. Live stream dramatically grows today, which also uses unicast transport. The video services provided by AF can not only be published by the content provider, but also can be published by users of the content provider dynamically. The consumer will not only be a receiver in today's video stream services, but also a participant to interact with the services, such as sending message to interact with the live stream salesperson, sending message when watching a video to share with all the viewers.

In most cases, the users visit the portal for requesting the content, and the AF holds most business logic for providing the services, e.g. the location related operations, the user authentication and authorization per the AF instead of the service, etc. And the service, in most cases, will contain multiple media streams that only part of the steams is demanded to be delivered via multicast transport. This business model is consistent for services provided by AF.

In order to use multicast transport for multicast streams of those services, the 5GC needs to identify the multicast data and uses multicast transport for the delivery and do not impact the AF service logic. And in order to not limiting the consumers based on the UE capability, the 5GC and AF needs to prepare unicast mode in case the UE does not support receiving data with multicast transport (this is out of the scope of this study).

Editor's note: Further explanation is required why the use cases in this clause cannot be addressed with Rel-17 MBS procedures.

The Rel-17 MBS AF may first request TMGIs (optional), creates the MBS session, and may provision the authorization information for allowing UEs to join (optional).

This solution provides a way for AF to deliver the traffic and knows who really joins the session for starting the interactive data exchange.

Editor's note: Multicast traffic delivery is typically not started each time a user joins a session. The AF could also know that a user requested to join a session via the same application level interactions if the UE subsequently sends the join request as in Rel-17.

This solution is based on the unicast business model that UE requests service from AF and AF requests resources from 5GC both for unicast and multicast transport for different flows.

Editor's note: For unicast delivery no AF interactions are required unless sponsored connectivity or special QoS is envisioned.

Editor's note: Compared to the Rel-17 interactions, sending separate join request for all UES may lead to far more signalling interactions between AF and network.

### 6.10.3 Procedures

#### 6.10.3.1 General

Following figure 6.10.3.1-1 shows the general concept of the solution:



Figure 6.10.3.1-1: General concept

The AF delivers the multicast data of different multicast sessions to the 5GC, which may be in a tunnel between the AF and the 5GC if the transport network between the AF and 5GC does not support multicast. The AF can send multiple MBS Session data in one tunnel, the 5GC distinguishes the multicast session based on the mapping between the packet filters and the MBS Session ID. The content delivery is requested by the UEs over application layer, and the AF handles the service logic.

Besides service announcement, the content provider may use a portal, which is out of 3GPP scope, to publish the services, which may be dynamically published, e.g. a live stream arranged by a live streamer, a live interview for breaking news, etc. The user may visit the portal via an APP in the UE and request the content of an MBS service, which may be interactive MBS service, i.e. contains multicast service data and unicast service data. Although service announcement for MBS Session is supported, but currently most content providers still want to use web portal, which is consistent as unicast service announcement.

Editor's note: Rel-17 allows for application dependent service announcements.

Similar as unicast business model, the AF of the content provider sends the flow descriptions per UE, which includes different multicast services, to the 5GC for asking transport for the services, but the flow descriptions includes multicast information, which could be seen as AF proxies the UE join to 5GC.

Editor's note: For unicast delivery no AF interactions are typically required.

Editor's note: For multicast, flow description will not depend on the UE and it may be preferable to provide it only a single time for an MBS session to avoid duplicated signalling.

#### 6.10.3.2 AF triggered MBS Session management procedures with PCC

This procedure is for AF triggered MBS Session Join or Leave when dynamic PCC is deployed. If the transport network between the AF and the 5GC does not support multicast transport, pre-configured tunnel is used for delivering multicast data from the AF to the 5GC.



Figure 6.10.3.2-1: AF triggered MBS Session management procedures with PCC

1. The UE established a PDU Session as described in clause 7.2.1.2 of TS 23.247 [4], during the PDU Session Establishment procedure, the UE indicates the MBS capability to SMF. The content provider may use a portal to publish the services, which may be dynamically published, e.g. a live stream arranged by a live streamer, a live interview for breaking news, etc. The user may visit the portal via an APP in the UE and request the content of an MBS service or stops the content of an MBS service, which may be interactive MBS service, i.e. contains multicast service data and unicast service data. The APP sends UE address and the UDP port for receiving the multicast data to the AF.

NOTE: In case the UE has multiple PDU Sessions, the URSP in the UE needs to make sure that the APP uses the associated PDU Session for unicast traffic delivery.

2-5. The steps are same as described in clauses 4.15.6.6 and 4.15.6.6a of TS 23.502 [3], with following differences:

- The name of service operations exposed by NEF is different, and the flow description(s), if included, includes some packet filters that additionally contains IP multicast address to indicate that the data of the unicast flow can be alternatively sent via multicast (in case unicast transport is used, the network can know that it is for a multicast service), c.f. figure 6.10.3.1-1.

- The flow description(s) sent to PCF includes some packet filters that additionally contains IP multicast address.

- If the MBS Session has not been created, the steps 10-17 in clause 7.1.1.2 or steps 10-26 in clause 7.1.1.3 of TS 23.247 [4] are performed to create the MBS Session.

If the AF is in trust domain, the AF can perform steps 3, 5, and 11 directly.

6. The PCF invokes Policy Update Notify towards the SMF, which includes unicast QoS information and flow description(s) that additionally contains IP multicast address (i.e. multicast flow descriptions).

7. The SMF may initiate PDU Session Modification procedure for updating unicast QoS flows.

8. **MBS Session Join:** For multicast flow creation, the steps 2-4 in clause 7.2.1.3 of TS 23.247 [4] are performed with following differences:

- If the authorization fails (feature level authorization is used for this procedure, i.e. whether the UE is allowed to use 5MBS or not based on subscription), go to step 10 and SMF indicates cause value to the PCF. The AF can use unicast transport for the multicast data delivery.

**MBS Session Leave:** For multicast flow releasing, the steps 3-6 in clause 7.2.1.4 of TS 23.247 [4] are performed with following differences:

- If the MB-SMF does not serve the MBS Session any more (i.e. all SMFs unsubscribed the MBS Session Context Status), steps 6-8 in clause 7.1.1.4 or 7-11 in clause 7.1.1.5 of TS 23.247 [4] are performed to delete the MBS Session.

9. **MBS Session Join:** For multicast QoS information creation, steps 5-12 described in clause 7.2.1.3 of TS 23.247 [4] are performed with following differences:

- The step 5 is Namf\_Communication\_N1N2MessageTransfer. If the MBS capability of UE is received and multicast streams are demanded, the SMF includes QoS rules for DL only in the N1 Message Container in step 5, which will include MBS Session ID as a parameter in the QoS rules for DL only. The QoS rules for DL only can be used by the UE to perform NATP, i.e. transfer the IP multicast address in the received multicast packets to the UE IP address, and to transfer the destination UDP port in the received multicast packets to the UDP port that the APP in the UE used to receive the data.

- If the MBS capability of UE is not received, the SMF does not include MBS Session related information in the N2 SM info send to NG-RAN (i.e. individual delivery is selected), as well as instructs the UPF to perform NATP as described in above bullet for the incoming multicast data of the MBS Session towards the UE (i.e. unicast mode is selected).

- If unicast QoS parameters are received in step 6, the SMF also update the unicast QoS flows during the PDU Session Modification procedure.

- If the UE denies the join, it can send a cause value to the SMF via PDU Session Modification Ack, and MBS session leave for the UE is triggered by the SMF then.

**MBS Session Leave:** For multicast QoS information removal, steps 3-11 and 13 described in clause 7.2.2.2 of TS 23.247 [4] are performed with following differences:

- The step 7 is Namf\_Communication\_N1N2MessageTransfer, and the SMF also update the unicast QoS flows during the PDU Session Modification procedure if unicast QoS flows need to be updated.

10. The SMF notifies the PCF.

11. The PCF Notifies the NEF with cause value related to MBS.

12. The NEF notifies the AF with the cause value. If the PCF does not support MBS (i.e. no corresponding cause value indicated), the corresponding unicast QoS flow will be established, the AF can use unicast transport for the multicast data delivery.

#### 6.10.3.3 AF triggered MBS Session management procedures without PCC

This procedure is for AF triggered MBS Session Join or Leave when dynamic PCC is not deployed. If the transport network between the AF and the 5GC does not support multicast transport, pre-configured tunnel is used for delivering multicast data from the AF to the 5GC.



Figure 6.10.3.3-1: AF triggered MBS Session management procedures without PCC

0. After the PDU Session Establishment procedure, the SMF creates the SMF-NEF connection with the NEF similar as described in clauses 4.25.2 and 5.2.6.15 of TS 23.502 [3], during which the SMF sends the UE address, i.e. IP address, to the NEF. The difference is that the subscription of the UE includes the NEF ID for MBS, the NIDD information in the request to the NEF is changed to MBS information with same content, i.e. GPSI, AF ID, and additional UE address is included.

1. Same as steps 1-2 in clause 6.10.3.2.

2. The NEF invokes the MBS On-demand Session Create/Update with SSM towards the SMF.

3. Same as steps 7-8 in clause 6.10.3.2.

4-5. The SMF responds to the NEF. The NEF responds to the AF.

6. Same as step 9 in clause 6.10.3.2.

7-8. The SMF notifies to the NEF. The NEF notifies to the AF.

### 6.10.4 Impacts on services, entities and interfaces.

**UE:**

- May support indicating MBS capability to SMF during PDU Session Establishment.

- May support NATP performance for incoming multicast data.

**NEF/MBSF:**

- Support handling on-demand MBS Session service to AF (similar as AF Session with QoS service).

- May support additionally handling UE address during SMF-NEF connection establishment procedure as described in TS 23.502 [3] clause 4.25.2, which is used to find out the serving SMF.

**SMF:**

- Support determining delivery method and instructs UPF to perform NATP for multicast data based on UE MBS capability.

- May support sending UE address during the SMF-NEF connection establishment procedure to NEF after associated PDU Session Establishment.

**PCF:**

- Support handling flow description(s) with SSM.

- Support sending cause value for handling multicast flows to NEF/AF.

## 6.11 Solution #11: Solution on enabling the on-demand multicast MBS session management

### 6.11.1 Introduction

This solution addresses Key Issue #3: On demand multicast MBS session.

### 6.11.2 Functional description

#### 6.11.2.1 Use cases

The use case for on demand MBS multicast session can be described as follows.

One typical use case for KI #3 is the content provider delivering its content. Before a content provider (CP) delivers content, its subscriber needs to firstly request the content by sending application level request (e.g. clicking the "view" link). Such framework doesn't take into consideration of the scale of the amount of subscribers.

As analysed by S2-2006311:

*if the requested content is real-time, popular, and high data rate (e.g. World Cup Soccer matches, American Football games or Chinese Spring Festival Gala), a huge number of viewers simultaneously watching will put a huge burden on the network service providers (SPs).*

*As more and more people watch content on their UEs, this will also impact MNOs because many duplicate copies of the same content will be delivered by the MNOs.*

One way to resolve the large scale delivery of real-time high data rate content is to enable on-demand multicast MBS session management triggered by the AF.

The trigger by the AF for enabling the on-demand multicast MBS session management, can be further based on network analysis result. To this end, the AF or CP subscribes to or requests the network analytics information from the NWDAF as specified in TS 23.288 [10]. Based on the analytics information, e.g. Observed Service Experience analytics defined in clause 6.4 of TS 23.288 [10], the AF decides to set/update the multicast related service parameters.

For one AF session, the AF uses "AF session with required QoS update" procedure" defined in clause 4.15.6.6a to provide multicast related service parameters, including a multicast indication which indicates that the service data flows of the AF session can be transmitted over a multicast MBS session identified by an MBS session ID, to the PCF via the NEF. Based on multicast related service parameters, the PCF provides the multicast service related policy in PCC rules to the SMF. Then the SMF decides to initiate a multicast MBS session join/establishment procedure based on the multicast service related policy.

The following procedures is on top of the procedures specified in clause 7.2.1.3 in TS 23.247 [4].

### 6.11.3 Procedures

#### 6.11.3.1 on-demand multicast MBS session management



Figure 6.11.3.1-1: On-demand multicast MBS session establishment

The key steps of the procedure for this solution are as follows:

1. MBS Session Creation with PCC procedure is performed as specified in clause 7.1.1.3 of TS 23.247 [4], where the AF may perform a Service Announcement towards the UEs.

2. The AF decides to set or update multicast related service parameters, including the multicast indication, for specific services/applications. The AF may, based on local configuration or triggered by e.g. event report from the NEF, subscribe to or requests network analytics information (e.g. Observed Service Experience analytics) from the NWDAF as specified in TS 23.288 [10], and decide to update the multicast related service parameters based on the analytics information.

The AF provides updated service parameters, which include the multicast indication and a MBS Session ID for the multicast MBS session to be established, to the PCF via the NEF by using Nnef\_AFsessionWithQoS\_Update request (as defined in clause 4.15.6.6a of TS 23.502 [3]). The "AF session with required QoS update" procedure continues as defined in TS 23.502 [3] and the PCF receives the updated service parameters.

NOTE 1: Those procedures are meant for individual UE joining the MBS session, and are not meant for an MBS session. If AF may send multiple requests in case multiple UEs are involved. Legacy procedures including PCF selection will be reused.

NOTE 2: It is assumed AF can have the private IP address by e.g. application level interaction, public safety AF and so on.

3a. The PCF initiates SM Policy Association Modification procedure as defined in clause 4.16.5.2 of TS 23.502 [3] to notify the SMF, with the multicast MBS session ID.

4a. Steps 2-19 specified in clause 7.2.1.3 of TS 23.247 [4] are reused to complete on-demand multicast MBS session establishment, for the UEs subscribed to the multicast MBS Session and with an associated PDU Session established for the multicast MBS Session, and Namf\_Communication\_N1N2MessageTransfer is used in step 5 instead of Nsmf\_PDUSession\_UpdateSMContext response message. The UE is informed of successfully joining the multicast MBS session upon receiving the PDU Session Modification Command which contains the MBS Session ID.

### 6.11.4 Impacts on services, entities and interfaces.

AF:

- The AF needs to support triggering the on-demand multicast MBS Session establishment, based on e.g. the network analytics information provided by the NWDAF.

PCF:

- The PCF is enhanced to provide to the SMF(s) the multicast service related policy, i.e. MBS session ID that the AF request UE to join, for triggering the SMF(s) to complete the on-demand multicast MBS session establishment.

## 6.12 Solution #12: Group Message Delivery

### 6.12.1 Introduction

This solution addresses the following aspect in Key Issue #4: Whether and how to enhance the MBS functionality to provide a similar group message delivery as available in eMBMS.

### 6.12.2 Functional description

This solution describes a NEF-based group message delivery via MBS method, which is comparable to the SCEF-based group message delivery via MBMS.

This solution utilizes the Object Delivery Method in MBSTF specified in TS 26.502 [11] for the group message delivery via MBS. The Object Delivery Method in MBSTF is equivalent to the File Delivery Method in eMBMS. The Object Delivery Method can benefit from Application Layer Forward Error Correction (AL-FEC) to achieve the reliable delivery, which is essential for group message delivery.

The NEF is responsible to handle Group Message Delivery request from the AF. It transforms the group message into a file and determine the meta data information of the file. In control plane, it performs Application Service Provisioning including MBS User Service creation and MBS User Data Ingest Session creation, which triggers the MBS session creation and MBS session start for broadcast towards 5GC and NR. In user plane, it is responsible for ingesting the file to the MBSTF, so that MBSTF can deliver the file to UE via 5GC shared traffic delivery and NR broadcast.

### 6.12.3 Procedures

#### 6.12.3.1 General

NOTE: The message names in the procedures below are descriptive. It is assumed that the names are updated with corresponding SBI based names where applicable during the normative phase.

#### 6.12.3.2 Group Message Delivery via MBS Broadcast



Figure 6.12.3.2-1: Group Message Delivery via MBS Broadcast.

NOTE 1: In the procedures referred to the TS 26.502 [11], the NEF is the MBS Application Provider.

1. The AF sends Group Message Request to the NEF, containing the Group Message Payload, MBS service area, Group Message Delivery Start Time, Stop Time, External Group Identifier.

2. The NEF checks authorization of AF. If geographical area information or civic address information was provided by the AF as MBS service area, the NEF translates the MBS service area to Cell ID list or TAI list.

NOTE 2: The NEF is mandated for group message delivery.

3. The NEF transforms the group message payload into a file, and determines the meta data information of the file (e.g. File URL, etc.). The NEF assigns a TLTRI that identifies this Group Message Request.

If Application Service Provisioning hasn't been performed, step 4 to step 8 needs to be executed. Otherwise, they can be skipped.

4. The NEF performs Application Service Provisioning towards the MBSF as specified in step 1 in clause 5.2 of TS 26.502 [11], which including invoking Nmbsf\_MBSUserService\_Create and Nmbsf\_MBSUserDataIngestSession\_Create on the MBSF.

- The Target service area is set to MBS Service Area.

- The Distribution method is set to Object Distribution Method which is used for file delivery.

- The Distribution Operating Mode is set to File or Carousel depends on the decision of the NEF.

- The Object acquisition method is set to Push or Pull depends on the decision of the NEF.

5. The MBSF performs MBS Session Creation as specified in clause 7.1.1.2 or clause 7.1.1.3 of TS 23.247 [4].

6. The MBSF performs Distribution Session Provisioning as specified in step 2 in clause 5.2 of TS 26.502 [11]. The MBSF invokes Nmbstf\_MBSDistributionSession\_Create on the MBSTF, passing the parameters of the MBS Distribution Session received in step 4 to the MBSTF.

7. The MB-SMF initiates the MBS Session Start for Broadcast procedure as specified in step 2 to step 9 in clause 7.3.1 of TS 23.247 [4].

8. If the MBSF performs the service announcement, it initiates the MBS User Service Announcement as specified in step 3 in clause 5.2 of TS 26.502 [11]. The application may receive the appropriate information through the MBS-6 API from the MBS Client (see TS 26.502 [11]). The NEF may receive the service announcement information via Nmbsf\_MBSUserDataIngestSession\_StatusNotify callback service operation (see TS 26.502 [11]).

9. The NEF sends Group Message Response to the AF, containing TLTRI, Acceptance Status, Cause. The Acceptance Status indicates whether the group message request is accepted or not. If not, the Cause indicates the appropriate failure reason. If the AF performs the service announcement, the service announcement information containing the file meta data can be optionally included in the Group Message Response.

10. If the AF needs to perform the Service Announcement, the AF sends the application service announcement to the UE as specified in step 4 in clause 5.2 of TS 26.502 [11].

11. The NEF performs the User Data Ingestion towards the MBSTF as specified in step 5 in clause 5.2 of TS 26.502 [11]. The NEF may push the file to the MBSTF or let MBSTF pull the file from the NEF.

12. The MBSTF performs packetization and optionally FEC encoding as specified in clause 4.3.3.2 of TS 26.502 [11].

13. The MBSTF delivers the packets to the MB-UPF to NG-RAN, and NG-RAN broadcast to the UE as specified in step 13 to step 15 in clause 7.3.1 of TS 23.247 [4].

14. Based on the service announcement information received in step 8 or step 10, the UE receives the packets, is required performs FEC decoding to restore the file, and gets the group message from the file, using the MBS Client as specified in clause 4.3.5 of TS 26.502 [11]. The MBS Client can expose the file towards the application in the UE using the MBS-7 API (see TS 26.502 [11]).

15. The NEF sends a Group Message Delivery to the AF, containing TLTRI, Delivery Status. The Delivery Status indicates whether delivery of Group Message Payload corresponding is successful or not. The delivery status information is received by the NEF via Nmbsf\_MBSUserDataIngestSession\_StatusNotify callback service operation (see TS 26.502 [11]).

#### 6.12.3.3 Modification of previously submitted Group message



Figure 6.12.3.3-1: Modify or Cancel Group Message Delivery via MBS Broadcast

NOTE: In the procedures referred to the TS 26.502 [11], the NEF is the MBS Application Provider.

1. The AF sends Modify Group Message Request to the NEF, containing the TLTRI, Request Action, Group Message Payload, MBS service area, Group Message Delivery Start Time, Stop Time, External Group Identifier. The NEF identifies the associated MBS Service using the external Group Identifier. Requested Action is either set to "Modify", or "Cancel". "Modify" indicates the request is to modify the group message delivery transaction. "Cancel" indicates the request is to cancel the group message delivery transaction. The TLTRI indicates the transaction to be modified or cancelled.

2. The NEF checks authorization of AF. If geographical area information or civic address information was provided by the AF as MBS service area, the NEF translates the MBS service area to Cell ID list or TAI list.

If Requested Action is "Modify" and Group Message Payload is updated, step 3 to step 6 are executed:

3. The NEF transforms the group message payload into a file, and use the determined file meta data (e.g. File URL, etc.) in clause 6.12.3.2.

4. If Object acquisition method is set to Push, step 4 to step 5 can be skipped. If Object acquisition method is set to Pull, the NEF updates MBS User Data Ingest Session on the MBSF as specified in clause 7.2 of TS 26.502 [11]. The update service operation needs to indicate an update of the file containing the updated group message.

5. The MBSF updates MBS Distribution Session on the MBSTF as specified in clause 7.3 of TS 26.502 [11]. The update service operation needs to indicate an update of the file containing the updated group message.

6. If Object acquisition method is set to Push, the NEF pushes the update file to the MBSTF. If Object acquisition method is set to Pull, the MBSTF pull the updated file from the NEF. And the MBSTF delivers the updated file towards the MB-UPF in 5GC as specified in clause 4.3.3.2 of TS 26.502 [11].

If Requested Action is "Modify" and MBS service area is updated, step 7 to step 8 are executed:

7. The NEF updates MBS User Service on the MBSF as specified in clause 7.2 of TS 26.502 [11]. The update service operation indicates MBS service area update.

8. The MBSF performs MBS Session Update as specified in clause 7.1.1.6 or clause 7.1.1.7 of TS 23.247 [4] to update MBS service area, which triggers MBS Session Update for Broadcast as specified in clause 7.3.3 of TS 23.247 [4].

If Requested Action is "Cancel", step 9 to step 14 are executed: step 9 to step 11 are needed when the group message delivery has started and MBSF needs to inform the MBS Client about the cancel of the file delivery. Otherwise, they can be skipped.

9. The NEF updates MBS User Data Ingest Session on the MBSF as specified in clause 7.2 of TS 26.502 [11]. The update service operation needs to indicate the cancel of the file delivery. The MBSF informs the MBS Client about the cancel of the file delivery if needed.

10. If Object acquisition method is set to Pull, the MBSF updates MBS Distribution Session on the MBSTF as specified in clause 7.3 of TS 26.502 [11]. The update service operation indicates the cancel of the file delivery. The MBSTF stops the file delivery.

11. If Object acquisition method is set to Push, the NEF may send HTTP DELETE to the MBSTF to cancel the file delivery. The MBSTF stops the file delivery.

12. The NEF destroys MBS User Data Ingest Session on the MBSF as specified in clause 7.2 of TS 26.502 [11].

13. The MBSF destroys MBS Distribution Session on the MBSTF as specified in clause 7.3 of TS 26.502 [11].

14. The MBSF performs MBS Session Deletion as specified in clause 7.1.1.4 or clause 7.1.1.5 of TS 23.247 [4], which triggers MBS Session Release for Broadcast as specified in clause 7.3.2 of TS 23.247 [4].

15. The NEF sends Modify Group Message Response to the AF, containing Acceptance Status, Cause. The Acceptance Status indicates whether the group message request is accepted or not. If not, the Cause indicates the appropriate failure reason.

After the modified group message is delivered, the NEF sends a Group Message Delivery to the AF as described in step 15 in clause 6.12.3.2.

### 6.12.4 Impacts on services, entities and interfaces

Functional entities defined in clause 5.3.2 of TS 23.247 [4] and clause 6.2 of TS 23.501 [2] are reused exception for the following additions:

NEF:

- Support group message delivery and modify group message interfaces towards AF, and optionally include the service announcement information in the group message delivery response to the AF.

- Transform the group message into a file and determine the meta data information of the file.

- Create MBS User Service and MBS User Data Ingest Session to the MBSF in group message delivery.

- Update MBS User Service to the MBSF for MBS service area update. Update MBS User Data Ingest Session to the MBSF when the group message is updated.

- Optionally update MBS User Data Ingest Session to the MBSF to cancel the file or DELETE the file to the MBSTF, when the group message delivery has started and MBSF needs to inform the MBS Client about the cancel of the file delivery. Destroy MBS User Data Ingest Session to the MBSF.

- Ingest file to the MBSTF.

## 6.13 Solution #13: Group message delivery for broadcast

### 6.13.1 Introduction

This solution addresses Key Issue #4.

### 6.13.2 Functional description

It is assumed to reuse the current architecture and TMGI definition in Rel-17 MBS work (see TS 23.247 [4]). In other words, MB-SMF is used to handle MBS session-level management while SMF performs per-UE MBS session management, e.g. authorization, multicast session information provisioning, managing 5GC Individual MBS traffic delivery.

For group message delivery, it mainly targeted for the Machine type communication services. The group message delivery has limited applicability and does not support all the scenarios, e.g. UEs not supporting MBS, UEs located in areas where MBS is not deployed.

In TS 23.682 [6], features of group message delivery are highlighted as follows:

*- "The specific procedure handling for group message delivery using MBMS is described in clause 5.5.1. The group message delivery using MBMS has limited applicability and does not support all the scenarios, e.g. UEs not supporting MBMS, UEs located in areas where MBMS is not deployed. The SCS/AS may recall or replace a previously submitted MBMS message; this is described in clause 5.5.2."*

This solution proposes how to use MBS for group message delivery for the case when the UEs locate in the area where MBS is not deployed. This architecture can be re-used for general group message delivery purposes (not limited to MTC devices).

Compared with Rel-17 defined mechanism, the case that UEs located in areas where MBS is not deployed needs to be considered for broadcast.

NOTE: This solution assumes that the AF is aware of the exact location of UEs.

### 6.13.3 Procedures

#### 6.13.3.1 General

NOTE: The message names in the procedures below are descriptive. It is assumed that the names are updated with corresponding SBI based names where applicable during the normative phase.

#### 6.13.3.2 Broadcast Session Establishment



Figure 6.13.3.2-1: Broadcast Session Establishment for Group message delivery

The procedure is based on clauses 7.3.1 and 7.1.1.1/7.1.1.2 of TS 23.247 [4], and clause 5 of TS 26.502 [11], the delta parts is highlighted at following:

0. AF optionally requests the 5GC to allocate the TMGI, details see steps 1-6 of TS 23.247 [4]. AF may send service announcement to the UEs.

1. The AF later further request to establish the MBS session, with including the requested MBS service area in Group message delivery request sent to NEF. If the TMGI is available (step 0 is executed), AF also includes the TMGI in the message. When included, Group Message Payload indicates the payload the AF intends to deliver.

2. NEF authorizes the request sent by AF, and the NEF may map the MBS service area to TA list or a list of cell ID.

3. NEF figures out the area which does not support MBS.

If Service Mode is used, or MBSF is not involved, step 4-6 are skipped:

4. NEF invokes Nmbsmf\_MBSSession\_Create Request, and uses the area supporting MBS as the MBS service area in the message.

5. MB-SMF continues the MBS Session Creation procedure as defined in TS 23.247 [4].

6. MB-SMF sends the response message to NEF. If MBSF is involved, the message will go through MBSF.

NOTE: For Transport Only Mode, it is assumed 5GC will not processing the ingested data therefore the AF is assumed to provide the functionalities e.g. reliability if needed.

If Transport Only Mode is used, step 7-12 are skipped:

7. If the Group Message Payload is included, and if Object Distribution Method is used, the NEF transforms the group message payload into a file.

NEF invokes Nmbsf\_MBSUserService\_Create Request, and uses the area supporting MBS as the MBS service area in the message. NEF also sends Nmbsf\_MBSUserDataIngestSession\_Create Request message to the MBSF in which the MBS service area is the area supporting MBS. If Object Distribution Method is used, the "PUSH" mode may be used if the NEF is not assumed to support buffering the DL data.

8. MBSF invokes Nmbsmf\_MBSSession\_Create Request.

9. Same as step 5.

10. MB-SMF sends Nmbsmf\_MBSSession\_Create Response message to MBSF.

11. MBS Distribution Session is created as defined in TS 26.502 [11].

12. MBSF responses the messages from NEF in step 7.

13. NEF responses AF with Group message delivery response. NEF includes the areas in the requested MBS service area that do not support MBS. NEF may also send the address to the AF.

14. AF may send service announcement.

15. For the UEs locating out of the supported area, AF uses unicast for sending the data to the UE.

16. If Group Message Payload was included in step 1, then the NEF delivers to MBSTF/MB-UPF the Group Message Payload(s). If Group Message Payload was not included in step 1, the AF transfers the content to be delivered to the group to the NEF using the address received at step 13.

If Object Distribution Method is used, the NEF transforms the subsequent message into a file and sends the file to MBSTF. If Object Distribution Method is not used, the NEF will not process the message and directly delivers the group message payload to MB-UPF. As mentioned in the NOTE of step 6, AF is assumed to provide the reliability if needed.

#### 6.13.3.3 Modification of previously submitted group message

0. The pre-condition for this flow is the successful completion of step 13 from clause 6.13.3.2.

1. AF may send service announcement to the UEs, to enable UE to retrieve the related service information, e.g. TMGI, start time, etc.

2. The AF requests to modify the previously accepted Group Message Delivery Request. The AF sends the Modify Group Message Request to the NEF. MBS service area might be included in the message. When included, Group Message Payload indicates the payload the AF intends to deliver. The Requested Action is either set to "Modify", or "Cancel". "Modify" indicates the request is to modify the transaction. "Cancel" indicates the request is to cancel the transaction.

3. NEF authorizes the request sent by AF. The NEF may map the MBS service area to TA list or a list of cell ID.

If Requested Action was set to "Cancel":

4a. If Transport Only Mode is used: NEF invokes the MBS session deletion procedures defined in clause 7.1.1.4 or 7.1.1.5 of TS 23.247 [4].

4b. If Service Mode is used: NEF invokes Nmbsf\_MBSUserDataIngestSession\_Destroy, and Nmbsf\_MBSUserService\_Destroy service operation to destroy the data ingest session and User service, respectively. MBSF invokes Nmbstf\_MBSDistribtutionSession\_Destroy service operation to destroy the distribution session.

If Requested Action was set to "Modify":

5a. If Transport Only Mode is used: NEF invokes the MBS session update procedures defined in clause 7.1.1.6 or 7.1.1.7 of TS 23.247 [4].

5b. If Service Mode is used: NEF invokes Nmbsf\_MBSUserService\_Update service operation to update the user service, if the AF requests to update the MBS service area, or QoS. If the Group Message Payload is included, and if Object Distribution Method is used, the NEF transforms the group message payload into a file. NEF may invoke Nmbstf\_MBSDistribtutionSession\_Update service operation, if the AF requests to update the QoS or file.

The NEF may further invoke MBS session update procedures defined in clause 7.1.1.6 or 7.1.1.7 of TS 23.247 [4].

6. NEF responses AF with Group message delivery response.

### 6.13.4 Impacts on services, entities and interfaces

Functional entities defined in clause 5.3.2 of TS 23.247 [4] is reused exception for the following additions:

**NEF**:

- Support differentiating the area with supporting MBS and non-supporting MBS.

- Support responding AF with the information that not supporting MBS.

- User plane handling of the group communication message.

## 6.14 Solution #14: MBS coexistence with power saving mechanisms of 5GS

### 6.14.1 Introduction

This is a solution for Key Issue #5.

Clause 4.5.18 of TS 23.682 [6] defines the mechanisms for co-existence between eMBMS and the power saving mechanisms that exist in EPS. The basic premise is that the time intervals the UE stays awake to receive MBMS user service or to discover if there is any MBMS user service scheduled for delivery, should not necessarily be the same as the reachable intervals negotiated for extended idle mode DRX or PSM.

### 6.14.2 Functional description

Same as in EPS, for 5GS also this solution proposes that the time intervals the UE needs to be awake for MBS service may not coincide with the wake up time windows mandated by eDRX (PTW) and/or MICO with active time (periodic Registration Update + active time) configuration.

For those intervals the UE needs to be awake for MBS user service, the following cases can be identified:

**Scenario 1:**

When the UE needs to be awake due to MBS coinciding with the UE already being in connected mode due to other reasons, the UE follows normal connected mode procedures.

**Scenario 2:**

When the UE needs to be awake due to MBS coinciding with the UE already being in idle mode and reachable (e.g. in active time for MICO or PTW for eDRX) the UE follows normal idle mode procedures.

**Scenario 3:**

When the UE needs to be awake due to MBS coinciding with the UE being in idle mode and in deep sleep, i.e. unreachable for paging to the network, the UE leaves the deep sleep for MBS service only:

- If the MBS service does not require the UE to transition to connected mode, i.e. the UE can receive the specific MBS service in idle mode using MBS broadcast, then the UE does not update the AMF to become reachable for paging. In other words, the UE would still be considered unreachable for paging in the core network. This minimizes the signalling between the UE and the network.

- If the MBS service requires the UE to transition to connected mode (e.g. MBS service that requires MBS multicast mode) then the UE performs regular procedures for CM connected mode. This would therefore make the UE become reachable.

**Scenario 4:**

When the UE is in the middle of an MBS data transfer, and the UE is scheduled to move to deep sleep due to power saving, e.g. end of PTW for eDRX, expiration of active time for MICO or the UE transitioning from CM-CONNECTED to CM-IDLE in the case of MICO with no active time, then the UE does not go to deep sleep during the remainder of the MBS data transfer:

- If at the end of MBS data transfer, the UE knows there is another MBS data transfer scheduled soon, in that case depending of the time between MBS data transfers, the UE may not go to sleep between MBS data transfers.

- The UE may in fact not go to deep sleep while in an MBS broadcast session.

### 6.14.3 Procedures

With extrapolation of the procedures defined in TS 23.682 [6] to 5GS power saving mechanisms and MBS the following is defined:

1. When the UE needs to be awake due to MBS coinciding with the UE already being in connected mode due to other reasons, the UE follows normal connected mode procedures.

2. When the UE needs to be awake due to MBS coinciding with the UE already being in idle mode and reachable (e.g. in active time in MICO or PTW for eDRX) the UE follows normal idle mode procedure.

3. When the UE needs to be awake due to MBS coinciding with the UE being in idle mode and in deep sleep, i.e. unreachable for paging to the network, the UE leaves the deep sleep state only to perform procedures related to MBS service.

- If the MBS service does not require the UE to transition to connected mode, i.e. the UE receives MBS service in broadcast mode and therefore can be in idle mode, then the UE does not update the AMF to become reachable for paging. The UE would therefore still be considered unreachable for paging in the AMF. This minimizes the signalling between the UE and the network.

- If the MBS service requires the UE to transition to connected mode (e.g. reception in MBS multicast mode) then the UE performs regular procedures for MBS multicast mode defined in TS 23.247 [4]. This would therefore make the UE become reachable in the network for other unicast services.

4. When the UE is in the middle of an MBS data transfer, and the UE is scheduled to move to deep sleep due to power saving, e.g. end of PTW for extended idle mode DRX, expiration of active time for MICO or the UE transitioning from CM-CONNECTED to CM-IDLE in the case of MICO with no active time, then the UE does not go to deep sleep during the remainder of the current MBS data transfer.

NOTE 1: If the NG-RAN node knows the UE is within a certain MBS session, the NG-RAN node will not configure the eDRX >=10.24s for the UE upon transiting the UE into CM-CONNECTED with RRC-Inactive state. The UE shall disable the MICO mode, after it successfully joins the MBS session.

NOTE 2: If at the end of the current MBMS data transfer, the UE knows there is another MBMS data transfer scheduled soon, in that case depending of the time between MBS data transfers, the UE can decide to go to sleep between MBS data transfers.

There are two possible ways the UE can be notified of an upcoming MBS broadcast session start:

1. If MBS User Services defined in TS 26.502 [11] is used, the UE needs to receive MBS service announcement while awake (i.e. while in connected mode, or while idle mode during PTW for extended idle mode DRX, or active time for MICO). The UE wakes up if not already awake for MBS service reception based on the schedule received in the service announcement. For this option, the MBS service announcement may be provided via MBS broadcast service announcement or via any of the possible unicast service announcement delivery mechanisms. In case the MBS service announcement is provided in application layer, similar mechanisms need to be provided.

NOTE 3: In order to allow all UEs using power saving function to receive the service announcement in time to be able to receive the MBS broadcast data delivery, the application server needs to be aware of the maximum unreachable period of the UEs.

2. The UE may be configured by the application server with specific times to perform MBS procedures, and wakes up from deep-sleep if needed at those times. The UE may also receive MBS service announcements and/or MBMS broadcast delivery at those times (if needed).

NOTE 4: The configuration (e.g. TMGI, start time) is out of scope of 3GPP and assumed to be performed between application server and UE at application layer. The application server needs to initiate MBS bearer service procedures during those time intervals.

### 6.14.4 Impacts on services, entities and interfaces.

In UE:

- Handle potential wake up out of deep sleep due to power saving (e.g. eDRX, MICO with active time) for MBMS user service session/data transfer when it knows a scheduled broadcast it is interested in receiving.

- Remain awake during reception of MBMS data transfer, even when power saving function would trigger moving to deep sleep (e.g. end of PTW in eDRX, end of active time in MICO).

- (The UE can already be configured by application server with maximum allowed delay tolerance, in this case it would be for MBMS service, which can translate to UE requesting specific eDRX cycle or periodic TAU).

- Configuration for periodic wake ups for MBMS and UE behaviour when waking up only for MBMS service.

In NW:

- No standards impacts.

- Service announcement needs to be started at least an eDRX cycle or periodic Registration Update length earlier than the actual data broadcast.

- If UE belongs to some certain MBS sessions, RAN will not configure the long eDRX parameter for the UE upon transiting the UE into CM-CONNECTED with RRC-Inactive state.

In AS:

- The application server needs to trigger start for service announcement at least an eDRX cycle or periodic Registration Update length earlier than the actual data broadcast.

## 6.15 Solution #15: Solution for coexistence of MBS delivery and power saving mechanisms

### 6.15.1 Functional description

This solution addresses Key Issue #5 (Coexistence with existing power saving mechanisms for capability-limited devices).

Capability-limited devices may use power-saving mechanisms to extend their battery live. Existing power saving mechanisms include MICO (Mobile Initiated Connection Only) mode, DRX (Discontinuous Reception), eDRX (Extended Discontinuous Reception).

When an MBS Session data delivery is required (e.g. for software/firmware update) is required, service announcement is needed. The service announcement using MBS Session data delivery may not be efficient from the network perspective since the capability-limited devices are not expected to be awake throughout the day, but only infrequently. Furthermore, the capability-limited devices do not wake-up at the same time and they are not reachable while being in power saving mode.

This solution proposes to inform the capability-limited devices about a newly scheduled MBS Session data delivery during their wake-up periods when the devices are reachable. When MBS Session data delivery is required, the MBS Session data delivery time can be scheduled as follows:

- When a new MBS delivery schedule for capability-limited devices become available, the network will send a service announcement to inform the UEs about the new schedule when they are reachable.

- The time interval from when MBS Session data delivery schedule is announced to when the first MBS Session data delivery as announced by that schedule will start can be shorter than the minimum power saving period of all capability-limited devices.

- The network may schedule multiple MBS deliveries. If at the end of the current MBS Session data delivery, the UE knows there is another MBS Session data delivery scheduled soon, in that case depending on the time between MBS Session data deliveries, the UE can decide to go to power saving between MBS Session data deliveries.

Editor's note: Regarding the coexistence of multicast MBS Session data delivery with capability-limited devices, the dependency with KI#1 is FFS.

### 6.15.2 Procedures

Existing procedure for 5MBS is used.

Editor's note: SA WG4 collaboration is required.

### 6.15.3 Impacts Analysis

**UE:** The UE needs to wake up according to the time scheduled for MBS delivery received in service announcement.

## 6.16 Solution #16: Public Safety services offered over both Broadcast and Multicast transport

### 6.16.1 Description

#### 6.16.1.1 General

This is a solution for Key Issue #6.

5G Broadcast and 5G Multicast services cater and are optimal in different scenarios:

- The more sparse the UEs receiving a same content are, the larger the service area, the more attractive using 5G Multicast is.

- The more concentrated in an area the UEs receiving a same content are, the more attractive using 5G Broadcast may become.

This solution consists on identifying areas of concentrated number of UEs for which 5G Broadcast services would be the optimal transport, areas of sparse UEs receiving the same public safety service for which multicast transport would be useful. Configuring Broadcast service and Multicast service for the same public safety service, and allow the UE to decide whether to receive the public safety MBS content via broadcast service if available, or multicast session.

The solution relies on GCS AS (MCX AS) activates MBS broadcast session in broadcast service areas where MBS capable UEs are or are expected to be located. For that, the GCS AS (MCX AS) shall use the MBS SAI(s) and/or cell id(s) information to construct the MBS broadcast area parameter. LMS will configure the LMC as defined in TS 23.280 [7] for the parameters to report and determine the "granularity" and "frequency" of location reports.

NOTE This solution requires that UEs provide accurate location reports to the GCS AS to enable the GCS AS to determine where UEs are concentrated. Those location reports require that UEs are in connected state and may lead to capacity bottlenecks. It is a trade-off between accuracy and frequency of the location reports and how fast switching between broadcast and multicast can be achieved.

#### 6.16.1.2 Functional description

NOTE 1: The use of GCS AS in reference to this solution refers to stage-2 procedures defined in TS 23.468 [12] and are used for public safety IMS procedures defined in SA6 specifications for GC-1/MCPTT-1 interface. The interface between GCS AS and 5GC is not restricted to be MB2 only. Possible enhancements to other interfaces e.g. xMB, Nmb8 and Nmb10 are possible.

NOTE 2: The term GCS AS is currently used in EPS only and not same in the context of this solution, the name to be used in 5GS only architecture is FFS.

The functional description of the solution is as follows:

1. GCS AS requests to establish a Broadcast service in a "Broadcast" Service Area to 5GC via MBS Session Start for Broadcast procedure (see TS 23.247 [4] clause 7.3.1), where the Broadcast Service Area is an identified area where of concentrated large number of UEs.

2. GCS AS also requests to establish a Multicast Service in a "Multicast" Service Area to 5GC via MBS Session Creation Procedure (see TS 23.247 [4] clause 7.1.1.2 or 7.1.1.3), where the Multicast Service Area is an identified area for Public Safety service that is larger than the Broadcast Service Area. Multicast and Broadcast service areas may overlap.

3. GCS AS configures the UE with both the Multicast service information (with its respective MBS session ID/TMGI) and the Broadcast service information (with its respective MBS Session ID/TMGI) and indicates to the UE that they correspond to the same public safety service. This can for example be done by allowing to include 2 TMGIs instead of one in service description that is sent to the UE in SIP. MESSAGE using the <announcement> parameter. The exact formatting and changes required to the XML format defined in TS 24.379 [8] will be decided in stage-3.

4. Both Broadcast Service Area (as in Service announcement) and Multicast Service Area (as part of Service announcement or NAS signalling) may be known to UE.

5. The UE may join the Multicast session based on the received information from the GCS AS.

6. If UE based approach for the switching is used, when UE is in Broadcast Service Area, and the UE detects the Broadcast Service is available, the UE enables reception of Broadcast MBS session ID, and if already joined ignores reception of Multicast MBS session ID internally.

If NG-RAN based approach for the switching is used, the procedure in clause 6.16.2.3b is followed.

7. When the UE is outside Broadcast Service Area, and in Multicast Service area the UE receives MBS service in multicast mode. If not already joined, the UE initiates UE join procedure for the Multicast Session.

### 6.16.2 Procedures

#### 6.16.2.1 GCS AS configuration of both Broadcast and Multicast Services



Figure 6.16.2.1-1: GCS AS configuration of both Broadcast and Multicast Services

Figure 6.16.2.1-1 shows the order of procedure execution for a GCS AS to provide a same public safety service via broadcast session in a specific service area and via Multicast session in a larger service area.

NOTE: In Figure 6.16.2.1-1 the 5GC CP (control plane) denotes for simplicity all transport 5GC NFs relevant to MBS procedures, e.g. MB-SMF, MB-PCF, SMF, AMF, NRF, etc.

1. In order to establish a Multicast session, the GCS AS initiates MBS Session Creation as defined in either clause 7.1.1.2 of TS 23.247 [4] (for case without PCC) or clause 7.1.1.3 of TS 23.247 [4] (for case with PCC). The GCS AS receives Multicast Session information.

2. The GCS AS may provide to UE(s) the Multicast session information necessary for the UE to join the Multicast session (i.e. TMGI for Multicast session).

3. UE may trigger UE join and Session establishment procedure (see clause 7.2.1 of TS 23.247 [4]) using the TMGI for Multicast provided by GCS AS.

4. When there is MBS data the GCS AS initiates MBS Session Activation for the Multicast TMGI (see clause 7.2.5.2 of TS 23.247 [4]). Step 4 may occur in parallel with steps 5 to 7.

5. The GCS AS may decide to establish a Broadcast session in a specific service area, e.g. based on UE reports in GC1/MCPTT-1 interface and detection of large number of UE receiving the same public safety service in a same area.

6. Based on the decision of step 5, the GCS AS initiates MBS session start for broadcast procedure as defined in TS 23.247 [4] for a Broadcast TMGI.

7. The GCS AS provides to UEs the information for broadcast reception, including the TMGI allocated for the Broadcast session.

8. A UE that has received both the Broadcast session information (including TMGI for Broadcast session) and Multicast session information (including TMGI for Multicast session) for the same service, determines whether to receive the public safety data via broadcast session or multicast session.

8.a. If the UE detects that the Broadcast session is available, UE enables reception of Broadcast for the TMGI allocated for the broadcast session, and if already joined ignores reception of Multicast internally. The UE may ignore a paging with the TMGI allocated for the Multicast session.

8.b. If the UE does not detect that Broadcast session is available, and the UE joined the multicast MBS session in step 3, when it receives paging during MBS session activation for the TMGI allocated for Multicast, the UE follows the behaviour defined in clause 7.2.5 of TS 23.247 [4].

#### 6.16.2.2 UE switching from Broadcast Reception to Multicast Reception

When a UE that is receiving public safety data via Broadcast session detects that it has moved to a cell that is not providing the broadcast session i.e. the UE detects it has stepped out of the Broadcast service data or if NG-RAN based suspension and resumption is used the related multicast radio bearer is "resumed", the UE proceeds as follows:

1. If the UE had not joined yet the corresponding Multicast session, the UE triggers MBS join and Session establishment procedure (see clause 7.2.1.3 of TS 23.247 [4]) using the TMGI allocated for Multicast session.

2. If the UE had already joined the corresponding Multicast session, the UE follows the procedures defined in TS 23.247 [4].

#### 6.16.2.3 UE switching from Multicast Reception to Broadcast Reception (UE based)

When a UE that is receiving public safety data via Multicast session detects that it has moved to a cell that is providing the broadcast session, i.e. the UE detects it has stepped inside of the Broadcast service area, the UE proceeds as follows:

1. While the UE is in CM-CONNECTED receiving the Multicast data, the UE should maintain this Multicast reception if still available. This avoids ping pongs when the UE steps in and out of the Broadcast service area.

2. Following a CM-CONNECTED to CM-IDLE transition, the UE may decide to receive public safety data via Broadcast session, e.g. at next Broadcast Session Start.

#### 6.16.2.3b UE switching from Multicast Reception to Broadcast Reception (NG-RAN based)

The UE based option for switching from multicast reception to broadcast reception assumes that the same content is provided in the same cell using both multicast and broadcast delivery modes.

In the case of congestion in multicast session, the related Multicast Radio Bearer (MRB) may also be 'suspended' by NG-RAN and the UE becomes aware using AS signalling.

For example, the UE may receive an explicit indication broadcast from the NG-RAN (similar to what is defined for E-UTRAN in MBMS Scheduling Information in TS 36.300 [15] and TS 36.321 [16]), where it is informed that transmission for the multicast MBS bearer is going to be, or has been, suspended or using other mechanisms decided by RAN.

Editor's note: The details of the AS procedures e.g. whether these are the only possible procedures or other procedures can be considered will be decided in RAN WGs.

The procedure used by the UE in these scenarios is depicted in figure 6.16.2.3b-1.



Figure 6.16.2.3b-1: Switching MBS Delivery to Broadcast following bearer suspension by NG-RAN

1. The UE has an ongoing group communication using MBS multicast mode.

2. The GCS AS decides to set up the Broadcast Delivery path for the downlink data for this service following the procedure in clause 7.3.1 of TS 23.247 [4].

3. NG-RAN (e.g. after detecting MBS congestion) decides to suspend one or more MBS bearer(s) (based on e.g. the ARP and/or on the counting results for the corresponding MBS service(s)), and trigger the migration of impacted UEs to receive DL data MBS broadcast mode, by some AS signalling.

For example, explicitly informing those UEs that the MBS bearer has been, or is going to be, suspended by broadcasting an indication similar to what is defined for E-UTRAN in MBMS Scheduling Information in TS 36.300 [15] and TS 36.321 [16], or using other mechanism decided by RAN.

NOTE 1: The decision of suspend in NG-RAN is independent with the broadcast session start from GCS AS, if NG-RAN suspends the MRB based on RAN congestion situation, while the broadcast MBS session hasn't been started by AF based on AF counting, it will cause service interruption for those joined UEs.

4. The UE detects the suspension of the corresponding MBS bearer service, but continues to monitor for MBS Multicast mode delivery.

5. The UE receives DL data by broadcast delivery and continues to monitor for resumption of the MBS bearer. RAN removes the radio resources for the "suspended" MBS bearer(s).

NOTE 2: UE receiving "suspend" signalling for the MBS bearer does not affect the UEs RRC state. For example, if the UE is RRC\_CONNECTED for other unicast services, continues to be in RRC\_CONNECTED and switches to RRC\_INACTIVE or RRC\_IDLE based on existing RAN triggers.

NOTE 3: The data associated with the suspended MBS bearer continues to be delivered by the GCS AS on the corresponding multicast transport infrastructure towards NG-RAN (e.g. because it is still delivered via MBS in non-congested cells). This also allows a quicker resumption of the MBMS service when congestion is over.

### 6.16.3 Impacts on services, entities and interfaces.

On GCS AS:

- Decision of delivery method, between multicast, broadcast and unicast with potentially different service areas:

- Use of on UE reports in GC1/MCPTT-1 interface for decision.

- Configuration of UE of both Broadcast and Multicast session for same service.

On UE:

- Receive configuration from GCS AS of both Broadcast session with a TMGI and Multicast session with another TMGI for the same public safety service.

- Decide between reception of public safety data over Broadcast session of over Multicast session.

- Trigger switch from broadcast reception of public safety data and multicast reception of public safety data.

- Trigger switch from multicast reception of public safety data and broadcast reception of public safety data.

On 5GC and NG-RAN:

- No impacts for the UE based switching option.

- New procedure and signalling in NG-RAN to perform "suspend" and "resume" of Multicast Radio Bearers for the NG-RAN based option as defined in clause 6.16.2.3b.

## 6.17 Solution #17: Performance Improvements for Public Safety

### 6.17.1 Introduction

This solution addresses leverages the improvements in KI#1 and further improves the call setup time for high number of public safety UEs for Key Issue #6.

### 6.17.2 Functional description

This solution enables AMF to get UE join/leave information of a multicast MBS session, so that AMF can maintain the complete group paging information (i.e. list of UEs and the paging area) for the joined CM-IDLE UEs when multicast MBS session is inactive. This solution focuses on the optimization on group paging, which may help group call setup time.

When the MBS session activation request is received, AMF understands the multicast MBS session is activated. The AMF sends group paging request to MBS supporting NG-RAN nodes and individual paging request for non-MBS supporting NG-RAN nodes for those joined CM-IDLE UEs in the AMF. Usually, the MBS session activation request will reach the AMF prior to the enable group reachability request. In case the enable group reachability request reaches the AMF before the MBS session activation request, AMF can also trigger the group paging and individual paging. The AMF triggers paging once for one multicast MBS session activation procedure. The enable group reachability request or MBS session activation request received afterwards will not trigger the paging again.

NOTE 1: RRC\_Inactive UEs will be paged using the typically quicker MBS session activation request. They will also not need to send a service request and will thus not benefit from this solution in most cases.

NG-RAN triggers RAN paging based on MBS session activation request, which is supported in Rel-17.

Editor's note: It is up to RAN WG to determine whether RAN paging can be performed upon receiving group paging request, if the MBS session activation request has not been received.

In this way, CM-IDLE UEs and CM-CONNECTED UEs with RRC\_INACTIVE state can be notified for the multicast MBS session activation as early as possible.

When multicast MBS session is activated, NG-RAN is expected to provide a method for those CM-CONNECTED UEs with RRC\_INACTIVE state to enable them to receive multicast MBS session data without being RRC-CONNECTED.

Editor's note: It is up to RAN WG to determine how the method can provided (e.g. NG-RAN updates SIBx/MCCH) when the multicast MBS session is activated.

When CM-CONNECTED UEs with RRC\_INACTIVE state are notified by the RAN paging, they can utilize the method provided by NG-RAN or locally stored RRC configuration which was configured by NG-RAN before, to receive the multicast MBS session data, in parallel with sending RRC RESUME to the network.

Editor's note: It is up to RAN WG to determine whether RRC RESUME is needed for RRC\_INACTIVE UE to receive the MBS data.

As AMF maintains CM-IDLE UEs which join the multicast MBS session, it may constantly prepare the group paging information to avoid the processing of UE list included in enable group reachability request, before sending the group paging request. Besides benefits of earlier notification, this solution further minimizes the number of the group paging signals between the AMF and the NG-RANs. Regardless the number of involved SMFs, the AMF only needs to send at most one group paging request to each NG-RAN node for one multicast MBS session. However, compared to the subsequent per-UE service request, the number of saved messages is not significant.

NOTE 2: It requires that SMFs provide UE join/leave information outside N2SM information.

NOTE 3: The constant preparation of group paging information requires the additional processing for UE CM state changes, when multicast MBS session is inactive.

NOTE 4: The AMF needs to maintain backward compatibility with Rel-17 SMFs that will not provide information about the MBS session for the AMF. And for those Rel-17 SMFs, the AMF has to rely on the provided UE list from them for group paging.

NOTE 5: In mixed deployments with Rel-17 AMFs and/ or SMFs, the benefit of signalling reductions is not much.

### 6.17.3 Procedures

#### 6.17.3.1 General

NOTE: The message names in the procedures below are descriptive. It is assumed that the names are updated with corresponding SBI based names where applicable during the normative phase.

#### 6.17.3.2 UE join multicast MBS session



Figure 6.17.3.2-1: UE join multicast MBS session

The following additions apply compared to clause 7.2.1.3 of TS 23.247 [4]:

5. In Nsmf\_PDUSession\_UpdateSMContext response, the SMF includes UE join information including the associated PDU Session ID and MBS Session ID outside the N2 SM information. The AMF stores the information and maintains the joined UE list of the MBS session with its associated PDU Session ID.

NOTE: Different AMFs may interact with the same RAN nodes for different PDU sessions. It is assumed that each such AMF only stores MBS session IDs and UE join information for the UEs it serves. Different AMFs also store information about the MBS session (MBS session ID and involver RAN nodes) when the shared delivery is established. Thus different information about the same multicast session may reside on multiple AMFs. It is assumed that no synchronisation is performed.

#### 6.17.3.3 UE leave multicast MBS session



Figure 6.17.3.3-1: UE leave multicast MBS session

The following additions apply compared to clause 7.2.2.2 of TS 23.247 [4]:

7. In Nsmf\_PDUSession\_UpdateSMContext response, the SMF includes UE leave information outside the N2 SM information. The AMF remove the UE from the joined UE list of the MBS session.

#### 6.17.3.4 Multicast session leave requested by the network or MBS session release



Figure 6.17.3.4-1: Multicast session leave requested by the network or MBS session release

The following additions apply compared to clause 7.2.2.3 of TS 23.247 [4]:

3. In Namf\_Communication\_N1N2MessageTransfer request, the SMF includes UE leave information outside the N2 SM information. The AMF remove the UE from the joined UE list of the MBS session.

#### 6.17.3.5 MBS Session Activation



Figure 6.17.3.5-1: MBS Session Activation

The following additions apply compared to clause 7.2.5.2 of TS 23.247 [4]:

**Paging:**

- At step 5 (enable group reachability request is received) or after step 11 (MBS session activation request is received), AMF performs group paging and individual paging based on joined UE list in the AMF, , when receiving an enable group reachability request from an SMF or MBS session activation request from the MB-SMF (if the AMF is used for shared delivery establishment), if the paging for the multicast MBS session hasn't been performed. The paging will be requested from each involved AMF once per MBS session activation procedure. A RAN node can receive paging request from multiple AMFs. A possible enable group reachability request or MBS session activation request received afterwards at the AMF from a different SMF will not trigger the paging again.

NOTE 1: Considering the service request handling contribute most of the latency for those CM-IDLE UEs, the early notification does not bring significant improvement on the group call setup time. However, the improved paging mechanism can reduce the signalling load between the AMF and the NG-RANs effectively depending on how much SMF serving this MBS session.

In step 11, to utilize MBS session activation request to trigger paging in the AMF, the MB-SMF needs to provide the MBS activation information to the AMF outside the N2 container.

NOTE 2: Steps 11 to 14 are required to reach those RAN nodes handling CM-CONNECTED UEs (including both RRC\_CONNECTED and RRC\_INACTIVE states).

Editor's note: It is up to RAN WG to determine whether RAN paging can be performed upon receiving group paging request in step 5, if the MBS session activation request has not been received.

**NG-RAN provide a method to allow UEs to receive multicast MBS session data without being RRC-CONNECTED:**

- After step 12, NG-RAN needs to provide a method for those CM-CONNECTED UEs with RRC\_INACTIVE state to enable them to receive multicast MBS session data without being RRC-CONNECTED.

Editor's note: It is up to RAN WG to determine whether and how the method can provided (e.g. NG-RAN updates SIBx/MCCH) when the multicast MBS session is activated.

**UE receives multicast MBS Session data without being RRC-CONNECTED**

- The CM-CONNECTED UE with RRC\_INACTIVE state is notified by CN-Paging in step 5 (if share the same Paging Occasion) or RAN-Paging in step 12. It utilizes the method provided by NG-RAN or utilizes the locally stored RRC configuration if it has such information and receives multicast MBS session data, in parallel with sending RRC RESUME to NG-RAN.

#### 6.17.3.6 N2 based Handover and IDLE Mobility

For N2 based handover, the following additions apply compared to clause 7.2.3.3 of TS 23.247 [4]:

3. In Nsmf\_PDUSession\_updateSMContext response, the SMF includes the UE join information to the T-AMF. The AMF stores/updates the information and maintains the joined UE list of the MBS session with its associated PDU Session ID.

For IDLE mobility, the following additions apply compared to the clause 4.2.2.2 of TS 23.502 [3]:

17. In Nsmf\_PDUSession\_updateSMContext response, the SMF includes the UE join information to the new AMF. The AMF stores/updates the information and maintains the joined UE list of the MBS session with its associated PDU Session ID.

### 6.17.4 Impacts on services, entities and interfaces.

Functional entities defined in clause 5.3.2 of TS 23.247 [4] are reused exception for the following additions:

SMF:

- Provide UE join information to the AMF when UE join the multicast MBS session.

- Provide UE leave information to the AMF when UE leave the multicast MBS session or when multicast session leave requested by the network or MBS session release.

- Provide UE join information to the T-AMF in N2 based handover and to the New AMF in IDLE mobility.

AMF:

- Receive UE join/leave information from the SMF in signalling related to the associated PDU session.

- Receive information about the MBS sessions a UE is participating in during N2 handover and IDLE mode mobility in signalling related to the associated PDU session.

- Maintain for each MBS session the joined UE list and the group paging information of the multicast MBS session.

- Trigger group paging and individual paging, when multicast MBS session activation request or enable group reachability request is received, if the paging for the MBS session activation hasn't been performed.

MB-SMF:

- Provide MBS activation information to the AMF when sending multicast MBS activation request.

NG-RAN:

- NG-RAN provides a method to configure those CM-CONNECTED UEs with RRC\_INACTIVE state to enable UEs to receive multicast MBS session data without being RRC-CONNECTED.

Editor's note: It is up to RAN WG to determine how the method can provided (e.g. NG-RAN updates SIBx/MCCH) when the multicast MBS session is activated.

Editor's note: It is up to RAN WG to determine whether RAN paging should be performed upon receiving group paging request, if the MBS session activation request has not been received.

UE:

- For CM-CONNECTED UEs with RRC\_INACTIVE state, when they are notified upon MBS session activation, they should utilize the method provided by NG-RAN or utilize the locally stored RRC configuration to receive multicast MBS session data, in parallel with sending RRC RESUME to NG-RAN.

## 6.18 Solution #18: MBS session management for RRC Inactive MBS data receiving UE

### 6.18.1 Introduction

This solution addresses Key Issue #1, especially on the enhancement of MBS session management for RRC Inactive MBS data receiving UE.

### 6.18.2 Functional description

This solution builds on top of solution 1. The multicast session management include following procedures:

- MBS session activation, for UEs in RRC-IDLE state, group paging may be performed to bring the UE to RRC\_CONNECTED as specified in TS 23.247 [4] for Rel-17.

Editor's note: For UEs in RRC-INACTIVE state, the handling of MBS Session Activation in NG-RAN is to be determined by RAN WGs.

- Multicast session deactivation/multicast session update, the existing procedure as defined in TS 23.247 [4] apply.

- Multicast session release, the handling for UEs in CM-IDLE or CM-CONNECTED with RRC-CONNECTED state follows clause 7.2.2.3 of TS 23.247 [4]. For UEs without activated UP, the following SMF behaviour in step 2 is assumed to avoid paging the IDLE UEs:

*Alternatively, for UEs without activated UP, the SMF does not trigger message to the AMF, instead the SMF marks that the UE is to be informed of the MBS Session release. In this case, the SMF initiates PDU Session Modification to inform the UE of the MBS Session release at next UP activation of the associated PDU Session, if needed.*

Editor's note: Paging procedures are under remit of the RAN groups and any related enhancements need to be confirmed by RAN groups.

### 6.18.3 Procedures



Figure 6.18.3.1-1: Multicast Session Activation/Release Procedure.

1. UE joins the multicast MBS session via the procedure as defined in clause 7.2.1.3 of TS 23.247 [4].

2. In some cases, e.g. due to radio resource shortage, NG-RAN could move one or multiple multicast group member UEs to RRC-INACTIVE state and those UEs are still able to received multicast MBS data.

3. The multicast MBS session becomes inactive via the procedure as defined in clause 7.2.5.3 of TS 23.247 [4]. The group member UE can be moved to any state (i.e. CM-IDLE or CM-Connected with RRC Connected/Inactive state).

4. After some time, MB-SMF triggers the multicast session activation or multicast session release.

5. MB-SMF sends Nmbsmf\_MBSSession\_ContextStatusNotify to SMF(s), same as step 2 of clause 7.2.5.2 or step 1a of clause 7.2.2.3 of TS 23.247 [4], which also includes the MBS session status, i.e. activation or release.

NOTE: Steps 1, 3-5 are same as the one defined in TS 23.247 [4].

6. Based on the event information, the SMF determines whether the event is for MBS session activation or MBS session release. The SMF invokes Namf\_MT\_EnableGroupReachability Request to AMF as specified in TS 23.247 [4].

Editor's note: Whether SMF needs to know that the function that RRC-INACTIVE UE can receive the MBS data is supported or not is FFS.

7. The AMF determines that there are UEs in CM-IDLE state among the UEs provided by the SMF in step 6, and triggers group paging as specified in TS 23.247 [4].

Editor's note: When group paging for CM-IDLE UE is performed, whether/how the RRC\_INACTIVE UE(s) sharing the same PO will respond and whether related signalling extensions are required is to be decided by RAN WGs.

8. The NG-RAN performs the group paging by sending the MBS session ID.

Editor's note: How to handle RRC-inactive UE(s) that joined the MBS session and is able to receive multicast service in RRC-INACTIVE state is to be determined by RAN WGs.

Editor's note: It needs to be confirmed that RRC-INACTIVE UEs also listen to the paging for RRC IDLE UEs, and not only to RAN paging.

Editor's note: It is FFS whether and how UEs, NG-RAN nodes, or AMF also need to consider the transmission mode used in the cell where the UEs are comping to decide whether they can remain in RRC-INACTIVE state.

For the UE(s) joined the MBS session and need receive multicast service in RRC-Connected state, the handling specified in TS 23.247 [4] will apply.

9. For MBS session activation, steps 6-15 of clause 7.2.5.2 of TS 23.247 [4] applies.

Editor's note: After receive step 12 in clause 7.2.5.2 of TS 23.247 [4], it is to be determined by RAN WGs whether the NG-RAN need page the UE if the UE is in RRC Inactive state.

Editor's note: After receive step 12 in clause 7.2.5.2 of TS 23.247 [4], it needs clarify the behaviour of RRC-inactive UE after it receives the group paging of the related MBS session ID, e.g. whether it is allowed the UE to be aware it can receive the MBS data in RRC inactive state.

For MBS session release, steps 3-9 of clause 7.2.2.3 of TS 23.247 [4] is not executed as for UEs without activated UP, the SMF does not trigger message to the AMF, instead the SMF marks that the UE is to be informed of the MBS Session release. In this case, the SMF initiates PDU Session Modification to inform the UE of the MBS Session release at next UP activation of the associated PDU Session, if needed.

### 6.18.4 Impacts on services, entities, and interfaces

UE:

- For RRC\_INACTIVE UEs, multicast session activation is to be determined by RAN WGs.

Editor's note: Detailed impact will be determined by (and/or in collaboration with) RAN WGs.

## 6.19 Solution #19: Procedures for Transmission mode tor inactive data reception

### 6.19.1 Introduction

This solution addresses Key Issue #1.

### 6.19.2 Functional description

This solution builds on top of solution 1.

UEs that transition to RRC inactive mode can move freely in their RAN notification area without notifying the RAN nodes. Their location is thus not known at cell level. At the moment only the RAN node serving a UE is aware that it is participating in an MBS multicast session. Additional RAN nodes not handling RRC connected UEs within the multicast session but within RAN notification areas of those UEs may need to be made aware of the multicast session and perform procedures for the multicast session, such as deciding whether to deliver data for the MBS session and choosing the delivery mode, transmitting data of the multicast session and managing the related the shared delivery path.

Editor's note: Related procedures need to be defined by RAN WGs. It also needs to be studied by RAN WGs whether it is possible to determine the presence of inactive UEs that desire to receive a multicast session in a cell. and whether and how a RAN can decide whether to deliver multicast data in cells without RRC connected UEs. Whether additional RAN nodes not handling RRC connected UEs within the multicast session need to be made aware of the multicast session and perform procedures for the multicast session needs to be decided by RAN WGs.

RAN nodes not serving any connected UEs in the MBS sessions may thus need to be aware of the MBS session. This solution describes two option to accomplish that with CN impacts:

**Option A**: RAN nodes inform their peers serving parts of RAN notification areas of UEs in an MBS session about the MBS session. The peer RAN nodes request assistance information from the CN via shared delivery establishment.

**Option B**: The MB-SMF informs all RAN nodes in a service area of an MBS session via the AMF about the MBS session

Editor's note: The RAN-centric option A is in scope of RAN WGs to a large extent. Whether this option is selected thus depends on RAN WGs.

Editor's note: How the NG-RAN node determines transmission at one cell is not needed due to no UE camped at that cell need be solved by RAN WG.As service areas are optional for multicast MBS sessions, all RAN nodes in a PLMN are possible affected by Option B.

NOTE 1: It may be preferable to only inform RAN nodes within RAN paging areas.

RRC\_inactive UEs can move to cells where the transmission mode for RRC connected state is applied and then need to transition to the RRC connected state to receive MBS data.

The current MBS session activation procedures use paging for the MBS session and trigger RRC-inactive UEs to transition to RRC-connected state. For the delivery mode for RRC\_inactive reception, RRC-inactive UEs should be made aware that the MBS multicast session is activated but remain in RRC-inactive state for multicast data reception.

NOTE 2: It is not assumed all the RAN node within the same RNA area have the same capability and choose the same delivery mode.

Editor's note: This assumption needs to be confirmed by RAN WGs. Procedures to support UEs that move between cells with different delivery mode need to be agreed by RAN WGs.

### 6.19.3 Procedures

#### 6.19.3.1 Moving a UE to RRC Inactive state and providing assistance information to additional RAN nodes (Option A)



Figure 6.19.3.1-1: NG-RAN node moves a UE in 5MBS session to RRC Inactive state

0. UE joined an MBS session and receives MBS data while in RRC connected state

1. NG-RAN 1 uses assistance information to decide whether to apply the delivery mode for RRC-inactive reception for an MBS session, and whether to move one or several UEs in MBS session to RRC inactive state.

2. RAN internal procedures.

3. NG-RAN 1 determines that part of the RAN notification areas of the UEs is served by NG-RAN 2. It informs NG-RAN 2 that handling of the MBS session for inactive UEs is required in that area,

Editor's note: Depending on RAN decision, assistance information for MBS might be transferred in that step.

4. The NG-RAN 2 establishes shared delivery with MB-SMF. The MB-SMF transmits assistance information as defined in solution 1for inactive reception in the shared delivery response.

5. RAN internal procedures at NG-RAN 2 to handle MBS session.

NOTE: Transfer of assistance information and shared delivery to additional RAN nodes has system impacts in SA WG2 scope.

#### 6.19.3.2 MBS service activation



Figure 6.19.3.2-1: MBS service activation

1. When triggered according to step 11 of Figure 7.2.5.2-1 of TS 23.247 [4], AMF sends NGAP activation request message to NG-RAN nodes.

2. Related RAN procedures. RAN nodes decides whether to deliver in mode for RRC inactive reception, and otherwise will perform RAN paging. For the delivery mode for RRC\_inactive reception, RRC-inactive UEs should be made aware that the MBS multicast session is activated but remain in RRC-inactive state for multicast data reception.

3. NG-RAN 1 determines that part of the RAN notification areas of UEs in MBS session is served by NG-RAN 2. It requests NG-RAN 2 to perform RAN paging for MBS session,

NOTE: Depending on RAN decision, assistance information for MBS might be transferred in that step.

4. If not yet done, the NG-RAN 2 establishes shared delivery with MB-SMF. The MB-SMF transmits assistance information (as defined in solution 1) for inactive reception in the shared delivery response.

5. RAN internal procedures at NG-RAN 2 similar to step 2.

#### 6.19.3.3 Triggering MBS service announcement by MB-SMF (Option B)

NOTE 1: Unlike the broadcast session start, the present procedure is only used to make the RAN nodes aware that an MBS multicast session enabling delivery for inactive reception is ongoing. RAN nodes can then apply appropriate procedures to handle the MBS session, e.g. decide whether to transmit data and whether to allow RRC\_INACTIVE UE receiving MBS data.

NOTE 2: UEs still need to join the MBS multicast session as outlined in clause 7.2.1.3 of TS 23.247 [4].

Editor's note: How the NG-RAN node determines the MBS session data can be transmitted due to UE is in RRC-inactive state need be solved by RAN WGs.



Figure 6.19.3.3-1: Triggering MBS service announcement by MB-SMF (Option B)

1. Multicast MBS session suitable for delivery mode for inactive reception is created is created at MB-SMF. The MB-SMF determines whether an MBS session is suitable for inactive reception either based on an indication whether the delivery mode for inactive reception is enabled received from the AF (see solution 1) or based on the QoS of the MBS session.

2-5. MB-SMF informs RAN nodes in service area of multicast session via AMFs of multicast session and asks them to announce multicast session. The MB-SMF may defer step 2 until a Nmbsmf\_MBSSession\_ContextStatusSubscribe request is received from an SMF. In step 4, AMFs only select NG-RAN nodes in service area supporting delivery mode for RRC\_inactive reception.

6. RAN nodes decide delivery mode for MBS session in a cell and whether to deliver data.

7. RAN nodes may establish shared delivery as outlined in clause 7.2.1.4 of TS 23.247 [4].

8. RAN related procedures, e.g. indication of delivery mode or delivery of data.

Editor's note: The steps 6 and 8 are to be decided by RAN WGs.

#### 6.19.3.4 MBS session release (Option A and B)



Figure 6.19.3.3-1: MBS session release

1. The procedures in Figure 7.2.2.2-1 of TS 23.247 [4] are executed.

2. After a grace period, the MB-SMF checks if shared delivery is still established towards RAN nodes. If so, it sends a request to each related AMF to release the MBS session.

Editor's note: It is to be clarified what is the criteria for MB-SMF to start the guard timer.

3. The AMF determines stored RAN nodes for the MBS session and forwards the request to those RAN nodes.

### 6.19.4 Impacts on services, entities and interfaces.

Functional entities defined in clause 5.3.2 of TS 23.247 [4] are reused.

In addition to impacts for solution 1:

**NG-RAN:**

- Decide transmission mode for a multicast session in a cell.

- Receive assistance information either as part of request for service announcement or within shared delivery Establishment.

**UE:**

- Receive MBS data in indicated transmission mode while MBS data is active.

**MB-SMF:**

- inform RAN nodes in service area of multicast session (Option B).

- provide assistance information as part of shared delivery establishment.

- inform RAN nodes of MBS session release.

## 6.20 Solution #20: Registration procedure enhancements for multicast reception

### 6.20.1 Introduction

This solution addresses Key Issue #1 and #6.

Editor's note: Further evaluation whether this solution relates to those key issues is required.

### 6.20.2 Functional description

When the UE moves to a new Tracking Area (TA) outside the UE's Registration Area in CM-CONNECTED (including CM-CONNECTED with RRC Inactive state) or CM-IDLE state, the UE needs to initiate an Mobility Registration Update procedure towards the 5GS.

If the UE is in CM-CONNECTED with RRC Inactive state and receiving multicast MBS session(s) before initiating the Mobility Registration Update procedure, in order to avoid interruption in data reception of the multicast MBS session(s), the UE should indicate to the network that the PDU Session(s) associated with the multicast MBS session(s) remain established.

NOTE 1: As described in clause 7.2.2.2 of TS 23.247 [4], if the associated PDU Session is released, the UE leaves MBS Session(s) associated with that PDU session implicitly. To resume the reception of the related MBS service(s), the UE needs to initiate the procedures as defined in clause 7.2.1 of TS 23.247 [4] to re-join the MBS Session(s).

In addition, since there can be more than one multicast MBS session associated with one PDU Session, it would be beneficial for the UE to also provide the (status) information of multicast MBS session(s) associated with the PDU Session, i.e. whether the UE wants to join or leave (e.g. due to triggers from the application layer) or remain joined an multicast MBS session, so that:

NOTE 2: The network already has information about the MBS sessions a UE joined before. A UE might want to join a multicast if the boundary of the new TA coincides with the boundary of the service area of the multicast session, but the likelihood of that scenario is low.

- the network will not trigger multicast MBS session establishment towards the NG-RAN if the UE indicates leaving the multicast MBS session.

- the multicast MBS session join/leave procedures is continued in the network and multicast MBS session resources can be reserved or released (if not reserved/released yet) during the registration procedure.

Compared to Rel-17 MBS specification in TS 23.247 [4] where the UE needs to initiate PDU Session establishment or modification procedures to join/leave the multicast MBS session after the registration, it would improve the signalling efficiency and reduce the time for the UE to join/leave the multicast MBS session(s) to allow the UE to initiate MBS session join/leave or indicate join status in Registration procedures.

### 6.20.3 Procedures

#### 6.20.3.1 Registration procedures

The following enhancements are applied to registration procedure with the following conditions:

- the registration type is Mobility Registration Update, e.g. upon the UE changing to a new Tracking Area (TA) outside the UE's Registration Area in CM-CONNECTED (including CM-CONNECTED with RRC Inactive state) or CM-IDLE state.

- the UE has established the PDU Session(s) that is or can be associated with the multicast MBS session(s) before the registration procedure.

The general registration procedure as defined in clause 4.2.2.2.2 of TS 23.502 [3] are used with the following enhancements:

- In step 1, the UE includes/indicates also the following information in the Registration Request:

- the PDU Session status of the associated PDU session(s) is set as established, if the UE remains joined or wants to join one or more multicast MBS Session(s) associated with the PDU session(s).

- MBS session information container, which contains the multicast MBS session information associated with the PDU Session ID identifying the associated PDU Session, as follows:

- MBS Session ID(s) and an indication of "join" for the multicast MBS session(s) that it wants to join, if any;

- MBS Session ID(s) and an indication of "leave" for the multicast MBS session(s) that it has joined and wants to leave, if any.

- In step 17, the AMF invokes the Nsmf\_PDUSession\_UpdateSMContext towards the SMF(s) serving the associated PDU Session(s). The Nsmf\_PDUSession\_UpdateSMContext contains the MBS session information container for the associated PDU Session. Then, based on the multicast MBS session information in the MBS session information container:

- if the multicast MBS session information contains the MBS Session ID(s) and indication of "join" for the multicast MBS session(s) that the UE wants to join, steps from step 2 onwards described in clause 7.2.1.3 of TS 23.247 [4] are executed to complete the multicast MBS session join procedure for the UE to join the multicast MBS session(s) identified by the MBS Session ID(s).

- if the multicast MBS session information contains the MBS Session ID(s) and an indication of "leave" for the multicast MBS session(s) that the UE wants to leave, steps from step 3a onwards described in clause 7.2.2.2 of TS 23.247 [4] are executed to remove the UE from the multicast MBS session(s) identified by the MBS Session ID(s).

- if, according to the MBS session context in the SMF, there is/are multicast MBS session(s) that the UE has joined but with MBS Session ID(s) not included the MBS session information container, the SMF considers that the UE remains joined in the multicast MBS session(s). If the network allows the UE to remain in the multicast MBS session, steps from step 5 onwards described in clause 7.2.1.3 of TS 23.247 [4] are executed to complete the multicast MBS session resource establishment procedure for the multicast MBS session(s); otherwise, steps from step 3 onwards described in clause 7.2.2.3 of TS 23.247 [4] are executed to remove the UE from the multicast MBS session(s).

### 6.20.4 Impacts on services, entities and interfaces

UE:

- sets the PDU Session status of the associated PDU session(s) as established, if the UE remains joined or wants to join one or more multicast MBS Session(s) associated with the PDU session(s).

- provides the information of multicast MBS session(s) associated with the PDU Session, i.e. whether the UE wants to join or leave multicast MBS session(s), in the MBS session information container in the Registration Request to the AMF.

AMF:

- sends the MBS session information container received in the Registration Request towards the SMF(s) serving the associated PDU Session(s) in Registration procedures.

SMF:

- performs the corresponding multicast MBS session procedures based on the information in the MBS session information container.

Editor's note: It is FFS whether there are RAN impacts due to a new SM container in registration request. The NG-RAN behaviour is to be determined by RAN WGs.

## 6.21 Solution #21: Mobility Procedures for UE supporting RRC Inactive MBS data reception with the MBS session container

### 6.21.1 Introduction

This solution addresses Key Issue #1.

### 6.21.2 Functional description

For the UE joined the multicast MBS session(s) and allowed receiving MBS data in RRC-inactive state, if it moves out its RNA and within RA, the UE triggers the RNA update procedure. If the resumption of the RRC connection fails, the UE may initiates the Mobility Registration Update procedure with the MBS session information (i.e. whether the UE wants to join or leave a multicast MBS session) in the MBS session information container together with the associated PDU Session ID(s), to trigger the network to complete multicast MBS session join and/or leave procedures.

NOTE: The UE may decide to join or leave a multicast session during the Mobility Registration Update procedure when the resumption of the RRC connection fails, e.g. due to pending application request.

Later on, if the network supports multicast MBS session transmission to the UE in RRC Inactive state, the UE may be changed to RRC Inactive state to receive the MBS data.

### 6.21.3 Procedures

#### 6.21.3.1 RRC-inactive multicast group member UE move out of RNA and within RA

For the UE joined the multicast MBS session(s) and allowed receiving MBS data in RRC-inactive state, if the UE moves out its RNA and within RA, it triggers the RNA update procedure as usual. Based on that procedure, the network may:

- keep the UE in the RRC Inactive state for MBS data reception, if the network supports multicast MBS session transmission to the UE in RRC Inactive state; or

- move the UE to RRC Idle state if the UE context cannot be retrieved successfully by the NG-RAN. In this case:

- the UE may invoke the Mobility Registration Update procedure by sending a Registration Request which contains the associated PDU session ID(s) and the MBS session information container. The MBS session information container contains the multicast MBS session information associated with the PDU Session ID identifying the associated PDU Session, as follows:

- MBS Session ID(s) and an indication of "join" for the multicast MBS session(s) that it wants to join, if any;

- MBS Session ID(s) and an indication of "leave" for the multicast MBS session(s) that it has joined and wants to leave, if any.

The AMF forwards the MBS session information container towards the SMF serving the associated PDU Session by invoking the Nsmf\_PDUSession\_UpdateSMContext service operation. Then, based on the multicast MBS session information in the MBS session information container, the SMF continues to perform multicast MBS session join and/or leave procedures as specified in TS 23.247 [4]. Later on, if the network supports multicast MBS session transmission to the UE in RRC Inactive state, the UE may be changed to RRC Inactive state to receive the MBS data.

### 6.21.4 Impacts on services, entities, and interfaces

UE:

- When the UE receives the MBS data in RRC Inactive state and moves to a new cell but the resumption of the RRC connection fails, the UE provides the MBS session information (i.e. whether the UE wants to join or leave multicast MBS session(s)) in the MBS session information container together with the associated PDU Session ID(s), in the Mobility Registration Update procedure.

SMF:

- Performs the corresponding multicast MBS session procedures based on the information in the MBS session information container.

AMF:

- Sends the MBS session information container received in the Registration Request towards the SMF(s) serving the associated PDU Session(s).

Editor's note: It is FFS whether there are RAN impacts due to a new SM container in registration request. The NG-RAN behaviour is to be determined by RAN WGs.

## 6.22 Solution #22: Session management for RRC Inactive MBS data receiving UE

### 6.22.1 Introduction

This solution addresses Key Issue #1, for the SM procedure handling for handling UEs in CM-CONNECTED/RRC\_INACTIVE state.

### 6.22.2 Functional description

This solution is alternative to solution #4 that is currently documented in the TR. The multicast session management include following procedures:

- When MBS session is de-activated as defined in clause 7.2.5.3 of TS 23.247 [4], the NG-RAN node keeps the multicast MBS session context and N3mb shared tunnel for the multicast MBS session as long as the NG-RAN has UE context for UEs in the MBS session context which may be in either RRC-CONNECED or RRC\_INACTIVE state. In other words, the NG-RAN does not trigger release of the shared delivery as described in clause 7.2.2.4 of TS 23.247 [4] if it maintains context for RRC\_INACTIVE UEs.

- During MBS session (re-)activation, the group-based paging is executed only for UEs in CM-IDLE state as currently defined. A UE in RRC-INACTIVE state is in CM-CONNECTED state in CN and therefore group paging is not needed for this UE.

Editor's note: RAN paging procedures are under remit of the RAN groups.

### 6.22.3 Procedures

#### 6.22.3.1 Modification to the MBS session de-activation procedure



Figure 6.22.3.1-1: MBS session de-activation procedure to allow keeping the UEs in CM-CONNECTED/RRC\_INACTIVE state

1. No changes to steps 1-4 compared to TS 23.247 [4] clause 7.2.5.3.

2-3. Steps 2 and 3 are shown in the figure for comparison with existing procedure since MB-SMF does not request de-activation of the MBS session and the AMF does not send NGAP deactivation request message (N2 SM information ()) to the NG-RAN nodes since the UEs are kept in CM-CONNECTED state. The NG-RAN node keeps the multicast MBS session context and N3mb shared tunnel for the multicast MBS session. NG-RAN can decide locally to change the RRC state of some UEs to RRC\_INACTIVE.

NOTE 1: Based on this procedure UEs are kept in CM-CONNECTED state while the MBS session is deactivated, and they do not transit to CM-IDLE state (as in Rel-17).

The MBS session context will never indicate that there are no UEs for the multicast MBS session, and therefore the NG-RAN will never trigger release of the shared delivery as described in clause 7.2.2.4.

NOTE 2: NG-RAN does not trigger release of the shared delivery if there are UEs in CM-CONNECTED and RRC-Inactive.

#### 6.22.3.2 Modification to the MBS session (re-)activation procedure



Figure 6.22.3.2-1: MBS session re-activation procedure to allow keeping the UEs CM-CONNECTED/RRC\_INACTIVE state

1. No changes to steps 1-4a compared to clause 7.2.5.2 of TS 23.247 [4]. After receiving the request, for each UE in the list, the AMF determines CM state of the UE and determines that specific UEs are CM-CONNECTED (since they are in RRC\_INACTIVE state in NG-RAN). The AMF indicates those UEs to the SMF, using Namf\_MT\_EnableGroupReachability Response (UE list).

2. No changes to steps 11-15 compared to clause 7.2.5.2 of TS 23.247 [4]. The shared tunnel has been established before, and therefore there is no need for it to be established. When the service is re-activated and there are UEs in RRC\_INACTIVE state, the NG-RAN needs to notify the UEs of this activation.

NOTE: How the UEs are notified in this case is up to RAN2 to decide.

### 6.22.4 Impacts on services, entities, and interfaces

NG-RAN:

- Keeps the MBS session context when it wants to allow reception in RRC\_INACTIVE.

MB-SMF:

- Does not de-activate the shared tunnel.

## 6.23 Solution #23: MBS session activation for RRC Inactive MBS data receiving UE

### 6.23.1 Introduction

This solution addresses Key Issue #1, especially on the MBS session activation for RRC Inactive MBS data receiving UE.

This solution builds on top of solution 6, i.e. reuse the Qos information to determine whether MBS session can be put into RRC inactive.

### 6.23.2 Functional description

This solution builds on top of solution 6. The solution is based on the following principles:

- For the MBS session deactivation procedure, there is no impact. After MBS session deactivation, the NG-RAN can determine how to handle the RRC inactive UE.

- The AMF know the 5GS support receiving multicast data in RRC inactive state. The AMF is aware of NG-RAN capability for supporting reception of MBS data in RRC Inactive state.

- When the AMF receives the Namf\_MT\_EnableGroupReachability from SMF, the AMF figures out the paging area covering all the registration areas of those UE(s), which need to be paged. This paging area includes the all the registration areas of those UE in CM-IDLE mode, and NG-RAN node where the CM-Connected mode UE(s) is camping on. For example, even all the UEs involved in the MBS session are in CM-Connected mode, the AMF need to figure out the NG-RAN node the UEs camp on, so the AMF need to inform these NG-RAN nodes to handle the potential RRC inactive UE.

Editor's note: There is a need for further explanation of this procedure. RAN paging will also be triggered by the MB-SMF, and this request is typically faster as it does not need to be forwarded by SMFs.

- When the NG-RAN receives the paging request from AMF with TMGI, it perform the paging for the UE (e.g. UE in idle mode and RRC Inactive mode).

NOTE: How the NG-RAN handle the UE in the RRC inactive when receives the paging request is in RAN scope.

Editor's note: When receiving the group paging, the behaviour of UE supporting RRC inactive reception will be further defined by RAN WGs.

Editor's note: Whether the radio resource (MRB) for multicast MBS can be established for the UE in RRC Inactive state depends on RAN WG decision.

### 6.23.3 Procedures



Figure 6.23.3.1-1: Multicast Session Activation Procedure

The procedure is on top of TS 23.247 [4] Figure 7.2.5.2-1, with following enhancement.

Before step 1, the NG-RAN may move some UE into CM-Connected with RRC Connected/Inactive state.

5. The AMF figures out the paging area covering all the registration areas of those UE(s), which need to be paged. This paging area includes the all the registration areas of those UE in CM-IDLE mode, and NG-RAN node where the CM-Connected mode UE(s) is camping on. The AMF sends a paging request message to the NG-RAN node(s) belonging to this Paging Area with the TMGI as the identifier to be paged if the related NG-RAN node(s) support MBS. If the NG-RAN node(s) do not support MBS, the AMF sends initiate the normal CN paging.

6. For the RRC inactive mode UE, the NG-RAN initiates the RAN paging.

For the UE(s) joined the MBS session and need receive multicast service in RRC-Connected state, the UE initiates the Service Request as usual.

NOTE 1: How the NG-RAN handle the UE in the RRC inactive when receives the RAN paging request is in RAN scope.

12. If step received before step 5, for the RRC inactive mode UE, the NG-RAN initiates the RAN paging. Which is similar with step 6.

NOTE 2: In most cases, the step 12 is before step 5.

Editor's note: The UE behaviour when received the group paging is to be defined by RAN WG.

### 6.23.4 Impacts on services, entities, and interfaces

AMF:

- The AMF figures out the paging area covering all the registration areas of those UE(s), which need to be paged. This paging area includes the all the registration areas of those UE in CM-IDLE mode, and NG-RAN node where the CM-Connected mode UE(s) is camping on.

Editor's note: The NG-RAN behaviour is RAN scope.

## 6.24 Solution #24: Solution based on configuration in RAN to support MOCN RAN Sharing

### 6.24.1 Introduction

This solution addresses Key Issue #2.

### 6.24.2 Functional description

This solution relies on RAN configuration does not need any new parameter as proposed in existing solutions but the service-id part of the TMGI of the RAN sharing partners that corresponds to the same content is configured in RAN.

For example, if PLMNs with MCC=234, MNC=15 (operator A) and MCC=234, MNC=10 (operator B) are doing MBS RAN sharing, the corresponding RAN nodes are already configured with the PLMN-ids of each of the sharing partner and can be configured with the specific respective service-id (6 digits numbers) of the TMGIs of two PLMNs that correspond to the same content or even range of service-ids. For instance, service-id=123456 (for operator A) and service-id=001234 (for operator B) corresponds to content from "TV channel X". This means that the corresponding MB-SMF in each PLMN will allocate the service ids for the TMGI based on the specific range expected for the same content. Then the RAN node can populate accordingly the MCCH with the respective TMGI of the RAN sharing partners. Based on rel.17 RRC encoding, it is possible to have common MTCH configuration and same G-RNTI mapped to different TMGIs. Based on RAN OAM configuration, it is possible to identify which TMGIs (belonging to different PLMNs in this case) providing same broadcast service.

In the service announcement for the broadcast MBS sessions delivering the same content, the respective MBSFs of each PLMN can indicate the PLMN specific TMGI to the UEs.

Editor's note: Support of the encrypted content reception is FFS.

### 6.24.3 Procedures

#### 6.24.3.1 General

#### 6.24.3.2 MBS Session Creation

As in clauses 7.1.1.2 and 7.1.1.3 of TS 23.247 [4] for each PLMN.

#### 6.24.3.3 MBS Session Start for Broadcast



Figure 6.24.3.3-1: Existing MBS Session Start for Broadcast for MOCN RAN sharing (as in clause 7.3.1 of TS 23.247 [4])

The following modifications apply compared to clause 7.3.1 of TS 23.247 [4] when MBS Session Start for the second and later broadcast MBS sessions:

1. Each PLMN needs to allocate the TMGIs based on the specific service-ids or ranges of service-ids. For example, MB-SMF of operator A allocates service-id=123456 and MB-SMF of operator B service-id=001234. This can happen in different ways:

a) NEF/MBSF will need to pass the afID defined in Nnef\_TMGI\_Allocate to MB-SMF using Nmbsmf\_TMGI\_Allocate (i.e. afID needs to be added in TS 29.532 [17]) and therefore allow MB-SMF to have a "policy" in TMGI allocation based on identification of AF. The afID is currently encoded in "string" format according to TS 29.522 [18], and it needs to provide enough information (e.g. indicating specific content) to NEF/MBSF in order to allocate the TMGI according to the required "policy".

b) MB-SMF can delegate a TMGI range to NEF to allocate for that purpose and keep the afID so it can assign based on some policy

c) (if MBSF is used) MB-SMF can delegate a TMGI range to MBSF to allocate for that purpose and it can assign the TMGI based on some "policy" depending on the identification of AF

Editor's note: Whether the afID will be provided to MB-SMF will be coordinate with CT WG4.

No changes required in steps 2-8.

9. Since NG-RAN is configured with the list of the associated specific service-ids or ranges of service-ids of the TMGIs of each RAN sharing partner whose content has been delivered over the air, the NG-RAN propagates the TMGI for the new PLMN for which the second or later broadcast session is established.

For example, if the service-id=123456 (for operator A) and service-id=001234 (for operator B) corresponds to content from "TV channel X" and MCCH already advertised TMGI= 123456 234 15, it also adds in MCCH TMGI= 001234 234 10.

NG-RAN configures the same MTCH for both TMGIs.

The UE from operator B, having received the service announcement is able to read the TMGI (001234 234 10) and receive the content.

15. Since NG-RAN understands the broadcast MBS Session is associated with another Broadcast MBS Session identified by the corresponding TMGI whose content has been delivered over the air, the NG-RAN can silently drop packets received in this broadcast MBS session, and do not deliver them again.

Editor's note: Details will be confirmed by the RAN WGs.

Editor's note: It is FFS whether NG-RAN should avoid establishing UP resources for the second and later broadcast MBS sessions for more saving.

#### 6.24.3.4 MBS Session Release for Broadcast



Figure 6.24.3.4-1: MBS Session Release for Broadcast for MOCN RAN sharing

The following modifications apply compared to clause 7.3.2 of TS 23.247 [4] when MBS Session Release for the broadcast MBS session which is created firstly:

5. If the NG-RAN intends to perform MBS Session Release for operator A but determines there are other corresponding broadcast MBS sessions for other PLMNs available, it removes only the TMGI for operator A from the MCCH while keeping the rest of the TMGIs. NG-RAN should switch to another MBS session to receive data (e.g. MBS session for operator B).

Editor's note: Details will be confirmed by the RAN WGs.

### 6.24.4 Impacts on services, entities and interfaces.

Functional entities defined in clause 5.3.2 of TS 23.247 [4] are reused exception for the following additions:

NG-RAN:

- RAN is configured with specific service-ids or service-id ranges corresponding to the same content for each of their RAN sharing partners.

- During MBS Session starts for each of the MOCN PLMNs NG-RAN adds to the MCCH the corresponding TMGI.

- During MBS Sessions releases for each of the MOCN PLMNs NG-RAN removes from the MCCH the corresponding TMGI.

- RAN configures the same MTCH for each of the TMGI corresponding the same content as allowed by existing Rel-17 RRC.

Depending on which option is used for TMGI allocation by the PLMN (a, b, or c) different impacts apply:

In the case of a):

MB-SMF:

- MB-SMF of each PLMN is configured with specific service-ids or service-id ranges corresponding to the same content based on AF ID provide from NEF.

NEF:

- NEF to provides AF Id to MB-SMF.

In the case of b):

NEF:

- NEF to allocate TMGI and keep the afID so it can assign TMGI based on some policy that applies per specific content from AF.

In the case of c):

MBSF:

- MBSF to allocate TMGI and keep the afID so it can assign TMGI based on some policy that applies per specific content from AF.

No other impacts in AF, and UE.

## 6.25 Solution #25: Triggering capability limited devices to receive MBS data

### 6.25.1 Introduction

This solution addresses Key Issue #5.

### 6.25.2 Description

To enable capability limited devices using power-saving mechanisms (MICO (Mobile Initiated Connection Only) mode, DRX (Discontinuous Reception), eDRX (Extended Discontinuous Reception) to extend their battery live, those devices need to wake up at coordinated times when the MBS data are being transmitted. For MBS multicast reception, the UEs send service requests at those times when being in idle state beforehand. While no MBS data are being transmitted, the devices follow the power saving procedures and may thus not be reachable

If periodic transmissions are scheduled in an MBS session or the MBS session is set up for a one-time delivery, the devices may be informed in advance via service announcement or when it joins the MBS session about the time(s) when MBS data transmission will take place. The AF provides information about the time(s) when MBS data transmission will take place via NEF/MBSF to MB-SMF when configuring the multicast session. MB-SMF activates/deactivates multicast session based on configured times. The UEs start to receive MBS data at the configured times.

If an MBS session is used to transmit data at irregular intervals, the devices need to be informed about the data transmission while the MBS session is ongoing. The AF sends a delayed activation request indicating the desired activation time for an MBS session to the MB-SMF, and the MB-SMF request the SMFs to perform a delayed activation. The SMFs in turn request the AMFs to perform deferred paging. If UEs negotiated an eDRX cycle and joined the multicast session, the AMF pages the UE in the Paging Hyperframes (PH) / time intervals calculated according to eDRX procedures before the transmission start and indicates the transmission start time.

NOTE: For a periodic transmission or a one-time transmission it is sufficient to let the AF activate or deactivate the MBS Session based configured time. For transmission at irregular intervals not known at service announcement time, UEs need to be informed before the transmission can start and the delayed activation request is required.

Editor's note: whether both scenarios will be supported will be assessed in the evaluation phase.

### 6.25.3 Procedures

#### 6.25.3.1 Periodic or one time transmission of MBS data to capability-limited devices



Figure 6.25.3.1-1: Periodic or one time transmission of MBS data to capability-limited devices

If periodic transmissions are scheduled in an MBS session or the MBS session is set up for a one-time delivery, the devices may be informed in advance via service announcement or when it joins the MBS session about the time(s) when MBS data transmission will take place. The AF provides information about the time(s) when MBS data transmission will take place via NEF/MBSF to MB-SMF when configuring the multicast session. MB-SMF activates/deactivates multicast session based on configured times. The UEs start to receive MBS data at the configured times.

#### 6.25.3.2 Deferred activation for aperiodic transmission of MBS data to capability-limited devices



Figure 6.25.3.2-1: Deferred activation for aperiodic transmission of MBS data to capability-limited devices

If an MBS session is used to transmit data at irregular intervals, the devices need to be informed about the data transmission while the MBS session is ongoing. The AF sends a delayed activation request indicating the desired activation time for an MBS session to the MB-SMF, and the MB-SMF request the SMFs to perform a delayed activation. The SMFs in turn request the AMFs to perform deferred paging. If UEs negotiated an eDRX cycle and joined the multicast session, the AMF pages the UE in the Paging Hyperframes (PH) / time intervals calculated according to eDRX procedures before the transmission start and indicates the transmission start time.

### 6.25.4 Impacts on services, entities and interfaces.

Editor's note: This clause describes impacts to existing services, entities and interfaces.

AF:

- Inform NEF about start times.

- Send delayed activation request indicating start time.

- Send MBS data at indicated times only.

UE:

- Receive and store start times via service announcement, join, or NAS transfer.

- wake up at indicated times.

AMF:

- For deferred activation, page UEs according to eDRX procedures and inform them about wakeup time.

SMF:

- Activate MBS session at indicated times.

- Forward request for deferred activation.

## 6.26 Solution #26: AF selects UEs to be kept in connected mode

### 6.26.1 Introduction

This solution addresses Key Issues #1 and #6.

### 6.26.2 Description

This solution applies to active MBS sessions, and inactive MBS sessions.

Editor's note: It is to be clarified whether and how this solution will be prevented to be applied to the UEs without joined MBS Sessions, due to no MBS related call flows involved in this solution.

As outlined in clause 4.2, solutions shall enable simultaneous reception of MBS session data for a higher number of UEs in a cell than can be operating in RRC\_CONNECTED state, to participate in public safety group calls using MBS-based service. This requires that many such UEs transition to RRC-inactive state. On the other hand there are requirements for short reaction times for floor control requests and some participants in an MBS session may be so frequent talkers that a very frequent transition between RRC-Connected state and RRC\_INACTIVE state would burden the network, and it is thus desirable to keep such UEs in RRC\_CONNECTED state.

For UEs in one or several MBS sessions, AF identifies UEs that should be kept in connected state, e.g. UEs of likely talkers in an MBS session such as dispatchers for public safety, and provides this information to CN as assistance information. The AF does this via Nnef\_ParameterProvision\_Create/Update service operations (see clause 4.15.6.2 of TS 23.502 [3]). The NEF only accepts related requests from authorized trusted AFs, e.g. related to public safety.

Editor's note: It is FFS whether AF can identify UEs to be kept in RRC\_CONNECTED state or AF should provide priority information (which may cooperate with solutions for KI#1) for NG-RAN to determine RRC states.

AF may use configuration or frequency of floor requests received from UE as criterion to select UEs and should only keep a small fractions of the UEs participating in an MBS session with many participants in connected state.

Editor's note: Details how the AF selects a small fraction of UEs will need to be studied by SA6.

NOTE 1: If the AF selects an excessive number of UEs for the connected state, this will limit the number of UEs that can receive an MBS multicast session and will also negatively impact the overall admission control of a RAN node. AF should remove information that UEs shall always be connected when related MBS session(s) end. The AF may also remove MBS UEs while the session is inactive for longer periods.

Editor's note: Specifications under the SA6 remit might require updates to ensure that AF to remove information when related MBS session(s) ends. This requires collaboration with SA6

NEF stores in UDM users that preferably shall be kept connected. The NEF may restrict the number of UEs that an AF is allowed to suggest for connected state by rejecting requests with the number of UEs exceeding a preconfigured limit.

Editor's note: It is to be clarified how the preconfigured limit can be determined in NEF.

For each indicated UE, the UDM stores as part of the UE subscription data that user shall preferably be kept connected

SMFs are notified about changes in UE subscription data based on previous subscription or inquire UE subscription data when PDU session is being established. This includes information that user shall preferably be kept connected.

SMF provides the information that UE shall preferably be kept connected as part of the SM management information via AMF to NG RAN node handling the user.

NG RAN nodes should keep UE for which such information was received and that are participating in at least one active multicast MBS session in RRC and CM connected state and may select to move other UEs to RRC Inactive or CM idle states if experiencing higher load, as long as this is feasible in its admission control.

NOTE 2: The RAN does not need check whether the UE is participating in any MBS sessions, as the AF is expected to only select UEs in MBS sessions.

Editor's note: How the RRC state is handled is to be determined by RAN WGs.

As an additional improvement, UEs do not send "listener reports" while in MBS service area and in RRC inactive mode. Listener reports can become a problem in particular for UEs close to cell border moving frequently between cells.

Editor's note: Coordination with SA6 is required on the implication that UEs do not send "listener reports" while in MBS service area and in RRC inactive mode.

### 6.26.3 Procedures



Figure 6.26.3.2-1: AF selects UEs to be kept in connected mode

1. AF identifies UEs to be kept in RRC connected state.

2. AF uses parameter provisioning procedure to provide UEs to be kept in connected state to NEF.

3. NEF stores in UDM users that preferably shall be kept connected. For each indicated UE, the UDM stores as part of the UE subscription data that user shall preferably be kept connected.

4. SMFs are notified about changes in UE subscription data based on previous subscription or inquire UE subscription data when PDU session is being established. This includes information that user shall preferably be kept connected.

5-6. SMF provides the information that UE shall preferably be kept connected as part of the SM management information via AMF to NG RAN node handling the user.

7. NG RAN nodes preferably keep UE for which such information was received in RRC and CM connected state.

### 6.26.4 Impacts on services, entities and interfaces.

**AF:**

- Select UEs to be kept in connected mode and provide those UEs to CN via parameter provisioning procedure

**NEF/UDM/SMF**

- Updates to parameter provisioning procedure to transfer UEs to be kept in connected mode

**SMF:**

- Inform NG-RAN that UE shall be kept in connected state via PDU session modification

**NG-RAN:**

- Keep indicated UE in connected state

**UE:**

- Do not send listener reports while in MBS service area and inactive state

## 6.27 Solution #27: AF providing list of prioritized UEs when creating multicast MBS Session

### 6.27.1 Introduction

This solution addresses the following bullet in Key Issue #1.

- Whether, how and what MBS assistance information to provide from 5GC to RAN for an MBS session allowing UEs in CM-CONNECTED with RRC Inactive state to receive MBS content, including the aspect which 5GC NF(s) determine the MBS assistance information and how they do so.

### 6.27.2 Functional description

When the AF creates multicast MBS session, the AF may provide to the 5GC list of UEs (represented by GPSI) whether they're privileged or not within the multicast group.

NOTE 1: Compared to Solution#3 in clause 6.3.2, this solution carries the UE list of privileged users in the existing MBS Session creation message, while Solution#3 provide the privileged user information using PDU Session signalling triggered by PCC.

NOTE 2: How to handle situations where different UEs are prioritized in different multicast groups is to be determined by RAN WGs.

NOTE 3: The merits of providing a prioritized UE list related to a multicast session need to be discussed in the evaluation phase.

NOTE 4: A UE involved in different multicast groups may be prioritized/privileged in one multicast group, but not prioritized/privileged in another group.

NOTE 5: When the MBS session is handed over to non-MBS supporting RAN node, if the 5GC Individual Traffic delivery is applied, the MBS data will be transferred via PDU Session which requires the UE to be in RRC\_CONNECTED, therefore the UE differentiation proposed in this solution does not apply to non-supporting NG-RAN.

The number of UEs to differentiate provided by AF is expected to be small. Exact number can be based on configuration, and in case the number exceeds the limit, the MB-SMF can do a throttling and include the list of dropped UEs in the response to the AF.

NOTE 6: The merits of selecting UEs to be dropped at the MB-SMF instead of the AF needs to be discussed in the evaluation phase.

NOTE 7: For multicast MBS Session, in SMF, the list of UEs that have joined the MBS Session is included in MBS Session context which is shared by all UEs. In this solution, the SMF retrieves the list of prioritized UEs as part of MBS Session context information. It is possible that some prioritized UEs in the list are not handled by an SMF (if those UEs have not joined yet, or joined in other SMF(s)). Due to that, later if the list of UE is updated, the unrelated SMF also need be notified.

When the 5GC provides the UE join information to the NG-RAN at UE join or MBS Session Activation, if the SMF has got information from MB-SMF that the UE is prioritized within the multicast group, the SMF provides such information to the NG-RAN to assist NG-RAN in its decision what UEs can be sent to RRC\_INACTIVE and continue receiving MBS data.

### 6.27.3 Procedures

In the existing procedure in clause 7.1.1.2 of TS 23.247 [4], step 8 & step 11 is enhanced as follows (**enhancement text in bold**):

*8. AF of content provider may provide description for an MBS session (possibly providing information for a previously allocated TMGI to NEF via a Nnef\_MBSSession\_Create request (([MBS Session ID], service type, MBS information, [TMGI allocation indication]). If step 1-6 has not been executed before, the AF may provide a SSM or it may request that the network allocates an identifier for the MBS session (i.e. TMGI). The AF provides the service type (i.e. either multicast service or broadcast service). MBS session information may further include QoS requirements and Any UE indication (indicating whether a multicast MBS session is "open to any UEs"), MBS service area, start and end time of the MBS session and MBS session state (Active/Inactive). In addition, MBS information may also indicate whether the allocation of an ingress transport address is requested.*

*If geographical area information or civic address information was provided by the AF as MBS service area, NEF/MBSF translates the MBS service area to Cell ID list or TAI list.*

*For broadcast communication, the AF may determine MBS FSA ID(s) for the Broadcast MBS session based on business agreements and include them in the description of the MBS session*

**For multicast MBS Session, the AF may provide a list of UEs that are to be differentiated (or prioritized) and those UEs are represented by GPSI.**

. . .

*11. NEF/MBSF sends Nmbsmf\_MBSSession\_Create Request (MBS Session ID, service type, TMGI allocation indication, MBS service area information, ingress transport address request indication) to MB-SMF, to request MB-SMF to reserve ingress resources for a MBS distribution session, The NEF/MBSF provides MBS Session ID or request allocation of a TMGI, and indicate the requested service type (either multicast service or broadcast service) and MBS session state (Active/Inactive). It also indicates that the allocation of an ingress transport address is requested if this was requested in step 8, or if the MBSF decides to insert an MBSTF into the user plane for the MBS session. The request also includes the Any UE indication if provided in step 8.*

*The MBS service area is provided by NEF/MBSF to the MB-SMF if provided by the AF in step 8.*

*MBS FSA ID(s) are provided by NEF/MBSF to the MB-SMF if provided by the AF in step 8.*

*If requested to do so, or if a source specific multicast is provided as MBS Session ID in step 11, the MB-SMF allocates a TMGI.*

*For broadcast communication, if no MBS FSA ID(s) have been received, the MB-SMF selects MBS FSA ID(s) for the Broadcast MBS session based on local configuration.*

**For multicast MBS Session, the NEF/MBSF forward to the MB-SMF the list of UEs that are to be differentiated (or prioritized) if provided by the AF.**

In the existing procedure in clause 7.2.1.3 of TS 23.247 [4], there is following enhancement (**enhancement text in bold):**

*3. [Conditional] For each MBS session in step 1, if the SMF has not subscribed to the MBS Session Context, it invokes Nmbsmf\_MBSSession\_ContextStatusSubscribe request (MBS Session ID) towards the MB-SMF to subscribe to events notifications related to the multicast MBS session and to request information about the MBS Session Context. The MB-SMF responds with the information about the indicated multicast MBS session in Nmbsmf\_MBSSession\_ContextStatusSubscribe response (multicast QoS flow information (e.g. QoS profile(s) for the multicast MBS session), [start time], [session state (Active/Inactive)], [Any UE indication], [multicast DL tunnel info],* **[List of prioritized UEs***]).*

*If it is the first time for the MB-SMF to receive Nmbsmf\_MBSSession\_ContextStatusSubscribe request of the indicated MBS Session from any SMF, the MB-SMF learns it is the first UE joining the multicast MBS session. For multicast transport between MB-UPF and content provider, if it is the first UE joining the multicast MBS session, and MB-UPF has not joined the multicast tree in the MBS session creation procedure, described in clause 7.1.1, the MB-SMF requests the MB-UPF to join the multicast tree towards the AF/MBSF, otherwise MB-SMF will not send the request to the MB-UPF.*

*NOTE 2: The MB-SMF can answer the Nmbsmf\_MBSSession\_ContextStatusSubscribe request either based on information received in the MBS session creation procedures in clause 7.1.1 or based on preconfigured information. The pre-configuration also includes information about the MBS session stored in the NRF. If the MB-SMF uses preconfigured information, the pre-configuration also includes MB-UPF configuration.*

*4. The SMF determines whether the user is authorized to join the Multicast MBS session taking into account the MBS subscription data received from the UDM and the Any UE indication if received from the MB-SMF. The SMF considers the UE as authorized to the Multicast MBS session if the UE is authorized to use multicast MBS services, and if the MBS Session ID(s) in the PDU Session Modification Request is included in the MBS subscription data or Any UE indication is received. If authorization check fails, the SMF rejects the join request with a cause value. If a UE joins prior to the start time of the multicast MBS session, the SMF may accept the join request and indicate to the UE the start time, or it may reject the join request with an appropriate error cause and optionally a back-off timer. If a UE joins while the multicast MBS session is inactive, the SMF accepts the join request.*

*5. If the join request is accepted, the SMF responds to the AMF through Nsmf\_PDUSession\_UpdateSMContext response (N2 SM information (PDU Session ID, MBS Session ID, [updated PDU Session information], [mapping information between unicast QoS flow(s) and multicast QoS flow (s)],* **[assistant information of UE differentiation/prioritization]***), N1 SM container (PDU Session Modification Command)) to:*

*- create an MBS Session Context for the indicated MBS session in the RAN, if it does not exist in the RAN already; and*

*- inform the NG-RAN about the relation between the Multicast MBS Session Context and the UE's PDU Session context by including the MBS Session ID and the mapping between the multicast QoS flow(s) and associated QoS flow(s).*

**- Inform NG-RAN the assistant information of UE differentiation (or prioritization).**

*Based on operator policy, the SMF may prepare for 5GC Individual MBS traffic delivery fall-back. The SMF maps the received QoS information of the multicast QoS Flow into PDU Session's unicast QoS Flow information, and includes the information of the QoS Flows and the mapping information about the QoS Flows (termed "associated QoS flow information") in the SM information sent to RAN. The SMF compares the QFIs of the multicast QoS Flows received from the MB-SMF with QFIs in use for the PDU Session and assigns unused QFIs to the PDU Session's unicast QoS Flows corresponding to multicast QoS Flows.*

*. . .*

*6. The N2 message, which includes the MBS Session ID(s) the UE has joined and, if applicable, associated QoS Flow, is sent to the NG-RAN.* **The N2 message may also include information whether the UE is differentiated/prioritized to assist the NG-RAN when deciding what UEs can be sent to RRC\_INACTIVE and continue receiving MBS data.**

*If the MBS is supported by NG-RAN, 5GC Shared MBS traffic delivery is adopted. If the MBS is not supported by NG-RAN, 5GC Individual MBS traffic delivery is used if the PDU Session's unicast QoS Flow include QoS Flows for the multicast session.*

*If the NG-RAN supports MBS, the NG-RAN uses the MBS Session ID to determine that the PDU Session identified by the PDU Session ID is associated with the indicated multicast MBS session.*

*If the NG-RAN supports MBS, the associated unicast QoS flow information, if provided, is not used to allocate the radio resource and CN resource for corresponding QoS flows.*

NOTE 6: UE join request via PDU Session signalling will fail if NG-RAN rejects the PDU Session Resource setup request (e.g. due to the number of UEs reaching a limit).

### 6.27.4 Impacts on services, entities and interfaces.

AF:

- Include new parameter with list of prioritized UEs (represented by GPSIs) that may assist the NG-RAN when determining to move the UEs when receiving MBS data to RRC\_INACTIVE.

NEF (if deployed)

- Forward the parameter of list of prioritized UEs to MB-SMF.

MB-SMF:

- Store the list of prioritized UEs (represented by GPSI) and provide the list to SMF when UE joins the multicast MBS Session.

SMF:

- If the UE differentiation information is provided by MB-SMF, the SMF provides the information to NG-RAN.

NG-RAN:

- The NG-RAN receives the UE differentiation information and may consider it when the NG-RAN determines whether to move the UE receiving MBS to RRC\_INACTIVE in PDU Session setup or modification.

NOTE: How the group member information is used by NG-RAN is to be determined by RAN WGs.

## 6.28 Solution #28: Session management and Mobility for RRC Inactive MBS data reception

### 6.28.1 Introduction

This solution addresses Key Issue #1, especially on the session management and mobility handling for RRC Inactive state UE MBS data reception.

There are several assumptions for this solution:

- In the RAN Notification Aare for the UE, all the RAN node are homogeneously supporting the UE receiving the MBS data in RRC-inactive state

- The RAN Notification Aare may span multiple RAN nodes.

- For the case, some RAN nodes within the RNA choose the delivery mode for connected mode reception and other RAN nodes choose the delivery mode for inactive mode reception for the MBS session:

- If the UE move from source node which deliver data in connected mode to target node which deliver the data in RRC Inactive mode, the target NG-RAN determine whether move the UE to RRC inactive reception.

- If the UE move from source node which deliver data in RRC inactive mode to target node which deliver the data in connected mode, how to move the UE to connected mode depend on the RAN WG decision.

Editor's note: The assumption need to be confirmed by RAN WGs.

### 6.28.2 Functional description

The session management for the RRC inactive state UE receiving the multicast MBS session data, includes the following procedures/principle:

- When the serving RAN node determines to move the UE into RRC Inactive state, it keeps the UE context and interacts with other RAN nodes in the RAN notification area. The serving RAN node forward the date received from shared delivery tunnel to other RAN nodes in the RAN notification area. The other RAN nodes need to send the multicast MBS session data in Uu.

NOTE 1: Whether and how to prevent that multicast data are also transmitted in cells where no UE in the multicast session is located depend on RAN WG decision.

NOTE 2: Whether and how the MBS RRC inactive assistant information is sent to RAN depends on other solution.

- If both RAN nodes in the same RAN notification area have established the shared delivery tunnel for the multicast MBS session, they do not forward the MBS session data to each other according to the interaction.

- If RAN nodes in the same RNA area which does not establish the shared delivery tunnel, may receive the MBS data from one RAN node or multiple RAN nodes which have established the shared delivery tunnel .

NOTE 3: how to prevent that such a RAN node receives multiple copies of the MBS data depend on RAN WG decision.

- When the UE move to RRC connected mode, the procedure is specified in the TS 23.247 [4].

Editor's note: RAN node procedures and The Xn interaction will be determined by RAN WG.

The mobility for the RRC inactive state UE receiving the multicast MBS session data, includes the following procedures/principle:

- Moving within the RNA. The UE does not need to move into RRC connected mode.

- Moving out of RNA and within the RA. The UE perform the RNA update procedure as specified in the R17.

- Moving out of the RA. The UE perform mobility registration. The SMF provides the MBS session information to the RAN to establish the shared delivery tunnel or individual delivery tunnel.

Editor's note: The functionality of this solution needs to be discussed and agreed in RAN WGs.

### 6.28.3 Procedures

#### 6.28.3.1 Moving the UE to RRC Inactive mode

Editor's note: The detailed solution will be defined by RAN WGs.

This clause describes the NG-RAN moves the UE to RRC Inactive state.



Figure 6.28.3.1-1: NG-RAN node moves a UE to RRC Inactive state

1. The UE has joined the multicast MBS session and is receiving the MBS data in CM-CONNECTED with RRC connected mode.

2. NG-RAN determines to move the UE to RRC Inactive mode.

NOTE: Whether and how the MBS RRC inactive assistant information is sent to RAN depends on other solution.

3. The NG-RAN interact with other RAN nodes in the RNA area to handle the multicast MBS session for inactive UEs in the RNA area.

When the NG-RAN receives the multicast MBS data, it forward to other RAN nodes in the RNA area.

4. All the NG-RAN nodes in the RNA area provide the Multicast MBS data in the RNA.

#### 6.28.3.2 Mobility within/out of RNA area.

Editor's note: The detailed solution will be defined by RAN WGs.

When the UE moves within the RNA area, it does not need to access to the new RAN node to receive the MBS data if the UE has joined the multicast MBS session.

The UE may access to the new RAN node in several scenario:

- Within RNA.

- Out of RNA.

If the new RAN node retrieves the UE context successfully, it may established the shared delivery tunnel and initiates the path switch to SMF.

If the new RAN node fails to retrieve the UE context, the new NG-RAN establish the RRC connection with UE. The UE initiate the mobility registration or service request. The SMF send the MBS session information to NG-RAN via N2 to establish the shared delivery tunnel and radio resource.



Figure 6.28.3.2-1: retrieve the UE context successfully

The UE(s) joined the multicast MBS session and is receiving the multicast service in RRC-inactive state.

1. If UE need to access to the new RAN node, it initiate the RNA update to target RAN.

2. The target NG-RAN retrieve the UE context from source RAN including MBS session information.

3. The target NG-RAN may initiate the shared delivery method establishment procedure as specified in TS 23.247 [4].

Steps 4~6. The path switch procedure is triggered. The SMF provides the MBS information to NG-RAN as specified in TS 23.247 [4].

NOTE: Whether and how the MBS RRC inactive assistant information is sent to RAN depends on other solution.



Figure 6.28.3.2-2: fail to retrieve the UE context

The UE(s) joined the multicast MBS session and is receiving the multicast service in RRC-inactive state.

1. If UE need to access to the new RAN node, it initiate the RNA update to target RAN.

2. The target NG-RAN fail to retrieve the UE context from source RAN.

3. RRC connection is established.

4. The UE initiate the Registration or Service Request procedure with PDU session status IE to activate the associated PDU session.

5-6. The SMF provides the MBS information to NG-RAN as specified in TS 23.247 [4].

NOTE: Whether and how the MBS RRC inactive assistant information is sent to RAN depends on other solution.

### 6.28.4 Impacts on services, entities, and interfaces

UE:

- When the UE receives the MBS data in RRC Inactive state and need to access to a new RAN node, the UE need activate the associated PDU session via the service request or registration procedure if RRC connection need to be established.

NG-RAN:

- The serving RAN interact with other RAN nodes in the RNA area to handle the multicast MBS session for inactive UEs in the RNA area.

- As the user plane anchoring point to forward the MBS data to other RAN node in the RNA area.

Editor's note: The impact of NG-RAN need to be confirmed by RAN WGs.

## 6.29 Solution #29: MOCN network sharing with a single TMGI

### 6.29.1 Introduction

This solution addresses Key Issues #2.

The present solution aims to use a single TMGI to minimize the required updates and to avoid that multiple TMGIs for the same multicast data are broadcasted over the radio to save bandwidth.

TMGIs contain a mobile country code (MCC) and mobile network code (MNC). For MOCN network sharing, if a single TMGI is used, core networks will need to accept TMGIs with a MNC of a different CN. While existing stage 2 procedures do not rule out such behaviour, many existing deployments will likely reject MBS session creation requests with such TMGIs and it is suggested to use an MOCN signalling flag to request a different behaviour.

### 6.29.2 Description

One TMGI is reserved for the MBS broadcast data for which MOCN network sharing applies. It is selected by the involved AF(s) and made known to all AFs performing service announcements for the MBS data and is used as part of those service announcements. For instance, one AF can be tasked by configuration to request the primary TMGI and share it with the other involved AFs.

If an AF contacts a NEF to create an MBS broadcast session for which MOCN network sharing applies, it provides the TMGI and an indication that MOCN network sharing applies. If the NEF/MBSF receives an MBS session create request with an MOCN network sharing indicator and an TMGI including a MNC (Mobile network code) that is not identical to the MNC of the network including the NEF/MBSF, the NEF/MBSF checks configured data whether there is a network sharing agreement with the network indicated by the MNC, and if so accepts the request to create the MBS session, but selects the MB-SMF not based on the TMGI but based on the service area.

The TMGI and the indication that MOCN network sharing applies are included in messages to establish the broadcast session from MB-SMF via AMF towards the NG-RAN node. Based on the indication that MOCN network sharing applies, the NG RAN node checks whether there are additional MBS sessions with the same TMGI and identifies the correlated MBS sessions via the same TMGI. For the identified correlated sessions, the NG RAN broadcast related data only once over the radio. the NG RAN nodes checks if it already receives data for the broadcast session for any of the correlated sessions and if so does not provide a downlink tunnel endpoint and does send a lower layer join request.

Editor's note: It is to be confirmed by RAN WGs whether different MBS broadcast sessions from different CNs should share the same TMGI, which was used to identify one MBS broadcast session in Rel-17, except for location dependent MBS, area session ID needs be considered together.

If an MBS RAN node receives a request to release an MBS session for broadcast, it checks whether there are still correlated MBS sessions. If so, the RAN node continues to broadcast data for the MBS session over the radio. The NG RAN checks if it requested to receive MBS data from the core for the MBS session that is to be released. If so, the NG RAN node sends a request for another of the correlated MBS sessions to receive the MBS data from the related core network.

### 6.29.3 Procedures



Figure 6.29.3-1: MBS session creation for MOCN network sharing

1. AF may request TMGI(s)

2. The same TMGI is used for all related MBS broadcast sessions where MOCN network sharing applies. If multiple AFs are involved and provide data for an MBS broadcast session with MOCN network sharing, the AFs coordinate to use the same TMGI. For instance, one AF may be tasked by configuration to request the TMGI, and to share it with the other involved AFs. The TMGI may also be provided as configuration to all involved AFs.

3. The TMGI is provided as part of the service announcement for the MBS session by all AFs performing service announcements for the MBS session.

The following steps are executed for each CN involved in the network sharing:

4. AF sends a request to create an MBS session, which includes TMGI, MOCN network sharing indicator, and a service area to NEF/MBSF and an identifier of the broadcast MBS service.

5. Due to the MOCN network sharing indicator, if the NEF/MBSF receives an TMGI including a MNC (Mobile network code) that is not identical to the MNC of the network including the NEF/MBSF, the NEF/MBSF checks configured data whether there is a network sharing agreement with the network indicated by the MNC, and if so accepts the request to create the MBS session. In addition, the NEF/MBSF selects the MB-SMF not based on the TMGI but based on the service area.

6. The NEF/MBSF forwards the request to create an MBS session to the MB-SMF. MB-SMF accepts TMGIs with external MNC based on network sharing indicator.

7. Interactions as described in Figure 6.29.3-2.



Figure 6.29.3.2-2: Broadcast Session start for MOCN NG-RAN

1. See Figure 6.29.3-1.

2. Same as in Figure 7.3.1-1 of TS 23.247 [4]. A MOCN network sharing indicator is included. AMF accepts TMGIs with external MNC based on network sharing indicator.

3. Same as in Figure 7.3.1-1 of TS 23.247 [4]. A MOCN network sharing indicator is included.

4. Based on the MOCN network sharing indicator, the NG RAN node checks whether there are additional MBS sessions with the same TMGI and identifies the correlated MBS sessions via the same TMGI.

5. If the NG RAN node does not yet receive data for the broadcast session, and if the NG-RAN node is configured to use multicast transport, NG-RAN node sends an IGMP/MLD join request for the LL SSMA received in step 2.

6. As in Figure 7.3.1-1 of TS 23.247 [4]. If the NG RAN node does not yet receive data for the broadcast session, and if the NG-RAN node is configured to use unicast transport, NG-RAN node provides a N3mb DL Tunnel endpoint in the N2 message response.

Editor's note: Details will be confirmed by the RAN WGs.

7. As in Figure 7.3.1-1 of TS 23.247 [4].

8. As in Figure 7.3.1-1 of TS 23.247 [4].

9. For the identified correlated sessions, the NG RAN broadcast related data and the related TMGI only once over the radio.

10.-15. As in Figure 7.3.1-1 of TS 23.247 [4].



Figure 6.29.3.2-3*: Broadcast Session release for MOCN NG-RAN*

If NG-RAN receives a request to release an MBS session for broadcast, NG-RAN checks if there are other correlated MBS sessions. If there are correlated MBS sessions, NG-RAN continues to broadcast data for the MBS session over the radio. NG-RAN checks if it requested to receive MBS data from the core via the MBS session that is to be released. IF so, NG-RAN sends a request via another of the correlated MBS sessions to receive the MBS data to the related core network. If the NG-RAN is configured to use unicast transport, it sends an N2 message indicating the TMGI and N3mb downlink (DL) tunnel information. If the NG-RAN 430 is configured to use multicast transport, it may transmit an IGMP/MLD join request for the IP SSMA received in a precious request of the other correlated MBS session.

Editor's note: Details will be confirmed by the RAN WGs.

### 6.29.4 Impacts on services, entities and interfaces

**AF:**

- Use same TMGI for all correlated MBS broadcast sessions with MOCN network sharing;

- Indicate network sharing in request to create MBS session.

**NEF/MBSF:**

- Authorize create request for MOCN network sharing with TMGI with external MNC;

- Select MB-SMF based on service area instead of TMGI.

**MB-SMF and AMF:**

- Accept TMGI with external MNC.

**NG RAN:**

- identify correlated MBS sessions;

- Broadcast TMGI and data for correlated MBS session only once;

- Select one correlated session to request data for MBS session.

## 6.30 Solution #30: On demand multicast MBS session set up by MB-SMF

### 6.30.1 Introduction

This solution addresses Key Issues #3.

TS 23.247 [4] already provides some support for on-demand multicast sessions in Rel-17:

- An AF can create a multicast session at any time, e.g. when noticing demand.

- A multicast session may be established without prior creation by an AF when a UEs tries to join it: If no MB-SMF is assigned for the MBS session ID (i.e. the NRF provides empty MB-SMF profile), the SMF may select an MB-SMF and request it to configure the multicast MBS session. However, details are left to SMF implementation.

The present solution avoids the need for an AF to establish the multicast session and fills related gaps that are left to implementation in Rel-17. It allows to have preconfigured policies for such on-demand multicast sessions. It allows to determine whether to establish a multicast session towards the radio based on the number/frequency/location of join requests.

The present solution enables that an MBS session for an external IP multicast session is established:

(a) either when the first UE within the PLMN request to join that IP multicast session; or

(b) when multiple UE within the same PLMN have requested to join that IP multicast session

NOTE 1: Whether Option (b) is required and its merits will be further discussed as part of the evaluation.

The present solution also enables UEs to receive data from an IP multicast session even if the network does not establish the multicast session towards the radio:

Operators may want to enable UEs to join an external IP multicast session via a normal PDU session while not setting up an MBS session in their network. An application on the UE would likely send IGMP join requests to join such external IP multicast sessions. As discussed in Rel-17, this IGMP join request in the user plane will likely be converted to CP join request by the UE protocol stack. If that join request is rejected, the UE is not able to join a multicast session at all. To enable a UE to join, a user plane join request would need to be generated by the UPF, and the UPF also needs to be configured to forward received related multicast packets to the UE. (Even if a UPF receives a UP IP join request and forwards the request, the UE would not receive related multicast packets without special UPF procedures or configuration to forward them.)

One could also consider a decentral solution to enable UEs to join an external IP multicast session where each SMF configures the related UPF separately. However, this complicates a subsequent full establishment of an MBS session for the multicast IP session and also makes it hard for an operator to observe that there are many UEs joining the same external IP multicast session. The immediate assignment of an MB-SMF and MB-UPF is meant to enable a subsequent conversion to a full IP multicast session and also provides means to monitor whether many UEs join an external multicast session.

Editor's note: More clarification and evaluation is required on the benefits of applying individual delivery versus immediately establishing the MBS session towards the radio as in the Rel-17 existing mechanisms, especially in the scenario of the second bullet above.

This solution focuses on IP multicast sessions (using the IGMP protocol for joining and source specific multicast addresses as identifiers) provided by an application server in the internet that does not directly interact with the 5GS. It enables the 5GS to dynamically detects that many UEs join the same IP multicast sessions and based on that set up a related MBS multicast session to save transmission resources.

The following related issues need to be resolved:

- How to enable UEs to join multicast IP sessions if no related MBS session exists in the network.

- How to detect that multiple UEs join the same multicast IP session (possibly at high rate or in proximity to each other).

- How to establish a related on-demand MBS session based on the detection.

- How to inform the UEs to join the on-demand MBS session established in step 3.

NOTE 2: This solutions is only applicable if a source specific IP multicast address is used as MBS session ID.

NOTE 3: This solutions allows that QoS for a multicast session is preconfigured by the operator, e.g. based on a SLA with a service provider. If there is no such preconfigured information, only a default QoS will be provided for the 5MBS session.

NOTE 4: Only CP join requests are supported. IP applications on the UE can either use that join method, or the protocol stack in the UE can convert IGMP join requests to CP join requests.

### 6.30.2 Description

If the SMF receives a join request for a source specific IP multicast address with no MB-SMF assigned, the SMF assigns an MB-SMF and informs it that a join request for the source specific multicast address was received and about the location of the UE that issued a join request. The MB-SMF decides based on operator policy and possibly based on PCF interactions to inquire predefined information about policies for the source specific IP multicast address in the UDR whether the join request shall be accepted and whether to establish the MBS session towards the radio, and informs the SMF about those decisions. Based on operator policy, the MB-SMF may immediately establish the MBS session towards the radio when the first UE joins or wait until more UEs join the join request for a source specific IP multicast address.

If the MB-SMF decides to accept the join request, the MB-SMF registers itself at the NRF as handling the source specific multicast address, and configures the MB-UPF to send an IGMP join request for the source specific IP multicast address towards the external network and to receive related data, irrespective of whether it decides whether to establish the MBS session towards the radio.

If the MB-SMF decides not to accept the join request, the SMF rejects the join request.

If the MB-SMF decides to establish the MBS session towards the radio, normal MBS multicast procedures apply from that point onwards.

If the MB-SMF decides not to establish the MBS session towards the radio, the SMF also informs the MB-SMF about subsequent join request for the same IP multicast request until the MB-SMF decides to establish the multicast session towards the radio.

If the MBS session is not to be established towards the radio, the SMF does not add MBS session information to the PDU session but still accepts the join request. Individual delivery is then used towards that UE.

If the MB-SMF does not establish the MBS session towards the radio, it will then be informed by SMFs about subsequent join attempts for this source specific multicast address, and can then decide to establish the MBS session towards the radio. The MB-SMF may count the number or log the join requests to determine their frequency and/or whether the attempts are concentrated in a specific area in order to decide whether to establish the MBS session, and in order to determine a service area for the MBS session. It can interact with the PCF to check whether the multicast session can be authorized. The PCF can consider the area and the load in the area for a related decision. The PCF can contact the UDR to check whether there is preconfigured policy for a multicast session with the specific source specific multicast address.

The MB-SMF stores the SMFs that subscribed to info about the MBS session. It notifies those SMFs when it decides to establish the MBS session towards the radio. The SMFs then update the PDU sessions of related UEs with the MBS session information.

Editor's note: It is to be clarified the benefit of applying individual delivery, instead of shared delivery when the first (a few) UEs join the MBS session.

To enable a UE to receive an IP multicast sessions within a PDU session if no related MBS session towards the radio is established, an IGMP join requests needs to be send towards the IP network. In Rel-17 it was assumed that a UE would only send join request in the control plane signalling. It was anticipated that the protocol stack in the UE could recognise IGMP join requests in the user plane and convert them to control plane join requests. An MB-SMF that it is informed about a join attempt for an IP SSMA with no related MBS session and decides not to establish the MBS session configures the MB-UPF to send an IGMP join request.

### 6.30.3 Procedures



Figure 6.30.3-1: UE join request when related MBS session is not yet created

1. UE sends a join request for an IP SSMA.

2. The SMF checks whether the UE is authorized to join 5MBS multicast sessions. The SMF inquires MB-SMF handling the IP SSMA at the NRF and detects that none is assigned. It inquires MB-SMF at NRF based on other criteria, e.g. UE location and selects MB-SMF to handle IP SSMA.

3. SMF requests MB-SMF to provide info about the MBS session for the IP SSMA and provides UE location.

4. MB-SMF may interact with PCF to check whether policies allow creation of MBS session. It indicates that MBS session is not yet established and possibly location(s) of UE(s) desiring to join or a service area selected by the MB-SMF based on those locations.

5. PCF may check at UDR whether there are preconfigured policies for IP SSMA.

6. PCF decides whether an MBS radio session is permissible at the indicated location(s) or a service area and selects QoS for the MBS session (e.g. based on policies in the UDR) and indicates that to the MB-SMF.

7. The MB-SMF decides whether to accept the join request and whether to establish the MBS session towards the radio. The MB-SMF may count the number or log the join requests to determine their frequency and/or whether the attempts are concentrated in a specific area in order to decide whether to establish the MBS session towards the radio and in order to determine a possible service area for the MBS session.

The MB-SMF also stores SMFs that subscribed in step 3.

8. The MB-SMF request the MB-UPF to create an N4 session of the MBS session with IP SSMA and to send an IGMP join request for the IP SSMA.

9. MB UPF sends IGMP join request for the IP SSMA.

10. If the MB-SMF does not establish the MBS session towards the radio, it still registers itself at the NRF as handling the source specific multicast address, and will then be informed by SMFs about subsequent join attempts for this source specific multicast address, and can then decide to establish the MBS session towards the radio.

11. The MB-SMF informs SMF whether the MBS session towards radio is to be established and informs about QoS flow(s) for the MBS session. It may instead request that the join request is rejected.

12.-14. SMF updates the PDU session with additional QoS flow unless that flow can be transported via default QoS flow. The SMF provides no other information about MBS session in N2 container if MB-SMF decided not to establish the MBS session towards the radio. It indicates towards the UE that the join request is accepted.

15. Same as step 11 in Figure 7.2.1.3-1 of TS 23.247 [4].

16. Same as step 13 in Figure 7.2.1.3-1 of TS 23.247 [4].

17-19. Same as in Figure 7.2.1.3-1 of TS 23.247 [4].



Figure 6.30.3-2: PDU Session modification when MB-SMF decides to establish MBS session towards radio

1. The MB-SMF decides to establish the MBS session towards the radio. The MB-SMF may count the number or log the join requests to determine their frequency and/or whether the attempts are concentrated in a specific area in order to decide whether to establish the MBS session towards the radio.

2. The MB-SMF notifies SMFs that subscribed to info about an MBS session when the MB-SMF decides to establish the MBS session towards the radio.

3. The SMFs then update the PDU sessions of related UEs with the MBS session information.

4. NG RAN nodes serving UEs within the MBS session request the MB-SMF to deliver MBS data towards them and start multicasting those MBS data over the radio.

### 6.30.4 Impacts on services, entities and interfaces.

**MB-SMF**

- Decide whether to establish MBS session toward radio.

- Inform SMFs when deciding to do so.

**SMF**

- Select MB-SMF when UE request to join IP SSMA and no MB-SMF is assigned.

- If MB-SMF decides not to establish MBS session toward radio, apply individual delivery and do not provide MBS session information within PDU session.

- If MB-SMF subsequently decides not establish MBS session toward radio, update PDU session with MBS session information.

**UDR**

- Store preconfigured information about MBS policies for an IP SSMA.

## 6.31 Solution #31: Multicast access control for high number of public safety UEs

### 6.31.1 Introduction

This solution addresses Key Issue #6. Considering the case that multiple departments from the same mission critical organization served by different AS may utilize the same PLMN network, as described in bullet 2 in clause 4.2, it is important to support the multicast resource is fairly used be by the different departments.

### 6.31.2 Functional description

During the UE join or the MBS session activation procedure, when the NG-RAN is going to allocate resource for the join requesting UE, the NG-RAN needs to check the resource availability for this UE who is mapped to a certain slice. Different departments' users may be mapped into different slices. If there are available resource in the dedicated/shared multicast resource for that slice, then the join/MBS session activation will success and continue, else the NG-RAN reject the PDU Session Resource setup and informs the UE, which may further reports the resource failure towards the AF to make further decision, e.g. release some low priority group communications which is using the MBS.

### 6.31.3 Procedures

This solution is on top of the procedure in 7.2.1.3 of TS 23.247 [4]. The enhancement are as follows:

In step 7, The NG-RAN checks the radio resource usage corresponding to the S-NSSAI.

In step 8, if the NG-RAN determined that there is no available dedicated and shared multicast resource for the slice. As part of the AN specific signalling exchange with the UE, no radio resources for the UE to receive the multicast MBS session is provided to the UE.

In step 9, a radio resource failure is included in N2 SM container and provided to the SMF. After the SMF receive the failure, it may trigger the network triggered multicast session leave as described in clause 7.2.2.3, and step 11-19 will not performed.

Editor's note: It is FFS whether network triggered multicast session leave can be triggered at this step.

After step 8, the UE(s) can report the failure events to the AF.

Editor's note: For public safety, related application level signalling is defined by SA6 and coordination is required.

Editor's note: It is to be evaluated the benefits of this solution compared with existing join failure event report from MCX Client to MCX Server.

NOTE 1: This UE signalling can cause extra overload and requires the UE to be in RRC\_Connected state.

Based on the reports from UE(s), the AF may release the multicast MBS session and may instead use an existing MBS broadcast session or establish a new MBS broadcast session for the group call, or the AF may release some low priority group communications which is using the MBS if there is not enough radio resource.

Editor's note: For public safety, related AF procedures are defined by SA6 and coordination is required.

Editor's note: More investigation whether a broadcast MBS session can avoid overload in a better manner than a multicast MBS session with transmission mode for inactive reception is required.

Editor's note: It is FFS why the broadcast MBS session can be established but radio resource allocation fails for multicast MBS session.

NOTE 2: In order to avoid the uplink overload, the application layer can provide mechanism to alleviate the overload, e.g. announcing to the UEs that no report is needed any more, or dynamic specifying some UE to report this event based on location. Or the application client can make the decision when to report considering the load conditions.

The MBS session activation procedure defined in clause 7.2.5.2 of TS 23.247 [4] is also impacted. As the radio resource allocation interactions in step 10b is referred from the step 8-12 in clause 7.2.1.3 MBS session join procedure. So the changes in above procedure is also applied to the MBS session activation procedure.

Editor's note: It is FFS about the resource allocation failure when multicast MBS session is activated in step 12 in clause 7.2.5.2 of TS 23.247 [4].

### 6.31.4 Impacts on services, entities, and interfaces

NG-RAN:

- Send failure events related with MBS session join or MBS session activation to the UE.

UE:

- Receive failure events related with MBS session join or MBS session activation from NG-RAN and report it to the AF.

Editor's note: Detailed impact will be determined by (and/or in collaboration with) RAN WGs.

# 7 Evaluation

Editor's note: This clause will provide evaluation of different solutions.

## 7.1 Key Issue #1: MBS session reception in RRC Inactive

### 7.1.1 Overview over available solutions

For Key Issue #1 "Multicast MBS data reception in RRC Inactive state", there are 14 solutions in the TR:

- #1,#3,#4,#5,#6, #18, #19, #20, #21, #22, #23, #26, #27, #28.

A comparison of solutions covering RRC\_Inactive MBS Multicast reception is shown in Table 7.1.1-1.

Table 7.1.1-1: Comparison of multicast solutions for KI#1 RRC\_Inactive mode reception

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Sol | CN Assistance/Recommend for Inactive Reception | Assistance Parameters | Mobility Handling | MBS session activation/release/deactivation | RAN selects UEs delivery mode | Remarks |
| 1 | Y. AF provides assistance to NG-RAN | Y. MBS priority, UE session priority, RRC\_Inactive enable |  |  | Y. RAN can decide when to switch UE mode for MBS | Per session allow/disallow RRC\_Inactive reception  In place of MBS priority ARP, 5QI can be used.  Discussion whether UE priority needs to be per MBS session is below Per user priority may be difficult to handle, per session allow/disallow sufficient |
| 3 | Y. AF provides assistance to NG-RAN | Y. MBS session ID, privilege/non-privilege users in MBS session. If privilege transition to RRC\_Inactive should be avoided |  |  |  | How paging is handled for privileged UEs in case of activation of MBS session is FFS |
| 4 |  |  |  | Y. Group CN paging with paging cause |  | Paging cause indicates the reason for paging to enable RRC\_Inactive UEs to remain inactive when MBS session is activated and enable UE to receive the MBS session data in RRC Inactive state. |
| 5 |  | Y. MBS context shared among RAN nodes in RNA | Y. Depends on UE moves within RNA, outside RNA | Y. Depends on whether target cell has MBS session support or not |  | Assumes all the NG-RAN nodes are homogeneous in terms of RRC\_Inactive reception capability.  RNA update procedure may be used. Mostly RAN centric |
| 6 | N. Existing QoS parameters for MBS QoS flows sufficient | Existing. PER, 5QI, ARP etc. will help RAN to decide enabling RRC\_Inactive reception |  |  | Y. RAN can decide when to switch delivery mode for MBS | 5QI, PER, ARP, etc. may be used to indicate a MBS level priority to NG-RAN but may not implicitly to decide to allow/disallow INACTIVE MBS reception.  They also propose to use existing "RRC Inactive Assistance Information" sent by AMF to NG-RAN. But this information may not have any co-relation with MBS session and can only be used as additional UE specific information to be used by NG-RAN to decide the RRC\_Inactive state for a UE |
| 18 |  |  |  | Y. Group paging without paging cause |  | Requires RAN input: Whether/how RRC Inactive UE responds when the CN initiated group paging is performed, it go back to the RRC Connected state. |
| 19 | Y. When requested by target NG-RAN, MB-SMF provides assistance information | Y. MBS context related info | Y. UE moves to NG-RAN where current MBS is not served | Y. RAN then decides delivery mode | Y. RAN can decide when to switch delivery mode for MBS | To enable RRC\_Inactive UE to continue reception when moving within RNA, either source RAN node informs serving/target RAN node about MBS, or MB-SMF informs all RAN nodes in a service area |
| 20 |  |  | Y. Move to new NG-RAN in a new TA. Initiate mobility procedure |  |  | UE can join or leave multicast session during a re-registration for TA updated. |
| 21 |  |  | Y. UE moves out of RNA but within RA |  |  | Assumes that when UE in RRC Inactive state moves out of the Registration Area or fails to perform the RRC Resume procedure (e.g. when moving out of the RNA), UE invokes the mobility registration update procedure. |
| 22 |  |  |  | Y. Page only CM-Idle UEs. Group paging not needed for RRC\_Connected, RRC\_Inactive |  | NG-RAN keeps context of MBS and shared tunnel live even if session is inactive. Resource consumption is not optimal  RAN-centric decision |
| 23 |  |  |  | Y. Individual paging to RRC\_Inactive and RRC\_Idle UEs |  | AMF observes and takes the decision (to page UEs) without the information about SMF on MBS context. |
| 26 | Y. CN sends (to RAN) list of UEs recommended to be kept in RRC\_Connected | Y. List of UEs recommended to be kept in |  |  | Y. CN list is only recommendation | Discussion whether list of recommended UEs/ UE priority needs to be per MBS session is below |
| 27 | Y. AF provides list of privileged UEs during MBS-creation. | Y. GPSI of list of privileged UEs |  |  | Y. List of shared UEs needs to be in RRC\_Connected mode | This solution requires that the AF be aware of the UEs’ GPSI. This solution does not depend on PCC deployment and does not require per UE/PDU Session signalling as in case of Sol#3  Discussion whether list of recommended UEs/ UE priority needs to be per MBS session is below. |
| 28 |  | Y. MBS context and data shared among RAN nodes in RNA | Y. different handling if UE moves within RNA, outside RNA, outside RA | Y. Depends on whether target cell has MBS UP already established or not |  | RNA update procedure is used if UE moves outside RNA and mobility procedure is used if UE moves outside RA  Prevention of multiple data between source and target gNB has to be ensured  Assumes all the NG-RAN nodes are homogeneous in terms of RRC\_Inactive reception capability |

### 7.1.2 Assistance Information

**Sol#1**: proposes to have assistance from AF:

- Indication of whether multicast reception by UEs in RRC\_Inactive state is allowed for specific multicast MBS service(s)/session(s).

- MBS session Priority.

- UE priority within MBS session.

- UE capabilities and preferences.

**Solution#3**: (Solution covers both KI#1 and KI#6) AF provides assistance information with "privileged" UEs of an MBS session, which are preferably to be kept in RRC\_Connected state. In Sol#3, the use case is targeted to public safety only and assuming that the private IP address of the UE is available (as in IMS case). The assistant information is provided via PCF.

**Solution#6**: Proposes that existing "RRC Inactive Assistance Information", and the existing QoS parameters, e.g. PER in the 5QI and ARP of MBS QoS flow can be used by NG-RAN to determine whether the receiving of the multicast MBS session data in RRC inactive state can be enabled and whether UEs can be sent to RRC Inactive state to receive the multicast MBS session data.

**Solution#26**: (Solution covers both KI#1 and KI#6) AF indicates for some UEs recommended (that may be part of one or multiple MBS sessions) should to be kept in RRC\_Connected state. The indication is independent of an MBS session.

**Solution#27**: (Solution covers both KI#1 and KI#6) This solution proposes that AF sends a list of privileged UEs in MBS Session creation. This solution requires that the AF be aware of the UEs’ GPSI. This solution does not depend on PCC deployment.

**Comparison of the solutions with assistance information:**

*Per MBS session assistance information*

Solution #1 proposes to have explicit assistance information (MBS priority and/or recommendation whether to enable inactive MBS reception to be used to decide which MBS sessions can be allowed RRC\_Inactive reception). Solution #6 proposes that the existing QoS parameters, e.g. PER and ARP in the 5QI of MBS QoS flow can be used to support the NG-RAN to decide which MBS can be allowed RRC\_Inactive reception. Whereas solution #6 advocates that that the existing QoS parameters, e.g. PER and ARP in the 5QI of MBS QoS flow is sufficient and can be used to support the NG-RAN to decide which MBS can be allowed RRC\_Inactive reception.

*Per UE assistance information.*

Solution #1 proposes a UE session priority as assistance information to enable RAN to decide which UEs in the MBS session can be switched to RRC\_Inactive state. Solution #3 and solution #27 also suggest that some UEs within an MBS session can be marked as privileged to assist NG RAN to decide which UEs should be kept in RRC\_Connected state. Solution#26 proposes that a recommendation can be provided for some UEs that they should be kept in RRC\_Connected state; this recommendation is not linked to an MBS session. In all those solutions, it is assumed that an AF provides the related information. Most of the solutions also address key issue 6 as a typical use case could be that a public safety AF has knowledge of privileged or frequently talking users. For such users frequent state transitions between RRC\_Connected and RRC\_Inactive state can in this manner be avoided.

Only solution 1 suggest multiple priority levels.

Solutions 26 has the advantage that it is well suited for users in multiple MBS sessions (as dispatcher for public safety) and that it avoids possible conflicting state recommendations obtained for the same user via different MBS sessions. If the UE is different role in different MBS session, the AF need coordinate the UE role in different MBS session and depending on which MBS session is in activate state, the AF may need give different information to 5GC.

The signalling procedure for the AF to provide the information also differ: Solutions 27 extends the MBS session create procedure. Solution 3 extends AF session with required QoS Create procedure and assumes that the information is propagated via the PCF to the SMF. Solution 26 extends the parameter provisioning procedure.

For UE level assistance information, one proposal (solution 6) is to reflect the UE level assistance information via the QoS information of associated QoS flow. This solution assumes that whether the UE can be moved into RRC Inactive state depend on the UE QoS requirement, i.e. RRC Inactive UE has lower QoS requirement because there is no HARQ.

*Parameter provision procedure*

For the MBS session level assistance information, it seems the only way to transmit from AF to 5GC is via the MBS session creation procedure.

Sol#1/#26 propose the AF provides the parameter (list of UE) (same as solution 1 as part of the MBS subscription data) to the UDM. When the UE joins the MBS session, the SMF fetches the data from UDM, which include the related UE level assistance information. The difference between two solutions is on whether this UE level assistance information is per MBS session or per UE granularity. As mentioned in Sol#26 if the UE level assistance information is per UE level, AF needs to consider whether the related MBS session is in active or inactive state and update the UDM accordingly. However, if this information is per MBS session level, this additional update per MBS session state is not needed. If the UE joins multi MBS session, at the NG-RAN side it may receive different UE level assistance information from different MBS session. NG-RAN nodes need to reconcile the information, e.g. it can take the highest request, e.g. whether the UE level assistance information in one of the MBS session prefer to be in CONNECTED state, as input parameter to decide whether it need keep in Connected state.

Sol#1 and Sol#26 (if Sol#26 is updated to be associated with MBS Session), requires the AF to perform Nnef\_ParameterProvision\_Create/Update procedure after the MBS Session in created.

Sol#3/#6 propose the AF provides the parameter as part of the QoS information to the PCF and SMF gets the related information during the SM policy association establishment/update procedure. By doing this, the deployment of PCF is mandatory. The AF cannot inject the related information before the UE activates the associated PDU session. Also this update need be done per UE granularity, i.e. for a list of UE, the AF needs to update one by one per UE.

Sol#27 proposes the AF provides the parameter (list of UE) as one parameter during the MBS session creation procedure. The MB-SMF store the received list of UE information. The MB-SMF provides full list of the UE information to all contacted SMF(s). It is possible that some prioritized UEs in the list are not handled by an SMF (if those UEs have not joined yet, or joined in other SMF(s)), and in case the list of UEs is changed, the MB-SMF needs to notify all SMF(s) involved in this MBS session.

For the MBS session level assistance information, it is better to be conveyed as other MBS session information parameter, e.g. QoS information. Then it is proposed to be delivered to NG-RAN node as part of the shared delivery tunnel establishment procedure.

For the UE level assistance information, all solution proposes to use the PDU session level signaling to deliver the parameter to the NG-RAN node.

### 7.1.3 Activation of MBS multicast session

**Solution#4**: Proposes to use group based CN paging as the trigger for activation and release of MBS session. If paging is for MBS session activation, the NG-RAN node determines for each cell whether transmission for RRC INACTIVE UE is enabled and includes a paging cause if RRC INACTIVE UE do not need go back to the RRC-CONNECTED state.

**Solution#18**: Unlike Solution#4 (where paging cause is used), solution#18 proposes that no paging cause is required for MBS Session activation. It follows existing Rel 17 paging procedures. It also proposes that, for releasing of MBS session, RRC IDLE UEs (without active UP) get notified by SMF only when they reconnect using PDU Session Modification procedure. In case RRC\_INACTIVE UE happens to share the same PO with any of the IDLE UEs and responds to paging, the RRC\_INACTIVE UE will be brought back to RRC\_CONNECTED.

Editor's note Whether the RRC\_INACTIVE UE need be aware the group paging is CN initiated or RAN initiated is FFS.

**Solution#19**: Existing MBS session activation procedures are used from CN towards RAN nodes. RAN nodes in RNA inform each other about MBS session activation. RRC-Inactive UE in cell shall remain RRC-inactive during MBS session activation when related delivery mode is used in that cell. RAN groups will determine related signalling.

**Solution#22**: NG-RAN node keeps the multicast MBS session context and N3mb shared tunnel for the multicast MBS session as long as the NG-RAN has UE context for UEs in the MBS session context which may be in either RRC-CONNECED or RRC\_INACTIVE state. (this seems existing REl-17 behaviour) Because of this, when the MBS session is (re-)activated, it should page only RRC\_Idle UEs and need not page RRC\_Inactive UEs (group paging is not needed).

**Solution#23**: Suggests using CN paging also for RRC\_Inactive UES. The paging area includes all the registration areas of those UE in CM-IDLE mode, and NG-RAN node where the CM-Connected mode UE(s) is camping. Unclear what the benefits compared to RAN paging would be are quite debatable.

**Comparison of the solutions focusing on Activation/Release:**

*On how to efficiently page RRC\_Inactive UEs during activation MBS session*

All the four solutions (#4, #18, #22, #23), propose group CN paging for RRC\_Idle UEs. However, they differ in the way they handle the RRC\_Inactive UEs.The overall view by all the solution are,

- For activation, only RRC\_Idle UEs should go to RRC\_Connected state (after paging) and RRC\_Inactive UEs should not switch to RRC\_Connected state.

- While Sol#4 proposes to include paging cause to not let RRC\_Inactive UEs to switch to RRC\_Connected state, sol#18 does not use paging cause. Not including the paging cause may allow RRC\_Inactive UEs switch to Connected state.

- Solution #22 proposes that only RRC\_Idle UEs should be group CN paged. And for RRC\_Inactive UEs, the NG-RAN node keeps the multicast MBS session context and N3mb shared tunnel for the multicast MBS session and when the service is re-activated and there are UEs in RRC\_INACTIVE state, the NG-RAN needs to notify the UEs of this activation. But they fail to explain that without using RAN paging how NG-RAN node can notify UEs.

- Solution 23 proposes that AMF will page all the NG-RAN where there are CM\_Idle UEs. For RRC\_Inactive UEs, NG-RAN will use RAN paging. However, it is unclear that how RRC\_Inactive UEs will react to CN paging.

*On how to efficiently page RRC\_Inactive UEs during release of MBS session*

Only solutions #4 and #18 talks about paging for release of MBS session. In Sol #18, the Rel-17 solution is assumed how RRC\_Inactive UEs can be notified about the release of the MBS session, solution #4 states that RRC\_Inactive UEs to be paged to go to RRC\_Connected state for release of the MBS session.

NOTE: Whether/how RRC\_INACTIVE UEs behave when group paging for CM-IDLE UE(s) is performed is to be determined by RAN WG(s).

*On whether the solution can able to differentiate between RRC\_Inactive MBS UEs than RRC\_Idle MBS UEs?*

Only solution #4 is proposing to have differentiated paging (with paging cause included) for RRC\_Inactive UEs. Because, in case RRC\_INACTIVE UE happens to share the same paging occasions with any of the IDLE UEs and responds to paging, the RRC\_INACTIVE UE will be brought back to RRC\_CONNECTED, which should be avoided.

### 7.1.4 Mobility for RRC\_Inactive UEs receiving MBS data

**Solution#5:** Proposes MBS session service continuity procedures in case of RNA change, but most aspects of the solution will need to be decided by RAN. If RRC\_inactive UE moves within RNA and if the target NG-RAN node does not deliver multicast data at target cell using delivery mode tor RRC\_inactive reception, the UE sends RRC message to transition to RRC\_connected state to target NG-RAN node. If target RAN node does not have UE context, it may fetch it from source RAN. If the UE moves out its RNA and within RA, it triggers the RNA update procedure as specified in TS 38.300 [13]. The evaluation will require RAN feedback.

**Solution#19:** It focuses on how to inform RAN nodes not serving any connected UEs in the MBS sessions? about the MBS session. This solution describes two options to accomplish:

i) source RAN informs serving/target RAN about MBS;

ii) MB-SMF informs all RAN nodes in a service area.

RRC\_inactive UEs can move to cells where the transmission mode for RRC connected state is applied and then need to transition to the RRC connected state to receive MBS data. The evaluation will require RAN feedback. Existing MBS session activation procedures are used from CN towards RAN nodes. RRC-Inactive UE in cell shall remain RRC-inactive during MBS session activation when related delivery mode is used in that cell.

**Solution#20 and #21:** The two solutions propose to allow a UE to request MBS session join/leave during mobility registration update procedure by using a multicast session information container in the Registration Request message, when the UE in Idle state or receiving multicast data in RRC Inactive state moves out of the Registration Area or fails to performthe RRC Resume procedure (e.g. when moving out of the RNA).

**Solution#28:** When the UE is moved into RRC Inactive state, the serving RAN node acts the anchoring point, to inform the other RAN nodes in the RNA to provide the Multicast MBS data. The UE performs the RNA update procedure as specified in the R17, if it moves outside RNA. If UE moves out of RA, the UE initiates mobility registration after the RNA update procedure fails. This solution proposes that RAN nodes in the same RNA area may receive the MBS data from one RAN node or multiple RAN nodes which have established the shared delivery tunnel.

**Comparison of the solutions focusing on Mobility:**

*On how to manage RRC\_Inactive UEs continuation of MBS data Outside RNA.*

Most of the solutions propose to use RNA update procedure by the UE when it moves outside RNA. Solutions #20 and #28 propose to use mobility registration procedure when UE moves outside RA. Solution #21 also advocates that if UE in Idle state or receiving multicast data in RRC Inactive state moves out of the Registration Area or fails to perform the RRC Resume procedure (e.g. when moving out of the RNA).

## 7.2 Key Issue #2: 5MBS MOCN RAN Sharing

Soln #2, #7. #8, #9, #24 and #29 are proposed to address Key Issue #2: 5MBS MOCN Network Sharing.

Soln#2 proposes a solution of providing an additional identifier by the AF towards the MB-SMF when creating MBS sessions. The MB-SMF passes it to the NG-RANs. Based on the additional identifier, the shared NG-RAN can understand multiple Broadcast MBS sessions are transferring the same content and deliver packets from one session over the air.

Soln#7 proposes to use associated session ID to be passed from the AF to NG-RANs via 5GCs, to enable shared NG-RAN to associate multiple Broadcast MBS sessions. The shared NG-RAN associate multiple Broadcast MBS sessions and deliver packets from one session over the air. The associated session ID can be SSM or TMGI as two options. To further saving CN resources and NG-RAN processing efficiency, Soln#7 proposes to establish one user plane within those broadcast MBS sessions. In case there is a failure in the on-going user plane, shared NG-RAN will initiate the establishment of another user plane towards another 5GC.

Soln#8 proposes to use MOCN TMGI to create one broadcast MBS session towards one 5GC for those shared NG-RANs, and if all NG-RANs under MBS service area are not shared, also create one broadcast MBS session towards each 5GC for each PLMN for those dedicated NG-RANs.

Soln#9 proposes pass all the associated TMGIs from the AF towards the MB-SMF when creating MBS sessions. The MB-SMF pass the TMGI list to the NG-RANs. The NG-RAN selects the primary TMGI and return the primary TMGI and its usage area to the AF via the MB-SMF, so that AF can update service announcement to let UEs to understand the TMGIs and their corresponding usage area. To further saving CN resources and NG-RAN processing efficiency, Soln#9 also proposes not to establish the user plane in case the TMGI of the broadcast MBS session is not the primary TMGI.

Soln#24 proposes to configure the associated TMGIs in NG-RANs, so that shared NG-RAN can associate multiple broadcast MBS sessions and delivery the content of one broadcast MBS session over the air.

Soln#29 proposes to use the same TMGI to create broadcast MBS sessions towards each 5GC together with a MOCN signalling flag to differentiate from normal broadcast MBS sessions. Soln#29 also proposes to establish one user plane within those broadcast MBS sessions. In case there is a failure, shared NG-RAN will initiate the establishment of another user plane towards another 5GC.

The evaluation can be performed from the following aspects:

**Whether the solution can enable shared NG-RAN to optimize radio resource utilization for MOCN network sharing deployment?**

These criteria can be used to evaluate whether the solution can address KI#2.

Soln#2 and Soln#7 introduce additional identifier and associated session ID to be provided by the AF. The AF provide it to the MB-SMF in MBS session creation. The MB-SMF passes it to the NG-RANs, so that shared NG-RAN can bring data from one broadcast MBS session over the air.

Soln#8 proposes to create only one broadcast MBS session towards shared NG-RAN, so the shared NG-RAN will only deliver the data from this broadcast MBS session over the air.

Soln#9 passes all the relevant TMGIs to the NG-RAN, so that shared NG-RAN will select the primary TMGI and deliver the data from the broadcast MBS session identified by the primary TMGI.

Soln#24 configures the associated TMGIs in NG-RANs, so that shared NG-RAN can bring data from one broadcast MBS session over the air.

Soln#29 proposes to create broadcast MBS sessions with the same TMGI and additional MOCN signalling flag, so that the shared NG-RAN can determine and bring one broadcast MBS session over the air.

All those solutions can address KI#2.

**Whether the solution can be applied to any deployments?**

In MOCN network sharing deployment, it is possible that not all NG-RAN nodes are shared. There may be some NG-RAN nodes dedicated to specific PLMN which connected to the corresponding 5GC. The assumption that all NG-RAN nodes are shared in MOCN network sharing deployment cannot be made.

In Soln#2, Soln#7, Soln#9, Soln#24 and Soln#29, AF creates each broadcast MBS session separately, so that the shared NG-RAN will receive multiple broadcast session setup requests and offer the service, while the dedicated NG-RAN will receive only the corresponding broadcast session setup request to offer the service.

In Soln#8, AF creates one broadcast MBS session towards one 5GC for those shared NG-RAN nodes, and if all NG-RAN nodes under MBS service area are not shared, creates one broadcast MBS session towards each 5GC for those dedicated NG-RAN nodes.

**Whether extra efforts are needed when introducing a new MBS service?**

To introduce a new MBS service (e.g. a TV channel), it is important to evaluate whether extra efforts are needed.

In Soln#2, Soln#7, Soln#8 and Soln#29, AF can perform TMGI allocation and broadcast MBS session creation as in Rel-17. Soln#9 requires all relevant TMGIs to be allocated prior to the broadcast MBS session creation, which are minor implications on the AF. For those solutions, the new MBS service can be introduced by the invoking Nmbsmf or Nmbsf APIs, without additional efforts.

Soln#24 requires the coordination of the O&M configuration in NG-RANs (provision relevant TMGIs) and service operation (TMGI allocation and broadcast MBS session creation). The O&M configuration is done prior to TMGI allocation, since the TMGI belongs on a pre-agreed service-id range amongst the participating PLMNs. For example, if PLMNs with MCC=234, MNC=15 (operator A) and MCC=234, MNC=10 (operator B) are doing MBS RAN sharing, the corresponding RAN nodes are already configured with the PLMN-ids of each of the sharing partner and can be configured with the specific respective service-id (6 digits numbers) of the TMGIs of two PLMNs that correspond to the same content or even range of service-ids. For instance, service-id=123456 (for operator A) and service-id=001234 (for operator B) corresponds to content from "TV channel X".

For all solutions, prior to introducing new MBS services, the configuration in all shared NG-RANs need to be done beforehand.

**How many TMGIs are advertised by a shared NG-RAN?**

The number of TMGIs advertised will cause some impacts on the radio resource efficiency.

Soln#2, Soln#7 SSM option and Soln#24 propose to have all the relevant TMGIs advertised, and those TMGIs point to the same radio resource for broadcast data delivery. Soln#7 TMGI option only has one TMGI advertised.

Soln#8 only has one MOCN TMGI advertised.

Soln#9 only has the selected primary TMGI advertised.

Soln#29 only has one common TMGI advertised.

**Is it backward compatible (service announcement impacted)?**

The backward compatibility is an important aspect in the evaluation. If the solution is backward compatible, it can benefit Rel-17 UEs to work in the optimized way. All the solutions are backward compatible in radio interface, but some are not in the service announcement.

In Soln#2, Soln#7 SSM option and Soln#24, there are no impacts on service announcement. Each UE will get the service announcement with its own TMGI with the PLMN ID it belongs to. In Soln#29 and Soln#7 TMGI option, each UE will get the service announcement with a common TMGI, which may have different PLMN ID from its network.

In Soln#8, there are no impacts on service announcement as well. Each UE may get the one service announcement with MOCN TMGI and another one with its own TMGI (i.e. TMGI dedicated to PLMN) if all NG-RAN nodes under MBS service area are not shared.

In Soln#9, AF needs to consolidate the information it receives from all shared NG-RANs and include TMGIs with their usage area in service announcement.

**How UE receives broadcast MBS session data?**

The complexity of the UE logic is not negligible.

In Soln#2, Soln#7 SSM option and Soln#24, a UE can receive the broadcast MBS session data with its own TMGI, as indicated in the service announcement. In Soln#29 and Soln#7 TMGI option, a UE receives the broadcast MBS session data with a common TMGI in the service announcement.

In Soln#8, each UE may use the MOCN TMGI or its own TMGI to receive the broadcast MBS session data, depends on whether it is served by a shared NG-RAN or dedicated NG-RAN.

NOTE: When the UE receives Service Announcement including MOCN TMGI and Service Announcement including its own TMGI (i.e. TMGI dedicated to the PLMN) for same service from the AF, the service layer (e.g. 5MBS client, MC service client) or the application layer of the UE needs to be able to understand the MOCN TMGI and its own TMGI are for same service based on the information in the service announcements, e.g. SDP info with IP multicast address and port#, Service ID, and UE needs to be able to switch the listening TMGI when moving to the new cell without broadcasting the currently used TMGI. However, the lower layer does not have to be aware that these two TMGIs are for same service.

In Soln#9, a UE needs to determine its location and find the appropriate TMGI to be used. And then, it can use the selected TMGI to receive broadcast MBS session data.

**Is the solution resource efficient in CN and NG-RAN processing?**

For those multiple broadcast MBS sessions, only the packets delivered over one broadcast MBS session will be used. The packets over other broadcast MBS sessions will be dropped, which wastes not only 5GC transportation resource, but also NG-RAN processing resource.

Soln#2 and Soln#24 propose to establish all user planes which improves the service reliability, but less resource efficient.

Soln#7, Soln#9 and Soln#29 propose to establish one user plane across those broadcast MBS sessions. In case the on-going one fails, NG-RAN initiates the establishment of another user plane, to improve the service reliability. In this approach, there will be some additional service interruption time for the user plane re-establishment (from MB-UPF to NG-RAN). However, compared with the error detection period, the additional user plane establishment period is small.

In Soln#8, each NG-RAN has only one broadcast MBS session. Note that there is a trade-off between *"resource efficient in CN and NG-RAN processing"* and *"the efforts to re-establish the shared tunnel when currently used N3mb tunnel is released"*. Having multiple shared tunnels could be beneficial for that case.

**Are there signalling impact in 5GC and NG-RAN?**

All solutions require service operation update provided by MB-SMF, as it is a new feature to be introduced. Some solutions avoid signalling impact in 5GC and NG-RAN, while some require.

Soln#2 and Soln#7 require an additional identifier (associate session ID) to be passed from the AF to NG-RAN via 5GC. Soln#9 requires the complete TMGI list to be passed. Soln#29 requires a MOCN signalling flag to be passed and the TMGI in use may have different PLMN ID.

Editor's note: It is to be confirmed by RAN WGs whether a shared NG-RAN can use a TMGI with a different PLMN ID which is not shared PLMN ID.

Soln#8 requires MB-SMF return shared MBS service area to AF, but there is no signalling impact in 5GC and NG-RAN.

Soln#24 avoids the signalling impact by the configuration in NG-RAN. However, depends on the alternatives to be chosen, it may require TMGI allocation to be delegated to NEF or MBSF.

Table 7.2-1 illustrate the comparison of the solutions for KI#2 5MBS MOCN Network Sharing.

Table 7.2-1: Comparison of solutions for KI#2 5MBS MOCN Network Sharing

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Solution | | | | | |
| Evaluation Aspects | 2 | 7  (NOTE 3) | 8 | 9 | 24 | 29 |
| **Enable shared NG-RAN to optimize radio resource utilization** | Yes | Yes | Yes | Yes | Yes | Yes |
| **Applicable to any MOCN network sharing deployment** | Yes | Yes | Yes | Yes | Yes | Yes |
| **Additional efforts required when introducing a new MBS service** | No | No | No | No | Yes | Yes |
| **Number of TMGIs advertised** | All | All/One | One | One | All | One |
| **Backward compatible (regarding no Service announcement impact)** | Yes | Yes | Yes | No | Yes | Yes |
| **Additional logic in UE when receiving data** | No | No/No?  (NOTE 1) | No? (NOTE 1) | Yes | No | No |
| **Resource Efficiency in 5GC and NG-RAN** | No | Yes | Yes | Yes | No | Yes |
| **Additional effort for recovering data transmission (NOTE 2)** | No | Yes | NA | Yes | No | Yes |
| **Signalling impacts in 5GC and NG-RAN** | Yes | Yes | No | Yes | No | Yes |
| NOTE 1: The service layer or application layer of the UE may be impacted as described in the NOTE under *"How UE receives broadcast MBS session data?"* It applies to Soln#8. It does not apply to Soln#7 SSM Option. It applies to Soln#7 TMGI option only when there are pre Rel-18 NG-RANs.  NOTE 2: The answer "No" means NG-RAN needs to detect the failure and switch the user plane locally, the "Yes" means NG-RAN needs to establish user plane towards another CN additionally, and the “NA” means it is the same as the MBS session for non-MOCN scenario.  NOTE 3: The first value refers to SSM option and the second value refers to TMGI option, when there are two values in the cell. | | | | | | |

Besides those criteria mentioned above, some other issues shall also need to be taken into consideration:

**Whether AF can release MBS sessions flexibly?**

It is possible for the AF to request to trigger the MBS session deletion procedure for one or several PLMNs after a while.

Soln#2 and Soln#7 SSM option use extra ID to identify the service, therefore the release of one PLMN will not affect other PLMNs. Soln#24 assumes the relationship is pre-configured therefore releasing will not affect others as well.

Soln#8, Soln#29, and Soln#7 TMGI option propose to use MOCN TMGI (or same TMGI). However, a TMGI can be allocated and released separately from an MBS session, and thus the MOCN TMGI (or same TMGI) must be kept not deallocated when the MBS session towards this PLMN is stopped, if it is still in use by other PLMNs.

Soln#9 proposes to pass all the associated TMGIs from the AF towards the MB-SMF when creating MBS sessions. When releasing the broadcast MBS session for one PLMN, the MBS session context of the PLMNs needs to be updated as well, which requires further clarification. Or the AF must keep holding the associated TMGIs till all relevant MBS sessions are released.

**Whether the solution can be compatible with pre Rel-18 NG-RANs?**

With the compatibility of pre Rel-18 NG-RANs, operators can deploy the MBS service freely. Otherwise, the optimization developed for KI#2 cannot be applied, until all the NG-RAN nodes are upgraded.

In Soln#2, Soln#7 SSM Option and Soln#9, the additional information (associated session ID, TMGI list) is sent to NG-RAN as an optional parameter. Pre Rel-18 NG-RANs will ignore the parameter and continue to establish the broadcast MBS sessions in legacy way. The optimization will not be applied to pre Rel-18 NG-RANs, i.e. the same MBS content will be broadcasted several times over the air interface. However, the Soln#9 brings additional requirements on AF to construct the mapping of the primary TMGI and the usage area manually.

In Soln#24, no additional information needs to be passed to NG-RAN, and thus pre Rel-18 NG-RANs could work naturally.

In Soln#8 uses MOCN TMGI and native TMGI to separately target different NG-RAN nodes. There are no issues for dedicated pre Rel-18 NG-RANs, but for those shared pre Rel-18 NG-RANs, the MOCN TMGI may not be supported.

Soln#29 assumes the TMGI from one certain PLMN as the common TMGI and uses it as the TMGI together with the MOCN signalling to create broadcast MBS sessions in all of the PLMNs requested by the AF. The MCC/MNC (i.e. PLMN ID) field of the common TMGI can be different from the current PLMN about to establish the broadcast MBS session, and there is no standardized requirement to check those fields or not. A dedicated pre Rel-18 NG-RAN nodes could not support the TMGI if it checks the MCC/MNC. There are different views on whether Rel-17 will be affected and whether the proprietary behavior can be ruled out. Depending on implementation, a shared pre Rel-18 NG-RAN node may only accept the first broadcast MBS session, while reject the later ones with the same TMGI. A shared pre Rel-18 NG-RAN node may accept all broadcast session setup requests with the same TMGI and only store the MBS session context of the latest one. However, the UEs from all PLMNs will be able to receive the MBS session using that TMGI and the MBS data will only be transmitted a single time.

Soln#7 TMGI option also uses a common TMGI to be associated session ID. Pre Rel-18 NG-RANs will ignore it and continue to establish the broadcast MBS sessions using the native TMGI (the TMGI in MBS session ID). The broadcast MBS session establishment and content delivery work in the legacy way. However, it also requires AF to use native TMGI in service announcement, which leads to the similar service announcement issue as Soln#8 (multiple TMGIs are provided to the UE for the same MBS service).

## 7.3 Key Issue #3: On demand multicast MBS session

There are three solutions proposed with the intention to address the objective to regarding the on demand multicast MBS session: Solutions #10, #11 and #30.

- Solution #10 proposes to reuses 4.15.6.6 and/or 4.15.6.6a, and includes flow description(s) with unicast and IP multicast address (i.e. MBS Session ID) to inform the PCF the MBS session that a certain UE wants to join. After the PCF informs SMF (with including the MBS session ID), the residual parts are similar as current defined procedure in TS 23.247 [4] with the following additions: 1) inform the MBS session to the UE via NAS and UE may further perform NATP for the received multicast data, and 2) associate the unicast flow and multicast data to further perform NATP by UPF for pre Rel-18 UE.

- Solution #11 proposes to reuse 4.15.6.6a, and includes MBS session ID to inform the PCF the MBS session that a certain UE wants to join. After the PCF informs SMF (with including the MBS session ID), the residual parts are similar as current defined procedure in TS 23.247 [4]. This solution alternative mandates deployment of dynamic PCC and assumes that UE's private IP address is available over N33. Solution#11, Alt#2 has impact on AF, PCF, SMF and UE. Besides, clause 4.15.6.6a of TS 23.502 [3] is intended for dynamic QoS update but the AF request join is not related to QoS control.

- Solution #30 proposes procedures for creation of an MBS multicast sessions towards the NG-RAN when UEs request to join an ongoing multicast session in an external IP network without the need of AF interactions. Based on operator policy, the MB-SMF may immediately establish the MBS session towards the radio when the first UE joins or wait until more UEs join. If the former, then this is Rel-17 solution, and if the latter, it is still to be clarified that is the benefit of applying individual delivery, instead of shared delivery when the first UE(s) join the MBS session.

Solutions #10 and #11 have a substantial number of unresolved issues.

Editor's note: The advantages of enabling an AF to request the core network to add users to an MBS session compared to the Rel-17 procedures where the AF invites UEs via service announcement and then the UEs request to join the session are FSS.

From the perspective of impact to 5GC, Solution #10 has the same part as solution #11 with the addition that the 5GC configures the NATP in UE, and optionally SMF uses individual delivery for pre Rel-18 UEs, and UPF performs NATP for them. Solution #11 requires AF provide the MBS session ID, and PCF initiate SM Policy Association Modification procedure with including MBS session ID.

Both Solution #10 and Solution #11 enhance the "AF session with required QoS update procedure.

Compared to solutions #10 and #11, solution #30 addresses a different use case and thus also proposes entirely different procedures, mainly enhancements to the Nmbsmf\_MBSSession\_ContextStatusSubscribe and Nmbsmf\_MBSSession\_ContextStatusNotify procedures between MB-SMF and SMF.

## 7.4 Key Issue #4: Group message delivery

Solutions #12 and #13 are proposed to address Key Issue #4.

Soln#12 proposes a solution on the NEF, which utilizing the Full-Service Mode offered by the MBSF/MBSTF (Object Delivery method).

Soln#13 proposes a solution on the NEF, which utilizing both the Full-Service Mode offered by the MBSF/MBSTF as well as the Transport-Only Mode offered by the MB-SMF/MB-UPF directly.

Both solutions keep the backward compatibilities with the group message delivery solution in eMBMS.

For the Full-Service Mode, Soln#12 and Soln#13 are aligned. The solutions described in Soln#12 and Soln#13 contain the delivery of the group message, as well as the cancel and the modification of the group message, which are required from group message handling perspective. There are no contradictions between those two solutions.

For the Transport-Only Mode, Soln#13 expects the reliability of the group message delivery to be implemented in the AF, and 5GC provides a transparent delivery bearer. In Transport-Only Mode, AF can interact with the MB-SMF/MB-UPF directly without the involvement of the NEF, which is supported in Rel-17. There are no additional benefits needs to include the NEF besides the existing exposure functionality (i.e. utilize the service operations defined for group message). Furthermore, the reliability delivery handling in AF does not fully take the advantage of the MBS. It increases the complexity of the AF implementation and requires each AF to implement the logic of reliable delivery, while such reliable delivery logic has already been offered by 5GC.

It is an alternative option to let the NEF packetize the received group message and deliver packets to the MB-UPF. However, without service layer protection, the UEs are not able to deal with any errors during the transmission (e.g. packet loss, packet disorder, etc.). And it is not appropriate to introduce service layer protection to the NEF.

Soln#13 points out the solution shall be re-used for general group message delivery purposes (not limited to MTC devices), which align with the proposal in group message delivery solution in eMBMS.

Soln#13 further include the area which does not support MBS in the response message towards the AF. Even though this function is not tightly coupled with group message solution, it could benefit the AF and hide the deployment complexity towards the AF. The solution proposes that the AF can then deliver data to UEs outside the area via unicast, but the AF will in some cases not be aware of the UE location

## 7.5 Key Issue #5: Coexistence with existing power saving mechanisms for capability-limited devices

For Key Issue #5, there are following solutions:

- Sol#14 is intended for both multicast and broadcast MBS Session.

- Sol#15 covers only broadcast MBS Session.

- Sol#25 is intended for multicast MBS Session.

For interaction between broadcast MBS and power saving mechanism, Sol#14 and Sol#15 are aligned.

The table below is to provide an overview of the solutions of KI#5.

Table 7.5-1: Comparison of multicast solutions for KI#5

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Solution #14 | Solution #15 | Solution #25  (periodic or one time transmission) | Solution #25  (Deferred activation) |
| Inform UE the scheduled time | service announcement | Service Announcement. | Service Announcement or PDU session modification command. | NAS message (built by AMF) |
| Method to control the "awake" timing | DRX level - counted in milliseconds. | SDP level (NTP time values) - counted in seconds. | SDP level (NTP time values) - counted in seconds. | SDP level (NTP time values) - counted in seconds. |
| 5GC enhancement | N/A. | N/A | MB-SMF activates MBS session at start time | MB-SMF: provides wake-up time to SMF(s) in delayed activation request.  SMF: provides wake-up time in delayed activation request with UE list.  AMF: finds the UE in power saving mode and paging them individually, and provide the wake-up time in NAS message. |
| UE behaviour | DRX for MBS takes precedence over the existing Power saving mechanism. E.g. MICO, PSM, or eDRX. | Provided time takes precedence over the existing Power saving mechanism. | Provided time takes precedence over the existing Power saving mechanism. | Provided time takes precedence over the existing Power saving mechanism. |
| Use cases | MBS service  Suitable data transmission at times known in advance, e.g. for periodically repeated data transmissions | MBS service  Suitable data transmission at times known in advance, e.g. for periodically repeated data transmissions | MBS service.  Suitable data transmission at times known in advance, e.g. for periodically repeated data transmissions | Multicast MBS service.  Suitable for data transmission at not previously known times |

NOTE: Note that the above-mentioned table may not exhaustively list the proposal of the solutions. For example, Solution#14 also suggest to keep UE connected for a while in the middle of an MBS data transfer.

In fact the main idea of DRX level control and SDP level control are not against each other, they are, on the other hand, the complementary solutions and therefore can be adopted at the same time. In addition, Solution #25, option 1 also proposes to make use of service announcement to convey the knowledge of session start/end time of the MBS session. Solution #25 option 2 proposes to provide such information via NAS message to UEs in the MBS session and is therefore suited for multicast MBS service.

Solution 25 Option 2 enables data transmission at times which are not known when the service announcement is performed.

For solution #25:

- The idea of "periodic or one time transmission" is to use the start time , which is already part of MBS session context, and provide the start time to the UE either via PDU Session Modification or service announcement, and 5GC triggers the session activation based on the start time.

This solution has impact on AF, MB-SMF, SMF and UE. The activation and deactivation of an MBS session is a prerequisite for Rel-17 UEs to enter IDLE state when no data transmission is ongoing.

- The idea of "Deferred activation" is another alternative to provide the time information, i.e. AF provides the wake-up time to 5GC whenever needed, and such information will be provided to UE via individual paging. The proposal uses session activation and provides the MBS information to UE by the AMF. The UEs start to receive MBS data at the configured times. From system impact perspective, the AMF is not supposed to be involved in the UE’s handling of MBS Session whenever possible (due to the SMF-centric multicast solution chosen in Rel-17), however the new procedure of NAS Transfer in Figure 6.25.3.2-1 is not aligned with that principle.

## 7.6 Key Issue #6: Improvement for potential performance issues related to high numbers of public safety UEs

Editor's note: It may need to be revised, depending on the conclusion of the updated solution and new solutions.

Solution #3, #16, #17, #20, #26 and #31 are proposed to address Key Issue #6: Improvement for potential performance issues related to high numbers of public safety UEs.

Below is a short summary of the solutions:

**Solution #3** proposes a solution to enable the AF to provide the group member information to NG-RANs via 5GC, which could be utilized by NG-RAN as assistance information when deciding which UEs can be sent to RRC\_INACTIVE when needed. The assistance information is provided via PCF.

**Solution #16** proposes a solution to enable AF to offer public safety service via broadcast and/or multicast sessions, which allows the UE to decide whether to receive the public safety MBS content via broadcast MBS Session if available, and/or multicast session.

**Solution #17** proposes a solution to enable AMF to become aware of the list of UEs that has joined a MBS sessions and get the UE list ready for group paging. When requested, the AMF trigger group paging without having to going through the UE list.

**Solution #20** proposes to allow the UE to request multicast MBS session join/leave during mobility registration update procedure, by including the associated PDU session status and the multicast session information container in the Registration Request message. The UE can be in CM-IDLE state or in CM-CONNECTED with RRC Inactive state.

**Solution #26** proposes a solution to let AF provide information to 5GC (via parameter provisioning interface) and then to NG-RAN that a UEs should stay in RRC\_CONNECTED. It also contains proposals to reduce the cell load for public safety UEs by reducing the amount of Listener Reports. However, it is to be clarified how the Listener Reports are to be reduced.

**Solution #31** proposes that the NG-RAN indicates the resource allocation failure (which can be per slice to the UE and then the UE reports the failure towards the AF which may take further action, e.g. releasing low priority group communications which is using the MBS, switching the group call to broadcast MBS session.

Following is a detailed evaluation of the solutions:

**Solution #3:**

This solution enables an AF to provide group member information (e.g. privileged or not) as part of the MBS session to assist NG-RAN when deciding which UEs can be sent to RRC\_INACTIVE. As there are similar proposals only submitted for KI#1, this solution will be further evaluated in KI#1.

**Solution #26:**

This solution also enables an AF to provide information about UEs recommended to be kept in RRC\_Connected state. The information is provisioned independent of the MBS session and thus applied for privileged users participating in multiple MBS sessions. As there are similar proposals only submitted for KI#1, this aspect of the solution will be further evaluated in KI#1.

The solution also contains proposals to reduce the cell load for public safety UEs by reducing the amount of Listener Reports to avoid that UEs frequently need to transition to RRC-Connected state to send such reports This needs to be clarified and evaluated together with SA6.

NOTE: It is up to SA6 to determine if the amount of Listener Reports should be reduced and how it can be achieved, which is independent from SA2.**Solution #20,**

The solutions enables that the UE requests multicast MBS session join/leave during mobility registration update procedure. In addition to the associated PDU Session status, the multicast session information container is also included in the Registration Request message to indicate whether the UE wants to join or leave (e.g. due to triggers from the application layer) or remain joined in one or more multicast MBS sessions associated with the PDU Session, so that:

- the multicast MBS session join/leave can be performed during the registration procedure.

- the network will not trigger multicast MBS session establishment towards the NG-RAN if the UE indicates leaving the multicast MBS session.

Considering UE(s) in RRC Idle or RRC Inactive state can join the multicast MBS session using mobility registration procedure, and then receive multicast data in RRC Inactive state, it will bring the benefits of less signalling interactions, time and radio resource consumption.

Utilizing the mobility registration to indicate “join” or “leave”, it requires the conditions for mobility registration update are met when UE requests session join or leave (e.g. due to pending application layer request). Even if such possibility for one UE may be low, it would be beneficial considering the large number of UEs.

**Solution #16,**

The intention is that AF starts a broadcast MBS session in some dense area and the UEs in that area receives MBS data via broadcast, and when moving out of broadcast coverage, UEs receives data via multicast.

The decision to suspend the MRB of multicast MBS session in NG-RAN is based on congestion situation in NG-RAN, and the decision of start broadcast session logic in GCS AS is based on the counting of UEs in a specific area. A possible misconfiguration is that in some areas, AF does not start the broadcast session, but NG-RAN suspends the MRB of the multicast session, which may require those joined UEs to fall back to unicast. It is also possible that in some areas, AF started the broadcast and NG-RAN keeps the MRB of the multicast session, which will cause double resource consumption.

Furthermore, to start broadcast MBS session effectively, accurate and frequent location reports are required, which may also lead to capacity bottlenecks. There is a trade-off between accuracy and frequency of the location reports and how fast switching between broadcast and multicast can be achieved.

**Solution #17,**

The intention is to shorten the group call setup time by letting the AMF be aware of UE join and get the list of UEs for group paging ready and constantly calculating the group paging area, which can avoid processing of the UE list when receiving enable group reachability requests. Whenever the multicast MBS session is activated, the AMF can trigger the group paging when receiving the first request (enable group reachability request or multicast session activation request). Furthermore, the AMF triggers a group paging for all the joined CM-IDLE UEs in the AMF, instead of trigging group paging per enable group reachability request. This solution is not intended to address the bottleneck in air interface.

As service request handling constitute most of the delay for a CM-IDLE UE in MBS session activation, Solution #17 can reduce the group call setup time but not significantly. The solution requires AMF constantly updates the group paging area for UE CM state change when MBS session is inactive. This requires the involved SMFs to include the joining/leaving message outside the N2SM information.

Another aspect, it may minimize the number of group paging requests from the AMF to the NG-RANs, which reduce the number of interactions between the AMF and the NG-RANs. If the frequency of multicast MBS session activation is low, the performance improvement will not be significant as well. Also, this depends on how many SMFs are involved in the MBS session, e.g. if there is only one SMF, the differences are not that much.

**Solution #31,**

This solution enables the AF to take actions (e.g. releasing low priority group communications which is using the MBS, switching the group call to broadcast MBS session, by the NG-RAN informs the UEs of the resource allocation failure and then the UEs further informs the AF.

It is not clear how the solution works in MBS session activation procedure. It requires further explanation on whether such application-level feedback works when the cell is overloaded. And it is to be evaluated the benefits compared with the solution using the join failure event report from the UE to the AF which exist already.

# 8 Conclusions

Editor's note: This clause will list conclusions that have been agreed during the course of the study item activities.

## 8.1 Key Issue #1: MBS session reception in RRC Inactive

### 8.1.1 Conclusions

The following conclusions is proposed for KI#1:

- It is possible to keep some UEs within the same MBS session in RRC\_CONNECTED and some in RRC\_INACTIVE state. NG-RAN nodes take the responsibility to determine (e.g. during congestion) which UE(s) within an MBS multicast session will be moved from CM-CONNECTED with RRC CONNECTED to CM-CONNECTED with RRC Inactive state and still receive MBS session data.

- The 5GC provides information about the MBS session as specified for Rel-17 and may provide additional assistance information to help NG-RAN to determine whether to apply delivery enabling reception by UEs in RRC\_Inactive state for an MBS session and which UE(s) to be moved to RRC Inactive state.

- The assistance information may include recommendations whether to enable delivery for reception in RRC\_Inactive state for an MBS session and information about UEs that should preferably be kept in RRC\_Connected state, i.e. the MBS session level and UE level MBS assistance information, and may be provided by the AF to 5GC and then to NG-RAN.

- For MBS session level assistance information:

- The existing MBS session QoS parameters (e.g. ARP, 5QI) can be used as the MBS session level assistance information by NG-RAN to differentiate different MBS sessions.

- For UE level MBS assistance information:

- The UE level MBS assistance information is an optional new parameter and set per MBS session. It is indicated by the AF to inform the network whether from the expected traffic pattern of the UE the indicated UE is preferred to be kept in the RRC Connected state even if it is able according to its radio capabilities to receive the MBS session data in RRC\_INACTIVE state, e.g. a frequent talker.

NOTE 1: The protocol detail and how the assistance information is formatted (e.g. as a flag, multiple choices (high/low/medium) or multiple integer values of the assistance information for the expected traffic pattern) is to be defined in normative phase and requires RAN WG feedback.

- The AF provides the UE level MBS assistance information as part of MBS subscription data during External Parameter Provisioning procedures as defined in clause 6.4.2 of TS 23.247 [4].

- The SMF provides the received UE level MBS assistance information to NG-RAN node as part of the PDU session information in N2 SM Info and sent to NG-RAN via AMF.

- NG-RAN use the MBS session level and UE level MBS assistance information as help for the decisions on whether to enable delivery for reception in RRC\_INACTIVE state for an MBS session and/or on which UEs to keep in RRC\_CONNECTED or. RRC\_INACTIVE state. How NG-RAN performs those decisions is up to NG-RAN implementation.

NOTE 2: How the NG-RAN handles the situation without assistance information for RRC Inactive multicast MBS data reception is to be determined by RAN WGs.

NOTE 3: What is defined in clause 5.3.3.2.5 of TS 23.501 [2] for "RRC Inactive Assistance Information" is sent by AMF to NG-RAN and may be used by NG-RAN together with any other MBS session level assistance information and UE level MBS assistance information for deciding whether to send a UE to RRC Inactive state.

- When the MBS session is activated, the UEs in RRC Inactive state in cells, where the MBS session is delivered allowing RRC-inactive reception, should be able to remain in RRC Inactive state for receiving the MBS session data.

- For group paging, the network notifies which MBS session is to be activated. For the UE in RRC\_INACTIVE state how the group paging is handled will be decided by RAN WGs.

- How NG-RAN notifies the UE that the MBS session is re-activated and whether the MBS session is allowed to be received in RRC-inactive state will be decided by RAN WGs.

- When an RRC\_INACTIVE UE is in the process of receiving ongoing MBS session data and moves to a new cell within the RNA, the UE shall be able to receive MBS session data.

- When the UE moves outside the RNA, the UE performs UE Triggered Connection Resume in RRC Inactive procedure to the target RAN node as per existing procedures in TS 23.502 [3].

- When the UE receives the MBS data in RRC Inactive state and move out of the RNA area but Connection resume fails, it follows existing procedures and transition to CM-IDLE. When the UE transition to CM-IDLE since is not able to receive the MBS multicast data at the new cell, the UE initiates the mobility registration update or Service Request procedure and activates the associated PDU session, so that the shared tunnel (if not already established) or the individual delivery can be established towards the NG-RAN node for multicast data delivery to the UE.

- When the UE moves outside the RA, the UE performs mobility registration procedure and as per the existing procedure in clause 5.3.3.2.5 of TS 23.501 [2] for "Mobile initiated NAS signalling procedure" for UEs in CM-CONNECTED with RRC Inactive state, the UE will resume the RRC Connection.

- During the handover procedure, the SMF includes the "MBS assistance information for RRC Inactive" if any in N2 SM Info and sent to NG-RAN via AMF.

The following requirements, which need be supported by RAN WGs, are concluded:

- Backward compatibility with Rel-17 UEs not supporting the RRC\_Inactive reception of MBS multicast data needs to be ensured.

- RAN WG2 define UE radio capability for MBS reception in RRC\_INACTIVE state.

- NG-RAN nodes decide for which MBS sessions to apply delivery enabling reception in RRC\_Inactive state. The NG RAN nodes handling RRC-Connected UE in an MBS multicast session also decides whether the UEs can transition to RRC\_Inactive state and may consider assistance information from the 5G core network for that decision. How NG-RAN performs those decisions is up to NG-RAN implementation.

- When the MBS session is activated, the UE in RRC Inactive state in cells where the MBS session is delivered in the delivery mode for RRC-inactive reception should be able to remain in RRC Inactive state for receiving the MBS session data.

- When the UE is in RRC Inactive state and moves within the RNA, it shall be able to continue receiving DL multicast MBS data unless it leaves the MBS service area.

## 8.2 Key Issue #2: MOCN network sharing

For conclusions, the following aspects will be considered:

- For solutions where the broadcast MBS sessions for different PLMNs are established towards a NG-RAN node, the NG-RAN node shall be able to identify the same MBS service and avoid multiple deliveries over radio.

- A solution compatible with Rel-17 UEs is preferred.

- A solution compatible with Rel-17 NG-RAN is preferred.

- The AF may provide associated session identifier (SSM used by AF) additionally to the NG-RAN nodes via 5GC so that the shared NG-RAN nodes can determine that the multiple broadcast MBS sessions are transmitting same content for the same MBS service (i.e. Soln#2 and Soln#7 SSM option), or

- The association of MBS session identifiers may be configured in NG-RAN, where there is no requirement on AF to provide associated session identifier.- It should be possible not to establish all the shared delivery tunnels to the same NG RAN from different PLMNs for the same MBS service.

- The solution should support the scenario where all NG-RAN nodes are shared by PLMNs and the scenario where only part of the NG-RAN nodes are shared by PLMNs.

## 8.3 Key Issue #3: On demand multicast MBS session

The use case in KI#3 is already possible in Rel-17 and no further normative work is needed in Rel-18.

## 8.4 Key Issue #4: Group message delivery

For group message delivery, the following principles have been agreed:

- It shall support reliable delivery of group messages via MBS. Full-Service Mode solution, which utilize the Object Delivery Method offered by the MBSF/MBSTF, is adopted.

NOTE: The AF can invoke the Nmbsmf service operations offered by the MB-SMF (optionally via the NEF) for Transport Only Mode, as supported in Rel-17.

- It shall support group message delivery request from AF. The group message is included in the group message delivery request.

- It shall support the cancellation of a previously accepted group message delivery request.

- It shall support the modification of a previously accepted group message delivery request.

- It shall be applied for general group message delivery purposes (not limited to MTC devices).

- The AF may be informed about the areas where MBS is not supported. The support of this feature is optional.

## 8.5 Key Issue #5: Coexistence with existing power saving mechanisms for capability-limited devices

The following principles are applied for normative work to allow UEs to receive multicast/broadcast MBS data when they are using power saving mechanisms (e.g. eDRX, MICO with active time etc):

- Solution #14 is used as the basis for normative work with the following further clarifications:

- The UE is configured by the AF via the service announcement about a session start time and a possible sequence of scheduled activation times when the AF may activate the MBS session and transmit MBS data.

- At the session start time and the possible scheduled activation times, the UEs apply the procedures of Solution #14 to receive MBS data. This means that for an MBS multicast session, if the UE has already joined the MBS session as defined in clause 7.2.1.3 of TS 23.247 [4], at the possible scheduled activation times, IDLE UEs need to listen for paging requests and if paged by the network with group paging follow the existing procedures in clause 7.2.5.2 of TS 23.247 [4]. In this case, how long the UE need to listen to paging is left up to UE implementation.

- If the UE has not previously joined the MBS multicast session, at the possible scheduled activation time it performs MBS join procedure as currently defined in clause 7.2.1.3 of TS 23.247 [4]. Whether the UE performs MBS join procedure in advance and stays "joined" or every time at activation time is left up to UE implementation.

- How to support NR capability-limited (RedCap) UEs in MBS will be decided in normative phase considering possible related decisions of RAN WGs

## 8.6 Key Issue #6: Improvement for potential performance issues related to high numbers of public safety UEs

No normative work on this key issue will be performed by SA WG2 in Rel-18.

NOTE 1: Solutions addressing both key issue #6 and other key issues can be selected in conclusions for other key issues.

NOTE 2: It is assumed that:

- An AF e.g. MCX AS is able to create additional broadcast session for the same service as per UE feedback;

- An AF e.g. MCX server can create broadcast and multicast session for the same service; and

- Public Safety UE procedures can be enhanced to reduce uplink signalling (e.g. location reports) without any further impacts in SA2 specifications. It is up to SA6 to decide upon such procedures.

NOTE 3: For public safety services, based on existing QoS mechanisms, the NG-RAN ensures that public safety UEs are able to complete the setup of the MBS services and then operate according to regulation and operator policy, e.g. pre-emption mechanisms can be activated for PDU sessions unrelated to MBS sessions, resulting in some UEs already in RRC\_CONNECTED state being transitioned to RRC\_IDLE or RRC\_INACTIVE to "make room" for some of the newly arrived mission critical enabled UEs to get to the RRC\_CONNECTED state necessary to start/complete their association with the public safety group of interest. Normative work is not required.

Annex A:  
Public Safety use cases of large number of UEs in a single cell

This Annex covers the case when the mission critical enabled UEs are concentrated in a single cell.

A general public safety use case, for example, can assume that:

- a cell with UEs receiving a mix of public safety and non public safety services: some UEs receive only non public safety services, other UEs receive only public safety services, being engaged in one or more mission critical one-to-one call or on single or multiple simultaneous group calls (e.g. PTT and video), and yet other UEs receive both public safety and non-public safety services at the same time;

- the number of UEs in RRC\_CONNECTED state in the cell is at, or very near to, the limit of the number of UEs in RRC\_CONNECTED state that can be accepted in that cell due to various limiting factors;

- at that moment, a number of mission critical enabled UEs (e.g. the occupants of a fire truck) interested in participating in group calls associated with a specific public safety group arrive roughly simultaneously in the cell with their UEs in various RRC states (or possibly, powered off) and attempt to perform the necessary connection steps to the RAN, CN and AF, to be able to connect and associate themselves to the public safety group of interest;

- this situation results in a larger number of UEs being or attempting to get in RRC\_CONNECTED state than can be admitted in the cell in that state. The admission control to the cell and/or pre-emption mechanisms will be activated, resulting in some UEs already in RRC\_CONNECTED state being transitioned to RRC\_IDLE or RRC\_INACTIVE to "make room" for some of the newly arrived mission critical enabled UEs to get to the RRC\_CONNECTED state necessary to start/complete their association with the public safety group of interest;

- some (or all) of the mission critical enabled UEs associated with public safety group(s) of interest which use or intend to use MBS for downlink communication may have to be transitioned to RRC\_INACTIVE or RRC\_IDLE state to ensure that the total number of UEs in the cell in RRC\_CONNECTED state does not exceed the limit for that cell;

NOTE 1: The transition from RRC\_CONNECTED state should not happen for just arrived public safety UEs before their association with the public safety group of interest is complete, which is needs to be ensured by public safety applications. Some application-function (AF) provided information about specific public safety participants in group calls (e.g. privilege status, priority) may be used to identify which UEs should be kept in RRC\_CONNECTED state and which UEs are candidates for being transitioned to RRC\_INACTIVE or RRC\_IDLE state.

- whether an MBS Session for public safety is active or inactive, a UE in RRC\_INACTIVE or RRC\_IDLE state, may request transition to RRC\_CONNECTED state to perform unicast uplink transmissions (e.g. to request the floor, send user data, send location reports, etc.). Since the number of UEs already in RRC\_CONNECTED state in the cell may be at or near the cell admissibility limit, one or more UEs already in RRC\_CONNECTED state may need to first be moved to RRC\_INACTIVE or RRC\_IDLE state, in order to "make room" for the UE wanting to transmit;

- while in RRC\_INACTIVE state receiving user data via MBS under a session, a mission critical enabled UE may request (see bullet above), and be able to additionally start receiving public safety service via MBS, in parallel, under another session.

NOTE 2: Treatment of failure by public safety UEs in RRC\_INACTIVE state to receive MBS downlink transmissions when expected to do so, is left to implementation.

Annex B:  
Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2022-02 | SA2#149E | S2-2201354 | - | - | - | TR skeleton (approved in S2-2201354) | 0.0.0 |
| 2022-09 | SA#97-e | SP-220822 | - | - | - | MCC editorial update for presentation to TSG SA for information | 1.0.0 |
| 2022-11 | SA#98-e | SP-221111 | - | - | - | MCC editorial update for presentation to TSG SA for approval | 2.0.0 |
| 2022-12 | SA#98-e | - | - | - | - | MCC editorial update for publication after approval at TSG SA#98-e (Release 18) | 18.0.0 |