5G-Xcast Tutorial

Broadcast and Multicast Communications Enablers for 5G

WP4: 5G-Xcast Mobile Core Network

WP4

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Disclaimer

The current presentation shows **work in progress**, supported in part by the European Commission under the 5GPPP project 5G-Xcast (H2020-ICT-2016-2 call, grant number 761498).

The content is not yet approved nor rejected, neither financially nor content-wise by the European Commission. The approval/rejection decision of work and resources will take place **at the Mid-Term Review Meeting planned in September 2018 and the Final Review Meeting**, after the monitoring process involving experts has come to an end.

Public Deliverables

- **D4.1**: Mobile Core Network, May 2018.
  Download
  News

- **D4.2**: Converged Core Network and Architecture, Aug. 2018.

- **D4.3**: Session Control and Management, Nov. 2018.

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1. Introduction

- WP4 is tasked with the Core part of the 5G-Xcast solutions

Task	Name	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23
T4.1	Mobile Core Network (EXP)	D4.1											
T4.2	Converged Core Network (BT)				D4.2								
T4.3	Session Control and Management (LU)	D4.3						D4.3					
T4.4	5G-Xcast Core Network PoC Prototype (O2M)				D4.4								

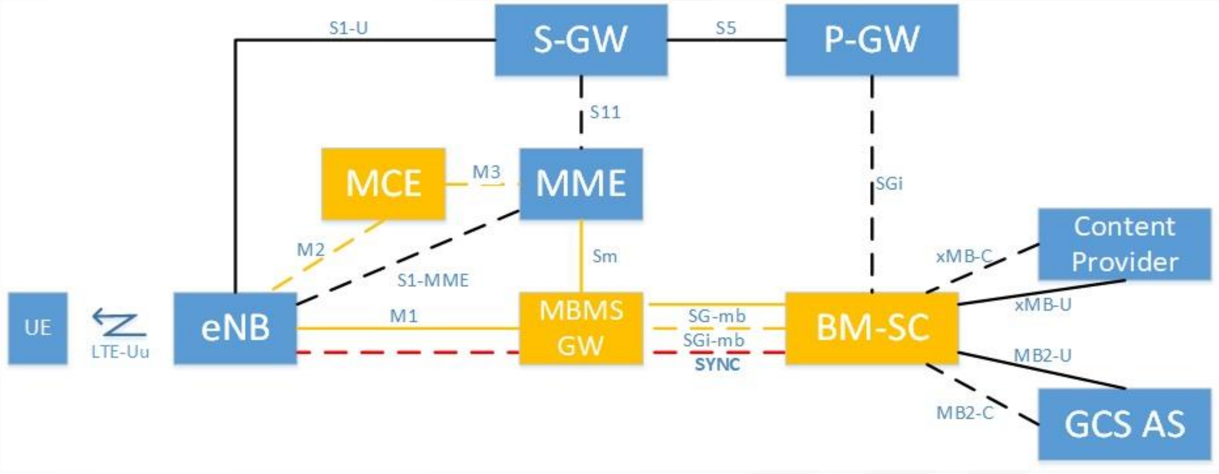
- **D4.1** on the Mobile Core Network has been published!
- **D4.2** on the Converged Core Network will finish in M15 (August 2018)
- **D4.3** on Session Control and Management will finish in M18 (November 2018)

Work in progress!

Contents

2.1 eMBMS Architecture

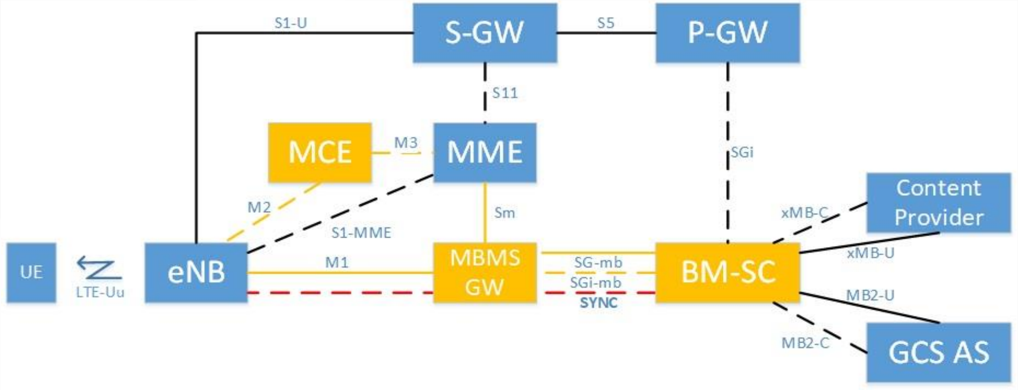
- evolved Multimedia Broadcast Multicast Service (eMBMS) is a point-to-multipoint complete solution for 3GPP cellular networks.
- Latest revision in Rel' 14 brought many improvements (EnTV):
  - Standardization of xMB interface between Content Provider and BM-SC
  - Transport-Only service. Use Network Operator infrastructure as pass-through for media
  - Receive-Only-Mode. Enable free-to-air content and UE devices without SIM to receive eMBMS transmissions
  - Shared MBMS Broadcast. Unite Network Operator MBMS networks into one to broadcast a single eMBMS transmission



2.1 eMBMS Architecture

- **eMBMS** introduces new entities in 4G Core in order to deliver broadcast content:

- **Broadcast Multicast – Service Center**. Most of the intelligence of the eMBMS system resides here. It is the entry point for external Content Providers who want to send media over the cellular network. Additionally, the BM-SC is tasked with:
  - <u>**Membership**</u>: used in multicast mode only.
  - <u>**Session and Transmission**</u>: all session related procedures. TMGI allocation
  - <u>**Proxy and Transport**</u>: Manages MBMS GW connection
  - <u>**Service Announcement**</u>: Provide MBMS Session description to UEs.
  - <u>**Security**</u>: Providing confidentiality to content. Distributing keys to UEs
  - <u>**Content Synchronization**</u>: Apply SYNC protocol to data for SFN operation.

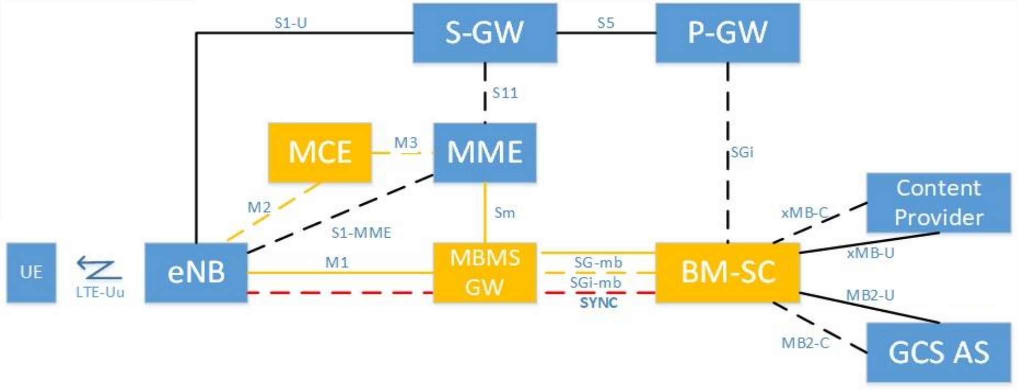


2.1 eMBMS Architecture

- **Multicast/Broadcast Gateway**. This entity resides at Core and manages the Multicast group of eNB that will form the MBMS SFN. It delivers BM-SC Control Plane signalling over Sm interface and User Plane signalling over M1 interface.

- **Multicast Coordination Entity**: This RAN entity decides the delivery mode used (SC-PTM or MBSFN), choosing the radio parameters and scheduling. It can be deployed in a centralized manner (connecting via unicast M2 to each eNBs) or in a distributed way (MCE in every eNB).

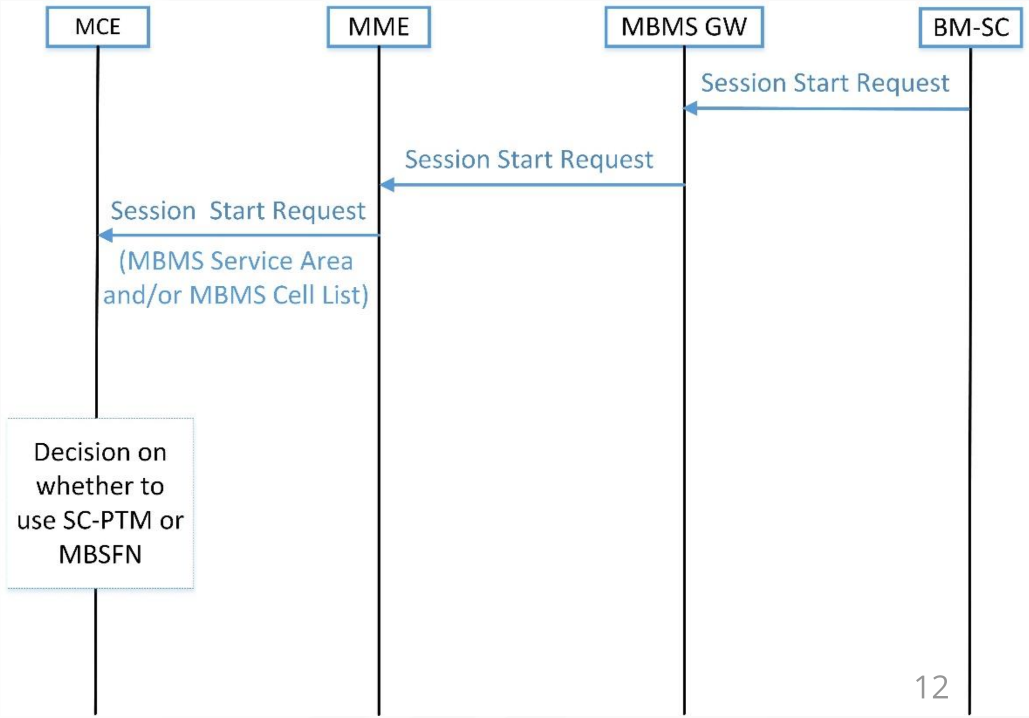
- **SYNC**: Protocol applied to User Plane data in BM-SC, designed to compensate network delays at RAN to enable SFN.



- **xMB**: Interface connecting Content Provider and BM-SC, allowing to authorized CP to manage BM-SC Services or Sessions (Push Operation).
BM-SC can also demand particular content using this interface (Pull Operation).

2.1 eMBMS Architecture: SC-PTM

- MCE can choose between SC-PTM or MBSFN → **Upon receiving Session Start Request**
- MCE is a RAN entity, this **decision is transparent to the BM-SC**
- SYNC is applied always no matter the delivery mode
- Additional overhead in Transport Layer since SYNC is not useful for SC-PTM

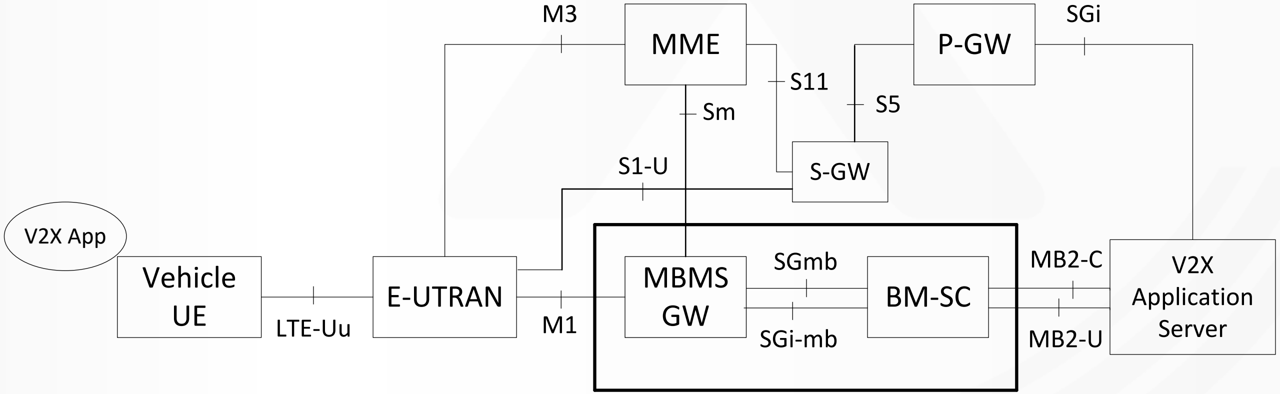


2.2 Limitations identified

Due to the backwards compatibility approach of 3GPP, limitations on the first releases have been carried to future revisions.

- **Lack of Dynamic Configuration for MBSFN**
- **No feedback for eMBMS Session Management**
- **No efficient mechanism to trigger UE reception of MBMS services (paging)**
- **Service continuity when moving between MBSFN Areas**

Other verticals (PWS, Critical Communications, V2X...) that can benefit from broadcast cannot use eMBMS (without modifications) because it was tailored for live-TV services



2.2 Limitations identified
Lack of feedback in eMBMS Management

- No error reporting for <u>ongoing</u> eMBMS sessions.

- MCE will not report the delivery mode chosen and the Core has no mechanism to prefer one mode over the other.

- As BM-SC does not know if an ongoing eMBMS sessions is pre-empted at eNodeBs, it can not provide feedback to the application layer:
  - Service Level Agreement (SLA) between Content Provider and Network Operator can not be applied effectively.
  - Inaccurate service reporting for statistics & analysis for OSS/BSS.
  - Inefficient resource usage.
  - Cannot provide alternative channels.
  - Cannot provide retransmissions at AL level.

2.2 Limitations identified
Lack of Dynamic Configuration in eMBMS

- Currently in eMBMS release 14 there is a lack of reconfigurability at several interfaces. Any change of MBMS Session forces the MNO to relaunch the session in order to apply any updates.
  - The subset of SAI that belong to a MBSFN Area can only be modified manually. Also SAI upper bound value is restricted to 64k, which hinders 1:1 Cell to SAI mapping for large SFN areas.
  - Having a non 1:1 mapping could make MooD inefficient in some cases.
  - MBMS Scheduling Information message over M2 interface (MCE to eNodeB) does not allow for updates.

- Also, since there is no interface between distributed MCEs to agree MBSFN radio parameters, the MNO must ensure that SFN requirements are being fulfilled.

2.2 Limitations identified
Lack of Efficient Paging and Mobility

- MBSFN Area mobility is not supported in Release 14, even in the same MBMS Service Area. This forces service interruption for an UE moving between MBSFN Areas.
  - One solution is to create an auxiliary unicast bearer with the content until the UE syncs to the new MBSFN Area.
  - Other solution is to overlap MBSFN Areas, so the UE can begin to decode the signalling from one MBSFN Area before interrupting the service. This requires additional procedures.
- Core Network cannot trigger MBMS Reception on UE. In PWS, is not feasible for the UE to continually monitor SIB15.
  - Also, there is not a standardized TMGI for PWS, which hinders roaming.

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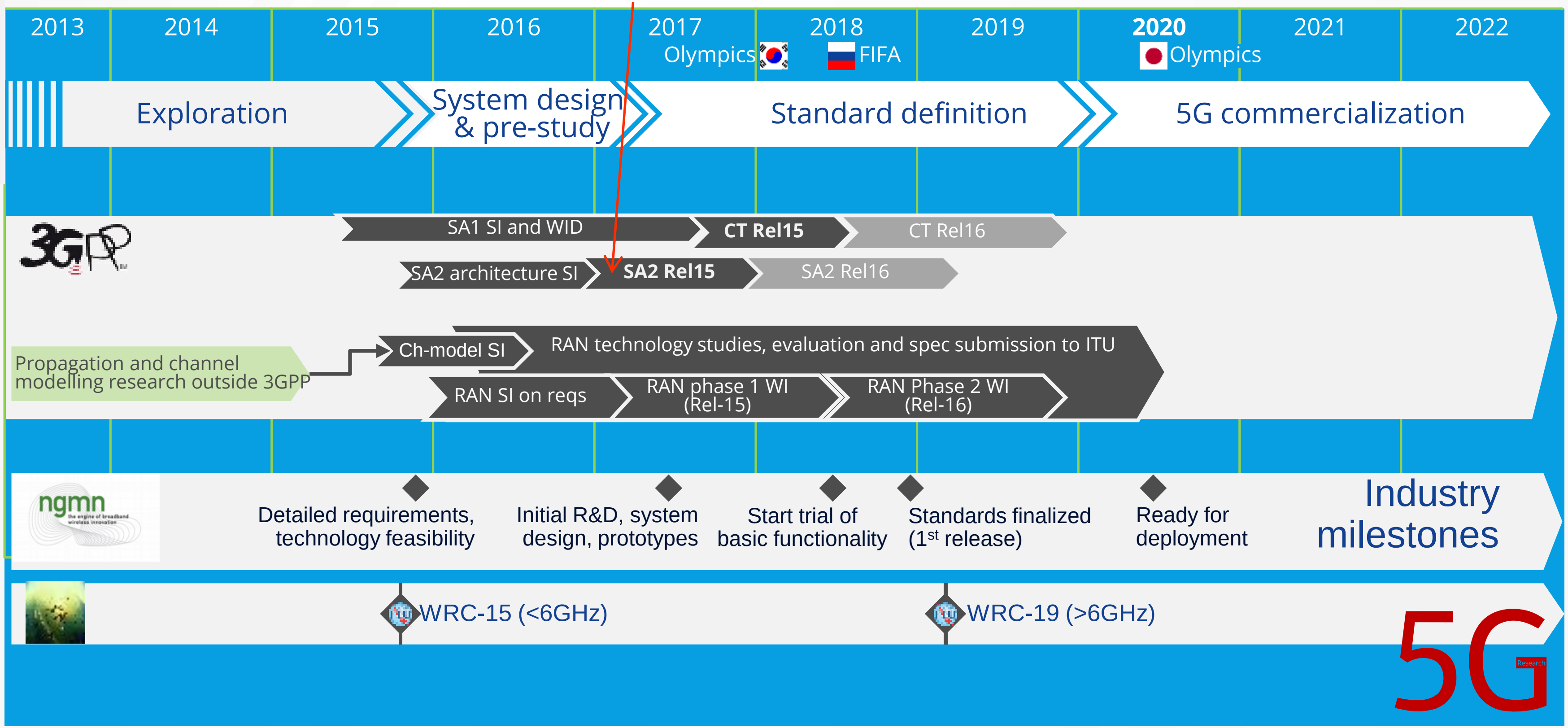
3.1 3GPP Status on Core standardization

Deadline = Sept 17 for the NGC architecture / Dec. 17 for the Stage 2 flows. June 18 for the stage 3



3.2 5G Core Overview

Three Key Factors

1

Converged Core, allow independent evolution of different parts of the network

2

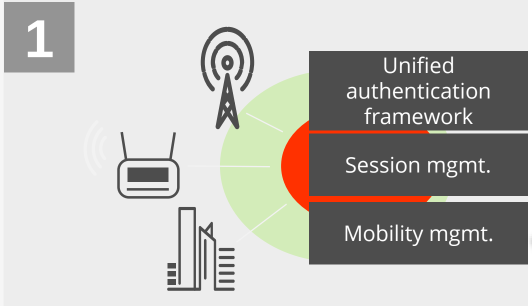
New business cases

3

Enable operational agility, extreme automation (faster deployments, upgrades, reduce TCO)

3.2 5G Core Overview

Universal Adaptive Core



Access-agnostic core for seamless user experience

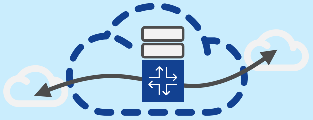
- **Common authentication framework supporting AKA and non AKA based.**
  - Unique temporary ID to access security context within the network.
- **Common Access control procedures for non-3GPP access and 3GPP access.**
  - Other MM procedures are supported mainly for 3GPP access. Non-3GPP access can use it but not mandated to use it
  - Where possible align signalling Connection Management procedures between access
- **Common session management**
  - Aims for common NAS SM procedures unlike WLCP and LTE NAS SM
  - Allows simultaneous usage of multiple access types for a PDU session (in phase 2)

1

Converged Core, allow independent evolution of different parts of the network

3.2 5G Core Overview

Mobile Edge Computing

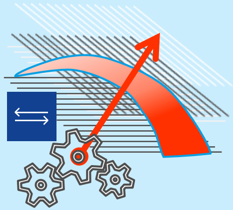


The emergence of the edge cloud for low latency and high performance

- Flexible UP traffic routing - via central / local UP function, UL classifier to route to local DN, IPv6 multi-homing,
- MEC Control of SM

E2E Network Slice

UE running diverse applications camp in multiple network slices simultaneously



Other…

Different PDU types: IP, Unstructured, Ethernet (self-Backhaul)

2

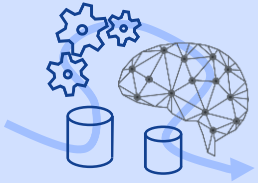
New business cases

Connectionless support (phase 2)

New QoS framework to handle short lived flows

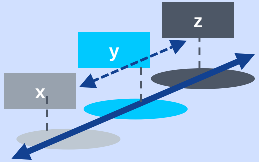
3.2 5G Core Overview

Integrating DL framework



- Decoupling (transient context) “Storage” from “Compute” improving Resiliency of a NF (1:n), save NF resources (e.g. mIoT).
- Data exposure via Data Layer (3rd parties, OAM, Data Analytics).

Simple network upgrade /extensions



- Clean split between AM and SM, + HPLMN ability to deploy new session types with no changes needed to the VPLMN.
- Procedures defined as services allow interface re-use (i.e. any/new Function can use them).
- Flow based QoS framework improving the flexibility to add new QoS (new applications).

3

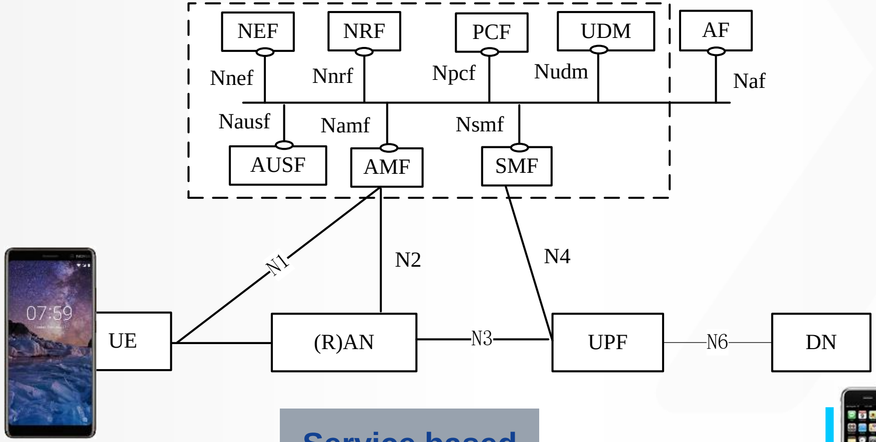
Enable operational agility, extreme automation (faster deployments, upgrades, reduce TCO)

3.3 5GC as a set of Network Functions

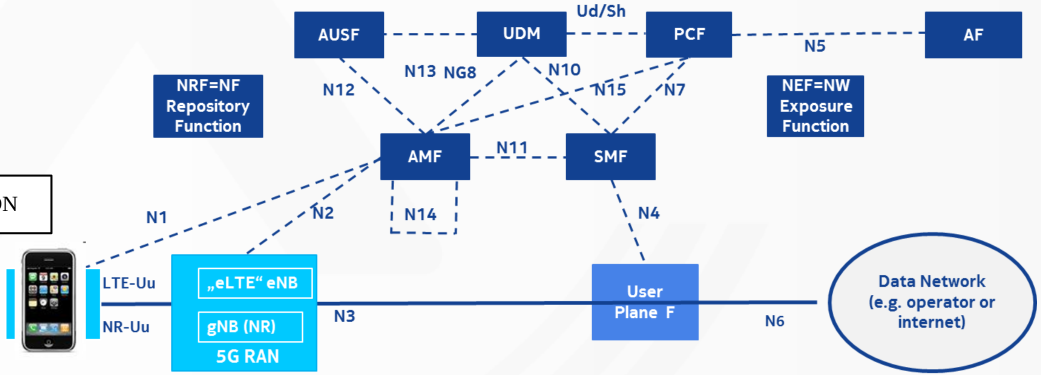
We have **ONE** System architecture but two equivalent **visual** representation in the spec:

1. Reference point
2. Service based

- Introduction of a Service Based architecture (SBA) in NGC with a bit conflicting statements:
  - “Network functions within the NG Control plane unless determined otherwise during the normative phase, shall exhibit service based interfaces for services that can be used by authorized network functions.”
  - This will be evaluated on a case by case basis when specifying the procedure”
  - NRF: Network Repository Function for NF discovery



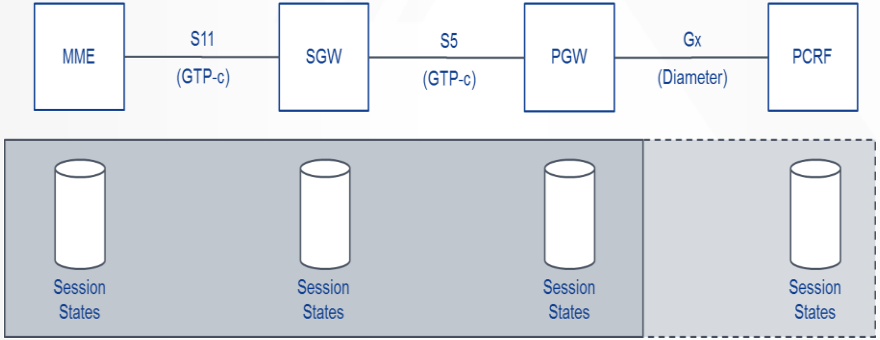
Service based



Ref. Point

3.3 5GC as a set of Network Functions

EPC control plane structure



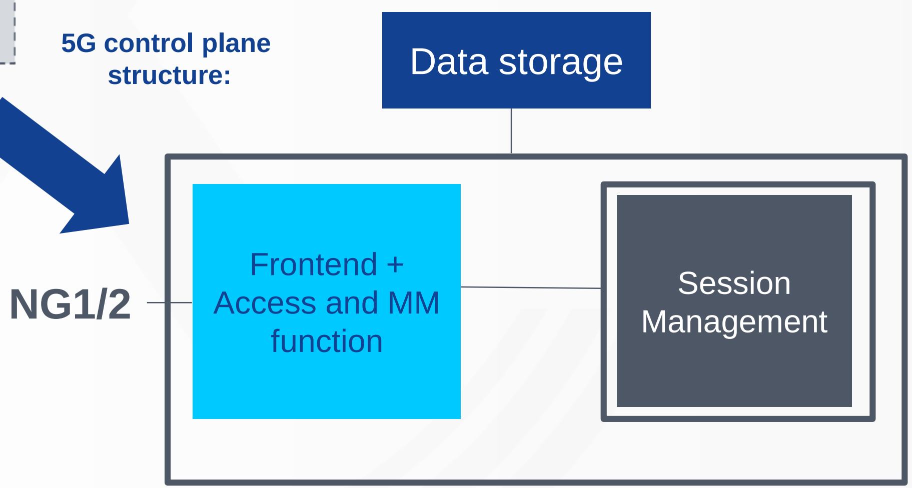
Simplify

- Remove overlaps in functional scope from network functions, e.g. consolidate session management into a single control plane function
- Facilitate easy recovery. Decoupling **compute** and **storage** allows any **compute** function to perform processing for any UE.

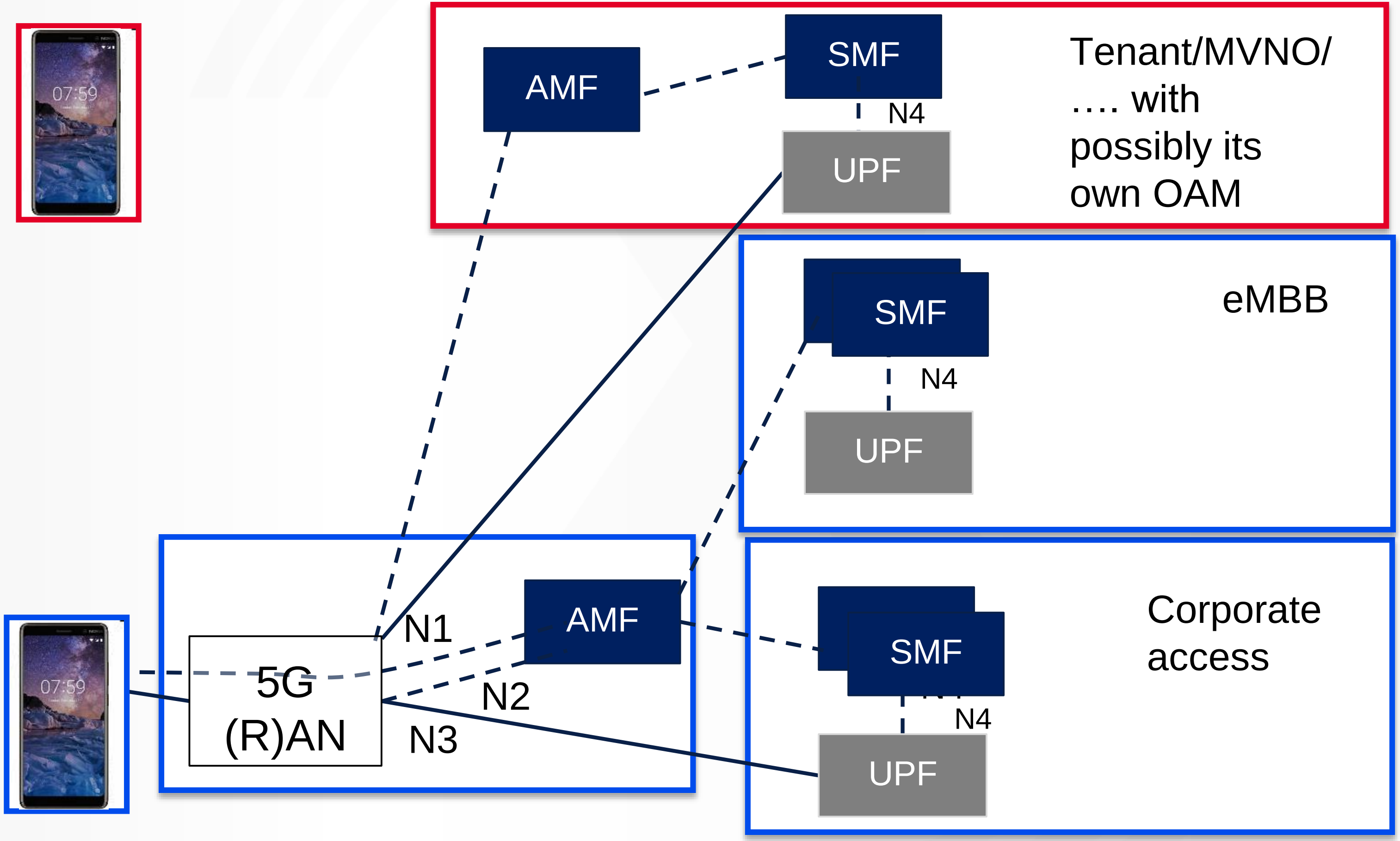
Enable DevOps and access agnosticism

- Minimize dependencies between function modules, e.g. decouple mobility management and session management as far as possible
- Enable a new modular RAN-core interface
- Contain access-specific functions in specific adaptation modules

5G control plane structure:



3.4 5G Core Network Slicing



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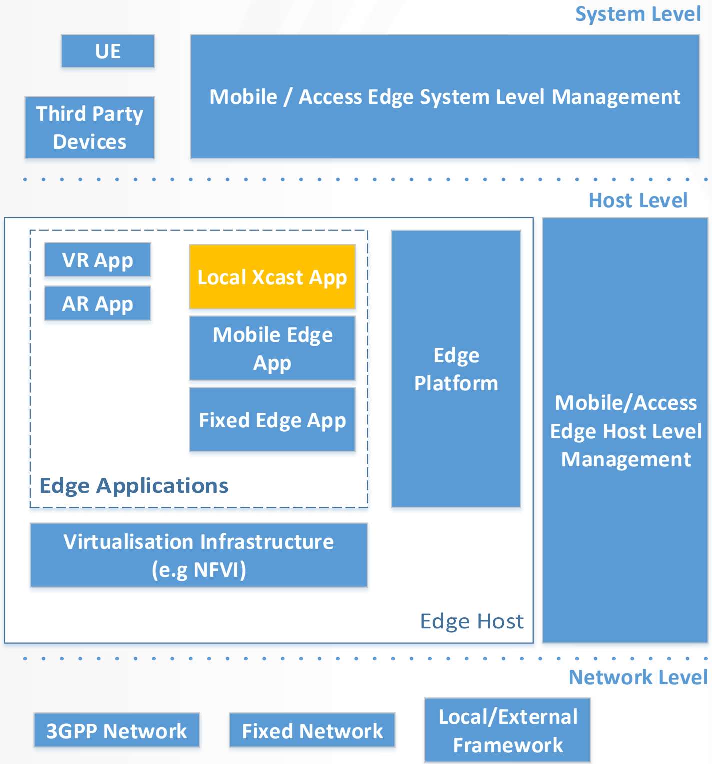
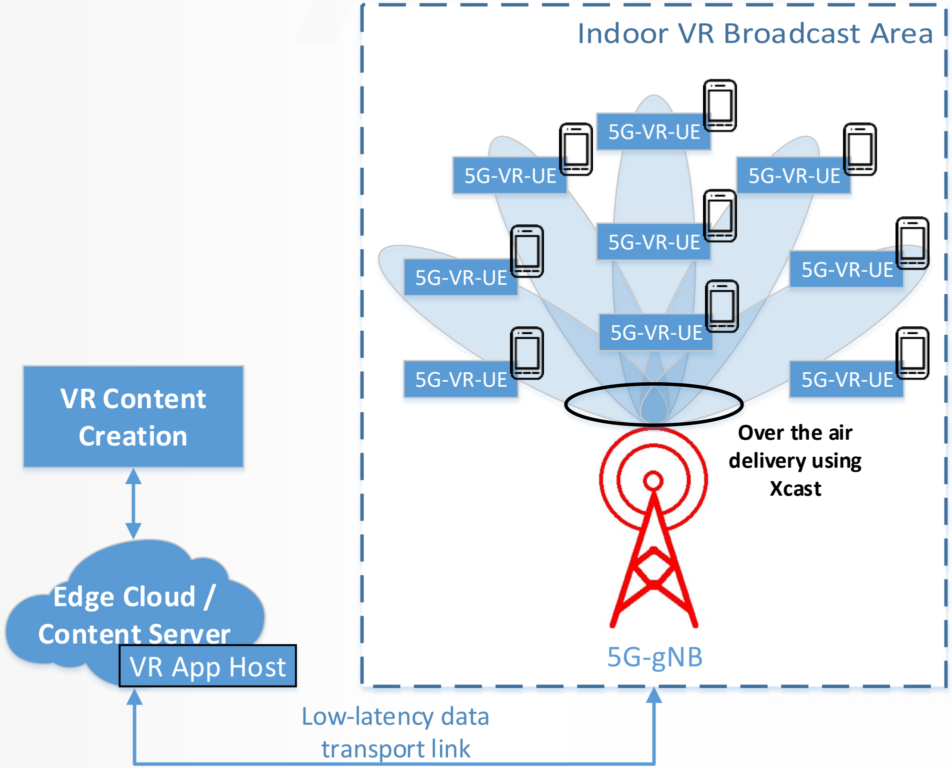
4.1 Technology Enablers: MEC



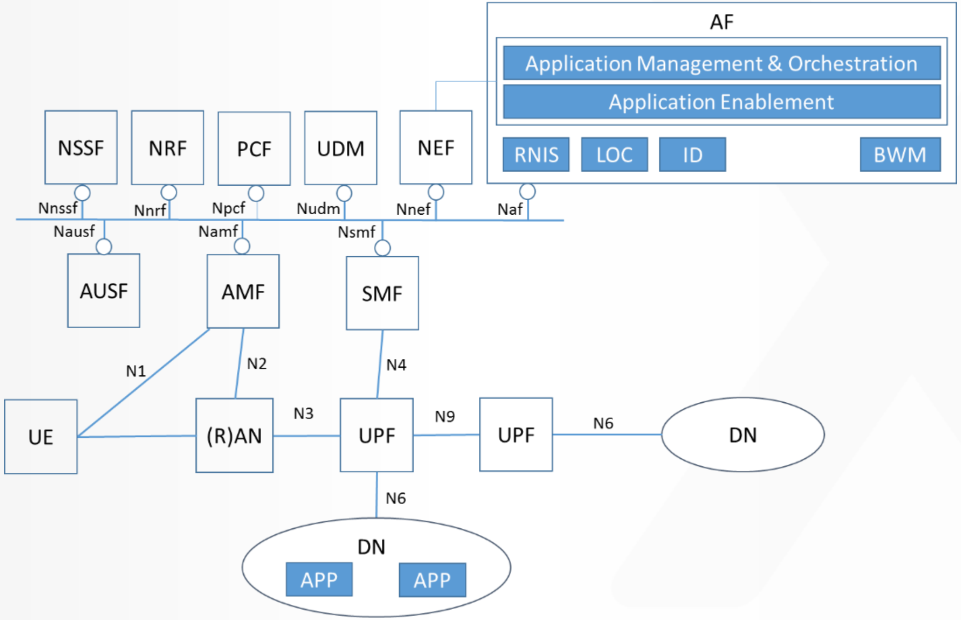
- **Key use cases for MEC from a 5G-Xcast perspective**
  - Video analytics,
  - IoT,
  - Mass delivery of augmented/virtual reality (AR/VR),
  - Data caching and optimized local content distribution.
- **MEC could play a key role in hosting the low-latency VR/AR applications**
  - Which could then be delivered to the end user clients using fixed/mobile access networks.

4.1 Technology Enablers: MEC



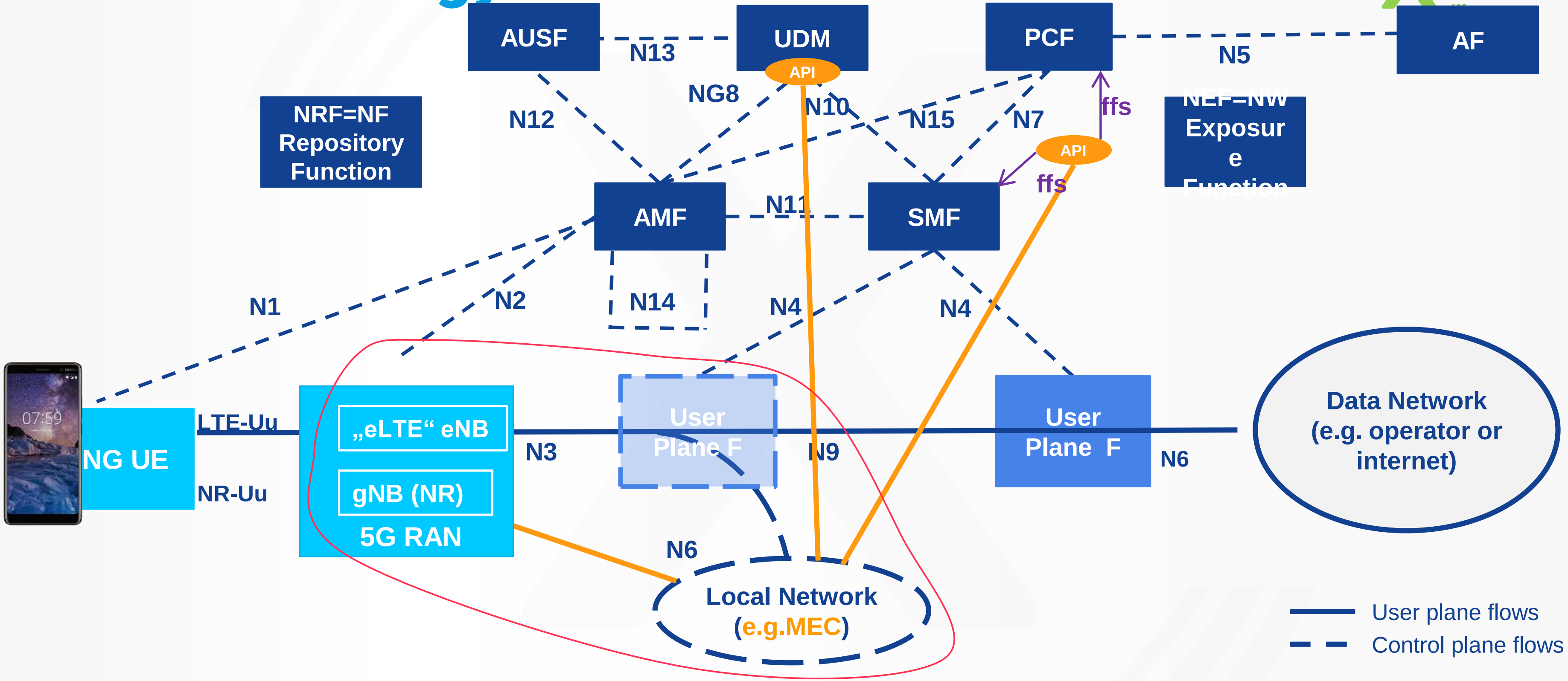
- VR application and related high-capacity, low-latency content can be hosted in the MEC.
- The mass delivery of high-volume data transmissions requires significant scaling of the transport network necessitating increased CAPEX investments for MNOs
  - This can be minimized if the content and related application is hosted in the edge of the access network.
  - The low-latency constraints for VR traffic requires the content to be hosted closer to the access network,
  - Possible dynamic update of the viewed content enabled through the low-latency application layer feedback between the VR application client in the end user device and the host server.

4.1 Technology Enablers: MEC



- 5G system architecture defines a generic network function, the application function, for the interaction with 3GPP 5G core network.
- The application function may influence
  - Traffic routing,
  - Interact directly or indirectly via the network exposure function with the other network functions
  - Use the policy framework for policy control.
  - MEC could play this role in 5G

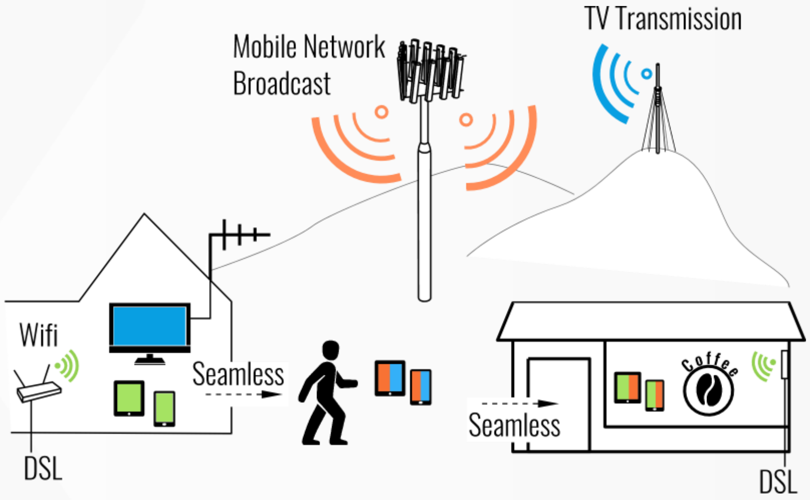
4.1 Technology Enablers: MEC



Built-in support for distributed deployment to tackle traffic explosion and low latency

4.1 Technology Enablers: Converged autonomous 5G-Xcast MooD

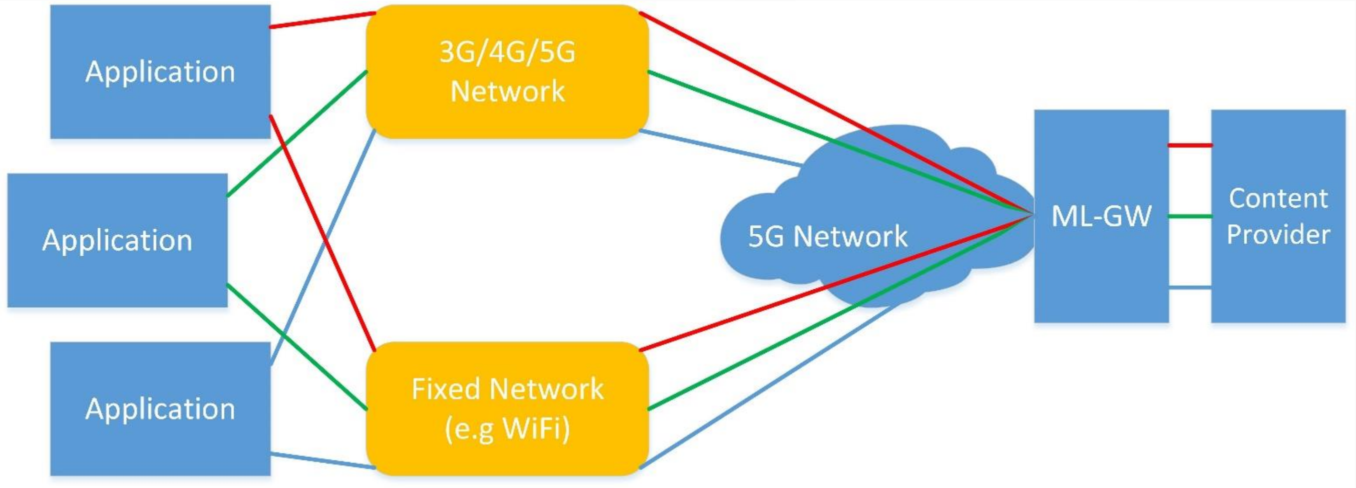
- 3GPP MooD (MBMS operation on Demand) in mobile network
  - Dynamically establish MBMS User Services in order to offload unicast content delivery
  - Find the best delivery mode between broadcast and unicast, at any given time, at any given place
  - Offer service continuity (e.g. smooth playout)



5G-Xcast MooD (Multicast operation on demand) offers a seamless switch between unicast/multicast/broadcast in **converged network including both fixed and mobile networks**

4.1 Technology Enablers: Multilink

- **Multilink**
  - Treat all available links as a single virtual broadband link
  - Split all the content between all available links based on criteria (e.g. actual performance, available throughput)
- **Benefits**
  - Increase overall bandwidth
  - Reliability and availability of the service
  - Mobility support



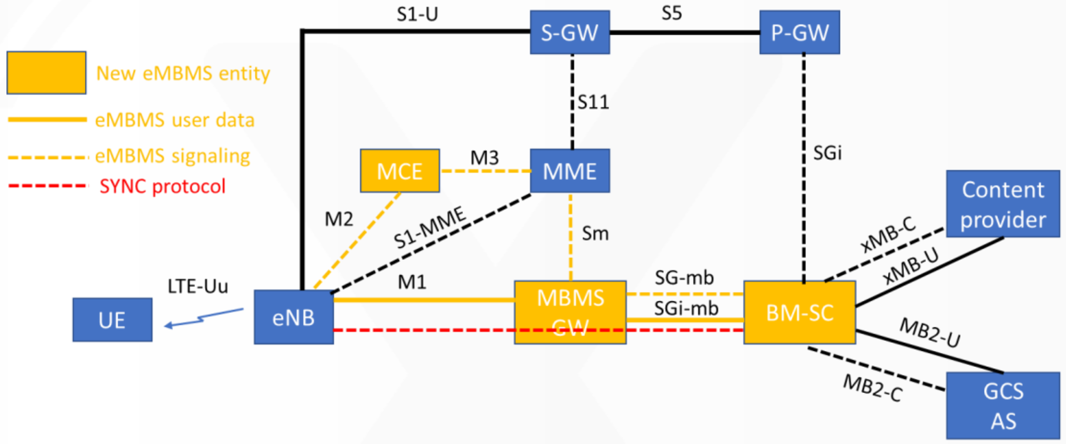
4.2 5G-Xcast Mobile Core Network

- Some important 3GPP 5GC design principles
  - Control user plane separation (CUPS)
  - Modularize the function design
  - Procedure as services
  - Minimize dependencies between the Access Network (AN) and the Core Network (CN)

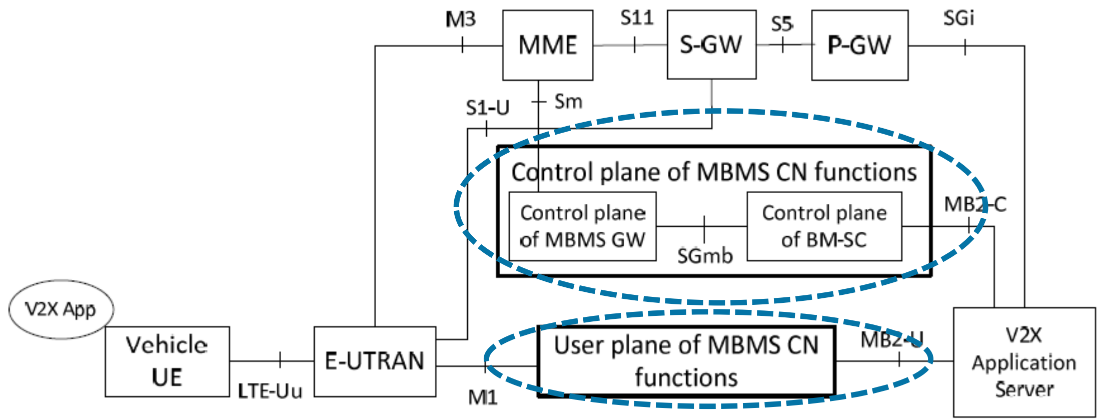
- 5G-Xcast design principles aligned with 3GPP 5GC ones
  - Small footprint on top of the existing unicast architecture
  - Internal optimization tool inside the network operator’s domain
  - Consider terrestrial broadcast as a service
  - Simplify the system setup procedure to keep the system cost marginal
  - Protocols that allows efficient IP multicast
  - Enable caching capabilities inside the network

4.2 5G-Xcast Mobile Core Network

How does CUPS principle apply to eMBMS architecture in LTE?



eMBMS architecture without CUPS



eMBMS architecture based on CUPS

4.2 5G-Xcast Mobile Core Network

- Two different approaches to enable multicast and broadcast capabilities
  1. **Transparent multicast transport**
     - 5GC could receive multicast user data directly from multicast source
  2. **Point-to-multipoint services**
     - Delivery methods (download, streaming, transparent delivery and group communication)
     - User data encapsulation (e.g. FLUTE) and reliable content delivery (e.g. AL-FEC and file repair procedure)
     - Geographical broadcast
     - Audience size measurement and metric reporting
     - Multicast operation on demand (MooD)

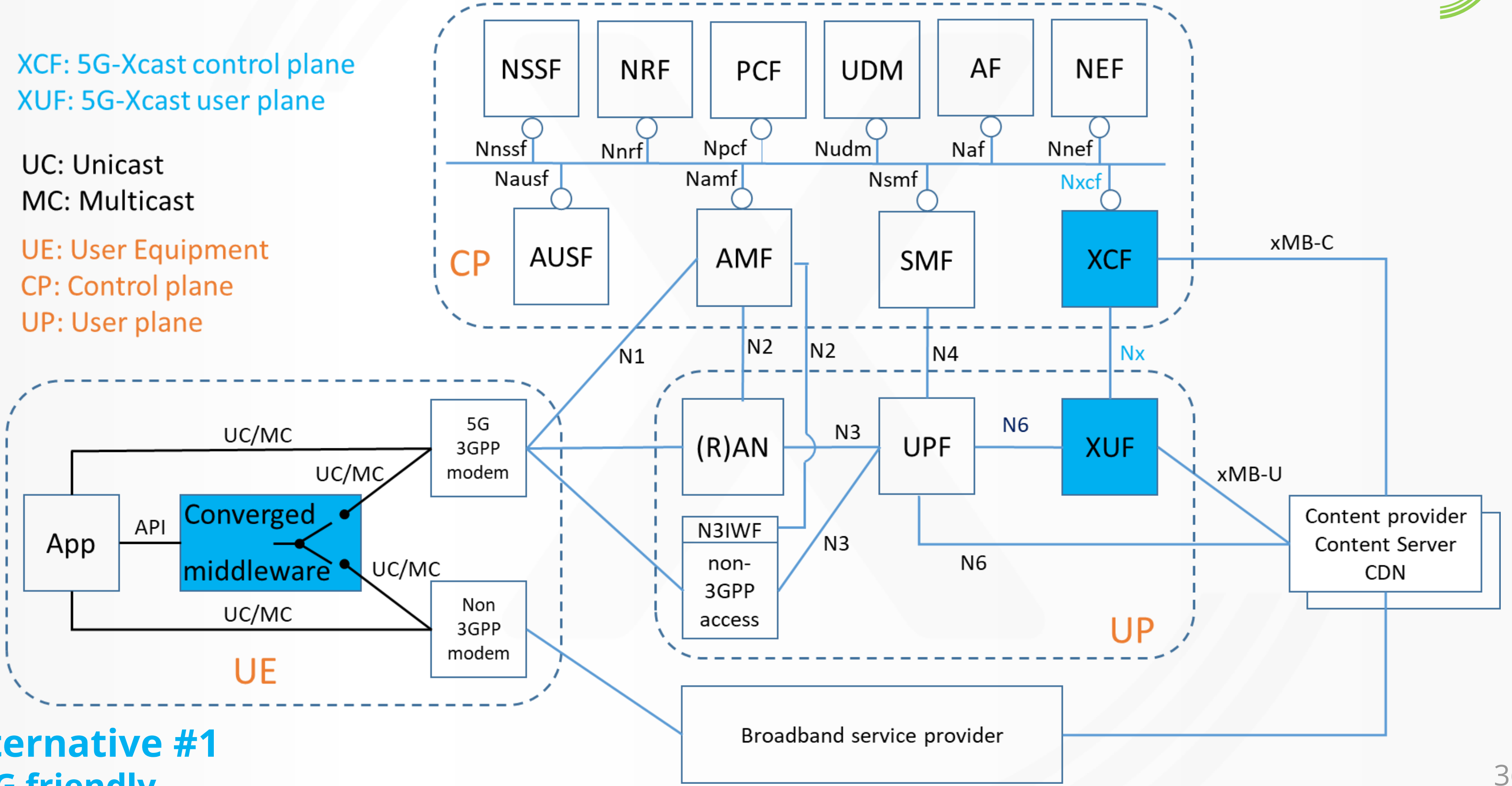
- Two primary mobile network architecture alternatives proposed
  - **Alternative 1: 5G architecture friendly**
  - **Alternative 2: minimal changes to the functionalities developed in LTE eMBMS**
  - Third possible alternative considered as an implementation option of Alternative 1

4.2 5G-Xcast Mobile Core Network

XCF: 5G-Xcast control plane
XUF: 5G-Xcast user plane

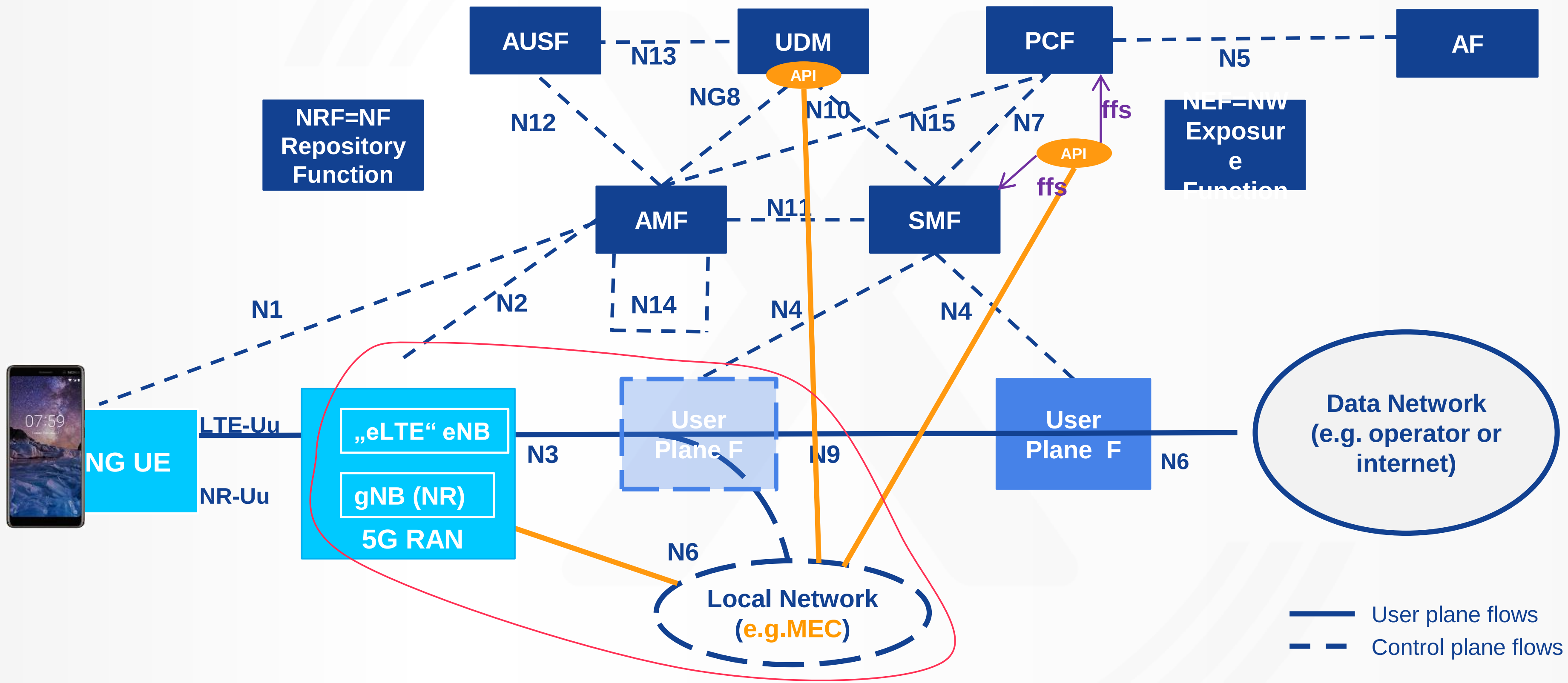
UC: Unicast
MC: Multicast

UE: User Equipment
CP: Control plane
UP: User plane



Alternative #1
– 5G friendly

4.2 Transparent multicast transport based on MEC-concepts



Built-in support for distributed deployment to tackle traffic explosion and low latency

4.2 5G-Xcast Mobile Core Network

XCF: 5G-Xcast control plane
XUF: 5G-Xcast user plane

UC: Unicast
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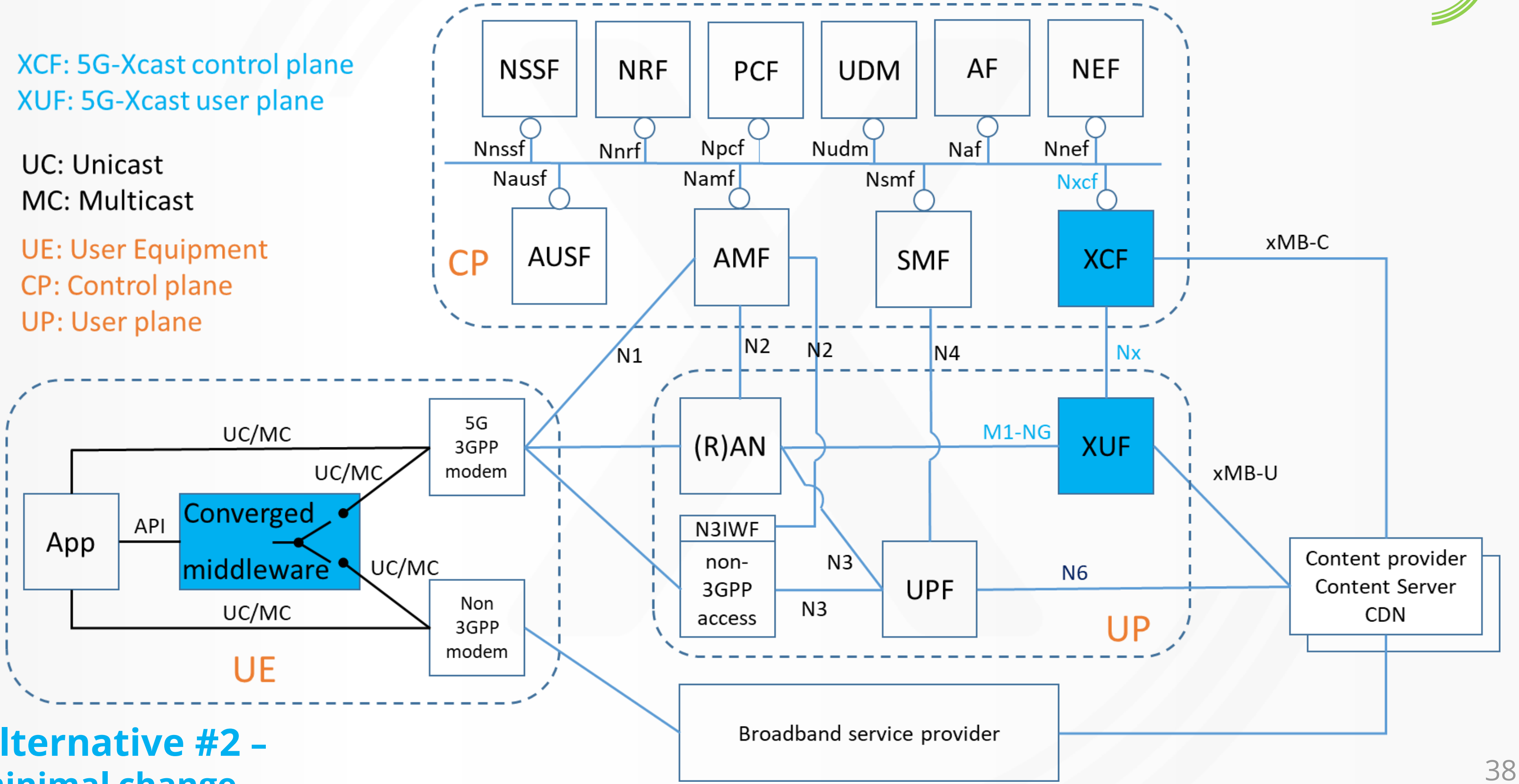
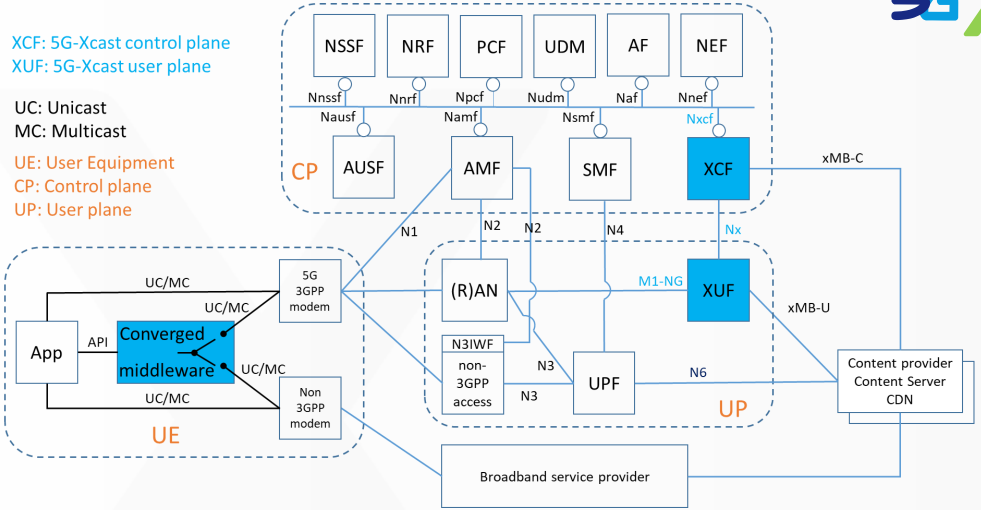
UE: User Equipment
CP: Control plane
UP: User plane

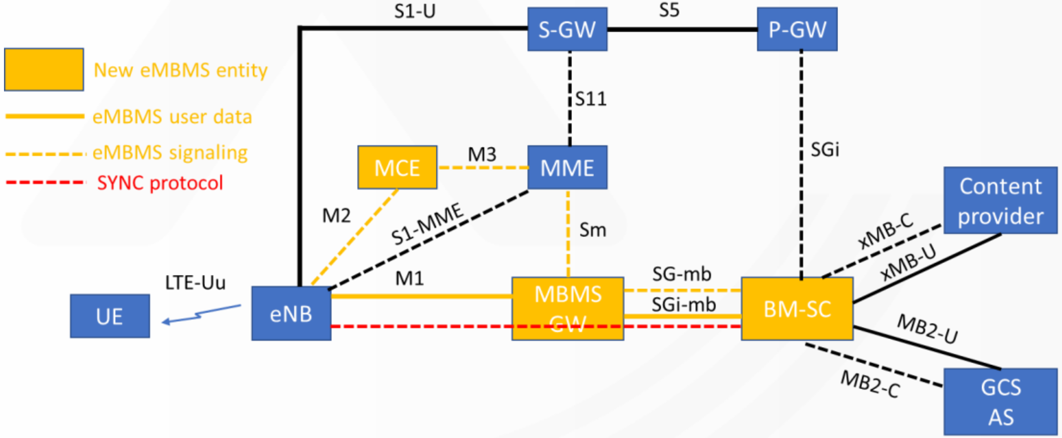


Alternative #2 – minimal change

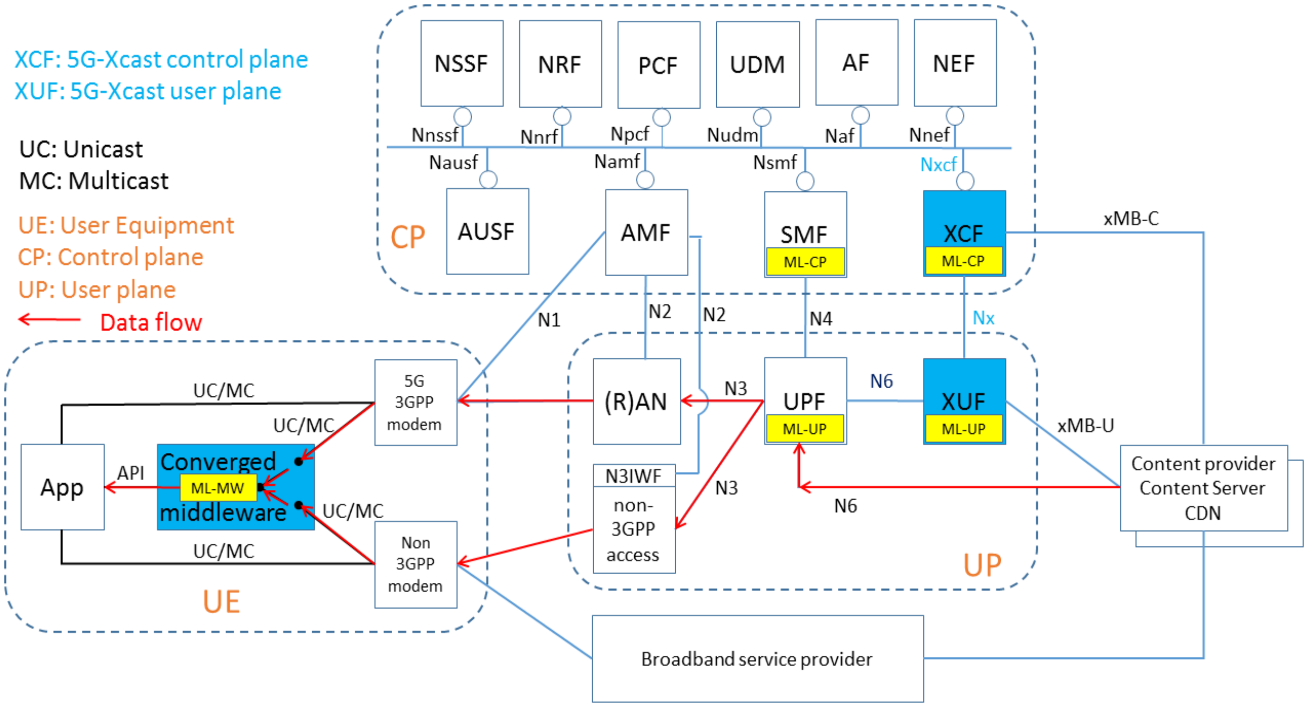
4.2 5G-Xcast Mobile Core Network

Similarity between 5G-Xcast mobile core network architecture alternative #2 and eMBMS architecture in LTE





4.2 5G-Xcast Mobile Core Network



ML-CP – additional functionality in Control Plane;

ML-UP - additional functionality in Data Plane;

ML-MW – ML middleware functionality.

Alternative #1
– 5G friendly

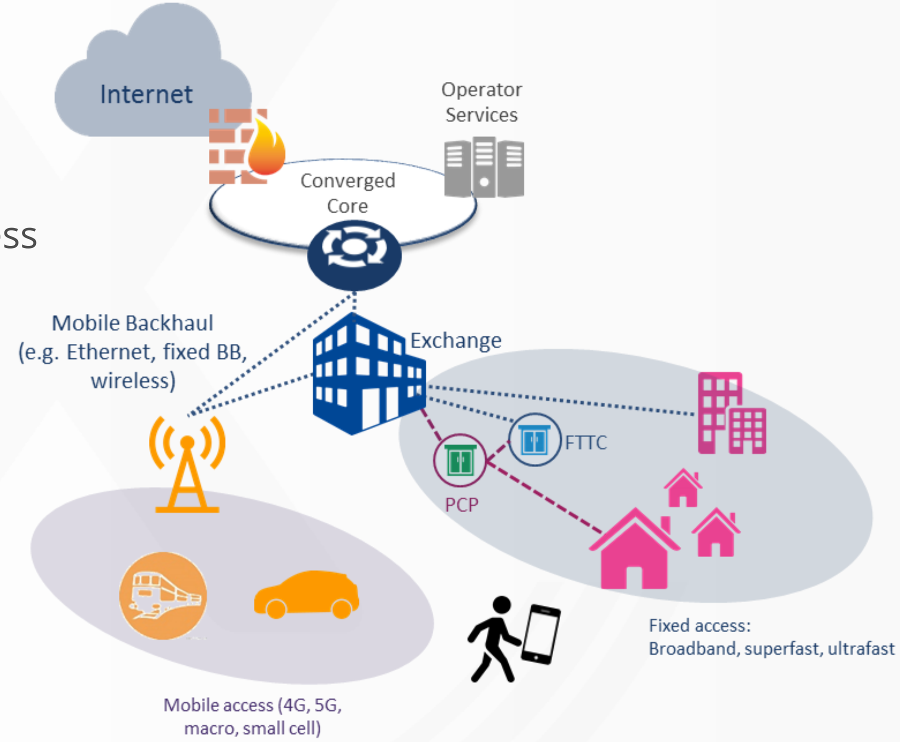
4.2 5G-Xcast Mobile Core Network

Additional functionality for:

- XCF
  - Multilink session setup and release initiation
  - QoS parameters estimation for data transfer via each available link
- UPF
  - Data split
  - Establishment of IP tunnels
- SMF
  - Multilink session setup and release
- Converged middleware:
  - Data combining
  - L session Setup Request (QoS parameters)
  - Signaling (channel quality data transmitting)
  - Caching

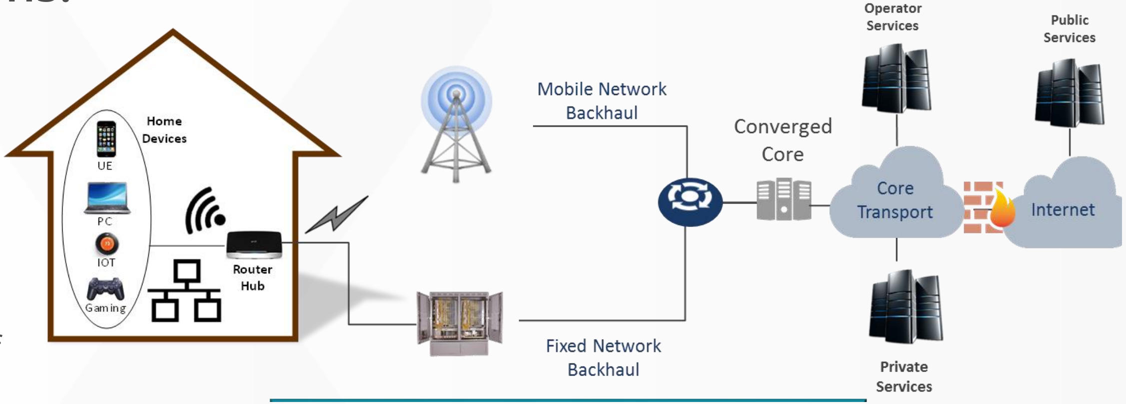
4.3 5G-Xcast Converged Core Network

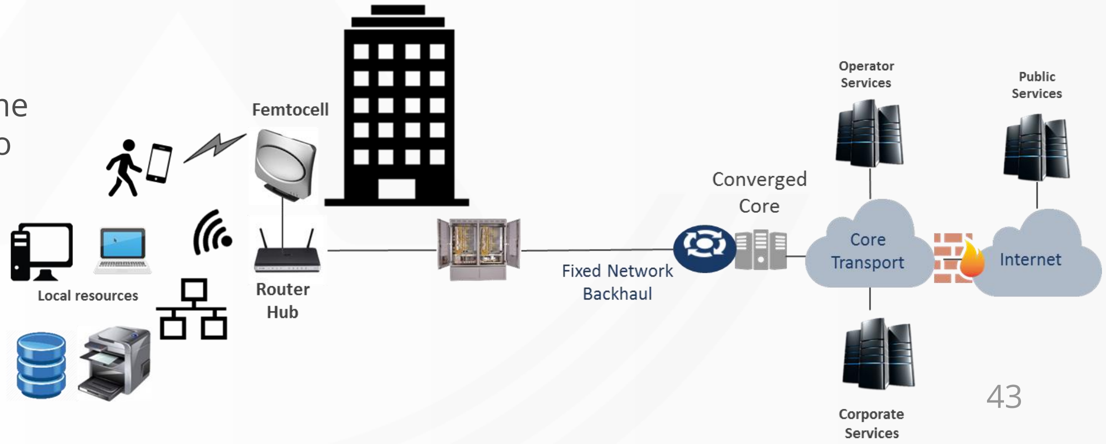
- Converged Core manages different access networks (mobile, fixed…)
- User side benefits:
  - Single set of credentials
  - Consistent set of policies across access technologies
  - Consistent set of services across access technologies
  - Automatic best network selection
  - Simultaneous network operation (Multilink)
  - Seamless mobility between Access network
- Operator can perform network optimization more efficiently



4.3 5G-Xcast Converged Core Network

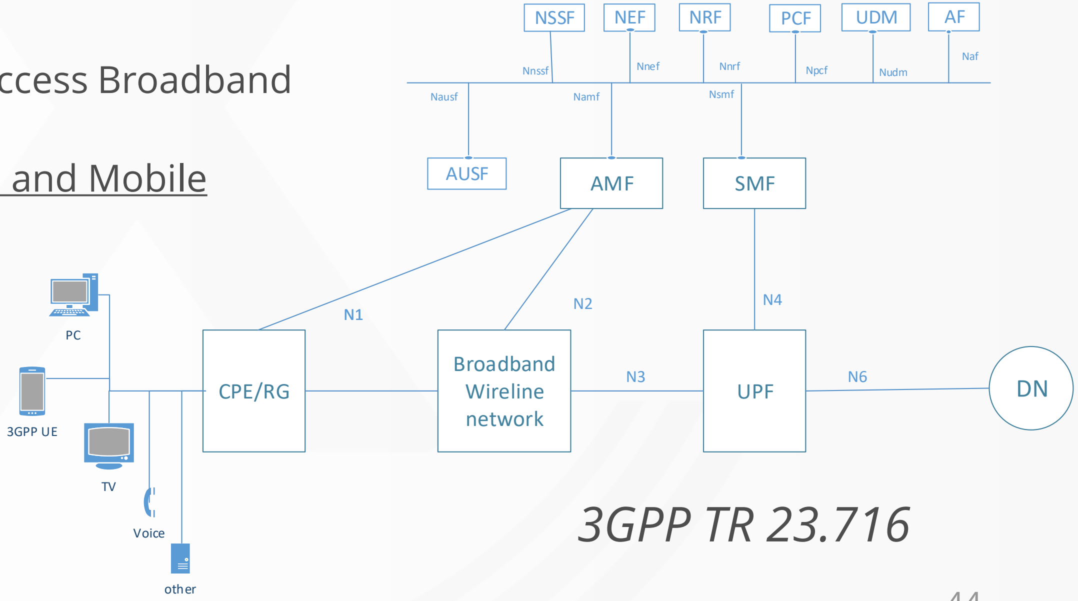
- Several deployment options:
  - Common Fixed Access
    - Home Router connects to several networks then provides local Wi-Fi/Ethernet
  - Mobile Hybrid Access
    - End devices can connect to mobile and fixed network of the same operator
  - Femtocell Access
    - Femtocell located at user home provides mobile connection to end devices





4.3 5G-Xcast Converged Core Network

- **Several Technical Reports inside 3GPP:**
  - 3GPP TR 26.891 - Media Distribution in 5G
  - 3GPP TR 23.716 - Study on Wireline & Wireless Convergence on 5GS
  - 3GPP TR 23.793 - Study on Access Traffic Steering, Switching and Splitting on 5GS
- **On Broadband forum:**
  - Broadband Forum TR.348 - Hybrid Access Broadband Network Architecture
  - Broadband Forum SD-407 - 5G Fixed and Mobile Convergence Study

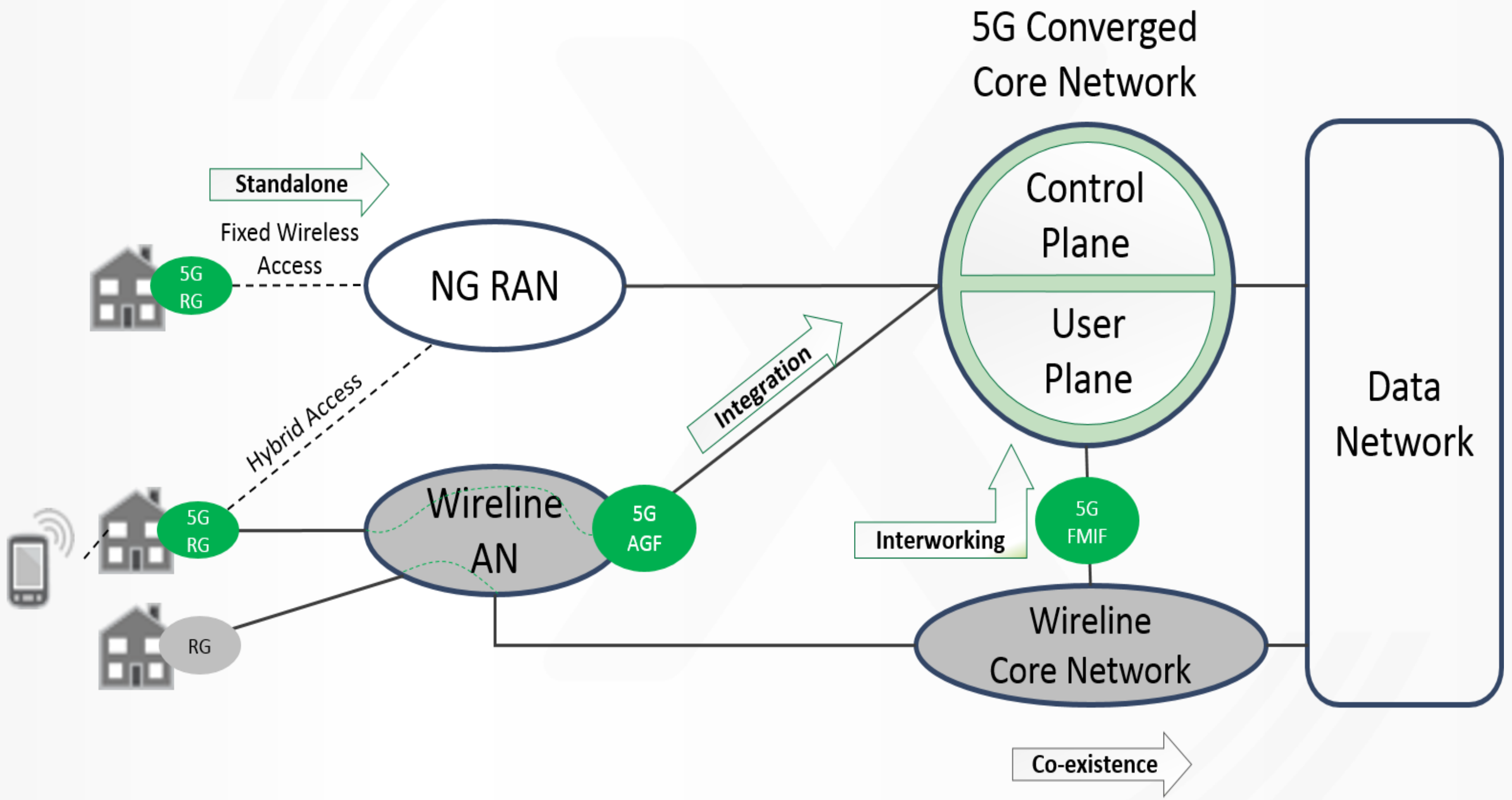


3GPP TR 23.716

4.3 5G-Xcast Converged Core Network

- TR 23.716
  - Functional Split between 5GC and Wireline
  - Research on enhancements for N1, N2 and N3 to support Convergence
  - Impact of the common network
- TR 23.793
  - Details on Access Traffic Steering: Selection of a new Access Network for a new data flow
  - Details on Access Traffic Switching: Moving existing data flows between Access Networks
  - Details on Access Traffic Splitting: Dividing existing data flows between Access Networks
- BBF SD-407
  - Two new models to have a clear migration path for Converged Access:
    - Integration. 5GC network delivers all functions required to support a wireline access network
      - Requires a new function inside 5GC, 5G Access Gateway Function (AGF).
    - Interworking. Wireline Core Network continues to provide most of the existing functions
      - Enables some convergence with the 5GC through an interworking function.

4.3 5G-Xcast Converged Core Network



4.4 5G-Xcast Session

- 5G-Xcast Session(s) Definition
  - PDU session(s)
  - MooD session
  - mABR session
  - PWS Session
  - MultiLink-Enhanced session
- Session Management (Task 4.3) is under work, to be finalized in Nov 2018

4.4 Goals of 5G-Xcast Session Management (T4.3)

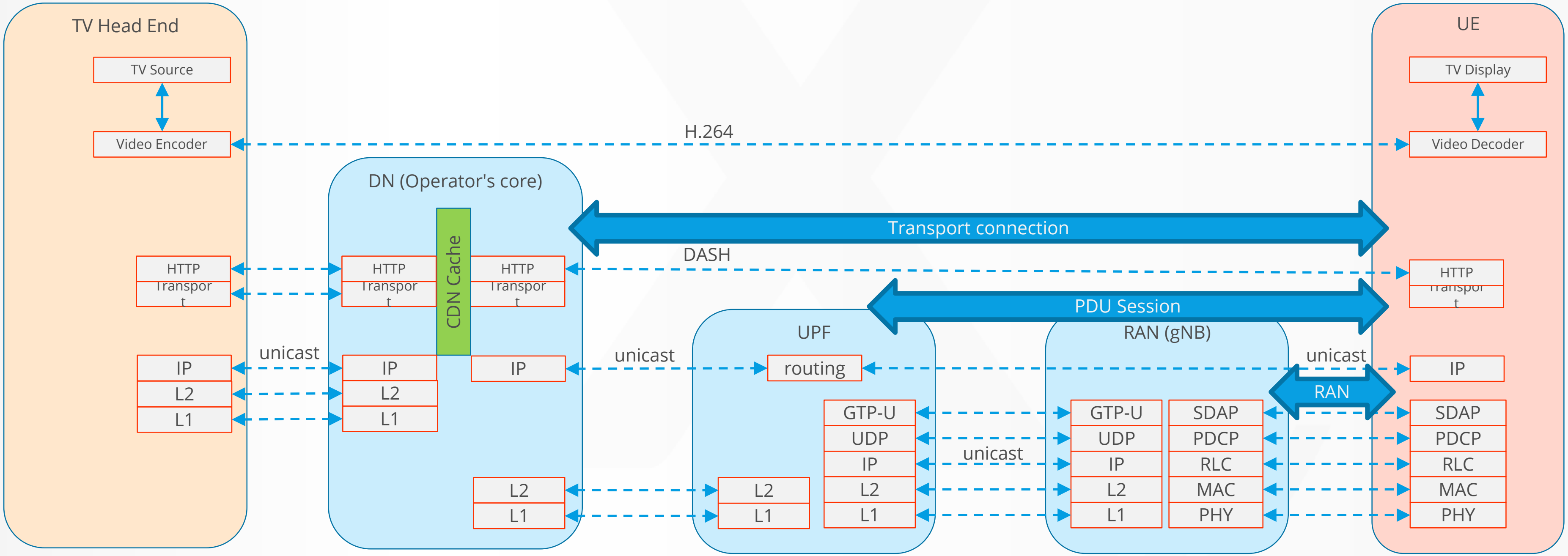
- Session management for both ad-hoc and scheduled multicast/broadcast sessions
- Flexible session management where resource, target geographic area, QoS and other parameters can be dynamically changed during the session lifetime
- Resource allocation strategies
- Define the resource allocation granularity from fine-grained for low bitrate (e.g. IoT, connected car) to coarse-grained for ultra-high bitrate (e.g. UHDTV)
- Leverage multilink, multi-connectivity
- Define a signalization of session announcement at the user devices without the need for continuous monitoring multicast/broadcast sessions on the air interface for PWS

4.4 What is a 5G-Xcast Session ?

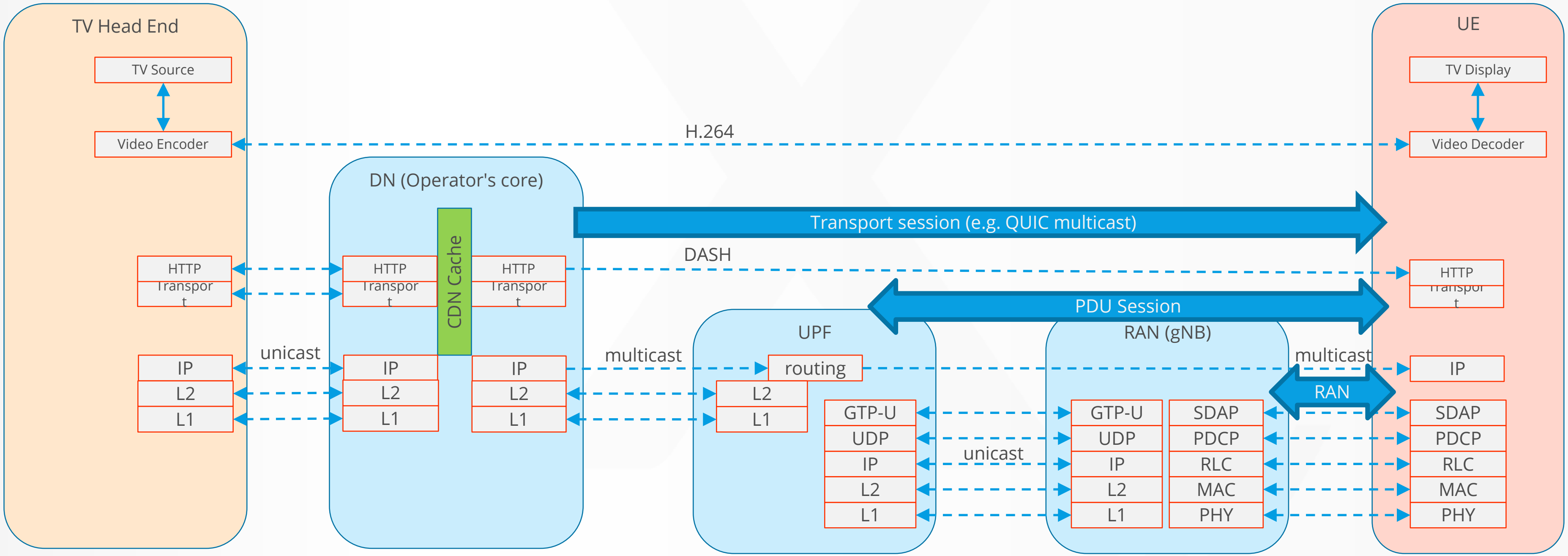
- 5G-Xcast session is not a single wholesome “end-to-end” session
  - Rather, it is comprised of multiple “sub-sessions” between the components en-route
  - Several different use cases (e.g. broadcast vs. PWS)
  - Different layers (RAN-WP3, Core- WP4)
  - Several different technologies (PDU level, MooD, mABR, MultiLink)

Session(s) interplay still under development

4.4 5G-Xcast Session: PDU Unicast



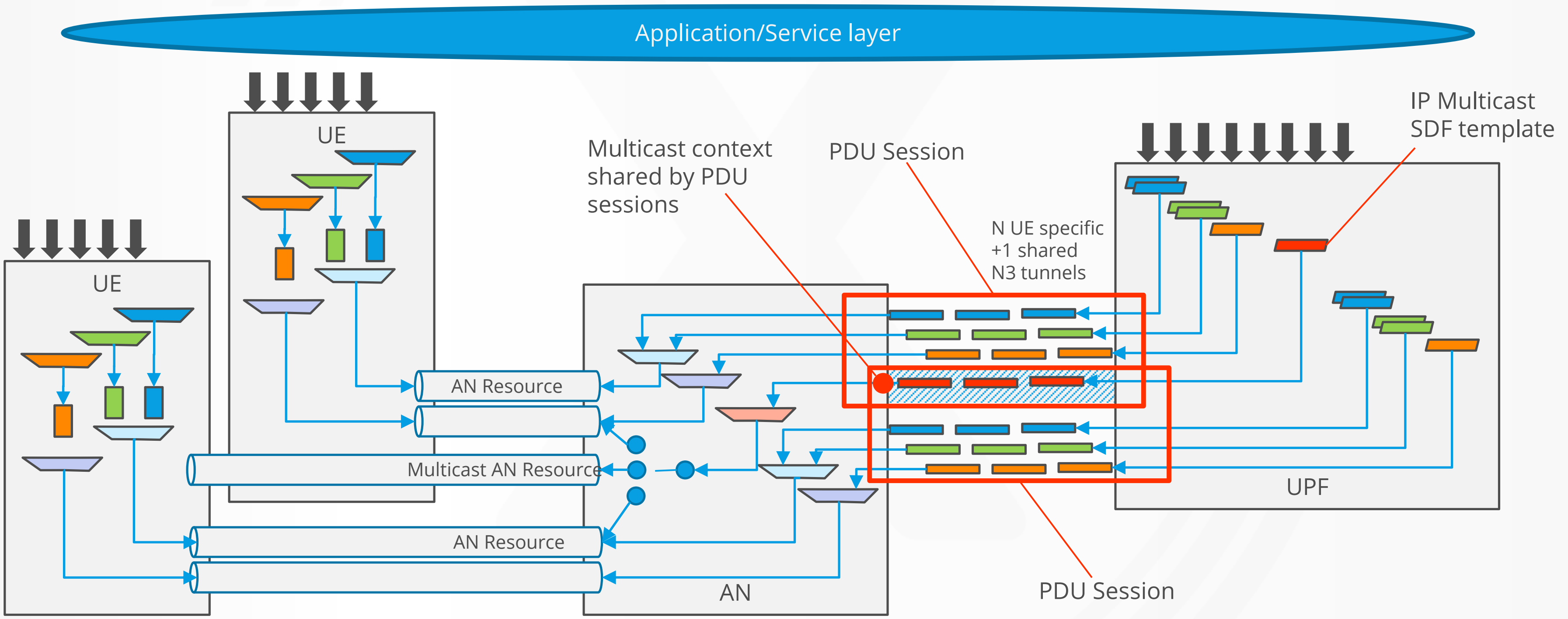
4.4 5G-Xcast Session: PDU Multicast



4.4 5G-Xcast Session: PDU Session Desc.

1. UE performs the registration procedure, establishes PDU session and, if UE entered CM-IDLE state, it also performs service request in order to send user data [3GPP TS 23.502]
2. User starts a native application or opens a web page (HTML5 application). The application may require user authentication.
3. The application downloads objects as web/cloud applications do. A list of available video feeds is also downloaded.
4. User selects a video feed to watch embedded in application view or full screen.
5. The application request the manifest for the video feed.
6. The application requests media segment(s).
7. CSP/CDN (HTTP server) decides to optimize the transport and offers multicast transport.
8. CSP/CDN (HTTP server) announces the availability of multicast transport in the HTTP response (i.e. Alt Srv in case of HTTP QUIC session).
9. Multicast transport is selected for media feed by HTTP (What is required from application/service design to use HTTP over multicast QUIC efficiently?) .
10. UE sends IMGP/ICMPv6 (MLR) to join IP multicast group.
11. PDU session update procedure is triggered (details in the following slides).

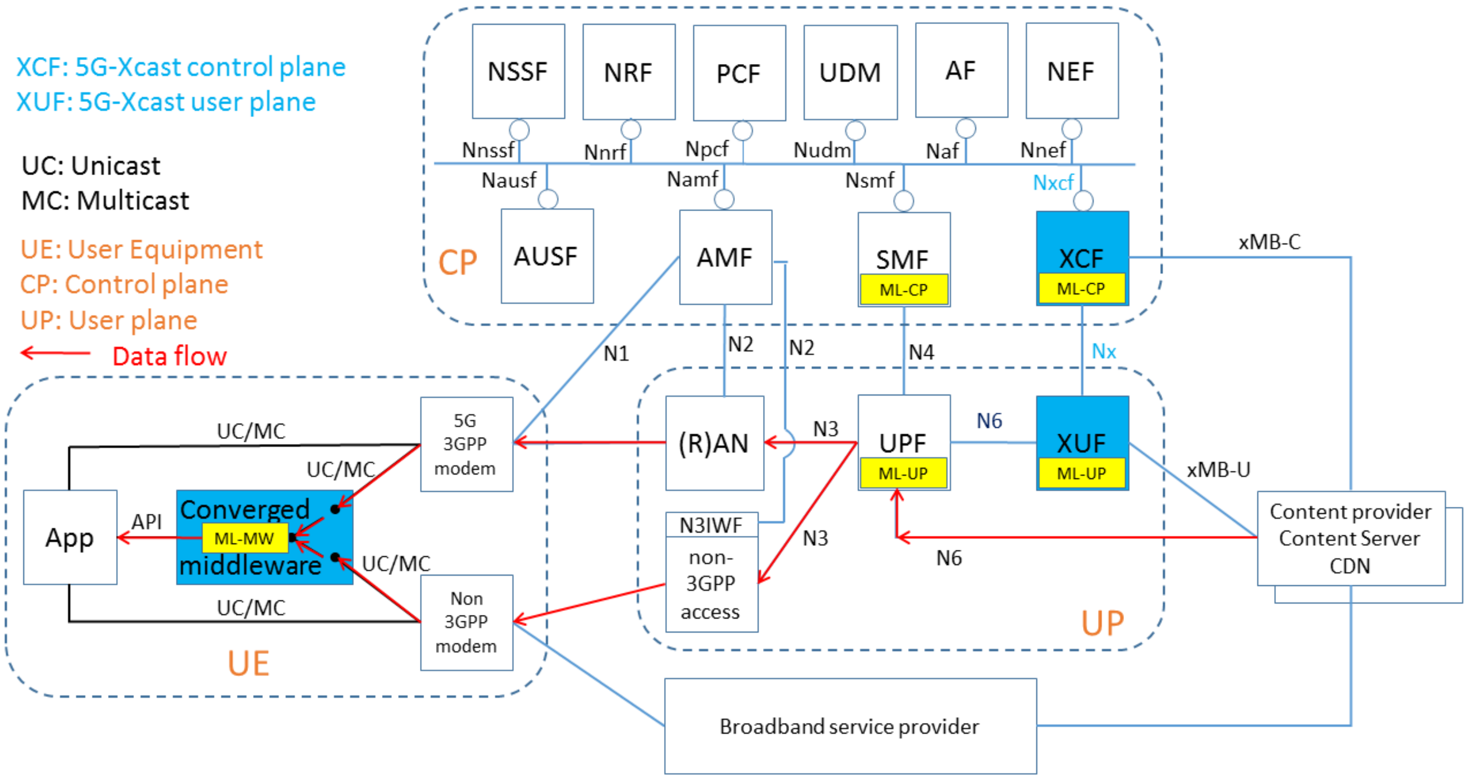
4.4 5G-Xcast Session: PDU Session



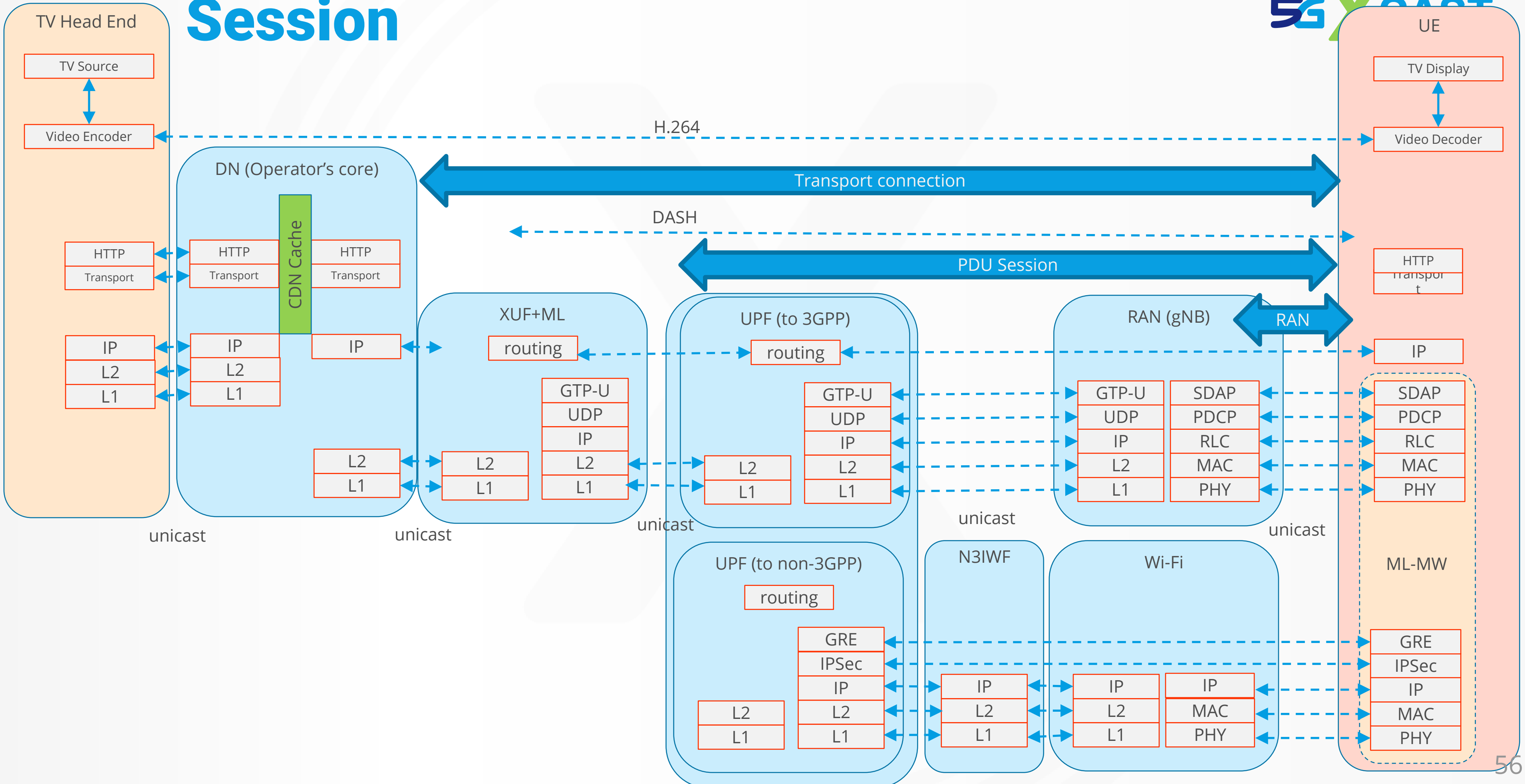
4.5 5G-Xcast Session: MultiLink-Enhanced Session

- ML-CP – additional functionality in Control Plane;
- ML-UP - additional functionality in Data Plane;
- ML-MW – ML middleware functionality.

4.4 5G-Xcast Session: ML-Enhanced Session



4.4 5G-Xcast Session: ML-Enhanced Session



Contents

5. Conclusions and future work

- **Achievements coming from WP4:**
  - Mobile core network architecture (Final version - Published)
    - Limitations of eMBMS in LTE
    - Key technology enablers for 5G multicast and broadcast (e.g. MEC, 5G-Xcast MooD, Multilink)
    - Several architecture alternatives proposed with analysis
  - Concept of converged network (Initial version – Internal use)
  - Session control and management (Initial version – Internal use)

- **Work in progress**
  - Converged network architecture (Final version in Aug. 2018)
  - Session control and work flow (Final version in November 2018)
  - PoC (June 2018 - May 2019)

Thank You

Any Questions ?