Technische Universität Berlin

Advanced Web Technologies

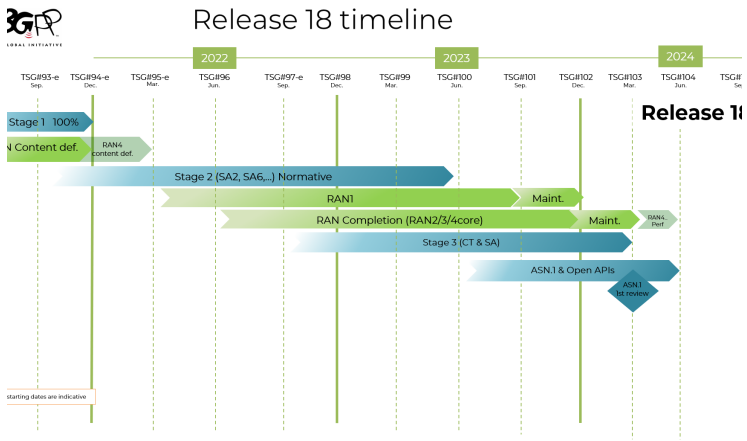
Media Delivery in 5G Networks

Dr. Louay Bassbouss, Daniel Silhavy | Open Distributed Systems | lecture winter term 2023/24

Schedule

No	Week	Date	Topic
1	42	16.10.2023	Introduction and Framework
2	43	23.10.2023	Web Technologies Basics & Media Entertainment for the Web
3	44	30.10.2023	Foundations of Media Streaming
4	45	06.11.2023	Advanced Media Streaming
5	46	13.11.2023	Multiscreen Technologies and Standards
6	47	20.11.2023	Context-Aware Media Streaming & Encoding
7	48	27.11.2023	Dynamic Advertisement
8	49	04.12.2023	Media Players - dash.js, Exoplayer
9	50	11.12.2023	HbbTV and Smart TV
	51	18.12.2023	Holiday break
	52	25.12.2023	Holiday break
	1	01.01.2024	Holiday break
10	2	08.01.2024	Media Delivery in 5G Networks (1)
11	3	15.01.2024	Media Delivery in 5G Networks (2)
12	4	22.01.2024	Interoperable Web-supported Learning Technologies
13	5	29.01.2024	Metaverse Platforms and Technologies
14	6	05.02.2024	Securing Content-Provenance and Authenticity
15	7	12.02.2024	Exercise and Test Preparation
16	8	19.02.2024	Written Test (60min) first slot (details will be announced during the semester)

Agenda



1 5G Foundation and Evolution of 5G

5G Core Concepts, Network Function Virtualization, Network Slicing and QoS Control, 5G Standalone (SA) vs Non-Standalone (NSA), MEC, eMBB, FWA, URLLC, …

2 5G Media Use Cases and Application Areas

Remote Media Production, Hybrid Broadcast/Unicast Delivery, Ultra Low Latency Streaming for Interactive Services, Metaverse, Cloud Gaming, 5G Terrestrial TV Broadcast, …

3 5G Media-related Standards and Technologies

Media-related specs in 3GPP releases, MBMS, 5GMS, 5G-MAG, DVB-I over 5G, Protocols: MPEG-DASH, HLS, CMAF, FLUTE, …

Section 01

5G Foundation and Evolution of 5G

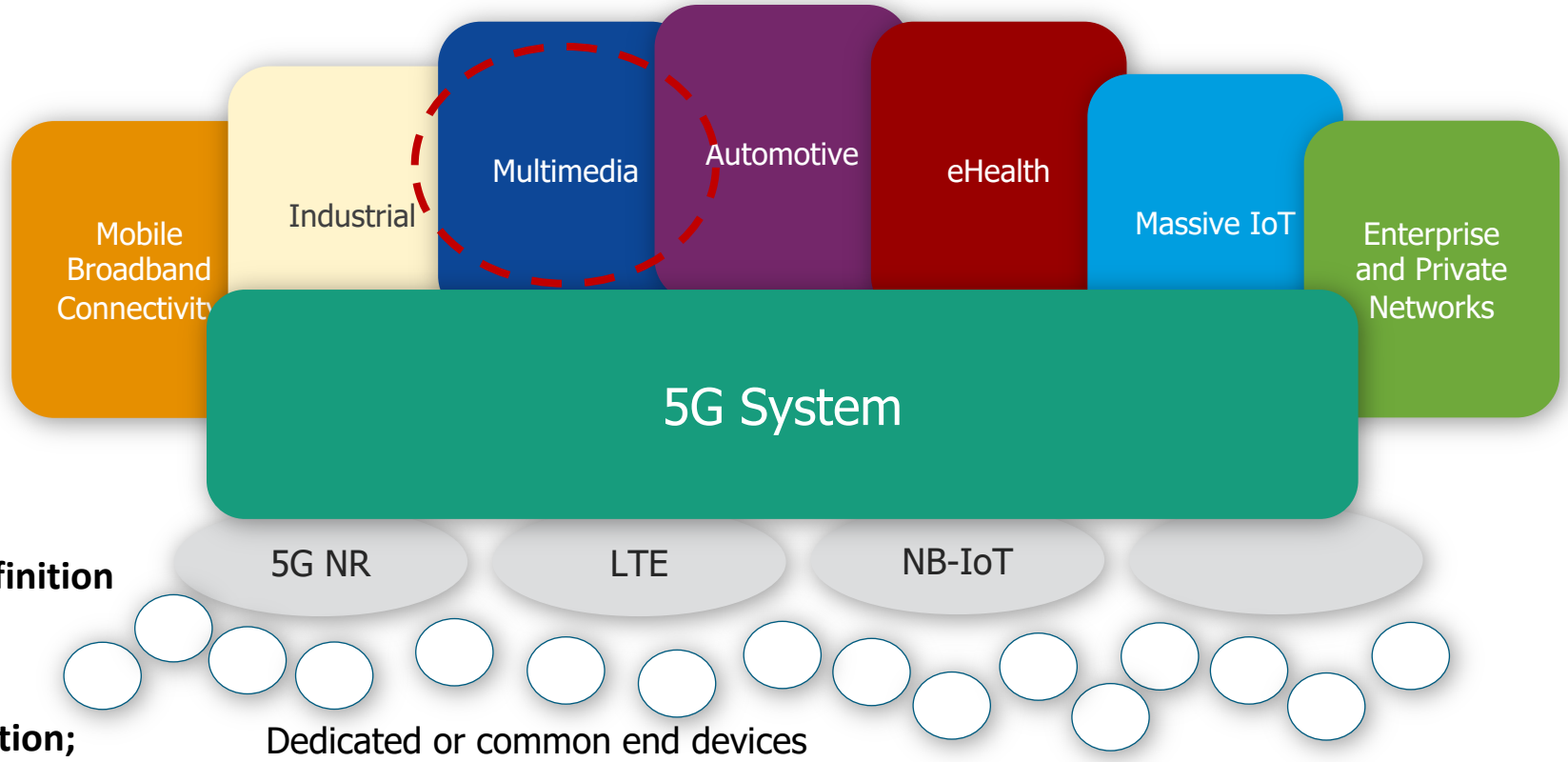
What is 5G?

- 5G refers to the fifth generation of wireless technology for cellular networks
- Offer faster data speeds, lower latency, increased network capacity and the ability to connect a significantly larger number of devices simultaneously compared to previous generations
- Operate on higher frequency bands and utilizes advanced technologies such as massive MIMO (Multiple-Input Multiple-Output), beamforming, and network slicing
- Support a wide range of applications, services and industries, including high-definition video streaming, virtual reality, augmented reality, and Internet of Things (IoT).
- Standards body, 3GPP, first standardized the world's first 5G New Radio (NR) solution in 'Release 15' → Key improvements in three areas: 1) enhanced mobile broadband (**eMBB**), 2) ultra-reliable low latency communications (**URLLC**), and 3) massive machine-type communications (**mMTC**).

What is 5G?

5G shapes the future of many industries:

- Manufacturing
- Public Safety
- Smart Cities
- Healthcare
- Automotive
- Agriculture
- **Media & Entertainment: Ultra-High-definition Video Streaming; Immersive Media (AR/VR/XR); Cloud Gaming; High-Fidelity/Holographic Video Communication; Remote Production; 5G Broadcast;**



Drivers for 5G
Enhanced Mobile Broadband (eMBB)

- Provide significantly **faster data speeds**, **lower latency**, and **increased capacity** compared to previous generations of mobile networks.
- Examples:
  - Data downloads/Uploads
  - 4K/8K video streaming; Real-time video
  - Online Gaming
  - Remote work and collaboration
  - Immersive AR/VR experiences

Drivers for 5G

Massive Machine-type Communications (mMTC)

- Designed to support massive connectivity requirements in IoT, where a large number of devices need to connect and communicate simultaneously
- Provide efficient, reliable and secure connectivity for devices with low data rate and low-power requirements
- Longer transmission range using narrowband communication
- Examples:
  - Wireless tracking of devices (warehouse, vehicles)
  - Remote monitoring, telemetry, and tracking systems
  - eHealth sensors (body temperature, blood pressure)
  - Smart cities
  - Industrial automation

Drivers for 5G

Ultra reliable Low-latency Communication (URLLC)

- Provide extremely reliable and low-latency connectivity for time and mission-critical applications that require real-time communication and high levels of reliability
- Incorporate edge computing capabilities where processing and decision-making are performed closer to the network edge
- Examples:
  - Industry 4.0 : Robots and other industrial machinery controlled and governed by a central server
  - Wireless remote surgery: Control of robotic tools by a surgeon in a remote location
  - Vehicle to everything (V2X) communication: Exchange of information between a road vehicle and other objects
  - (Cloud gaming: Rendering of video on server side)

Drivers for 5G
Fixed Wireless Access (FWA)

- Provide high-speed broadband connectivity to fixed locations, such as homes, offices, and businesses, without the need for traditional wired connections like fiber or cable
- Open new possibilities for delivering high-speed broadband connectivity to areas where traditional wired infrastructure is challenging or economically unviable
- FWA can deliver multi-Gbps data rates, enabling fast downloads, streaming, online gaming, and other data-intensive applications

Source: https://news.samsung.com/medialibrary/global/photo/11717/tag/networks

History of mobile communications

1G (1970s)

- Analog cellular networks with voice-only communication
- Basic voice calls with limited coverage and low capacity

2G (1990s)

- Digital cellular networks using technologies like GSM
- Introduction of digital voice calls, SMS, and limited data services (WAP)
- Improved call quality, security, and capacity compared to 1G

3G (2000s)

- Universal Mobile Telecommunication System (UMTS)
- Significant improvement in data rates
- Video calls, mobile internet browsing, multimedia messaging, and early-stage mobile applications

4G (2010s)

- Long-Term Evolution (LTE) technology
- Faster data speeds, capacity
- Multimedia streaming, high-quality video calls, mobile gaming

5G (2020s)

- Advanced technologies like mmWave, Massive MIMO, and network slicing
- Significantly faster data speeds, ultra-low latency, increased network capacity
- Massive IoT, 4K Video Streaming, AR/VR, Industry 4.0

Towards 5G Advanced and 6G

- 3GPP "Release 18" is considered the start of 5G Advanced and an intermediate milestone towards 6G standardization. It is considered as the foundation for more sophisticated applications such as truly mobile augmented reality services.
- 6G is still in the very early stages, however based on ongoing research and industry discussions, several potential features and objectives have been proposed for 6G
- Some of the envisioned features for 6G: Terahertz (THz) Frequencies; Hyperconnectivity; Extreme Data Rates in Tbps range; Ultra-Low Latency in sub-ms range, AI-Driven Networks, Energy Efficiency, High accuracy positioning

Source: https://www.nokia.com/networks/5g/5g-advanced/

6G NeXt – 6G Native Extensions for XR Technologies

Visit 6G NeXt Booth to discover more

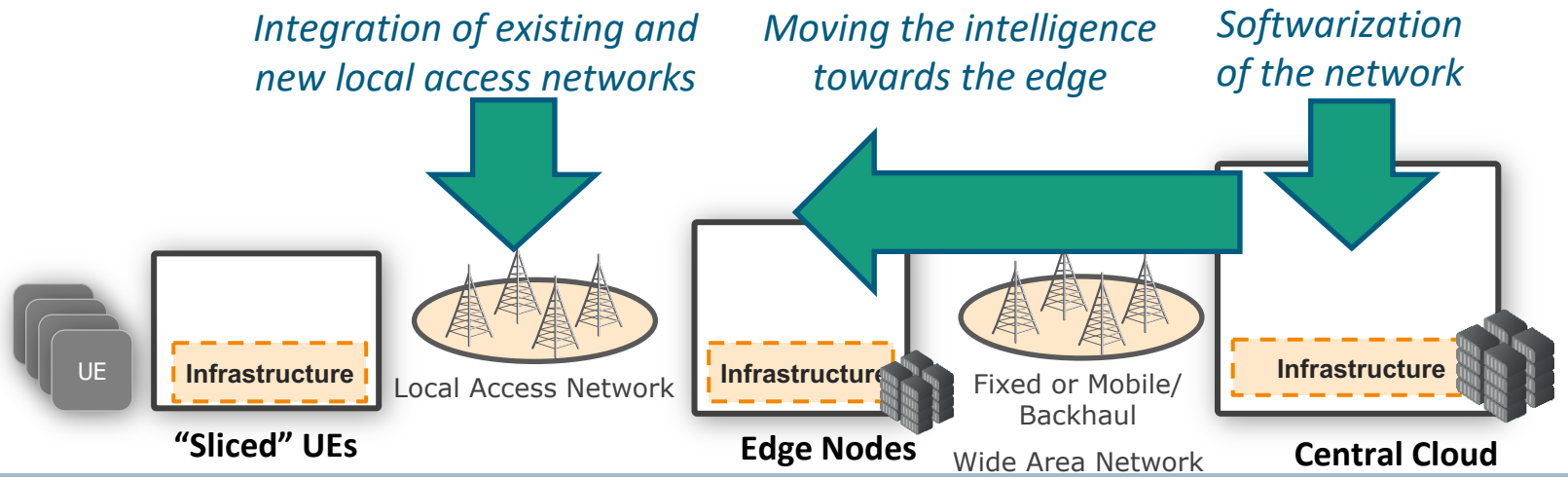
- Project with 11 German partners from industry and research funded by the Federal Ministry for Research and Education
- Develop a scalable, modular and flexible infrastructure to enable a variety of industrial and end-user use cases with requirements exceeding the capabilities of today's 5G network in terms of intelligence, performance and efficiency
- Two Use Cases:
  1. **Intelligent drones**: A novel anti-collision system for aviation using the example of drones at airports with mixed air traffic
  2. **HOLOCOM (Holographic Communication)**: An interactive end-to-end transmission of real-time 3D holographic video with photorealistic content and realistic 3D depth for video conferencing

Source: https://6gnext.de/

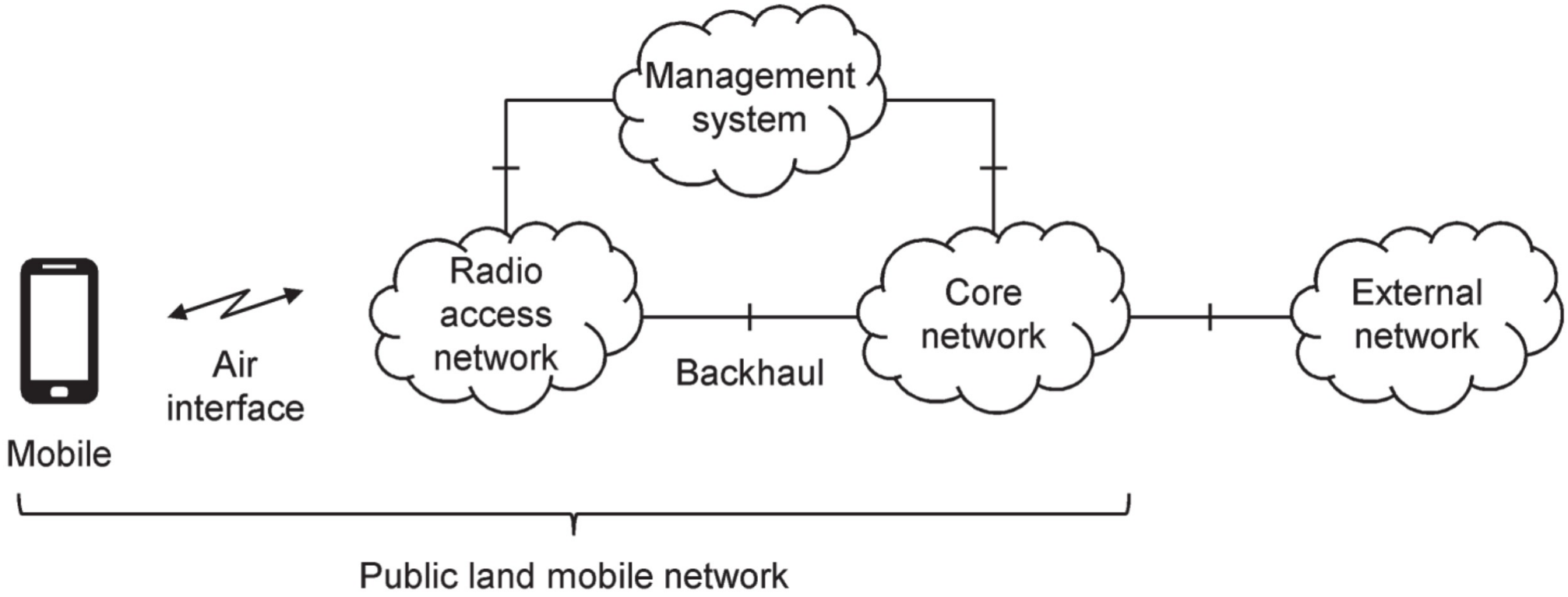
Key Communication Changes with 5G

5G is based on a comprehensive software system

- The network functions are becoming software only → convergence with IT & very high deployment flexibility
  - More flexible network infrastructures (growing on demand, adapting to changes)
  - Enabling the parallel deployments of multiple dedicated networks
- Network functions can be installed on compute & storge nodes at the edge of the network
- Development of new types of local access networks (and integrating existing ones)



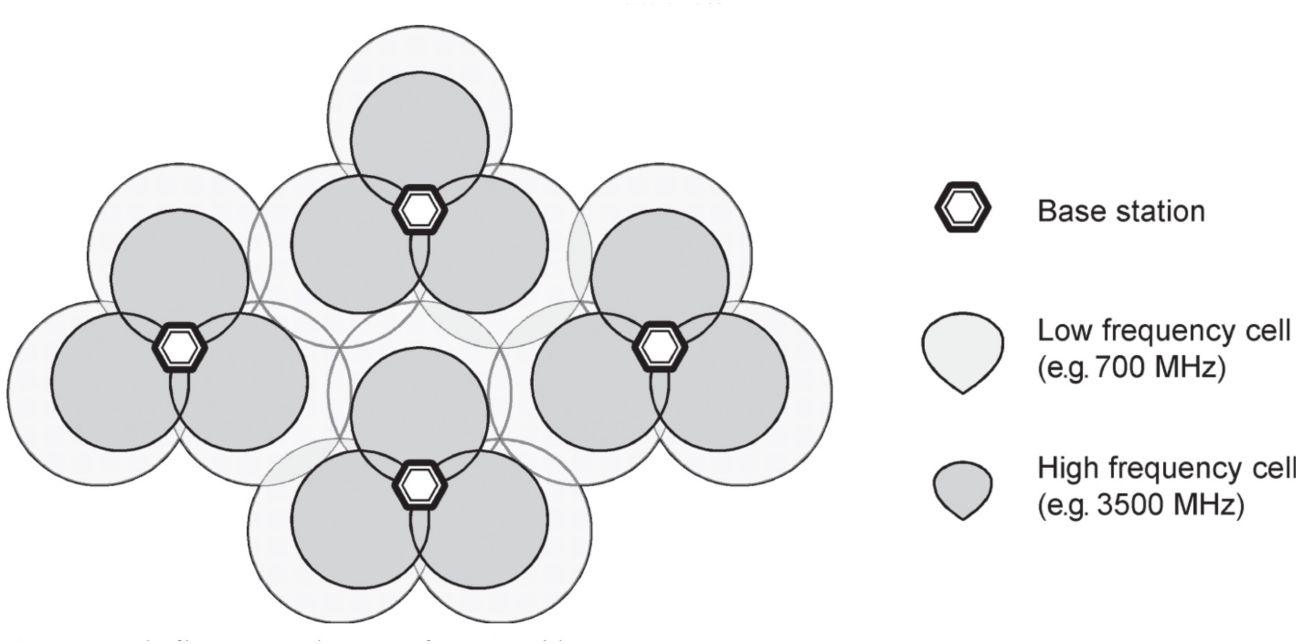
Typical Architecture of a Mobile Telecommunication System



Source: Christopher Cox – An introduction to 5G

Architecture of a RAN

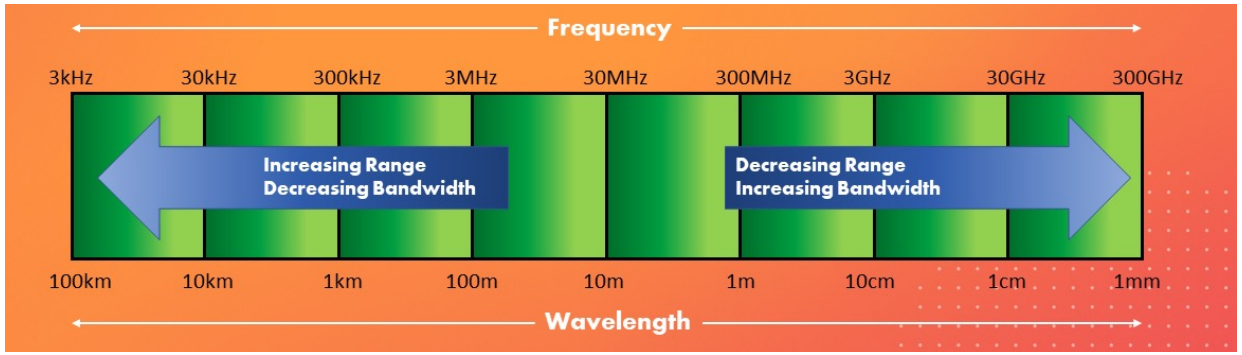
- Most important component is the base station
- Transmits and receives data using one or more radio frequencies known as carrier frequency
- Around each carrier, a certain bandwidth is occupied. Example:
  - Carrier frequency: 3500 MHz
  - Bandwidth 40 MHz
  - Range: 3480 – 3520 MHz
- Each base station controls multiple cells with a particular carrier frequency and bandwidth



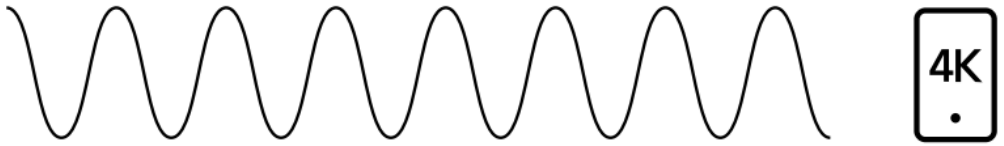
Source: Christopher Cox – An introduction to 5G

5G New Radio (5G NR) – 5G Frequency Spectrum

"The radio waves used in 5G are nothing new, but what is new is how cleverly 5G uses all three to enable better ways of communicating"



High radio frequencies are used for sensors in cars and for communicating with satellites and for 5G and add even more capacity for 5G



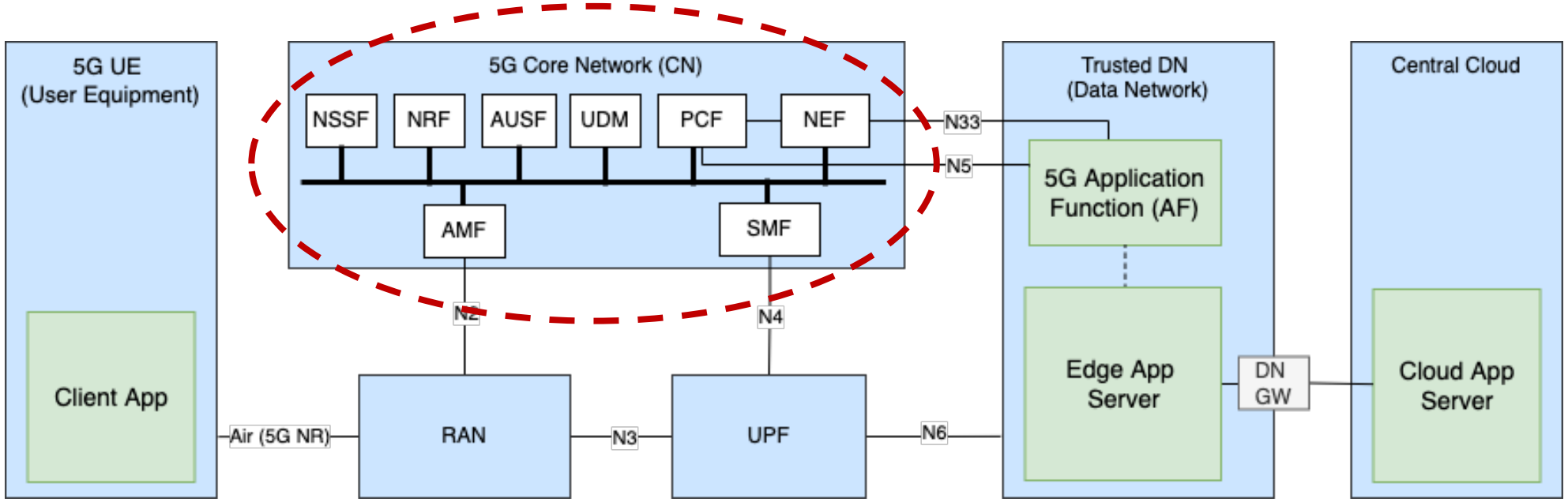
Mid radio frequencies (4G and Wi-Fi) help to add capacity

Low radio frequencies (1G, 2G, 3G) were used for broadcast TV and are still used for mobile communication. They are good for covering large areas

Sources: "This is 5G" Booklet by Ericsson
https://www.emnify.com/blog/5g-spectrum-service-grades

5G Core Network (CN)

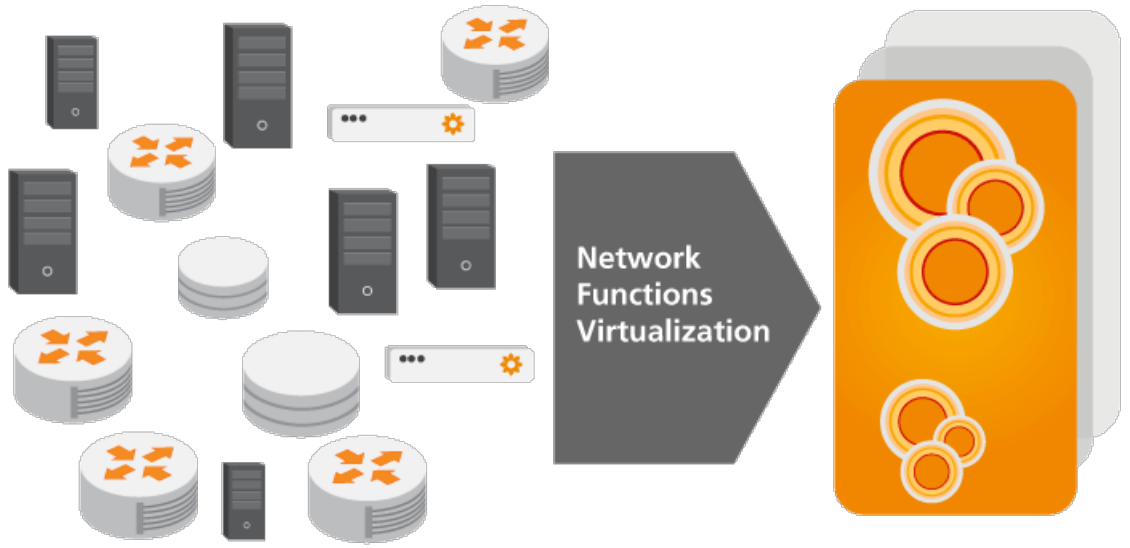
- The 5G core is the brain of the network. It establishes reliable, secure connectivity to the network for end users and provides access to its services.
- The core performs various important functions in the mobile network, such as connectivity and mobility management, authentication and authorization. 5G Core network functions are completely software-based.



AF: Application Function
AMF: Access and mobility Management Function
AUSF: Authentication Server Function
DN: Data Network
NEF: Network Exposure Function
NRF: NF Repository Function
NSSF: Network Slice Selection Function
PCF: Policy Control Function
RAN: Radio Access Network
SMF: Session Management Function

Network Function Virtualization (NFV)

- Traditionally, network elements such as routers, signaling functions and databases have been implemented using special purpose hardware.
  - Hardware manufactured in low volumes; Expensive
  - Hardware and Software are coupled together
- **NFV approach**: Network elements are implemented using software in the form of virtualized network functions (VNFs).
  - Run on general off-the-shelf hardware
  - Software and hardware decoupled
  - Vendor independent
  - Management system can manage the network functions independently of the underlying hardware
  - VNF is implemented within one or more virtual machines or containers running different software and processes

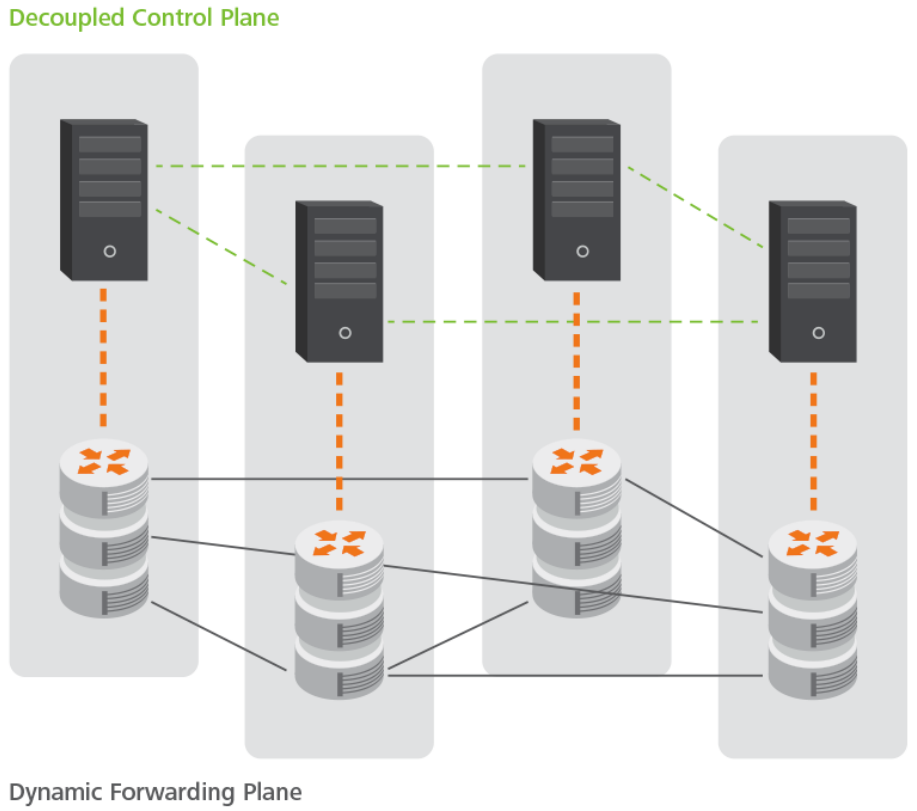


From specialized Hardware components to Software Programs in Datacenters

source: https://www.fokus.fraunhofer.de/en/ngni/workingareas/nfv

Software Defined Networking (SDN)

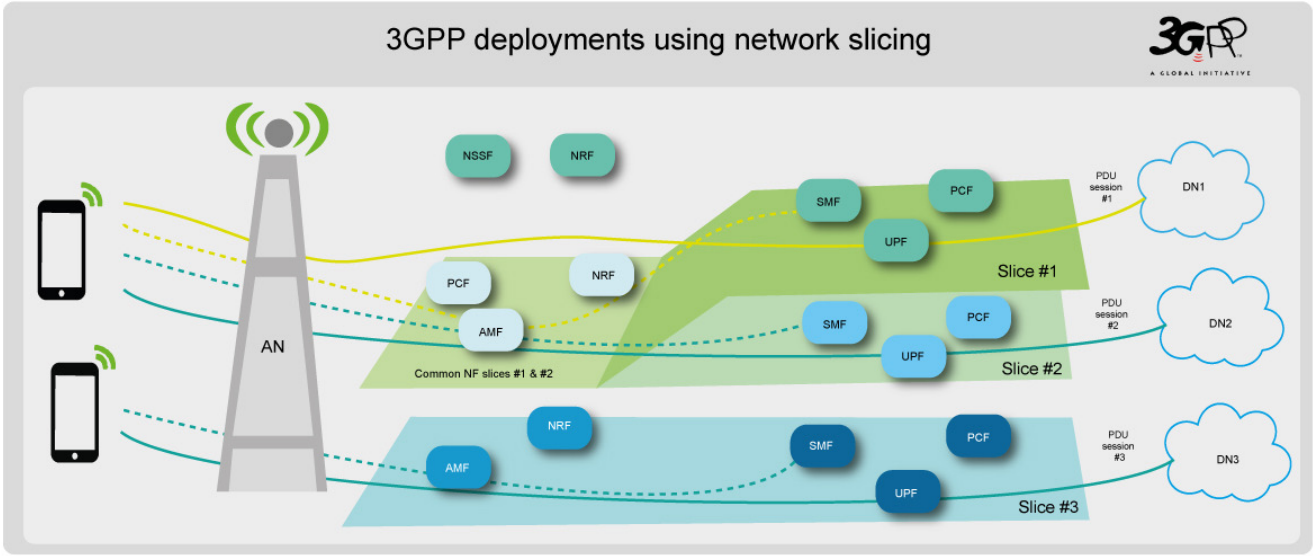
- In a traditional communication network, we distinguish between the
  - **User Plane**: Forward traffic from one network element to another for example by using routing tables
  - **Control Plane**: Carry out higher level tasks such as configuration of routing tables and managing network resources
- In the traditional approach, the control plane can be become very complex as decision making is distributed over the entire network
- **Software defined networking (SDN)**:
  - Clear separation between control and user plane
  - Centralization of control plane functions to enable simpler control over the network
- NFV and SDN are complementary technologies: The first separates hardware and software in the communication network while the second separates control and user planes



source: https://www.fokus.fraunhofer.de/en/ngni/workingareas/sdn-in-telco

Network Slicing (NS)

- Network slicing is a fundamental concept in 5G that allows the creation of multiple virtual networks, known as network slices, on a shared physical infrastructure.
- Each network slice is designed to meet the specific requirements of different applications, services, or industries, providing a customized and isolated environment with dedicated network resources.
- Realized using SDN and NFV
- Network operation can configure and teardown individual slices on demand
- It enables the coexistence of multiple use cases with different characteristics: eMBB, mMTC, URLLC, IoT
- Slices are isolated in respect of data transport and security

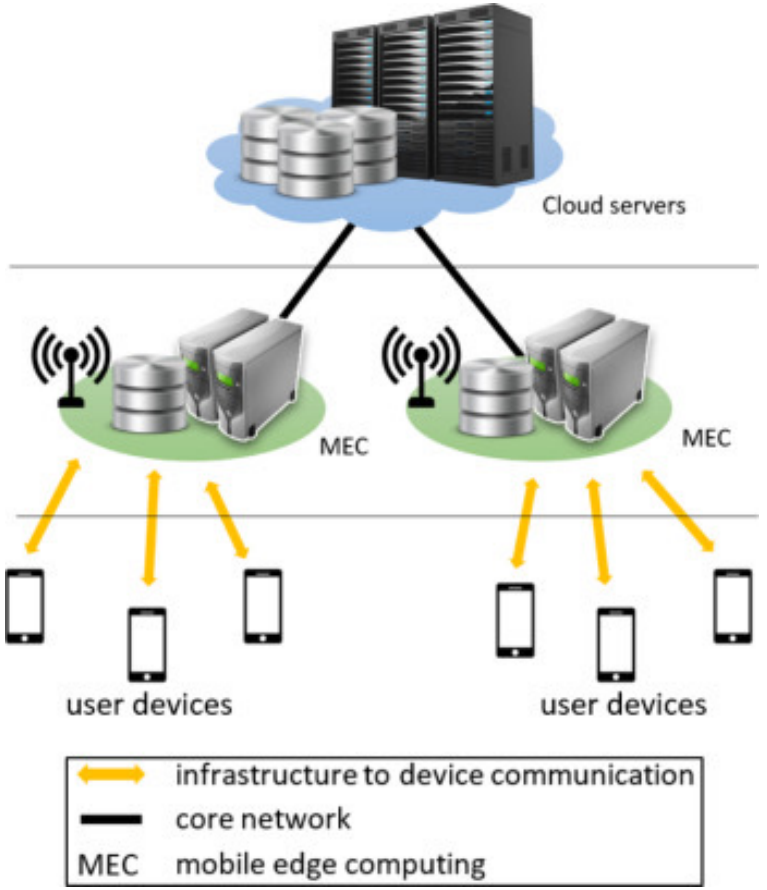


Source: https://www.ericsson.com/en/network-slicing
https://www.3gpp.org/news-events/1930-sys_architecture

Multi-access Edge Computing (MEC)

Goal: Bring computation and data storage closer to the originating source (UEs).

- Rather than transmitting raw data to a central data center for processing and analysis, that work is instead performed where the data is generated.
- Only the result of that computing work at the edge is sent back to the main data center for review and other human interactions.
- For 5G:
  - Implement logic close to the cell site or even at the cell itself
  - MEC application server provides hosting environment for applications. The applications can be delivered as virtual machines or containers.

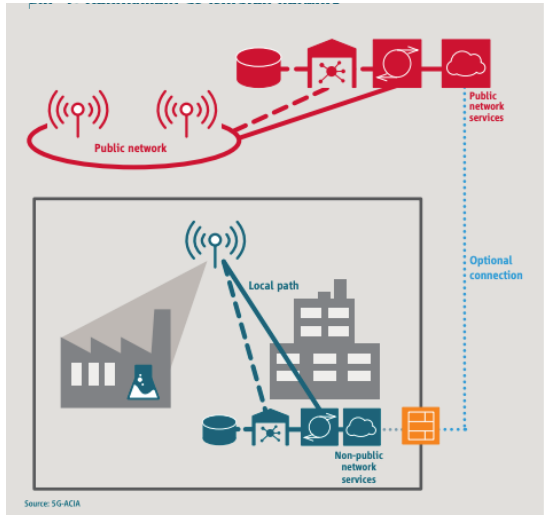


Source: https://www.ericsson.com/en/network-slicing
https://www.3gpp.org/news-events/1930-sys_architecture

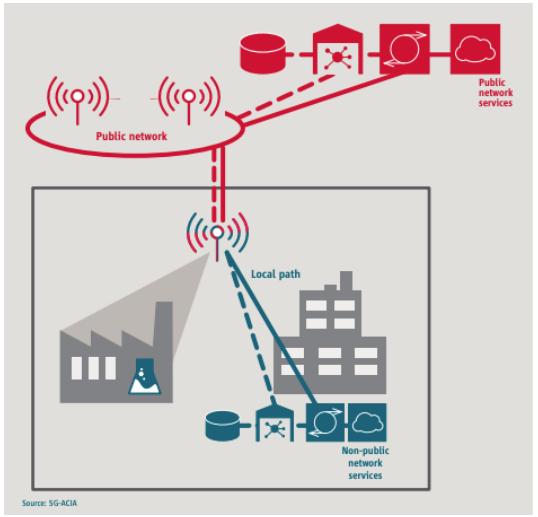
5G Non-Public Networks (NPN)

- 5G Non-Public network (NPN) provides 5G network services to a clearly defined user group of organization(s). It is deployed on the organization's premises, such as a campus or a factory.
- NPNs are desirable for several reasons: **1)** High quality-of-service requirements **2)** High performance, security, privacy, and safety requirements **3)** Isolation from other networks, as a form of protection against malfunctions in the public mobile network. NPNs can be classified in 4 categories:

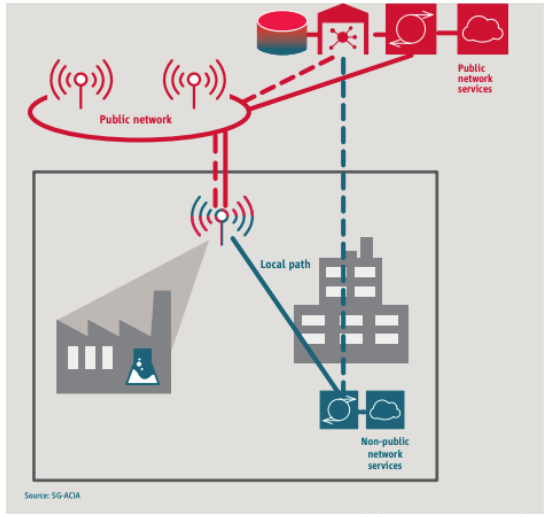
1) Isolated Network



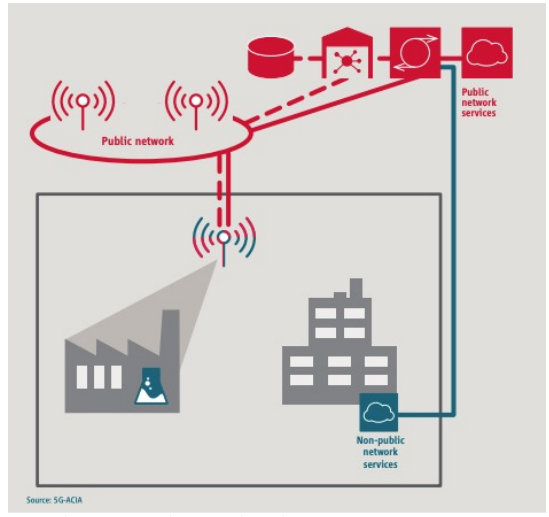
2) Shared RAN



3) Shared RAN and control



4) Deployed in public Network



Source: https://5g-acia.org/wp-content/uploads/2021/04/WP_5G_NPN_2019_01.pdf

5G Non-Standalone (NSA) vs. 5G Standalone (SA)

5G Non-Standalone (NSA)

- Faster market launch of 5G by leveraging existing 4G infrastructure rather than deploying a completely new network
- Introduce new 5G spectrums to boost capacity and increase delivery efficiency
- High-speed connectivity with 5G enabled devices
- In the long-term, 5G NSA should be replaced by 5G SA

5G Standalone (SA)

- Targets SA 5G NR and 3GPP core network architecture
- Simplified RAN and device architecture
- New 5G Core based on NFV approach
- Supports advanced network-slicing functions
- Brings ultra-low latency
- Usage of high frequency bands / mmWave
- Focus on new capabilities for businesses and enterprises

Source: https://www.ericsson.com/en/blog/2019/7/standalone-and-non-standalone-5g-nr-two-5g-tracks

5G Key Performance Indicators (KPIs)

	Speed Peak Rate down/Up	Latency	Availability Reliability Security	Mobility	Position accuracy	IOT Device density
4G	1/0.2 Gbps	10ms	99.99X%	350Km/h	45m	100k/Km^2
5G	20/10 Gbps	1ms	99.9999%	500Km/h	1m	1000k/Km^2

It is important to note that these values are not universally applicable and can vary depending on the specific requirements, network deployment scenario, and regional or local factors.

Source: https://www.ericsson.com/49f1c9/assets/local/5g/documents/07052021-ericsson-this-is-5g.pdf

The 3rd Generation Partnership Project - 3GPP

"The 3rd Generation Partnership Project (3GPP) unites [Seven] telecommunications standard development organizations (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC), known as "Organizational Partners" and provides their members with a stable environment to produce the Reports and Specifications that define 3GPP technologies"

- "3GPP uses a system of parallel "Releases" which provide developers with a stable platform for the implementation of features at a given point and then allow for the addition of new functionality in subsequent Releases"

Release Code	Name	Status	Start date	End date	Closure date
Rel-19	Release 19	Open	2021-06-18		
Rel-18	Release 18	Open	2019-09-16	2024-06-21 (SA#104)	
Rel-17	Release 17	Frozen	2018-06-15	2022-06-10 (SA#96)	
Rel-16	Release 16	Frozen	2017-03-22	2020-07-03 (SA#88-e)	
Rel-15	Release 15	Frozen	2016-06-01	2019-06-07 (SA#84)	
Rel-14	Release 14	Frozen	2014-09-17	2017-06-09 (SA#76)	
Rel-13	Release 13	Frozen	2012-09-30	2016-03-11 (SA#71)	
Rel-12	Release 12	Frozen	2011-06-26	2015-03-13 (SA#67)	
Rel-11	Release 11	Frozen	2010-01-22	2013-03-06 (SA#59)	
Rel-10	Release 10	Frozen	2009-01-20	2011-06-08 (SA#52)	
Rel-9	Release 9	Frozen	2008-03-06	2010-03-25 (SA#47)	
Rel-8	Release 8	Frozen	2006-01-23	2009-03-12 (SA#43)	
Rel-7	Release 7	Closed	2003-10-06	2008-03-13 (SA#39)	2014-09-17 (SA#65)
Rel-6	Release 6	Closed	2000-03-28	2005-09-28 (SA#29)	2014-09-17 (SA#65)
Rel-5	Release 5	Closed	2000-05-01	2002-09-12 (SA-#17)	2014-09-17 (SA#65)

Release	Name	Scope
Release 15	5G Phase 1	Initial 5G specifications, Non-Standalone (NSA) and Standalone (SA) architecture, New Radio (NR), core network enhancements, support for higher data rates, IoT, and massive Machine-Type Communications (mMTC)
Release 16	5G Phase 2	Enhancements to 5G Phase 1, expanded support for industrial automation, Vehicle-to-Everything (V2X) communication, URLLC enhancements, network slicing, interworking with other technologies
Release 17	5G Phase 3	focus on expanding and refining 5G capabilities, addressing new use cases and requirements, improvements to efficiency, security, performance, and optimizations based on real-world deployments

Source: https://portal.3gpp.org/#/55934-releases

Section 02

5G Media & Entertainment Use Cases and Application Areas

5G Media & Entertainment Use Cases

The media and entertainment industry is one of the most significant sectors that benefit from 5G technologies

- Improved In-stadium Viewing Experience
- 5G Remote Media Production
- Distributed Media Production
- Immersive Real-Time Communication
- Metaverse (AR/VR/XR)
- 5G Terrestrial TV Broadcast
- Cloud Gaming
- CDN enabled by 5G mmWave connectivity in a railway environment

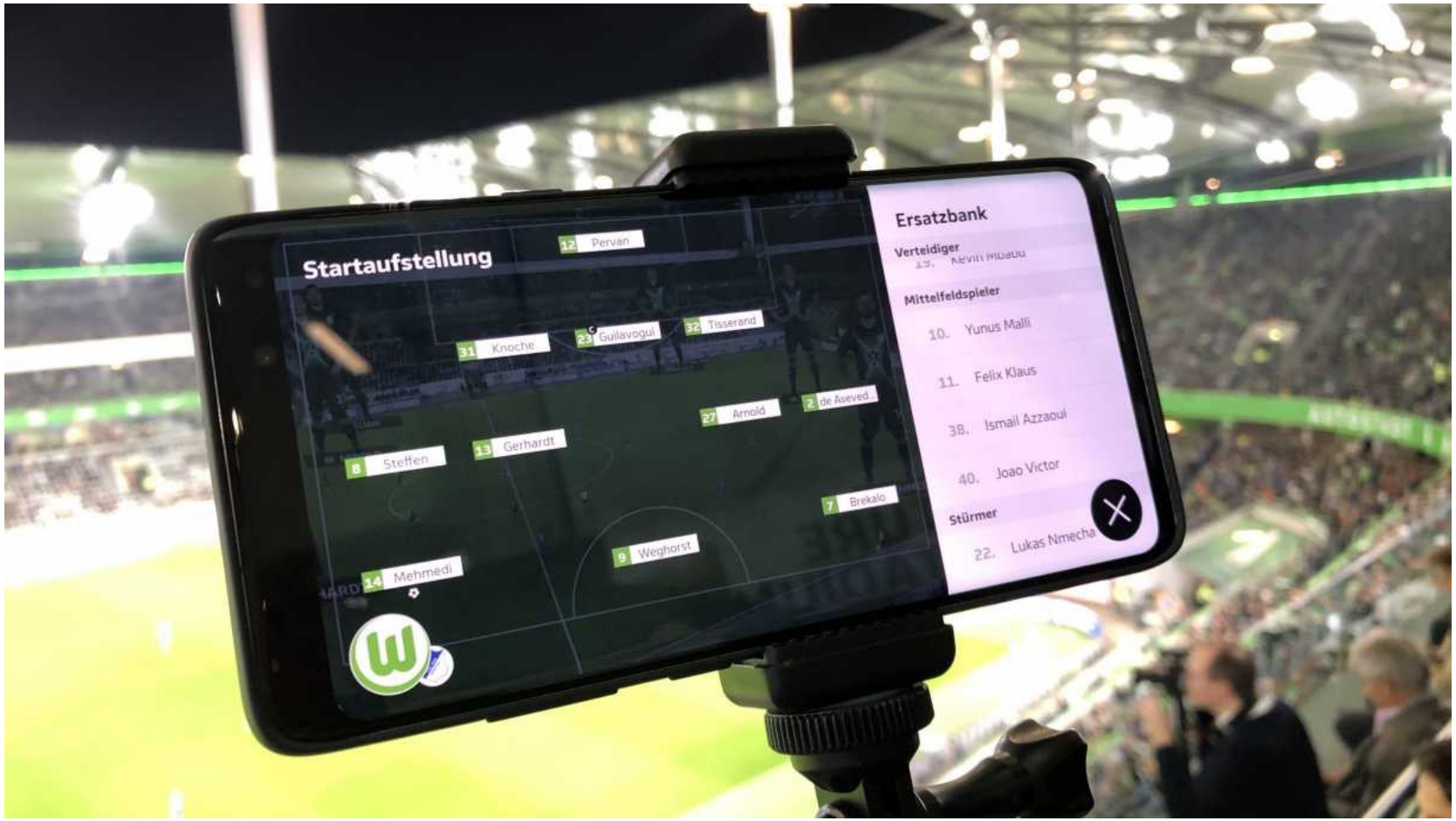
Improved In-stadium Viewing Experience

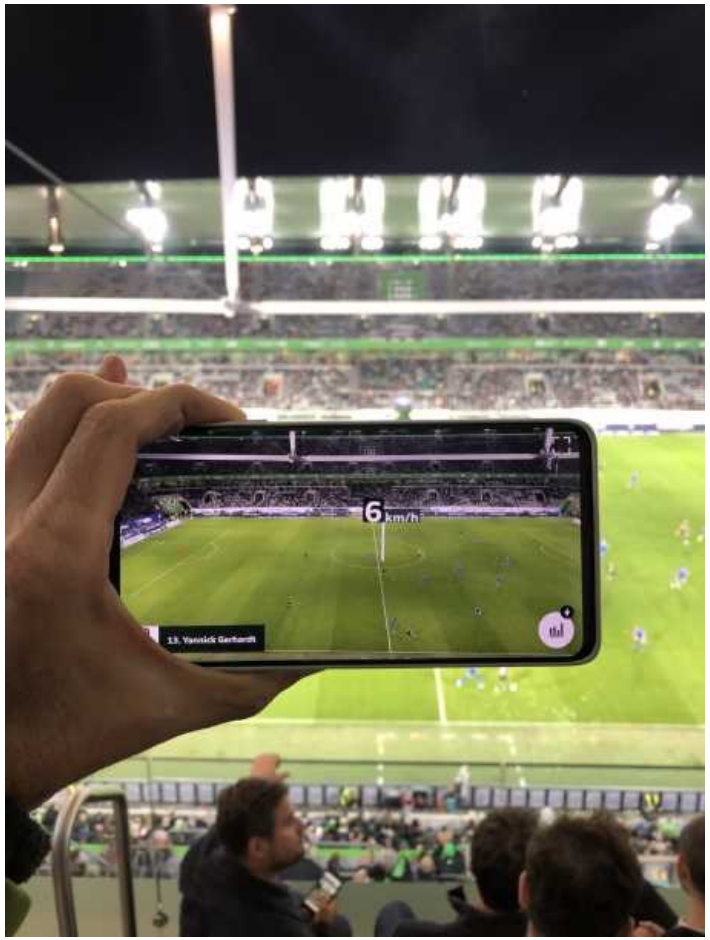
Goal: Improved viewing experience at large-scale events like sport events and densely-populated environments like crowded stadiums

- Use Smartphone as a companion device to access in-game stats, watch replays, multiple camera angles, additional parallel games, interact with friends, …
- Connectivity in densely populated areas like stadiums with 80.000 spectators has been a challenge for years.
- 5G (especially mmWave) enables high-definition multimedia services to all kinds of venues like crowded stadiums and provides sufficient capacity to limit the effects of network congestion.
- Augmented Reality (AR) improves the viewing experience by allowing spectators to get augmented real-time stats on their smartphone just by pointing the camera to the game field. This experience will even be more improved when using AR glasses.

Improved In-stadium Viewing Experience

AR application by Vodafone and the “Deutsche Fußball Liga” (DFL) powered by 5G MEC to enable real-time in-game stats





Source: https://www.heise.de/newsticker/meldung/5G-Anwendung-Vodafone-und-Fussball-Bundesliga-nutzen-Augmented-Reality-4537577.html

5G Remote Production

Allows for high-quality video and audio transmission in real-time, enabling production teams to remotely control cameras and switch between different camera angles

- Cameras with 4G/LTE connectivity offer a flexibility for ingest, especially in situations where mobility is key like sport events, news gathering, etc.
- 5G with its significantly greater bandwidth, lower latency, and defined quality of service, is creating a lot of excitement in the broadcast industry
- Centralized production to make optimum use of equipment and production staff
- Provides cost-effective, portable and mobile production with less cables
- 5G enablers for remote production: High (Uplink) Throughput, Low Latency, MEC (perform heavy media processing on the Edge), Network Slicing, NPN (Campus Networks)

Live Video Production using 5G Network Slicing

Telekom and RTL Deutschland developed a 5G standalone network slicing solution for live video production

- Live video production on site with 5G smartphones using 5G network slicing.
- Broadcast data-intensive video signals live from the scene of action assuring necessary bandwidth
- No need for "Satellite News Gathering" (SNG) vehicles.
- Networks with 5G standalone (SA) infrastructure in the 3.6 gigahertz frequency using a dedicated Network Slice tailored exactly to the needs of live video production (reliability, uplink bandwidth, low latency).

Source: https://www.telekom.com/en/media/media-information/archive/5g-standalone-simplifies-tv-productions-648244

Distributed Media Production

Use 5G Technology for media production from different event locations e.g. hybrid live concerts.

- For example, a live concert taking place at a main location where musicians are preforming on the main stage while audience are joining at main and satellite locations.
- Ultra low latency video feeds between the different locations is required to enable interactivity between audience
- Musicians at different locations can only perform together if the round-trip latency of the audio connection does not exceed 20ms

Source: https://www.fokus.fraunhofer.de/de/news/fokus/fame/virtual_live_21-12


Fraunhofer
FOKUS
HYBRID LIVE CONCERT WITH
FRAUNHOFER TECHNOLOGY

Metaverse (AR/VR/XR)

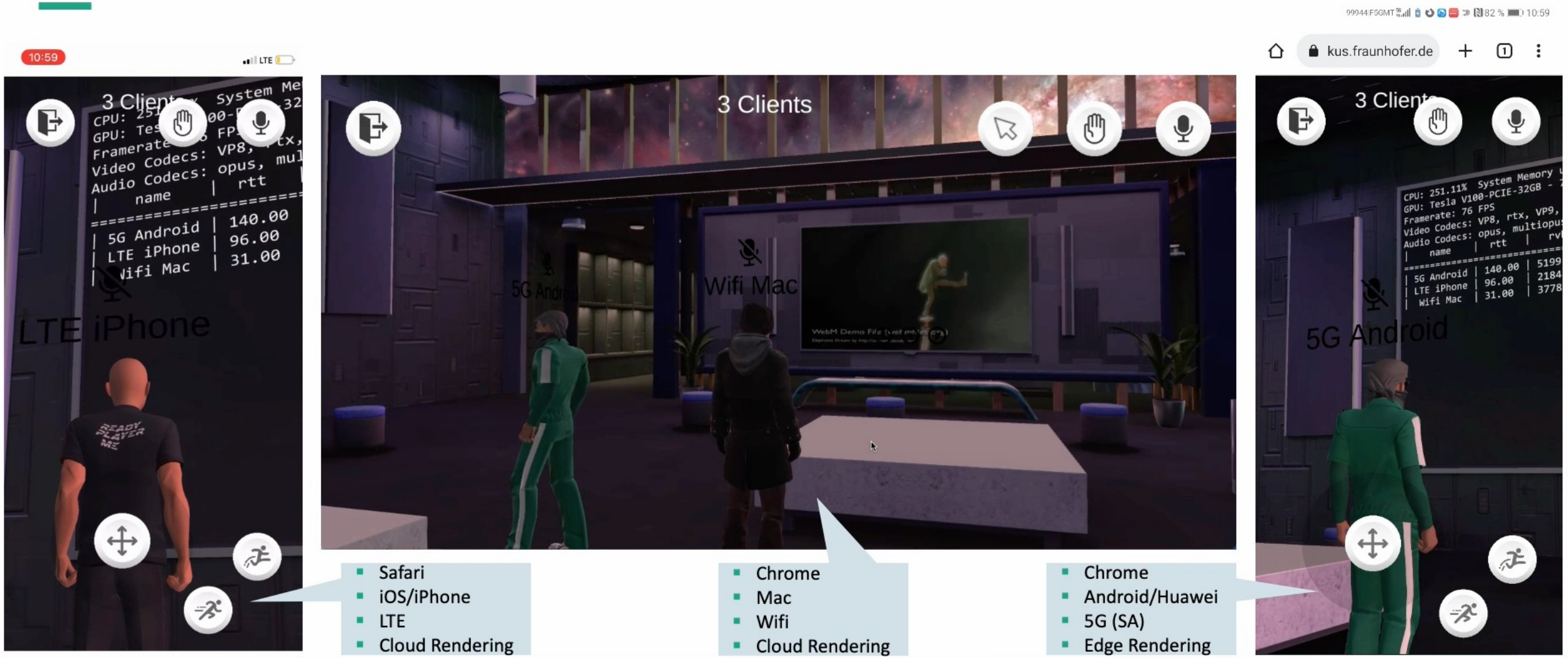
- 5G is counted as a key technology to enable the use of Extended Reality (XR) in the Metaverse
- 5G (eMBB) offers rate, range, reliability, latency to deliver high bitrate XR experiences including 3D assets, volumetric videos, holograms, etc. to end-user devices like HMDs and XR glasses in real-time.
- 5G MEC enables Edge/Cloud XR processing by offloading the rendering of the XR experience. This facilitates the development of more lightweight XR devices.
- 5G Network Exposure Function (NEF) provides 3rd party access to the 5G CN

Source: https://www.ericsson.com/en/blog/2022/4/why-metaverse-needs-5g

Demo

1ClickMetaverse Testbed

5G/Android/Chrome/Edge - LTE/iOS/Safari/Cloud - Wifi/Mac/Chrome/Cloud



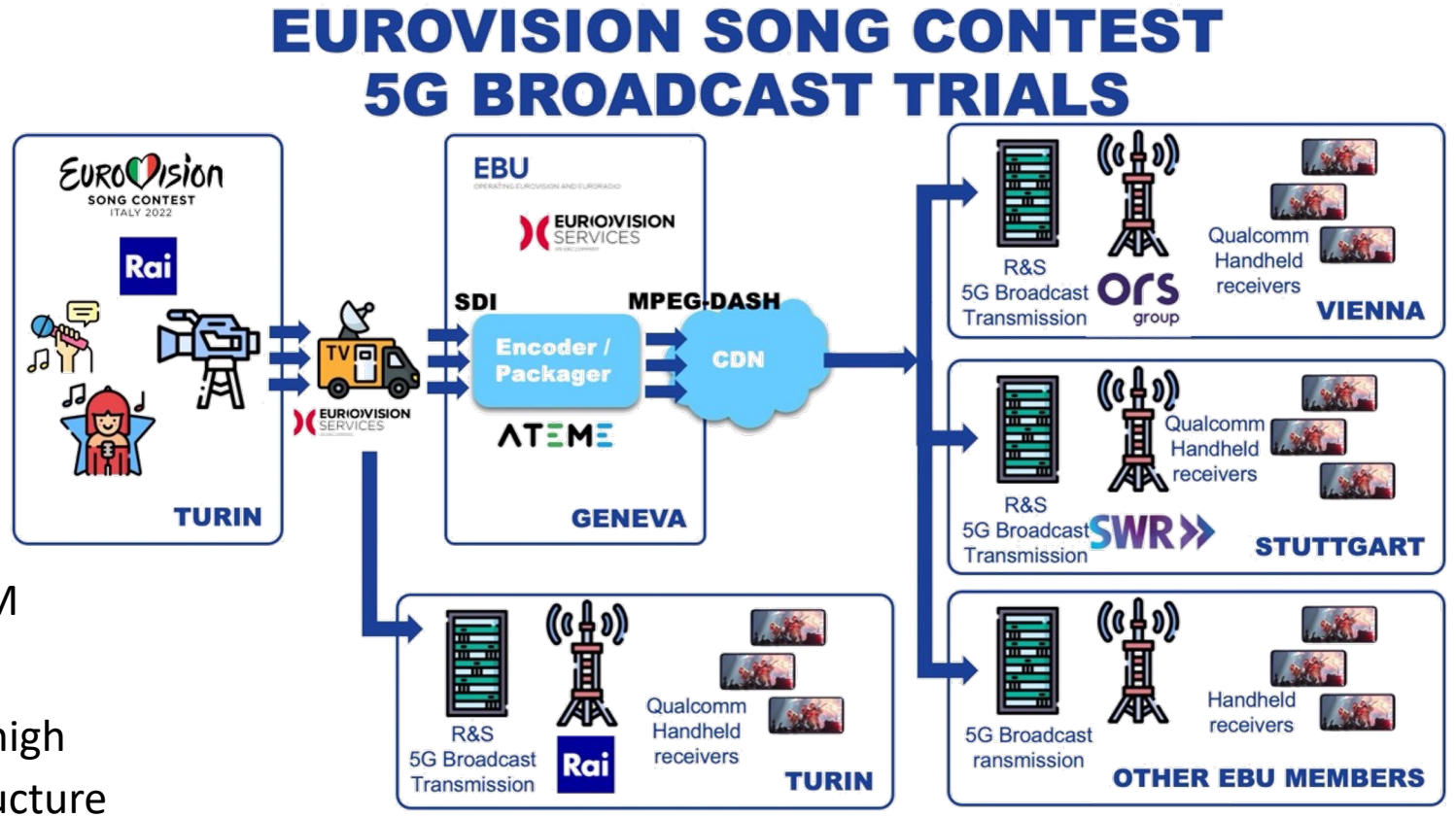
- Safari
- iOS/iPhone
- LTE
- Cloud Rendering

- Chrome
- Mac
- Wifi
- Cloud Rendering

- Chrome
- Android/Huawei
- 5G (SA)
- Edge Rendering

5G Terrestrial TV Broadcast

- A 5G Broadcast signal transmitted the European Song Contest live and in high quality from sites in 4 European cities simultaneously
- Select group of users with 5G Broadcast-enabled smartphones in Paris, Stuttgart, Turin, Vienna was able to see these transmissions
- Receive free-to-air content without a SIM card and no need to 3rd party services
- 3GPP Release 16 features such as DTT ‘high tower high power’ transmission infrastructure compatibility, and SIM-card-less free-to-air reception



Source: https://tech.ebu.ch/news/2022/05/5g-broadcasts-of-the-eurovision-song-content--the-what-how-and-why

Cloud Gaming, Cloud PC

- Cloud Gaming Platforms are becoming more popular. Sometimes are called gaming-as-a-service.
- Examples: GeForce Now, PlayStation Plus (Premium), Amazon Luna, Xbox Cloud Gaming, Shadow (cloud PC), Paperspace (cloud PC)
- This kind of online gaming runs video games on remote server and streams the video to the client device. No need to download games.
- No expensive hardware is needed. Low performance device like TVs and Streaming devices can be used instead.
- Challenges: Latency, Bandwidth
- 5G and MEC provide a solution to address these challenges
  - Low Latency by running games on servers close to the user using 5G MEC capabilities
  - High Bandwidth

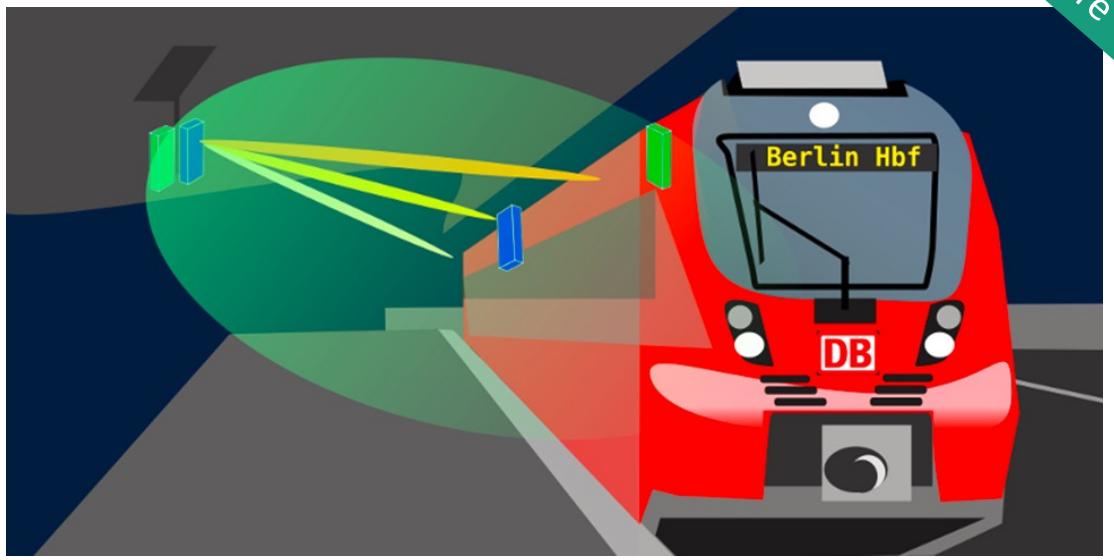
Source: https://stadia.google.com/

Source: https://www.amazon.com/luna/landing-page

CDN enabled by 5G mmWave connectivity in a railway environment

Visit 5G Medie Testbed
Booth to discover more

- In the 5G-VICTORI project public broadcasters (RBB), communications (IHP), media (FhG), rail experts (PXI) and transport operators (DB) join forces to build an end-to-end system for managing CDNs embedded into railway vehicles
- Media pre-caching in combination with **mmWave** connectivity and **5G-based** data showers can remedy that too a large extent
- On the “regular” internet, CDNs carry the bulk of data transfer loads, but they cannot “just” be installed on trains or buses where bandwidth and storage capacity are limited



a) Link T-S1 b) Link T-S2 c) View from S1 d) View from S2

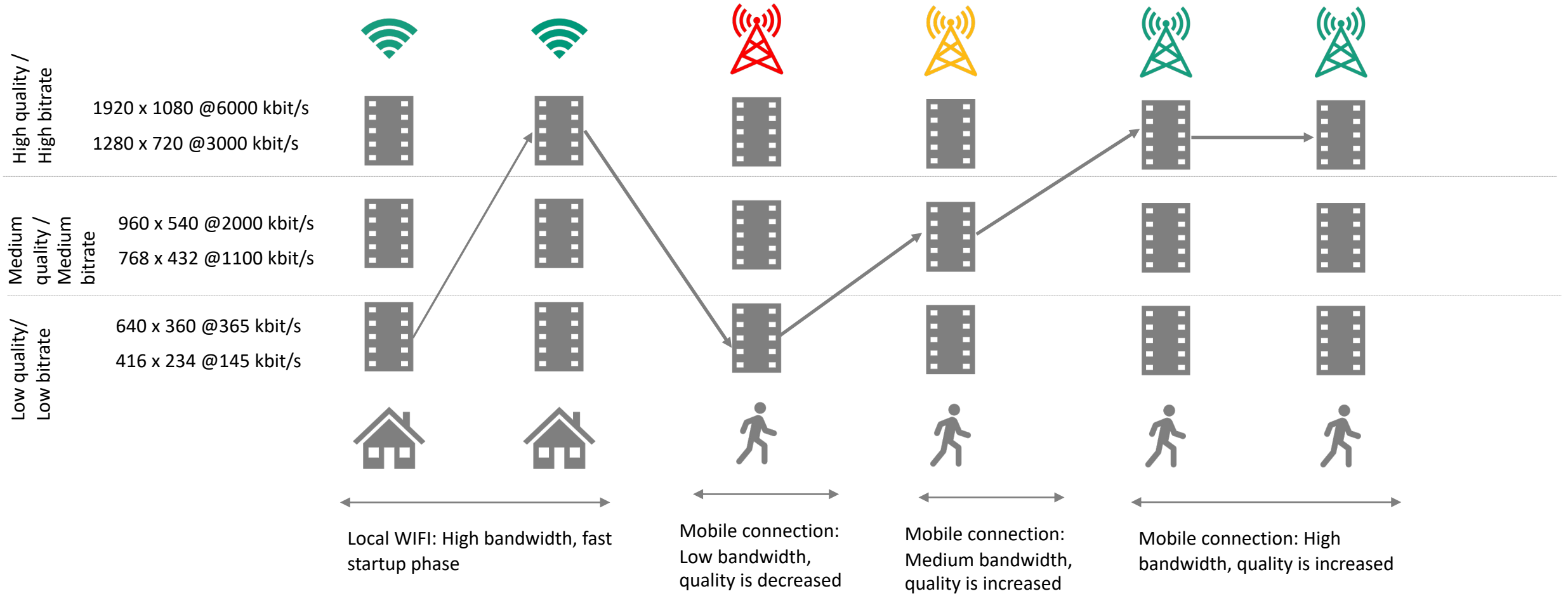
Source: https://www.5g-victori-project.eu

In the context of the 5G-VICTORI project, the final review for three use cases took place in Berlin-Schöneweide on April 26.

Section 03

5G Media-related Standards and Technologies

Background – Adaptive Bitrate Streaming (ABR)



Background - Streaming Formats - MPEG-DASH/HLS

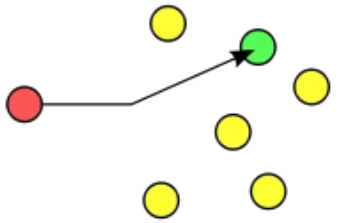
MPEG – DASH (Dynamic Adaptive Streaming over HTTP)

- Based on an MPD (Media Presentation Description) file
- Provides a structured description of the content in XML
- Typically used on non-Apple devices and platforms
- Serves as input for dash.js, ExoPlayer
- Typically uses the ISOBMFF/CMAF media container

HLS (HTTP Live Streaming)

- Based on master and media playlists (m3u8 files)
- Master playlist links to media playlists
- Media playlists describe the content
- Mainly used on Apple platforms due to native support
- Typically uses the MPEG Transport Stream (TS)
- Added support for fMp4/CMAF

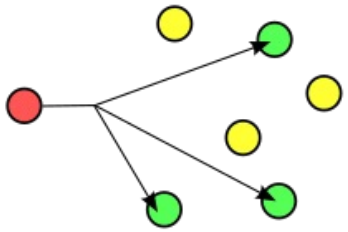
Background - Unicast vs. Multicast vs. Broadcast



Unicast
1:1

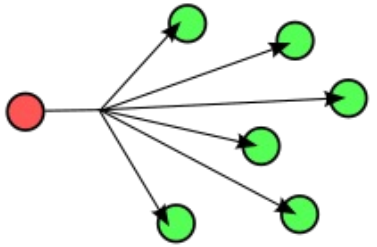
Send IP packets to one or multiple receivers in a single transmission

- Unicast
  - 1:1 connection, example 5G Media Streaming
  - OTT streaming relies on CDNs for a scalable unicast



Multicast
1:many

- Multicast
  - 1:many communication over IP-infrastructure in a network
  - Uses specially reserved multicast address blocks in IPv4 and IPv6
  - The router determines which downstream interfaces are destinations for this multicast group, and sends the packet out through the appropriate interfaces



Broadcast
1:all

- Broadcast
  - 1:all connection
  - Must not explicitly express interest to receive the data (Receive Only Mode - ROM)

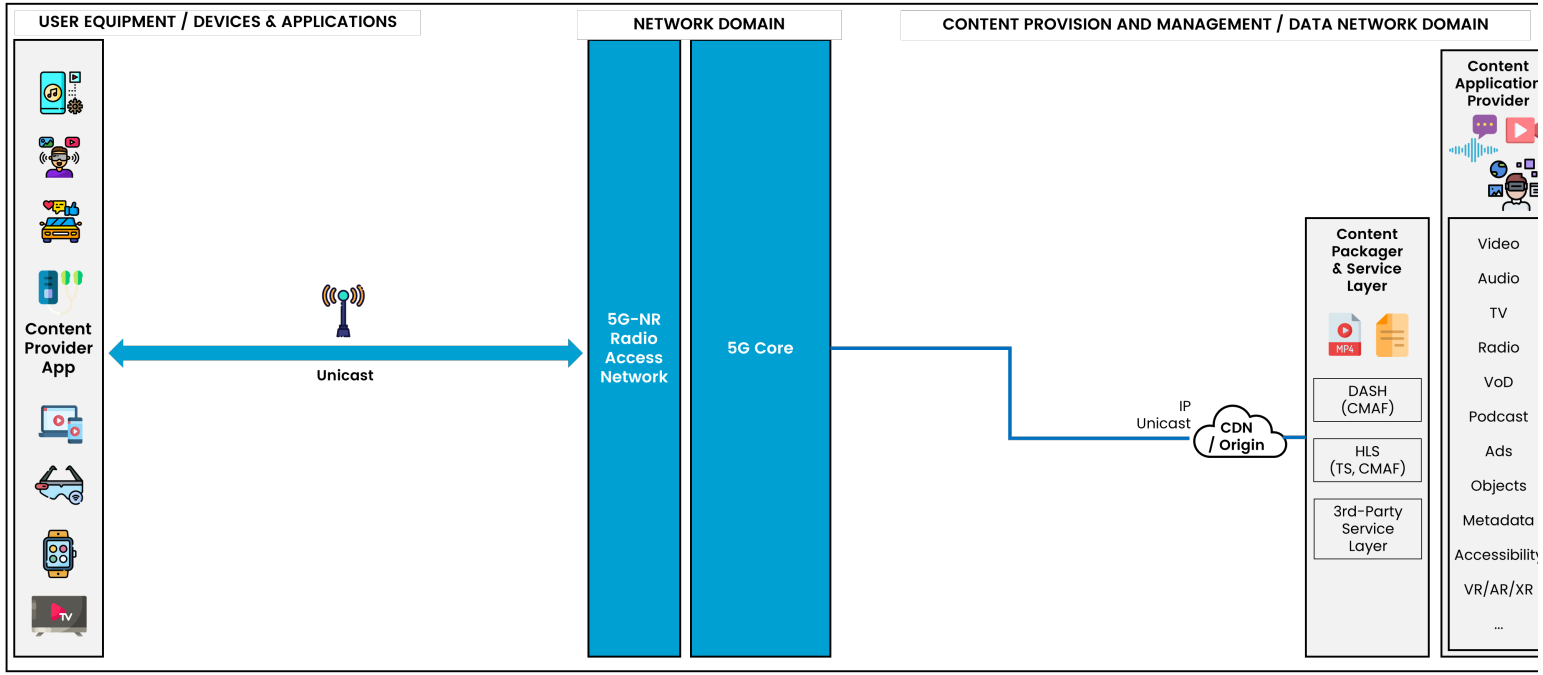
Background - FLUTE Protocol

File Delivery over Unidirectional Transport (FLUTE)

- A protocol for unidirectional delivery of files over the Internet
- FLUTE designed for broadcast/multicast delivery of large objects
  - In contrast to HTTP for unicast delivery
- **Used in MBMS context to send DASH and HLS manifests and segments via broadcast to client devices**
- One of the key elements of FLUTE is the use of a File Delivery Table (FDT) to inform clients about the files (and their characteristics) transmitted within a FLUTE session
- IETF specification: https://datatracker.ietf.org/doc/html/rfc6726

Plain OTT streaming over a 5G network

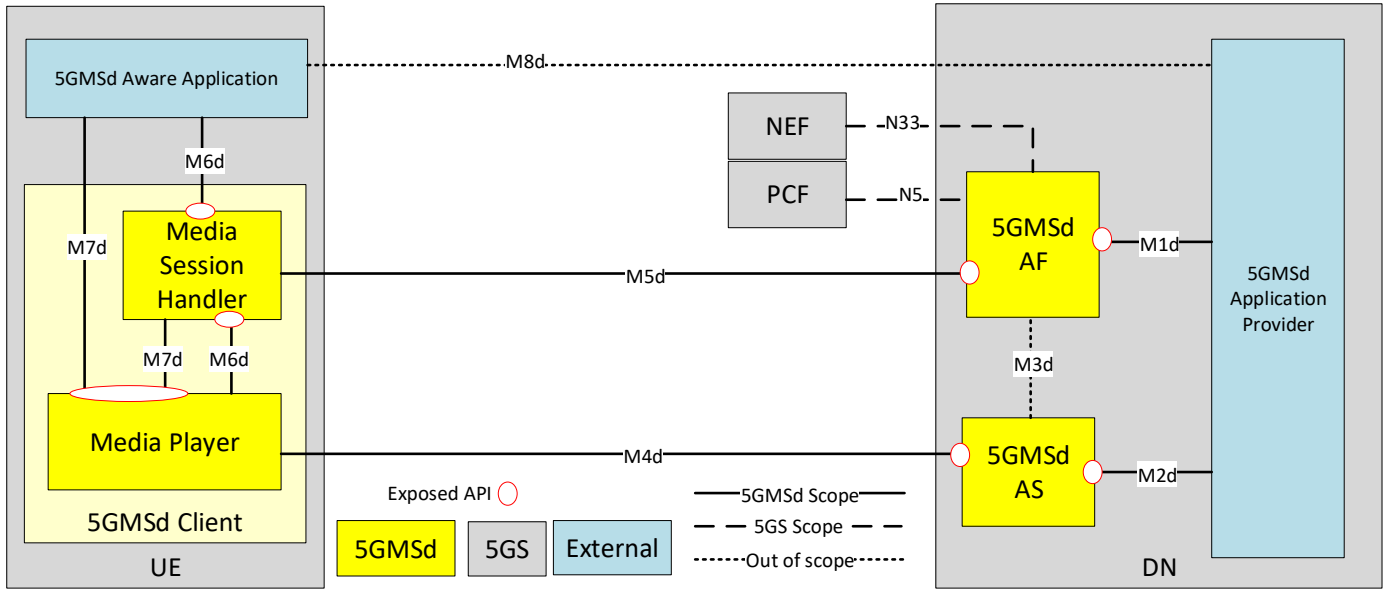
- No direct integration of media streaming components into the 5G network.
- Viewers are simply uses the 5G connection to stream media data over the internet
- More or less a “dumb bit pipe”



5G Media Streaming (5GMS)

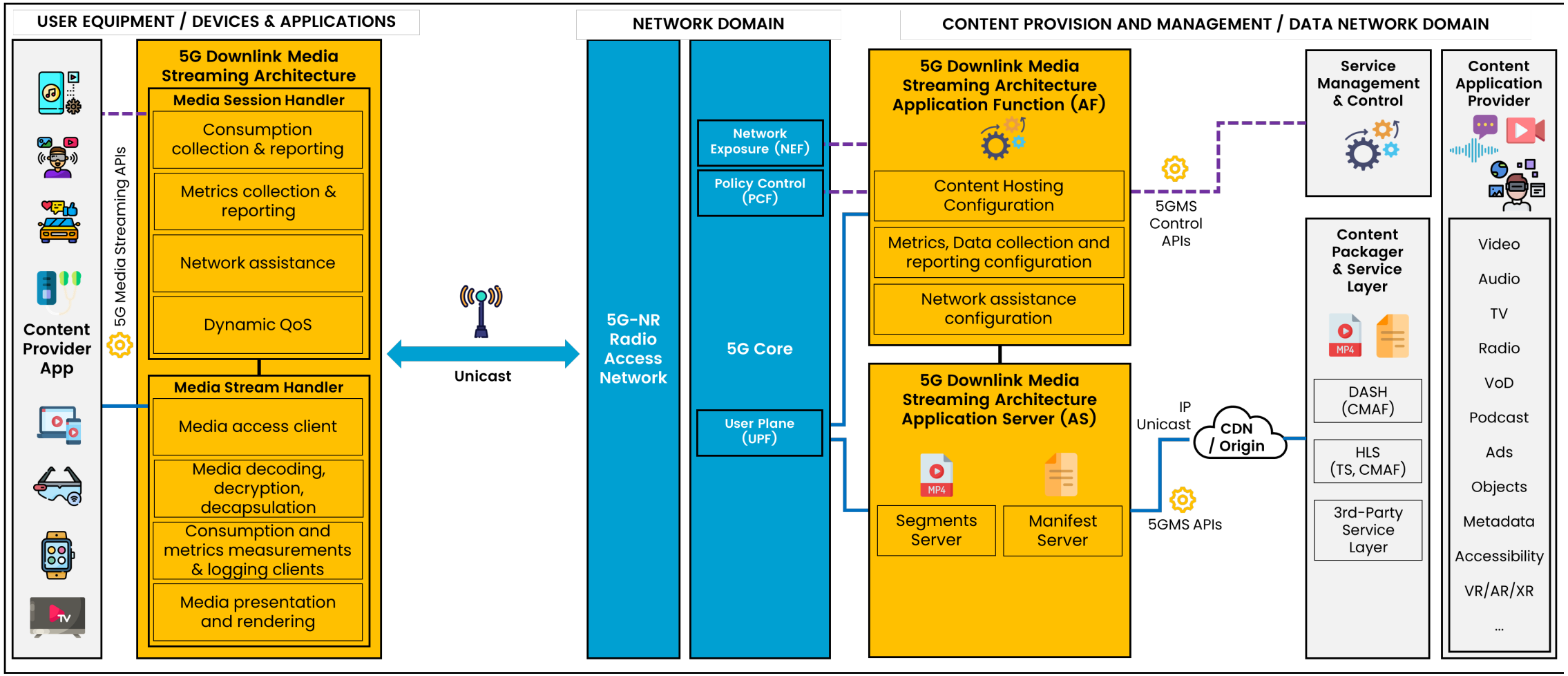
"Framework aligned with today's OTT media distribution practices by Supplementing MNO and third-party media services to easily access 5GMS features"

- Integration of streaming related components into the 5G network
- On-Demand and Live Streaming
- Uplink streaming
- Different deployments, incl Telco CDN – MNO acts as distributor/CDN
- Content Hosting
- Dynamic Policies, incl Premium QoS and charging policies
- Consumption and Metrics Reporting
- Network Assistance



Sources: https://www.etsi.org/deliver/etsi_ts/126500_126599/126501/16.05.00_60/ts_126501v160500p.p
https://drive.google.com/file/d/1pxwkaB-NgaGtO1-Dw_-nqObSNoPRLN4u/view (5G-MAG - Introduction to 5
Media Streaming by Thorsten Lohmar)

5G Media Streaming (5GMS)



5G Media Streaming (5GMS) - Components

- **Media Session Handler (MSH)**: A function on the UE to establish, control and support the delivery of a media session. The MSH reports metrics and consumption data to the AF.
- **Media Player**: Responsible for playback of the content. Provides APIs for media playback and media session control (reporting of errors, notifications, status information).
- **5GMS-Aware Application**: The 5GMSd Client is typically controlled by an external media app which implements external application or content service provider specific logic and enables a media session to be established.
- **5GMSd AS**: An Application Server which hosts 5G media functions. There are different realizations of the 5GMSd AS, for example a Content Delivery Network (CDN) or a DRM server.
- **5GMSd Application Provider**: External application or content-specific media functionality, e.g., media creation, encoding and formatting that uses 5GMSd to stream media to 5GMSd-Aware applications.
- **5GMSd AF**: An Application Function that provides various control functions to the Media Session Handler on the UE and/or to the 5GMSd Application Provider. It may relay or initiate a request for different Policy or Charging Function (PCF) treatment or interact with other network functions via the NEF.

5G Media Streaming (5GMS) - The relevant specifications

TS 26.501 - 5G Media Streaming (5GMS); General description and architecture

- Specifies the 5G-Media Streaming architecture
- Support for 3rd party and MNO downlink and uplink media streaming services
- Backwards compatible to EUTRAN deployments (LTE)

TS 26.512 - 5G Media Streaming (5GMS); Protocols

- Specifies the set of protocols and APIs for 5G Media Streaming (5GMS) services based on the 5G Media Streaming Architecture (5GMSA)
- Detailed information about the interfaces M2, M4, M5, M6, M7
- Provide architecture for DASH distribution using CMAF as segment format

TS 26.511: 5G Media Streaming (5GMS): Profiles, codecs and formats

- TS 26.116: TV video Profiles
- TS 26.117: Speech and audio profiles

5G Media Streaming End-to-end setup with Android Clients

- Source: https://www.youtube.com/watch?v=L5nGVf-WhNE

5G Multimedia Broadcast/Multicast Service (MBMS)

Goal

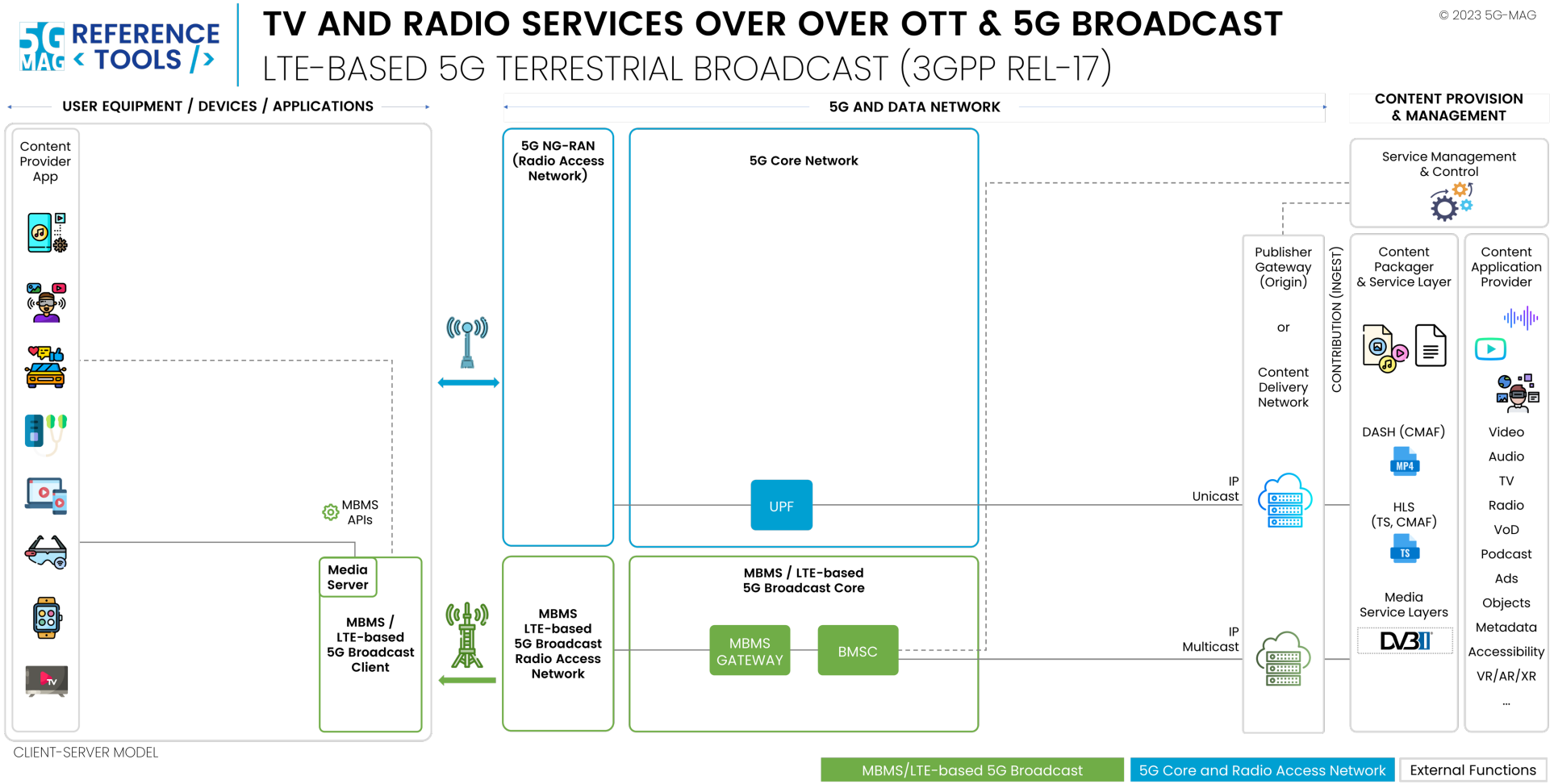
- Deliver content to multiple users simultaneously with a fraction of the resources required by normal data services.
- Network resources are used to send the same multimedia content to everyone (broadcast) or to a group of subscribers (multicast) rather than sending content to individual subscribers (unicast)

The relevant specifications

- 3GPP 23.246: Multimedia Broadcast/Multicast Service (MBMS); Architecture and functional description(Rel. 16)
- 3GPP 26.347: Multimedia Broadcast/Multicast Service (MBMS); Application Programming Interface and URL (Rel. 16)
- 3GPP 26.346: Multimedia Broadcast/Multicast Service (MBMS); Protocols and codecs (Rel. 16)

Related Technologies: DASH, CMAF, FLUTE

5G Multimedia Broadcast/Multicast Service (MBMS)



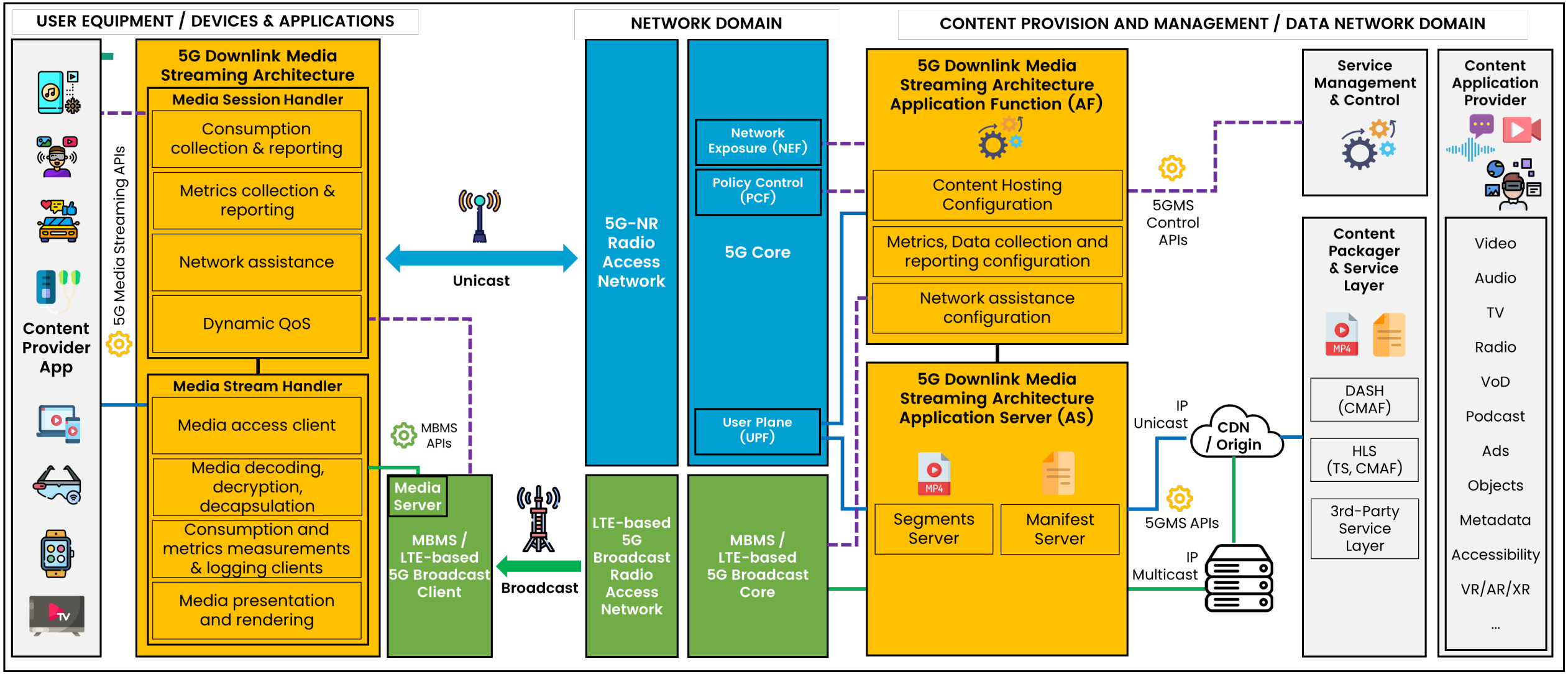
Hybrid Unicast-Broadcast

- Seamless switching between broadcast and OTT/unicast delivery
  - On high demand the content is broadcasted otherwise the viewers are consuming the content via unicast (5GMS).
  - Offer additional audio languages or subtitle tracks via unicast while the default content is consumed via broadcast.
  - Personalized OTT advertisements that replace the common broadcast ads.
  - Dynamic switch from broadcast to unicast once the viewer moves to an area with bad broadcast reception.

▪ Switch from broadcast to unicast

5G-MAG REFERENCE TOOLS

Hybrid Unicast 5G Media Streaming and MBMS/LTE-based 5G Broadcast (3GPP Release 17)



CLIENT-SERVER MODEL

LEGEND

5G Media Streaming Architecture | MBMS / LTE-based 5G Terrestrial Broadcast | 5G Core and Radio Access Network | External Functions

5G Broadcast-Broadband Seamless Switching

- Source: https://www.youtube.com/watch?v=Jbir8B-gC4c

Contact

Dr.-Ing. Louay Bassbouss
+49 (30) 3463 - 7275
louay.bassbouss@fokus.fraunhofer.de
www.linkedin.com/in/lbassbouss/

Fraunhofer FOKUS
Institute for Open Communication Systems
Kaiserin-Augusta-Allee 31
10589 Berlin, Germany
www.fokus.fraunhofer.de

Contact

Daniel Silhavy

- Email: daniel.silhavy@fokus.fraunhofer.de
- LinkedIn: https://www.linkedin.com/in/daniel-silhavy-21650a129/

Fraunhofer FOKUS
Institute for Open Communication Systems
Kaiserin-Augusta-Allee 31
10589 Berlin, Germany
info@fokus.fraunhofer.de
www.fokus.fraunhofer.de