Metaverse Related Projects (SID/WID) in 3GPP SA1/SA2/SA4/SA6

(Update since IETF-116 in 2023/03)

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Agenda

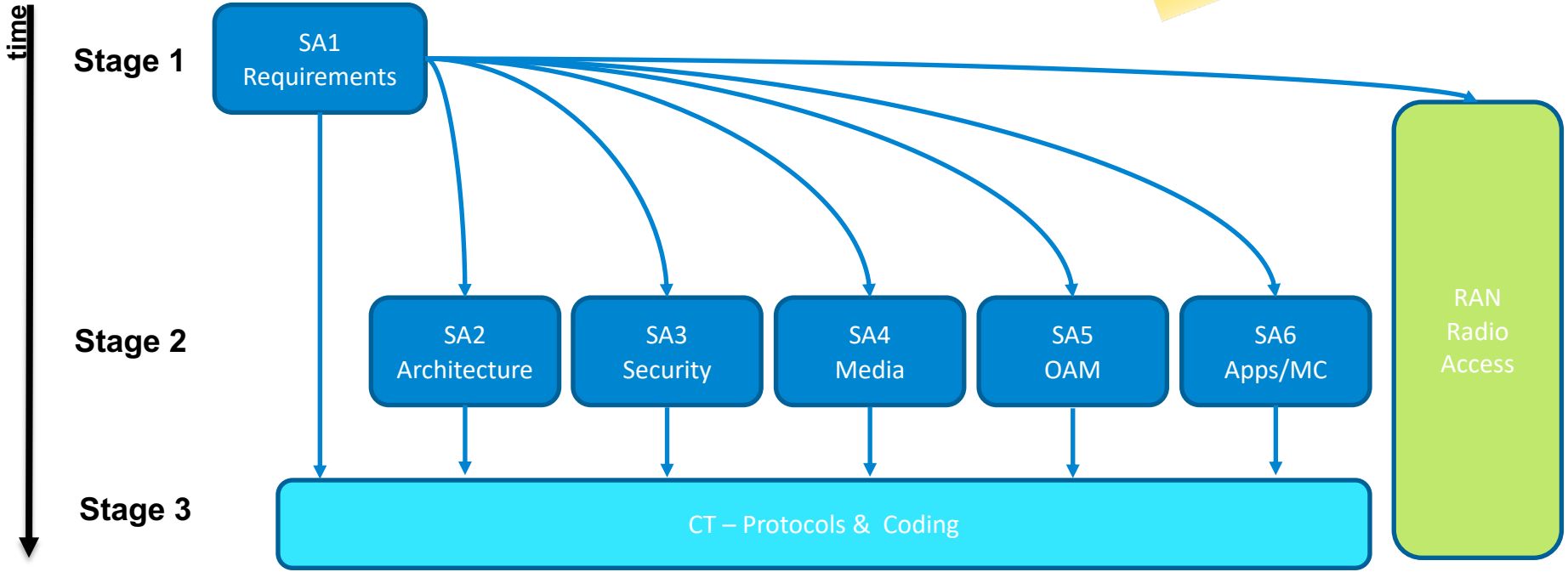
- 3GPP 5G work: Stage -1, -2 & -3
- 3GPP 5G Rel-18 (subset of Metaverse):
  - SA1 TACMM (Tactile & Multi-Modality Communication Services)
  - SA2 XRM (eXtended Reality & Multi-Modality Media Services)
- 3GPP 5G Rel-19
  - SA1 Metaverse (Localized Mobile Metaverse Services)
    - Study work: Done (Use cases & KPIs consolidated)
    - Normative work: To-be-done
  - SA2 XRM_Ph2
  - SA4 (Rel-16, 17, 18)
  - SA6 FS_AEXRS, FS_MetaApp

Background: 3GPP Stage 1/2/3 (A very brief SA view)

3GPP - the 3rd Generation Partnership Project:

- A global standards organization for mobile communication;
- 3 TSGs: SA, CT & RAN

No Update



SA1 TACMM: Tactile & Multi-Modality Communication (Rel-18, Stage-1, Done)

- **TACMM:** Considered as a subset of the more-general 'Metaverse' application
- A type of 5G advanced service that enables multi-modality interactions, combining ultra-low latency with extremely high availability, reliability and security.
- Normally 4 categories (or modalities): **video, audio**, **ambient-sensor** (e.g., brightness, temperature, humidity), and **haptic data** (e.g., the feeling of touch like the pressure, texture, vibration of medias, and the kinaesthetic senses, like the gravity, pull forces, position awareness)
- Typical use cases with immersive real-time experience (AR, VR, XR)

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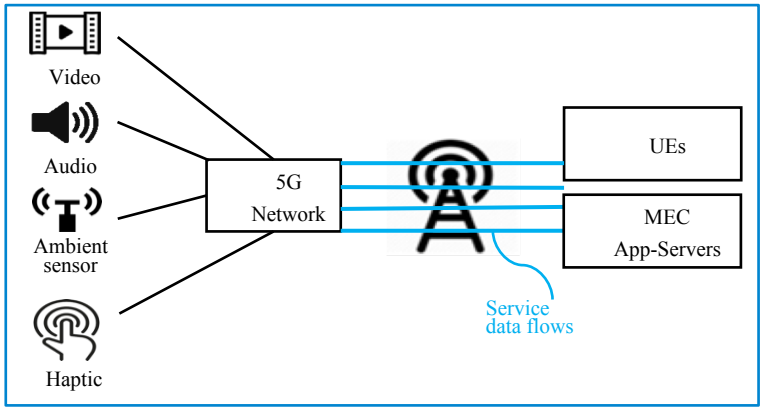

- Some Req. challenges across different types of media steams (i.e., multi-modality) with coordinated throughput, latency and reliability

1. Data characteristics
2. Accurate synchronization across & within modalities
3. QoS differentiation
4. large volume of small packets & packet-size variation

- *3GPP TR 22.847: Study on supporting tactile and multi-modality communication services (Stage 1, Rel-18)*

SA1 TACMM: Requirement Challenges & To Address Them:

1. Characteristics of generated data across modalities: high frequency and low latency to achieve 'acceptable' quality across a large area
   - E.g.: haptic-data may generate a traffic stream with 1000 PPS; video @ 50-60 FPS, etc.
2. Accurate synchronization across & within modalities
   - Multiple data inputs across modalities with high accuracy (~sub-1ms of time-sync), large scalability (involving a large number of wireless devices possibly over a relatively large area); e.g., visual-haptic feedback process
3. QoS differentiation (across modalities):
   - E.g. communication latency, data reliability, average data rate across modalities
4. large volume of small packets & packet-size variation
   - E.g., Haptic Packet-size related to the capacity of DoF; data-size/DoF: 2-8 Byte; a haptic device might support 6+ DoFs; high traffic volume

No Update

Potentially addressed via IETF related technologies:

1. Sub-1ms sync accuracy: e.g., IETF DetNet WG: layer-3, and IEEE802.1 TSN: layer-2.
2. Inter-modality time-sync: IETF has a draft by introducing a reference stream for clock synchronization.
3. Prioritized processing with a modality: E.g., video data transmission thru RTP by utilizing the different level of criticalness of MPEG image frames : I, P and B, etc.
4. Small-size packets with large volume: E.g., IETF QUIC: providing zero RTT connection establishment and transmission - could potentially benefit the haptic data transmission.

- *International Conference EDGE-2021, "On the 5G Edge Network Challenges of Providing Tactile & Multi-modality Communication Services", Dec. 2021*

SA1 Metaverse (Study the Localized Mobile Metaverse Services) (Rel-19, Stage-1; Concluded)
SA1 Metaverse (Mobile Metaverse Services) (Rel-19, Stage-1; To-be-done)

- **Metaverse**: A type of 5G advanced service that investigates specific *use cases* and *service requirements* for 5GS support of enhanced XR-based services to offer shared and interactive user experience of local content and services, accessed either by users in the proximity or remotely.
- Support of interactive XR media shared among multiple users in a single location
  - Perf KPIs, e.g. latency, throughput, connection density, scalability
  - Identification and digital representations of entities (e.g., users, devices)
  - Acquisition, utilization & exposure of local info (physical & digital): e.g., local spatial/environmental, users' positioning/viewing/directional/haptic, etc.
- Compared to (SA2) XRM: Metaverse involves coordination of input data from different devices/sensors from different users and coordination of output data to different devices at different destinations to support the same task or application.

28 Use Cases have been proposed (select.)

1. Localized Mobile Metaverse Service
2. Mobile Metaverse for 5G Traffic Flow Simulation & Situational Awareness
3. Concurrent & Collaborative Engineering Design via Metaverse services.
4. Immersive Gaming & Live Shows
5. Multi-service Coordination in Metaverse
6. Critical HealthCare Services via Metaverse
7. Interconnection of Mobile Metaverse Services)
8. …

Requirements: User Experience/ Performance	• Multi-user audio & video stream synchronization under the strict RTT latency req. (~20ms) • Distribution, provisioning & execution of digital representation prediction model • Session creation between digital avatars
	• End-to-end latency：5-20ms • Bandwidth：200-2000Mbps • Positioning precision：<1m • Delay jitter：2ms(haptic)；50ms(audio/video) • Area capacity：39.6Tbps/km2 • Reliability：99.9999%
Spatial reconstruction	• Mgmt. of spatial anchor; • Generation of spatial mapping & positioning info.

- *3GPP TR 22.856: Feasibility Study on Localized Mobile Metaverse Services (Stage 1, Rel-19)*
- *3GPP TS 22.156: Mobile Metaverse Services (Stage-1, Rel-19)*

3GPP SA1 XR/Metaverse Network KPIs.

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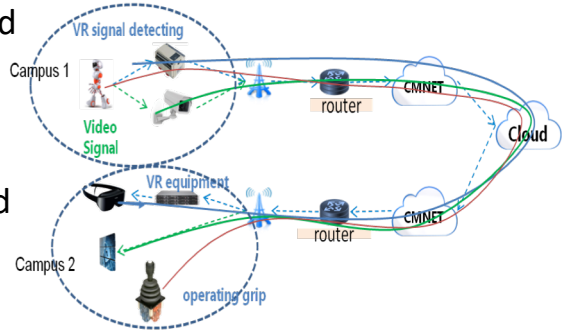
KPIs of all use cases (28) consolidated in Aug. 2023

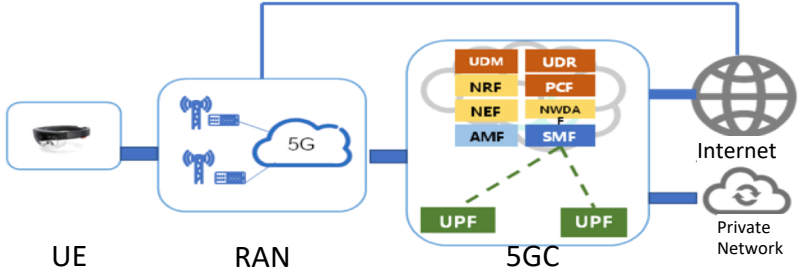
Use Cases	Characteristic parameter (KPI)				Influence quantity					Remarks
	Max allowed end-to-end latency	Service bit rate: user-experienced data rate	Reliability	Area Traffic capacity	Message size (byte)	Transfer Interval	Positioning accuracy	UE Speed	Service Area	
5G-enabled Traffic Flow Simulation and Situational Awareness (NOTE 2)	[5-20] ms (NOTE 1)	[10~100 Mbit/s] [25] (NOTE 6)	> 99.9%	[~39.6 Tbit/s/km²] (NOTE 5)	-	20~100 ms (NOTE 3)	-	< 250 km/h	City or Country wide (NOTE 4)	UL
Collaborative and concurrent engineering	[≤10] ms [14] (NOTE 7)	[1-100] Mbit/s [14]	[> 99.9%] [14]	[1.55] Tbit/s/km² (NOTE 8)	Video: 1500 Audio: 100 [14]	-	-	Stationary or Pedestrian	typically < 100 km² (NOTE 9)	UL and DL audio/video
	[5] ms UL [1-50] ms DL [14] (NOTE 7)	[<1] Mbit/s [14]	[> 99.9%] (without compression) [> 99.999%] (with compression (NOTE 10)) [26]	[2.25] Tbit/s/km² (NOTE 8)	1 DoF: 2-8 3 DoFs: 6-24 6 DoFs: 12-48 [14]	0.25-10 ms [14]				UL and DL haptic feedback
Metaverse-based Tele-Operated Driving (NOTE 16)	[100] ms [25] (NOTE 11)	[10~50 Mbit/s] [25]	99% [25]	[~360 Mbit/s/km²] (NOTE 14)	-	20~100 ms [25] (NOTE 12)	[10] cm [25]	[10-50] km/h (vehicle) [25] Stationary/Pedestrian (user)	Up to 10km radius [25] (NOTE 13)	UL real-time vehicle data (video streaming and/or sensor data) [25]
	[20] ms [25]	[0.1~0.4 Mbit/s] [25]	99,999% [25]	[~4 Mbit/s/km²] (NOTE 14)	Up to 8Kb [25]	20 ms [25] (NOTE 12)	[10] cm [25]	[10-50] km/h (vehicle) [25] Stationary/Pedestrian (user)	Up to 10km radius [25] (NOTE 13)	DL control traffic (commands from the remote driver) [25].
	1-20ms (NOTE 15)	16 kbit/s -2 Mbit/s (without haptic compression encoding); 0.8 - 200 kbit/s (with haptic compression	99.999% (NOTE 15)	[~20 Mbit/s/km²] (NOTE 14)	2-8 (1 DoF) (NOTE 15)			Stationary/Pedestrian (user)	Up to 10km radius [25] (NOTE 13)	Haptic feedback

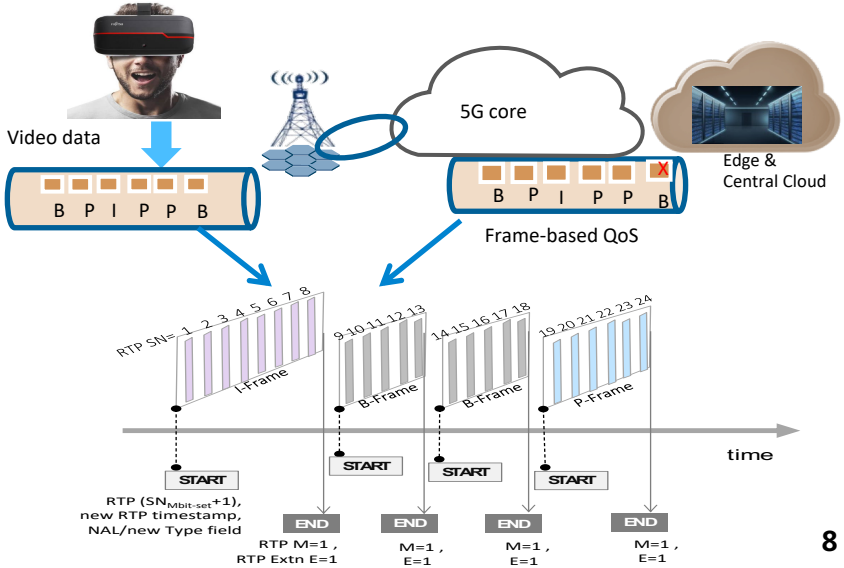
SA2 XRM: eXtended Reality & Media Services (Rel-18, Stage-2, Concluded)*

- **XRM:** Considered as a subset of the more-general 'Metaverse' application; related to the Rel-18 stage-1 work SA1 TACMM (study of use-cases and KPIs)
- A type of 5G advanced service to provide immersive real-time experience (XR); characterized by the Reqs. of high data rate and low latency, including multi-modality transmission, congestion control of media streams, PDU/PDU-set -based QoS handling, uplink-downlink transmission coordination, Packet Delay jitter handling, and etc.



- Various networking related issues to address:
  - Network information exposure & congestion control of media streams: L4S with ECN/AQM (3 RFCs in 5G Spec. already), etc.
  - QoS handling: (PDU/PDU-set –based, RTP w/ extension): PSDB/PDB, PSER/PER; GBR/Non-GBR w/ feedback control, etc.
  - Delay/Jitter (UL/DL): provisioning, measurement, guarantee, etc.





- *3GPP TR 23.700-60: Study on XR (Extended Reality) and Media Services (Rel-18)*

SA2 XRM_Ph2: FS_eXtended Reality & Media Services (Rel-19, On-going) *

Objectives: -- Note that they are **very much IETF-related…**

As a Phase-2 SID, to continue studying the support of XR advanced media services (i.e. High Data Rate Low Latency (HDRLL):

- Enhance PDU Set based QoS handling.
- Enhance QoS handling for XR services.
- Enhance support of XR based on non-3GPP access.
- Expose XR related network capability/information towards the application layer.

Key Issues: -- Note that they are **very much IETF-related…**

1. Support of PDU set based QoS handling enhancement: e.g. new standardized 5QI, enhancements to Alternative QoS profiles, FEC, etc.
2. Support PDU Set information identification for end-to-end encrypted XRM traffic: If and how the 5GS performs PDU Set information Identification in an end-to-end encryption scenario.
3. Leverage PDU Set QoS information for DSCP marking over N3/N9 in the transport network: i.e., DSCP marking on the outer header of downlink packets of the PDU Set over N3/N9 in the transport network.

- *3GPP TR 23.700-70: Study on XR (Extended Reality) and Media Services, Phase-2 (Rel-19)*

SA4 XR Related Projects (Rel-16, 17, 18)

SA4 focuses more on the application layer interaction between the UE and video/audio **media services**. AR, VR along with media services are the foundations for the support and implementation of Metaverse.

- **Rel-16 FS_5GXR** studied XR and AR device types, use case, KPIs, device architectures, media formats, call flows, and more.
- **Rel-17 FS_5GSTAR** studied the end-to-end encoding, rendering, functional framework, transmission interaction, and KPI of AR/MR glasses.
- **Rel-17 XRTraffic** studied the traffic characteristics of different XR service types and how they are related to the 3GPP RAN-1 Rel-17 XR study item. The conclusions led to implications for the current rel-18 SA2 & RAN XR projects.
- **Multiple Rel-18 projects** explore the media capabilities of AR devices, the split rendering to enable UE to share rendering to edge, the optimization of the use of RTP for the uni-directional and bi-directional transport of real-time immersive media, and the support of a specific device type, tethering AR glass, etc.

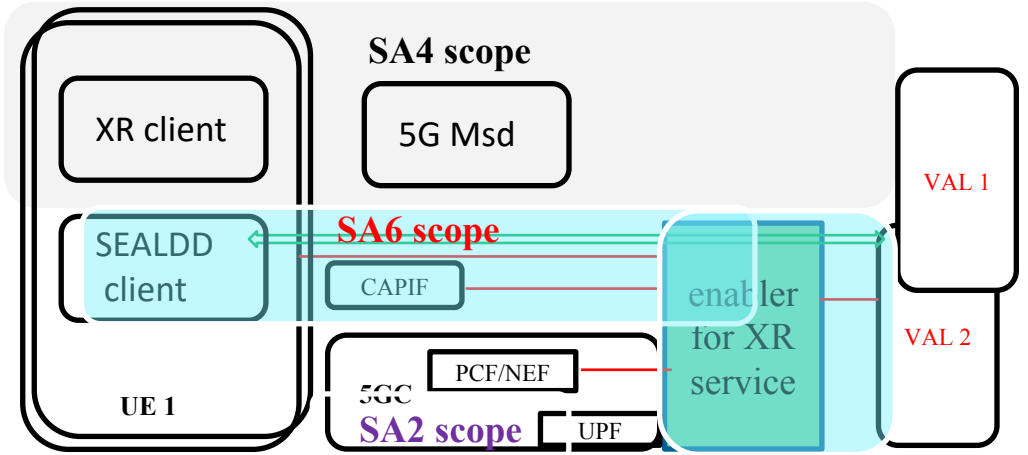
SA6 FS_AEXRS: Study on Application-Enabler for XR Services (Rel-19, just approved 2023/10):

SA6 SID FS_AEXRS: Provide value-added services via application-enablement:

- Help with multi-service coordination, by coordinating the traffic flows that has dependency. For example, to coordinate the robotic control data and the camera output.
- Help to provide a consistent service experience on devices with varying capabilities by providing more transmission guarantee services in the **SEAL/SEALDD**, which could lighten the burden of the transmission path monitoring and adaptation of the application in the user device.

[Note]

- SA4 focuses on the media processing aspect (i.e., the codec, rendering, etc.), and the application layer transport mechanism (i.e., the RTC etc.), and SA2 focuses on the transmission based on 5G connection with little knowledge of the service(s).



SA6 FS_MetaApp: application enablement for Localized Mobile Metaverse Services (Rel-19, just approved 2023/10):

Background:

- SA1 (Rel-19) has completed working on a study where specific use cases and service requirements for localized mobile metaverse services to offer shared and interactive user experience of local content and services, accessed either by users in the proximity or remotely.
- Many of the requirements captured in SA1 are well suited for **application enabler** layer (SA6).
  - Some use cases - Localized Mobile metaverse Service, Spatial Anchor Enabler, Spatial Mapping and Localization Service, interconnection of mobile metaverse services, Access to avatars, etc.
  - E.g. **localized mobile metaverse services**: (AR services and contents associated with locations in the physical world) could be potentially enabled by means of application layer service enablers.

Objectives & Scopes:

- Investigate requirements for **application enablement** architecture to support localized mobile metaverse services in 3GPP specified networks, including the interactions between UE and application enablement layer:
  - Potential management and exposure service of avatar related information and spatial anchors;
  - Potential enhancement to SEAL LMS to support localization service (e.g., based on Spatial mapping);
  - Identify gaps, if any, and potential enhancements to the existing edge enabler features/services ;

More coming in SA3/RANs…

- **SA3:** New SID Proposal: Security for XR services
- **RAN-2**: XR Enhancements for NR
- **RAN-3**: XR Enhancements for NR (same name)

Note:

- The **SA5** focuses on OAM, Charging, etc.; currently having **no** XR related SID/WID.

Thank you!