3GPP Highlights

ISSUE 06
May 2023

3GPP - the 5G Standard

Technical News

We start with Uncrewed Aerial Vehicles' use of NR... then we have an explanation of Resource owner-aware Northbound API Access (RNAA)... and then a summary of the SA3 security work in Rel-18.

We also have two new perspectives on the impact of Extended Reality (XR) on 5G and finally, we get a brief overview of Management, Orchestration and Charging in Rel-18

Partner Focus

The 5G Media Action Group reports on work to accelerate the adoption of new features for media services. Then, we have an article on how network nodes are set to evolve from IAB to IRS, by 3GPP OP TSDSI member – ITT.

The GSOA celebrate the Non-Terrestrial Networks (NTN) standard - developed jointly by satellite and mobile stakeholders and the TCCA tell us how critical broadband over 4G and 5G is building a safer world.

A look inside

Our in-house section has an interview with Lionel Morand, our TSG CT Chair, at the end of two successful & eventful mandates. He talks about some of the changes needed to carry on under Covid conditions and he tells us about some of the recent achievements in TSG CT.

We also have some membership statistics, a list of the new member companies in 2023 and details of the major meetings scheduled for the second half of the year.

FORE - WORD

Strong progress on Rel-18 as we return to business-as-usual

This issue of Highlights contains the good vibrations of a project on its way back to a level of activity and productivity that was the norm pre-Covid 19.

The articles in this issue describe some of the main projects that fit into the Release 18 timeline, covering UAV-related optimizations, Security and privacy advances, Requirements for eXtended Reality, Broadcast conformance tools, NTN beyond Rel-17, Mission critical progress and details of Management, Orchestration and Charging features. There are contributions from eight of the technical groups in 3GPP, the best return to date from our experts.

In the last section of this issue we have an interview with Lionel Morand, held immediately after his last TSG CT meeting in the Chair. He reflects on the challenges and some of the highlights of four successful years leading the group.

We also have a list of the new member organizations in 2023 and some key dates for the diary, in our A LOOK INSIDE section.

We hope that you enjoy this new issue of 'Highlights'. If so, please tell a friend to subscribe. If not, please tell me and I will work to be better next time.

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CONTENTS

NR SUPPORT FOR UAVS

By Jedrzej Stanczak, WI Rapporteur, Nokia

Recent technological advances have led to a continuous increase in the number of use cases where the application of Uncrewed Aerial Vehicles (UAVs) – also known as drones - can maximize time and cost efficiency, including; emergency services, security services, goods transportation or air quality monitoring.

To ensure the smooth and safe integration of UAVs onto the airspace, a reliable communication between the UAV and its controlling unit or the application server is essential. The ubiquity of cellular networks and their infrastructure make them a perfect candidate to provide such continuous connectivity.

The first efforts to connect UAVs via 3GPP networks were made in Release 15 of LTE, when a study to identify potential enhancements for aerial UEs was conducted; several of which were subsequently specified during the work item (WI) phase, completed in 2018. With the arrival of Release 18 UAVs are set to fly into the 5G-Advanced technology.

Before the work in RAN Working Groups (WG) began, 3GPP SA WG2 had already started work aimed at using cellular technology for supporting the Uncrewed Aerial Systems (UAS). The work there was mostly focused on identification, authentication and authorization of Aerial UEs. The Rel-18 WG RAN2-led work is focused on radio measurements, mobility and interference mitigation enhancements that should allow smooth integration of UAVs within the existing NR networks.

As the UAV UE is likely to fly above the rooftops, where Line of Sight (LOS) conditions dominate, it may detect multiple strong neighbour cells and face an increase in interference conditions.

Because of that, the NR measurement framework will support height-dependent measurement report triggering (i.e. Events H1 and H2, to be specified in TS 38.331) which will help the network in identifying at what altitude the UAV currently operates. When the network has such knowledge, it may adapt the UAV UE configurations, ensuring the interference level is kept at minimum.

> To ensure the smooth and safe integration of UAVs onto the airspace, a reliable communication between the UAV and its controlling unit or the application server is essential.

To avoid continuous measurement reporting, the network will be able to instruct the UAV to send the report only if more than a configurable number of cells (i.e. larger than one) simultaneously meet the reporting criteria (so-called: multi-cell report triggering). Another technique considered in RAN2 is to allow the UAV UE to use height-specific configurations, e.g. different set of parameters for the altitudes below and above the rooftops.

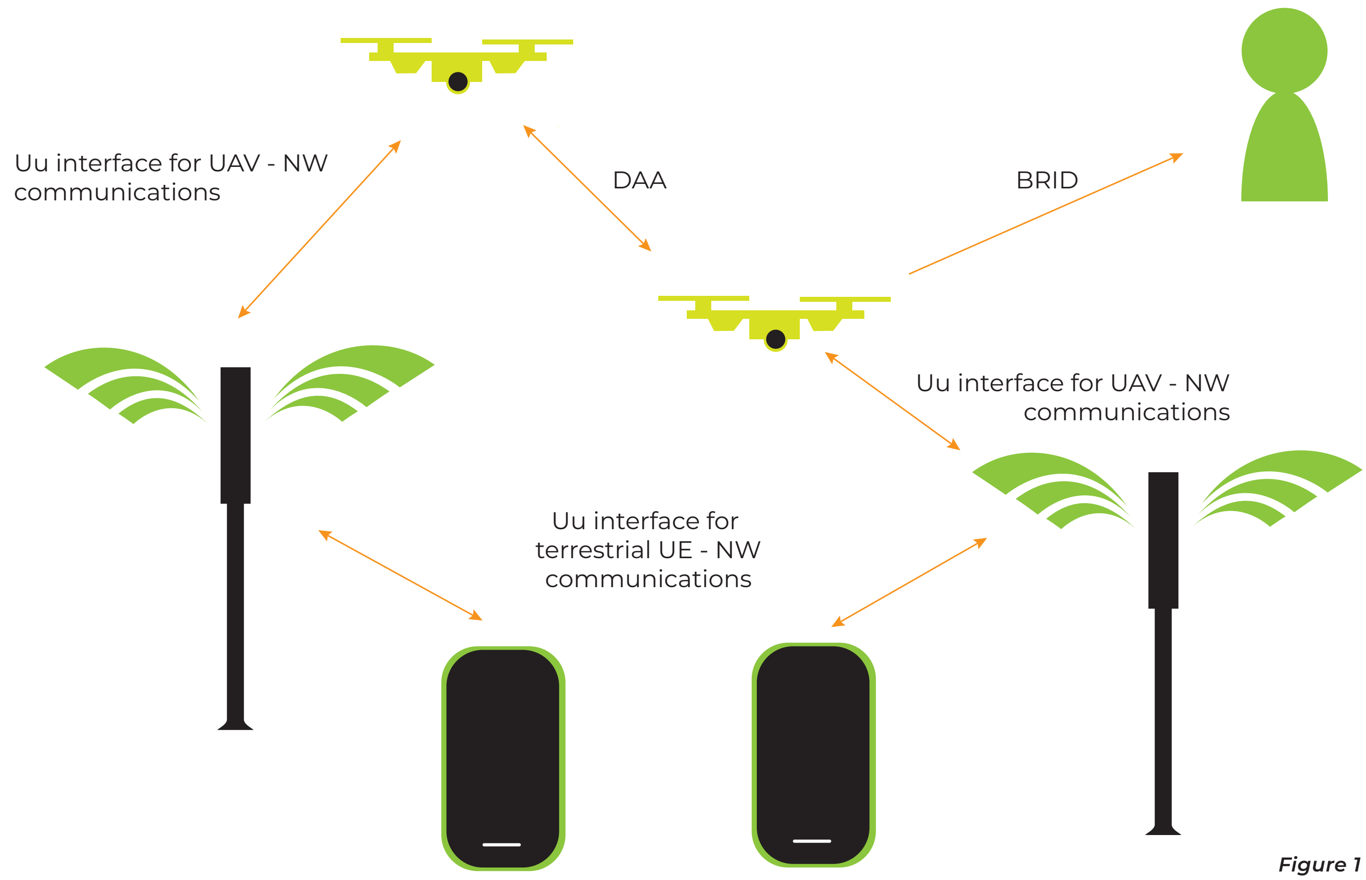


Figure 1

Flight path reporting is another UAV-specific procedure that is expected to help the gNB in radio resource planning. As the name implies, the UE may be asked by the network to provide its expected aerial route, comprising a set of geolocation points and associated timestamps. Using such information, the network can estimate what is the probable sequence of visited cells and approximately when the drone will appear in their coverage. The UAV UE will also be allowed to inform the network once there are any significant modifications to the previously reported flight path plan, so that the network stays up-to-date and can reassign resources accordingly.

The UAV-related optimizations are not only pursued in WG RAN2, other 3GPP WGs are also actively involved. RAN1's role in Rel-18 is to investigate how to support the Frequency Range 1 (FR1) beamforming for UAV's UL transmissions. Beamforming may be especially helpful in the higher end of FR1 spectrum and shall lead to reduced interference caused by NR-capable aerial UEs. WG RAN3 has been assigned the task of defining the subscription-based UAV UE identification which shall ensure only the drones with proper 3GPP-compliant subscription will be served by 5G-Advanced networks. Relevant information elements are to be provided via NG and Xn interfaces.

The Rel-18 WI has lately extended its scope to address recent changes on regulatory requirements to ensure UAV UEs are identifiable in certain geographic areas. To reach this goal a PC5-based functionality called BRID (Broadcasting UAV ID) is introduced so that the authorities or other users equipped with appropriate receiver could be capable of detecting flying drones in the specific territory. A somewhat related mechanism is Detect and Avoid (DAA), which is to also rely on broadcasting via the PC5 interface. DAA's aim is to avoid and resolve potential collisions between two or more UAV UEs.

As can be seen in Fig. 1 the UAV UE will support the communications via Uu interface with the gNB which will be used for various services and applications, but also for controlling the radio connection established with the network. The UAV UE will also send DAA and BRID messages using NR or LTE PC5 interfaces to meet the specific regulations described above.

The aforementioned set of functionalities is partly based on what has been supported in Rel-15 LTE, with several 5G-Advanced enhancements to be introduced as well.

The Rel-18 WI has lately extended its scope to address recent changes on regulatory requirements to ensure UAV UEs are identifiable in certain geographic areas.

These provide a good toolkit to ensure the aerial UEs are efficiently integrated with NR networks – they are not causing interference issues to the existing terrestrial users and simultaneously they reap benefits from ubiquitous connectivity. The first release including the support for UAVs is a solid foundation for connecting drones with 5G cellular networks. It can be also a starting point for further evolution which may involve UAV-specific Conditional Handover (CHO) improvements or more advanced UAV beamforming schemes.

RNAA: PROTECTING API RESOURCE OWNERS THROUGH 3GPP CAPIF FRAMEWORK

By Yuji Suzuki (SNAAPP Rapporteur, NTT docomo), Basu Pattan (SA6 Vice-chair) and Alan Soloway (SA6 Chair)

3GPP specified the Common API Framework (CAPIF) in Rel-15 to provide a framework for accessing 3GPP northbound APIs[1].

In Rel-18 SNAAPP work, 3GPP SA6 studied CAPIF (3GPP TS 23.222) enhancements to support Resource owner-aware Northbound API Access (RNAA), which enables the authorization of API invokers when the APIs are invoked in the context of resource owners (e.g., MNO subscribers).

RNAA Use cases

3GPP has introduced various northbound APIs exposed to API invokers inside and outside the PLMN trust domain. For example, Service Capability Exposure Function (SCEF) and Network Exposure Function (NEF) expose the 3GPP network capabilities via APIs, and Service Enabler Architecture Layer (SEAL) APIs offer commonly used functionalities among different vertical applications. The API invoker accesses the resources exposed by 3GPP northbound APIs and some of these resources may directly impact end user's service experience (e.g., modify QoS) or may handle end user specific information (e.g., obtain user location). Up to Rel-17, if the API is invoked on behalf of the end user, the end user is not aware of the API invocation or does not have any control over which APIs can be executed on their behalf. RNAA aims to protect users against such unintended access to their resources via APIs.

An example use case of RNAA is QoS modification while consuming gaming services. Assume that an end user (also a subscriber of the MNO in this case) is playing a game provided by a game provider and the gaming experience of the end user has to be improved. In such a scenario, two potential use cases are elaborated below.

Use case 1: The application on the UE directly invokes the NEF API to modify the end user's QoS. The end user, acting as an API invoker and a resource owner, authorizes this API invocation with NEF.

Use case 2: The end user triggers the gaming server for enhanced gaming experience. Based on the trigger from gaming application on the end user's UE, the gaming server, which is acting as an API invoker, invokes the NEF API to modify the end user's QoS and the end user authorizes this API invocation with NEF.

In both use cases, the end user, acting as a resource owner, can control whether API invoker can change their QoS before the end user is potentially charged for the high-quality service.

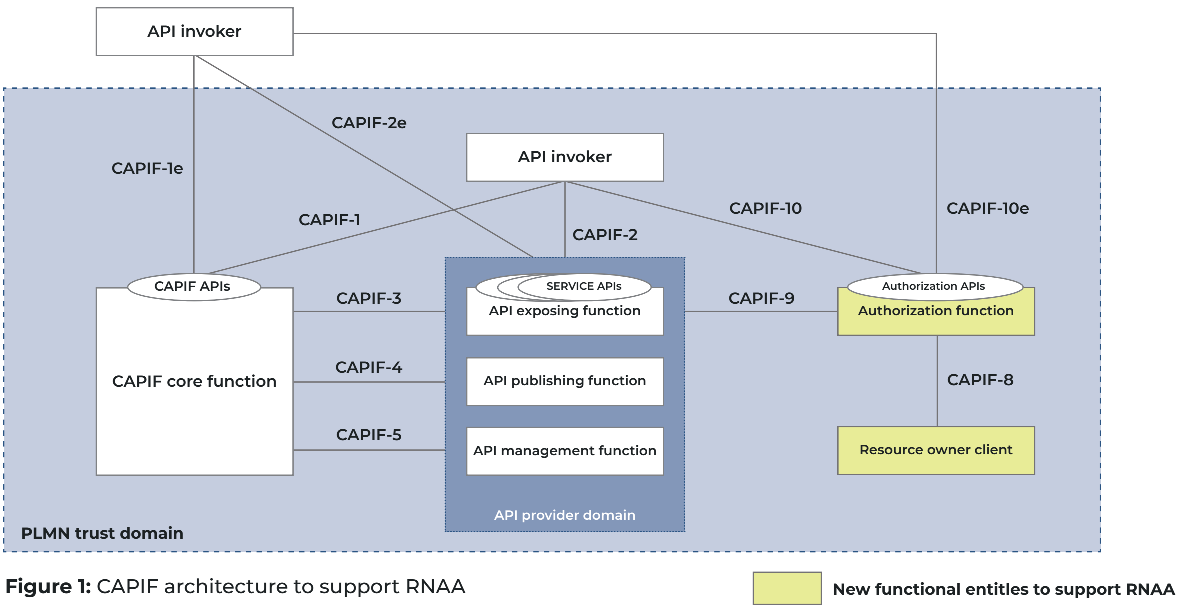


Figure 1: CAPIF architecture to support RNAA

[1] https://www.3gpp.org/news-events/3gpp-news/sa6-verticals2.

CAPIF architecture to support RNAA

Figure 1 shows the CAPIF architecture to support RNAA. Compared with the CAPIF architecture up to Rel-17, this architecture has new functional entities, namely the resource owner client and the authorization function, and new reference points related to those new entities.

The resource owner client is a functional entity that provides authorization for resource access. This is typically a client application on the resource owner's UE, and the resource owner (human) can allow or deny the resource access by the API invoker via the resource owner client.

The authorization function is a functional entity to receive authorization from the resource owner client. When receiving authorization from the resource owner client, the authorization function may provide the API invoker with the authorization information, which is needed to access the resource owner's resources.

Note that, in Rel-18, these two functional entities shall be in the PLMN trust domain.

Features of RNAA

To support the use cases described above, the following features have been studied.

1. **Discovery of target API information:** The API invoker may serve UEs that belong to different PLMNs. For example, in the gaming use cases, the game server of a game provider serves clients who subscribe different MNO's network services. If the game server wants to change the QoS of an end user who is a subscriber of a particular MNO, the game server needs to find the right API exposing function provided by the MNO. RNAA supports the feature to help the API invoker to discover the proper API information in the multi-PLMN cases.

2. **Obtaining authorization from the resource owner:** CAPIF can ask the resource owner whether they allow the API invoker to access their resources. In the QoS use case above, the end user affected by the QoS change will inform whether the QoS change is acceptable. With this feature, the API invoker cannot invoke service APIs without authorization from the resource owner.

3. **Supporting UE- and AF-originated API invocation scenarios:** As shown in the use cases above, RNAA supports two API invocation scenarios, namely UE- and AF-originated API invocation. For example, in the gaming use case, service APIs can be invoked by the game client on the end user's UE (UE-originated) or by the game server owned by the game provider (AF-originated). In Rel-17 CAPIF, the API invoker was regarded as a general functional entity that invokes the exposed service APIs, but in the Rel-18 SNAAPP study, SA6 has clarified that the API invoker may reside in the UE or the server.

Figure 2 illustrates the realization of the AF-originated API invocation use case 2 described above (i.e., gaming server invoking service API based on the trigger from gaming client on the UE) using the enhanced CAPIF procedures in Rel-18 3GPP TS 23.222.

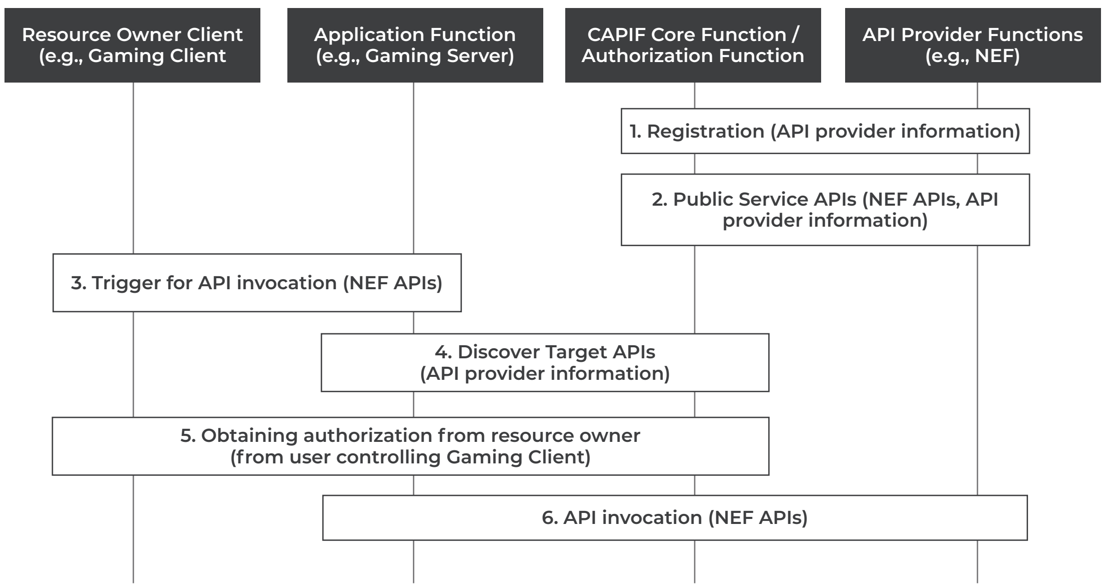


Figure 2: Typical flow diagram for the AF-originated API invocation scenario

Conclusion

With the new RNAA features, the 3GPP CAPIF system can support more flexible API invocation scenarios that require the authorization from the resource owner. The vertical applications provided by different industries can use the 3GPP northbound APIs while offering additional protection to the end users.

3GPP will further specify security aspects and protocol-level features of RNAA in Rel-18. Additional enhancements, such as supporting RNAA outside PLMN trust domain and AF-invoked RNAA, are expected in future releases.



REL-18 SECURITY FEATURE SUMMARY

By Minpeng Qi, Rajavelsamy Rajadurai, SA3 Vice Chairs and Suresh Nair, SA3 Chair

Release 18 is the first release for 5G-Advanced systems and a big step forward in security and privacy aspects of specifications, with 3GPP SA WG3 making progress on the enhancements in five key areas:

Security Enablers for Verticals

In Rel-18 the objective for Phase 2 of **Proximity based services** security is to specify security for UE-to-UE based relay Proximity Services, secondary authentication for remote UE connected through UE-to-Network Relay and security for path switching. For Authentication and Key Management for Applications (AKMA), Rel-18 adds roaming support. A further two work items are in progress to specify on how to use the AKMA / Generic Bootstrapping Architecture (GBA) to bootstrap the security context of IETF DTLS or OSCORE.

On **Mission critical services**, SA3 is specifying the security architecture for the SA6 specified new mission critical features like discreet listening and logging, temporary user identities, off network enhancements (such as ProSe) and so on.
The **EDGE** computing framework is a promising new feature for which 3GPP built a foundation in Rel-17, in phase 2 (Rel-18), EDGE security features such as: privacy of new parameters exposed by UPF to AF, authentication mechanism negotiation and selection between Edge Enabler Client (EEC) and Edge Configuration Server/Edge Enabler Server (ECS/EES), authentication and authorization between Application Client and EEC and transport security for EDGE-9 and EDGE-10 interfaces are introduced.

Personal IoT Network (**PIN**), security aspects such as PIN Element authentication and authorization with 5G Core, security protection and access control protection for communications between PIN Elements, e.g. via PEGC or via 5GC, or for communications between PIN Elements and PEGC are added in Rel-18.

Subscriber-aware northbound API access in CAPIF (SNAAPPY) introduces "resource owner", e.g. subscriber or user, as an entity capable of granting access to a protected resource and expands the CAPIF API Invoker to include UE applications. New security requirements related to API invocation, support for obtaining authorization from the resource owner and revocation of authorization by resource owner are considered to address in Rel-18.

Security Enhancement in 5G Core Network

Service Based Architecture (SBA), as the most important and outstanding feature designed for 5G networks, is also a big challenge for its security design. Currently SBA security discussions focus on security requirements on the SBA TLS certificate, on correction of the Oauth subscribe-notification case, and security clarification on NF consumer registration, etc.

Another feature - **Security Impact on Virtualization** is aimed to extend the 3GPP security capabilities which are required to provide direct explicit security visibility of the underlying virtualized infrastructure platform at the 3GPP layer and extensions to 3GPP functions to make use of such capabilities.

Home Network Triggered Authentication specifies which network function in the Home Network is better suitable to trigger the primary authentication and corresponding procedures as well as the potential impacts on the serving network, home network and the existing procedures.

In security aspects of **Enablers for Network Automation (eNA)** for 5G phase 3, security aspects of potential architecture enhancement on roaming, supporting federated learning, interaction between NWDAF and MDAS/MDAF are addressed. Further handling of sensitive information inherent to application detection, roaming and location information by NWDAF further enhances the security aspects for eNA.

In **network slicing** phase 3, the main objective is to specify the security procedure to support the HPLMN to provide roaming UE with the VPLMN slice information, enhanced authorization procedures for a UE to access network slices which support temporary slices, slice service areas mismatched with Tracking Area (TA) boundaries, and slices where S-NSSAI is not available in partial TAs of Routing Areas (RAs) and to support secured NSAC procedures to prevent DoS in the cases of NSAC for multiple service areas and network controlled UE behaviors.

In **NG Realtime Communication** security feature, support of existing service-based architecture in IMS media control interfaces and potential security aspects to support Data Channel usage in IMS network are specified.

Security assurance (for physical and virtualized network products)

Complementing 3GPP specifications for network architecture and services, to ensure the compliance of these specifications in network and system implementations of network and systems security, assurance certifications have been introduced by industry bodies such as GSMA. 3GPP SA3 has been developing test cases for these certifications.

SA3 has also started interacting with the European Union Agency for Cybersecurity (ENISA EU5G WGs) as they start to provide technical guidance on the security requirements in existing 5G standards and any additional requirements for future certification schemes.

Rel-18 introduces enhancements for all **generic 5G SCAS** specification, and introduces SCAS for specific network function such as AAnF, PCF and MnF. It defines security requirements and test cases for technical baseline, hardening and basic vulnerability test.

In another aspect, as 5G NFs are getting deployed as virtualized network functions, the gaps between virtualized implementation and physical implementation need to be considered. The **SCAS specification for virtualized network** product (TS 33.527) covers the specific security requirements for virtualized nodes.

Security Function Evolution

The **Certificate management** study looks at how to standardize the use of a single automated certificate management protocol and procedures for certificate life cycle events within intra-PLMN 5G SBA (i.e. to be used by all 5GC NFs including NRF, SCP, SEPP etc.), study the impact of service mesh in certificate management within 5G SBA, certificate lifecycle events like enrolment, renewal, revocation (e.g., OCSP, CRLs), status monitoring of a certificate and relation between certificate management lifecycle and NF management lifecycle.

Security Enhancement in RAN

There are a few features being introduced for security enhancements in the access stratum.

Privacy of identifiers over radio access (TR 33.870) is a comprehensive investigation of various 3GPP identifiers (e.g., user, subscriber, access network, core network, etc.), their privacy requirements, potential privacy threats and remediation.

Wireless Wireline Convergence phase2 (TR 33.887) addresses whether and how to identify, authenticate and authorize the Authenticable Non-3GPP devices and 3GPP devices (i.e. UE or N5CW devices) behind the Residential Gateway (RG) connecting to the network. Security aspects of supporting network slice in 5WWC and UE TNAP mobility in the 5GS are also part of this study.

In the **RAN AI/ML study** (TR 33.877) security aspects of employing AI/ML techniques in RAN are studied, with focus on the applicability of existing security mechanisms and whether any user privacy issues exist for the selected use cases in the related RAN group studies, without changing the current system design.

In **Non public Networks (NPN)** phase2 objectives are to support enhanced mobility by enabling support for idle and connected mode mobility between SNPNs without new network selection, support for non-3GPP access for SNPN, address new 3GPP WG SA1 requirements (e.g. TS 22.261 requirements from PALS work) related to NPN.

Uncrewed Aerial Systems (UAS) phase2 feature enhances security and addresses privacy threats. It looks at the corresponding security requirements that derive from the new architecture enhancements; in particular transport Broadcast Remote Identification and C2 communications via the 3GPP system or support aviation applications such as Detect And Avoid (DAA).

Another feature introduces mechanisms to securely identify the application for which the UE route selection policy **(URSP)** rule should be applied. The security and privacy issues specific to **Ranging based services** and sidelink positioning are also enhanced in another feature.

A feature on **Zero Trust** Analyses the 3GPP 5GS security scenarios related to the 5G core network that may benefit from a Zero Trust principle and identifies the associated threats.

Another feature ensures User Consent for 3GPP services to comply with user privacy choices.

MBS Phase2 features ensures security for UE's receiving Multicast MBS Session data in RRC Inactive state and efficient resource utilization for the same broadcast content to be provided to 5G Multiple Operator Core Network (MOCN) sharing scenarios.

The **Enhanced SBA** feature enables end to end authentication in roaming case if no cross-certification between operators is enabled, NF Service Consumer authentication of NRF and the NF Service Producer, impact of different deployment scenarios including the several SCPs, Verification of URI in subscription/ notification, Dynamic authorization between SCPs or NF and SCP, End-to-End Critical HTTP headers/body parts integrity protection and Security of NRF service management.

In the **NTN satellite access** feature, enhanced security supporting discontinuous coverage with satellite access is provided.

In SA3 Rel-18 studies and normative works are now in progress and expected to be complete by September 2023.

Security features in Rel-18

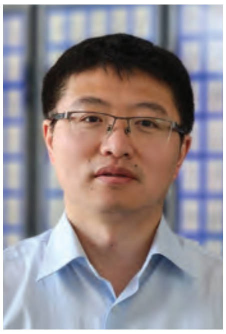
Enablers for Verticals
- ProSe Sec
- ProSe SA
- UAS SEC
- AKMA
- AKMA GBA DTLS
- USIA
- Edge
- PIN
- Ranging
- SNAAPPY
- AKMA GBA Oscore
- Satalite Sec

Security Enhancements in RAN
- ID Priv
- 5WWC sec
- AI/ML in RAN

Security Enhancements in 5GC
- eSBA sec
- HNTA
- NG RTC sec
- MCX Sec 3
- eNA sec
- eNPN sec
- AI/ML in 5GC
- SIV
- Slicing sec
- 5MBS sec

Security Function Evolution
- ACM SBaA
- Zero Trust
- User Consent

Security Assurance
- SCAS for management Function
- SCAS for AAnF
- SCAS for split gNB
- SCAS for PCF
- SCAS for 5G Enh
- SECAM and SCAS for Virtualized network product



EXTENDED REALITY FOR NR

By Benoist Sébire, WI Rapporteur RAN2 (Nokia) and Huilin Xu, WI Rapporteur RAN1(Qualcomm)

The combination of high bit rates and low latency required by eXtended Reality (XR) services poses new challenges to wireless access. To quantify these challenges, 3GPP has extensively studied the support of XR services in several working groups (RAN1, RAN2, SA2, SA4) and the recently approved Rel-18 work items will introduce the first mechanisms that these studies have identified as beneficial.

This article will explain what those RAN mechanisms are.

XR Overview

Extended Reality (XR) refers to all real-and-virtual combined environments and human-machine interactions generated by computer technology and wearables. XR is an umbrella term for different types of realities: Virtual reality (VR), which aims at giving the user the feeling of being physically and spatially there, Augmented Reality (AR), which provides a user with additional content overlaid upon their environment, and Mixed Reality (MR), which is an advanced form of AR where some virtual elements are inserted and can be interacted with.

An acceptable XR experience requires frame rates of at least 60fps and 2K resolution per eye, while a truly immersive one requires 90 or even 120fps with resolutions up to 8K per eye to remove graphics pixelation.

In all cases, XR content is generated by XR engines, which typically include a rendering engine for graphics, an audio engine for sound, and a physics engine for emulating the laws of physics.

An acceptable XR experience requires frame rates of at least 60fps and 2K resolution per eye, while a truly immersive one requires 90 or even 120fps with resolutions up to 8K per eye to remove graphics pixelation. This translates into bit rates of tens of Mbps. Creating content at such bit rates requires powerful XR engines which typically cannot be hosted on the user device, for instance due to heat dissipation and battery constraints.

Thus, typically, the rendering is assisted or split across the network: the UE sends real-time sensor data in uplink to the cloud, which then performs rendering and produces the multimedia data which is sent back to the user devices for display in downlink as shown on Figure X below. It is then the responsibility of NR to carry these tens of Mbps.

While this helps to reduce the processing requirements on the device, it also imposes additional requirements in terms of delay. Indeed, to provide an immersive experience as well as reduce the chances of motion-sickness, the motion-to-photon latency has an upper limit of 20ms. With split rendering, this includes the time for the UE to send sensor data in uplink, transport and processing delay in the core network as well as sending back the multimedia data to the user device for display. For the RAN, this translates into very short delays in both uplink and downlink, in the order of 10-15ms.

In summary, with split rendering, XR services require RAN to guarantee tens of Mbps with a latency in the order of 10ms measured at transport/application layer. The combination of such high bit rates and low latency is a new challenge for NR.

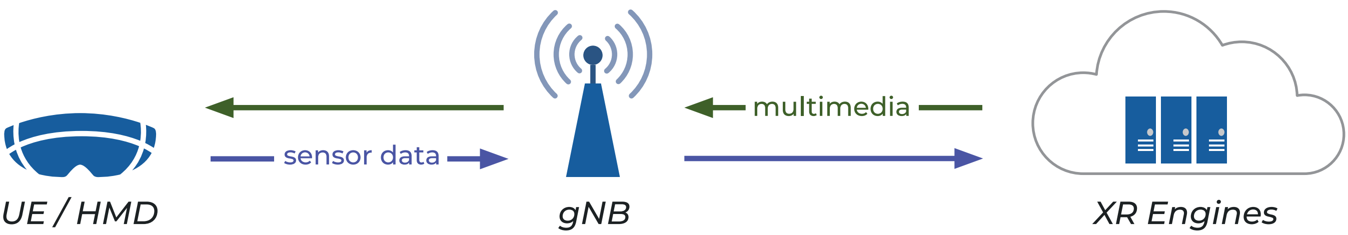


Figure X: Split Rendering

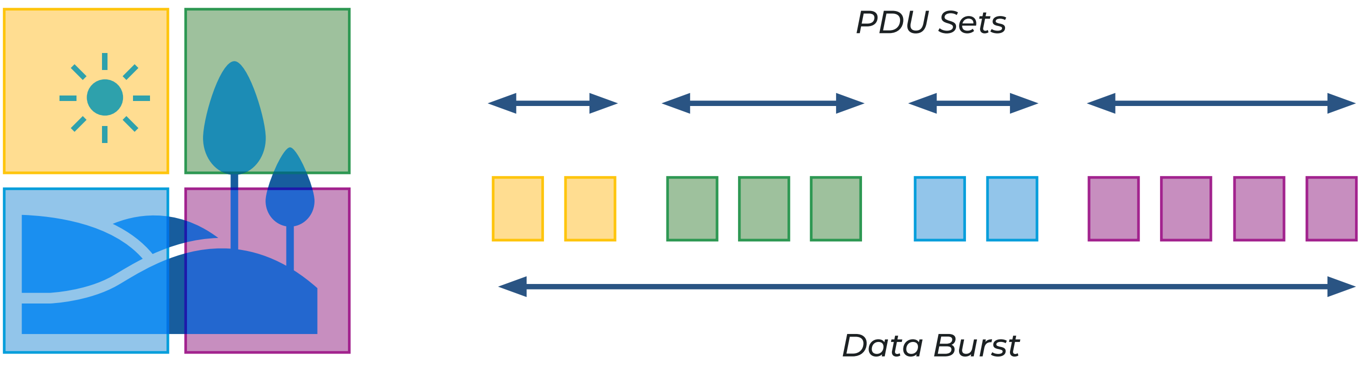


Figure Y: PDU Sets and Data Burst Example

3GPP RAN Enhancements

XR Awareness

In both uplink and downlink, XR-Awareness contributes to optimizations of radio resource and relies on the notions of PDU Set and Data Burst defined by 3GPP Working Group SA2 (See Page 16, 5G architecture support for XR and media services). PDU sets and Data Bursts enable the RAN to identify the PDUs which carry content that the application processes as a single unit (e.g. portion of an image, an audio frame) and the duration of a data transmission, respectively as examplified on Figure Y above.

With the PDU Set Integrated Handling Indication (PSIHI), RAN knows whether all PDUs of the PDU Set are needed for the usage of PDU Set by application layer. This allows RAN to stop transmitting a PDU set as soon as one of the PDU of the set is known to be lost (as other PDUs would be useless anyway). Finally, each PDU set can be signalled with an importance, which identifies the relative importance of a PDU Set compared to other PDU Sets. The RAN may then use it in case of congestion to discard the PDU sets of lower importance.

Power Saving

Various power saving techniques were evaluated during the Rel-18 XR study. It is shown that aligning periodicity between UE DRX and the XR traffic is critical for both power saving and capacity performance. Indeed most XR frame rates (e.g. 60, 90 and 120fps) correspond to periodicities which are – unlike what has been specified so far - not an integer (16.66, 11.11 and 8.33ms respectively) and new mechanisms will be introduced to deal with these periodicities.

> It is shown that aligning periodicity between UE DRX and the XR traffic is critical for both power saving and capacity performance.

On top of this, PDCCH monitoring adaptation techniques including search space set group (SSSG) switching and PDCCH skipping can be applied. SSSG switching together with PDU Set information can adjust PDCCH monitoring time to counter the relatively large jitter of XR PDU arrivals. Specifically, sparse to dense PDCCH monitoring can be triggered as soon as a new XR PDU is ready for transmission.

Additionally, the end of a data burst can be used to trigger PDCCH skipping to stop the UE DRX active time earlier than originally configured.

> For XR capacity enhancements, two PHY related techniques are being specified including the configured grant (CG) period with multiple PUSCH occasions and the UCI indicating unused CG PUSCH occasion(s).

Capacity

For XR capacity enhancements, two PHY related techniques are being specified including the configured grant (CG) period with multiple PUSCH occasions and the UCI indicating unused CG PUSCH occasion(s). The CG period with multiple PUSCH occasions provides periodic resources for XR UL data transmission with low signalling overhead. Depending on the actual size of the UL data, the UE may indicate a subset of the PUSCH occasions as unused in the UCI. After the gNB receives the UCI, it can reallocate partial or all the unused UL resources to other users so that overall capacity of the cell is improved. This also helps gNB save energy by skipping PUSCH detection over unused PUSCH occasions. For DL, the conventional dynamic grant scheduling is shown to have sufficient flexibility in Rel-18 XR study and hence no PHY related enhancements were introduced.

At layer 2, the main capacity enhancements help the gNB be aware of what the UE must transmit. Given the very high bit rates and low latency requirements of XR services, it is indeed crucial to tailor the grant precisely to minimise padding and delay. To achieve this, the Buffer Status reports will be enhanced to reduce the quantisation errors, and delay knowledge of the data buffered will also be reported.

Conclusion

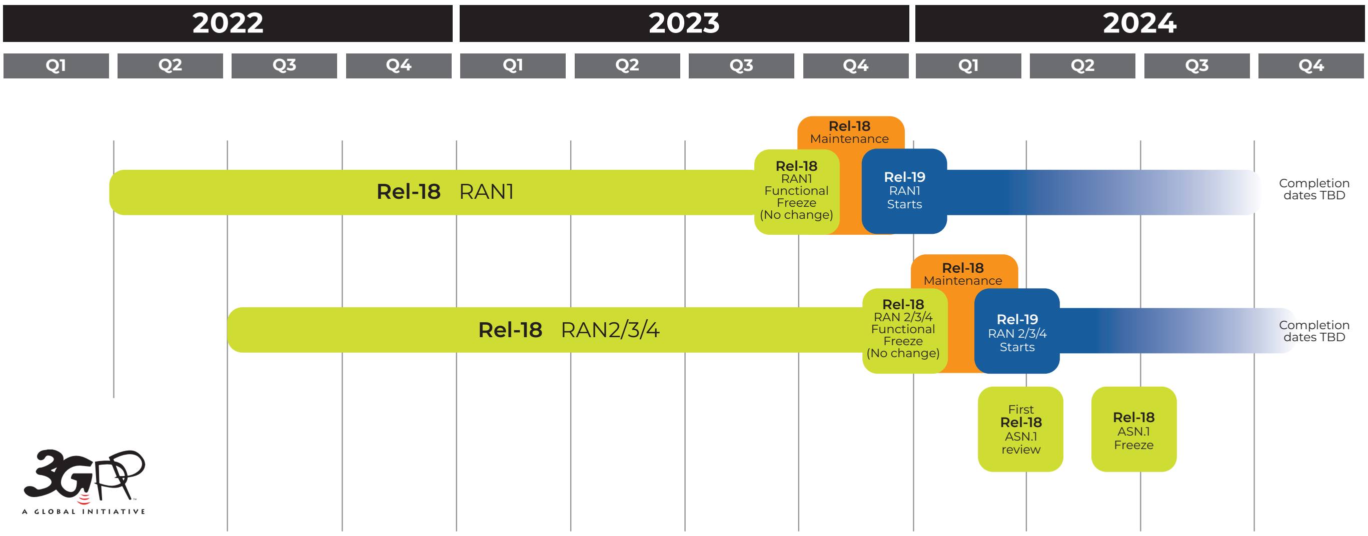
NR can successfully provide high bit rates for some services and low latency for some others, but these two requirements had not been combined so far. With XR, this is about to change, and this article has reviewed the RAN enhancements that will allow NR to face these new challenges. On average, it is estimated that with those new enhancements, gains of 10~30% can be achieved in power saving and capacity.

3GPP RAN IN ROTTERDAM

By Wanshi Chen, TSG RAN Chair

The recent TSG RAN plenary #99 meeting, held in Rotterdam, was the first plenary in the nine months since the return post COVID-19 face-to-face (F2F) plenary, held in Budapest last summer.

This was a long awaited F2F meeting, a happy get-together for the more than 400 registered delegates, marked by good progress on a variety of important topics.
One primary focus of RAN#99 was to ensure Release 18 remains on track. In RAN#98-e, after careful discussion - including a joint session with TSG SA & TSG CT - the Release 18 timeline was endorsed as below:



Thanks to the concerted efforts in resuming F2F meetings for RAN WGs in 2022 (two F2F for RAN1, and one F2F for RAN2/3/4/5) and further meetings in 2023 (five F2F and one e-meeting), RAN Release 18 can largely keep to the original timeline, with one additional quarter allocated for dedicated Release 18 maintenance (4Q'23 for RAN1, and 1Q'24 for RAN2/3/4). In addition, a first check of Release 18 ASN.1 review is scheduled in March 2024, with the final ASN.1 freeze in June 2024.

RAN#99 handled numerous topics essential to Release 18 consistency and completion. This involved discussions on:

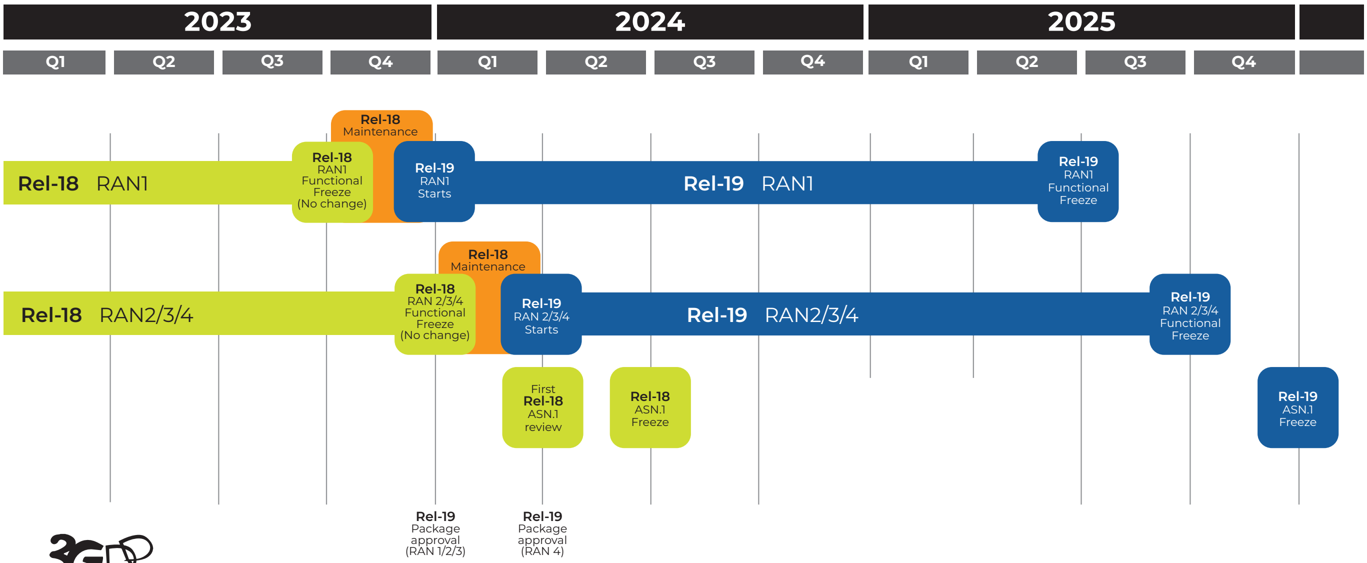
- NR sidelink evolution
- NR support for dedicated spectrum less than 5MHz for FR1
- NR Multicarrier enhancements
- eRedCap
- UAV (for both NR and LTE, in response to an LS from ECC)
- XR (particularly with respect to 2 Rx)
- NR NTN

Additional RAN4-led Rel-18 spectrum-related items were approved.

Several RAN-led items had further progress, particularly the completion of the study on UE support of regionally-defined subsets of an NR band, and the additional progress on study on ambient IoT. Moreover, in order to better align with the work in SA2, three new RAN3-led work items were approved, namely:

- New WID on further enhancement of RAN Slicing for NR in RP-230787
- New WID on NR Timing Resiliency and URLLC enhancements in RP-230754
- New WID on Further Enhancement of Private Network Support for NG-RAN in RP-230788

There were also other involved discussions, e.g., the topics of device compliance and BWP (bandwidth part) without restriction. Discussion for the former resulted in a conclusion endorsed by RAN, while the discussion for the latter ended up with a new WID in RP-230805, titled "Complete the specification support for BandWidth Part operation without restriction in NR".



More about Release 19... to follow

Another major issue for RAN#99 was the decision on the Release 19 timeline. In RAN#98-e, the steps for preparing RAN Release 19 were endorsed (in RP-222730). Subsequent discussion converged to the following more concrete steps:

- RAN#100 (June 12–14, 2023): 3-day F2F, no Rel-19 discussion
- Dedicated RAN Rel-19 workshop (June 15–16, 2023): a 2-day F2F
- RAN#101 (September 2023, 5-day): to consolidate RAN1/2/3-led proposals
    - o Contributions on RAN4-led proposals are allowed, but will not be discussed
- RAN#102 (December 2023, 5-day) to approve RAN1/2/3 package for Rel-19, and to consolidate RAN4-led proposals
    - o Ensure that RAN4 impacts of RAN1/2/3-led items are included in the approved WIDs/SIDs, including Time Unit (TU) impact
    - o Some RAN4 capacity needs to be reserved for RAN4-led items!
- RAN#103 (March'2024) to approve RAN4 package for Rel-19

A joint contribution was prepared by the RAN Chair and RAN WG Chairs (RP-230050), which was carefully discussed and endorsed by RAN on Monday of RAN#99. In particular, the figure above shows the endorsed Release timeline, which has a duration of 18 months.

Subsequently, a joint session was organized on Thursday of RAN#99, in order to better coordinate Release 19 timeline across different TSGs. The 18-month duration and December 2024 for Rel-19 ASN.1 Freeze was endorsed as a working assumption also for TSGs SA and CT.

With Release 18 well under way and Release 19 preparation and timeline being drafted, we are building the foundations for solid success moving forward.

5G ARCHITECTURE SUPPORT FOR EXTENDED REALITY AND MEDIA SERVICES

By Dan Wang, WG SA2 WI Rapporteur, China Mobile

To provide immersive experiences for users, XR and Media services (XRM) are usually characterized by high data rate and low latency.

3GPP SA2 has started the XRM Work Item in Rel-18 to identify 5GS functionality and capability enhancements, including multi-modality transmission, 5G system (5GS) information exposure, PDU set-based QoS handling, uplink-downlink transmission coordination, Packet Delay Variation monitoring and reporting, and Power Saving enhancements.

Policy control enhancements to support multi-modality flows for single UE/ multiple UEs

For XR services, there are multiple types of traffic, e.g. audio, video, sensor, pressure, and tactile, all generated to enhance the user experience. In the existing 5GS, the policy control is applied to a single data flow. To guarantee that the multi-modal data is transmitted in a coordinated fashion, the policy control of 5GS is now being enhanced with alignment policy control, e.g. same 5QI, same priority, or integrated network resource allocation.

5GS information exposure for XR/ media service

The 5GS exposes network information towards it, which can assist an application to make timely adjustment to the media codec/traffic rate. There are two methods standardized:

Use of ECN marking for L4S

L4S (Low Latency, Low Loss and Scalable Throughput) is an evolution of explicit congestion notification (ECN). The L4S can be used in 5GS to perform ECN marking for the L4S services to report the congestion condition quickly to the application through the user plane, to facilitate the rate adaptation at the application layer.

The NG-RAN is responsible for detecting congestion, and NG-RAN or UPF performs ECN marking using the following options:

i) NG-RAN detects the congestion and performs ECN marking for uplink and downlink in IP layer of the received packets, and then sends the packets to UE (downlink) and UPF (uplink).

ii) NG-RAN detects the congestion for uplink/downlink flow and sends the latest congestion information to UPF. Based on received congestion report, the UPF performs ECN marking for uplink and downlink IP layer of the received packets.

API based information exposure towards AF

The 5GS information, including congestion information, QoS Notification Control, and data rate are generated in NG-RAN and sent to SMF/PCF/NEF/AF for general exposure or sent to UPF/local NEF/AF for low-latency exposure. What's more, UPF can also calculate the data rate and expose it by using the above two exposure paths. The round-trip-delay for multiple QoS flows are reported from UPF to PCF and exposed to NEF/AF.

Besides the above parameters, 5GS also supports the exposure of the estimated bandwidth based on the NWDAF calculation, providing more information to the application server.

Support PDU set based QoS handling including PDU set integrated handling and differentiated handling

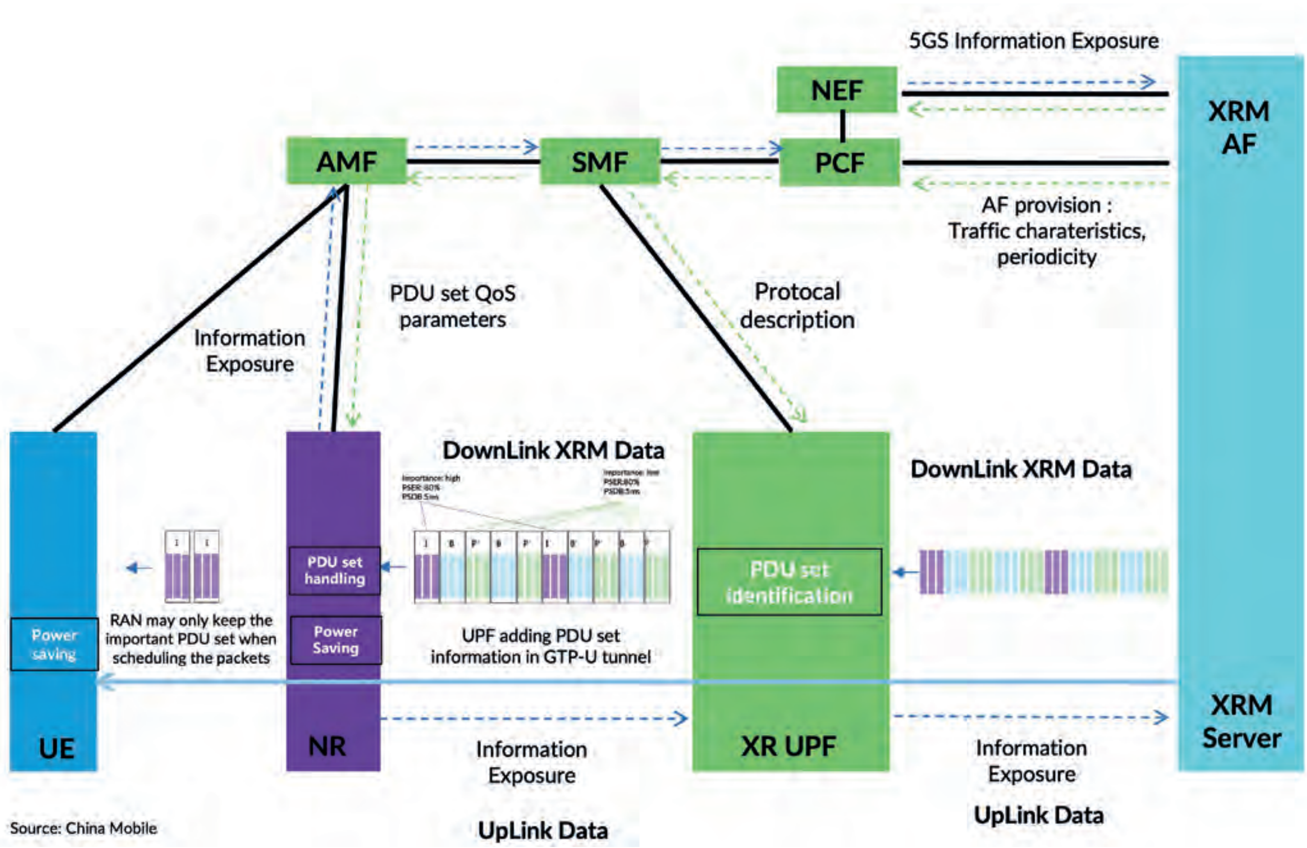
In traditional mobile network since GPRS, the QoS control is based on the concept of flow and packet. However, such scheduling didn't consider the relationship between packets, which are important for especially interactive media services like XR, since it's common that one unit of media layer needs to be delivered via multiple packets. Furthermore, different media units may contribute differently to the user experience even they are within a single steam. Thus the importance of these media units is not unique from media layer point of view.

To support the above integrated and differentiated transmission of media units (e.g. a frame or a video slice), a PDU Set concept is introduced to denote the collection of packets (i.e. PDU, Protocol Data Unit in 5G) carrying a media unit. The 5GC obtains the following information to support PDU Set level QoS handling:

- PDU Set information, including PDU Set Sequence Number, End PDU of the PDU Set, PDU Sequence Number within a PDU Set, PDU Set Size and PDU Set importance.
- PDU Set level QoS parameters. PDU Set Delay Budget (PSDB) and PDU Set Error Rate (PSER) are introduced to control the delay and error rate on PDU Set level instead of PDU level.

Uplink-Downlink transmission coordination to meet round-trip latency requirements

In 5G system, the AF provides RT latency requirements together with a RT latency indication to the PCF, which indicates the service data flow needs to meet that the RT delay overhead doesn't exceed the RT latency requirement. The PCF is responsible to split the RT latency into an UL PDB and a DL PDB. The restriction is that the UL PDB and DL PDB can be unequal but their sum shall not exceed the RT latency. The PCF generates two PCC rules for UL stream and DL stream and assigns the 5QIs according to PDBs respectively.



Packet Delay Variation monitoring and reporting

In 5G system, the AF provides Packet Delay Variation requirement for specific QoS flow. The PDV can show the network transmission stability. Once the PCF accept the PDV requirement, the corresponding PCC rules for QoS monitoring can be generated and sent to SMF to trigger the QoS monitoring for packet delay. When the PCF receives the packet delay values, the PCF itself can calculate the PDV based on IETF RFC 1889 or 3393.

UE power savings for XR services based on network assistant information

XR terminals, e.g. glass or headset, usually handle dense computation demands with very limited battery. Power saving is an outstanding issue to resolve for such terminals. For most XR and media service, the media stream follows a roughly periodicity. For example, a 60 fps video is composed of continual bursts with 16.67ms periodicity. Considering the periodicity, the RAN/terminal can consider the CDRX cycle length to match the arrival time of the media packets better to save the power. Another important information is the end of burst, with this RAN can understand the end of transmission and therefore indicate UE to enter power saving state immediately.
Based on above analysis, 5GC can provide periodicities and N6 jitter range of media services to RAN node via control plane signals, and also end of burst indication to RAN node via user plane packet. With the above information, RAN can generate an appropriate CDRX configuration to enable suitable power saving behavior without impact on traffic delivery.

5QI	5G quality of service identifiers
AF	Application Function
AMF	Access & Mobility Management Function
CDRX	Connected mode discontinuous reception
GPRS	3GPP General Packet Radio Service
N6	The N6 Reference point is between the UPF (UP Function) and a Data Network.
NEF	Network Exposure Function
NWDAF	Network Data Analytics Function
PCF	Policy Control Function
PDB	Packet Delay Budget
PDV	Packet Delay Variation
RT delay/ latency	Real Time
SA2	3GPP Working Group System Architecture and Services (TSG SA WG2)
SMF	Session Management Function
UPF	User Plane Function
XR	eXtended Reality
XRM	XR and Media services

MANAGEMENT, ORCHESTRATION AND CHARGING IN REL-18

By the SA5 Leadership, Thomas Tovinger, Zou Lan and Gerald Görmer

Within the 3GPP Technical Specification Group Service and System Aspects (TSG SA), the main objectives of 3GPP TSG SA WG5 (SA5) are:

- Management and Orchestration – Covering aspects such as operation, assurance, fulfilment and automation, including management interaction with entities external to the network operator (e.g. service providers and verticals).
- Charging - Aspects such as Quota Management and Charging Data Records (CDRs) generation, related to end-user and service-provider.

SA5 specifies the requirements, solutions and protocol specific definitions for both OAM and Charging, with solutions that include architecture, service definitions and data definitions.

Progress of Rel-18 Studies

Study on charging aspects for enhancements of Network Slicing Phase 2 (FS_NETSLICE_CH_Ph2, TR 32.847): On three new enhancements for Network Slice converged charging: converged charging for Network slice admission control (NSACF) associated services (i.e. monitoring and controlling the number of registered UEs and/or the number of PDU Sessions per network slice), converged charging for Network Slice-Specific Authentication and Authorization (NSSAA) enabled in the 5G System architecture, and converged charging capabilities relying on a new interface between the Converged Charging System (CCS) serving the UE and the CCS serving the Network Slice Tenant.

Study on 5G roaming charging architecture for wholesale and retail scenarios (FS_CHROAM, TR 28.827): Identifies the potential use cases, requirements, and solutions for the 5G charging for additional roaming scenarios and actors, with regards to roaming local break out and home routed to fulfill the GSMA requirements for the Billing and Charging Evolution (BCE) process.

Study on Charging Aspects for Enhanced support of Non-Public Networks (FS_eNPN_CH, TR 28.828): Investigates charging use cases and potential charging requirements for Stand-alone Non-Public Network (SNPN) and Public Network Integrated NPN (PNI-NPN). The charging solutions for non-public networks with potential impact on charging architecture, charging functions and charging procedures are now in development.

Study on Time Sensitive Networking charging (FS_TSNCH, TR 28.839): Identifies the use case, potential charging requirements and solutions for management and configuration charging for the 5GS bridge integrated with Time sensitive networking, time sensitive communications and time synchronization service enabler charging.

Study on enhancement of autonomous network levels (FS_eANL, TR 28.910): Identifying additional L4 MnS requirements for network optimization, RAN NE deployment and fault management.

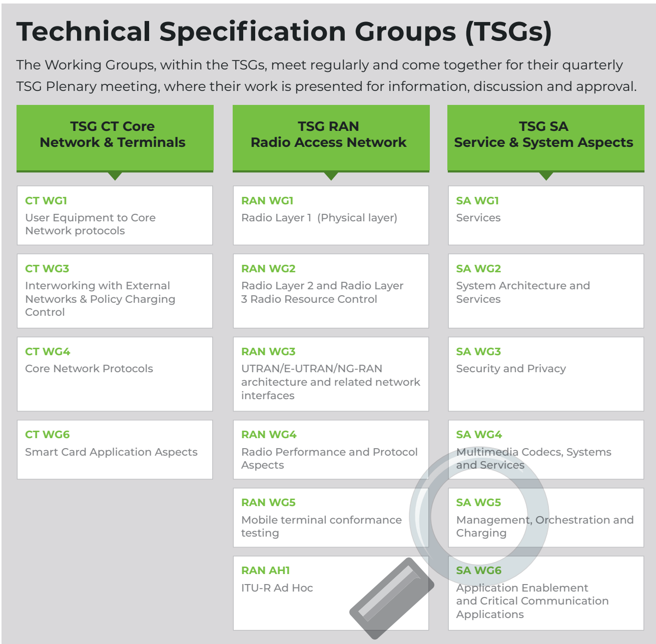
Study on evaluation of autonomous network levels (FS_ANLEVA TR 28.909): Studies generic methodology for autonomous network levels evaluation concept and KEI for evaluating autonomy capability for radio network optimization.

Study on enhanced intent driven management services for mobile networks (FS_eIDMS_MN, TR 28.912): Intent driven solutions for RAN energy saving, radio network intent expectation, radio service intent expectation and 5GC intent expectation.

Study on intent-driven management for network slicing (FS_NETSLICE_IDMS, TR 28.836): Intent driven management for network slice life cycle management, Intent driven management for network slice service assurance.

Study on AI/ML management (FS_AIML_MGMT, TR 28.908): Investigates management capabilities for ML training phase, management capability for AI/ML inference phase. Trustworthy Machine Learning capabilities for ML training and AI/ML inference phase.

Study on Enhancement of the management aspects related to NWDAF (FS_MANWDAF, TR 28.864): NWDAFFunction IOC enhancement to support Multiple NWDAF deployment and logical decomposition of NWDAF. Performance Measurement related to NWDAF Interaction, NWDAF Data Collection, Data Collection Exposed by NWDAF and NWDAF analytics result generation.



Study on Fault Supervision Evolution (FS_FSEV, TR 28.830): Concepts of event, error, failure, fault, alarm and root cause.

Study on measurement data collection to support RAN intelligence (FS_MEDACO_RAN, TR 28.838): Requirements and potential solutions for collecting measurement data required for supporting RAN3 defined AI/ML functions in OAM.

Study on Enhancement of service-based management architecture (FS_eSBMA, TR 28.925): Analyzes the management capabilities including inventory management, performance management which to be improved with SBMA, and description regarding management of MnF.

Study on Basic SBMA enabler enhancements (FS_eSBMAe, TR 28.831): Investigates issues including targeted notification subscriptions, definition of createMOI, definition of modifyMOIAttributes, HTTP error response format, Operation for multiple MOI updates, advertising communication options, and logging.

Study on Management Aspects of URLLC (FS_URLLC_Mgt, TR 28.832): Provides classification of URLLC related RAN features to be managed, support for performance management related on URLLC resource load and reliability in RAN and configuration of URLLC.

Study on Management Aspect of 5GLAN (FS_5GLAN_Mgt, TR 28.833): 5G VN group data management, 5G VN group performance measurement management, 5G VN group end-to-end network KPIs management and PDU Session management.

Study on Management of Cloud Native Virtualized Network Functions (FS_MCVNF, TR 28.834): Investigates use cases, potential requirements and solutions and their potential impacts on the 3GPP management system, taking into account the relevant use cases from ETSI NFV.

Study on Management Aspects of 5G MOCN Network Sharing Phase2 (FS_MANS_ph2, TR 28.835): Investigates interactions between Participating Operator (POP) and Master Operator (MOP), and between MOP and Network Equipment Provider (NEP).

Study on Management of Trace/MDT phase 2(FS_5GMDT_Ph2, TR 28.837): Possible enhancements to Trace and MDT, including the management of new functionalities specified by RAN2 and RAN3, changes to Trace/MDT necessary due to SBMA framework.

Study on Management Aspects of IoT NTN Enhancements (FS_IoT_NTN, TR 28.841): Investigates key issues associated with service and network management (NG-RAN or E-UTRAN).

Study on Data management phase 2 (FS_MADCOL_ph2, 28.842): Key issues about retrieval of storage of management data and Discovery of stored management data.

Study on enhancement of management of non-public networks (FS_OAM_eNPN, TR 28.907): Enh. management of Standalone NPN and Public Network Integrated-NPN, management capabilities exposed to Verticals as and to support end-to-end network management in NPN scenarios.

Study on new aspects of EE for 5G networks Phase 2(FS_EE5G_Ph2, TR 28.913): Key issues related to energy efficiency, energy saving and digital sobriety, and elaborated potential solutions. Conclusions of this study are pushed into the Rel-18 work item EE5GPLUS_Ph2.

Study on Network and Service Operations for Energy Utilities (FS_NSOEU, TR 28.829): About a) exposure of MNO management capabilities to external energy utility service providers and b) how they can provide MNOs with standardized reports of network performance problems and information about energy service interruption.

Study on Key Quality Indicators (KQIs) for 5G service experience (FS_KQI_5G, TR 28.863): Clarifies the concept of KQI.

Study on Deterministic Communication Service Assurance (FS_DCSA, TR 28.865): Investigates issues including Provisioning of network functions related to deterministic communication service, Service assurance for video monitoring and Service assurance for PLC control.

Study on network slice management capability exposure (FS_NSCE, TR 28.824): Use cases and derive requirements regarding the exposure of management capabilities and management services to externals, e.g. verticals, and elaborate potential solutions.

Study on alignment with ETSI MEC for Edge computing management (FS_MEC_ECM, TR 28.903): Alignment with ETSI MEC and with GSMA OPG.

Targets of normative OAM work in Rel-18:

Self-Configuration of RAN Network Entities (RANSC, TS 28.317/TS 28.313): To provide self-configuration management of RAN NEs of NR and future RAT technology in the context of SBMA.

Enhancement of Management Data Analytics phase 2 (eMDAS_Ph2, TS 28.104): To provide an analytics mechanism, including statistics and/or predictions for an existing management data, control of MDA process, coordination between MDAFs (e.g., cross-domain MDAF and domain specific MDAF) and new capability related to resource related analytics.

Network slicing provisioning rules (NSRULE, TS 28.531): Targets to extend allocation and modification use cases and procedures to allow the MnS consumer to provide a list of additional rules including network slice sharing, isolation etc.

Additional NRM features phase 2 (AdNRM_ph2, TS 28.541): To enhance NRM to support of 5G core and NR including support of NR_feMIMO related attributes.

Enhanced Edge Computing Management (eECM, TS 28.538): Specifies solutions to support GSMA OPG requirements and enhance 3GPP NRMs supporting Lifecycle management, Performance Assurance and Fault Supervision related to EAS, EES, ECS, EASDF.

Enhancement of QoE Measurement Collection (eQoE, 28.307/28.404): Targets QoE management of Signalling Based Activation in UMTS and LTE.

Access control for management service (MSAC, TS 28.533): Working in cooperation with SA3, extending service based management architecture to support authentication and authorization capabilities.

5G performance measurements and KPIs phase 3 (PM_KPI_5G_Ph3, TS 28.554): Defining the 5G performance measurements and KPIs for MIMO, Multi-carrier, NR small data transmissions, 5GC LoCation Services, Access Traffic Steering and enhanced Service Enabler Architecture Layer for Verticals.

Enhancements of EE for 5G Phase 2(EE5GPLUS_Ph2, TS 28.310): New KPIs, including for Energy Consumption (EC) and Energy Efficiency (EE), enhance the KPI definition of the EC of VM-based Network Functions, address Containerized Network Functions EC, specify new use cases, requirements and solutions for energy saving, applying to NG-RAN and/or 5GC and/or network slicing.

Network slice provisioning enhancement (eNETSLICE_PRO, TS 28.531): To enhance Network slice resource reservation and feasibility check capabilities and support asynchronous mode of operation.

Methodology for deprecation (OAM_MetDep, TS 32.156/TS 32.160): Specifies the methodology for how deprecation shall be used in SA5 TSs for attributes, data types, IOCs, operations and notifications.

For more on WG SA5: **www.3gpp.org/3gpp-groups**

DRIVING SPECIFICATIONS THROUGH 5G-MAG'S OPEN-SOURCE REFERENCE TOOLS

By 5G-MAG

3GPP has progressed and completed the enablers for media services on 3GPP-based systems. However, a reference and conformance programme to validate and prototype the 3GPP specifications and catalyze the adoption was lacking.

As the 3GPP Market Representation Partner serving the media industry vertical, the 5G Media Action Group (5G-MAG) has undertaken the task to fill this gap by co-ordinating the creation of a set of open-source reference implementations of relevant 3GPP technical specifications, which are available freely at **www.5g-mag.com/reference-tools.**

3GPP specifications for multimedia applications

3GPP started developing functionalities for multimedia services and applications as part of the Rel-16 and Rel-17 specifications. These include enablers for 5G Media Streaming and extensions such as edge processing, analytics and event exposure; improvements to LTE-based 5G Broadcast and hybrid services; 5G Multicast Broadcast Services (MBS); eXtended Reality (XR) and Augmented Reality (AR) experiences. In parallel to this work, 5G-MAG is developing reference software – the 5G-MAG Reference Tools.

To this date, the following components and functionalities are available in our repositories (www.5g-mag.com/repositories):

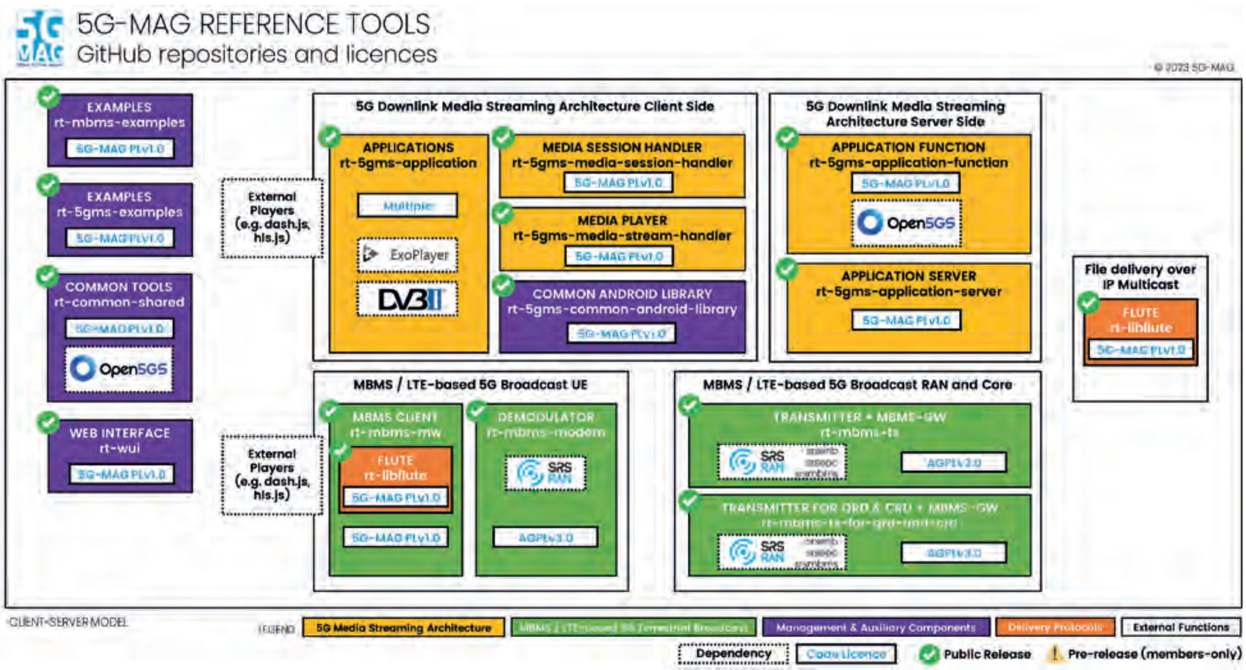
- End-to-end MBMS and **LTE-based 5G Broadcast** system with a set of Rel-17 features supported in a standalone transmitter, modem and middleware.
- A reference implementation of the **FLUTE** protocol for multicast file transfer.
- Network-side support for downlink 5G Media Streaming (5GMSd) with:
    - A reference **5GMSd Application Function** supporting northbound provisioning operations (at reference point M1d) and southbound network operations (at reference point M5) to UEs via the User Plane.

- A reference **5GMSd Application Server** implemented to act as a CDN node and supporting basic functionalities for content ingest (at reference point M2d), content hosting, and media serving to UEs via the User Plane (at reference point M4d).

- A reference Android **5GMSd Client** including:
  - A reference **Media Session Handler** that manages 5GMSd session and which exposes basic media session handling client APIs to 5GMS-Aware Applications via reference point M6d.
  - A reference **Media Player**, based on Exoplayer, that fetches media content via M4d from the 5GMSd AS under the control of a 5GMS-Aware Application using media stream handling client APIs at reference point M7d.

- Reference applications for testing, including:
  - A **5GMSd-Aware Application** with support for the M6d and M7d client APIs. This also supports an application-private means to obtain a list of available 5GMSd services from an external source, including media entry points and provisioning session IDs via reference point M8d.
  - An Android DVB-I player implementation.

The upcoming months will bring collaborative efforts towards the support of additional 5G Media Streaming features, including UE data collection and reporting, dynamic QoS policies, 5GMS over eMBMS, emergency alerts over LTE-based 5G Broadcast or MBS. Initial thoughts around XR are also envisaged.



Open community and close collaboration with 3GPP SA4

MAG Reference Tools development programme is open to the industry as well as to individual contributors. As such, different tools are being used to handle communication, developer team meetings, contributions and fixes. Check our GitHub, Google Group and Slack channels.

Regular communication with 3GPP is essential to progress both implementing specifications while providing useful feedback on them.

For this purpose, a regular ad hoc liaison with 3GPP SA4 has been established to discuss specific details of the technical specifications in relation to the ongoing reference implementations. Our GitHub repository on Standards provides a framework to collect feedback issues on the relevant specifications.

In addition, developers are invited to provide insight into their contributions under a DEVELOPER XCHANGE events programme.

Moreover, the 5G-MAG developer community is in close contact with the maintainers of other open-source software such as SRS and Open5GS to align the activities of the projects.

Plenty of opportunities ahead

The 5G-MAG Reference Tools community invites the media and ICT industries to leverage the open-source tools and reference services for their own trials and services, and to provide feedback in terms of comments, bugs reports or contributions to create a truly collaborative and global reference system. For the next target, it is expected that remaining Rel-17 functionalities as well as initial Rel-18 functionalities will be addressed. Plenty of opportunities are ahead towards supporting XR and new media, as well as uplink streaming or non-public network setups. Join and contribute at developer.5g-mag.com.

Thanks to Daniel Silhavy (Fraunhofer FOKUS) and Jordi J. Gimenez (Head of Technology 5G-MAG) for coordinating this 5G-MAG article.

EVOLUTION OF NETWORK NODES: FROM IAB TO IRS

By Shyam Gadhai and Rohit Budhiraja, TSDSI Member - IIT Kanpur

As we move towards higher operating frequencies, i.e., mmWave in the new radio (NR) standard, and towards THz frequency range for 6G, network coverage issues will become severe.

To improve coverage, different network nodes e.g., Integrated Access Backhaul (IAB), radio frequency (RF) repeaters, network-controlled repeaters (NCR) have been proposed in the standard. These nodes not only enhance the coverage, but also improve the end user throughput.

The IAB node, which was introduced in NR Release 16, is essentially a decode-and-forward relay with functionality up to Layer-2. Its wireless backhaul and access link are integrated to operate in a similar frequency range.

The IAB architecture is based on the centralized unit/distributed unit (CU/DU) split of the 5G base station (gNB), which is shown in Figure 1. An IAB node includes an MT ("mobile terminal") unit, and a DU unit. The MT unit connects to the DU of the parent node as a normal user equipment (UE). The DU has up to Layer-2 functionality, and acts as a decode-and-forward unit for UEs. An IAB node, therefore, has its own physical layer cell-id, and it is not transparent to a UE. Further enhancements to support simultaneous transmission and reception in IAB were introduced in Release 17.

Another network node known as NCR was introduced in Release-18. It is a smarter version of the conventional amplify-and-forward RF repeater, which does not have any intelligence. The NCR is also an amplify-and-forward repeater, but with an additional capacity of beamforming towards UEs, manage downlink and uplink transmissions, switch itself on and off, based on the side-control information received from the gNB.

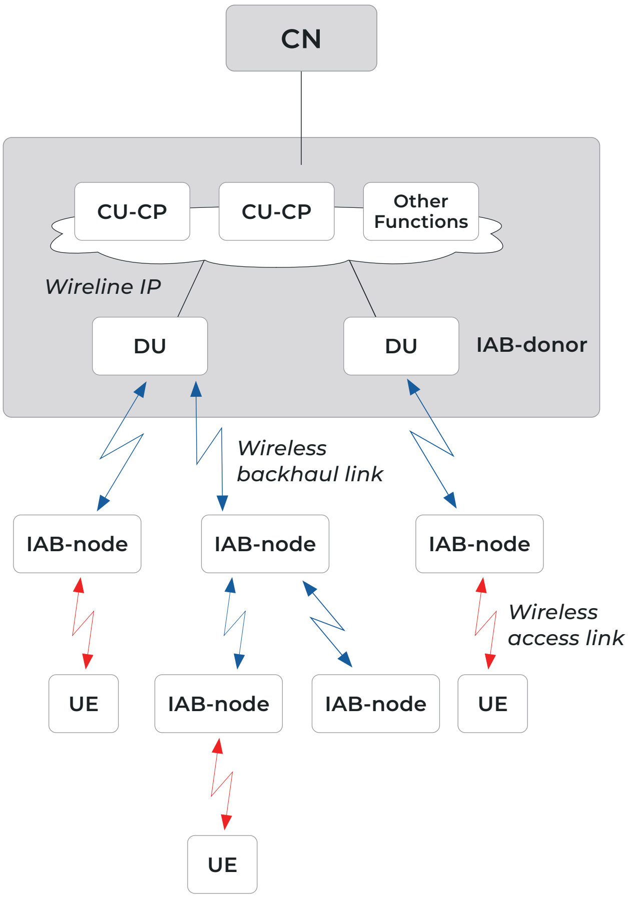


Figure 1: IAB node architecture (TR 38.874)

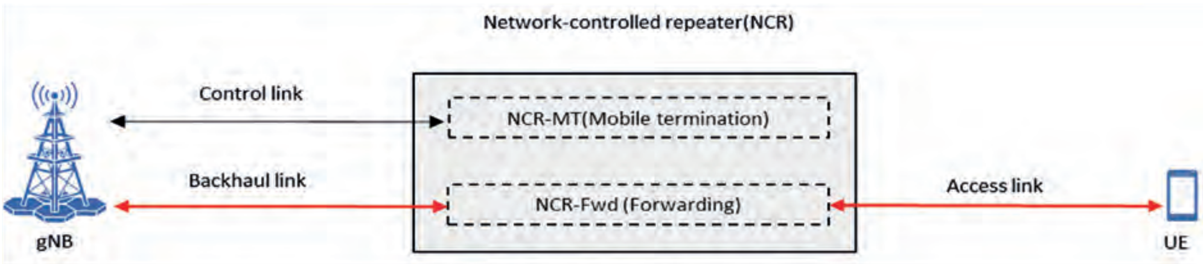


Figure 2: System model of Network-controlled repeater (source: 3GPP TR 38.867)

The NCR, as shown in Figure 2, consists of:

1) NCR-MT unit, which is similar to the IAB-MT unit. It connects to its parent gNB as a normal device, and identifies itself as an NCR to the network. It also decodes control information for forwarding; and

2) NCR-Fwd unit, which is its amplify-and-forward unit. It consists of only an RF layer, and thus does not decode any data intended to/from a user. NCR is, thus, a device which is more capable than the conventional RF repeater, but lesser capable than an IAB.

The NCR, when compared with an IAB, only decodes control information applicable to NCR. It does not decode any control/ data/signal intended for UE. It thus has a lower cost than IAB. Also, it does not have its own physical layer cell ID, and hence is transparent to a UE. The release-18 NCR is envisaged only as a stationary single-hop device support. Further enhancements to NCR may be possible in Release-19.

The intelligent reflective surfaces (IRS), as a network node, has gained significant attention recently. When compared with a repeater, it does not amplify the signal, but only forwards it. More specifically, it is a smart reflecting device which can help in controlling the channel by reflecting the signal in the desired direction. It does so by applying appropriate phase-shifts to the received signal. Different IRS architectures have been investigated in literature, and can have active and/or passive antenna elements. However, from 3GPP standardization point of view, as the IABs and NCRs already have active antenna elements, and IRS being envisaged as a very low cost and energy efficient device, it is more likely to have only passive elements. However, this configuration can also be a part of study when IRS is introduced as a study item or work item (SI/WI) in 3GPP. Figure 3 shows the basic difference between NCR and IRS. When compared with NCR and IAB, IRS may not have a MT unit, but rather a simple controller unit, which may be connected using either a wired or wireless backhaul. Also, it does not have two antenna panels for Rx and Tx, but a single panel for reflection.

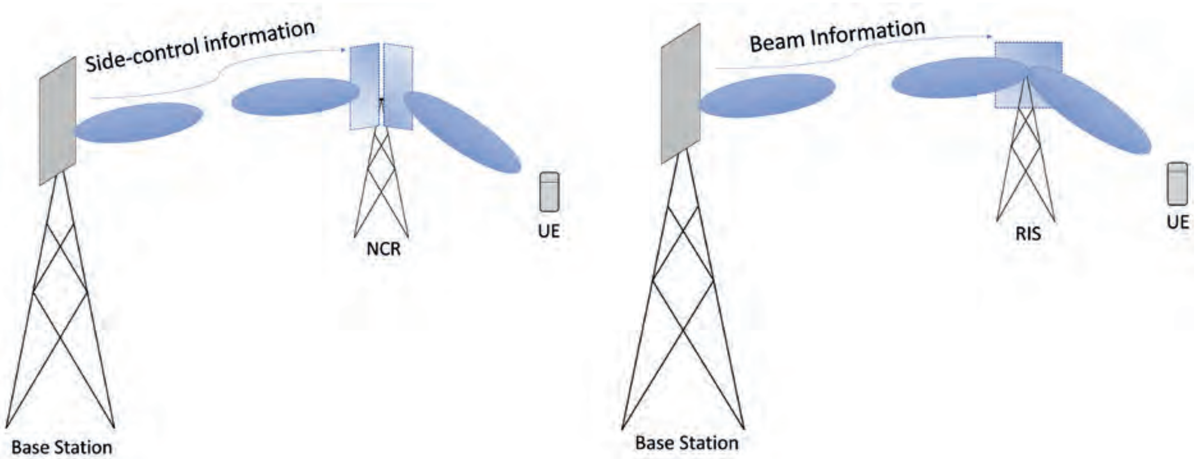


Figure 3: Difference between NCR and IRS

IRS is not yet a study item in 3GPP, more discussion is expected prior to Rel-19. Some of the important proposals for its study would be:

- Use case /Deployment scenario: Study of use cases and scenarios where IRS will fit in. A major use case of IRS being envisaged is that of improving the network throughput by providing a strong non-line-of-sight (NLOS) path in blockage scenario.
- Signalling protocol: Define signalling between parent nodes and IRS controller to indicate control information such as beam weights.
- Channel Modeling: IRS is envisaged as a reconfigurable cluster in a channel model. The existing 38.901 channel model needs to be studied. This will also include the size of IRS for practical deployment scenarios, and the study of near-field/far-field radio propagation characteristics.
- Impact on existing procedures: Impact of IRS on existing procedures such as initial attach, beam management, radio link/ beam failure recovery, interference mitigation also needs to be studied.

With all these network nodes being standardized in 3GPP, future wireless networks are envisaged to have a hybrid combination of gNBs and IABs, which make up the macro and small cells, and NCR and IRS enhancing the coverage and connectivity to the UE, and thus forming a ubiquitous intelligent and connected network. Such an intelligent network will become essential to enable future applications of integrated sensing and communication, ultra-high precise positioning, and augmented and virtual reality applications.

3GPP STANDARD FOR SATELLITE NETWORKS (NTN)

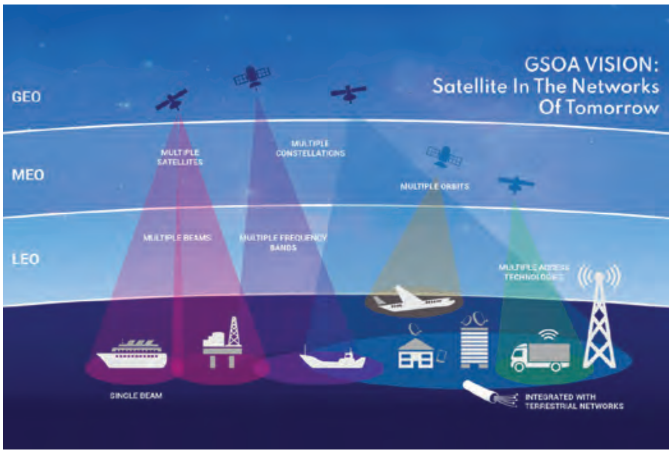
By Munira Jaffar, GSOA Standards Working Group Chair, EchoStar and Nicolas Chuberre, WI Rapporteur, Thales Alenia Space

The long-awaited global standard for satellite networks is now in place.

Serving handheld, IoT, and vehicle mounted devices, this standard supports the promise of worldwide access to enhanced Mobile Broadband (eMBB), massive Machine Type communication (mMTC), and Highly Reliable Communication (HRC) services. The Non-Terrestrial Networks (NTN) standard has been developed jointly by satellite and mobile industry stakeholders to help accelerate greater integration and coexistence between both network components. The NTN standard completed as part of 3GPP Release 17 defines key enhancements to support satellite networks for two types of radio protocols/interfaces:

- **5G NR radio interface family also known as NR-NTN**
- **4G NB-IoT & eMTC radio interfaces family known as IoT-NTN**

These critical enhancements including adaptation for satellite latency and doppler effects have been carefully defined to support a wide range of satellite network deployment scenarios and orbits (i.e., LEO, MEO and GEO), terminal types (handheld, IoT, vehicle mounted), frequency bands, beam types (Earth fixed/Earth moving) and sizes. The NTN standard also addresses mobility procedures across both terrestrial and non-terrestrial network components. Release 17 further includes Radio Frequency and Radio Resource Management specifications for terminals and satellite access nodes operating in two FR1 frequency ranges allocated to Mobile Satellite Services (i.e., n255 and n256).



The NTN standard paves the way for satellite network solutions addressing the challenges of reachability and service continuity in unserved and underserved areas. Additionally, it will enhance reliability through connectivity between various access technologies and will provide improved network resilience and dependability in responding to natural and man-made disasters.

From the outset, the NTN standard benefits from broad acceptance across the full 3GPP ecosystem: chipset/terminal/network/satellite vendors; satellite and telecom network operators; and many user groups. The NTN Rel-17 standards have been developed and verified by dozens of companies – not just satellite stakeholders but also verticals, OEMs, vendors (network, UE, chipset), Telcos, and many more. Commercial products and services are expected to be available soon, and deployment of satellite supporting the 3GPP NTN standard will offer a wide range of 5G services and applications.

3GPP is already working on further NTN enhancements to be part of Release 18: optimizing satellite access performance, addressing new frequency bands and their specific regulatory requirements, and supporting new capabilities and services. This will include the definition of new bands above 10 GHz, enabling expanded access to broadband services to nomadic and moving platforms (e.g., aircraft, vessels, UAV). As the standard evolves these and other additional features will be needed to ensure increasingly efficient deployment and further expanded benefits to end users. 3GPP functionality is "modular" and can be backward-compatible, which allows for deployment of a Rel-17 network with later upgrades to Rel-18 functionality, if desired.

Looking ahead, GSOA (Global Satellite Operator Association, https://gsoasatellite.com) members and other satellite industry stakeholders have started discussions to consolidate a further list of enhancements for both NR-NTN and IoT-NTN to be considered in Rel-19. The aim is to further enhance network capabilities and add new features to benefit end users. The continuing evolution of the NTN 3GPP standard promises to further broaden and deepen the menu of options for satellite to play an increasingly central role in global communications.

GSOA GLOBAL SATELLITE OPERATORS ASSOCIATION https://gsoasatellite.com

ON THE BRINK OF TRANSFORMATION

By Tero Pesonen, Chair of TCCA's Critical Communications Broadband Group and TCCA Board Vice-chair

3GPP Release 19 Stage 2 prioritisation is one of the key forward looking activities at the 3GPP plenary level over the coming months, followed by Stage 1 work for Release 20 next year.

The decisions made now will influence the development and manufacture of products in the second half of this decade Serving handheld, IoT, and vehicle mounted devices, this Those products will directly impact how critical communications users can operate in the upcoming critical broadband 4G and 5G networks. Critical user sectors include public safety such as police, fire and ambulance; critical infrastructure such as power- and water utilities, transport including air and rail travel, and resource industries including oil, gas and mining. A common factor is that the safety of lives and infrastructure depend on successful communication. In these sectors, communication is mission critical. For critical communications users, the most important general requirement of the sector is coverage – disasters can happen anywhere. The second general requirement is access and capacity at all times, and closely related is resilience.

As these are in order, sector specific Mission Critical Services (MCX) – MCPTT for voice, MCVideo and MCdata – that have been defined in SA6 can be utilised.

In Release 19, everything that can be done for coverage enhancements is highly welcome, specifically with regard to uplink as it is the limiting factor. Non-Terrestrial-Network (NTN), i.e. satellite connectivity, needs to be further enhanced. To address out-of-network situation for instance underground device-to-device multi-hop capability is required to extend coverage beyond the limit a device can reach.

To minimise interruptions in field operations special attention needs to be paid to mobility enhancements to ensure communication does not break in handovers. On the capacity side more work on (Mission Critical) broadcast services should be done to support IoT services.

Resilience enhancements such as Time as a Service could be used to provide back-up to GNSS in case of a disasters etc. This would be particularly beneficial for the Utilities segment but, as with the other stated needs, would increase the overall reliability of a high performance network.

Naturally, enhancements to MCX services to support multi-national and cross-border operations also need to be addressed. Innovations to improve network provided location services are operationally highly welcome.

As critical communications move from narrowband to broadband networks, we can begin to visualise paradigm shifts in working practices. What if ... at a fire site the network could identify and pinpoint people trapped in the building? What if the network constantly provided accurate three-dimensional positioning of each first responder, and could recognise changes in the structural integrity of the building? What if base stations and devices automatically could go to reduced power mode in a case of a power outage to extend their in-service time and give citizens more time to call for help and first responders more time to perform their operations.

We are on the brink of having the capability to bring these transformations to critical communications users – this can be seen clearly in Erillisverkot's Virve network in Finland – host country of this year's Critical Communications World. However, ensuring coordinated and compatible transformation begins with the specifications. By working together, we can build a safer world for everyone - success is in cooperation.

TCCA https://tcca.info

Photograph by Olavi Airaksinen

ENGINE ROOM TO BRIDGE!

We spoke to the TSG CT Chair at the March 2023 Plenaries in Rotterdam

Lionel Morand has completed two mandates as the TSG CT Chair. Guiding TSG CT through a full release cycle despite pandemics and worldwide travel restrictions.

He was previously a delegate and then Working Group (WG) CT4 Chair before his election to the plenary Chair, in 2019. In this short interview we discuss the role of the WG and TSG Chairs and how Lionel Morand sees the work evolving.

Highlights: You came from a deep technical involvement in the work, how easy was it to switch to a management role, as CT Chair?

Lionel Morand: When I was CT4 Chair, I tried to always remain above the technical give-and-take, but I was still able to be active and involved. For me, it was not so easy to adapt to the broader role of the CT Chair position, after having been so close to the CT4 work. I think I managed and learnt a lot in the process.

Highlights: Your first meeting was in Sitges, Spain (CT#86, Dec.2019). Then, we had a dramatic halt to 3GPP meetings and a lot more besides. How did CT cope with the evolving Covid situation?

An early task as CT Chair, at that face-to-face meeting in Sitges, was to discuss the Release 17 timeline. It was quite a stressful time, culminating in joint RAN/SA/CT TSG sessions on the duration and content to release. In parallel, along with the CT Working Group (WG) Chairs, again at in person meetings, we set about further developing coordination at both WG level and plenary level.

We did make a lot of progress on that and I can say that having the Rel-17 discussions already ongoing and our coordination in a good place – particularly within CT - really helped us to deal with what was to come.

An early task as CT Chair, at that face-to-face meeting in Sitges, was to discuss the Release 17 timeline. It was quite a stressful time, culminating in joint RAN/SA/CT TSG sessions on the duration and content to release.

In next to no-time we had to define what successful electronic meetings would look and feel like. For twenty years it had been possible to make things happen in and around the meeting room. From early 2020 it wasn't possible to do that.

Across the groups we put email discussions in place and arranged short on-line events where we could have a live discussion. As a result of that effort throughout the project, we managed to carry on, dealing with the same number of documents as a 'normal' release, and to get Release 17 done, almost on the schedule!

Highlights: What were the advantages and disadvantages of going to e-meetings. Is there an argument for staying with them?

There is support for and a lot of experience gained from the organization of e-meetings. One key advantage for me is the better preparation of the meeting, especially with a reinforced deadline for document submission before the meeting and early exchange of comments before the start of the meeting saving scarce online meeting time.

We managed to be very efficient, so there would be a high degree of confidence that we can hold e-meetings successfully. However, what can't easily be measured looking at only the amazing work produced in a pure e-meeting mode – and it is the main drawback – is the overloading of the delegates. I know that to be actively involved in one e-meeting the delegates were often having to work too long hours to review & address the large number of comments received by email overnight, prepare the daily online session and work late to revise the contributions and send comments to be addressed the following day. One single e-meeting usually lasted between 7 and 10 working days and that surely took its toll on delegates. We did manage to hold online meetings at slightly more convenient times of the day, but it was always hard for one or more of the regions!

Highlights: On the technical aspects of the work, what has excited you the most over your terms as CT Chair?

With no doubt, it is the work on the APIs used in the core network. The adoption of the SBA (Service-Based Architecture) with APIs exposing services has contributed to migrate the mobile core network, traditionally conceived as a walled garden relying on telco-specific point-to-point protocols (e.g., Diameter), to a scalable, resilient and extensible service-oriented environment, more open to third-party developers and vertical industries for the creation of on-demand tailored services.

With the adoption of the principles of REST (Representational State Transfer) for the design and OpenAPI for the description of APIs, CT has created a unified framework that has considerably simplified the development and the implementation of enriched functionalities in the core network. Once the functional requirements have been finalized, we usually just need a couple of meetings to specify the corresponding APIs.

Highlights: What has the leadership been doing to get the newcomers and 'verticals' onboard?

Looking at the newcomers to 3GPP, particularly the verticals, we need to ensure that we have clear processes, showing clearly how to get from the service requirements part, through the definition of the functional aspects, towards the protocol work. Having some tools there at the process level will help a lot. The three TSGs are progressing on this.

We have also started newcomer's training sessions at the plenary and we do have a clearer introduction to 3GPP on the website now – with a better visibility of the TSG/WG activities, a delegates corner, information about the work plan, the use of 3GPP portal and other processes. A lot of information is already out there.

> Previously, we needed a year to develop a new interface, now it's just taking a couple of meetings for the specification to be there with implementable code.

Highlights: Looking to 5G. When you came in as a new TSG CT Chair, you identified your ambition to help to put CT at the heart of system transformation. Has that happened?

Yes, I think so – honestly. What we managed to do in CT is to have a system where we can introduce anything and to be very efficient, and to see the impact on the other parts of the network. Previously, we needed a year to develop a new interface, now it's just taking a couple of meetings for the specification to be there with implementable code.

What we have done will help future systems to be developed.

Highlights: We are here in Rotterdam, at the 99th plenaries. How are Release 19 discussions progressing here?

In CT we are still focused on Rel-18, but we are part of the discussion on the Rel-19 timeline. Here this week we are in discussions (with RAN and SA) to get a working assumption on the timing of Rel-19. This will be revisited in June. It is important to keep CT in mind. We (CT) rely on SA and RAN to collect the functional requirements and what needs to be implemented at the protocol level. As soon as we fix the deadline for the delivery for the release, we will do retro-planning on protocols and for specification updates.

TSG SA especially will drive their stage 2 work to make sure we have enough time for Stage 3 updates. One thing is sure, all will be clearer on Rel-19 in June!

Congratulations to Lionel Morand on two successful terms as CT Chair. Going forward, he will be a familiar face at both TSG CT and TSG SA as a lead delegate for Orange.

▼ TSG CT#99 room and top table, March 2023

A LOOK INSIDE

MEMBERSHIPS IN 2023

A full list of the companies in 3GPP is available online at: **https://www.3gpp.org/about-us/membership.**

3GPP has welcomed the following organisations* into the project during 2023 so far. We currently have 816 participating companies and organizations in 3GPP.

New 3GPP Industry Members in 2023	Partner
Alibaba (China) Group., Ltd.	CCSA
Cosmian Tech SAS	ETSI
DigitalPlatforms SpA	ETSI
Frequentis AG	ETSI
Honda Motor Co., Ltd	ARIB
Institut de recherche technologique Saint Exupery	ETSI
Jio Estonia OÜ	ETSI
National Chung Cheng University	ETSI

New 3GPP Industry Members in 2023	Partner
Nokia	ETSI
OneWeb	ETSI
Operational Technology Division (OTD), FBI	ATIS
Plan S Uydu ve Uzay Teknolojileri A.S	ETSI
Richtek, Korea	TTA
Samsung	CCSA
Terrestar Solutions	ATIS
ZTE Japan K.K.	ARIB

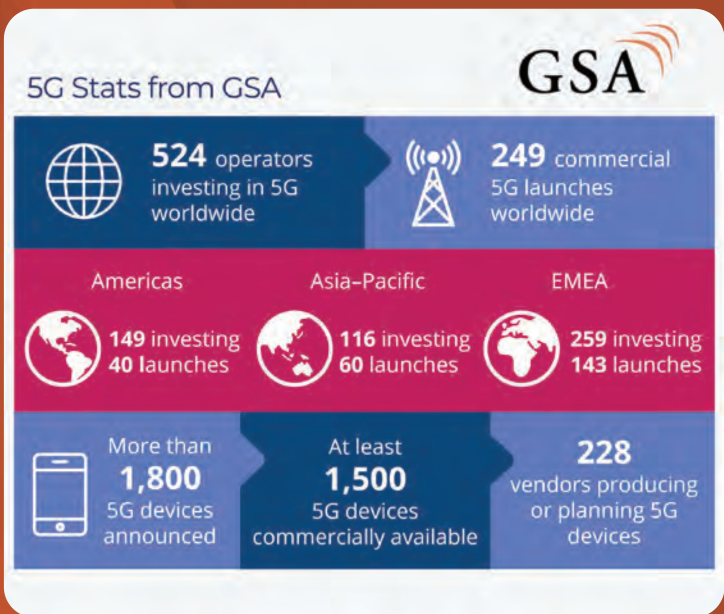
*NB. The list above may represent the recent evolution of an existing membership, or a change of company name, in addition to being a list of new members.

PARTNER FOCUS

GSA has been promoting and supporting its Members in the deployment of standardized mobile technologies via research initiatives and globally focused reports, covering everything from devices, mobile networks, fixed wireless networks, deployed mobile technologies, chipsets and far beyond.

More recently, there has been a growing focus on spectrum allocations, pricing, and usage. GSA also has an increasing global reputation for promoting the 3GPP technology roadmap and producing distinctive reports based on the current status of the industry.

https://gsacom.com/



CALENDAR OF MEETINGS

A selection of the major meetings for the period June 2023 - December 2023.

Only the August cycle of WG meetings is shown. A similar spread of WG meetings takes place each May, August, November and February – prior to the Plenaries (TSGs).

Meeting	Start	End	City
3GPP CT#100	12-Jun-23	13-Jun-23	Taipei
3GPP RAN#100	12-Jun-23	14-Jun-23	Taipei
3GPP SA#100	12-Jun-23	16-Jun-23	Taipei
3GPP SA-Release 19 Workshop	13-Jun-23	14-Jun-23	Taipei
3GPP RAN-Release 19 Workshop	15-Jun-23	16-Jun-23	Taipei
3GPP CT1#143	21-Aug-23	25-Aug-23	Goteborg
3GPP CT3#129	21-Aug-23	25-Aug-23	Goteborg
3GPP CT4#117	21-Aug-23	25-Aug-23	Goteborg
3GPP CT6#116	22-Aug-23	25-Aug-23	Goteborg
3GPP SA1#103	21-Aug-23	25-Aug-23	Goteborg
3GPP SA2#158	21-Aug-23	25-Aug-23	Goteborg
3GPP SA3#112	14-Aug-23	18-Aug-23	Goteborg
3GPP SA4#125	21-Aug-23	25-Aug-23	Goteborg
3GPP SA5#150	21-Aug-23	25-Aug-23	Goteborg
3GPP SA6#56	21-Aug-23	25-Aug-23	Goteborg

Meeting	Start	End	City
3GPP RAN1#114	21-Aug-23	25-Aug-23	Toulouse
3GPP RAN2#123	21-Aug-23	25-Aug-23	Toulouse
3GPP RAN3#121	21-Aug-23	25-Aug-23	Toulouse
3GPP RAN4#108	21-Aug-23	25-Aug-23	Toulouse
3GPP RAN5#100	21-Aug-23	25-Aug-23	Toulouse
3GPP CT#101	11-Sep-23	12-Sep-23	Bangalore
3GPP RAN#101	11-Sep-23	15-Sep-23	Bangalore
3GPP SA#101	11-Sep-23	15-Sep-23	Bangalore
3GPP CT#102	11-Dec-23	12-Dec-23	Edinburgh
3GPP RAN#102	11-Dec-23	15-Dec-23	Edinburgh
3GPP SA#102	11-Dec-23	15-Dec-23	Edinburgh

Source: https://portal.3gpp.org

▲ Georg Mayer, Wanshi Chen and Lionel Morand share a moment at a joint session at TSGs#99

Leadership elections

The March 2023 plenaries (#99) heralded the appointment of a new leadership team for the Technical Specification Groups (TSGs). On Monday, the re-election – for a second term - of Wanshi Chen to Chair of TSG RAN (Radio Access Networks) was completed my acclimation.

Next up was TSG CT (Core Network and Terminals), where Peter Schmitt was appointed to succeed Lionel Morand – after his two terms - as Chair for the next two years.

The week was completed by the election of Puneet Jain to the Chair of TSG SA (Service and System Aspects), replacing Georg Mayer – also after two terms.

With the elections in all three TSGs now finalised, 3GPP's top technical leadership is in place for Release 18 completion and the planning phase of the Release 19 work, which will be the focus of the groups from early 2024. The 3GPP community is united in wishing the outgoing and newly appointed TSG Chairs the best of luck and great success.

Landmark meeting for the project

3GPP will hold its 100th TSG meetings in Taipei, June 12-16. The meetings will be memorable, not least because of the fantastic location, but also because it provides an opportunity to celebrate the achievement of such a number: 100 is quite an age!

Fittingly for such a landmark event, the Taipai week will also be an important one for the future work of the groups, with Rel-19 workshops scheduled during TSG RAN#100 and TSG SA#100. Once completed, the leadership of the TSGs and WGs will work to shape the priorities and schedule of the release's content. This is a familiar task, with 18 releases started in the first 100 plenary cycles, the balancing act between the demand for new work and time available is well rehearsed.

NR based NTN solutions

The Release 17 work item on NR based NTN solutions was completed at RAN#99 in Rotterdam (core and performance parts). In Release 18, work is set to continue - towards the optimization of satellite access performance, with Rel-17 deployments built to be 'upgrade ready'. See the article covering the achievement in this issue (P22) by the Global Satellite Operators Association.

3GPP's MRPs:

Thanks to the 3GPP Market Representation Partners in 3GPP, for their continued support and generous inputs to each edition of 3GPP Highlights.

3GPP A GLOBAL INITIATIVE

www.3gpp.org/about-3gpp/partners

5GAA 5GACIA 5G americas 5G DNA 6G SNS IA 5G MAG 5G SLICING ASSOCIATION AECC BIF CHINA SAE COAI ctia GCF GSA GSOA GSMA IPv6 FORUM MFA MITRE ENGENUITY Open Generation SIAINDIA NGMN PSCEurope SCF TCCA TDIA TD-SCDMA Industry Alliance Wireless Broadband Alliance