3GPP A GLOBAL INITIATIVE

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3GPP Highlights

3GPP - the 5G Standard

Technical News

We have a clean sweep of the Technical Specification Groups this issue, with contributions from the TSG CT, TSG RAN and TSG SA Chairs.

There is also a contribution from our WG RAN1 leaders and expert articles taking us deeper into the work on Network Slice charging for NSAC and NSSAA, Security features for Non-public Networks (NPN), Critical Communications and Application Enablement for Verticals, NR duplex operation and more about the IVAS Codec for voice and audio.

Partner Focus

This issue we have invited the Market Representation Partner MFA, the Alliance for Private Networks to tell us how they are Supporting NPN Adoption.

The TCCA tell us about networking capabilities referred to as 'QPP' (Quality of Service, Priority and Pre-emption) and about their White paper on the regulatory aspects for QPP realisation.

The TSDSI also feature, with a snap-shot of their recent Outreach activity.

A look inside

Our in-house section has an interview with Antti Toskala, Head of 3GPP Radio Standardization, Nokia Bell Labs. As he celebrates reaching a landmark of TSG attendance that may not be equalled.

We have some facts and figures about our membership as well as a listing of the major meetings for the next six months. There is also news about a recent Award and a listing of our TSG and WG chairs, following the completion of the 2023 election cycle.

FORE - WORD

Both Rel-18 and Rel-19 battle for centre stage as the first 5G-Advanced specs are published

In this issue we herald the availability of the first Release 18 specs and get the latest news from our experts on the stream of work that will now be unleashed as the release heads towards its functional freeze date - scheduled in March 2024 (ASN.1 freeze in June'24).

In June 2023 we had the first workshops on the content of Release 19. In this issue we have two articles from the Chairs that touch on the headway made there and on the subsequent progress, as TSG RAN and TSG SA look to have a stable pack of Rel-19 projects by the December Plenaries (TSGs#102).

Happy 25th Anniversary

On December 4, 1998 the 3rd Generation Partnership Project Agreement was co-signed by the originating Partners (ARIB, ETSI, ATIS, TTA and TTC) and by the only Market Representation Partner at the time (UMTS Forum).

As we reach the 25th anniversary of the Agreement, 3GPP now has 853 member companies or organizations from the 7 SDO Partners (CCSA from 1999 and TSDSI joined in 2015) and we count on the support of 26 MRPs. A small celebration is planned during the December Plenaries, in Edinburgh (TSGs#102).

One of the pioneers from the early years is Antti Toskala, who has represented Nokia at almost all of the Plenaries, reaching his 100th TSG during TSGs#101. In this issue we have a chat with Antti about his quarter of a century in RAN and markedly in RAN1.

In Highlights Issue 7 we feature articles from nine of the 3GPP technical groups, and two from the MRPs. On the MRP side, we have our first article from the MFA, the Alliance for private networks and a regular contribution from the TCCA, this time on Quality of Service, Priority and Pre-emption (QPP).

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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NEWS IN BRIEF

Lifetime Achievement Award 2023

Chris Pudney was presented with a 3GPP Lifetime Achievement Award during the SA Working Group meetings, in May.

Chris has been involved in almost all 3GPP working groups - representing Vodafone - keeping an overall system perspective, but with an acknowledged passion for 5G Network Architecture and the arrival of the Internet of Things (IoT). Both topics are areas where his fair minded and expert opinion is constantly sought.

His two decades of involvement in 3GPP and a catalogue of achievements make Chris Pudney the worthy eighth recipient of the 3GPP Lifetime Achievement Award.

For more:
https://www.3gpp.org/news-events/3gpp-news/chris-pudney

Celebrating 100 Plenaries

The 100th Plenaries of the Technical Specification Groups in 3GPP were celebrated in Taipei during June 2023.

On the Wednesday evening of TSGs#100 delegates took time off to attend a social event, organised by meeting hosts TAICS and MediaTek Inc., celebrating the 100 Plenaries with a 'Formosa Night - 100 touches of Taiwan'.

At TSGs#102, in Edinburgh during December, the project will celebrate the 25th Anniversary of the first signing of the 3GPP Agreement (December 4, 1998). There is some speculation that delegates may be treated to a few touches of Scottish beverages to mark the occasion. In moderation of course.

Charity Run in Toulouse

Our delegates at the August RAN WG meetings ran for fun, and to raise over €8K to help the Simon de Cyrene charity to build houses in Toulouse for adults with severe handicaps, to allow them to live alongside their carers, as part of an inspiring co-housing project. See our front cover photo of the post run presentation.

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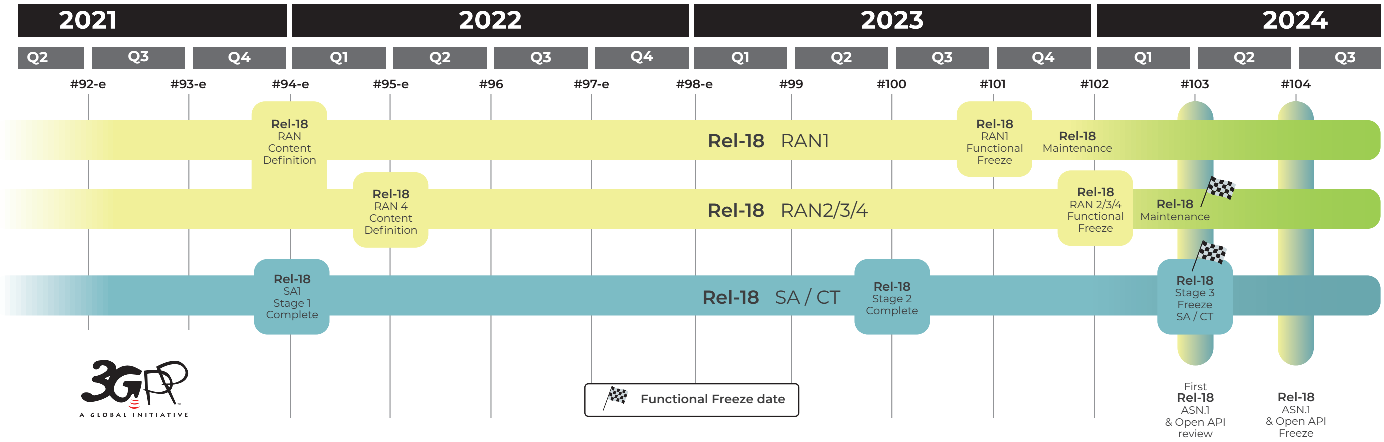
REL-18 STATUS AND REL-19 PROGRESS IN TSG SA

By Puneet Jain, 3GPP TSG SA Chair

Figure 1: Rel-18 timeline



Release 18 Status

Rel-18, the initial release for 5G-Advanced, signifies the subsequent stage in the progression of 5G technology. 5G-Advanced aims to provide new functionalities extending beyond mere connectivity, thus unlocking a broader spectrum of sophisticated applications tailored to vertical industries and sectors.

During SA#98-e meetings in December 2022, the challenges associated with e-meetings prompted a decision to extend the Rel-18 deadlines by three months. Consequently, the Stage-2 functional freeze has been rescheduled to June 2023, the Stage-3 freeze deadline has been moved from December to March 2024, and the ASN.1/OpenAPI freeze deadline has been adjusted from March to June 2024.

I am pleased to report that Stage 2 has been successfully finalized in all SA Working Groups, and we remain on track to deliver the implementable Rel-18 specifications by June 2024.

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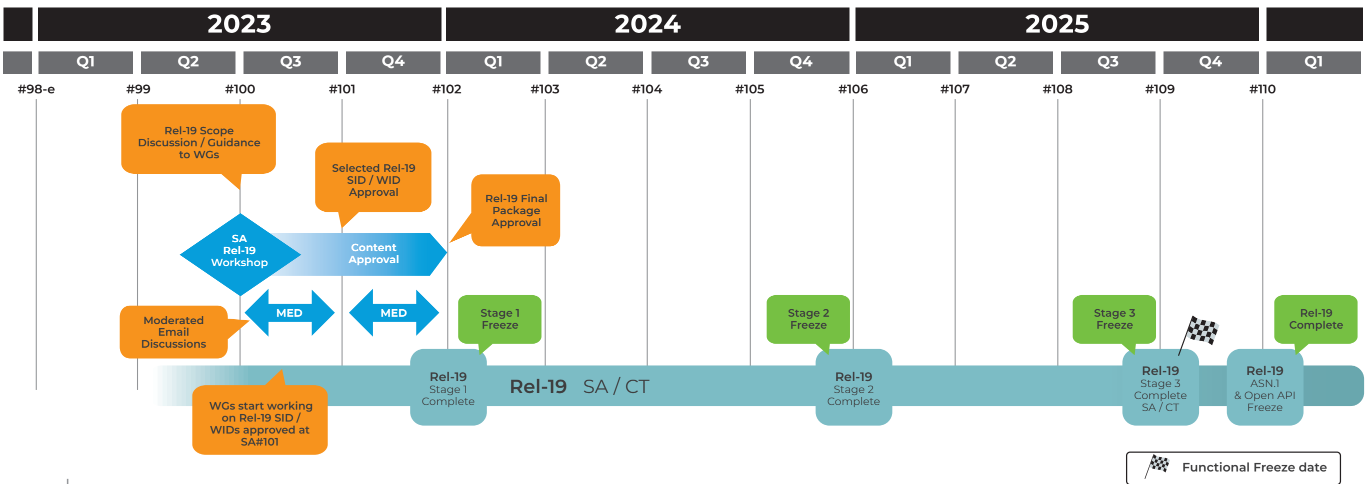
Figure 2: Rel-19 Content definition Process and timeline



Release 19 Progress

Rel-19 is the second release for the 5G-Advanced. In SA1 (Services), work on the use cases and normative service requirements for Rel-19 Stage 1 has been in progress. This effort is currently 80% complete and is expected to reach full completion by December 2023.

The planning for Stage 2 work was initiated during the SA Rel-19 workshop conducted in Taipei, in conjunction with the SA#100 meetings. This event garnered active participation from a diverse spectrum of 3GPP members, encompassing vendors, operators, verticals, and MRPs. A notable total of 65 valuable contributions were made during this workshop. In the process, the definition of Rel-19 content, employing a two-step approval procedure consisting of moderated email discussions and approval during physical meetings was agreed upon (See Figure 2 on page 4).

TSG SA Core & Miscellaneous topics for inclusion in Release 19

After two days of in-depth discussions, TSG SA identified 17 "core" and 15 "miscellaneous" potential topics for inclusion in Rel-19, as illustrated in Figure 3. Subsequently, during the SA#101 meeting, following further deliberations, 5 SIDs were approved for Rel-19 topics (highlighted in green in Figure 3), marking the commencement of work in SA2 (System Architecture and Services) during Q4.

The core items and miscellaneous topics highlighted in cyan color in Figure 3 will be further discussed in WG SA2 in Q4, 2023 for final Rel-19 content approval in SA#102 (Dec). The remaining topics will not be part of the Rel-19 content definition but may be considered for TEI19 (Small Technical Enhancements and Improvements).

Core topics:

1. Satellite Architecture Enh.
2. XRM Enh. and Metaverse
3. AI / ML Enh.
4. Multi-access (Dual 3GPP + ATSSS Enh.
5. Integrated Sensing and Communication
6. Ambient IoT
7. Energy Efficiency/Energy Saving as a Service
8. IMS and NG_RTC Enh.
9. Edge Computing Enh.
10. Proximity Services Enh.
11. TSC/URLLC/TRS Enh.
12. Network Sharing
13. User Identities + Id of device behind RG/AP
14. 5G Femto
15. UAS Enh.
16. VMR Enh.
17. UPEAS Enh.

Misc. topics:

1. SBA framework Enh. / 5GS Enh. for Cloud Native Deployment
2. Network Slicing
3. 5G SA Roaming services and Intermediaries (GSMA 5MRR request)
4. Traffic Management (Monitoring + + QUIC)
5. Enh. in handling of Radio Capabilities
6. 5GC Enh. for IP routing
7. Enh. Emergency Services when Zero CS network coverage
8. NPN Enh.
9. Ranging Phase 2
10. LCS Enh.
11. Mobile VPN
12. Architecture Enh. for Energy Utilities
13. eUEPO (UE Policy) Enh.
14. Interworking of Non-3GPP Digital Terrestrial Broadcast Networks with 5GS Multicast Broadcast Services
15. RVAS (Roaming Value-Added Services)

Green denotes topics for which SIDs were agreed at SA#101 meeting | Cyan denotes topics that will be discussed further in Q423 | The remaining topics will not be part of Rel-19 content

Figure 3: Rel-19 Topics

SA6 (Application Enablement and Critical Communication Applications) has decided to enhance existing specifications for application enablement, such as Mission Critical Services, Enabling Edge Applications, Location Services, IoT Messaging, Data Delivery, and Uncrewed Aerial Systems (UAS) in Rel-19. They are also working on new AI/ML and eMMTel services specifications. Additionally, they are considering new topics like Localized Mobile Metaverse and XR Services, Satellite-access-enabled 5G Services, and Sensing Enablers for Vertical Applications within Rel-19.

Discussion on Rel-19 topics are concurrently taking place within SA3 (Security), SA4 (Multimedia Codecs, Systems and Services), and SA5 (Management, Orchestration and Charging) and some early projects are expected to be approved in TSG#102.

It is noteworthy that SA2 has the capacity to accommodate a range of 10 to 14 study/work items within the scope of Rel-19, as determined by the Time Unit (TU) budget estimate. Should prioritization become necessary, it will be addressed during SA#102. In contrast, other SA Working Groups do not anticipate requiring prioritization, as their current workload remains manageable.

It may be worth pointing out that SA#101 also engaged in preliminary discussions regarding the 6G work plan, prompted by an incoming liaison from ITU-R related to finalizing the IMT2030 framework document. No definitive conclusions were reached on this matter, and we anticipate further discussions on the 6G work plan and its timeline during the SA#102 meetings scheduled for December.

5G NETWORK SLICE CHARGING FOR NSAC AND NSSAA

By Gerald Görmer,
WI Rapporteur, MATRIXX Software

After the study on charging aspects for enhancements of Network Slicing Phase 2 (TR 32.847) has been concluded, two new charging capabilities are specified for Rel-18 for monetization of Network Slice(s) service provided by Communication Service Providers (CSP), which are the focus of this article:

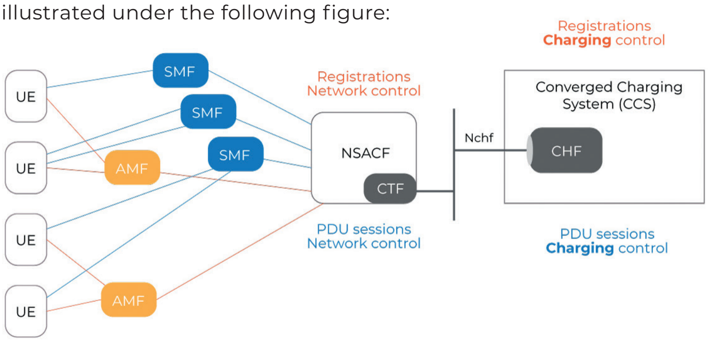
- **Converged charging for Network Slice Admission Control (NSAC);**
- **Converged charging for Network Slice-Specific Authentication and Authorization (NSSAA) enabled in the 5G System.**

Network Slice Admission Control (NSAC) charging (TS 28.203)

Network Slice Admission Control Function (NSACF) in the 5G System monitors and controls the number of simultaneous registered UEs and/or the number of simultaneous PDU Sessions per network slice, based on maximum values for both configured in the NSACF.

This functionality is enhanced with charging capabilities allowing MNOs to monetize per network slice, variation of number of simultaneous registered UEs and number of simultaneous PDU Sessions over different periods and/or within different ranges.

These capabilities rely on the NSACF embedded Charging Trigger Function (CTF) using CHF Nchf ConvergedCharging API, as illustrated under the following figure:

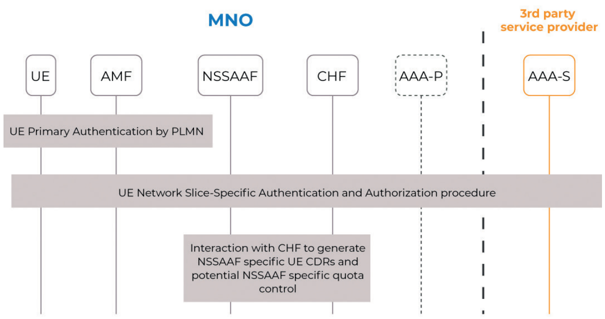


While the NSACF controls the UE registrations across AMFs for a given network slice, the Converged Charging System (CCS) performs charging control of UE registrations for the network slice, based on CCS owned criteria such as specific UE registrations thresholds crossed upwards or downwards subject to dedicated rating.

In addition, Online Charging control provided by the CCS quota management functionality allows quota limitation or extension of simultaneous UE registrations in the network slice under certain circumstances, e.g. status balance of network slice tenant.

The mechanism can also apply for number of simultaneous PDU Sessions controlled across SMFs, and both can be combined.

Network Slice-Specific Authentication and Authorization (NSSAA) charging (TS 28.204)



Network Slice-Specific Authentication and Authorization (NSSAA) charging (TS 28.204)

Another charging capability is introduced for MNOs to monetize 3rd party service providers per allocated network slice.

This capability is based on Network Slice-Specific Authentication and Authorization (NSSAA) procedure allowing such service providers to grant authorization or not to individual UEs for accessing a particular network slice. The charging solution is built on invocations of Nchf ConvergedCharging CHF API by the Network Slice-Specific Authentication and Authorization Function (NSSAAF) on a per UE procedure towards the 3rd party service provider AAA Server (AAA-S).

Generated CDRs will be used for the MNO to invoice the 3rd party service provider for the NSSAA service which is enabled in the PLMN of the MNO for interaction with the AAA server. In addition, the MNO can supervise such enablement via
quota control.

TSG CT PROGRESS TOWARDS REL-18 COMPLETION

By Peter Schmitt, TSG CT Chair

The recent TSG CT plenary meeting held in Bangalore (TSGs#101) was the first after the freeze of stage 2 of Release 18, in June.

More than 100 delegates registered to the September meeting, at which the CT working group chairs reported good progress on all 74 work items for stage 3 of Rel-18, with five already reported as completed

Progress on study items for Rel-18

Two more of the six TSG CT study items in Rel-18 are now complete:

- Study on Network Repository Function (NRF) API enhancements to avoid the storage of redundant data and excessive data exchanges caused by duplicate information in the APIs or massive data change notification signalling - caused by duplicate profile data held (CP-231022).
- Study on IETF QUIC Transport for Service Based Interfaces (SBI). The study on QUIC (UDP-Based Multiplexed and Secure Transport protocol) was long term topic started in 2018. Now, after analysing the final IETF documents the conclusion is to stick to the current protocol stack using TCP and to not change the protocol stack on SBI interfaces, so no normative work will be needed for 5G Advanced.

The following CT4 study items are in progress and still expected to be finalized within the Rel-18 timeframe:

- Study on IMS Disaster Prevention and Restoration Enhancement (CP-232281). IMS-related or IMS-affected communication accidents happen. This study looks at creating and enhancing a restoration mechanism to support the normal use of voice, video and SMS services in the IMS network. Specifically, it adopts the context data of registered online users stored by HSS/UDM, S-CSCF, P-CSCF and MMTEL to bypass the faulty network functions or links.

- Study on Reducing Information Exposure over SBI (CP-231350). Looks at the need and potential solutions for avoiding excessive exposure and for avoiding indirect access to data.

Another important discussion during the TSG CT#101 meeting in Bangalore, was a request in CT1 for the allocation of an EtherType value for 3GPP TS 24.193 (v18.0.0.) on 5G Access Traffic Steering, Switching and Splitting (ATSSS); Stage 3.

"An Ethertype provides context (protocol identification) for interpretation of the data that follows within a frame" (Source: IEEE). TSG CT has asked the IEEE Registration Authority Committee (RAC) to clarify the need and to allocate a value.

CT is now setting up a way to track 3GPP Ethertype requests to IEEE in a similar manner to the data kept on the 'IANA registration request tracking' page, with a link via the CT1 WG home page (trial phase) and soon to be accessible via the Delegates corner.

As Release 19 gets underway, TSG CT will try to anticipate the impact of new work on the core network. This new release will see a new level of coordination between the groups, inside and outside of 3GPP, to meet the diverse needs of the industries coming into the work.

Technical Specification Groups (TSGs)

The Working Groups, within the TSGs, meet regularly and come together for their quarterly TSG Plenary meeting, where their work is presented for information, discussion and approval.

TSG CT Core Network & Terminals	TSG RAN Radio Access Network	TSG SA Service & System Aspects
CT WG1 User Equipment to Core Network protocols	RAN WG1 Radio Layer 1 (Physical layer)	SA WG1 Services
CT WG3 Interworking with External Networks & Policy Charging Control	RAN WG2 Radio Layer 2 and Radio Layer 3 Radio Resource Control	SA WG2 System Architecture and Services
CT WG4 Core Network Protocols	RAN WG3 UTRAN/E-UTRAN/NG-RAN architecture and related network interfaces	SA WG3 Security and Privacy
CT WG6 Smart Card Application Aspects	RAN WG4 Radio Performance and Protocol Aspects	SA WG4 Multimedia Codecs, Systems and Services
	RAN WG5 Mobile terminal conformance testing	SA WG5 Management, Orchestration and Charging
	RAN AH1 ITU-R Ad Hoc	SA WG6 Application Enablement and Critical Communication Applications

For more on TSG CT: **www.3gpp.org/3gpp-groups**

SECURITY FEATURES FOR NON-PUBLIC NETWORKS

By Christine Jost, WI Rapporteur
SA3, Ericsson

The Non-Public Network (NPN) is one of the main new scenarios for 5G compared to earlier generations of mobile networks. NPNs are network deployments intended for usage of a private entity, such as an enterprise (see clause 6.25 of TS 22.261 **[o]**). 3GPP SA3 has included security features for Non-Public Networks from Rel-15 and extended them in Releases 16, 17 and 18.

The term "Non-Public Network" was introduced in Rel-16. In Rel-15, the terms "private network" and "isolated deployment" were used. The starting point for the security of NPNs is that the same level of security for 5G deployments in Public Land Mobile Networks (PLMN) of course also applies to Non-Public Networks.

The difference between NPN and PLMN from a security standardization point of view is only based on different use case requirements for security features, for example on the support of certificate-based authentication methods. But let's take it step-wise and see how the security features of NPN have evolved from Rel-15 to Rel-18.

Release 15

The most basic feature that many of the later additions rely on is the introduction of the EAP framework at the fundamentals of 5G authentication in Rel-15.

EAP stands for Extensible Authentication Protocol and is specified in the IETF RFC 3748 **[x]**. EAP itself is not an authentication method, but a framework that allows the usage of several authentication methods.

For 5G, the most illustrative examples are EAP-AKA' and EAP-TLS. EAP-AKA' **[z]** allows to run the 3GPP specified AKA (Authentication and Key Agreement) protocol, for authentication to 3GPP networks, over EAP. The predecessor of EAP-AKA', namely EAP-AKA **[z1]**, was introduced to 3GPP already in Rel-6 for non-3GPP access to 3G.

The other example is EAP-TLS **[y][y1]**, which specifies the usage of TLS over EAP. With that, EAP-TLS allows the usage of TLS and certificate-based authentication, which is widely used on the internet and for enterprise use cases, over EAP.

In Rel-15, SA3 specified that EAP-AKA' is, besides 5G-AKA, one of the two mandatory authentication methods for accessing the 5G core network via any access type. This integrates the EAP framework firmly into 5G security, compared to EPS where EAP-AKA/EAP-AKA' support was used only for the non-3GPP access type. The authentication framework for 5G and the usage of EAP-AKA' for authentication to 5G networks is described in clause 6.1 of TS 33.501 **[m]**.

In Rel-15, SA3 also described the usage of EAP-TLS, for private networks or IoT devices in isolated deployments of 5G, in the informative Annex B of TS 33.501 **[m].** There is one interesting technical detail in this procedure, related to the derivation of the 5G key hierarchy from the keys agreed between UE and AUSF as a result of a successful run of EAP-TLS. In EAP-TLS, the authentication server derives both the MSK (Master Session Key) and the EMSK (Extended Master Session Key) from the TLS master secret. The MSK is exported from the EAP-server, while the EMSK is not shared outside the EAP-server.

> The most basic feature that many of the later additions rely on is the introduction of the EAP framework at the fundamentals of 5G authentication in Rel-15.

When EAP-TLS is used between UE and AUSF, the key hierarchy is based on the EMSK. This avoids that the master key from which the key hierarchy is derived leaves the AUSF. In consequence, this also prevents that another network using the same credentials infrastructure (e.g., in a factory or an enterprise) can impersonate the 5G Non-Public Network, since this network would only have access to the MSK.

Release 16

While Rel-15 was the release for the basic 5G security features, Rel-16 was the release for the first line of feature extensions, and enhanced support for Non-Public Networks was one of them.

SA3 took a closer look at authentication for Standalone Non-Public Networks (SNPN) and clarified how the 5G key hierarchy extends to any key-generating EAP method, not only EAP-TLS. More specifically, the derivation of the key KAUSF and the serving network name binding of the key hierarchy were clarified. Besides Standalone Non-Public Networks, Public Network Integrated Non-Public Networks (PNI-NPN) is an important use case. According to TS 23.501 **[p]**, clause 5.30.3.1, "Public Network Integrated NPNs are NPNs made available via PLMNs e.g. by means of dedicated DNNs, or by one (or more) Network Slice instances allocated for the NPN."

Fortunately, the security specifications for PNI-NPN are straightforward, since the security of the PLMN in which the PNI-NPN integrates applies. The only thing that needed to be clarified was authentication for UE access to PNI-NPN, however

> Another new use case for NPN in Rel-16 was the CAG (Closed Access Group)

secondary authentication and slice-specific authentication, both specified in other contexts, can be used for that. Another new use case for NPN in Rel-16 was the CAG (Closed Access Group). SA3 specified that CAG ID lists need to be sent protected. With respect to SUPI (Subscription Permanent Identifier) privacy, it extends to NPN with the only exception that the location of the functionality on the UE is out of scope. All of this is specified in subclauses of Annex I in TS 33.501 **[m]**.

Release 17

Rel-17 brought another series of important features for the security of Non-Public Networks.

One of the main pieces of work was the authentication procedure between UE and network using an external Credentials Holder using a AAA (Authentication Authorisation Accounting) server. This authentication procedure is also based on the usage of EAP. However, since the AAA server is assumed to be legacy, there is an interesting difference to the key hierarchy compared to the case where the EAP authentication is run directly with the 5G core network. The legacy AAA server cannot derive the 5G specific key K_{AUSF}, and it will not export the EMSK to another entity which could derive it. Hence the key hierarchy needs to be based on the MSK instead of the EMSK for this case. This procedure is specified in Annex I.2.2.2.2 of TS 33.501 **[m]**.

The procedure for authentication with a Credentials Holder using AAA includes another important technical detail, the introduction of the anonymous SUCI (Subscription Concealed Identifier). While AKA-based authentication methods to 5G use public-key based encryption of the SUPI to construct the SUCI, certificate-based authentication methods like EAP-TLS have the option that the client (UE) first sends an anonymous identifier before encryption has been established and later, after the establishment of an encrypted tunnel, sends the certificate with the identifier. To make this option available for 5G SNPNs, it was necessary to specify the anonymous SUCI (done by CT4 in TS 23.003 **[n]**) and the handling of the anonymous SUCI in the network (in Annex I.5 and Annex I.2.2.2.2 of TS 33.501 **[m]**).

Compared to the situation for a Credentials Holder using a AAA server, the authentication procedures for a Credentials Holder using an AUSF/UDM (i.e. PLMN or SNPN) were straightforward to specify, since the authentication procedure is the same as in the roaming scenario for PLMN.

In Rel-17, SA3 also specified authentication between UE and an Onboarding Network for the purpose of onboarding a UE to an SNPN, i.e., provisioning of the UE with SNPN credentials and other necessary information. The pre-requisite is that the UE is configured with Default UE credentials for authentication between UE and the Onboarding Network. Default UE credentials are "Information configured in the UE to make the UE uniquely identifiable and verifiably secure to perform UE onboarding" as specified in TS 23.501 **[p]**. Authentication using Default UE credentials is possible both with and without a Default Credentials Server (DCS). The procedures are specified in Annex I.9 of TS 33.501 **[m]**.

Further, in Rel-17 SA3 explained how token-based authorization applies to Non-Public Networks and that roaming related security procedures extend to the Credentials Holder scenario, even though the UE is not considered to be roaming.

Last but not least, in Rel-17 SA3 also described the usage of another certificate-based authentication method, namely EAP-TTLS **[a]**, in the informative Annex U of TS 33.501 **[m]**.

Release 18

The main addition in Rel-18 was the security for access to SNPN service via non-3GPP access, captured in Annex I.10 of TS 33.501 **[m]**. Specifically, SA3 specified the security for untrusted non-3GPP access, trusted non-3GPP access, NSWO (Non-Seamless Wireless LAN Offload) and N5CW (Non-5G-Capable over WLAN) devices to SNPN. Fortunately, most of the security procedures for PLMN apply also in the SNPN case. However, the selection of authentication method and the option to use the anonymous SUCI required some adaptations. Especially for the different deployment models with and without Credentials Holder, using AAA or AUSF/UDM, some detailed description of the authentication applicable to these specific cases were necessary.

Furthermore, security for accessing a localized service was described in Annex I.11 of TS 33.501 **[m]**.This could be done by simply referring to existing authentication procedures.

Summary

3GPP security specifications for 5G Non-Public Networks are based on the same level of security for 5G deployments of PLMNs, but extend security features to NPN specific use cases. The main addition is the adoption of the EAP-framework allowing the usage of additional authentication methods within the EAP-framework, and the description of different certificate-based authentication methods with and without external Credentials Holder for usage in Non-Public Networks.

[o] 3GPP TS 22.261 "Service requirements for the 5G system"

[m] 3GPP TS 33.501 "Security architecture and procedures for 5G System"

[n] 3GPP TS 23.003 "Numbering, addressing and identification"

[p] 3GPP TS 23.501 "System architecture for the 5G System (5GS)"

[x] "Extensible Authentication Protocol (EAP)" IETF RFC 3748

[z] "Improved Extensible Authentication Protocol Method for 3GPP Mobile Network Authentication and Key Agreement (EAP-AKA')" IETF RFC 9048

[z1] Extensible Authentication Protocol Method for 3rd Generation Authentication and Key Agreement (EAP-AKA) IETF RFC 4187

[y] "The EAP-TLS Authentication Protocol" IETF RFC 5216

[y1] "EAP-TLS 1.3: Using the Extensible Authentication Protocol with TLS 1.3" IETF RFC 9190

[a] "Extensible Authentication Protocol Tunneled Transport Layer Security Authenticated Protocol Version 0 (EAP-TTLSv0)" IETF RFC 5281

REL-18 STATUS AND REL-19 PROGRESS IN TSG RAN

By Wanshi Chen, TSG RAN Chair

The first release of 5G's "2nd phase" of standardization in 3GPP, Release 18 (aka 5G-Advanced), is close to the finish line in TSG RAN. At the same time, discussion on Release 19 is ongoing, aiming at having the Rel-19 package approval for RAN WG1, 2 and 3 (RAN1/2/3) completed by the end of 2023.

Release 18 Status in TSG RAN

The release is providing a steady evolution in terms of:

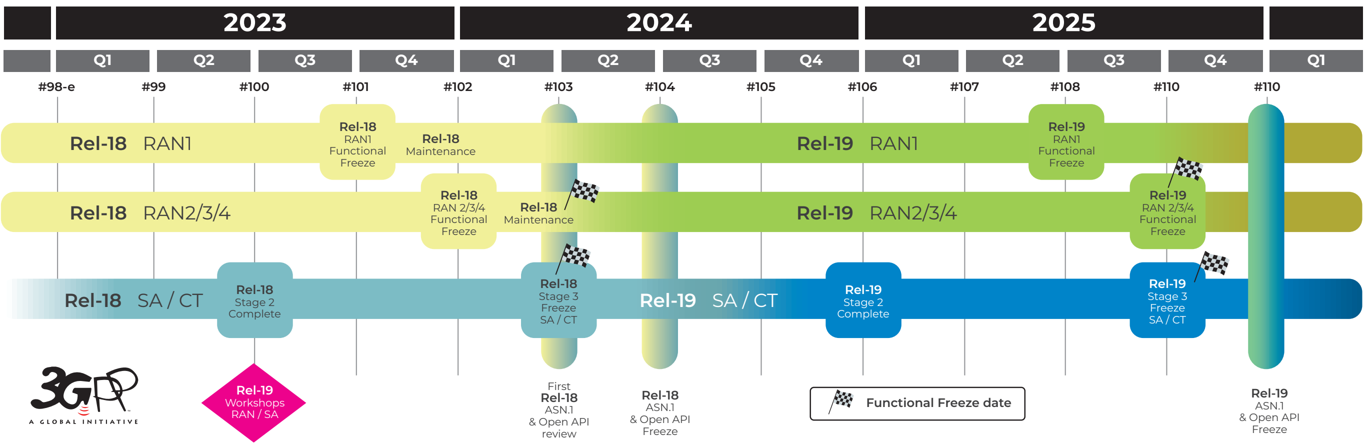
- Balanced mobile broadband evolution vs. further vertical domain expansion,
- Balanced immediate vs. longer term commercial needs, and,
- Balanced device evolution vs. network evolution.

The work started in 2Q'2022 in RAN1, and in 3Q'2022 in RAN2/3/4, in the usual staggered manner. Rel-18 was planned to have the functional freeze in September 2023 for RAN1, and in December 2023 for RAN2/3/4, forming an 18-month duration for the release.

> To ensure sufficient specification stability, RAN1 will be dedicated to Rel-18 maintenance in 4Q'23

Despite the challenges of the slow resumption of face-to-face meetings from the second half of 2022 and the inevitable negative impact on the meeting efficiency, RAN was able to declare that functional freeze in RAN1 on time.

To ensure sufficient specification stability, RAN1 will now be dedicated to Rel-18 maintenance in 4Q'23. The functional freeze for RAN2/3/4 is expected to be in December 2023, with the first ASN.1 review scheduled for March'24 and the ASN.1 freeze date of June'24.



Release 19 Workshop in RAN

The discussion on Rel-19 in RAN had a strong start with the Rel-19 workshop. The two days of sessions in June 2023 drew strong interest around the globe, with ~480 submissions presented by over 80 different companies & organizations.

Release 19 will primarily focus on continuing investing in 5G-Advanced commercial deployments to further improve performance and address critical needs, including:

- Continuing balanced evolutions as in Rel-18, and
- Addressing real and urgent commercial deployment needs.

Release 19 can also serve as a bridge to 6G, including the strong interest to initiate some studies (e.g., channel modeling for new spectrum such as 7-24GHz, etc.). The following list (and graphic below) illustrates the categorization of the topics based on the contributions to the workshop. The overall Rel-19 load is expected to be lower than Rel-18.

Release 19 in RAN#101 (September, 2023)

RAN#101 (Bangalore, September 2023) provided the first consolidation of the potential Rel-19 projects. A first-order Time Unit (TU) estimate was provided for some RAN1/2/3-led projects. Some TUs were also reserved for purposes such as necessary cushion, flexibility for WG chairs, preparation for urgent commercial needs, and dedicated handling of inter-WG/inter-TSG matters.

For RAN1, the first-order TU estimate was provided for the following RAN1-led projects:

- AI (Artificial Intelligence)/ML (Machine Learning) for Air interface
- MIMO Evolution
- Duplex Evolution
- Ambient IoT
- Network energy savings
- LP-WUS/WUR
- ISAC & Exploring study in new spectrum (7-24 GHz)

With the above arrangement, RAN1 may have room for up to 2 additional RAN1-led small projects.

For RAN2, the first-order TU estimate was provided for the following RAN2-led projects:

- Mobility Enhancements
- Enhancements for XR
- NTN (Non-Terrestrial Networks) evolution for NR
- NTN (Non-Terrestrial Networks) evolution for IoT
- AI/ML for Air interface SI (Mobility)

With the above arrangement, RAN2 may have room for up to 3 additional RAN2-led small projects.

For RAN3, the first-order TU estimate was provided for the following RAN3-led projects:

- AI/ML for NG-RAN
- SON/MDT Enhancements
- Additional Topological Enhancements

With the above arrangement, RAN3 may not have any room for additional RAN3-led projects.

Note that the first discussion for potential RAN4-led projects occurred during RAN#101 as well.

Decisions in December

In December 2023, TSG RAN (RAN#102) is primarily focusing on projects led by RAN 1, 2, and 3, then focusing on the projects led by RAN4 in March 2024.

It is expected that RAN#102 will be a busy meeting, in order to finalize the set of RAN1/2/3-led projects including the final drafting of corresponding SIDs/WIDs. All the discussion will be based on the progress so far, including agreements and summaries achieved in the Rel-19 workshop (June 2023) and during RAN#101 in September.

As probably the last release dedicated to 5G NR in RAN, careful discussion and management are necessary to ensure Rel-19 continues to serve all critical commercial needs and that it stands ready to provide a bridge to 6G.

RAN CATAGORIZATION OF TOPICS BASED ON REL-19 WORKSHOP CONTRIBUTIONS

- AI/ML Air Interface
- MIMO Ev.
- Duplex Ev.
- Ambient IoT

- Network Energy Saving Enh.
- Mobility Enh.
- NTN Ev.
- XR Ev.

- AI/ML for NG-RAN
- SON / MDT
- Chanel modelling

& possibly additional aspects (ISAC, etc) for further Ev.

Additional RAN1 led candidate topics

- LP-WUS/WUR
- Multi-carrier Enh.
- Coverage Enh.
- Positioning Enh.
- SL Ev.

Additional RAN2 led candidate topics

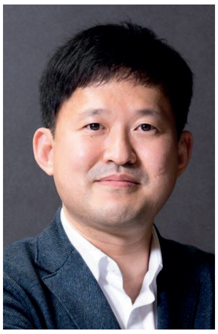
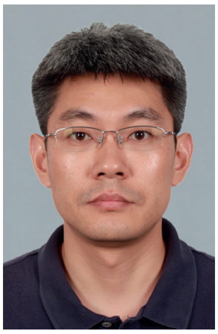
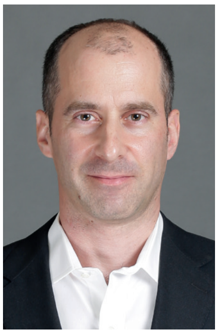
- NCR
- UAV / UAM
- MU-SIM
- SL Relay Enh.
- Broadcast / multicast
- UE aggregation, collaboration and backup

Additional RAN3 led candidate topics

- Topological Enh.
  - IAB/WAB/Femto
  - Public safety, emergency services, etc
- QoE

Additional / Other candidate topics

- Lean protocl stack / High speed packetization / Layer 2 UP Enh.
- RAN architectural Enh. / AS Security Enh.
- Network / Outer coding
- RedCap Enh. / High reliability and low complexity IoT
  - Combition w/ SL or NTN to be discussed in the SL / NTN topics respectively
- TaaS (Timing as a service) / High Accuracy Timing Service
- SDT Enh.
- LTE Enh.
- Dynamic UE capability update
- Others (Idle/Inactive Enh., RAN slicing Enh., etc.)

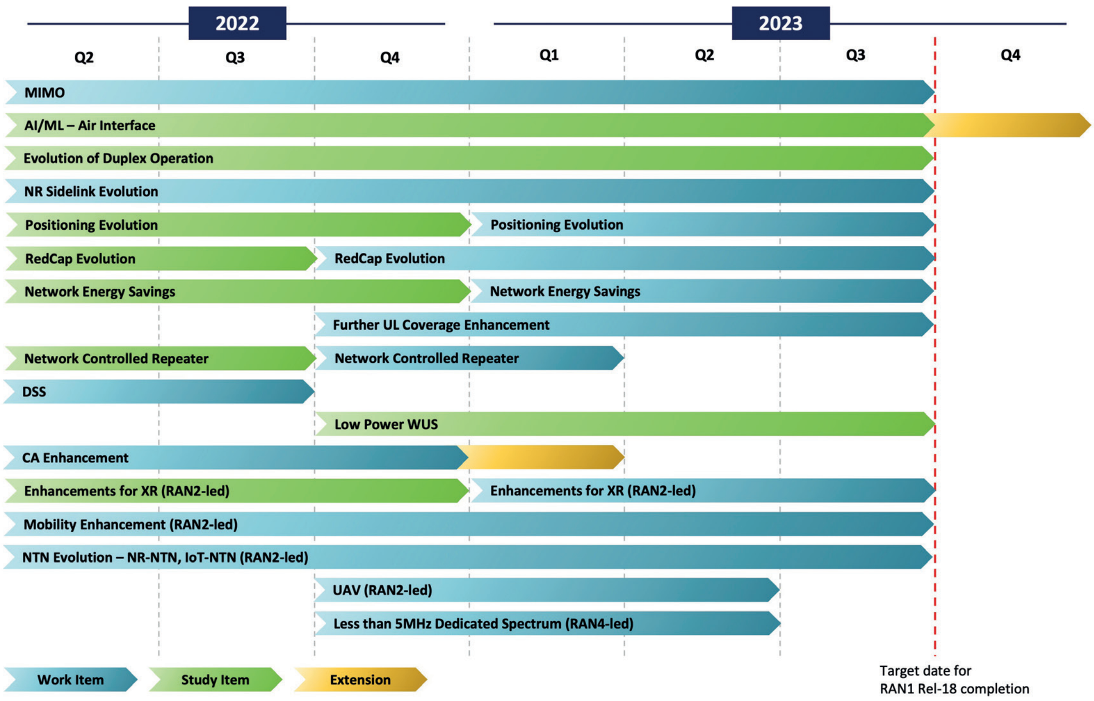




RAN1: 5G-ADVANCED AND REL-18 COMPLETION

by Younsun Kim (RAN1 Chair), Xiaodong Xu and David Mazzarese (RAN1 Vice-Chairs)

In December 2021, RAN#94-e endorsed the Release 18 work/study item package. It is the first release of 5G-Advanced – the next evolutionary step for 5G - bringing more capabilities to enable wider use cases and to enhance radio performance to a new level.

RAN1 was tasked with 17 topics over a period of 18 months starting from Q2 of 2022 until Q3 of 2023. Some of these topics were enhancements to existing RAN1 features (e.g. MIMO, coverage enhancement, RedCap) while some were relatively new to the group (e.g. AI/ML, network energy savings, duplex evolution, low power wake up signal). This article introduces some of the Release 18 (Rel-18) work/study items that RAN1 worked on.



1. MIMO Evolution

Rel-18 MIMO continues the enhancement on multi-antenna technology which has been a key component of NR since Release 15, focusing on 4 key areas: Channel State Information (CSI), multi-Transmission and Reception Points (TRP), uplink and reference signals. CSI for high/medium UE velocities and coherent-Joint Transmission (JT). Uplink was enhanced to facilitate multi-panel uplink transmission and up to rank 8 transmission. To better support multi-TRP deployments, unified Transmission Configuration Indicator (TCI) framework which was introduced in Rel-17 for single-TRP use case was expanded to multi-TRP use case and two TAs are supported. Uplink/downlink DeModulation Reference Signal (DMRS) was enhanced to support up to 24 orthogonal ports for MU-MIMO while Sounding Reference Signal (SRS) gets better randomize interference among different TRPs.

2. AI/ML for NR air interface

Rel-18 was the first release in which Artificial Intelligence (AI) and Machine Learning (ML) was studied in RAN1 and despite the potential for a large amount of RAN1 work, the study focused on only three representative use cases: CSI feedback, beam management, and positioning. For each use case, RAN1 studied the benefits of augmenting the air interface with features enabling AI/ML based algorithms for enhancing performance and/or reducing overhead. In addition, extensive study was done on the AI/ML framework that includes defining stages of AI/ML related algorithms, various levels of collaboration between UE and gNB, lifecycle management, and necessary dataset(s). The RAN1 study was extended for an extra quarter to ensure proper study on all three Rel-18 use cases. The work will lay the foundation for future normative work on AI/ML and for additional studies on other use cases.

3. Evolution of Duplex Operation

The study on duplex evolution focused on subband full duplex and potential enhancements for dynamic/flexible TDD. RAN1 was tasked to identify possible specification enhancements to enable the duplex schemes and evaluate the schemes in terms of feasibility and performance. Solutions to address inter-gNB and inter-UE cross link interference were studied and evaluated. In addition, the impact of the duplex schemes on legacy operation assuming their co-existence in co-channel and adjacent channels was evaluated.

4. Sidelink Evolution

The support for NR sidelink introduced in Release 16 primarily targeted communications between/with vehicles for advanced V2X applications, as a complement to LTE-based V2X. Enhancements for power savings and inter-UE coordination for resource allocation were introduced in Release 17. Owing to the growing interest on D2D for commercial use cases, and recognizing that large bandwidths enabling very high data rates can be found in unlicensed spectrum, RAN1 was tasked to specify the support for sidelink in unlicensed spectrum, targeting FR1 unlicensed bands (n46 and n96/n102), i.e. 5 GHz and 6 GHz unlicensed bands, in accordance with the latest regulations. Rel-18 also introduced the support for sidelink carrier aggregation for ITS band n47, as well as mechanism(s) for co-channel coexistence for LTE sidelink and NR sidelink, with both semi-static and dynamic resource pool sharing.

5. Expanded and Improved NR Positioning

Positioning solutions for NR were introduced in Release 16 and enhanced in Release 17. Expansion and improvements to the NR positioning solutions started with a study item in Rel-18, and was followed by a work item. RAN1 introduced the support for positioning over sidelink, i.e. positioning or ranging between two UEs (smartphones or vehicles). Additionally, RAN1 introduced the support for carrier-phase based positioning, increasing accuracy of positioning methods to centimeter level. Support for Low-Power High-Accuracy Positioning (LPHAP) was also introduced with UL and DL+UL positioning for UEs in RRC Inactive state. Increased positioning accuracy was also made possible for RedCap UEs by allowing frequency hopping beyond the maximum RedCap UE bandwidth for reception of DL PRS and transmission of UL SRS for positioning. Finally, RAN1 specified bandwidth aggregation for positioning measurements across up to three intra-band contiguous carriers.

6. Network Energy Savings for NR

Rel-18 network energy savings started with a study item and was followed by a work item. During the study item, RAN1 defined a base station energy consumption model along with necessary evaluation methodology and KPIs. Using the model and evaluation methodology, RAN1 studied and evaluated various techniques in time, frequency, spatial, and power domain. Based on the outcome of the study item, during the work item phase, RAN1 specified enhancement for network energy savings in spatial/power domain and enhancement on cell DTX/DRX.

7. NTN Enhancements

Support for non-terrestrial networks was introduced into 3GPP specifications in Release 17 for eMBB using NR (aka NR NTN) and for Internet of Things using LTE (aka IoT NTN), for transparent payload based GSO and NGSO network scenarios addressing UEs with Global Navigation Satellite System (GNSS) capability. For Rel-18 NR NTN, RAN1 was tasked to specify uplink coverage enhancements for commercial smartphones with -5.5 dBi antenna gain and 3 dB polarization loss, leading to the specification of repetitions for PUCCH for Msg4 HARQ-ACK, and enabling the support for DMRS bundling for PUSCH in NTN scenarios. For IoT NTN, RAN1 specified a mechanism allowing the network to disable HARQ feedback in order to mitigate the impact of HARQ stalling on UE data rates. RAN1 also specified improved GNSS operations during long connection times and for reduced power consumption.

8. Further NR Mobility Enhancements

Rel-18 mobility enhancements was introduced to reduce the latency, overhead, and interruption time of L3 based approach in legacy releases. To that end, mechanisms and procedures of L1/L2 based inter-cell mobility were specified in Rel-18. Compared to legacy releases, the latency required for measurements has been significantly reduced. Furthermore, the handover procedure has been simplified and does not require a random access procedure to the target cell. Rel-18 mobility enhancements are applicable to diverse mobility scenarios such as intra/inter-frequency mobility, FR1/FR2 mobility, and synchronized/non-synchronized cells. To enable L1/L2 based mobility, non-serving cell beam management and non-serving cell TA acquisition were specified in Rel-18.

9. Low-Power Wake-Up Signal and Receiver for NR

The study item focused on evaluating the feasibility and benefit of utilizing low-power wake-up signal (LP-WUS) for UE power consumption reduction. RAN1 was tasked to define the evaluation methodology, study low-power wake-up receiver architectures, and study necessary wake-up signal designs and procedures. RAN1 evaluated potential UE power saving gains compared to the existing UE power saving mechanisms, network coverage/capacity/resource overhead, as well as latency impact for different LP-WUS waveform alternatives.

10. Network Controlled Repeaters

Rel-18 Network Controlled Repeaters (NCRs) started with a study item and was followed by a work item. An NCR is an inband RF repeater used for extension of network coverage on FR1 and FR2. During the study item, RAN1 focus on identifying which of the potential side control information would be necessary for NCRs. Based on the outcome of the study item, during the work item phase, RAN1 specified side control information for beamforming, UL-DL TDD operation, and ON-OFF information.

In addition to the 10 topics mentioned above, RAN1 also worked on RedCap evolution, further uplink coverage enhancement, dynamic spectrum sharing enhancement, XR enhancement, NR support for UAV, and support for dedicated spectrum less than 5MHz in Rel-18.



3GPP SA6 REL-18 – 5G CRITICAL COMMUNICATIONS AND APPLICATION ENABLEMENT FOR VERTICALS

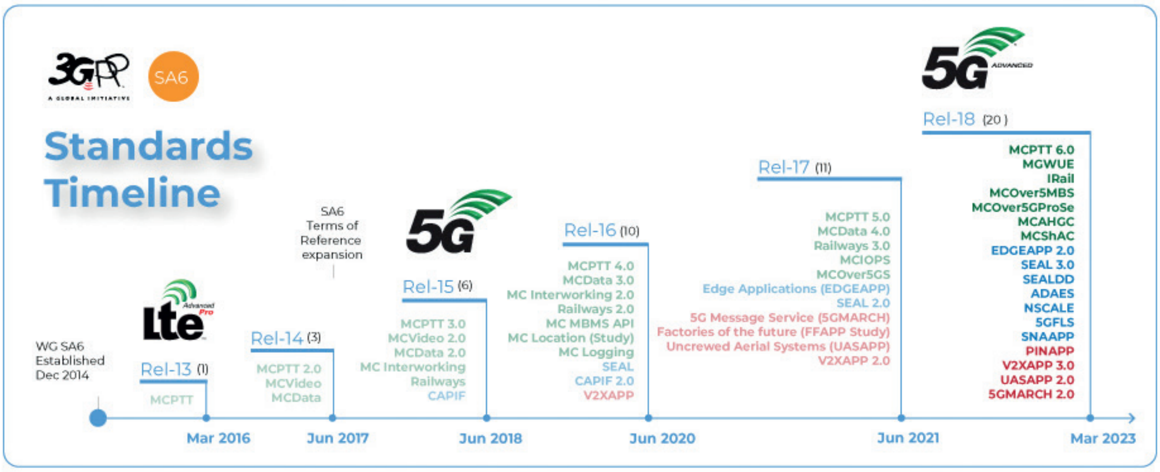
By Basu Pattan (SA6 Vice-chair), Alan Soloway (SA6 Chair) and Jukka Vialen (SA6 Vice-chair)

3GPP TSG SA WG6 (SA6) has, since its inception, championed application layer architecture specifications for mission critical systems (public safety, railways) as well as application enabler layer specifications for supporting the integration of 3GPP systems with other verticals such as - V2X, UAS, IoT.

Furthermore, SA6 has developed and specified service frameworks, such as the Common API Framework (CAPIF), the Service Enabler Architecture Layer (SEAL) and Edge Application enablement (EDGEAPP).

In this context, SA6 defined functionality serves as an application middleware, with capabilities that can be used to develop "Platform as a Service (PaaS)", to enable interactions between the application providers and the 3GPP network layer, across both user equipment (UE) and the core network. The Standards Timeline diagram below shows the evolution of SA6 specifications from Release 13 to Release 18, under three broad categories:

- Mission Critical Services
- 5G Service Frameworks
- Vertical Application Enablers



Recently, SA6 completed Release 18 specifications development. What follows is a brief overview of some of the main features that have resulted from that work.

Mission Critical Services

Mission Critical (MC) standards development within 3GPP started in 2015 in Release 13, following a major initiative from the public safety industry to create global standards with the collaboration of various government organisations, vendors and users from around the world.

In Release 18, some of the key new features developed include:

- MC gateway UE, that enables MC service access for a MC service user residing on non-3GPP capable devices and for devices which cannot host MC service clients
- Ad hoc group communication, that allows an MC user to select other users and setup group communication on the fly across one or more MC systems
- MC services using 5G MBS supports both Multicast and Broadcast modes to provide efficient downlink delivery of user traffic in group communication
- 5G ProSe UE-to-network relay leverages newly designed radio and core network for providing MC service UE, connectivity and relaying of MC traffic to remote MC service UE(s), using 5G ProSe Layer-2 and Layer-3 UE-to-network relaying techniques
- Enhancements to the Railways functionality (applicable also for Mission Critical verticals) e.g. location management across MC systems, migration during ongoing communications.

SA6 also completed a study (TR 23.700-38) for sharing of the administrative configuration between interconnected MC Service systems of MCPTT, for which the normative specification is expected in Release 19.

Further reading:
TS23.379, TS23.280, TS23.281, TS23.282, TS23.283, TS23.289

5G Service Frameworks

5G service frameworks, simplify and enhance the capabilities of the underlying 5G system, allowing 3rd party applications to rapidly develop and deploy new vertical services over 3GPP networks.

Prior to Release 18, EDGEAPP specified capabilities such as Service Provisioning, EEC registration, EAS registration, EAS discovery, capabilities exposure, support for service continuity. Release 18 mainly focused on enhancements to support emerging industry requirements such as roaming and federation, Edge node sharing, discovery of common EAS, dynamic EAS instantiation, ACR between EAS and Cloud, Bundle EASs, EDGE-5 APIs, Exposure of EAS Service APIs using CAPIF.

SEAL specified a set of common capabilities like Group Management, Configuration Management, Key Management, Identity Management, Location Management and Network Resource Management utilized by V2X and UAS applications and potential usage by many other verticals. Release 18 introduced new capabilities and enhancements including:

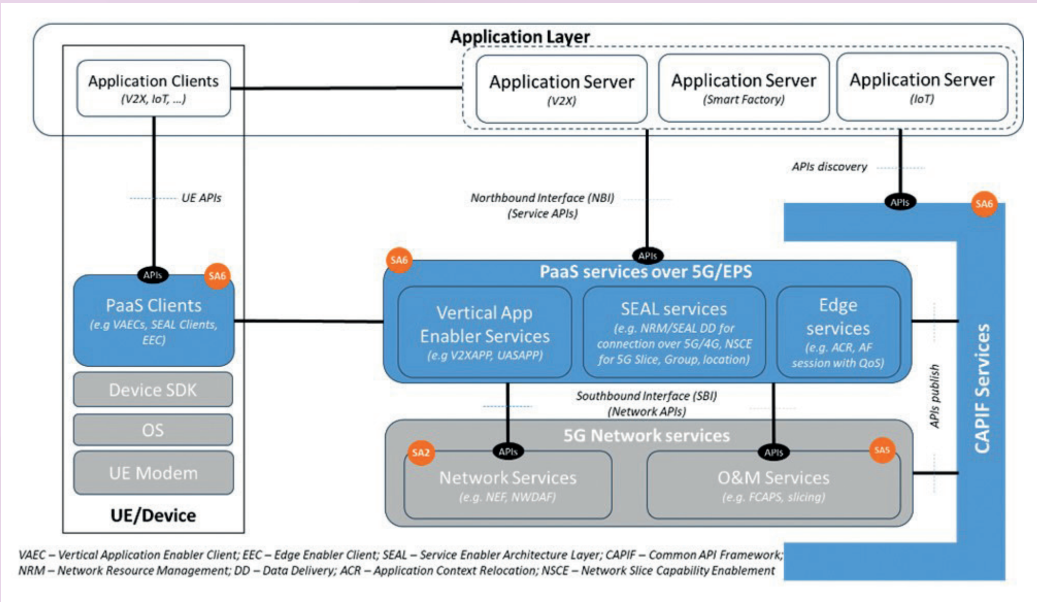
- Notification Management, that enables VAL clients to get notification service from the VAL servers, offloading the complexity of delivery and reception of notifications to the enabler layer
- Data Delivery, that eases the application content delivery for vertical applications and also provides storage capabilities
- Application Data Analytics Enablement (ADAE), that offers value-add application data analytics capabilities which cover statistics/predictions for the end-to-end application service
- Network Slice Capability Enablement (NSCE) is enhanced to support network slice lifecycle management, optimizations, performance and analytics monitoring, diagnostics, adaptation, prediction etc.
- Location Management service is enhanced to support fused location function and the VAL service area

Subscriber-aware northbound API access (SNAAPP) made enhancements to CAPIF in Release 18 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).

Further reading:
TS23.558, TS23.434, TS23.435, TS23.433, TS23.436, TS23.222

Vertical Application Enablers

While 5G service frameworks offer horizontal capabilities, SA6 has also introduced vertical application-enabling initiatives that cater to vertical-specific application developers. These initiatives can leverage the capabilities offered by 5G service frameworks by 'layering on top' and employ their services. In addition, 5G Vertical Application Enablers offer specific customized features meeting the requirements of individual verticals.



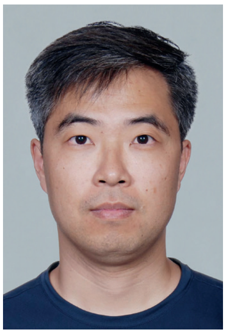
Application layer support for Personal IoT Network (PIN) introduced in Release 18 enables PIN applications over 3GPP networks supporting capabilities registration, service discovery of PIN elements, PIN profile and management, communication between PIN elements, service switch and continuity, relay selection for direct communication etc.

V2XAPP, UASAPP and 5GMARCH specifications were enhanced in Release 18. V2XAPP enhanced with features such as Vulnerable Road User (VRU) zone configuration and operation, V2P communications. UASAPP enhanced the support for multi-USS deployments, detect and avoid services and applications, tracking dynamic UAVs in an application defined area relative to a host UAV. 5GMARCH enhancements included Application Server Registration, UE bulk registration, Broadcast message delivery, Messaging Topic handling between multiple partner servers.

Further reading:
TS23.286, TS23.255, TS23.542, TS23.554

Next steps

Currently, SA6 is finalizing the scope for Release 19 and expected to conclude by Dec 2023. While the plan is to continue developing enhancements to some of the existing specifications from Release 18 including Mission Critical Services, Enabling Edge Applications, Location services, IoT Messaging, UASAPP, and SEAL Data Delivery, we are developing new specifications for application layer support to AI/ML and eMMTel services. We are also witnessing high interest in more new topics such as application layer support for Metaverse, XR Services, Sensing and Satellite connectivity, that can offer a comprehensive set of application enablement features for 5G-Advanced. We encourage you to join us in this exciting journey of application enablement over 3GPP networks.



REL-18 DUPLEX EVOLUTION

By Wang Fei (Rapporteur, China Mobile) and Kyungjun Choi (Samsung)

3GPP WG RAN1 has now completed its study on the evolution of NR duplex operation (TR38.858). This article presents RAN1's key findings.

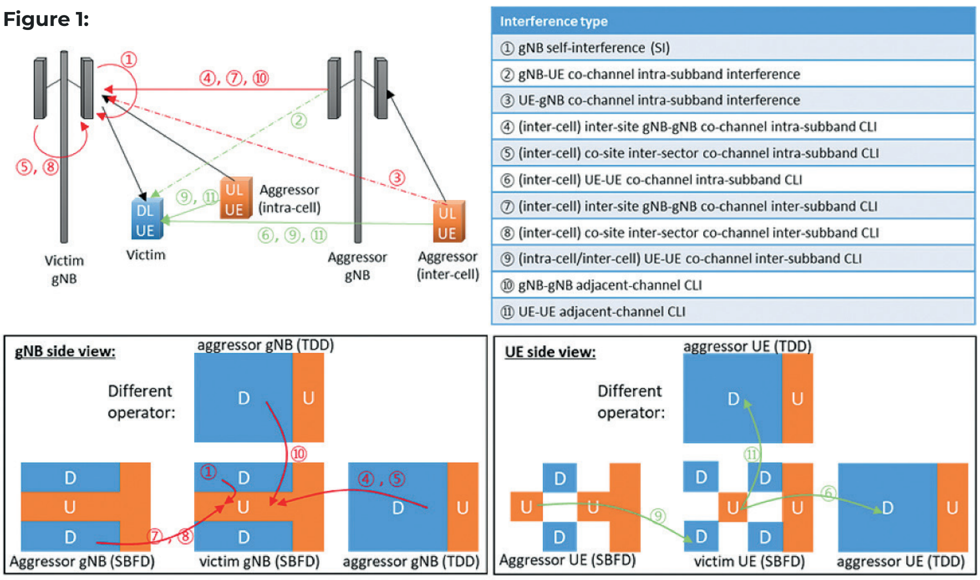
SubBand non-overlapping Full Duplex (SBFD) is an attractive solution for the uplink (UL) bottlenecks in the legacy Time Division Duplex (TDD) scheme, by introducing simultaneous transmission and reception at the gNB side. The solution has been studied for decades outside 3GPP and the time is now right for 3GPP to consider the feasibility of SBFD from the performance, implementation and specification perspective.

The NR system has been widely and successfully deployed on TDD bands of Sub-6GHz and mmWave, but there is a continuous demand from operators for improvement of UL performance of the TDD bands. In Rel-18 NR Duplex Evolution study item, SBFD at the gNB side within a conventional TDD band was studied to allow the simultaneous existence of Downlink (DL) and Uplink (UL) in different frequency subbands.

New interference and CLI handling schemes

SBFD and flexible/dynamic TDD allow DL/UL transmission from gNB/User equipment (UE) at the same time, introducing new interference types (Figure 1). The proper modelling of these interferences is crucial for adequate performance evaluation. In this study, cross link interference (CLI) handling schemes for SBFD and flexible/dynamic TDD are also studied and evaluated.

Figure 1:



The Design/Specification perspective

Study assumptions and Basic SBFD operations

It is assumed SBFD operation is within a TDD carrier and within a single configured DL and UL BWP pair with aligned center frequencies. Non-SBFD aware UEs, including legacy UEs, and SBFD aware UEs can coexist in cells with SBFD operation at the gNB side. Up to one UL subband (located at one side or middle of the carrier) and up to two DL subbands are assumed in a SBFD symbol configured as DL or flexible.

At least for RRC_CONNECTED state, it was concluded both time and frequency locations of subbands for SBFD operation are known to SBFD aware UEs. UE behaviors for non-SBFD aware UEs follow existing specifications, and new UE behaviors can be introduced for SBFD aware UEs.

SBFD subband(s) configurations

Semi-static time/frequency subband configuration with the same subband frequency resources across different SBFD symbols was studied as baseline. Whether a slot can consist of both SBFD and non-SBFD symbols was also studied. In order to avoid frequent transition between SBFD and non-SBFD symbols, potential limitation on the maximum number of transition points can be considered from a SBFD subband configuration perspective. A maximum of two transition points within a TDD configuration can be considered.

Semi-static SBFD and Dynamic SBFD

RAN1 studied whether to allow transmission/reception within/outside subbands for a SBFD aware UE, and identified semi-static SBFD and dynamic SBFD. For semi-static SBFD, DL reception is only allowed in DL subband and UL transmission is only allowed in UL subband in DL/flexible symbol. For dynamic SBFD, DL reception outside DL subband(s) and/or UL transmission outside UL subband may or may not be allowed in flexible symbol.

Dynamic SBFD can better adapt to the UL/DL resource requirements based on UL/DL traffic loads, but may increase implementation/scheduling complexity and CLI, incur loss of resources, and can result in additional specification impact.

Transmission and reception across SBFD symbol and non-SBFD symbol

The impact and potential enhancements for UL transmissions and DL receptions across SBFD symbols and non-SBFD symbols were studied. Potential enhancements include resource allocation enhancements in time, frequency, power and spatial domain. RAN1 studied whether for a SBFD aware UE to allow transmission/reception across SBFD and non-SBFD symbols in the same or different slots. Also, RAN1 studied unaligned frequency boundaries and frequency resource allocation enhancements in case of the transmissions/receptions in SBFD and non-SBFD symbols with different available resources. In addition, RAN1 concluded that separate resources, frequency hopping parameters, UL power control parameters and/or beam/spatial relation may be beneficial on SBFD and non-SBFD symbols.

CLI handling schemes for SBFD and Flexible/Dynamic TDD

RAN1 identified and evaluated the following inter-gNB/UE CLI handling schemes for SBFD and flexible/dynamic TDD:

- Inter-gNB/UE co-channel CLI measurement and/or channel measurement and reporting
- Coordinated scheduling for time/frequency resources between gNBs
- Spatial domain coordination method
- UE and gNB transmission and reception timing
- Power control scheme based on gNB/UE transmission power adjustment

Performance evaluation results and analysis

Key Evaluation Assumptions

System level evaluation was performed to see performance benefits of SBFD over static TDD. Non-coexistence case (one single operator), co-channel co-existence case (2-layer topology for a single operator with macro layer using static TDD and indoor layer using SBFD) and adjacent-channel co-existence case (two operators using two adjacent carriers with one operator using static TDD and the other operator using SBFD) were evaluated. For all cases, the same SBFD configuration was assumed amongst all gNBs.

Four alternatives were considered regarding the TDD and SBFD configurations and corresponding DL/UL resource ratio, where X represents a SBFD slot and the numbers are UL resource ratio.

- Alt-1: {DDDSU} for static TDD (20%) and {DXXXU} for SBFD (32%)
- Alt-2: {DDDSU} for static TDD (20%) and {XXXXU} for SBFD (35%)
- Alt-3: {DDSUU} for static TDD (40%) and {XXXXU} for SBFD (40%)
- Alt-4: {DDDSU} for static TDD (20%) and {XXXXX} for SBFD (20%)

Key assumptions were used for drawing observations and conclusions, e.g., 1dB desense for gNB self-interference suppression capability, twice the total number of antenna elements and same total number of TxRUs for gNB antenna configuration, piece-wise linear model as a function of the total received power for BS noise figure.

System-Level Performance of Semi-static SBFD

RAN1 concluded semi-static SBFD provides user-perceived throughput (UPT) gain in specific evaluation scenarios, as summarized in Table 1. RAN1 concluded that the DL/UL UPT gain of SBFD with XXXXX comes from more DL/UL transmission opportunities. For SBFD with XXXXU, the UL UPT gain comes from more UL resources and more UL transmission opportunities and the DL UPT loss comes from less DL resources. Also, the UL UPT loss comes from gNB-gNB CLI and noise figure increase due to higher blocker power and the DL UPT loss comes from UE-UE CLI.

		Alt-4 (XXXXX)	Alt-2 (XXXXU)
Non Coex	FR1 Indoor	DL/UL gain at all loads	UL gain (79%~150%) but DL loss (-0.35%~-54%) at all loads
	FR1 UMa	DL gain at low load and UL gain at all loads with small packet size, DL loss at all loads and UL gain at low load with large packet size	UL gain (41%~206%) but DL loss (-3%~-86%) at all loads
	FR1 Dense UMa	DL gain at low load and UL gain at all loads with small packet size, DL/UL gain at low load with large packet size	UL gain (68%~147%) but DL loss (-27%~-64%) at all loads
	FR2-1 Indoor	DL/UL gain at all loads	UL gain (79%~201%) but DL loss (-4%~-40%) at all loads
	FR2-1 Dense UMa	DL/UL gain at all loads	UL gain (76%~139%) but DL loss (-21%~-50%) at all loads
Co-channel Coex	FR 1 Indoor layer	DL gain at low/medium load and UL gain at all loads with small packet size, UL gain but DL loss at all loads with large packet size	UL gain (42%~218%) but DL loss (0.43%~-81%) at all loads
Adjacent-channel Coex	FR1 UMa (0% grid shift)	**SBFD operator:** UL gain at all loads but DL loss at all loads **TDD operator:** limited or large DL/UL loss at all loads	**SBFD operator:** UL gain (23%~168%) but DL loss (-21%~-65%) at all loads **TDD operator:** limited DL/UL gain and loss (less than -5% DL loss) at all loads
	FR1 UMa (100% grid shift)	**SBFD operator:** UL gain at low/medium load but DL loss at all loads **TDD operator:** limited or large DL/UL loss at all loads	**SBFD operator:** UL gain (37%~94%) but DL loss (-21%~-52%) at all loads **TDD operator:** limited DL/UL loss (less than -4%) at all loads

Table 1. Performance Summary of semi-static SBFD

Note: no less than 93dB for FR1 UMa and Dense UMa and no less than 98dB for FR2-1 Dense UMa are assumed for co-site inter-sector spatial + digital isolation capability

UL Coverage Gain of Semi-static SBFD

Link level evaluation was performed to evaluate UL coverage improvement of SBFD with XXXXU over TDD with DDDSU. Based on the assumption of 1dB desense for gNB self-interference suppression capability and different co-site inter-sector isolation values, RAN1 observed semi-static SBFD with PUSCH repetition type A provides the UL coverage gain of 5.41dB in FR1 UMa and 6.92dB in FR2-1 Dense UMa, respectively.

IVAS CODEC FOR THE NEXT GENERATION 3GPP VOICE & AUDIO SERVICES

By IVAS codec Public Collaboration contributors (WG SA4)*

The new 3GPP codec for low-delay Immersive Voice and Audio Services (IVAS) has been selected as standard at the WG SA4#125 meeting (August 2023) for Release 18. The new codec enables completely new service scenarios by providing capabilities for interactive stereo and immersive audio communications, content sharing and distribution.

Some envisioned service applications are conversational voice, multi-stream teleconferencing, XR conversational services, and user-generated live and pre-produced content streaming, as well as corresponding applications in the AR/MR space. More details on potential use cases are provided in 3GPP Highlights Issue 05 and the IVAS-9 Usage Scenarios (S4-231523).

The present article focuses on the main features of the new IVAS codec together with a high-level overview of the codec architecture and performance. In addition, the SA4 Audio SWG efforts that lead to the successful selection of the new codec are highlighted.

Main features and properties of the IVAS codec

The IVAS codec is an extension of the 3GPP Enhanced Voice Services (EVS) codec offering:

- Complete bit-exact EVS codec functionality for mono speech/audio signal input
- Support of stereo and binaural audio
- Support of audio formats beyond stereo which include multi-channel audio (5.1, 5.1.2, 5.1.4, 7.1, 7.1.4), scene-based audio (Ambisonics up to 3rd order), metadata-assisted spatial audio (MASA), and object-based audio.
- Support of combined immersive audio formats: object-based audio with scene-based audio (OSBA) and object-based audio with metadata-assisted spatial audio (OMASA)
- VAD/DTX/CNG for rate efficient stereo and immersive conversational voice transmissions
- Error concealment mechanisms to combat the effects of transmission errors and lost packets
- Jitter buffer management
- Binaural rendering functionality for headphone playback including head-tracking and scene orientation control, and loudspeaker rendering functionality for loudspeaker playback

The codec is optimized for services over 5G mobile networks and implementations on 5G devices with:

- Operation on 20 ms audio frames
- Multi-rate/multi-mode operation at the following discrete bit rates [kbps]: 13.2, 16.4, 24.4, 32, 48, 64, 80, 96, 128, 160, 192, 256, 384, and 512
- Ability to switch bitrate upon command
- Support of sampling frequencies of 8 kHz (only EVS interoperable coding), 16 kHz, 32 kHz and 48 kHz (fullband audio content)
- Low algorithmic delay (≤38 ms)
- Complexity and memory footprint within design constraint limits defining three levels, suitable for different device types and application scenarios, with Level 1: not exceeding 3 x EVS, Level 2: not exceeding 6 x EVS and Level 3: not exceeding 10 x EVS

Beyond the features and properties outlined above, the IVAS codec is compliant with all IVAS design constraints set forth by 3GPP (S4-231031).

Codec architecture

The encoder analyzes the sound scene, derives spatial audio parameters, and downmixes input channels to so-called transport channels which are processed by the encoding tools. These tools include Single Channel Element coding (SCE comprising one core-coder), Channel Pair Element coding (CPE comprising two core-coders), and Multichannel Coding Tool (MCT comprising a joint coding of multiple core-coders). The core-coder is inherited from the EVS codec with additional flexibility and variable bitrate support.

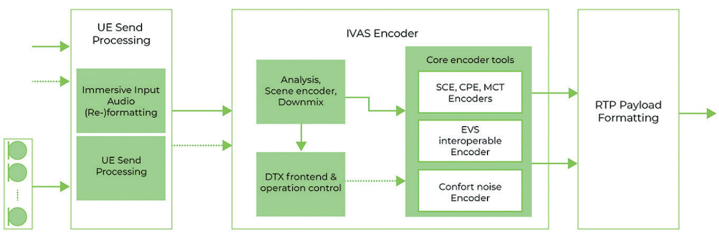


Figure 1: Overview of audio processing functions - Transmit Side

The decoder processes the received bitstream and outputs either the same audio format as the signaled input format (pass-through mode) or any given supported audio format including rendered output for binaural or loudspeaker playback with use of the integrated renderer.

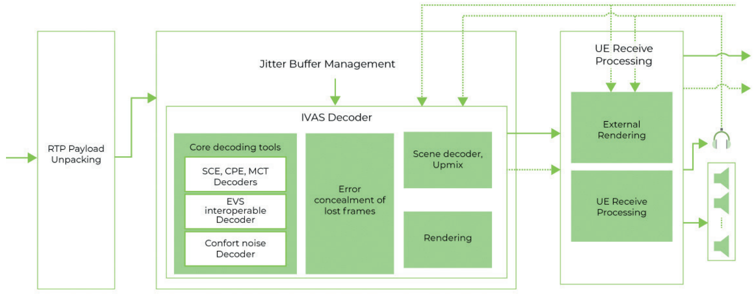


Figure 2: Overview of audio processing functions - Receive Side

IVAS rendering

Rendering is the process of converting the decoded audio signals for reproduction on various playback devices. The IVAS decoder provides integrated rendering functionalities for reproduction on headphones and different loudspeaker configurations. A standalone renderer is also provided, which can be applied without prior IVAS encoding/decoding of the input audio signal or when rendering multiple sources (e.g. from several decoders). Both renderers support the same feature set.

The IVAS binaural rendering generates audio signals for headphones simulating a real-life listening experience. It features binauralization, relying on head-related impulse responses, head-tracking, listener orientation processing and supports room acoustics using binaural room impulse responses or late reverb and spatialized early reflections synthesis. Default rendering parameter sets are available and an option to override these with custom sets is provided. The rendering implementation utilizes several algorithms, depending on encoding schemes, input formats, bitrates, and output format. These algorithms operate either in time or in frequency domain for optimal performance at minimum complexity.

IVAS codec performance

For the IVAS codec selection test, the performance of stereo and immersive operation modes was evaluated against EVS codec based reference systems in 18 voice-communication-oriented ITU-T P.SUPPL800 (ITU login required) experiments with naïve listeners and 28 ITU-R BS.1534 audio-oriented expert-listener experiments. The experiments were carried out by 4 listening labs independent from the codec proponents, with expertise in subjective voice and audio quality testing.

In total, 319 requirements were tested out of which the codec exceeded the requirements in 54% of the cases, while meeting the requirements totally in 98.4% of the cases and failing in 1.6% of the test cases. There was no case where the codec failed a requirement systematically in two labs. The results can be found in the Global Analysis Lab report (S4-231573).

Demo material illustrating some of the user experience enabled by the new IVAS codec is accessible at https://forge.3gpp.org/rep/ivas-codec-pc/ivas-codec/-/wikis/Demos

SA4 Audio SWG – Successful IVAS Codec Standardization

The IVAS codec work item was launched in Sept. 2017. After extensive discussions, in May 2022, a Public Collaboration (PC) was established for the development of a joint IVAS codec candidate. The Terms-of-Reference (ToR) stipulated an entirely open collaboration, which gave the chance to every 3GPP individual member to contribute to or observe the development. The PC made use of the 3GPP Forge repository, which provided public access to source code, documents and meeting reports.

The IVAS codec standardization process was fully defined in 3GPP SA4 in a set of permanent documents (Pdocs). In particular, requirements to be met relate to the implementation of the codec and to the suitable performance for the intended use cases.

A budget of 1.2 million euros, funded by proponent companies (contributors to the Public Collaboration), was collected to cover selection tests and tasks of the characterization phase. The 3GPP Mobile Competence Centre (MCC) contracted qualified laboratories for the testing.

> The IVAS codec work item was launched in Sept. 2017. After extensive discussions, in May 2022, a Public Collaboration (PC) was established for the development of a joint IVAS codec candidate.

The actual subjective listening tests were conducted in the summer of 2023, assessing the submitted IVAS PC candidate codec (based on floating-point code). Test results and the technical information were reviewed at the 3GPP SA4#125 meeting. WG SA4 concluded that the Public Collaboration candidate meets the selection criteria to become the new 3GPP IVAS standard. TSG-SA approved the decision, the floating-point C source code specification, and the lab reports in September 2023.

Future activities include the IVAS codec characterization, which covers conversion of the approved floating-point C code to fixed-point C code and additional testing. The full set of Codec for Immersive Voice and Audio Services specifications being developed for Rel-18 can be found at the 3GPP Portal:

- TS 26.250 - General overview
- TS 26.251 - C code (fixed-point)
- TS 26.252 - Test sequences
- TS 26.253 - Detailed Algorithmic Description
- TS 26.254 - Rendering
- TS 26.255 - Error concealment of lost packets
- TS 26.256 - Jitter Buffer Management
- TS 26.258 - C code (floating-point)

The characteristics and performance of the IVAS codec will be further described in a Technical Report (TR 26.997), including both selection and characterization test results.

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MFA, THE ALLIANCE FOR PRIVATE NETWORKS: SUPPORTING PRIVATE NETWORK ADOPTION

Through Industry Standards and 3GPP Collaboration

By Asimakis Kokkos, MFA Technical Specification Group Chair

The concept of private networks is gaining traction like never before. These dedicated communication channels provide a secure and seamless way for enterprises to stay connected, ensuring reliability, low latency, and enhanced control of key business processes across industry verticals.

Proper understanding of what it takes to establish a private network – and knowing who to trust – poses a challenge for interested enterprises. This is where MFA, the Alliance for private networks, steps in, offering guidance to businesses looking to harness the potential of private networks. From demystifying the implementation process to collaborating with industry giants, MFA plays a pivotal role in driving the global adoption of private networks.

MFA is making significant strides to facilitate the adoption of private networks within various industry verticals. MFA's approach is centered around the development of the MFA's Uni5G™ technology blueprints for 5G, a pioneering tool designed to bridge the gap between industry requirements and the vast array of optional features offered by the 3GPP specification. At the core of MFA's mission lies the continuous refinement and expansion of these blueprints, ensuring that they remain in step with 3GPP standards and the ever-evolving needs of vertical industries.

The Bottleneck in Industrial Devices

MFA's decision to begin developing the Uni5G technology blueprints was driven by a critical realization—the ecosystem for industrial devices was lagging. While commercial 5G systems catered to the smartphone market, they flourished due to the significant input and customization offered by cellular service providers (CSPs). CSPs have the ability to choose which features to enable based on their understanding of the market and end-users' needs.

One of the significant hurdles that MFA recognized in the journey towards private network adoption was the lack of clarity and guidance for enterprises and vertical industries in utilizing the 3GPP specification to establish their private networks. Traditional mobile network operators have an inherent advantage in this regard, as they possess the market insights and expertise to select and implement the 3GPP features that align with their specific business requirements.

However, when it comes to enterprises and industries such as manufacturing, mining, ports, and oil and gas, their diverse backgrounds and unique needs make it challenging to determine which 3GPP features are essential for their operations. The Uni5G technology blueprints are designed to simplify the complex world of 3GPP features across these industry verticals.

Simplifying 5G Implementation with Uni5G

For enterprises venturing into the realm of 3GPP, standards bodies, telecom complexities, and spectrum availability, the journey can be overwhelming. The 3GPP specification boasts a plethora of features, making it an achievable goal for non-telecom experts. While essential for mobile telecommunications across a variety of areas, not all of them are relevant for private networks. For the Uni5G technology blueprints, MFA meticulously combed through the 3GPP standard's extensive offerings to identify features crucial for meeting the unique demands of enterprises such as coverage, reliability, connection density, positioning, time-sensitive networking and latency. The Uni5G technology blueprints act as a roadmap, seamlessly aligning the features with businesses' requirements, streamlining the deployment process, and allowing enterprises to communicate their needs effectively to their chosen vendors. The Uni5G technology blueprints not only simplify the implementation process but also sparks innovation in the ecosystem of 5G private network devices.

Understanding Verticals' Private Wireless Needs

MFA undertook a research project with Beecham Research to help identify and categorize a range of verticals needs to better determine the common elements that exist from industry to industry, while still allowing for each industry's unique challenges.

> MFA meticulously combed through the 3GPP standard's extensive offerings to identify features crucial for meeting the unique demands of enterprises such as coverage, reliability, connection density, positioning, time-sensitive networking and latency.

For example, in the case of private network requirements for a maritime port, Beecham Research helped identify connectivity requirements for various port applications, such as crane operations, autonomous vehicles for cargo movement, video surveillance, and robotic material handling in warehouses. Not surprisingly, crane operations and autonomous vehicles both require high data rates but have very different needs in terms of latency or mobility requirements.

As a result of this and other work, MFA identified four key attributes which, in addition to enhanced mobile broadband (eMBB) were critical needs for industrial private wireless deployments: latency, reliability, coverage, and connection density. While these industry verticals know they need lower latency, higher reliability, improved coverage, or increased connection density, they lack the expertise to select the specific 3GPP features that will deliver them and achieve these objectives. This is the critical gap that MFA aims to address.

The Uni5G Technology Blueprint: A Guide for Verticals

MFA's Uni5G technology blueprints were meticulously crafted to bridge this knowledge gap. These blueprints serve as invaluable tools for vertical industries, providing them with a clear roadmap for navigating the complex landscape of 3GPP specifications. Rather than expecting these industries to wade through the myriad optional 3GPP features, the Uni5G technology blueprints distill the relevant information into easily digestible categories. They simplify the process of selecting the right features for specific performance attributes, enabling industries to create tailored 5G solutions that align with their unique requirements.

To that end, MFA went through hundreds of 3GPP features in Release 15 such as Ultra reliable CQIU/MCS, Mini-slots, PDCCH processing, UL configured grant, for example, and mapped them all to the key attribute categories to show how they related to latency, reliability, coverage, and connection density. [Figure 2] This resulted in Uni5G technology blueprint families that cover the combination of all attributes. The first blueprint family addresses reliability and coverage needs, the second latency and density needs, and the third outlines combinations for them all - latency, reliability, coverage and density.

Application	Data Rate	Latency	Site Area Coverage	Density (of devices)	Power Effi y	Mission Critical Reliability	Need For Low Cost	Mobility	Indoor/ Outdoor
Crane Operation	High	Slow	Large	Medium	Low	High	Low	Low	Outdoor
Autonomous/Semiautonomous Vehicles (Cargo Moving)	High	Fast	Large	Medium	Low	High	Low	High	Both
Environmental Sensing	Low	Slow	Large	Large	High	Low	High	Low	Both
Docking Ship Communications	High	Fast	Large	Medium	Low	High	Low	Medium	Outdoor
Video (Surveilance)	High	Slow	Large	Large	Low	Low	Medium	Low	Both
Drone (Inspection)	High	Fast	Large	Small	High	Low	Medium	High	Outdoor
Operational Equipment Monitoring	Low	Slow	Large	Large	Low	High	Low	Medium	Both
Remote Control: Static Machines e.g. Cranes	High	Fast	Large	Medium	Low	High	Low	Low	Outdoor
Remote Control: Loading Bays	High	Fast	Large	Medium	Low	High	Low	Low	Outdoor
Robotics (Material Handling w/in Warehouses)	High	Fast	Large	Large	Low	High	Low	High	Indoor

Figure 1: Beecham Research Connectivity Requirements for Port Applications

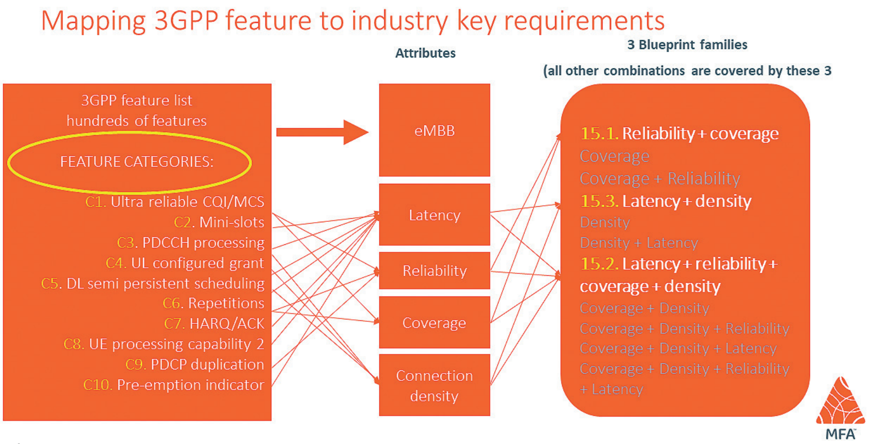


Figure 2: Mapping 3GPP Features

The Blueprint in Action: Meeting Vertical Industry Needs

With the 3GPP features categorized into different families based on their impact on these crucial attributes, MFA's Uni5G technology blueprints can now be used to guide industries into a better understanding of what is available and select the features that align with their specific needs.

For instance, if an industry seeks to improve coverage and reliability, they can refer to Family Blueprint 1 (F1) for guidance. [Figure 3]. The F1 row outlines the features that are necessary to enhance coverage and reliability. Furthermore, MFA has provided additional information that offers a choice between basic coverage and reliability (base) and enhanced coverage and reliability (extended) based on 3GPP specifications. Each attribute in the technology blueprint maps directly to the relevant 3GPP feature and includes a complete list of additional 3GPP features that may be beneficial.

Table 5: Table 5: Mapping Between UE Blue-print Families and Candidate FGs

UE: Blueprint	Targeted Attributes	Feature Categories Lists		Complete List of Corresponding Candidate FG Indices
		Base	Extended	
F1	Coverage, Reliability	{C1, C6}	{C9}	{2-32c, 5-34, 5-34a, 5-34b, 5-34c, 5-17, 5-17a, 5-14}, {1-6*}
F2	Connection density, Latency	{C3, C4}	{C2, C5, C7, C8, C10}	{3-2, 3-5, 3-5b, 5-19, 5-20, 3-6*} {4-28, 5-18, 5-21, 5-6, 5-6a, 5-11, 5-lla, 5-llb, 5-12, 5-12a, 5-12b, 5-5a, 5-5c, 5-13, 5-13a, 5-13c, 5-13d, 5-13e, 5-13f}
F3	Coverage, Reliability, Connection density, Latency	{C1, C6}, {C3, C4}	{C9} {C2, C5, C7, C8, C10}	{2-32c, 5-34, 5-34a. 5-34b, 5-34c, 5-17, 5-17a, 5-14}, {3-2, 3-5, 3-5b, 5-19, 5-20, 3-6*}, {1-6*} {4-28, 5-18, 5-21, 5-6, 5-6a, 5-11. 5-1 la, 5-11 b, 5-12, 5-12a, 5-12b, 5-5a, 5-5c, 5-13, 5-13a, 5-13c, 5-13d, 5-13e, 5-13f}

Note: *Indicates Layer 2 FG index.

UE blueprints examples consist of a list of selected FGs. Recommended UE blueprints examples are outside the scope of this document. The examples shown in Table 6 are for illustrative purposes only.

Table 6: UE Blueprint Examples†

UE: Blueprint	Class	Targeted Attributes	Selected FG Iudices
F1.0	Basic	Coverage, Reliability	{5-17, 5-17a, 2-32c, 5-34, 5-34a}
F1.1	Advanced	Coverage, Reliability	{5-17, 5-17a, 2-32c, 5-34, 5-34a, 1-6*}
F2.0	Basic	Connection density, Latency	{3-2, 5-20, 3-6*}
F2.1	Advanced	Connection density, Latency	{3-2, 5-20, 3-6*, 5-18, 5-6, 5-6a, 5-11, 5-12, 4-28, 5-21, 5-5a, 5-5c}
F3.0	Basic	Coverage, Reliability, Connection density, Latency	{5-17, 5-17a, 2-32c, 5-34, 5-34a, 3-2, 5-20, 3-6*}
F3.1	Advanced	Coverage, Reliability, Connection density, Latency	{5-17, 5-17a, 2-32c, 5-34, 5-34a, 1-6*, 3-2, 5-20, 3-6*, 5-18, 5-6, 5-6a, 5-11, 5-12, 4-28, 5-21}
F3.2	Ultimate	Coverage, Reliability, Connection density,	{5-17, 5-l 7a, 5-14, 5-16, 2-32c, 5-34, 5-34a, 5-34b, 5-34c, 1-6*, 3-2, 3-5b, 5-20, 3-6*, 5-18, 5-6, 5-6a, 5-5a, 5-5c, 5-11, 5-lla, 5-12, 5-12a, 4-28, 5-21}

Note:
* Indicates Layer 2 FG index.
† UE Blueprint examples from mf2022.001.00 [5].

With Release 16, MFA has undertaken to expand the technology blueprint's scope to include 3GPP features such as positioning, IIOT, unlicensed, time synchronicity and URLLC and is currently working on producing the relevant blueprints. Mapping the right features with the needs of various industrial use cases will help determine in which cases, for example, there is a need for positioning accuracy down to a centimeter or whether accuracy to within half a meter will be acceptable. Likewise, the latency and reliability features are under examination to create guidance for the industry on what would be the industrial-grade values that would be needed to satisfy the use case needs.

This clear roadmap empowers a vertical industry with the information they need to make informed decisions and speak with their private network consultants and network architects, and even device manufacturers and chipset vendors, to ensure their unique private network's needs are met. More importantly, the benefits of using the Uni5G technology blueprints in industrial use cases, including increased efficiency and quality, higher production output, and near-zero restarts, will be orders of magnitude higher than the potential cost of the Uni5G technology blueprint implementation.

Becoming a 3GPP Market Representation Partner

To help ensure that MFA's efforts to promote the adoption of private networks align with key industry initiatives, MFA has developed a strategic partnership with 3GPP. As a standards organization, 3GPP brings together the best minds in telecommunications to define and develop cutting-edge mobile technologies. MFA's role as a 3GPP Market Representation Partner is pivotal, as it enables MFA members to channel unique market insights and requirements directly into asset and resource development. This partnership ensures that the technical standards set by 3GPP are leveraged effectively to create solutions tailored to the needs of various industries.

MFA actively works with its member companies who are involved in 3GPP to bring the benefits of 5G technology to vertical industries. The input MFA provides on 3GPP specifications through its member companies ensures that the unique needs of vertical industries are considered in the development of 3GPP standards. While MFA serves as a marketing promotion vehicle, its focus on practical implementation and prioritization of features for vertical industries adds substantial value to the standardization process.

By ensuring that the real-world challenges and needs defined by 3GPP are considered in the development of these materials, MFA serves as a catalyst for shaping mobile telecommunications standards for private networks.

Looking Ahead: Evolution with 3GPP

MFA's commitment to supporting vertical industries in their journey towards private network adoption, now and into the future. As 3GPP continues to develop new releases, such as Release 18 and beyond, MFA plans to evolve its Uni5G technology blueprints in tandem. The aim is to remain in sync with emerging industry needs and trends, ensuring that the blueprints remain relevant and effective tools for industrial verticals.

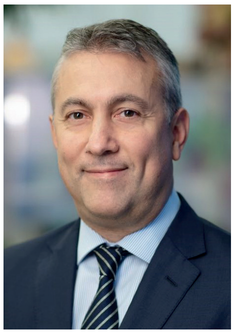
One significant aspect of MFA's forward-looking approach is its intention to conduct periodic interviews and engage with industry verticals. By staying attuned to evolving industry needs, MFA can adapt the blueprints to address changing requirements effectively. The relationship between the 3GPP community, MFA, and other organizations like 5G-ACIA will be pivotal in gathering feedback and insights to enhance the blueprints.

Supporting the Future of Private Networks

MFA's collaboration with 3GPP and introduction of the Uni5G technology blueprints are just an example of the many ways MFA is encouraging the adoption of private networks. As a 3GPP Market Representation Partner, MFA ensures that market requirements are raised in time to be integrated into the fabric of telecommunications standards and that the technical specifications align with actual industry needs. The Uni5G technology blueprints function as a simple, clear path, guiding enterprises through the complex 3GPP standards and smoothing the implementation process for their private networks. Through collaboration, innovation, and practical solutions, MFA is nurturing an ecosystem where industries across any number of verticals can harness the power of private networks for growth and success.

To learn more about MFA, the Alliance for private networks, visit
https://www.mfa-tech.org
To access MFA's Uni5G technology blueprints, visit
https://www.mfa-tech.org/technology/uni5g-technology-blueprints

QUALITY OF SERVICE, PRIORITY AND PRE-EMPTION



Enabling new markets through advances in 3GPP technology and use of commercial networks, whilst diligently navigating the legal and regulatory environment

By Jason Johur and Nina Myren, Board members, TCCA

TCCA as an advocate for mission-critical mobile broadband services concluded early on that key sectors of the economy such as public safety, defence, utilities and transportation would require these services as the use of data and video moves from best effort to essential forms of communication, supported by sufficient spectrum resources to meet the foreseen needs of these sectors.

Although spectrum has been made available by governments and regulators across a number of countries, for most sectors this initial allocation has not been enough – necessitating additional capacity (spectrum) to be provided by commercial operators. In order for this type of 'shared' or 'hybrid' approach to work, critical communications carried over commercial operator networks must have mission-critical service levels.

> Whilst the development of standards, coordinated by 3GPP, has been pivotal in enabling key sectors to finally acquire sufficient mission-critical mobile broadband services, it is paramount that these new network services operate within the legal framework of any given country, region or within any related international agreements.

To achieve this, 3GPP has developed an extensive suite of networking capabilities over multiple Releases[1]. Over time, these capabilities have been increasingly referred to in the community by the abbreviated term 'QPP' (Quality of Service, Priority and Pre-emption) and this is now the de facto baseline for commercial operators seeking to address the critical communications market.

Whilst the development of standards, coordinated by 3GPP, has been pivotal in enabling key sectors to finally acquire sufficient mission-critical mobile broadband services, it is paramount that these new network services operate within the legal framework of any given country, region or within any related international agreements.

Despite key sectors such as public safety being fundamental to the safe and secure functioning of society and government, it is not a given that legislation is keeping pace with their operational needs. To assist this process, the Legal and Regulatory Working Group (LRWG) within TCCA has been working to understand the limits of existing legislation and the changes likely to be needed in the future with regards to the communication services they require.

September 2023

TCCA White Paper

Legal and Regulatory aspects regarding the realisation of Quality of Service, Priority and Pre-emption (QPP) in commercial networks

TCCA's LRWG has issued a white paper on legal and regulatory aspects regarding the realisation of QPP in commercial networks. The white paper addresses legal and regulatory challenges in terms of providing QPP services that are connected to the European regulation on net neutrality. The white paper concludes that the principle of net neutrality in Article 3 of Regulation (EU) 2015/2120 of the European Parliament and of the Council of 25 November 2015 laying down measures concerning open internet access and amending Directive 2002/22/EC on universal service and users' rights relating to electronic communications networks and services, and Regulation (EU) No 531/2012 on roaming on public mobile communications networks within the Union (Text with EEA relevance), is likely to be deemed applicable for MCX services for PPDR users if the services are reliant on public networks.

Although it may be possible to adopt national rules that enable the use of QPP services, it is concluded that adjustments should be made to the existing EU Regulation on net neutrality which provide an explicit exemption for public safety operators. Until adjustments are made, the individual countries are recommended to create national rules that allow traffic management measures in favour of public safety.

TCCA is highlighting this key issue to stakeholders across the critical communications ecosystem in order to garner support and help drive regulatory change.

The white paper 'Legal and Regulatory aspects regarding the realisation of Quality of Service, Priority and Pre-emption (QPP) in commercial networks' can be read here.

TCCA https://tcca.info

[1] https://tcca.info/documents/CCBG-Definition-of-QPP.pdf/

ENHANCING ENGAGEMENT WITH 3GPP FOR INDIA – THE TSDSI APPROACH

by A K Mittal, TSDSI Advisor Networks, Systems & Technologies and Bindoo Srivastava, TSDSI Director Marketing and Communications & Partner Relations

India, the 2nd largest telecom market in the world, is primarily a 'mobile first' country. We are also home to the 3rd largest startups ecosystem out of which approximately 9000 are technology led (source: Startupindia).

The Indian industry, including tech startups, research and academia recognise the role of global standards in taking their innovations to the world.

Development of standards related to digital technologies is carried out in India by TSDSI. In turn, TSDSI participates as an Organizational Partner (OP) in 3GPP, which provides a mature and collaborative environment for entities from around the world to collectively develop technical reports and specifications for telecom technologies.

TSDSI is engaging with the community strategically to enhance their participation in 3GPP.

The approach taken is to:

- Increase awareness,
- Facilitate participation,
- Promote Individual Member (IM) level collaborations and
- Steer research towards contributing to standards.

A few activities in the above areas are described below.

Increasing Awareness:

TSDSI organised an online series of 3GPP Release 19 micro-workshops on "Advancing 5G towards 6G" in partnership with DoT, Government of India in the first half of CY'23 to disseminate information about 3GPP technology areas and timelines related to Release 19. The five workshops conducted in this series, were very well attended and widely appreciated. A feedback survey to elicit interest from the participants for contributing to 3GPP has created a pipeline of potential contributors to the project. TSDSI is working towards onboarding them as members. The workshop recordings can be accessed via the TSDSI website (https://tsdsi.in/).

Facilitating participation:

A major concern among startups and research & academic communities is the finances for membership and the resources required to participate consistently in meetings of 3GPP that need regular travels. The Indian Government has rolled out schemes to promote participation in global standards development activities. TSDSI is assisting its members to avail these.

> No matter how good the technical ideas are, it may still take several meetings, sometimes even spanning 2-3 years for those ideas to become part of the standards.

The current method of holding and allocating 3GPP meetings to different regions has provided an opportunity for TSDSI to host more meetings in India, which has enabled its members to participate in larger numbers and experience the meetings locally.

The Government is encouraging hosting of standards forums meetings in India. A recent example is the 3GPP TSG#101 meetings hosted by TSDSI in Bengaluru in September 2023. As expected, representatives from TSDSI IMs participated in the meetings in large numbers. TSDSI would especially like to acknowledge the tremendous support received from the Department of Telecommunications and other concerned Ministries of the Government, for travel related formalities of foreign delegates to the meeting. 5G Industry Forum associated with TSDSI by providing logistics support.

TSDSI also organised an outreach workshop at the end of the TSG#101 meetings, to discuss ways of enhancing contributions from Indian entities to the project. A panel discussion, led by Professor Brejesh Lall from IIT Delhi, featured various participants, including 3GPP expert Balazs Bertenyi (former 3GPP TSG Chair), newcomers to the project Soumava Mukherjee (IIT Jodhpur) and T S Ramu (Lekha Wireless), experienced contributors Subhas Mondal (HFCL) and Vinosh James (5GIF), as well as industry expert Vikram Tiwathia (COAI).

They recognized that no matter how good the technical ideas are, it may still take several meetings, sometimes even spanning 2-3 years for those ideas to become part of the standards. Socialising the proposals to garner support by being "present" continuously in the meetings is equally important. Provisioning of dedicated resources and funds for long term horizon (multi-year) is essential to be able to do this effectively. The experiences and learnings from 3GPP engagement so far can be leveraged to develop the next cohort of Standards Engineers in India. The Workshop presentations and recordings are available via the TSDSI website (https://tsdsi.in/).

During the pandemic, when everything was online, Indian IMs were able to participate in the meetings of 3GPP remotely, without the need to commit financial or time resources on travel. It also gave an opportunity to several new IMs to join the meetings for the first time and learn about 3GPP and its workings, to help them to identify their contribution areas.

TSDSI is a strong supporter of remote online participation in the 3GPP meetings, as a means to initiate the new IMs and to allow them to identify their areas of interest as they become effective contributors.

Promoting IM level collaborations:

TSDSI has been running workshops for its IMs before and after content finalization of releases to create awareness, exchange of views on various topics and identify potential areas of contributions and collaboration in the activities related to the release.

These are over & above the general workshops that are organized for induction of new IMs and to update them on the ongoing technical activities, workplans and timelines, potential opportunities for creating WIDs/contributions. The TSDSI workshops also help new members receive guidance and support from the more experienced contributors.

Steering research towards standards (Standards Driven Research):

Research that leads to solutions for real world problems should be contributed to standards to enhance its benefits to the larger community. The Indian industry has been exploring the outsourcing of its research needs to academic institutes using innovation centres, partnership projects, and other approaches. TSDSI has been engaging with academic and research institutes to encourage "Standards Driven Research" (SdDR). TSDSI regularly conducts workshops to facilitate exchange of notes between researchers and standards experts on technology trends and standardization roadmaps. These are helping the researchers in selecting problems that have a potential for standardization and standardization experts drawing inspiration from the research world for potential solutions. Due to these efforts, participation in global standards activities, including 3GPP, by the research and academic community from India is witnessing a rise in recent months.

The above efforts of TSDSI are beginning to yield results. In 2015 when TSDSI became a partner in 3GPP, 15 TSDSI members joined as IMs. This number has grown to 58 in 2023. Our participation and contribution levels have been increasing steadily over the years. The recent sharp increase in participation in 3GPP meetings by TSDSI IMs is expected to enable the 3GPP community to directly absorb the diverse requirements and innovations from the largest telecom market in the world, further enabling wider usability of standards.

In conclusion, it can be stated that - having gained valuable experience of contributing to the development of 5G standards in 3GPP and ITU, TSDSI is well positioned to enhance its efforts to contribute to 5G-Advanced and the next generation of standards.

tsdsi
India's Telecom SDO

▼ 3GPP TSGs#101 hosted by TSDSI in Bengaluru in September 2023

THE INTERVIEW

Antti Toskala is a Bell Labs Fellow and Head of 3GPP Radio Standardization, at Nokia Standards. He has worked with 3GPP for more than 20 years, recently passing a significant milestone. We talk to him about that and ask for his perspective on where next for 3GPP.

Highlights: You were at the Working Groups in Toulouse during August and the latest TSG Plenaries, in Bangalore this September. How is the Release 18 work progressing there?

Antti Toskala: It is great to be able to say that we are on track and that the first Release 18 - the first 5G-Advanced – specifications are now published. These are for layer 1, which is the start, with the next specs due out in December 2023. We will soon be in a phase where people can start implementing those first 5G-Advanced features.

Highlights: What is the significance of having these Layer 1 specs and what happens next?

Antti Toskala: Other groups will follow with their features and support for the physical layer features that will then lead to protocol specs three months later. This is always a building process where alignment and maintenance of the release features follows on from the Layer 1 specs – in cases where there is a dependency.

I would add that while RAN1 defines the physical layer, this is just a foundation. All of the groups have their responsibilities and the whole system is the sum of its parts.

Highlights: You were the RAN1 Chair from 1999 to 2003 and you still spend a lot of time in that group. Can you sum up the role and place of RAN1 in your work

▲ TSG RAN WG1 - In session in Toulouse, August 2023.

Antti Toskala: Currently my main role is to look after the Nokia team in 3GPP, including RAN WG1. I still spend time in 3GPP WGs, but I am not at every meeting. Now the emphasis is on team work to get good and consistent outcomes from 3GPP. As a big company we are active in basically every topic, so the teams have grown and I have found myself taking some responsibility for the bigger picture, as well as being close to some specific detail on the RAN side.

Highlights: You have recently celebrated your 100th 3GPP Plenary meetings (TSGs). This gives you a rare perspective on how the work has evolved. What have been the major changes you've seen in the 3GPP work and your role?

> It is great to be able to say that we are on track and that the first Release 18 - the first 5G-Advanced – specifications are now published.

Antti Toskala: Over time the project has grown. When I started a typical Working Group was running in a single session and a single expert could follow everything that happened inside that WG. RAN1 is now running multiple parallel sessions, which makes it impossible for one person to follow everything. Also, 3GPP has become more and more global, compared with the early ETSI days when regions were in follow-up mode. Now the regions work on-a-par.

One other development is that the systems are becoming more complex, so you need more people to be involved. As I mentioned, one group can run five parallel technical sessions, so more people are needed for us to contribute in an expert way. I would say that RAN1 doesn't really look so different from what it was, but that it now needs to run sessions in parallel instead of a single session. This partly explains the size of the group.

Highlights: A quick word about another dimension of growth. We have seen new industrial sectors coming into the groups. Has the trend of public safety, automotive, broadcasters, industry automation, etc. coming in to 3GPP continued or has this interest peaked with the 5G specifications for evolved broadband, URLLC and massive IoT?

Antti Toskala: No, I see that it's growing more and more with each generation. An example of how this seems to evolve is the railway sector. Some time ago we had enquiries from the rail companies as they considered some 3GPP features and 4G connectivity in advance of the GSM-R system coming to the end of its life, scheduled for the early 2030s.

Now, we see that they are demanding the 'real thing' and they see their communication needs aligned to 5G. So, although initial ideas were to replace outdated (2G) systems with something similar, they are actually on the way to a full transition. We also see other major vertical industries coming in, of course.

Highlights: As the project deals with these changes. Can you reflect on one or two of the lessons learned along the way, or that may need to be addressed?

Antti Toskala: There are one or two areas, one speaking with hindsight and another looking to how new participants may best succeed.

Project-wide I feel we should learn from having a phased 5G architecture. While it sounded appealing at the time to have first LTE as anchor and then later full 5G, we now have the majority of the market in Phase 1 with the LTE core. This means there is less room for deploying the new features which would rely on the full 5G architecture. My view is that having more options in the standards hasn't resulted in more options being offered in the market.

In a similar way, while it has been great to see new ecosystems coming into 3GPP, that too could be an area where we improve by ensuring that their needs should stay close to the mainstream track and we would deliver the smallest 'delta' of special requirements. Otherwise, the extra development cost, especially for the chip vendors, is going to be hard to justify for new markets with smaller volumes than the mass market.

> . . . we can't ignore the growing 5G legacy we have. A smooth migration to 6G will be important.

Highlights: You spoke about 5G-Advanced arriving with Release 18. Even so, 6G is on the horizon. What are your thoughts and expectations for that?

Antti Toskala: 6G should embrace simplicity and be implementation friendly. This could start from having a single architecture alternative to reduce number options for doing the same thing.

There are also some important issues for which we need a better and more efficient system. Energy efficiency, coverage and overall performance from the system and user perspective will all help ensure that 6G will be a success.

On the other hand, we can't ignore the growing 5G legacy we have. A smooth migration to 6G will be important.

Our thanks to Antti Toskala and congratulations of reaching and surpassing the 100 TSGs. 100 out of 101 is a good attendance record.

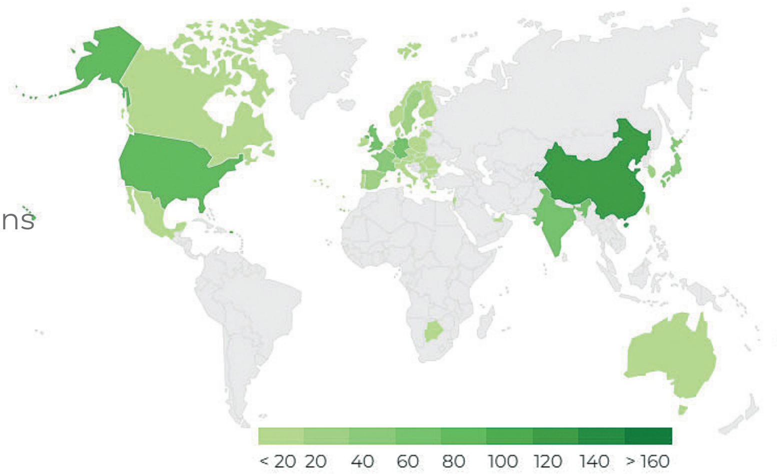
Antti is a former RAN1 Chair (1999 to 2003) and co-author of eight books on 3G, 4G and 5G. His most recent is '5G Technology: 3GPP New Radio' published by Wiley.

▼ Antti Toskala speaking on behalf of 3GPP at the NG Communications summit, held during the TSGs#100 week, June 2023

A LOOK INSIDE

3GPP'S GLOBAL MEMBERSHIP

- 42 Countries
- 858 Member companies or organizations
- 20,920 Delegates in 2023
- 143 Meetings in 2023
- 4,152 Specifications



3GPP Technical Specifications are transposed by our seven Organizational Partners into their appropriate National and Regional deliverables (Specifications/Standards).

atis ARIB CCSA TTC ETSI TTA tsdsi

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

CALENDAR OF MEETINGS

A selection of the major meetings for the period November 2023 - December 2024.

Only the 1H24 cycle of WG meeting is represented.
A similar spread of WG meetings takes place throughout the year – in-and-around the Plenaries (TSGs).

Meetings	Start Date	City
SA3	06-Nov-23	Chicago
CT1, CT3, CT4, CT6, RAN1, RAN2, RAN3, RAN4, RAN5, SA1, SA2, SA4, SA5, SA6	13-Nov-23	Chicago
TSGs#102 (CT/RAN/SA)	**11-Dec-23**	**Edinburgh**
CT1	22-Jan-24	Online
CT3	22-Jan-24	Online
SA4	29-Jan-24	Sophia-Antipolis
SA5	29-Jan-24	Sophia-Antipolis
CT1, CT3, CT4, CT,6, RAN1, RAN2, RAN3, RAN4, RAN5, SA1, SA2, SA3, SA4, SA5, SA6	26-Feb-24	Athens
TSGs#103 (CT/RAN/SA)	**18-Mar-24**	**Maastricht**
SA4-bis-e	08-Apr-24	Online
CT1, CT3, CT4, CT6, RAN1, RAN2, RAN3, RAN4, SA2, SA5, SA6	15-Apr-24	China
RAN1, RAN2, RAN3, RAN4, RAN5	20-May-24	Japan
SA3, SA4, SA6	20-May-24	Korea
CT1, CT3, CT4, CT6	27-May-24	India
SA1, SA2, SA3	27-May-24	Korea
TSGs#104 (CT/RAN/SA)	**17-Jun-24**	**China**
TSGs#105 (CT/RAN/SA)	**09-Sep-24**	**Melbourne**
TSGs#106 (CT/RAN/SA)	**09-Dec-24**	**Europe**

ELECTION YEAR 2023

This has been a year of elections with all but one (SA6) of the groups holding leadership contests. Here is a list elected or re-elected TSG and WG Chairs:

TSG	CT	Peter Schmitt (Huawei)
WG	CT1	Lena Chaponniere (Qualcomm)
WG	CT3	Yali Yan (Huawei)
WG	CT4	Yue Song (China Mobile)
WG	CT6	Heiko Kruse (IDEMIA)
TSG	RAN	Wanshi Chen (Qualcomm)
WG	RAN1	Younsun Kim (Samsung)
WG	RAN2	Diana Pani (InterDigital)
WG	RAN3	Yin Gao (ZTE)
WG	RAN4	Xizeng Dai (Huawei)
WG	RAN5	Jacob John (Motorola)
TSG	SA	Puneet Jain (Intel)
WG	SA1	Jose Luis Almodovar Chico (TNO)
WG	SA2	Andy Bennett (Samsung)
WG	SA3	Suresh Nair (Nokia)
WG	SA4	Frederic Gabin (Dolby)
WG	SA5	Lan Zou (Huawei)
WG	SA6	Alan Soloway (Qualcomm)

Full details of the present and past leadership of the groups can be found via the 3GPP Groups section of the website.

www.3gpp.org/3gpp-groups