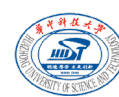


BOOK #3  
MARCH 2019



# SETTING THE STANDARDS FOR THE HYPER-CONNECTED WORLD

HARMONISATION OF 5G AND IOT STANDARDS BETWEEN EUROPE AND CHINA





NFV

FUTURE INTERNET

5G

CLOUD

IOT

MOBILE  
INTERNET

GENI

IPV6

FIRE

SDN

# EUCHINA: SETTING THE STANDARDS FOR THE HYPER-CONNECTED WORLD

## HARMONISATION OF 5G AND IOT STANDARDS BETWEEN EUROPE AND CHINA

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**EXCITING WP3 White Paper**



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### ABSTRACT

Europe and China are at the forefront of technological advances in areas related to the Future Internet. While both parties share common technological objectives, there is still room for improvement in what concerns bilateral co-operation. The Project EXCITING (EU-China Study on IoT and 5G) was created to support the development of favourable conditions for co-operation between the European and Chinese research and innovation ecosystems in the key strategic domains of IoT and 5G, with a focus on standardisation and interoperability.

The two prime anchors of standardisation between Europe and China are 3GPP for 5G and oneM2M for IoT. Both have been initiated by the European standard body ETSI and include the China Communications Standards Association (CCSA) as a partner, as well as other world standardisations bodies (ARIB, ATIS, TSDSI, TTA, TTC)<sup>1</sup>.

The collaboration between the 5G IA, the 5G Forum China and the AIOTI with the China All<sup>2</sup> adds another dimension of cooperation of joint harmonisation and alignment in the industry efforts.

In this white paper we review the ongoing standardisation activities related to the Future Internet, 5G and IoT, and reflect on the need for harmonisation and alignment between Europe and China.

<sup>1</sup> ARIB (Association of Radio Industries and Businesses, Japan), ATIS (Alliance for Telecommunications Industry Solutions, USA), TSDSI (Telecommunications Standards Development Society, India), TTA (Telecommunications Technology Association, Korea), TTC (Telecommunication Technology Committee, Japan)

<sup>2</sup> 5G IA (5G Infrastructure), AIOTA (Alliance for Internet of Things Innovation), All (the Alliance of Industrial Internet, China)



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# EUCHINA: SETTING THE STANDARDS FOR THE HYPER-CONNECTED WORLD

## 1 INTRODUCTION

The Future Internet, the foundation of the Hyper-Connected World, will be based on two technological concepts: the Fifth Generation Mobile Communication System (5G) and the Internet of Things (IoT).

Building on advances in technology and system architecture development, 5G will bring new network and service capabilities and enable a large variety of new and innovative applications.

Providing an order of magnitude improvement in performance in the areas of capacity, latency, mobility, accuracy of terminal location, reliability, and availability, 5G presents a huge opportunity for the digitisation of the economy and the modernisation of all industry sectors. This transformative potential makes 5G a matter of major societal importance and a subject of high expectations from economic and political bodies in Europe and globally.

In addition, 5G is regarded a key enabler for the IoT by providing a platform to connect a massive number of sensors, rendering devices and actuators with stringent energy and transmission constraints.

While forecasts vary widely, there is a consensus that the IoT holds an enormous market potential and that within a few years from now there will be tens of billions of IoT devices deployed.





## 2

## EU-CHINA COLLABORATION ON THE FUTURE INTERNET

Home to approximately 25% of the world's population and generating 34% of the world's GDP [1], Europe and China are global champions in the research, development, and deployment of the Future Internet. Companies from both regions dominate the market for mobile infrastructure equipment: In 2017, Ericsson and Nokia had a combined market share of 50%, while the two biggest Chinese suppliers, Huawei and ZTE, held 41% [2]. China held about 10% of the "5G-essential" IPRs in radio access, modulation and core networking [3].

By 2025, 1.2 billion people worldwide will have access to 5G networks, with China (428 million subscribers [4]) and Europe (214 million subscribers [5]) accounting for more than half of the global subscriber base.

In September 2015, China and the European Union (EU) signed an Agreement on 5G to deepen their collaboration research, standardisation, spectrum harmonisation, and the Internet of Things. The objective of this Agreement was to ensure that China and Europe maintain an equivalent level of industrial transparency between the two parties. Under the declaration, China and the EU aimed to reach a consensus on the concept, basic functionalities, key technologies, and timeline for 5G.

To foster collaboration specifically in the domain of the IoT, both parties established the EU-China IoT Advisory Group in 2011. A report published by the Group in 2016 [6] listed a number of cooperation items, including standardisation.

## 3

## STANDARDS FOR THE FUTURE INTERNET

The economic impact of standards has been widely researched, and the potential benefits of standards are undisputed. Common and open standards ensure the interoperability of systems, devices, applications, and services, foster innovation, and lower market entry barriers. Effective interoperability guarantees that connected devices such as cars, phones, appliances and industrial equipment can communicate seamlessly with each other, regardless of manufacturer, operating system, or other technical components.

Information and Communications Technologies (ICT) standardisation is a cornerstone of the Digital Single Market Strategy adopted by the European Commission (EC) to strengthen Europe's productivity and competitiveness in the global digital economy. 5G Communications and the IoT are two of the five key ICT standardisation priorities that have been identified by the EC [7].

### 3.1 5G STANDARDISATION BODIES

The essential responsibility for defining the global 5G standard lies with the 3rd Generation Partnership Project (3GPP). Seven major Standards Developing Organisations (SDOs) from Europe, Asia, and North America are associated with the project. A variety of committees, task groups and working groups are active within - and between - the major standardisation and regulatory bodies: 3GPP, BBF, ETSI, IEEE, ITU-T, ITU-R, CEPT<sup>3</sup>, and, in addition, there are a large number of forums and 5G research and promotion initiatives.

**In China**, international standards in the field of ICT are mainly formulated by the CCSA (China Communications Standards Association), which was established in 2002. The membership of the CCSA includes operators, chip and system manufacturers, universities and other companies.

The CCSA contributes to the global standardisation of 5G through its memberships in 3GPP, the ITU, and other international initiatives and organisations. Furthermore, it collaborates with the SDOs of Japan and Korea within the CJK (China Japan Korea) group.

<sup>3</sup> 3GPP (3rd Generation partnership Project), BBF (Broadband Forum), ETSI (European Telecommunications Standards Institute), IEEE (Institute of Electrical and Electronics Engineers), ITU-T (International Telecommunication Union-Telecommunication), ITU-R (International Telecommunication Union - Radiocommunication), CEPT (Conférence Européenne des Postes et des Télécommunications)



The **IMT-2020 (5G) Promotion Group** was established in 2013 by the Ministry of Industry and Information Technology (MIIT), the National Development and Reform Commission (NDRC), and the Ministry of Science and Technology (MOST). It is the major platform to promote 5G research in China, with its core objectives being to aggregate the power of industry-academia-research-application cooperation in mobile communication, promoting 5G technology research, standards formulation, industrial development, and international cooperation. Its members include leading operators, equipment manufacturers, chip / instrument enterprises, universities, and research institutes in the field of mobile communications. The IMT-2020 (5G) Propulsion Group was initially composed of Chinese entities and is now open to foreign companies. Important foreign companies such as Ericsson, Nokia, Samsung, Qualcomm, Intel, NTT DoCoMo and Keysight have joined the group.

Several organisations in China are involved in the standardisation of Smart Mobility/Intelligent Transport Systems and therefore have an interest in the specification and development of 5G technology for these applications. Two prominent organisations are the Telematics Industry Application Alliance (TIAA) and the China ITS Industry Alliance (C-ITS).

**In Europe**, ETSI produces standards for ICT, which are globally applicable and adopted by many countries worldwide. Being one of the principal members of the 3GPP, its more than 25 Technical Committees and Working Groups contribute to the definition of the global 5G standard.

Another major contributor to standardisation in Europe is the 5G Public Private Partnership (**5G-PPP**), the 5G collaborative research programme established under the umbrella of the European Commission's Horizon 2020 Programme. The 5G-PPP was initiated by the EU Commission for the public side, the 5G Infrastructure Association (**5G IA**) representing the private side with a wide range of stakeholders including equipment manufacturers, telecommunication and satellite operators, vertical industries, SMEs, universities and research institutes.

The 5G-PPP aims at fostering industry-driven research, monitored by business-related, technological performance and societal KPIs. Its objective is to deliver solutions, architectures, technologies and standards for a ubiquitous next-generation communication infrastructure.

In 2015, the 5G-PPP and the IMT-2020 Promotion Group signed a Memorandum of Understanding (MoU) with the objective to strengthen communication and cooperation in the areas of 5G concepts, spectrum planning, international standards and 5G experiments, and to promote the formation of consensus between the two regions.

Other initiatives that are focusing on the promotion of 5G in Europe and globally are the 5G Automotive Association (**5GAA**) and the 5G Alliance for Connected Industries and Automation (**5G-ACIA**). The 5GAA has been established to connect the telecommunication industry and vehicle manufacturers to develop end-to-end solutions for future mobility and transport services. The 5G-ACIA has been established to serve as the central and global forum for addressing, discussing, and evaluating relevant technical, regulatory, and business aspects with respect to 5G for the industrial domain.

## 3.2 IOT STANDARDISATION BODIES

IoT is expected to comprise tens of billions of networked devices, high-performance networks, and powerful data processing facilities which will generate, transport, and process huge amounts of data and thus enable new applications and services that will transform industry and society.

Addressing very diverse applications and use cases, and utilising a variety of hardware and software technologies, IoT is an extremely complex structure. Unlike 5G, which started from one specific application, i.e. mobile communications, and which can build on a global standardisation framework and process that has been refined for more than 15 years, the IoT has no such common background. Consequently, the IoT standardisation ecosystem is much more fragmented. In 2016, there were more than 600 standards related to the IoT [7].

A global initiative aiming to ensure the most efficient deployment of Machine-to-Machine (M2M) communications systems and the IoT is **oneM2M**. Launched in 2012, oneM2M adopted the successful 3GPP partnership model. Its main objective is to develop technical specifications for a common M2M Service Layer that can be embedded within various hardware and software to connect the wide range of devices worldwide with M2M application servers. oneM2M comprises fourteen partners including ETSI, CCSA, and six other leading ICT SDOs as well as representatives of different industry sectors including Telematics and intelligent transportation, Healthcare, Utilities, Industrial automation, and Smart homes.

In addition to oneM2M there are several committees, task and working groups active within and between the major standardisation and regulatory bodies such as 3GPP, BBF, ETSI, IEEE, ITU-T and, in addition, a large number of forums and IoT research and promotion initiatives, such as AIOTI, IoT Forum and All.

**In Europe**, ETSI's Technical Committee SmartM2M, develops specifications for requirements, functional architecture, and interface descriptions for a standardised M2M platform. SmartM2M is also addressing IoT standardisation gaps identified by the European Commission's Large Scale Pilot projects.

In analogy to the 5G-PPP, the **AIOTI** was initiated by the European Commission in 2015 as a result of European and global IoT technology and market developments. Currently, the AIOTI has more than 190 members from industry and academia.

The AIOTI aims to create and master sustainable innovative European IoT ecosystems in the global context to address the challenges of IoT technology and applications deployment, which include standardisation, interoperability and policy issues, in order to accelerate sustainable economic development and growth in the new emerging European and global digital markets.

Within the AIOTI, its Working Group 03 identifies and, where appropriate, makes recommendations to address existing IoT standards, analyses gaps in standardisation, and develops strategies and use cases.

**In China**, the field of IoT standard development is very complicated. National SDOs, industrial associations and alliances are all involved, but have different technology priorities. Some SDOs spans over multiple levels of work and there is some overlapping among organisations.

At the national level, China has initially established a multi-tier collaborative working mechanism for the standardisation of IoT. Since 2010, NDRC, China's National Standardisation Committee and related authorities have successively established the National IoT Standards Promotion Group, the National IoT Basic Standards Working Group, and IoT Industrial Standards Application Working Groups.



The IoT National Standards Promotion Group guides the set-up and planning of the national IoT standard system, as well as coordinating project establishment, drafting, revision and implementation of national standards for basic and applied fields of IoT; The IoT Basic Standards Working Group organises the drafting of the basic and common national standards for IoT, under which there are 3 project teams working on general activities, coding and identification, and information security. The project team members are composed of domestic standards organisations such as standardisation technical committees or standardisation associations that are engaged in IoT technology.

Within the IoT Industry Application Standards Working Group, there are several specific working teams including public security, transportation, medical treatment, agriculture, forestry and environmental protection. They are responsible for developing and implementing related industrial standards.

At present, China has set up more than 200 national standard projects, working on general standards for work guidelines, terminology, architecture, interface general requirements, identification and security, common standards of sensors, radio frequency identification, network enhancement, information fusion, application support, etc. and industrial networking and other industry application standards for agriculture, security, transportation, modern forestry, medical care, home furnishing, M2M and tourism.

At the industrial level, the industrial SDOs have their different priorities. They usually build on existing industrial standards to tailor them to the specialised and individualised needs for different sectors.

Multiple industrial standards organisations including the CCSA TC10, the China National Information Technology Standardisation Network (NITS), the Standardisation Working Group on Sensor Networks (SWGSN), SAC/TC426, ITS China and TC260 are working on IoT.

For example, the CCSA is working on, and developing, related technical standards such as ubiquitous networks, IoT and sensor networks, architectures, interfaces, identification and security. The SWGSN is working on the standardisation of terminology of sensor networks, communication and information interactions, interfaces, security, identification, and application standardisation. The industry standard organisations are all open to foreign companies, where foreign companies can be formal members, or observers. At present, several foreign large and medium-sized enterprises are actively involved.

At the Alliances level, to enhance cooperation from production, research to application of the industrial Internet, and jointly promote the standardisation, industrialisation and internationalisation of the industrial Internet, the Alliance of Industrial Internet (All) was established in 2016. As an open organisation, the All has more than 900 members now, 7% of which are foreign companies. It is an important communication platform for domestic and foreign companies in the field of the industrial Internet. In addition, the All has signed an MoU with the IIC of the US to promote the cooperation between industrial Internet architecture, test beds and standardisation. An MoU between the All and the AIOTI - facilitated by EXCITING - was signed in November 2018.

China is also becoming increasingly active in international standardisation, leading and participating to more and more standards. China joined other countries to set up oneM2M, to provide a common platform for communication service providers to ensure that the IoT devices can be interconnected worldwide. A research group for IoT and Smart Cities has been set up under ITU-T SG20, to promote the standardisation of the IoT end-to-end architecture and interoperability mechanisms for applications and data sets adopted by different vertical industry sectors. China has also actively promoted the establishment of the ISO/IEC JTC1 Working Group for Sensor Networks under the International Standardisation Working Group, to promote multiple sensor network communication technology standards.

### 3.3 3GPP STANDARDISATION

#### 5G DEFINITIONS AND STANDARD UPDATES

5G Wireless is defined by the 3GPP Release 15 (R15) and later releases (R16, 17, etc.) of Long-Term Evolution (LTE) and New Radio (NR) mobile communication systems. It is thus an LTE advanced pro evolution and a NR technology that adds to existing networks in a 3GPP Non-Stand Alone (NSA) or 3GPP Stand Alone (SA) architecture configuration. 3GPP will propose its standards to be adopted by ITU, being compliant with the International Mobile Telecommunications (IMT) for 2020 and beyond (ITU IMT 2020), which expands and supports diverse usage scenarios and applications with respect to current mobile network generations, purposed primarily for voice, mobile internet and video experience.

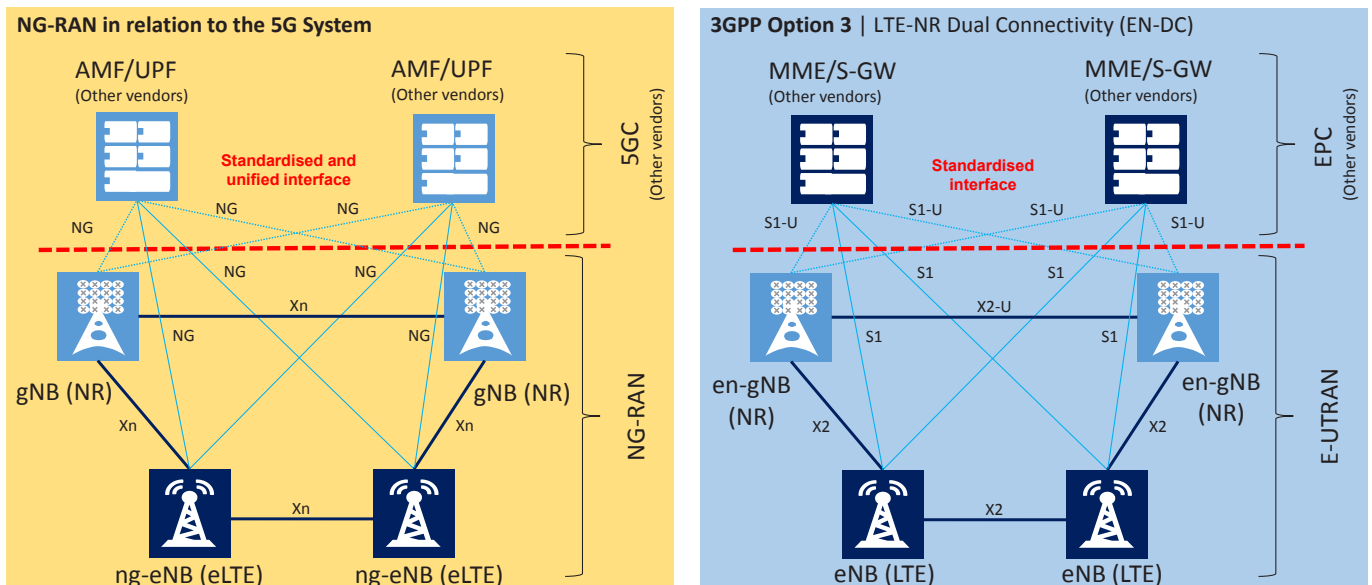
**The Next Generation Radio Access Network (NG-RAN)** represents the newly defined radio access network for 5G, and provides both NR<sup>4</sup> and LTE radio access, see *Figure 1*.

An **NG-RAN** node (i.e. base station) is either:

- A **gNB**<sup>5</sup> (i.e. a 5G base station), providing NR user plane and control plane services; or
- An **ng-eNB**<sup>6</sup>, providing LTE/E-UTRAN<sup>7</sup> services towards the User Equipment (UE).

The **5G System (5GS)** consist of **NG-RAN** and **5G Core Network (5GC)**, as shown in *Figure 1*.

Figure 1: Overall 5G Architecture: a) 5G system (5GS)



AMF (Access and Mobility Management Function)  
 UPF (User Plane Function)  
 MME (Mobility Management Entity)  
 S-GW (Serving Gateway)  
 EPC (Evolved Packet Core)

<sup>4</sup> NR (New Radio)

<sup>5</sup> **gNB** (5G base station)

<sup>6</sup> **ng-eNB** (Next generation eNodeB)

<sup>7</sup> E-UTRAN (Evolved Universal Terrestrial Radio Access)



The NG RAN operates in both so-called “**Stand-Alone**” (SA) operation and “**Non-Stand-Alone**” (NSA) operation. In SA operation, the gNB is connected to the 5G Core Network (5GC); in NSA operation, NR and LTE are tightly integrated and connect to the existing 4G Core Network (EPC), leveraging **Dual Connectivity (DC)** toward the terminal. In a DC architecture, a **Master Node (MN)** and a **Secondary Node (SN)** concurrently provide radio resources towards the terminal for an enhanced end-user bit rate (speed or throughput).

Moreover, 3GPP has defined the following architecture configurations on top of the first option above:

### Option 2: NR gNB connected to 5GC

In this option, the gNBs are connected to the 5GC through the NG interface. The gNBs interconnect through the Xn interface.

### Option 3: Multi-RAT<sup>8</sup> DC with EPC

In this option, commonly known as **LTE-NR Dual Connectivity (EN-DC)**, a UE is connected to an eNB that acts as a Master Node (MN) and to an en-gNB that acts as a Secondary Node (SN). An en-gNB is different from a gNB in that it only implements part of the 5G base station functionality, which is required to perform SN functions for EN-DC. The eNB is connected to the EPC via the S1 interface and to the en-gNB via the X2 interface. The en-gNB may also be connected to the EPC via the S1-U interface and to other en-gNBs via the X2-U interface. Note that the en-gNB may send UP<sup>9</sup> to the EPC either directly or via the eNB.

### Option 4: Multi-RAT DC with the 5GC and NR as Master

In this option, a UE is connected to a gNB that acts as a MN and to an ng-eNB that acts as an SN. This option requires the 5G Core to be deployed. The gNB is connected to 5GC and the ng-eNB is connected to the gNB via the Xn interface. The ng-eNB may send UP to the 5G Core either directly or via the gNB.

### Option 5: LTE ng-eNB connected to 5GC

In this option, the ng-eNBs are connected to the 5GC through the NG interface. The ng-eNBs interconnect through the Xn interface. Essentially this option allows the existing LTE radio infrastructure (through an upgrade to the eNB) to connect to the new 5G Core.

### Option 7: Multi-RAT DC with the 5GC and E-UTRA as Master

In this option, a UE is connected to an ng-eNB that acts as a MN and to a gNB that acts as an SN. The ng-eNB is connected to the 5GC, and the gNB is connected to the ng-eNB via the Xn interface. The gNB may send UP to the 5GC either directly or via the ng-eNB.

## FAMILY OF USAGE SCENARIOS

The family of usage scenarios for IMT-2020 and beyond for 5G include: 1) “**Enhanced mobile broadband (eMBB)**” addressing human-centric use cases for access to multimedia content, services and data; 2) “**Ultra-reliable-low latency communications (URLLC)**” with strict requirements, especially in terms of latency and reliability; and 3) “**Massive machine type communications (mMTC)**” for a very large number of connected devices and typically transmitting a relatively low volume of non-delay-sensitive information.

<sup>8</sup>RAT (Radio Access Technology)

<sup>9</sup>UP (User Plane)

### 3GPP 5G ROADMAP

As illustrated in Figure 2, the completion of the **first 5G phase** (Phase 1 or Release 15, R15) of the NR Access technology was achieved in June 2018, in its NSA configuration [9]. The SA option was finalised in September 2018. The 3GPP R15 supports eMBB and some elements of URLLC, e.g. flexible numerology and reduced scheduling interval.

Both LTE and NR use orthogonal frequency-division multiplexing (OFDM) as the waveform. LTE uses a *fixed numerology* of 15 kHz sub-carrier spacing (SCS) and *operates below 6 GHz*. The new 5G radio is for all spectrum options. To this end, 5G supports a

*flexible numerology*, which consists of different *Sub Carrier Spacing (SCS)*, *nominal Cyclic Prefix (CP)*, and *Transmission Time Interval (TTI)*, or scheduling interval, depending on bandwidth and latency requirements. At higher SCS, the symbol duration decreases, and hence also the length of a slot. The slot is the basic frame structure at which most physical channels and signals repeat. In NR, slots can be complemented by a “mini-slot” based transmissions to provide shorter and more agile transmission units than slots. In LTE and NR a slot comprises 14 OFDM symbols, which leads to a slot length of 1 ms at 15 kHz SCS.

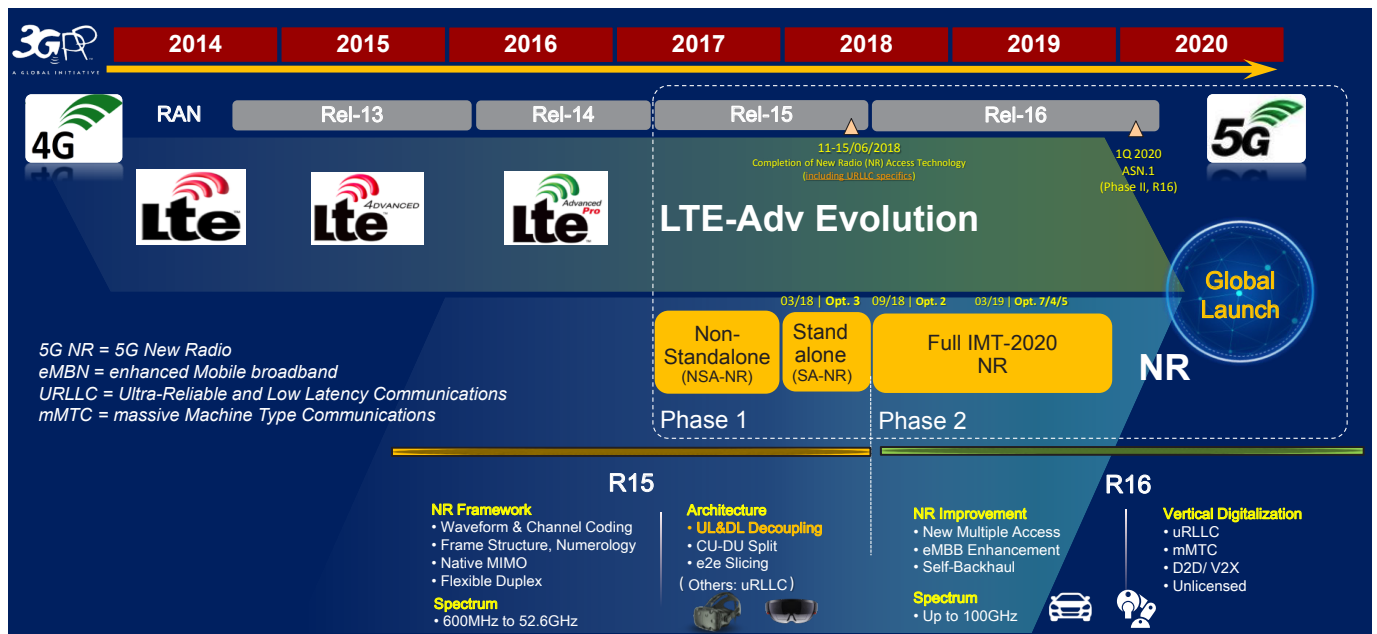


Figure 2: 3GPP definition of 5G: LTE evolution and New Radio (NR), supporting new usage scenarios [9]

By using higher numerologies in NR, the slot duration decreases, which is beneficial for lower latencies. The intention of NR is to support a mix of numerologies on the same carrier. A more profound URLLC analysis can be found, e.g., in [10].

**The second 5G phase** (Phase 2 or Release 16, R16), supporting usage scenarios, including URLLC and mMTC, will be frozen in Q1 of 2020, or later [9].

<sup>8</sup>RAT (Radio Access Technology)  
<sup>9</sup>UP (User Plane)



## SPECTRUM

5G NR is expected to increase spectrum efficiency and support contiguous, non-contiguous, and much broader channel bandwidths than available to current mobile systems. 5G NR will be the most flexible way to benefit from all available spectrum options from 400 MHz to 90 GHz, including licensed, shared access and license-exempt bands, FDD and TDD<sup>10</sup> modes, including Supplementary Uplink (SUL), LTE/NR uplink sharing (ULS), and narrowband and wideband Carrier Components (CC).

A multi-layer spectrum approach is required to address such a wide range of usage scenarios and requirements

- The «**Coverage and Capacity Layer**» relies on spectrum in the 2 to 6 GHz range (e.g. C-band) to deliver the best compromise between capacity and coverage.
- The «**Super Data Layer**» relies on spectrum above 6 GHz (e.g. 24.25-29.5 and 37-43.5 GHz) to address specific use cases requiring extremely high data rates.
- The «**Coverage Layer**» exploits spectrum below 2 GHz (e.g. 700 MHz) providing wide-area and deep indoor coverage.

5G networks will leverage the availability of spectrum from these three layers at the same time, and administrations are expected to make available contiguous spectrum in all layers in parallel, to the greatest extent possible.

## 5G REFERENCE ARCHITECTURE AND MIGRATION STRATEGIES

The most likely initial deployment options are illustrated in *Figure 3*.

**3GPP Option 3x** (NSA LTE plus NR with EPC) is the configuration that, most likely, more carriers (network operators) will adopt, due to minor investments for their initial 5G deployment, and so it is by the local players in Australia. It supports eMBB and FWA<sup>11</sup> usage scenarios and Voice over IP (VoIP) over LTE (VoLTE) or Circuit Switch Fall Back (CSFB) to earlier network releases (3G, 2G).

**The 3GPP Option 2** (SA NR with 5GC) is initially adopted by only a few carriers globally. For taking full advantage from it, a wide coverage rollout is needed, as the interoperation with 4G/EPS is less efficient. Initial partial coverage rollouts may be more suitable for enterprise or overlay deployments. In the long round, it will support all scenarios (eMBB, URLLC, mMTC), plus other functionalities than Option 3x, such as Network Slicing and Voice over NR (VoNR).

<sup>10</sup> FDD (Frequency Division Duplex), TDD (Time Division Duplex)

<sup>11</sup> FWA (Fixed Wireless Access)

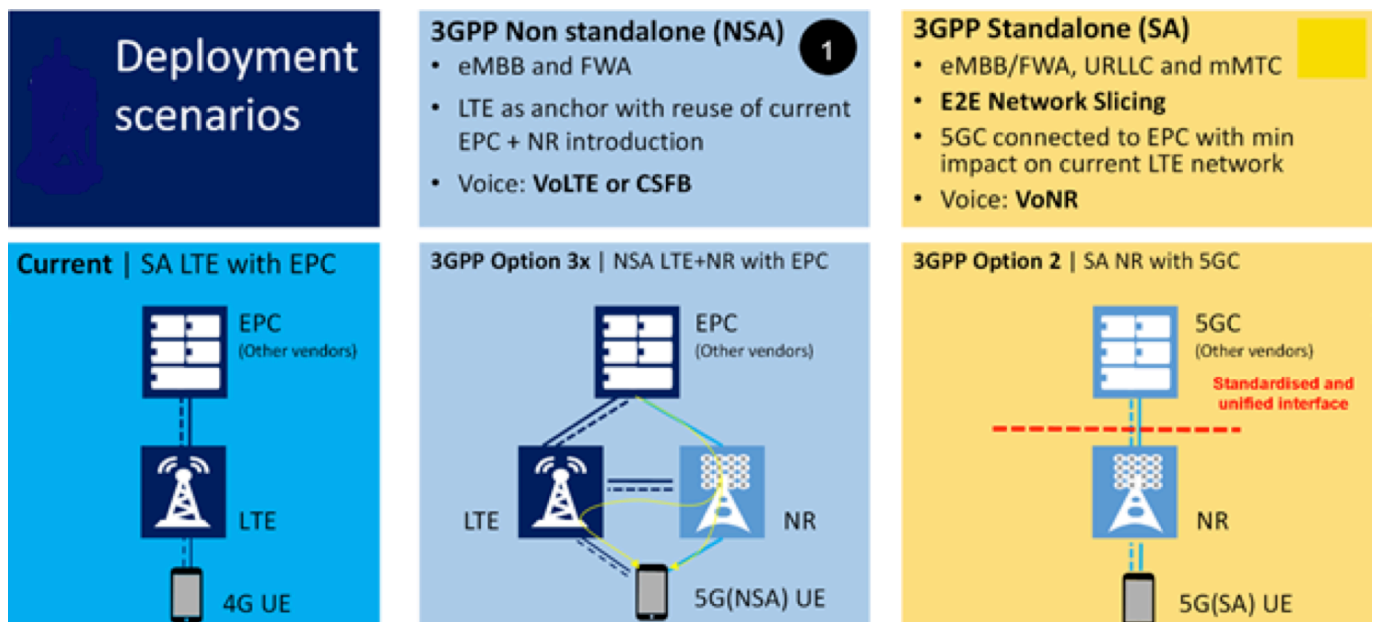


Figure 3: Main initial 5G deployment options

The medium-long term migration path of 5G networks is illustrated in *Figure 4*. Ultimately, all networks will converge to a 3GPP Option 2 architecture configuration (SA NR with 5GC).

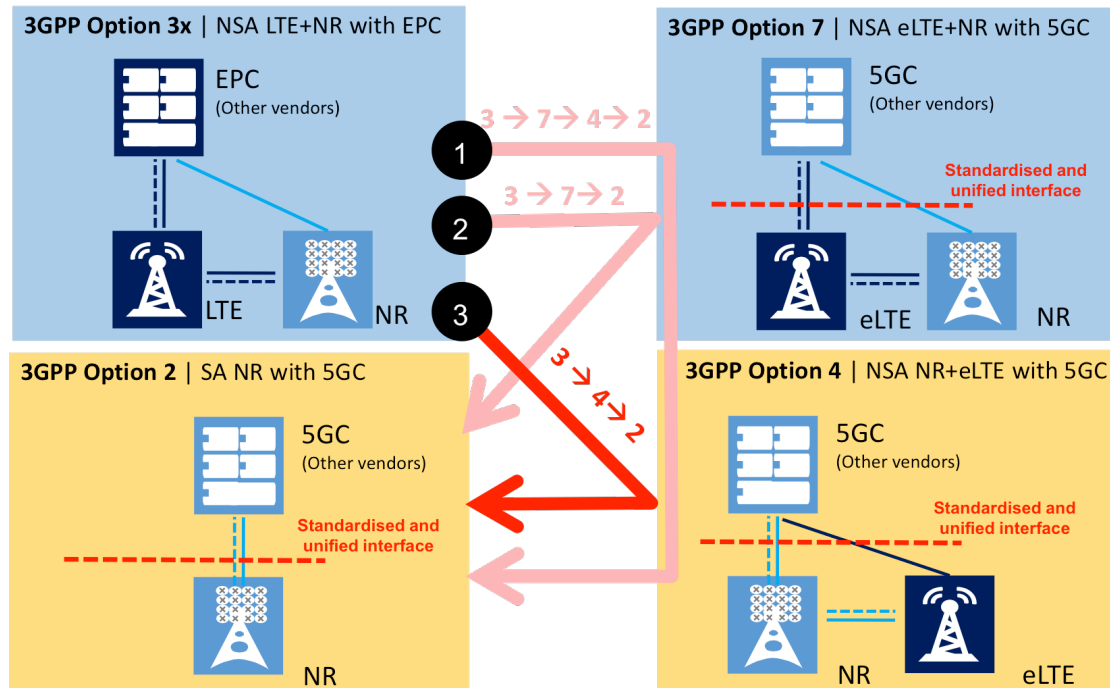


Figure 4: Long term migration paths

The middle term migration strategies are basically two, depending on the carriers' spectrum availability for deploying the NR:

- From deployed 3GPP Option 3x (NSA LTE + NR with EPC) to 3GPP Option 7 (NSA eLTE + NR with 5GC).**  
 The reasons to go for that are: Leverage 4G (LTE/EPC) installed base; NR rollout driven by better service (not coverage); and evolved LTE (eLTE) for all wide area coverage and all use cases. The drawbacks are: Full Dual Stack eNB/ng-eNB in LTE RAN to EPC/5GC; LTE RAN upgrades to eLTE; and required Interworking between LTE and NR. UE availability is also, currently, questionable. The migration scenario is shown in *Figure 5*.

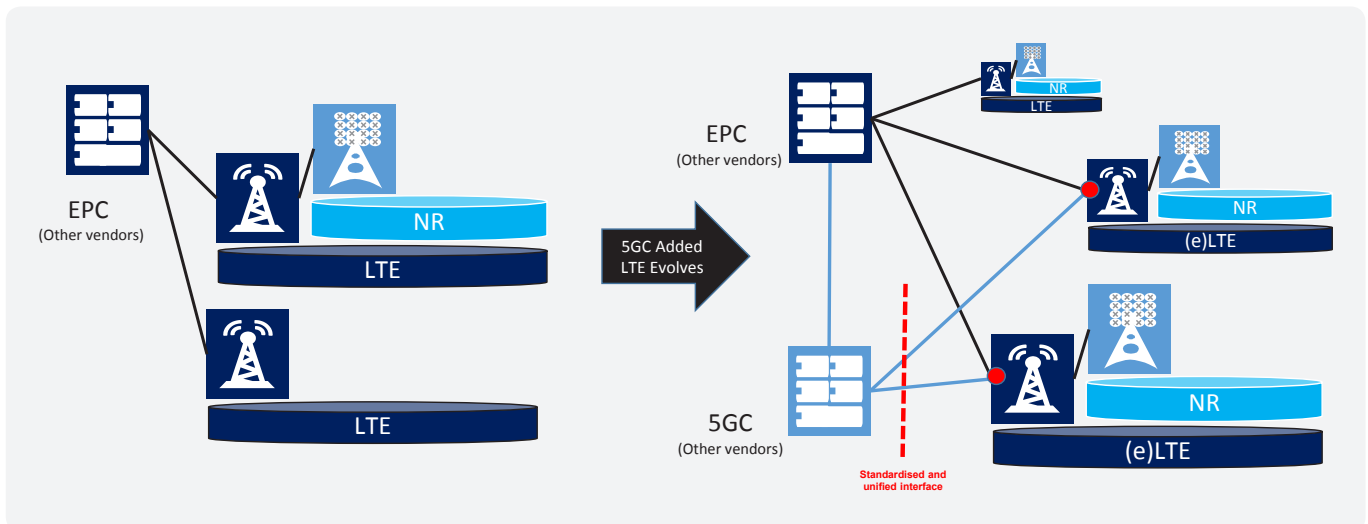


Figure 5: Main migration strategy in Europe From 3GPP NSA Option 3x to 3GPP NSA Option 7



**2 From deployed 3GPP Option 3x (NSA LTE + NR with EPC) to 3GPP Option 4 (NSA NR + eLTE with 5GC).** This choice is driven by the availability of low band NR (<3 GHz, <1 GHz for rural). The 5G services are launched with LTE+NR NSA on EPC, the NR and 5GC rollout are driven by needs of 5G coverage; outside the NR coverage, 5G services may be provided by 3GPP LTE NSA Option 4 with 3GPP Option 5 (SA eLTE with 5GC). The interworking between eLTE and NR is also required. The migration scenario is shown in *Figure 6*.

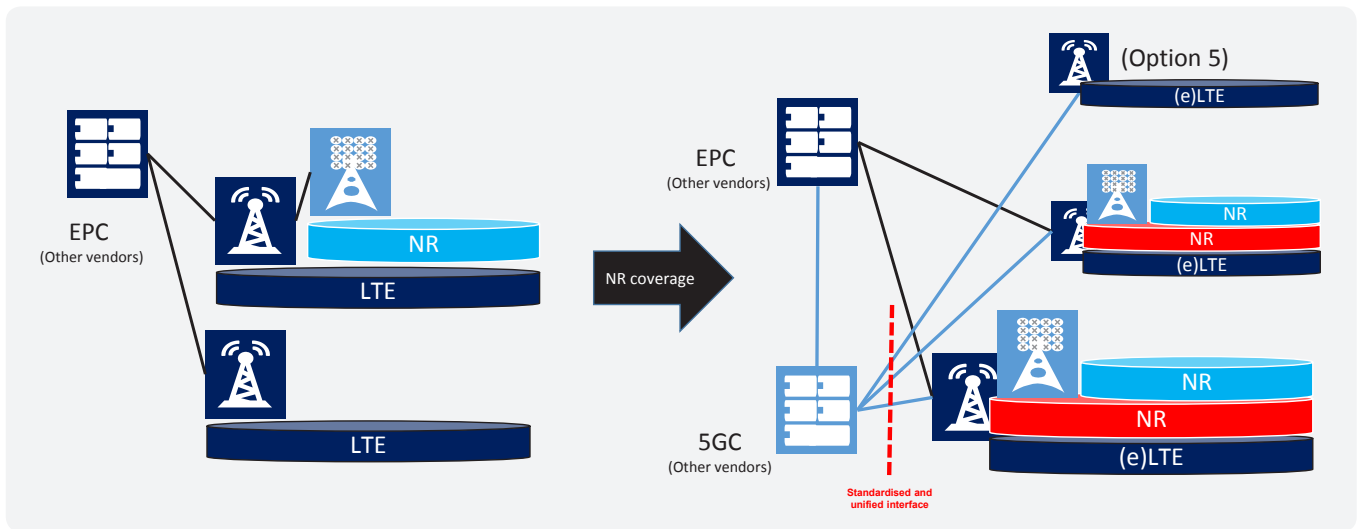


Figure 6: Other possible migration strategy: From 3GPP NSA Option 3x to 3GPP NSA Option 4

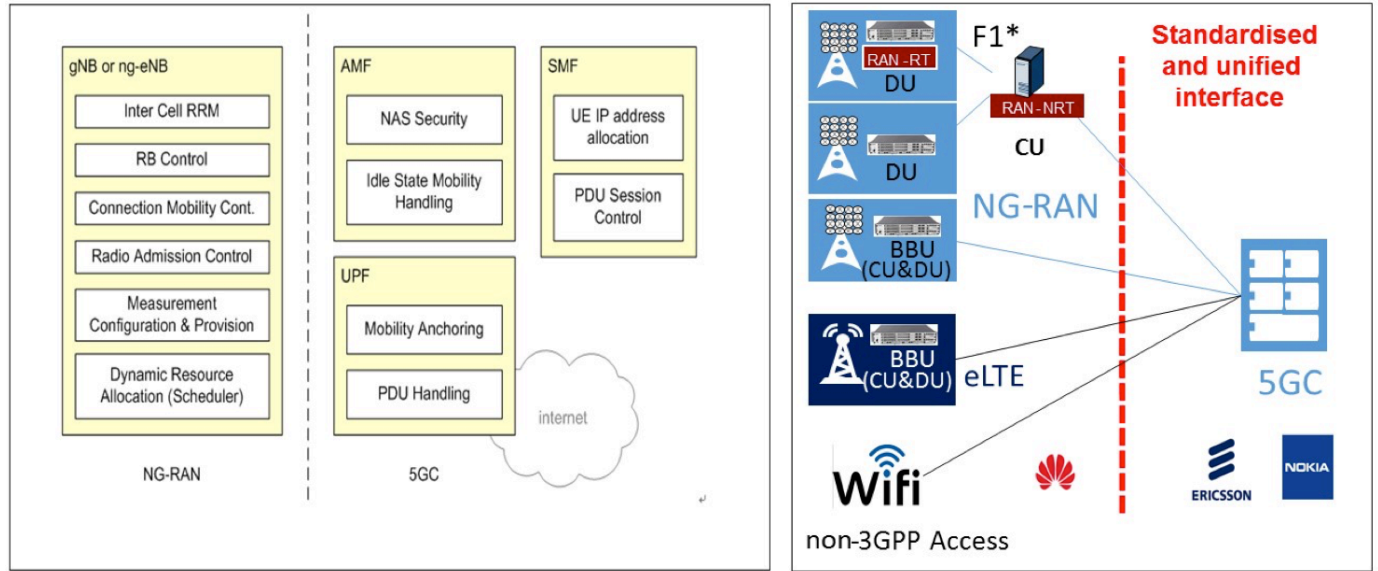
As in previous mobile system generations, 3GPP defines a clear functional split between the Access Network (NG-RAN) and Core Network (5GC) with the overall 5G System architecture defined in the 3GPP “[System architecture for the 5G system; Stage 2](#)”, 3GPP TS 23.501 v.15.2.0. and a more convenient overview of the AN and CN functions in the 3GPP “[Procedures for the 5G System; Stage 2](#)”, 3GPP TS 23.502 v.15.2.0. The two network domains are separated by a standardised interface (N2 and N3) defined in a set of specifications, with the “[NG-RAN; NG general aspects and principles](#)”, 3GPP TS 38.410 v.15.0.0. as the overarching specification which enable multi-vendor RAN – CN deployments. Also, this interface has been now unified, meaning that all next generation accesses (trusted/untrusted fixed/mobile 3GPP access points) must support this interface.

The NG-RAN supports inter cell radio resource management (RRM), radio bearer (RB) control, connection mobility control, radio admission control, measurements configuration and provisioning, and dynamic resources allocation.

The 5GC is responsible for non-access stratum (NAS) security and idle state mobility handling; user equipment (UE) IP address allocation and protocol data unit (PDU) control, and mobility anchoring and PDU session management.

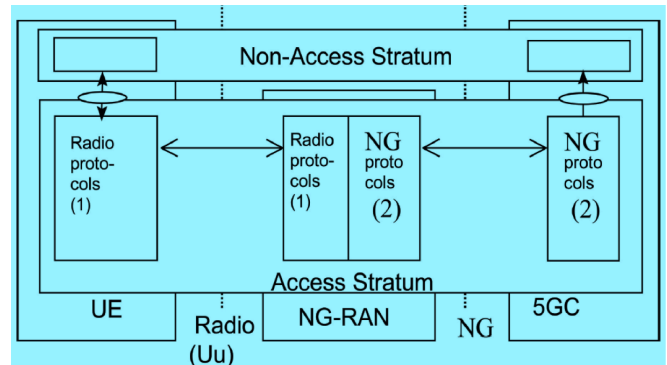
The functional split between the NG radio and core domains is shown through *Figure 7*, where the multi-vendor implementation (equipment from different vendors) of the corresponding functions is also illustrated.

Figure 7: NG-RAN and Core Function Splits in 3GPP Standard



**AMF** = Access and Mobility Function    **UPF** = User Plane Function    **SMF** = Session Management Function

Figure 8: Overall NG-RAN architecture



Both the user plane and control plane architectures for NG-RAN follow the same high-level architecture scheme, as depicted in *Figure 8*. *Figure 9* and *Figure 10* show the 3GPP 4G and 5G protocol stacks for user and control plane, respectively. The two systems, with similar architecture, also use the same protocols, except for the Service Data Adaptation Protocol (SDAP). The SDAP has been introduced in 5G for *flow based QoS*, as described in the following sections. It provides mapping between QoS flows and data radio bearers and marking QoS flow ID (QFI) in both DL and UL packets. There is a single SDAP entity for each PDU session (GTP Tunnel).

In 4G, the non-access stratum (NAS) supports mobility management (MM) functionality and user plane bearer activation, modification and deactivation; it is also responsible of ciphering and integrity protection of NAS signalling. In 5G, NAS-MM supports registration management functionality, connection management functionality and user plane connection activation and deactivation; as well as ciphering and integrity protection of NAS signalling. NAS-Session Management (SM) is responsible for user plane PDU Session Establishment, modification and release; it is transferred via the AMF, and transparent to the AMF.

As in the previous 3GPP network releases, *the NG-RAN and 5GC have crystal clear boundaries, regardless the implementation. Hence security risks in NG-RAN are manageable as in previous RAN generations.* In Australia, the Huawei equipment are only in the access part of the network. The core network is provided by other vendors, such as, for example, Nokia and Ericsson.



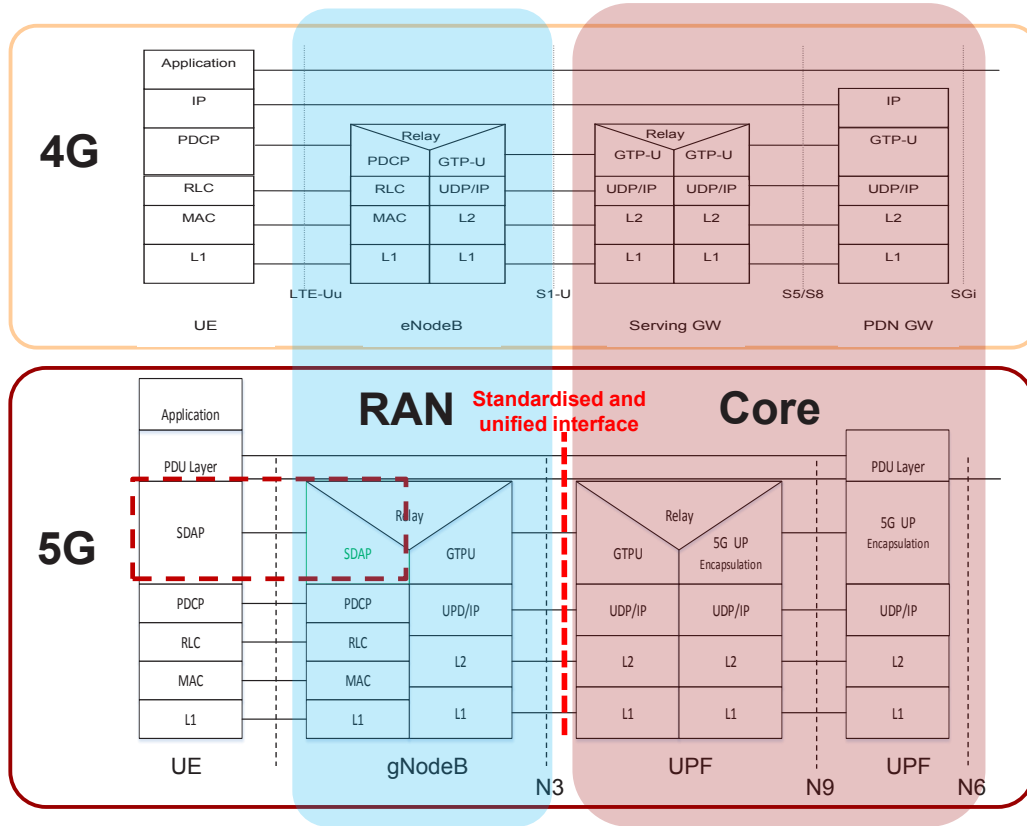


Figure 9: 4G/5G User Plane protocol stack

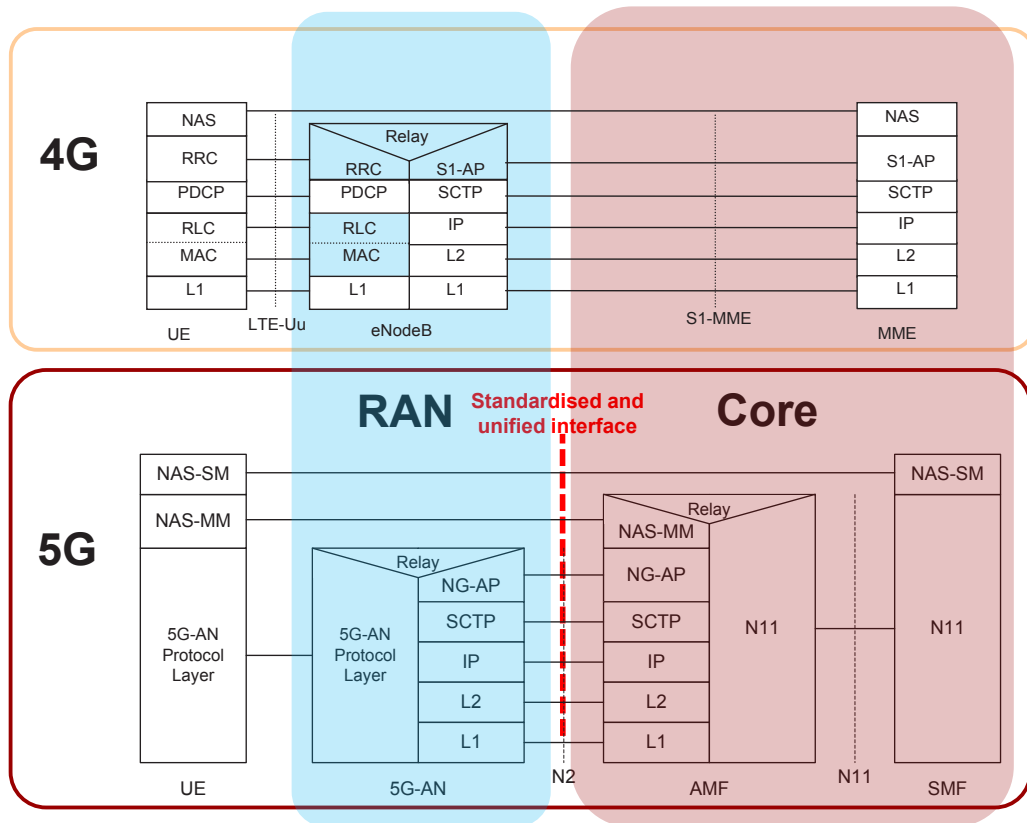
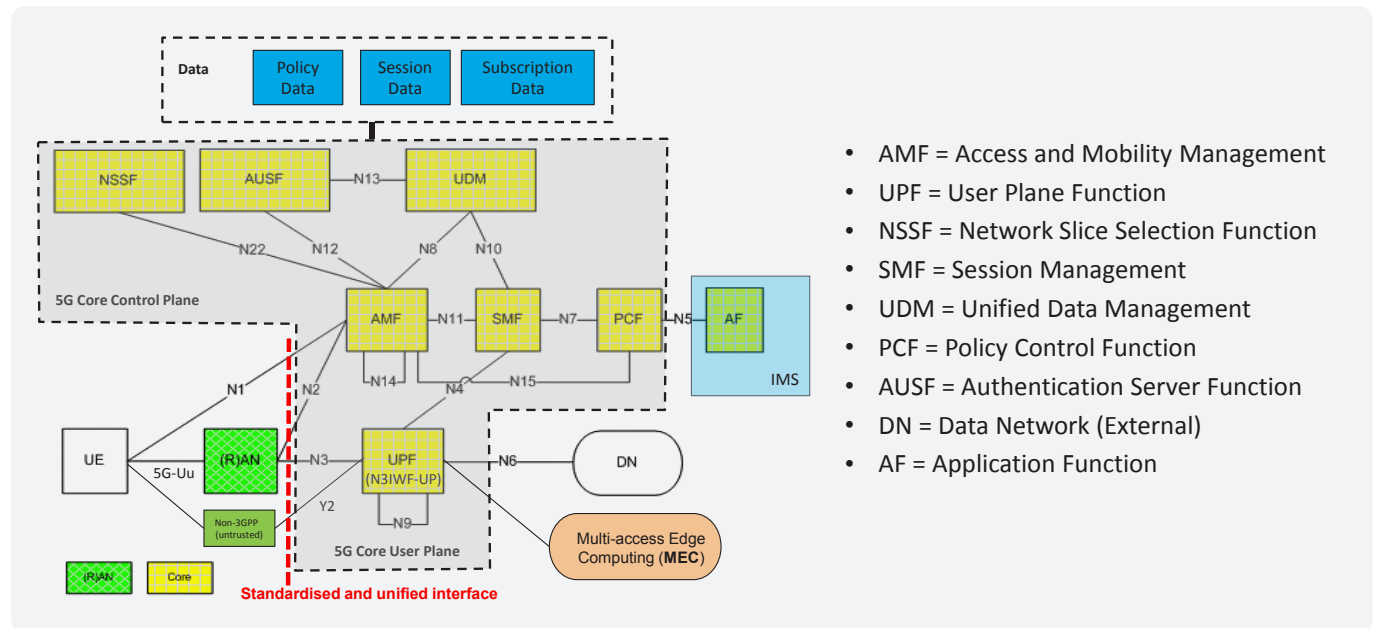


Figure 10: 4G/5G Control Plane protocol stack

## 5G CORE AND SLICING

The 5G core (5GC) supports many new enabling network technologies. Among other fundamental technology components, as depicted in *Figure 11*, the 5GC is characterised by a layered and service oriented architecture, with control plane (CP) and UP split, and interfaces to subscription, state and policy data. Moreover, the 5GC supports: User plane session continuity, while the terminal moves across different access points; interworking with untrusted non-3GPP access; a comprehensive policy framework for access traffic steering, switching and splitting; and wireless-wireline convergence.

Figure 11: 5G Core (5GC) functions and interface



The separation of control and user planes provides deployment flexibility and independence. The distribution of core functionality, especially user plane functions, closer to the radio nodes, i.e. at the edge of the network, enables the placement of applications in the proximity of the end-user, reducing transport network load and latency. The service based architecture – including the related Network Repository Function (NRF) for 5GC control plane functions – allows flexible addition and extension of network functions. Slicing and related Network Slice Selection Function (NSSF) enable a flexible assignment of users to different network slice instances that may be tailored to different use cases. The 5GC also supports unified subscriber management, authorisation and authentication functions.

*The NG-RAN is not aware of any end user data:* as in earlier network generations, all user plane and signalling traffic is transparently forwarded to the 5GC through secure tunnels and third party security gateways, as detailed in the next session.

Other fundamental 5G enabling technologies, end to end, are: Flow based QoS, with a much higher level of granularity than LTE, which is limited to the bearer service concept (single pipe between terminal and core network); multi-connectivity, where the 5G device can be connected simultaneously to 5G, LTE, and WiFi, offering a higher user data rate and a much more reliable connection; terminal assisted Network Slicing, and E2E network management and orchestration, with in-built support for cloud implementation and edge computing. The 5G flow based QoS and slicing concept are illustrated in *Figure 12*. The NG-RAN and UE are only Slice and QoS aware. Slices consisting of chains of virtual network functions (VNFs) are supported by the 5GC only.



3GPP for terminal (UE) assisted network slicing defines a new parameter denoted as Single-Network Slice Selection Assistance Information (S-NSSAI). Each S-NSSAI assists the network in selecting a network slice instance. The S-NSSAI is composed by the following attributes:

- **Slice/Service Type (SST):** 1 (eMBB), 2 (URLLC), 3 (MIoT) are the standardised values for roaming; operator specific settings are also possible;
- **A Slice Differentiator (SD):** Tenant ID, for further differentiation during the NSI selection.

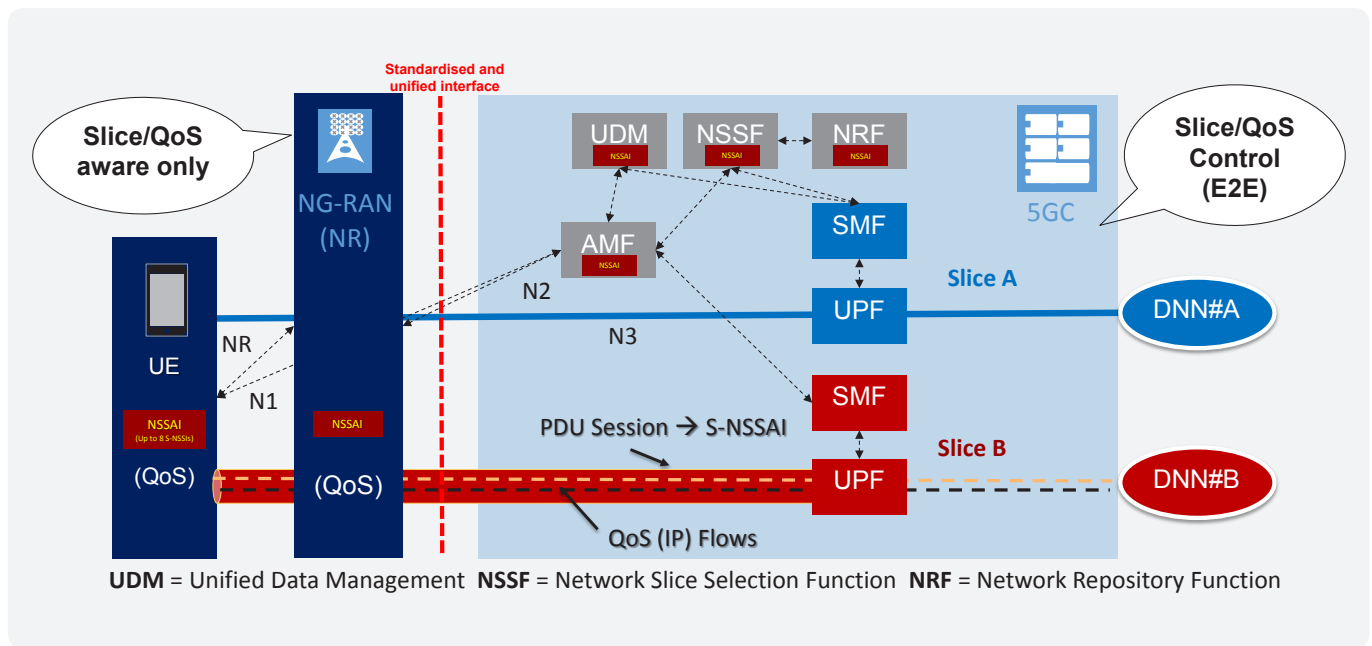


Figure 12: E2E QoS management and 5GC Slicing

The Network Slice Selection Assistance Information (NSSAI) consists of a collection of S-NSSAIs. Maximum eight S-NSSAIs may be sent in signalling messages between the UE and the Network. The NSSAI is configured (Configured NSSAI) in the UE per Public Land Mobile Network (PLMN) by the Home PLMN (HPLMN).

The terminal uses the Requested NSSAI (UE) during the Registration Procedure and the Allowed NSSAI, received from the Access and Mobility Function (AMF), within its Registration Area (RA). The RA allocated by the AMF to UE has homogeneous support of network slices. The 5GC supports AMF level slicing per UE type, and SMF and UPF level slicing per Service or per Tenant, based on S-NSSAI and DNN.

IP Flows are mapped onto QoS Flows, which are mapped onto one or more data radio bearers (DRBs). DRBs are associated to one PDU Session, which is mapped onto one S-NSSAI. The S-NSSAI is mapped

onto one Network Slice Instance (NSI), i.e. one Network Slice; and the NSI is mapped onto a single Data Network Name (DNN). However, it is not true the vice versa, as described in the following text. This is how 5G handles the 5G flow based QoS within a given NSI.

The NG-RAN is aware of the slice at PDU Session level, because the S-NSSAI is included in any signalling message containing PDU Session information. Pre-configured slice enabling in terms of NG-RAN functions is implementation dependent. An example of NG-RAN slicing is depicted in Figure 14. The medium access control (MAC) scheduling – based on radio resource management (RRM) policy related to the service level agreement (SLA) in place, between communication service provider and tenant, for the supported slice and QoS differentiation within the slice – is vendor dependent. The 5GC has full control of slice and QoS management, end to end (E2E).

## RAN Support for Network Slices



### Radio Access Network (RAN) awareness of slices

- NG-RAN selects the RAN part of the network slice based on assistance information provided by the UE or the 5G Core Network
- NG-RAN provides differentiated handling of traffic for network slices by differentiated radio resource scheduling and by applying specific L1/L2 configurations

### Slice specific Radio Resource Management

- NG-RAN applies Radio Resource Management policies specific per slice (type)
- An NG-RAN node can support multiple network slices
- Resources may be reserved exclusively for certain slices to fulfil SLAs, e.g. to prevent service degradation in one slice due to shortage of resources in another slice

### Slice Availability and steering of UEs

- Some slices may be deployed only in part of the network coverage area, dependent on service needs
- Regardless of the number of slices used simultaneously there is one signaling connection with the network and the network steers the UE to the slice related resources
- UEs in idle mode the network provides with selection policies to steer the UE to its slice related radio resources

Jumeirah Himalayas Hotel Shanghai, MWC Shanghai 2018, Shanghai, China, June 28<sup>th</sup> 2018

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Figure 13: 3GPP RAN Support for Network Slicing

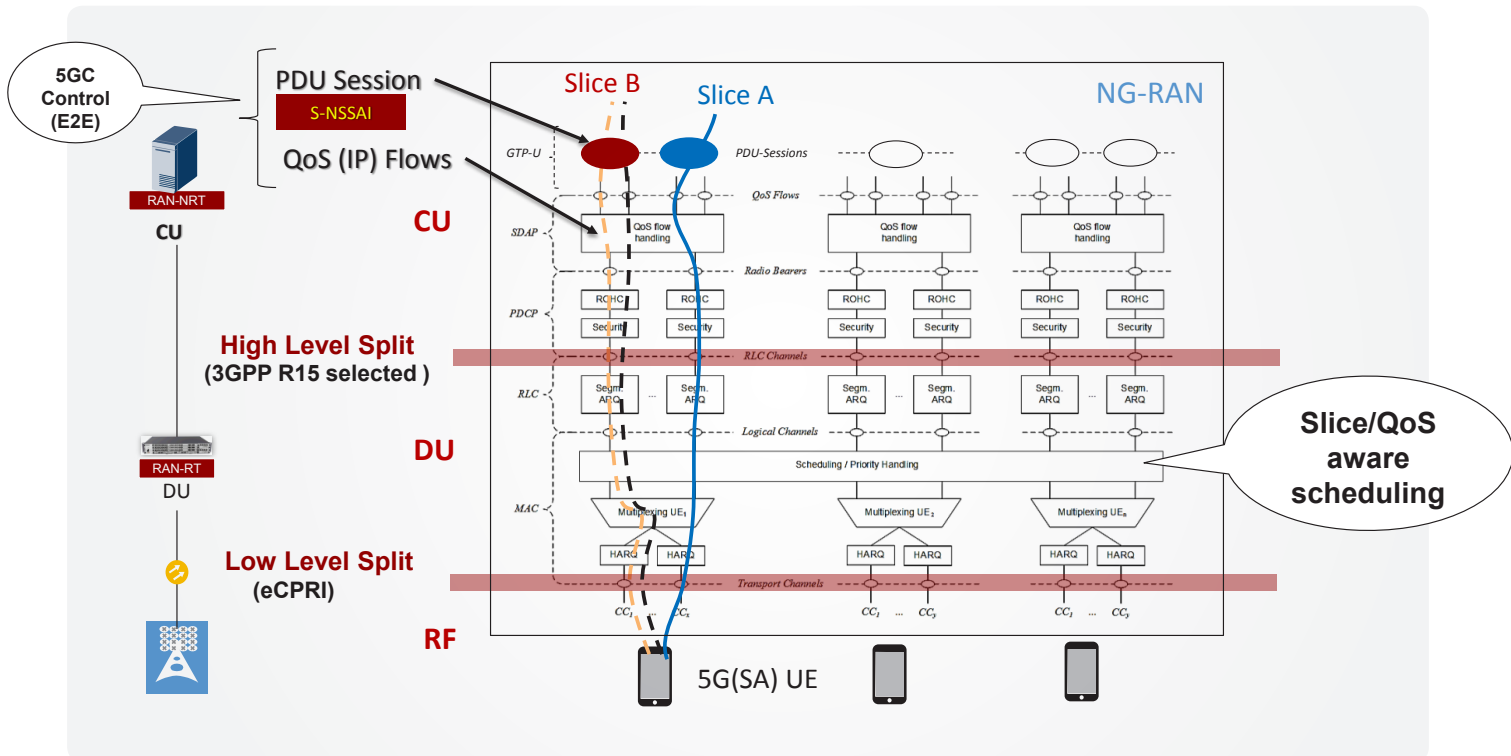


Figure 14: NG-RAN Slicing



### 5G SECURITY ASPECTS

5G System security is based on the well-established and proven 4G/EPS security, which has been further enhanced. NAS security and keying hierarchy are as in 4G. NAS security is established via the 3GPP Authentication and Key Agreement between NAS entities in UE and CN (AMF). *Figure 15* shows the 5GS keying hierarchy, which is comparable to 4G for the functionality towards the RAN, i.e. all keys for the Access Stratum (AS = RAN or AN) are derived from the NAS security parameters inside the Core Network and signalled the RAN. *The main new model of the 5GS is on how the security functionality is decomposed and distributed inside the Core Network.* This enables also that the globally unique 5G Subscription Permanent Identifier (SUPI, which is comparable to the IMSI<sup>12</sup> of earlier system generations) is always signalled encrypted via the RAN towards the CN. It is decrypted by the home-PLMN and delivered from there to the serving Core Network for any user service, management and regulatory purposes. In contrast to earlier system generations, where the IMSI was used in the RAN for recovering from network failures and enabled thereby certain attacks, the 5G System never exposes the SUPI to the RAN nor does it transfer it in clear via the radio. Further, 3GPP 5G Release 15 adds an option to perform user plane integrity protection between UE to gNB. And, in 3GPP Release 16, security algorithms use up to 256-bit keys, see *Figure 16*.

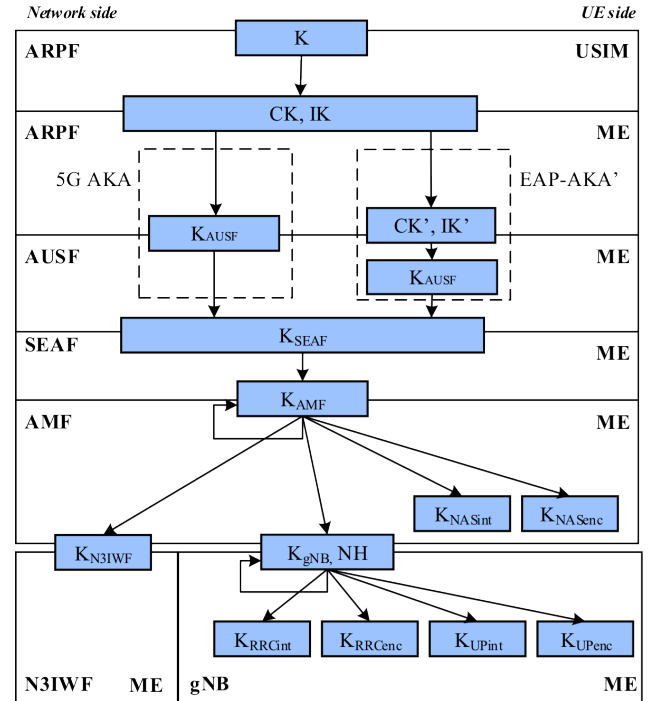
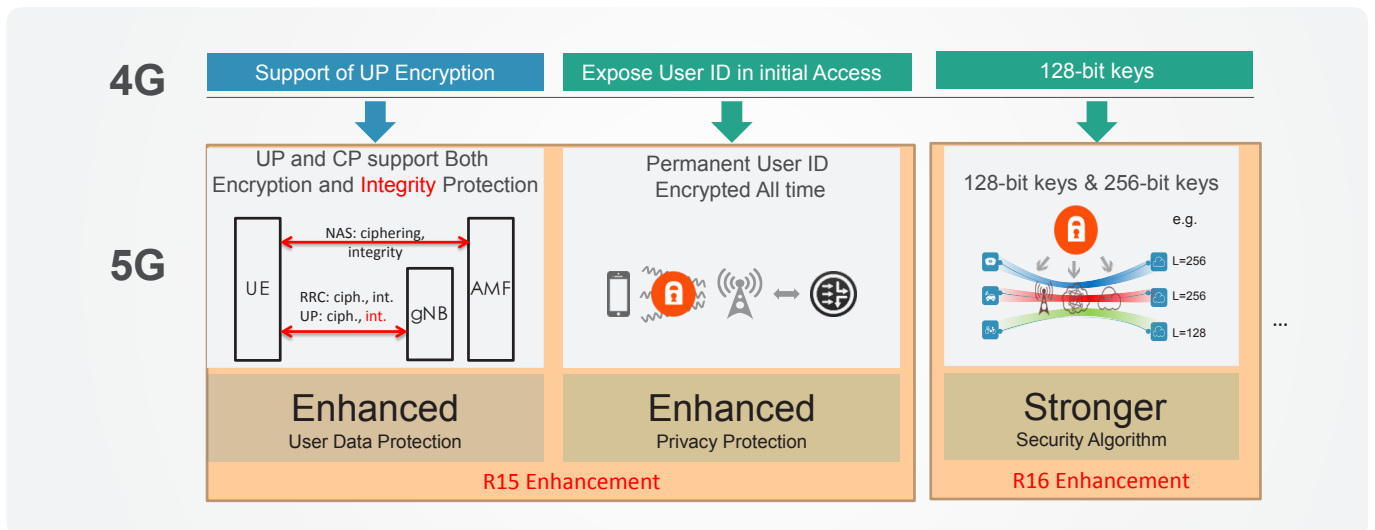


Figure 15: Key hierarchy generation in 5GS

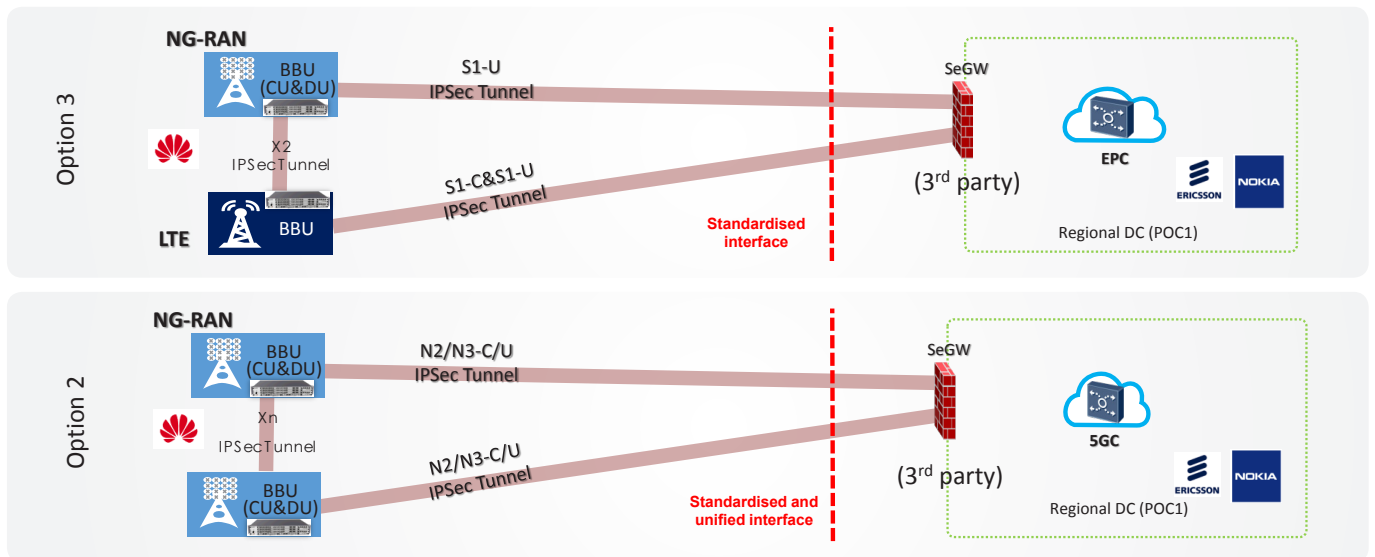
Figure 16: E2E Security Enhancement with 5G Evolution



<sup>12</sup> IMSI (International Mobile Subscriber Identity)

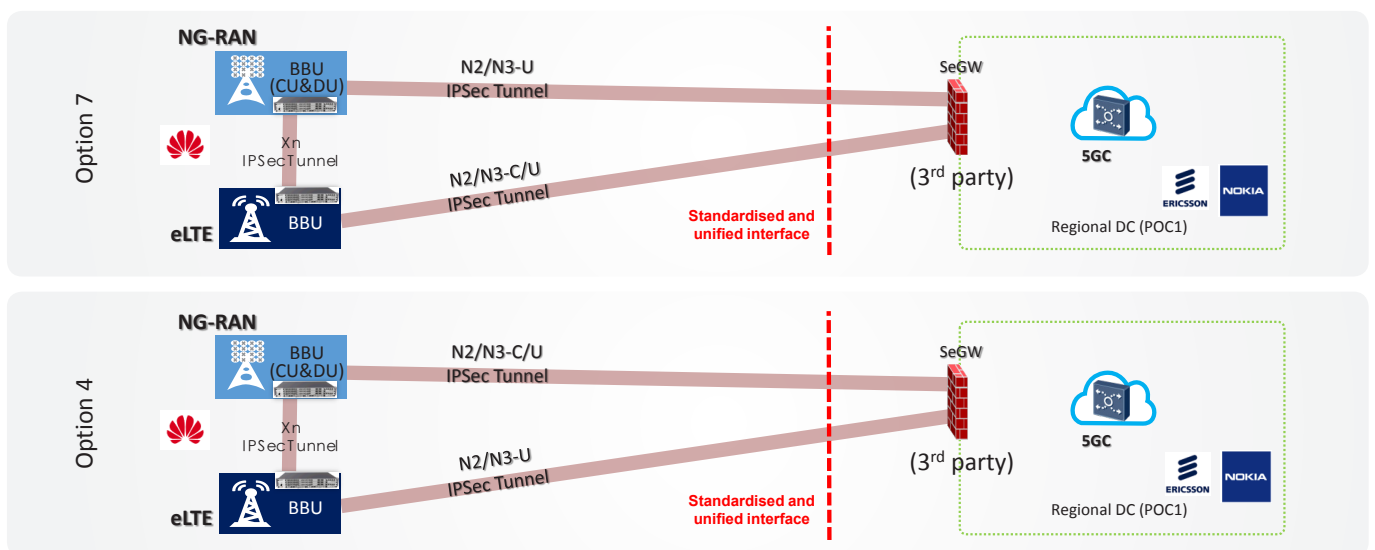
Also, as in 4G, the transport network layer within the RAN and between RAN and core network domains is protected using IPsec tunnels. Examples of security deployment scenarios for 3GPP NSA Option 3x (which is the same as with 4G) and SA Option 2, NSA Option 7 and NSA Option 4, architecture configurations are illustrated in *Figure 17* and *Figure 18*, respectively. As shown in the figures, here with 3GPP Option 2 as an example, the 5G system RAN related transport adopts the same means as 4G and, therefore, for this aspect, it has the same level of security as 4G and as 3GPP Option 3x. The Security GateWay (SeGW) is a 3<sup>rd</sup> party product.

In summary, it can be concluded that the 5G RAN security level is at the same or higher level than for 4G, depending on deployment options, and is fully under operator control. 3GPP aims at ensuring the security of data transmission. The Packet Data Convergence Protocol (PDCP) encryption in the RAN (downlink), and UE (uplink), ensures security over the air interface. Carriers ensure the security of Intranet transmission (transport network layer connecting the access and core network equipment). The application layer ensures the security of services.



**Figure 17: 3GPP NSA Option 3 and SA Option 2 security deployments**

*(The Security Gateway (SeGW), Evolved Packet Core (EPC) and 5G Core Network (5GC) are 3rd party equipment, e.g. from Nokia or Ericsson)*



**Figure 18: 3GPP SA Option 7 and SA Option 4 security deployments**

*(The Security Gateway (SeGW), Evolved Packet Core (EPC) and 5G Core Network (5GC) are 3rd party equipment, e.g. from Nokia or Ericsson)*



## 3.4 ONEM2M

oneM2M brings together several major ICT Standards Developing Organisations (SDOs) around the world, namely ARIB, ATIS, CCSA, ETSI, TTA, TSDSI, TTA and TTC. These SDOs, referred to as Partners Type 1, share the common objective of developing common standards for the Internet of Things Service Layer across different industry segments. Partners Type 1, have made a great effort to achieve a much-needed convergence in the IoT standards landscape through ceasing developing own IoT standards. Instead, they contribute in promoting the oneM2M effort through publication of oneM2M specifications as own standards, de-facto ensuring a global and institutional reach for oneM2M.

In addition to these SDOs, several fora and industry alliances working on IoT related topics joined oneM2M where they play an important contributing role in shaping oneM2M specifications and ensuring a coordinated approach. Referred to as Partners Type 2, their list includes: the Broadband Forum, Global Platform, etc.

Currently there are 200 active members in oneM2M. All share the vision of specifying an IoT Service Layer, a layer that sits between applications and networks and expose functions needed by IoT applications across different industry segments. As opposed to proprietary approaches, oneM2M specifications development is open and contribution driven, meaning the industry at large can influence the direction of the specifications, therefore market deployments.



Figure 19: oneM2M Partnership Project organisation structure

## OPEN AND CONTRIBUTION DRIVEN APPROACH TO SET STANDARDS

As opposed to proprietary approaches, oneM2M specifications development is open and contribution driven, meaning the members can influence the direction of the specifications. In addition, oneM2M maintains a list of liaisons with other fora and standards initiatives, to ensure complementary approaches.

To seek efficiency and expedite time to market for oneM2M specifications, the work is being handled by different working groups who actually develop the output specifications. The Technical Plenary coordinates between the working groups, oversees the progress and manages the work program. The list of working groups is as follows: Requirements, Architecture, Protocols, Security, Management Abstraction and Semantics, Testing.

## INTEROPERABILITY TESTING FOR SHORTER TIME TO MARKET

oneM2M believe in running code and interoperable products. 2 plugtests are organised every year where engineers get together and test their products against each other and in accordance to test specifications. Regular interoperability testing events are a real asset.

As these events are always held in the week prior to a Technical Plenary meeting, they allow immediate feedback to the oneM2M working groups where the issues discovered can be addressed very quickly.

This is a key element to the stability of the oneM2M platform.

<sup>13</sup> OCEAN (OCEAN Protocol: <https://oceanprotocol.com/#why>)

<sup>14</sup> Eclipse Foundation (<https://www.eclipse.org/org/foundation/>)

## MEMBERS OF ONEM2M KEEP THE SPECIFICATIONS AND OPEN SOURCE ALIGNED

Despite not chartered to build open source, the role of open source in the ICT industry cannot be underestimated in helping market uptake and fostering a developer community. Members of oneM2M have driven open source implementations according to oneM2M specifications in several established open source initiatives such as OCEAN<sup>13</sup>, Linux Foundation, Eclipse Foundation<sup>14</sup>. In addition, ATIS and its members developed a lightweight oneM2M client targeted for device quick prototyping and deployments.

## A USE CASE DRIVEN APPROACH TO IOT STANDARDS

Use cases are a great way to express real world scenarios. Once properly described, they are used to derive requirements for the IoT service layer. It is however important to recognise that IoT is about use case proliferation, therefore the specifications should be built to address the need of multiple use cases including the ones we did not even think of at the time of the specification. To achieve this endeavour, use cases are used to derive service requirements which in turn drive guidelines (referred to as Technical Reports in Figure 20) and interoperability specifications (referred to as Technical Specifications in *Figure 20*).

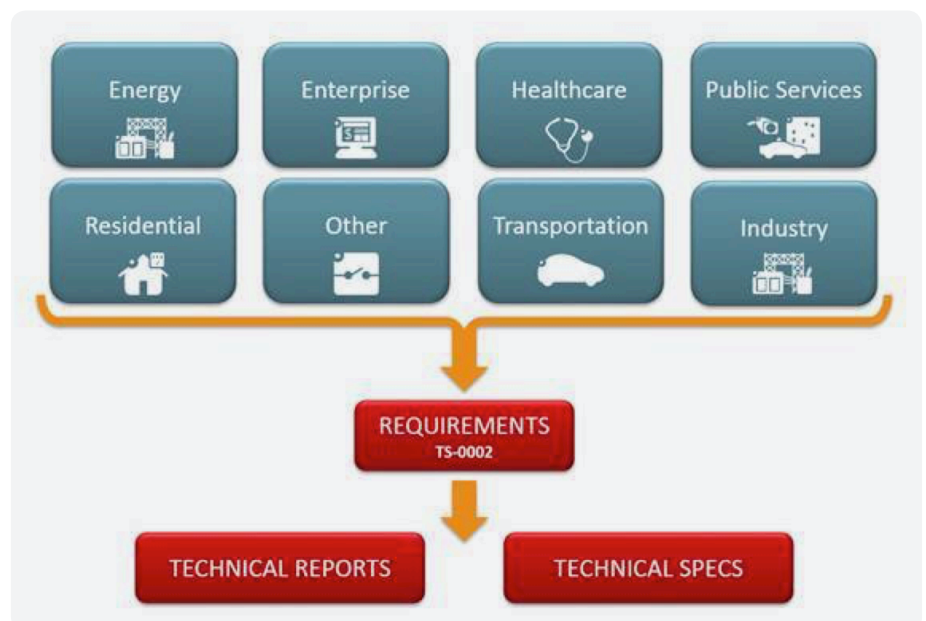


Figure 20: A use-case-driven approach to set market-driven specifications



## ONEM2M'S HORIZONTAL ARCHITECTURE

Figure 21 provides the oneM2M layered architecture approach. Since day one, oneM2M considered IoT as a largely distributed system where application level processing could happen at the device, the gateway, the edge or the central cloud level. Taking into account this market fact, the architecture looks the same for device, gateway or cloud deployments of oneM2M. As depicted in Figure 21, the Service Layer is the glue between the network and applications. Its value is in offloading applications from handling aspects such as protocol conversion, different network types, data collection, security, device management, etc. With oneM2M applications can access all those functions from the oneM2M Service Layer, helping therefore the application developers focus predominantly on the application business logic, defacto the use case implementation.

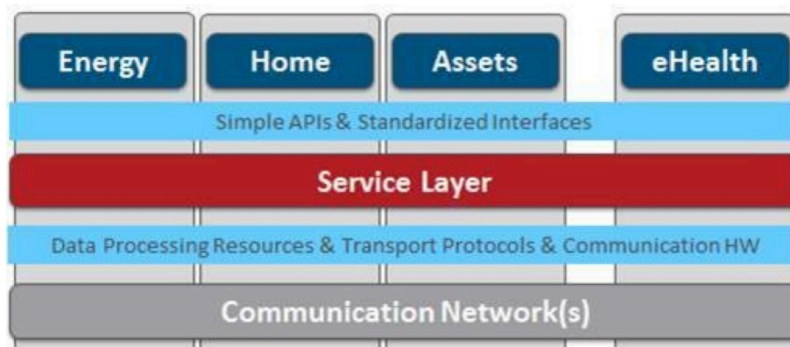


Figure 21: oneM2M layered architecture

The oneM2M Release 2 set of specifications can be found at: <http://www.onem2m.org/technical/partner-transpositions>

They are also endorsed as ITU-T Y.4500.X series: <https://www.itu.int/rec/T-REC-Y/en>

## 4

## HARMONISATION OF 5G AND IOT STANDARDS IN CHINA AND EUROPE

Acknowledging the need for global standards and building on the experience from 3G and 4G standardisation, the global wireless communications community collaborates within the 3rd Generation Partnership Project (3GPP) to define the 5G standard.

While both the EU and China have their dedicated 5G research initiatives and promotion groups as well as deployment plans and technology roadmaps they appear to adopt the same concept of a unified 5G core standard, a set of clearly defined KPIs plus a number of key technologies for connectivity. Through the collaboration of both regions' standardisation bodies in 3GPP, the exchange between their major 5G technology initiatives, and the global orientation of their major communication equipment manufacturers a considerable degree of harmonisation is being achieved. The same can be said with respect to IoT where the world's major SDOs are cooperating within oneM2M.

In the past, the global standardisation process was sometimes hampered by national solo efforts, typically to protect a certain market or gain dominance, which resulted in products never reaching economies of scale, or making it to the market at all. To improve this situation, it was recognised that harmonisation of standards between different SDOs was a useful thing to attempt.

This has resulted in parties involved in standardisation employing a different approach to push their interests, i.e. by actively participat-

ing in, and contributing to, the work of the major SDOs. Leading global manufacturers of communications equipment no longer try to define dedicated local standards but rather argue their case for introducing certain elements into 3GPP standards, such as Huawei's "Polar code" technology for 5G channel coding. This can be seen as a more open and collaborative approach, where standards will be agreed, based on the merit of the contributions.

In the IoT domain, China has increasingly engaged in international standardisation bodies during the past years and made numerous contributions that have been adopted as global standards<sup>15</sup>.

Another successfully practised approach is to occupy key positions within the SDO Technical Committees and Working groups, with 3GPP being one example [3]. Harmonisation of standards developed by different SDOs has therefore become less of an issue; instead, harmonisation has to be achieved within the standardisation process.

Of course, there may, and will still be differences between regions/markets, for instance in terms of implementation, development and deployment priorities, and technology choices. Standards typically define many different options and thus leave many freedoms to implementers. The harmonisation of interoperability processes with a view to achieving the highest possible level of interoperability is therefore essential<sup>16</sup>.

<sup>15</sup> Examples are the international standard ITU-T Y.2068 on the functional framework and capabilities of the IoT led by CAICT, and the approval of the ISO/IEC 30141 project jointly promoted by the Wuxi IoT Industry Research Institute and the China Electronics Standardisation Institute

<sup>16</sup> The subject of interoperability harmonisation is addressed by a second white paper published by the EXCITING project



A proven approach to achieve interoperability is through joint trials, large pilots, and dedicated interop events (“plug-tests”).

The 5G standardisation process provides an example for different development priorities: Unlike the 3GPP which foresees the development of 5G for high-speed communications (enhanced Mobile Broadband - eMBB) and the IoT (massive Machine Type Communications - mMTC) in different phases, China advocates equal priorities for both application cases. Europe, with its focus on involving vertical industries, including Industry 4.0, in the development process, appears to be more in line with China here, targeting the deployment of full 5G (eMBB, mMTC, URLLC) by 2020.

Thirdly, countries or regions may make different technology choices, which again cannot be addressed through harmonisation measures for standards but for interoperability processes. Two examples of such choices are shown below, focusing on the NB-IoT (Narrowband -IoT) and ITS (Intelligent Transport Systems):

- 1 Following a decision of the MIIT in June 2017 all major Chinese operators began deploying NB-IoT for low-power, wide-area IoT services in the country [8]. While NB-IoT has also been adopted by major European operators, their counterparts in the United States mainly opted for LTE-M. Although NB-IoT is currently not part of the 5G technology, 3GPP has a clear migration path to integrate NB-IoT features into 5G in the next two to three years.
- 2 While field trials of both IEEE 802.11p-based DSRC (Dedicated Short Range Communication) and C-V2X (Cellular - Vehicle to everything) have been conducted in Shanghai and other cities, the creation of a C-V2X WG in the [IMT-2020 \(5G\) Promotion Group](#) indicates a preference for cellular solutions for future vehicular communication applications. In 2016, the China Academy of Telecommunication Technology had advocated the adoption of LTE-V<sup>17</sup>, a TD-LTE (time-division LTE) based solution for V2X, and the MIIT named V2X one of the core scenarios for 5G in China. The same year, the MIIT approved the 5905-5925MHz frequency range for LTE-V2X testing and research in China.

On 5 January 2018, China’s National Development and Reform Commission (NDRC) issued a draft Strategy for Innovation and Development of Intelligent Vehicles (“Draft Strategy”) for public comment. The public consultation was closed on 20 January 2018; as of today results are not known. Visions set out in the Draft Strategy include that 90% of the highways in China’s big cities will be covered with LTE-V2X by 2020 and 5G by 2025.

Although primarily a matter of regulation, harmonisation of the radio spectrum across countries and regions is of major importance. In the case of 5G, the only bands that have been commonly identified for 5G use are the 3.4 - 3.6 GHz and 24.25 - 27.5 GHz bands. However, the Chinese Government is supposed to free up the 3.6-4.2 GHz for future 5G allocation, but has not yet made a final decision on the availability of the upper band [9].

Several key IoT challenges and gaps identified by AIO-TI and ETSI (see *Table 1*) can be jointly addressed to consolidate EU-China common views by cooperating and solving these challenges.

<sup>17</sup> LTE-V is now a global 3GPP standard

Table 1: Key IoT challenges and gaps, based on [10] and AIOTI

DOMAIN	GAPS
<b>IoTArchitecture</b>	<ul style="list-style-type: none"> <li>• Multiplicity of IoT HLAs, platforms and discovery mechanisms</li> </ul>
<b>Connectivity</b>	<ul style="list-style-type: none"> <li>• Fragmentation of the standardisation landscape</li> <li>• Large number of heterogeneous &amp; competing communications and networking technologies</li> </ul>
<b>Integration/ Interoperability</b>	<ul style="list-style-type: none"> <li>• Global-level standards (international vs. regional level)</li> <li>• Fragmentation due to competitive platforms and standards</li> </ul>
<b>Device/Sensor Technology</b>	<ul style="list-style-type: none"> <li>• Quality assurance and certification</li> <li>• Device modularity</li> </ul>
<b>Service and applications</b>	<ul style="list-style-type: none"> <li>• Data interoperability: lack of easy translation mechanisms between different specific models. Need of a global and neutral data model. Seamless inter-working between data systems</li> <li>• Interoperable processing rules: lack of definition for advanced analysis and processing of sensor events and data to interpret the sensor data in an identical manner across heterogeneous platforms</li> <li>• APIs to support application portability among devices/terminals</li> <li>• Specific solutions at Service Layer to enable communications between the platforms (e.g., plugins to oneM2M platform)</li> </ul>
<b>Applications Management</b>	<ul style="list-style-type: none"> <li>• Usability</li> <li>• Applications tailored to individual needs: evolution, flexibility of the components</li> <li>• Harmonised Identification</li> <li>• Interoperability between IoT HLAs, platforms and discovery mechanisms</li> </ul>
<b>Security / Privacy</b>	<ul style="list-style-type: none"> <li>• Privacy and security issues can be a blocking factor for user's acceptance and prevent large scale deployments. Security and privacy are addressed on an isolated basis for part of the applications</li> <li>• Lack of highly secure and trusted environments</li> <li>• Liability for data privacy</li> </ul>
<b>Deployment</b>	<ul style="list-style-type: none"> <li>• Safety</li> <li>• Deployment tools</li> </ul>
<b>Regulation</b>	<ul style="list-style-type: none"> <li>• Regulations for frequency harmonisation and usage</li> </ul>
<b>Business</b>	<ul style="list-style-type: none"> <li>• Collaboration between vertical domains, silo-ed applications</li> <li>• Lack of a reference for business cases and value chain model to guide choices for deployment</li> <li>• Lack of knowledge about potentialities of IoT among decision makers, users</li> </ul>
<b>Societal</b>	<ul style="list-style-type: none"> <li>• Green Technologies</li> <li>• Ethics. Transparency and choice for citizens</li> <li>• Not everything should be smart</li> </ul>



## AIOTI – AII COOPERATION

In 2017 the H2020 EXCITING project stimulated the initiation of the cooperation between the Alliance for IoT Innovation (AIOTI) and the Alliance of Industrial Internet (AII).

AII is established by the China Academy of Information and Communications Technology (CAICT) with joint efforts of the industrial sectors, which is under the support and guidance of the Ministry of Industry and Information Technology (MIIT). Industrial Internet is an important part of and a key instrument in the transformation and upgrading of advanced manufacturing industry in China and abroad, is a major component in the strategic layout for “China Manufacturing 2025” and “Internet + Collaborative Manufacturing” Initiatives. The purpose of AII is to facilitate exchanges and in-depth cooperation among related entities, promote alignment between demand and supply as well as share of knowledge for complementing advantages to make solid efforts for the industrial Internet sector to move forward and provide effective solutions to enterprises.

After negotiations that took place between AIOTI and AII, common topics of interest were found and an AIOTI - AII Memorandum of Understanding (MoU) was signed on 8<sup>th</sup> November 2018, at the Wuzhen IoT Summit, China.

The key goal of this cooperation is to promote the development of a digital economy by preventing fragmentation and harmonising various aspects in the field of IoT. In particular, it is expected that AIOTI and AII will cooperate on the following activities:

- Standardisation
- Promotion of interoperability by harmonising reference architectures
- Identification and exchange of good practices
- Collaboration on projects implementing topics of joint interest (test beds)

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## CONCLUSION

In this whitepaper we reviewed the ongoing standardisation activities related to the Future Internet, in particular 5G and IoT, with a focus on harmonisation between Europe and China.

Being at the forefront of technological advances in areas related to the Future Internet, Europe and China are playing particularly important roles in the global standardisation process. While both parties are deeply involved in the global standardisation process through their participation in all relevant standardisation bodies and initiatives, the centralisation of power in China enables fast decisions for or against a particular technology as well as effective implementation, with NB-IoT being a prominent example. In what appears to be a departure from the past strategy of defining distinctively local standards, China now embraces global standards and influences their definition through active participation of government and industry in relevant standardisation bodies and initiatives.

In the domain of IoT considerable work in terms of coordination and harmonisation remains to be done, not only between Europe and China but on a global scale, with security and privacy, semantic interoperability, and radio spectrum allocations being prominent examples.

To further increase the level of harmonisation of standards between Europe and China an open and transparent exchange of information through mutual participation in research and standardisation activities would be beneficial.

Several key IoT challenges and gaps identified by AIOTI and ETSI can be jointly addressed to consolidate EU-China common views by cooperating and solving these challenges.

As far as openness and transparency on the research side are concerned, improvements have been made over the past years. However, certain limitations still exist concerning the participation of non-Chinese companies in Chinese 5G initiatives and the participation of non-EU companies in EU 5G initiatives, which leaves room for improvement.



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