ENSURING CONVERGENCE IN NEXT-GENERATION WIRELESS NETWORKS

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Abstract

Presented cconvergence between 5G and Wi-Fi, wich is happening not only at the technical level, but this convergence is driving all telco industries to the more challenging convergence of IT and Telecom toward integrated Information & Communication Technology (ICT). The analysis showed that traditional voice and data services have prevailed over the past two decades, but now they have reached their ceiling and more vertical services are needed to grow the business. Wi-Fi 6 will not only deliver higher speeds and capacity, but it will enable new business models and use cases independently and also in convergence with Mobile 5G Technology, which is not limited to voice and data offload only but spanning over IT/IoT Convergence.

In 2020, 5G services were launched in Asia, Europe, the Middle East and North America. In total, about half of the world's operators have announced their intention to launch commercial 5G networks. In 2020, 15 million connections were registered on 5G networks. In South Korea, where all three operators have been providing commercial 5G services since April this year, there have already been 3 million 5G connections. China is experiencing a real boom in 5G connections, where commercial 5G services have been available to subscribers since 2020.

In turn, 5G New Radio standard (5G NR) will natively support small cells, more antennas with massive MIMO (Multiple In, Multiple Out) technology, as well as many other enhancements. But a key aspect of 5G NR is the ability to mobilize higher spectrum bands that were previously not available for mobile applications. 5G NR is designed to natively support all spectrum types (licensed, unlicensed, shared) and spectrum bands (low, mid, high).

On Figure 1 shows extended spectrum for 5G NR.

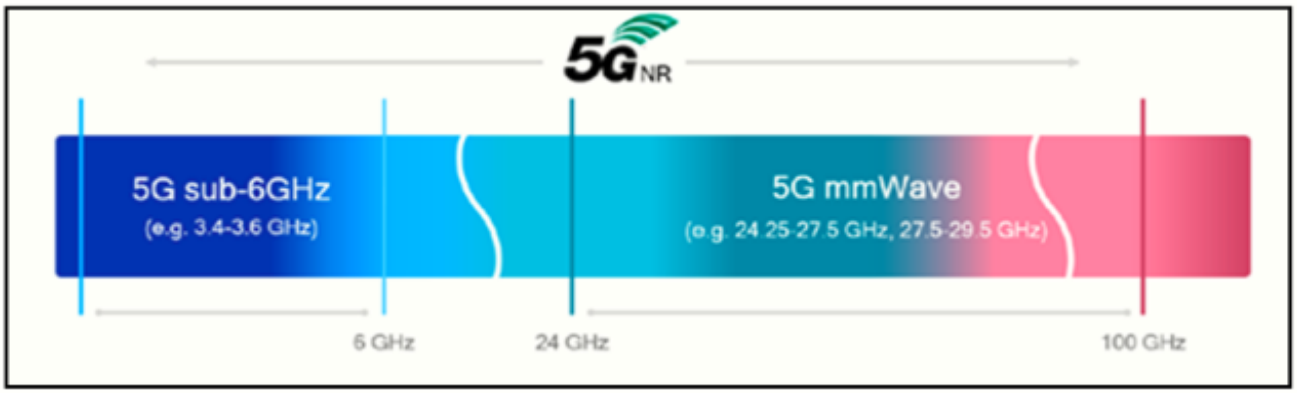

Fig.1. Extended spectrum for 5G NR (New Radio)

The term Convergence, frequently used recently, has got more meaning due to above mentioned and other technologies influence. Present put forward the following considerations (see fig. 2).

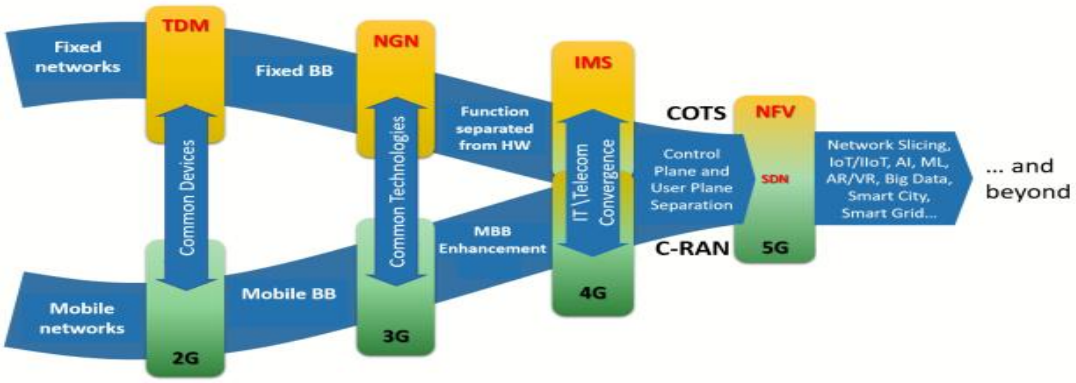

Fig.2. IT and Telecom convergence and Digital Transformation

1. Fixed networks and mobile networks are merging into unified structure of 5G virtualized networks, which is able to provide network slicing for different platforms, applications, and services.

2. Time Division Multiplexing (TDM), Next Generation Networks (NGN), IMS (IP Multimedia Subsystem) and further NFV are steps in continuous process of software and hardware separation, functions and equipment boxes separation. Network elements (functions) as 'hardware boxes' in TDM/2G, NGN/3G, and in less extent in IMS/4G platforms, are becoming software functions in the SDN/NFV infrastructure of 5G

3. 2G/TDM networks were oriented to voice and texting. 3G/NGN were oriented to fixed and mobile broadband (BB) access. 4G/IMS convergence both voice and BB (BB-IoT), and began to blur a border between fixed and mobile networks.

4. In 5G/SDN/NFV infrastructure, functions are moving to Data Centers, as for Core networks, as for Edge Networks. Network boxes are gradually transforming into software functions working in DCs.

These technologies (including but not limited to) are the examples of Digital Transformation trends in IT/Telecom Industry.

Telecom networks have evolved from circuit-switched 2G networks, with an initial focus on telephony, to fully packet-switched 4G networks focused on internet data communications. Yet, voice and video services incorporate many technology features. To quote the common proverb "the devil is in the details." There will not be just one single technical solution in the 5G system offering voice services.

Due to 5G's extended flexibility and various network deployment scenarios, operators need to adapt their service introduction scheme to the underlying infrastructure scenarios. To put it simply: two major circumstances influence the methodology of introducing voice services into 5G.

First, can need to consider the radio access network (RAN) within the 5G system — whether 5G new radio (NR) is offered in addition to LTE as non-standalone access (NSA, or option 3 deployment) or whether there is a 5G standalone (SA mode, or option 2 deployment) network. To go further into the details, the NSA mode includes network deployment options offering dual-connectivity scenarios where either LTE is the primary radio access technology (EN-DC) or 5G is the primary radio access technology (NE-DC).

The second question is what type of core network — Evolved Packet Core (EPC) or the 5G core (5GC) — is used, and if an operator will offer voice services. In a dual-connectivity scenario, there can be a voice service restriction indicated by the radio access technology (RAT). This description concentrates on voice or speech services, though 5G may certainly offer video or communication services, e.g. Rich Communications Services (RCS). These are managed in a very similar way to the voice services. A marginal difference is the support of emergency services. From a signaling perspective, a network distinguishes between an emergency voice call and a general voice call. Regarding protocol and transport, emergency and voice are handled in a similar way, except for quality of service (QoS) profiles, but a network may indicate the support of both services as separated offerings.

There is a small difference between legacy networks and a 5G network offering voice services, as the latter exchanges connection parameters and service access policies during the registration procedure. The user equipment (UE) will indicate its capabilities to the network. In reverse direction, the network offers subscribed services, i.e. voice or video calls, to the UE. With respect to the details, the offering of voice services can be described as a per-UE policy. The network offers its services during the registration pro-

cedure in attach accept message and not as general system information indication to all. The main reason is to sustain a high level of flexibility, especially with respect to the types of UEs. For example, there may be a machine type oriented device without the voice capability. The indication that a network supports emergency services is broadcast via system information. Thus, depending on legal aspects, an anonymous emergency call could be supported without a subscriber module known as SIM card [6].

Voice over 5GNR is voice over IP incorporating the IP multimedia subsystem (IMS) infrastructure previously introduced in LTE. Its advantage comes in the ability to have in place a management and orchestration system that guarantees QoS for each application from an end-to-end perspective, as opposed to VoIP provided via traffic-channel-only approach. The purpose of IMS is the establishment, control, and maintenance of a packet data unit (PDU) session, including all relevant data bearers with corresponding QoS flow for best end-user quality experience.

The network must establish at least two data bearers, one for the content &emdash; the speech packets containing the encoded audio itself — a second bearer for IMS signaling. Like in VoLTE, there is a major difference with voice over IMS in 5G system (5GS) when compared to voice services offered by external applications, e.g. so-called over-the-top (OTT) speech services. This is because OTT speech may operate transparently to the connectivity network and there is no IMS management to ensure QoS. This raises the question: how to connect IMS to the 5G core representing the next generation network.

For certain reasons such as time-to-market acceleration, stepwise network deployments, disaggregation of network entities, and the coexistence with legacy technologies, there is no single 5G deployment scenario. The following section will shed some light on the plethora of 5G deployment options supporting voice services (see fig. 3).

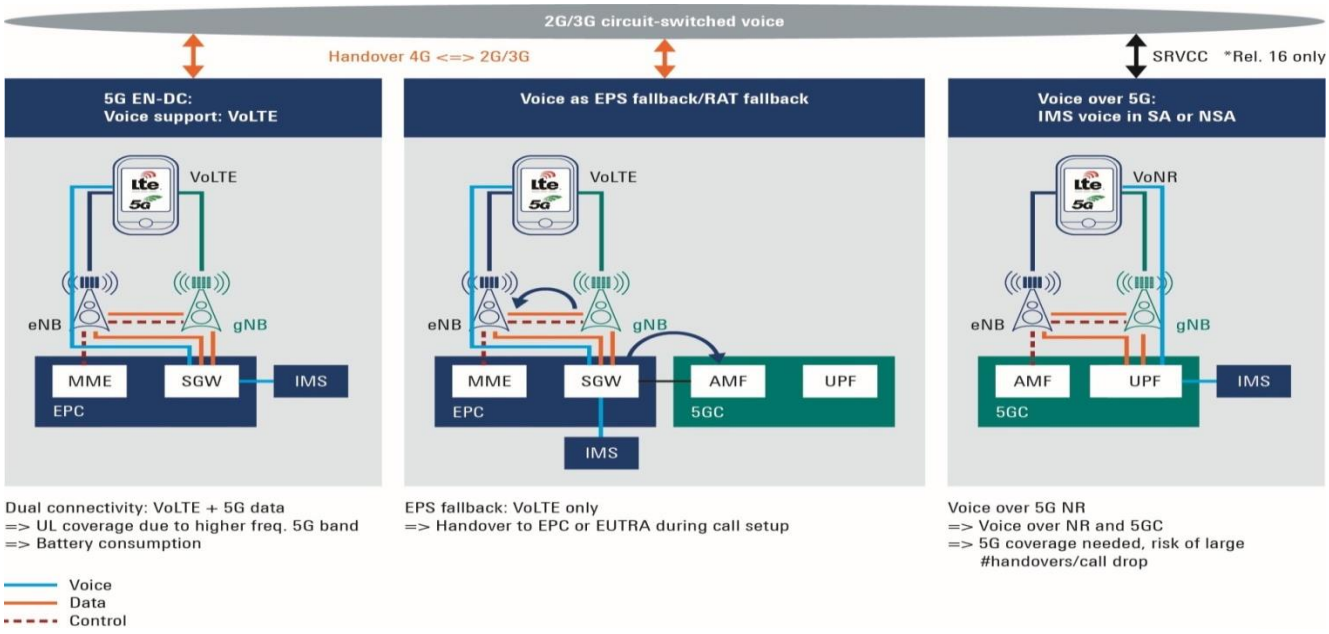

Fig. 3. Existing mobile devices can use VoLTE or RAT fallback because native support for voice over 5G comes with 3GPP Release16

The evolutionary paths describe whether in an NSA connection voice will be supported by Evolved Universal Terrestrial Radio Access (E-UTRA) only and if the simultaneous NR data connection can either sustained or suspended. This option is referred to as the voice over LTE in EN-DC setup. The Evolved Packet System (EPS) fallback describes the scenario where 5GC does not offer voice services. If needed, the voice call will transfer to an EPS connection (VoLTE), including also a RAT change from 5G NR to LTE. The advantage is that the UE camps in 5G NR and the handover to legacy network executed only when the voice call is connected [1].

Another fallback mode is the RAT fallback. The assumption in this mode is that the core network supports voice connection, but the current RAT, presumably NR, does not. What that occurs, a voice connection transfers from NR to E-UTRA, representing a RAT change only. Voice over NR (VoNR) indicates a scenario where the NR network does support voice services and the 5GC offers a connection to

IMS. The primary deployment focus of VoNR is standalone operation (SA) where 5GC connects to IMS supporting voice services. VoNR also works in non-standalone (NSA) operation modes like E-UTRA and NR dual connectivity (EN-DC).

5G supports multimedia telephone services for IMS (MTSI), representing the application layer. The media flow consists of audio, video and "text"(here corresponding to general data as images, text, web-sites, etc.) leveraging modern collaboration and communication tools. To cherish the QoS support, the real-time protocol (RTP), real-time streaming protocol (RTSP) and the real-time control protocol (RTCP) coordinate the media transport and tackle impairments such as delayed, disordered, or misguided packets.

The transport and network layers are realized by the well-known protocols TCP, UDP and IP (IPv4 and IPv6). The RAT functions are provided by either E-UTRA or 5G NR. The session initiation protocol (SIP) and the session description protocol (SDP) undertake the control plane of the voice connection.

In case convergence comes to how Wi-Fi6 and 5G will work together in future networks, coexistence is a common diagnosis among those in the industry, and the only Wi-Fi and cellular combo really present today. However, there is also a strong case for Wi-Fi 6 and 5G convergence, which would mean that the two technologies are combined into a single radio network pillar for some larger venues (IIoT).

For mobile operators, according to The RAN Convergence White Paper developed by WBA and the Next Generation Mobile Networks (NGMN) Alliance, Wi-Fi and 5G convergence offers improved visibility into Wi-Fi networks, allowing them more control over customer experiences and the ability to provide better service. Further, mobile operators are in a better position to provide enterprise Wi-Fi network management solutions to enterprise customers.

Although it is still being defined, 5G is becoming a priority for telecom operators and it comes with the promise of unseen services and a broad range of new use cases and business models ranging from enabling autonomous vehicles to smart agriculture and factories. 5G is expected to push the digitization of the economy further due to its ability to handle large volumes of data with low latency in real time.

3GPP's definition of its 5G Core Network re-enforces this with the ability to better integrate with Wi-Fi access networks as well as its 5G defined New Radio (NR). It includes a more flexible authentication & policy control framework to cater to both types of access. Wi-Fi is also now integrated into 5G key concepts of Multi-Access Edge computing architecture & Network Virtualization to have a slice to support Wi-Fi enabled use cases.

In parallel to 3GPP, Wi-Fi capabilities are also being incorporated to support 5G even for existing Wi-Fi5 and will be more enhanced with Wi-Fi 6. Wi-Fi Alliance has defined the paradigm for the capabilities basis to support 5G [2].

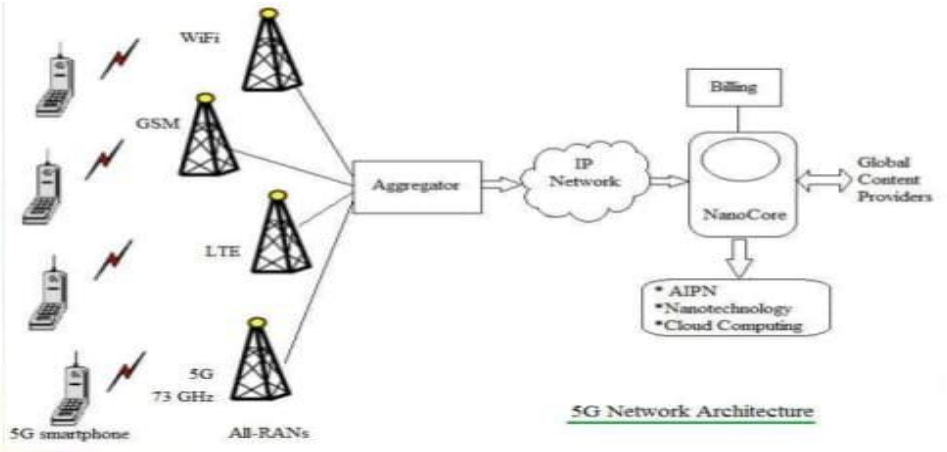

Fig.4. Wi-Fi capabilities for 5G delivered with Wi-Fi 5 & 6

With these initiatives in parallel, both Wi-Fi Alliance and 3GPP introduced standards for convergence.

Many key scenarios can be envisioned for converged Wi-Fi and 5G access to Core.

1. Smartphone accessing the internet via private Wi-Fi (including optional Wi-Fi extender), the fixed access network, and the fixed core.
2. TV accessing home media server via private Wi-Fi.
3. Smartphone accessing:
   – 5G services over a bonded connection of macro-cellular and private Wi-Fi;

– 5G services over a bonded connection of macro-cellular and community Wi-Fi.

4. Tablet accessing 5G services via private Wi-Fi, the fixed access network, and the fixed core and 5G core

5. Smartphone accessing the internet via community Wi-Fi, the fixed access network, the fixed broadband core, and the public (community) Wi-Fi core.

In figure 4 shows Wi-Fi capabilities for 5G delivered with Wi-Fi5&6.

In figure 5 shows example broadband core at the intellectual home which converged 5G access Wi-Fi.

Fig.5. Example broadband core at the intellectual home which converged 5G access Wi-Fi

As Wi-Fi 6 and 5G continue to follow a comparable rollout timeline, many find themselves wondering just what to expect from the two technologies, especially when considered together. 5G is implementation will create a new set of use cases around the world, many of which may require a combination of resources to achieve truly enhanced throughput, latency, connection density, coverage, availability and reliability [3].

Telco's past and present, which are not going to adopt this integration from traditional telecom only mode to ICT mode, they may struggle to survive in a competitive market.

Traditional services of voice and data have prevailed over the past 2 decades, but now they have hit their ceiling, and more vertical services are required to drive the business of Telcos.

Reference:

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3. Huawei White Paper: Unleashing the Power of Wi-Fi Enterprise-Grade Wi-Fi 6 Forecast, 2019~2023. – pp.12-18.