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Understanding 3GPP – starting with the basics

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In my previous blog, "Demystifying 3GPP – An insider's perspective to how 4G and 5G standards get created," I introduced 3GPP and the vast impact this global standards body has had. In this blog, we go back to the basics — breaking down the 3GPP organization and working procedures — to provide you the necessary knowledge of how new technologies get developed in 3GPP. As discussed in my previous blog, this knowledge is not only essential for assessing which companies are driving 3GPP standards, but also important when engaging with the 3GPP ecosystem on these advanced technologies as cellular technologies expand to connect virtually every industry with 5G. But first — some background and history on 3GPP.

3GPP background and history

3GPP, or the 3rd Generation Partnership Project, was initially formed in December 1998 when the European Telecommunications Standards Institute (ETSI) partnered with other standard development organizations (SDOs) from around the world to develop new technologies (or more specifically, technology specifications) for the third generation (3G) of cellular networks.

3GPP was heavily influenced at the start by existing 2G TDMA-based GSM standards. At the same time, another group in the

United States formed the 3rd Generation Partnership Project 2 (3GPP2), which intended to develop global specifications for 3G systems based on the evolution of the 2G IS-95 CDMA standards. There were several companies, including Qualcomm, that were members of both the groups, which competed with each other, and the standards continued to develop in parallel. Ultimately, both 3GPP and 3GPP2 converged towards using the CDMA technology, which was pioneered by Qualcomm, as the underlying baseline technology for 3G standards, although some differences remained. The 3G technologies developed by 3GPP were called W-CDMA or UMTS and utilized a 5 MHz bandwidth carrier, whereas 3GPP2 technologies were called cdma2000 and utilized a 1.5 MHz bandwidth carrier. Both were endorsed by the International Telecommunication Union (ITU) as 3G standards, continued to evolve with new data-optimized technologies (3GPP2 EV-DO, 3GPP HSPA), and have been in use throughout the world.

In the mid-2000s, as it started to become clear that 3G networks would be overwhelmed by the need for faster Internet access, work begun on 4G standards. The requirements for 4G were not only faster peak data rates exceeding 100 Mbps, but it also required that 4G systems be built such that they are ideally suited for data-transmission, which equated to an all-IP (Internet Protocol) packet-switched architecture. Based on these requirements, three competing standards bodies worked on potential solutions for 4G. The 3GPP standards organization worked on a system called Long Term Evolution (LTE), 3GPP2 started developing its own solution called the Ultra Mobile Broadband (UMB), and IEEE started developing a system called WiMAX. After several technical challenges and solutions, the LTE system developed by 3GPP became the 4G standard most predominantly used and deployed, and has since become the global standard for 4G with close to 600 LTE networks launched in 189 countries worldwide (source: GSA,

May 2017). Mobile broadband, fueled by these evolving 3G and 4G LTE standards, has had a tremendous impact on society, the economy, and everyday life as demonstrated in Figure 1 below.

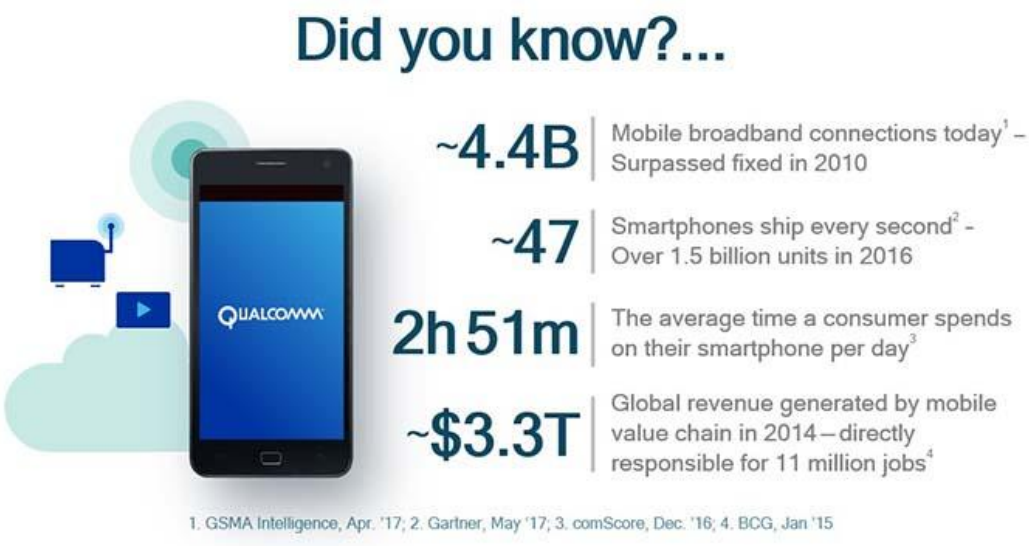

Figure 1: The revolutionary impact of mobile broadband.

And that brings us to 5G. 5G is perhaps the most ambitious generation to-date, as it not only aims to deliver new levels of performance and efficiency to enhance today's mobile broadband services, but also expand mobile networks to be a unifying connectivity fabric for a wide-range of use cases. 3GPP began work in 2016 on defining 5G global standards for a new radio access technology — 5G NR (New Radio) — and a next-generation network architecture — 5G NextGen — to address these requirements. In parallel, 4G LTE continues to evolve as it will play an essential role in next-generation 5G networks. In fact, it is expected that both 4G LTE and 5G NR will be submitted together to meet ITU 5G (or IMT-2020) requirements. Unlike previous generations, there is no longer competing standard bodies working on potential solutions for 5G. The vast impact that 5G is expected to have across a wide-range of industries makes understanding the 3GPP organization and working procedures more important than ever.

3GPP Organization – Fixing three common misconceptions

1. 3GPP develops technical specifications, not standards. This is a subtle, but important organizational clarification. 3GPP is an engineering organization that develops technical specifications. These technical specifications are then transposed into standards by the seven regional Standards Setting Organizations (SSOs) that form the 3GPP partnership (as seen below in Figure 2). The regional SSOs are also responsible for establishing and enforcing an Intellectual Property Rights (IPR) policy.

Figure 2: Regional Standard Setting Organizations (SSOs).

2. There is no "Mr. or Mrs. 3GPP" — 3GPP is a member-driven organization. Beyond administrative IT services such as managing the 3GPP website, all the engineering work that gets initiated and completed in 3GPP relies on the R&D, technology inventions, and collaboration of 3GPP individual members from across the ecosystem and world. In fact, even the chairperson and vice chair-people of the different 3GPP groups are elected from the member companies, and must act impartially on behalf of 3GPP.

3. 3GPP work is done in a distributed, piecemeal manner with limited overall end-to-end supervision. 3GPP does define specifications for complete end-to-end cellular systems including the user equipment (or devices), radio access, core network, and service framework. However, the complexity and scale of these systems, requires division of work for these specifications into smaller, more specialized pieces (e.g., RF, security). Thus, 3GPP is organized into 16 specialized Working Groups (WGs) as seen in Figure 3 below. These Working Groups, along with the three governing Technical Specification Groups (TSGs), is where most

technical work and decisions is accomplished.

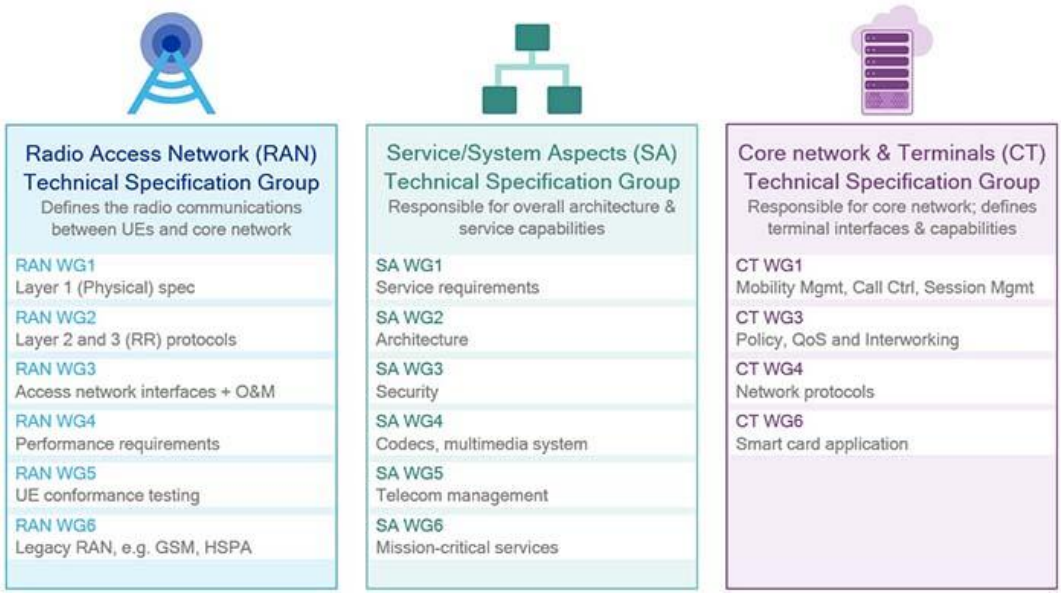

Figure 3: 3GPP distributed organization structure.

3GPP Releases – the measure of real progress in 3GPP

Although we sometimes focus on the generations of cellular technology that happen every 10 years or so, cellular technology is constantly evolving with new features and new services that add significant value to the ecosystem. New features are introduced into the cellular system by 3GPP via Releases — very similar to Releases of major of Operating Systems for smartphones or personal computers.

As I write, 3GPP is finalizing work on Release-14 and work is already well in progress on Release-15 — Releases are staggered and work is done on multiple Releases in parallel at different stages. When a Release is finalized, it means that all new features are functionally frozen and ready for implementation. Furthermore, each 3GPP Release is self-contained, meaning that one can build a cellular system based on the set of frozen specifications in that Release. As such, Releases do not just contain the newly implemented features, but instead are introduced in a highly iterative manner that builds upon previous Releases.

The best way to visualize Releases is to look at the history of 4G LTE across multiple 3GPP Releases (see Figure 4 below). Note that 4G LTE was first introduced with 3GPP Release-8 and is still evolving today with Release-14 and Release-15. It is also important to note that in Release-8+, 3G technologies in 3GPP (e.g., WCDMA, HSPA) continued to evolve, just as 4G LTE technologies will continue to evolve in parallel in Release 15+ as 5G NR technologies are introduced.

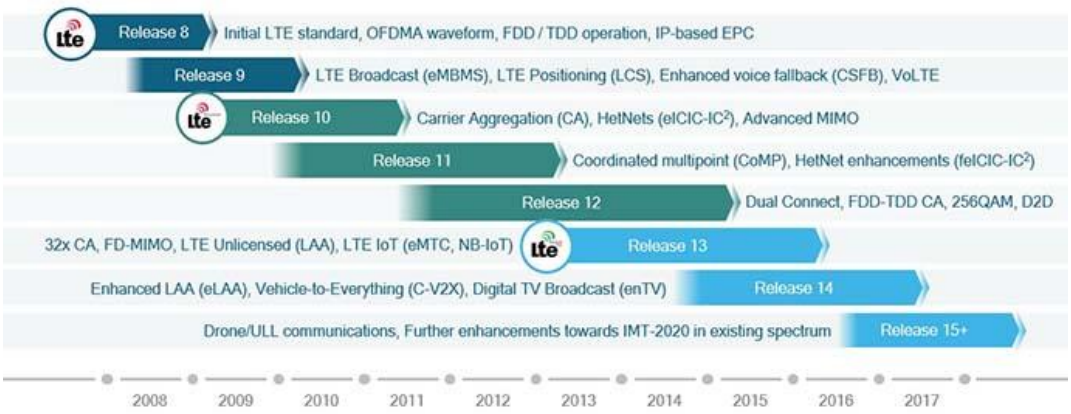

Figure 4: 4G LTE evolution by 3GPP Release.

3GPP working procedures – a collaborative, systems-engineering effort

Due to the complexity of both the cellular system and the fact that 3GPP is a collaborative effort amongst hundreds of different entities with potentially diverse interests/incentives, understanding how work gets done and decisions are made inside 3GPP can sometimes be a mystery to those who do not regularly attend and participate in 3GPP meetings. One way that I've found helps in demystifying the 3GPP process is to compare it to how any system-engineering effort works in any engineering company across the world. And utilizing this simple analogy helps to breakthrough some of the 3GPP complexity and confusing acronyms.

Let's say that instead of developing new technology specifications

for cellular networks, we are instead a company that desires to build a new jet airplane, as depicted below in Figure 5.

Figure 5: High-level system-engineering steps for building a plane.

Step 1: We would likely begin the process by conducting some early R&D to specify requirements, assess constraints, and gather other useful data for the project before bringing the proposal to management. These initial efforts can be instrumental in setting the project in the right direction, or even allowing it to see the light of day. We would then likely enter a project proposal phase where we present the project to management for approval. This may require multiple iterations, where management requires us to go back and collect further data before being approved to proceed.

Steps 2 and 3: If approved, a jet plane would obviously need to be broken down into different sub-systems to allow different, specialized groups within (or outside) our company to work on it, for example, the jet engine or the cabin/seat design. Within each of those specialized areas, engineers would likely begin by conducting feasibility studies to test various potential solutions before proceeding with development.

Step 4: Once an agreed-upon solution was selected, development work would then proceed. Within a company-driven effort, it is likely someone or some group would be responsible for overseeing the overall project to ensure the different sub-systems come together as planned, on time and within budget.

Although the nuances may change from effort to effort, and

company to company, this process is relatively consistent for most system-engineering efforts. And 3GPP's development of technical specifications is very much analogous to this. The only fundamental differences are that 3GPP develops technical specifications (vs. jet planes), is constrained by meeting time (vs. OPEX $ and resources), and is a collaborative effort across hundreds of different entities with potentially diverse interests/incentives. Furthermore, 3GPP has tens, if not hundreds of these system-engineering efforts going on at once. Some are more minor projects and some of them are very big projects — like designing a jet airplane.

3GPP is a collaborative, system-level engineering effort, and thus, the 3GPP work-flow and working procedures reflect this. Below (Figure 6) is a high-level view of the 3GPP process where you will notice a lot of similarities to our analogy above.

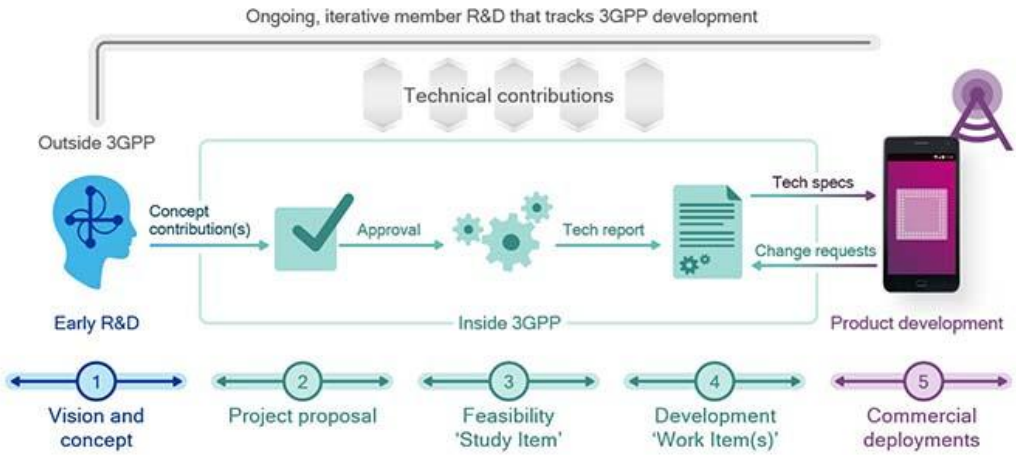

Figure 6: 3GPP working procedures and process.

I will not have time in this blog to go into tremendous detail on these working procedures, however I encourage you to join us for our upcoming FierceWireless webinar, where I will step through this process in detail. For now, let me summarize with a few key points:

- Project proposals (Step 2 above) introduce new technical features/services into the cellular system and are initiated by

individual members based on early development work (Step 1 above) done outside of 3GPP. In other words, there is no "Mr. 3GPP" deciding or driving what the next big cellular feature will be — it relies on the leadership of individual 3GPP members.

- All new 3GPP work activity must be approved at quarterly plenary meetings. Approval of significant features usually results in one or more approved Study Item(s) to conduct feasibility on multiple technology options/solutions (Step 3 above) based on the technical contributions of individual 3GPP members. The output of a Study Item is a Technical Report (TR) that details the agreed-upon concepts from the feasibility study.
- Once the Study Item is complete and TR approved, this may result in corresponding Work Item(s)* to begin development work on the feature implementation details based on the agreed-upon concepts from the Study Item TR, as well as continued technical contributions from 3GPP members (Step 4 above). Agreed-upon implementation details are executed in 3GPP Tech Specification(s) — either creating new specifications or making updates to existing specifications. Once Technical Specifications are released, it kicks-off a race to deliver standards-compliant devices and infrastructure to enable wide-scale commercial deployments (Step 5 above).

  ** Note: Not all Work Items are the result of a Study Item — smaller, more evolutionary efforts may start directly and may have some study phase at the start of the Work Item*

  There is one final and essential point on the way decisions are made in 3GPP. Decisions in 3GPP are technology-driven and result from a consensus-based process open to all members. It is often surprising to people outside 3GPP that most technology decisions are not made via a vote in 3GPP meetings. So how does it work?

  3GPP members submit technical documents, often referred to as

contributions, to propose solutions and technologies. These contributions are discussed publicly in 3GPP meetings (time permitting). Any member can reject a contribution at any time, in which discussions about the contribution (and related alternative contributions) continue well beyond the 3GPP agenda and the 3GPP meeting in which the contribution(s) were originally presented. Thus, the 3GPP decision-making process is iterative and non-linear. Very few of the agreed-upon concepts in a Technical Report resulting from a Study Item or agreed-upon implementation details in Technical Specifications resulting from a Work Item are untouched from the initial member contribution(s). The agreed-upon concepts and implementation details instead come from a collaborative effort that involves iteration and negotiation between 3GPP members.

This iterative, non-linear, consensus-based approach to decision making is one of the primary reasons that simplistic approaches to assessing 3GPP leadership based on *contribution counting* do not work. We'll explore this reason, and more, in my next blog "Top 5 drawbacks of 3GPP contribution counting. (Don't count on it!)."

I hope this relatively short tutorial on 3GPP organization and working procedures was helpful. For more details, I encourage you to check out our webinar and/or download the full presentation on "Demystifying 3GPP."