Five technologies for building 5G

Kalyan Sundhar - September 07, 2017

5G is widely considered a mobile technology that won't be available until perhaps 2020 or 2021, and even then, not widely. But, as mobile data traffic continues to grow (18-fold over the past 5 years), we're marching towards the need for 5G speed quicker than ever. Cisco predicts that by 2021, a 5G connection will generate 4.7 times more traffic than the average 4G connection. **Figure 1** shows that growth.

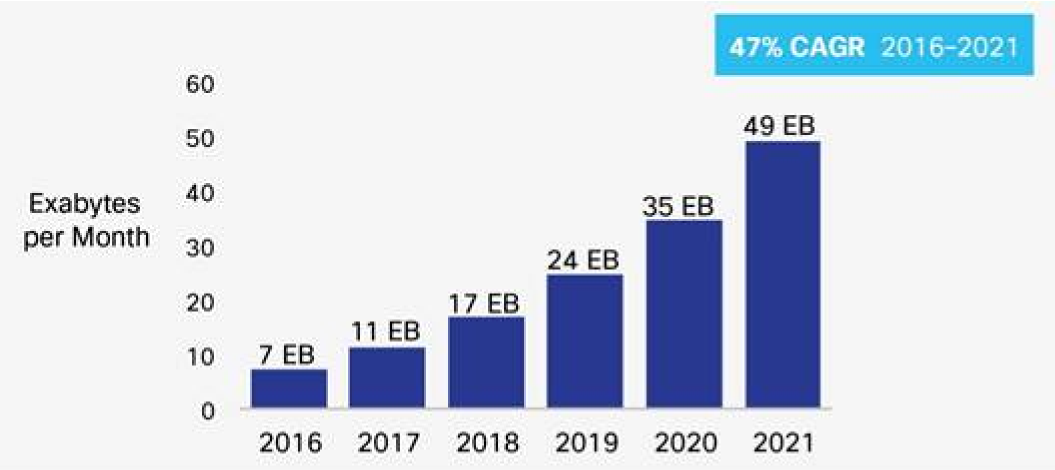

Figure 1. Mobile data traffic continues to grow. Source: Cisco.

5G will be a quantum leap from today's LTE-Advanced networks. Therefore, it's necessary to examine five key areas that will help lead the migration from 4G to 5G. Four of the five areas make this transition through an intermediate step called LTE-Advanced Pro (4.5G), which makes the revolution more of an evolution.

Speeds and Feeds

This area is the one where the access technology increases from 1 Gbps in LTE-Advanced to 20 Gbps throughput/downlink speed to each cell in 5G. Getting to that speed requires multiple steps starting with LTE-Advanced Pro, which is defined in the specs today and can scale to 3 Gbps using a combination of carrier aggregations (up to 32 carriers), massive MIMO (multiple input, multiple output) of up to 16 antennas, and higher modulation schemes such as 256 QAM (**Figure 2**).

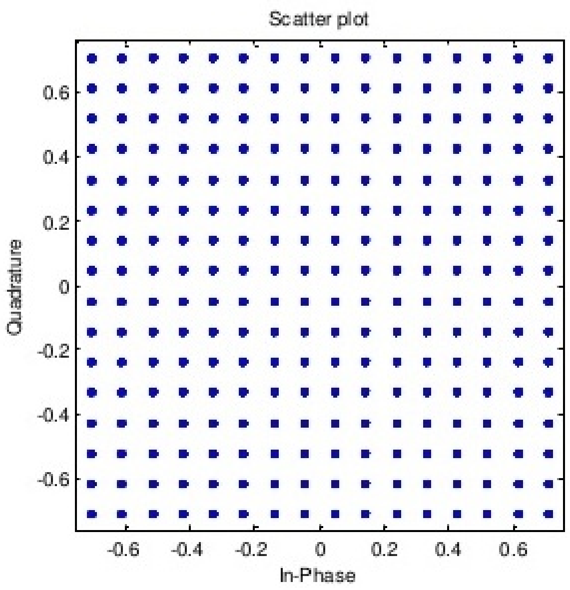

Figure 2. 256 QAM is of the technologies that 5G will use to increase data rates.

Data rates of 3 Gbps is achievable without overhauling radio technologies. This is an intermediate step that every operator must take to leverage their current infrastructure and prepare for 5G.

Utilizing the unlicensed spectrum

LTE in unlicensed frequencies (LTE-U) is already being deployed now by several major carriers including T-Mobile and Verizon, while AT&T is actively pursuing virtual-machine solutions to the issue.

To achieve the higher throughput requirements, the licensed carrier spectrum is not enough. Wi-Fi, the distant cousin to cellular, has been using the unlicensed spectrum for years.

I'm referring to Wi-Fi as the "distant cousin" because it does very similar things to the licensed carrier spectrum, except it's not regulated. Wi-Fi is free, and as such, quality was largely a non-issue—until recently. Operators have begun to roll out hotspots to offload the cellular traffic wherever possible to Wi-Fi, placing an extra strain on the networks. But, Wi-Fi has a lot of unlicensed spectrum that could be tapped into by LTE.

Because end customers and operators weren't overly worried about the quality of this "free service," it was typically fine in residential settings. This mentality has shifted in the last couple of years because of improved techniques in Wi-Fi technologies to attain better quality and regulated access:

- Usage of polar codes such as LDPC for error correction.
- Higher QAM, meaning Wi-Fi can currently do 256 QAM and approaching 1024 QAM.
- 4×4 MIMO and Multi-user MIMO to increase throughput and work with more users simultaneously.

Extending the concept of carrier aggregation to unlicensed carriers, which is the same spectrum used in Wi-Fi, will deliver more options for operators to increase bandwidth to a cell.

With the vast amount of spectrum in unlicensed bands today, and what will be released, 5G networks will need to tap into this space to get to ultra-high speed access requirements in addition to finding ways to offload billions of IoT devices.

IoT devices
IoT devices pose a diverse set of requirements and challenges.

- There is no question that the sheer volume of devices will pose a huge challenge to 5G networks.
- IoT devices, unlike traditional cellular devices, are very sporadic in nature. Many of them “sleep” for long periods of time before sending just a few bytes of data. A 5G network needs to plan for infrequent, yet important, communication from these devices.
- IoT devices also open a wide variety of security threats. Many of these devices can be used to spread malware or other security attacks to the network.

Handling IoT devices at the same time as regular cellular devices such as smartphones is a daunting task for access and core networks. Starting this with LTE networks now will enable a smoother transition to 5G networks when they arrive. For example, Nokia, Sprint and Verizon are just a few of the big names that began testing 5G this year, although many other carriers claim that they’ll start testing 5G networks "soon."

Virtualization: NFV & SDN
The benefits of virtualization in terms of cost savings for operators, handling elastic demands of a network, and increasing choices for operators, is very clear. 5G networks, due to the extreme needs at both ends of the gamut, which includes sending a few bytes on an infrequent basis, as well as a massive increase in data for a different use case, creates a strong need, and tie, to virtualization of network functions (NFV, **Figure 3**).

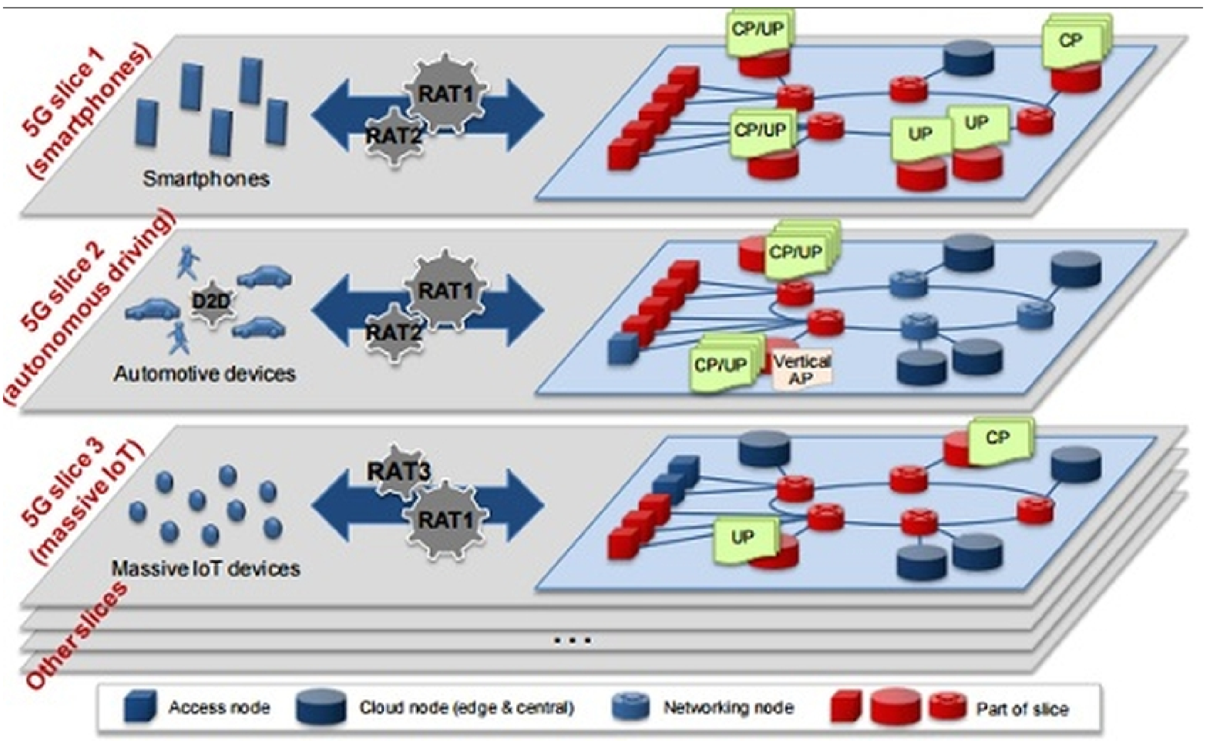

Figure 3. NFV slices core network based on the type or data they will carry.

Many operators are well on their way to virtualizing their network—especially the packet core. The packet core side is all Internet Protocol (IP) based. This means that much like how data centers were virtualized, the packet core side of wireless (from 3NodeB to the internet) can all be virtualized.

Even on the access side, the split between lower layers of protocols as to what stays in the edge and what moves into the central core is currently being discussed and decided by industry decision makers at network equipment manufacturers (NEMs).

The move to virtualizing and slicing networks to suit the needs of different user devices is starting now, and will gain momentum as 5G networks are deployed.

NR: new radio

The 5G-NR has not yet been standardized, and will require a new radio access technology that will increase speeds to 20 Gbps. It requires new millimeter wave (mmWave) radios, which is the band of spectrum between 30 gigahertz (GHz) and 300 GHz that can send/receive data over the air at very high speeds. Per cell bandwidth is expected to be between 10-20 Gbps, with each user potentially able to get 1 Gbps. Things like high-end augmented reality/virtual reality applications need that kind of bandwidth.

5G-NR is the one area that is true 5G. The other four areas below have strong starting points in LTE-Advanced Pro specs and are, as a result, more evolutionary.

There has been a concerted industry push to publish the specifications of 5G that the 3rd Generation Partnership Project (3GPP), met in Dubrovnik, Croatia after the 2017 Mobile World Congress, and advanced the date for release of a portion of the specification to the end of 2017 as opposed to June 2018.

The two big things that are being discussed in 5G-NR are: Supporting a flexible underlying OFDM technology and support for massive MIMO that would enable using mmwave spectrums.

This flexible underlying OFDM technology can enable a multitude of services such as a high broadband video application along with a low-latency, mission-critical application at the same time to a different user in that same cell. Technologies such as scalable numerology based OFDM and scalable An overview of the LTE physical layer—Part III transmission time intervals (TTI)—tie interval in which a user gets data—are being discussed by 3GPP.

While the massive move to 5G is still in early stages, the areas described above will be major steps is leading us to that migration.

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