TOYO Corporation
Quest for Precision

Network Management Challenges in the 5G Era

WHITE PAPER

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INTRODUCTION

5G is the term used to describe the next-generation of cellular mobile networks. As of late 2019, 5G rollouts are taking place all around the world. In the United States, Verizon started providing limited 5G services to their subscribers in Chicago and Minneapolis in early April.

For many people, they will think of the increased speeds they can be getting on their mobile devices. While the increase in bandwidth is one of the benefits that 5G has to offer, there is so much more to it than just faster downloads.

5G brings improved technologies that not only optimizes typical consumer Internet access, but also allows new and emerging technologies and applications to connect to 5G networks and perform their important roles. As the deployment of 5G continues, the new technology will bring both more optimized networks and new devices to the table that can allow for a greater amount of potential applications that run on 5G networks.

This white paper provides a primer to 5G technology, discusses the newer applications it unlocks, and the challenges that this new standard will present to network management operations of service providers.

5G TECHNOLOGY OVERVIEW

At its core, 5G operates similarly to previous cellular networks. Cellular devices connect using an antenna to a base station, and this base station covers an area called a cell. The base station is connected to the telephone network and the Internet via wired connections. Backhaul connections are also used for areas that are far away from the main network. The new improvements brought by 5G include increased performance and new frequency ranges.

Technology	Bandwidth	Latency
Evolved EDGE (2G)	1894 Kb/s	300-150 ms
HSDPA (3G)	14.4 Mb/s	70 ms
LTE (4G):	326 Mb/s	<5m
5G	1 Gb/s	1-4 ms

Table 1: 5G, Legacy and Existing standards

As most would expect from a cellular network upgrade, 5G provides an increase in bandwidth and a decrease in latency. For example, at this time in the United States with an early deployment, speeds of around 500Mb/s and latency to the base station of 30 milliseconds is common. The increased performance of 5G lends itself to being able to run multiple high bandwidth tasks such as streaming videos and also for cases where timing is important, such as in a video call.

Comparing the various legacy and existing standards (*see table 1*). Latency (more specifically, network latency) is the term used to indicate any kind of delay that happens in data communication over a network[1]. High latency creates bottlenecks in any network communication[2].

5G networks latency profiles tend to be better than 2G by a factor of over 300% while being able to deliver bandwidth that is 4X faster.

5G also defines new frequency ranges that base stations will operate in. Compared to previous cellular network technologies, 5G supports similar frequencies that were used prior, called Frequency Range 1.

The new frequency range introduced in 5G called Frequency Range 2 operates at frequencies greater than 24 GHz. These higher frequencies avoid the issue of interference seen in lower frequencies, which can comprise of many other cellular transmissions.

However, higher frequencies have a much shorter range as the frequency increases, and therefore more cells that cover a smaller area are required. These cells are called “small cells” since they cover a smaller area and tend to serve fewer people at once.

Small cells typically have a range as low as 10 meters up to a few kilometers. Uses of small cells range from urban areas in spots that lower frequencies can’t reach, to rural

areas that tend to have little to no connection. While the currently existing frequency ranges can be used with 5G and operate with the typically large cell sizes, high frequencies are also available to help fill in the gaps. By serving smaller areas and less people, higher frequencies and small cells can help to avoid interference, offload congestion on the network, and offer signals in hard to reach areas.

BENEFITS

The benefits that 5G offers is significant, boasting increased bandwidth and higher frequencies to easily reach difficult areas. There are also newer technology applications that can benefit from what 5G networks have to offer. The ITU-R is a sector of the ITU, which governs communication technologies around the world.

The industry envisions three main uses for 5G: Enhanced Mobile Broadband (eMBB), Ultra Reliable Low Latency Communications (URLLC), and Massive Machine Type Communications (mMTC). Enhanced Mobile Broadband is used like 4G LTE mobile broadband services, with greater speeds and latency than the previous generation. Ultra Reliable Low Latency Communications (URLLC) uses the network for mission critical purposes, requiring an extremely stable connection.

Massive Machine Type Communications (mMTC) connects many low power and low bandwidth devices in a wide area to the network. mMTC can be thought of as running Internet of things devices that connect to a 5G network. With the ITU-R's defined uses of 5G, there are potential applications coming soon that will leverage 5G networks.

First up, URLLC requires both a highly reliable connection and very low latency to perform some important tasks. Some tasks that require a stable and high performance connection include remote surgery, autonomous vehicles, and drones.

Remote surgery is a technology that has already existed for quite some time. With the added bandwidth and decreased latency of 5G, performing surgery remotely using 5G can result in a more reliable experience with less visual delay caused by latency which ultimately can lead to more favorable medical outcomes.

Autonomous vehicles require many sensors to be able to view road conditions and other obstructions that are in the way. The vehicles also need some kind of connection to transmit information, whether it be supplied by the vehicle manufacturer or to other vehicles. With 5G, communication for autonomous vehicles is a reality due to the low latency it can provide.

For vehicle to vehicle communication, low latency is a must for the vehicle's computer to respond in critical and emergency situations.

A vehicle's connection to a server for route planning also benefits from a stable connection, as the onboard computer might be more limited in what it can do on its own. Drones are operated remotely, and require a strong connection for the pilot to be able to react to situations on the fly. The use of 5G for drones ensures that visuals are sent to the pilot clearly and quickly, and the low latency will help in being able to smoothly control the drone in flight.

Lastly, mMTC is a use case that leverages many low power and low bandwidth devices to be connected to a network. Internet of things devices encompasses computing devices that transmit data over a network automatically.

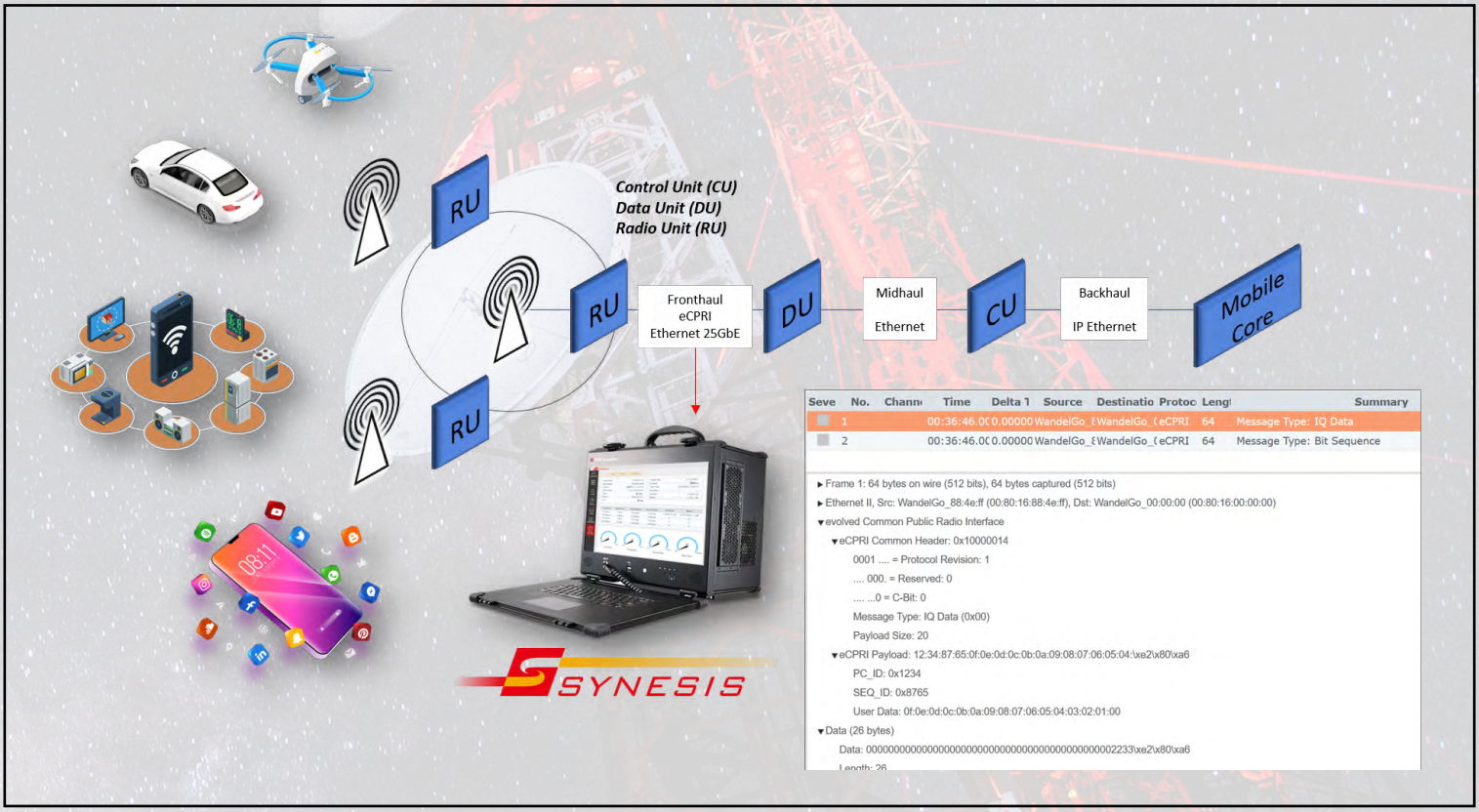
Currently, Internet access options for IoT devices range from connecting via a non mobile broadband network, to mobile broadband. Connecting IoT devices with 5G can create a low-power wide-area network (LPWAN), where a specific group of devices in a large area are connected together. The benefits of 5G with support for high frequencies and small cells means that a large number of IoT devices can be set to connect to a specific base station, which may be used only for the IoT devices.

Thus, instead of relying on a provider's network, a LPWAN can be used for mMTC use cases to have devices that connect to the device operator's own network. For example, sensor networks that supply information about the environment or specific targets run with low power devices.

By relegating these devices to their own network, congestion caused by other non-IoT devices is avoided and the operator has more control over where their devices are connecting to. With mMTC being a use case for 5G, a large number of IoT devices can be easily operated on a single network with the improvements brought by 5G.

NETWORK MANAGEMENT CHALLENGES

Given the use cases described above, network engineers will be challenged on how to collect network packets, a critical data source required for in depth troubleshooting. The 5G implementation involves splitting the Fronthaul into two segments. The segment between the Control Unit (CU) and Data Unit (DU) is the "Midhaul". The new "Fronthaul" is now the segment between the DU and Radio Unit (RU).



eCPRI[4], the heir apparent to CPRI[4] in 4G, specifies 25GbE communication between the DU and RU in the Fronthaul. Considering 25GbE support along with the required increase in the number of towers, packet capture availability will be problematic.

Existing network packet recorder solutions will be overwhelmed by the increased data volume.

TOYO'S continuous interactions with 5G service providers and carriers have yielded some important findings. More importantly, these interactions have helped us understand the requirements sought out by these customers. They include:

- Multi-data rate support in a single instrument
- Data analysis capabilities for Fronthaul of 5G networks
- Time synchronization capability
- Traffic replay capabilities
- Portability

The optimal packet capture solution should include the following as a minimum:

25GbE lossless stream to disk with support for Fronthaul eCPRI SFP28 (25GBASE-SR/LR/BiDi) AND 10G/40G/100G. What good is a packet tracefile if there's even the slightest chance that it may not be complete? If packets are missing, was it caused by the network infrastructure components or the packet recording system? Confidence level in the result from any network troubleshooting session is directly associated on the completeness of the input data set used. So, it's very important that the capture solution provides data sets that leave no doubt of their completeness. As a minimum, the solution must support 25GbE as well as 10GbE/40GbE, and 100GbE, and be able to record continuously up to the maximum interface rates.

Hardware and software filtering. Sometimes network troubleshooting is like trying to find a needle in a haystack. Why not reduce that haystack to only the relevant set of straws? The result will be a smaller data set without all the noise. The solution should allow the network engineer to limit or filter packets not just when they're being recorded but also post-capture when trying to extract packets based on specific characteristics: IPv4, IPv6, VoIP Caller, Callee, ENUM/DNS and so forth.

eCPRI Decode Aware. The solution should be able to decode eCPRI for analysis. This allows the network engineer to quickly view eCPRI specific fields to confirm network equipment settings.

Precision Time Protocol (PTP) Telecom Profile Support. Captured data must be timestamped and synchronized to a common clock for easier analysis when combined with investigations involving data from other data collection or monitoring tools.

Packet Replay. The solution should collect AND be able to replay the data. This allows intermittent problems to be easily replicated in a controlled environment as well as to confirm subsequent fixes.

Portability and All-In-One. With the required increase in the number of possible capture points at the Fronthaul, how feasible is it to deploy a packet capture system at the outset? The solution should be portable enough so that a massive investment in packet capture is avoided and if deployed, to only critical locations. A portable system greatly reduces the logistics and onsite requirements involved: pre-configuration, shipping, rack space, and power requirements.

All-in-One and Ease-of-use. The solution should be an "all-in-one" system where no outside components (hardware/software) are required for full operation. It should be easy enough to use where packet capture can start within minutes of deployment. It should also be remotely accessible through a common browser.

TOYO SOLUTION

TOYO recognizes the dilemma network engineers face in a 5G environment. The TOYO SYNESIS Portable, SYU-100G-HPP2B, configured with a 25G network capture card powered with FPGA3-based technology, is a must have tool for the 5G network engineer whose primary function is to troubleshoot the most problematic and complex network issues that lead to loss of business in terms of customer loyalty and revenue. With lossless high-fidelity capture of up to 25Gbps into 57TB of storage, it's the perfect solution when a network engineer requires quick deployment to remote sites. Being an all-in-one portable system greatly reduces logistics and costs related to pre-configuration, shipping, and onsite placement. It provides packet visibility at any GbE rate and the collected data may be used for problem replication, fix confirmation, and future regression testing.

CONCLUSION

As 5G continues to be deployed around the world, the new network technology is more than just fast downloads. 5G provides increased bandwidth and lower latency, while also operating on a new high frequency range. The higher frequencies ensure less interference and more base stations to provide signals in hard to reach areas. 5G also has three use cases defined, and the two that provide promising new advancements are called URLLC and mMTC.

Situations that require a reliable and low latency connection include remote surgery, autonomous vehicles, and drones to be able to perform consistently and with immediate feedback. IoT devices also benefit from 5G, with a multitude of low power and low bandwidth devices being able to connect to their own network over a large area. The coming of 5G has new improvements and applications that aren't just for Internet access, they are also for advanced devices that need to exchange information in great amounts.

Model	SYU-100G-HPP2B
System Configuration / OS	Portable type / Ubuntu 16.04
CPU / Memory	2 x Intel® Xeon® E5-2637 v3 / 64GB
Operating Environment (Temperature/Humidity)	10-35°C / 8%-85% (Without dew condensation)
Power Supply	800W(100-240VAC)
Weight (kg)	19.8
Dimension	339mm (H) × 430mm (W) × 250mm (D)
Management Port	2 10/100/1000Base-T
Storage	57.5TB
Capture port	100GBase-SR4/LR4 QSFP28 x2 or 40GBase-SR4/LR4 QSFP+ x2 or 25GBase-SR/LR SFP28 or 10GBase-T/SR/LR/ER SFP+ or 1000Base-T/SX/LX SFP (Optional)
Capture Filter / Packet Slice Support	○ / ○
PacketReplayer (Optional)	Keep Original Speed / Wire Rate mode
PTP/1PPS synchronization	○
Note	This product is delivered with wheeled soft case, optional wheeled hard case is highly recommended for transportation. SYNESIS CASE(L) (**https://www.synesis.tech/en/lineup/case-sysl/**)

REFERENCES

[1] *Techopedia*
[2] *Techopedia*
[3] *Field-programmable gate array*
[4] *CPRI defines key interface specification between REC (Radio Equipment Control) and RE (Radio Equipment) of radio base stations used for cellular wireless networks. eCPRI is used in 5G wireless technology*

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