5G front haul, backhaul architectures present wireline test challenges

Daniel Gonzalez - September 12, 2017

Wireless front-haul and backhaul infrastructures have been undergoing an evolution for the past few years. Base stations now employ Centralized-Radio Access Networks (C-RAN), Common Public Radio Interface (CPRI) and fiber to meet the high bandwidth demands of today's consumer. That will only continue as the industry prepares for 5G. To accommodate the network changes, test instruments are evolving to address new standards and emerging designs, both for wireless and wireline links.

5G will not be built solely from wireless standards. Its foundation is 3GPP-defined radio, but to deliver the high bandwidth services expected, wireline links will be important. To that end, the International Telecommunications Union's (ITU) wireline division recently published recommendations for data networking to support 5G. Another indicator of the wireless/wireline convergence is that more mobile operators are joining the Central Office Re-architected as a Datacenter (CORD), an open-source initiative originally started by wireline leaders.

5G will introduce many revolutionary and evolutionary wireless and wireline changes to address increasingly demanding applications. One main element with be integrating Software Defined Network (SDN) and Network Function Virtualization (NFV) into the network to divide signal transmissions by service, as shown in **Figure 1**.

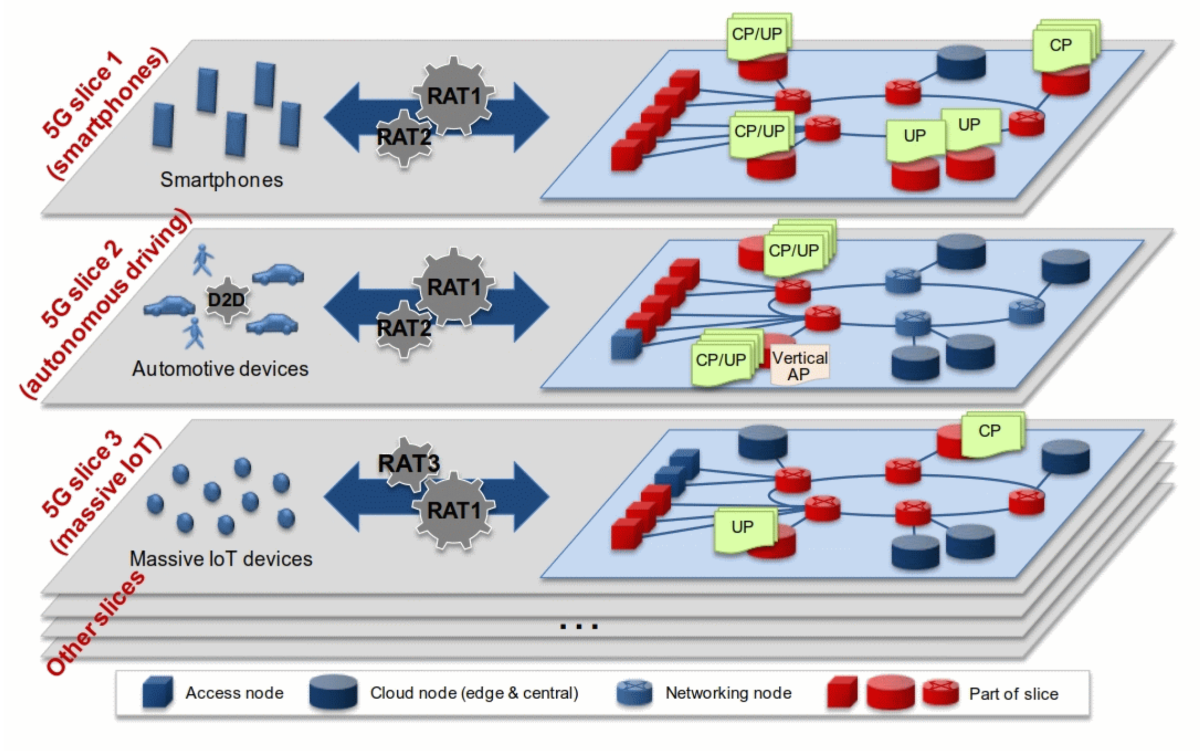

Figure 1. 5G networks may divide signal transmissions by service using SDN and NFV. Source: NGMN.

Even as SDN orchestration separates data planes from control planes and NFV consolidates network functionality, carriers will still need to verify service level agreement performance. Tests for packet reliability, throughput, delay, and network timing will remain in place. How to conduct tests on these next-generation networks and where those tests will be conducted are key considerations that can't be overlooked.

Complex TCP/IP channel performance

One important modification will be that networks will operate via Transmission Control Protocol (TCP)/User Datagram Protocol (UDP)/Internet Protocol (IP), not simply via LTE Layer 2. Complex TCP/IP channel performance between the user equipment (UE) and the small cell will be required to ensure adequate application throughput and latency are achieved. **Figure 2** provides some options for fronthaul/backhaul architectures to transition from 4G to 5G that will be used to accommodate the projected bandwidth demands shown in **Figure 3**.

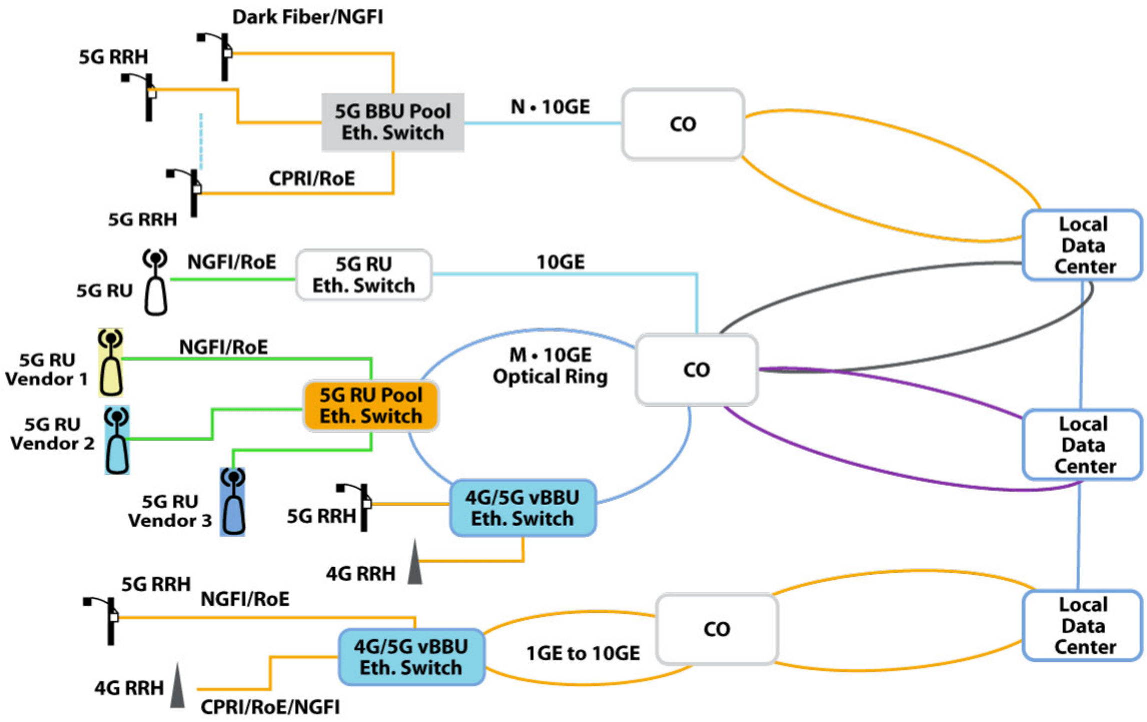

Figure 2. Possible fronthaul/backhaul architectures that will be implemented during the transition from 4G to 5G.

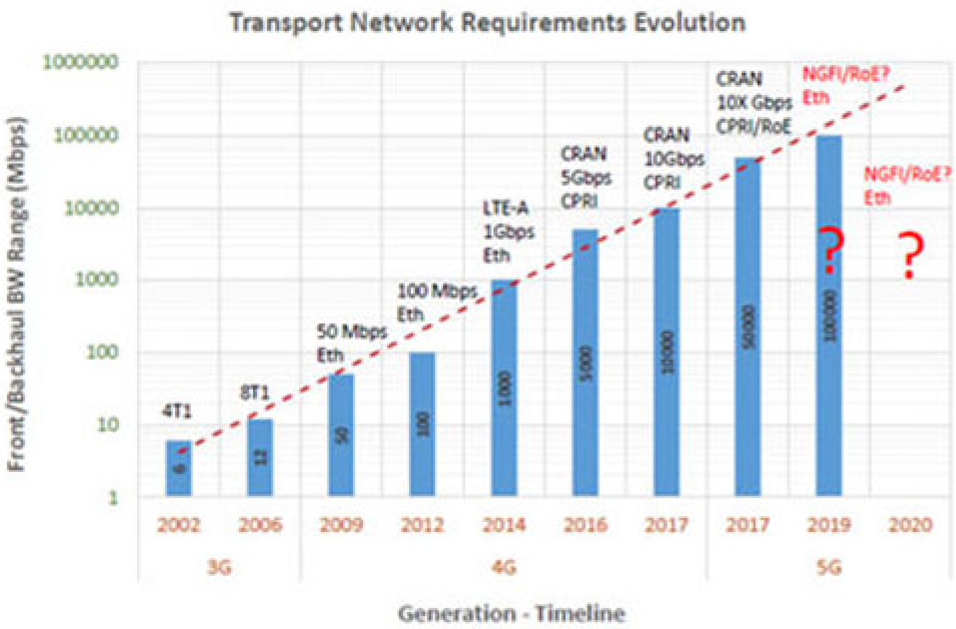

Figure 3. Bandwidth requirements for wireless networks continue to grow.

These developing architectures create some different concerns. Although frames may be intact and count towards throughput, the payload—whether video, voice, or data—may be corrupt. Additionally, TCP/IP traffic requires two-way communication between transmitter and receiver. The balance of acknowledged received messages and Maximum Transmission Unit (MTU) settings determines frame re-transmissions and directly affects TCP traffic bandwidth efficiency. A third concern is Inter-Frame Gap (IFG). As bandwidths increase, frames will be generated faster. The result is shorter IFG time periods. If IFG becomes corrupt, frame losses increase and bandwidth decreases, lowering the Quality of Experience (QoE) for users.

These new variables will make testing payload bit-error rate (BER), MTU size optimization, and IFG critical. Such measurements can't be performed with server-based Internet Performance Working Group (iPerf) tools. iPerf was developed to measure TCP and UDP bandwidth performance in traditional data center environments. By tuning various parameters and characteristics of the TCP/UDP protocol, users can enter iPerf commands to gain an insight on the network's bandwidth availability, delay, jitter and data loss. This analysis, shown in **Figure 4**, will now be necessary on 5G networks, too.

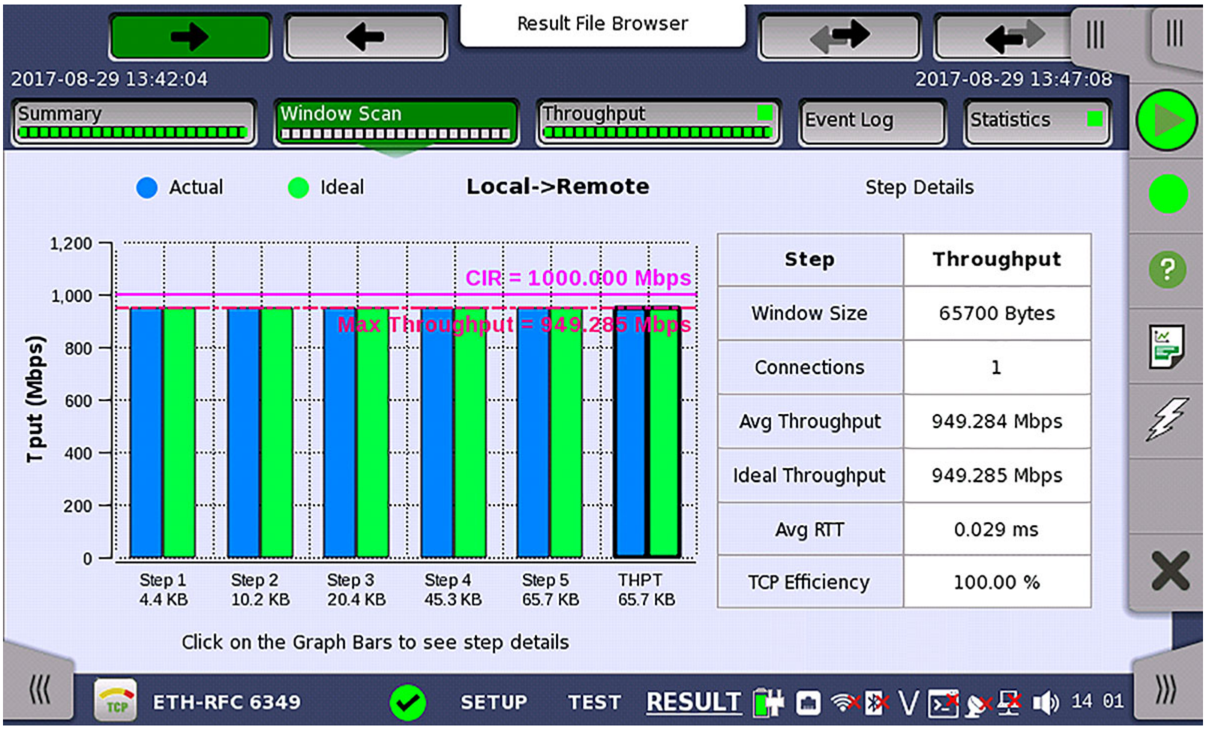

Figure 4. TCP bandwidth throughput performance measurement example.

Traditional optical transport testers can conduct BER, MTU size optimization, and IFG tests. Such test equipment will need advanced iPerf software to measure these higher layer TCP/IP characteristics.

Precise network-based timing

Transitioning to more precise network-based timing will become more essential in 5G due to the lack of GPS access. That's because 5G networks will utilize small cells in heavily congested urban environments, often lacking the line of site necessary for GPS-based network timing. To address this dynamic, packet-based timing protocols such as Enhanced Synchronous Ethernet (SyncE) and IEEE 1588 v2 Precision Time Protocol (PTP) are emerging to provide network synchronization with limited or no GPS clock. PTP synchronizes clocks across a computer network by providing ToD (time of day), phase, and frequency synchronization. Another issue is low latency. Again, standards are being developed to address ultra-low latency/high bandwidth applications. Among those that are being implemented are Coordinated Multi-point Processing (CoMP), Further Enhanced ICIC (feICIC), and 5G time division duplex (TDD). These standards support multi-Gbps and ms latency connectivity simultaneously at noticeably lower energy consumption. Field test products are now being rolled out with PTP support that incorporate tests such as maximum absolute time error (max TE), constant time error (cTE), and dynamic time error (dTE) metrics, in accordance with IEEE 1588 v2. Engineers and technicians can use these tools to conduct accurate time and phase network verification measurements in accordance with the G.827.x Time Sync standard to properly measure future 5G RAN performance (**Figure 5**).

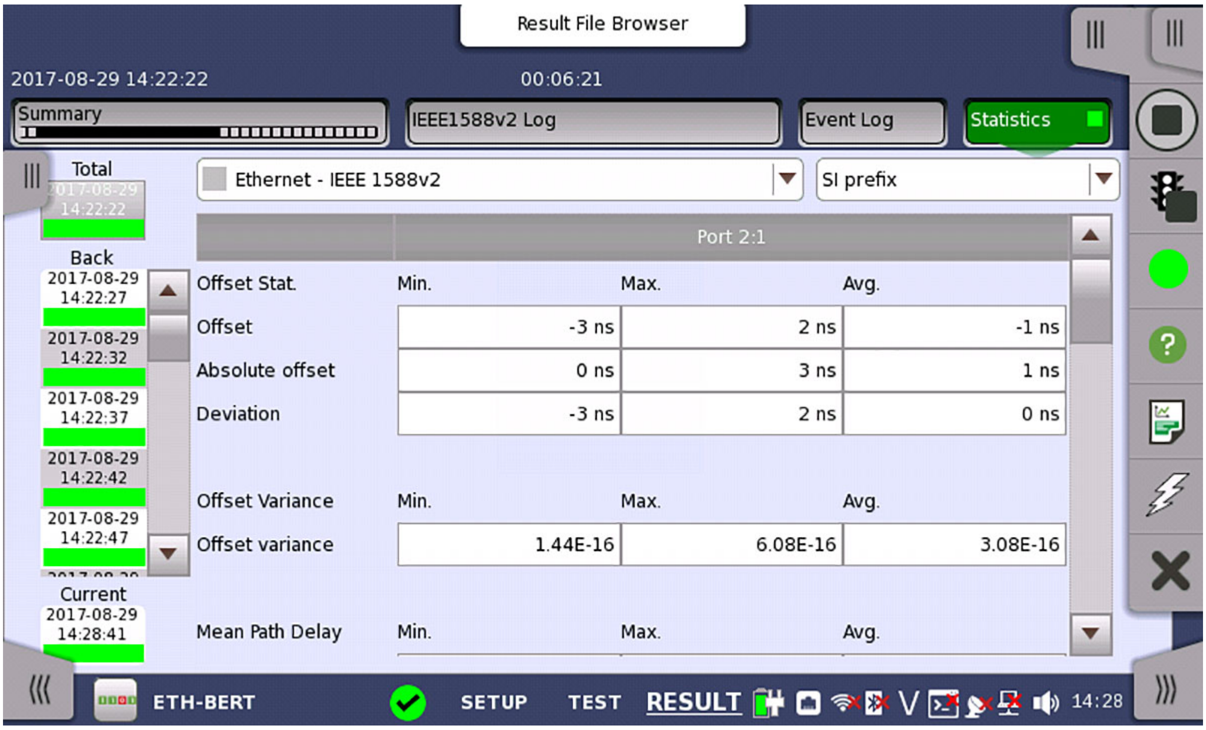

Figure 5. 1588v2 Precision Time Protocol measurement will be needed in 5G backhaul protocols.

Test migration

One of 5G's goals will be to simplify many data processes so they can be conducted at the network edge and thus reduce traffic on the core network. As a result, complex, high bandwidth, low-latency test requirements will move from a centralized office and eNode B to the edge of the network. Service level agreements, QoE and Quality of Service (QoS) verification will continue into the foreseeable future, only under more difficult circumstances and farther away from highly trained centralized engineering resources. Because of that distance, test equipment will need to let engineers create scripts from actual keystrokes for customized automation routines created by technicians. Such a tool could also field technicians record their keystrokes for playback later, in the lab, to recreate test scenarios.

Virtual Network Computing (VNC) will need to let local technicians and remote engineers view each other's respective instruments, or multiple remote engineers can view and contribute to the troubleshooting simultaneously. Technicians could need manual control of a local instrument and remote control of a distant instrument for testing parameters such as throughput, latency, and reliability.

Conclusion

Recognizing the new architectures necessary is only part of 5G's evolutionary path. There will be a significant need to test the data plan with an emphasis on throughput efficiency and latency. Due to this, testing initiatives that address SDN orchestration and NFV network functionality will become necessary to ensure 5G network performance. Additionally, test solutions will need to be built on flexible, scalable platforms that integrate expanded capabilities as needs change and standards advance will ensure next-generation networks perform according to their specifications.

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