APPLICATION NOTE

Converging and Automating 5G Networks

The aspirational promise of 5G mobile networks

As mobile networks evolve from 4G to 5G, significant leaps in network performance gains are being promoted across the industry. When compared to today's 4G LTE networks, touted 5G aspirational goals include order of magnitude improvements in speed, capacity, latency, and connected devices (mainly IoT-related machines). But the actual 5G network performance that subscribers—humans and machines—will actually experience ultimately will depend on the Mobile Network Operator's (MNOs) performance goals, supported applications, targeted subscriber base, technology limitations, financial constraints, and other interrelated factors.

End-users will experience significantly improved performance compared to what they see today—a requirement, if MNOs are to migrate existing subscribers (and attract new subscribers) to their 5G networks and the new applications and use-cases this new mobile network will enable. This means the mobile networking industry must stretch its aspirational performance goals and push technology to its physical limits.

Three categories of 5G services

5G will enable three categories of 5G services and associated applications, which are based on end-to-end network performance requirements over wireless and wireline domains. These are referred to as enhanced Mobile Broadband (eMBB), massive Machine-Type Communications (mMTC), and ultra-reliable Low-Latency Communications (urLLC), illustrated in Figure 1. Each category will have a direct impact on how wireline technology and network architecture will be designed, deployed, and managed, as summarized below:

- eMBB requires significant increases in wireline capacity
- mMTC requires automation and analytics to best connect millions to billions more machines
- urLLC will require Multi-access Edge Computing (MEC) and deterministic packet-optical transport to achieve low latency targets

Benefits:

- Complete, open solution allowing MNOs and wholesale operators to build best-in-breed networks for competitive advantage while enjoying a broader and more secure vendor supply chain
- Vendor-agnostic network slicing and dynamic planning capabilities allowing service providers to leverage their multi-vendor networks and support a broad range of new and competitive 5G-centric use-cases and applications
- Converge 4G and 5G fronthaul, midhaul, and backhaul traffic onto a simpler and more cost-effective network designed from inception to support 5G network slicing
- Ciena's new Adaptive IP provides open, standards-based IP connectivity, albeit differently, by leveraging openness, Blue Planet automation software, and a lean IP protocol implementation

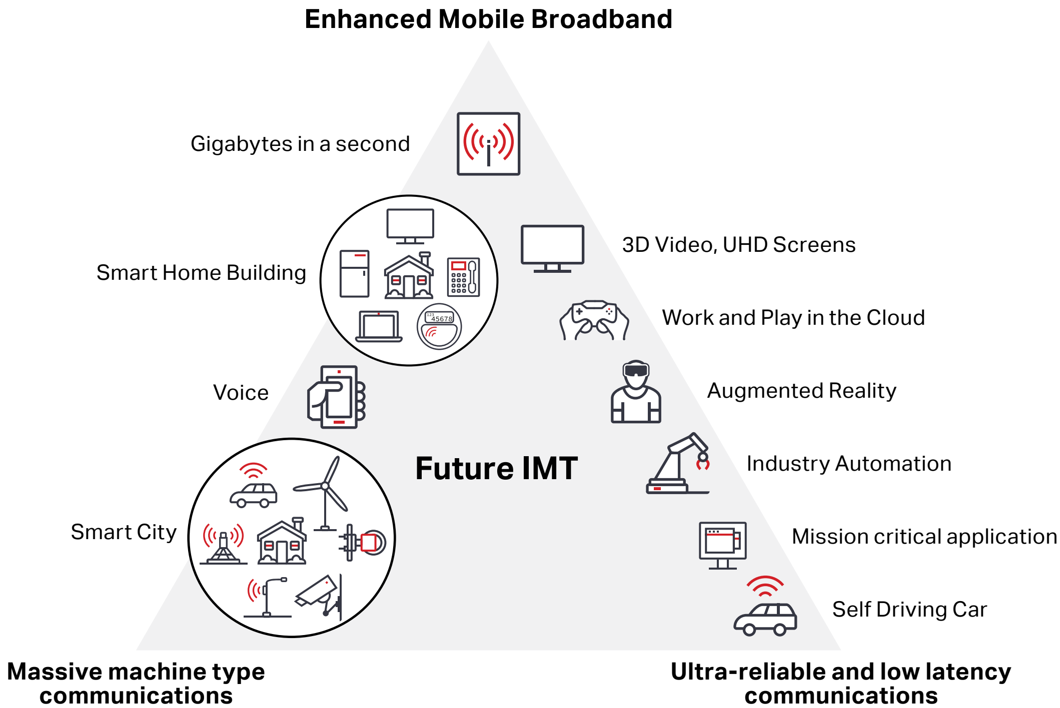

Figure 1. 5G network performance vs. use-case categories (reference: ITU-T IMT-2020)

Open, automated, and lean IP delivery

Of critical importance to 5G networks is IP, the 'glue' that interconnects 5G network elements, virtual and physical. IP connectivity must cost-effectively scale and is critical to the success of 5G network services. This is because the number of IP-enabled nodes will proliferate due to the significant number of new small cells operating in the higher frequency bands in the millimeter wave (mmWave) spectrum that provide improved coverage and performance.

Although mmWave small cells will provide greatly increased capacity, for eMBB applications, mmWave wireless signals simply do not travel as far as lower frequency signals or move well through physical obstacles. As a result, upwards of 10x to 20x more small cells (mmWave and/or mid-band) than existing macro cells may be required to meet broad 5G coverage and Full 5G (5G New Radios [NRs] and 5G Core packet network) end-to-end performance guarantees. This mandates a different and better way to interconnect all these IP-enabled cell sites, something that is open, automated, and lean. We call this better and different way Adaptive IP™, which offers open, standards-based IP and software-based analytics and automation. It's the same IP we use today, albeit delivered differently.

Migrating from 5G Non-Standalone to 5G Standalone

To accelerate the availability of 5G network services, the industry has introduced the 5G Non-Standalone (NSA) configuration, which connects 5G NRs to existing 4G Evolved Packet Core (EPC) networks. This allows for improved wireless network performance but is still limited by the 4G wireline network infrastructure. This means end-to-end 5G Quality of Service (QoS) is not offered, yet. However, eMBB end-users will experience significant improvements in download speeds, with the exact performance being MNO-specific.

As the 4G EPC is upgraded to a new 5G Core in the 5G Standalone (SA) configuration, the complete benefits

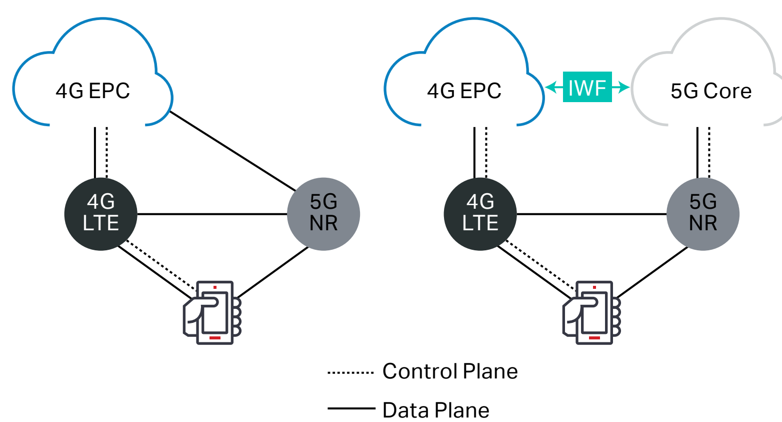

Figure 2. 5G NSA vs. 5G SA network configurations

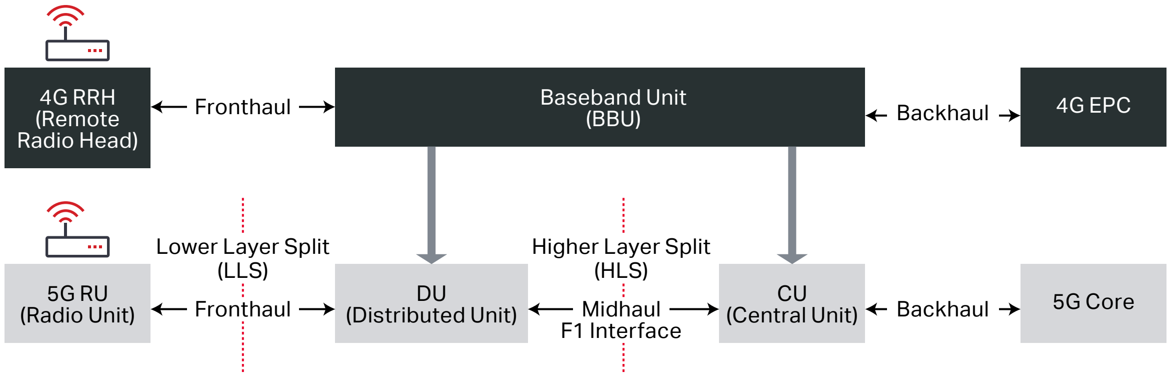

Figure 3. 4G C-RAN vs. 5G C-RAN architecture

of Full 5G, such as guaranteed end-to-end network performance and network slicing, can be experienced and will change how people interact with one another, and with machines. This requires a network transport infrastructure that is compatible with 5G NSA today, and with 5G SA tomorrow. To facilitate the transition from 4G to 5G, an Interworking Function (IWF) is required, to allow 4G and 5G network elements to interconnect and interoperate with each other.

Converged xHaul transport networks

5G networks will use Distributed Radio Access Network (D-RAN) and Centralized/Cloud RAN (C-RAN) architectures. Although 4G C-RAN, which physically separates Remote Radio Heads (RHH) from their Baseband Units (BBU) hosted into a centralized location, was essentially closed and proprietary, 5G C-RAN is moving to a more open, increasingly cloud-based architecture based on open standard interfaces.

5G introduces the midhaul network, which interconnects a BBU that is disaggregated into a Central Unit (CU) and Distributed Unit (DU), using the 3GPP F1 interface, as shown in Figure 3. The industry's goal is to make xHaul (fronthaul, midhaul, backhaul) networks open and standards-based, allowing MNOs and wholesale operators alike to benefit from increased solution offerings, rapid technology innovation, broader and more secure supply chains, and lower costs due to increased vendor competition.

A key benefit of open, standards-based xHaul is the ability to converge traffic onto a simpler common wireline infrastructure, making it more cost-effective to own and operate. Converging existing 4G fronthaul and backhaul traffic onto a common transport network offers economies of scale and further network simplification.

To achieve this, a common transport infrastructure must support multiple 4G and 5G xHaul protocols, such as the 4G Common Public Radio Interface (CPRI), 4G Radio-over-Ethernet (RoE) interface, 5G evolved CPRI (eCPRI), and Open RAN (O-RAN) interface. The wireline network must also support an interoperable, automated, and lean IP implementation.

To support a simpler, converged 4G/5G xHaul network, Ciena is launching three new routing platforms supporting its unique Adaptive IP, which delivers open, standards-based IP—albeit differently—by leveraging the company's Blue Planet® automation software. These three new packet platforms, summarized below, leverage Ciena's extensive, field-proven backhaul network experience providing cell site connectivity to mobile network and wholesaler operators. These new open and programmable platforms support soft and hard network slicing capabilities via technologies such as Segment Routing and FlexEthernet (FlexE)/G.mtn (Metro Transport Networking) switching for converged 4G and 5G xHaul networks over a simpler, common wireline infrastructure.

- **5168 Platform:** an xHaul network slicing router enabling C-RAN architectures with support for CPRI/eCPRI/RoE/ORAN, Adaptive IP, and high-density 10/25GbE to 100/200GbE aggregation
- **5166 Platform:** cost-effective network slicing router implementing Adaptive IP and optimized for 10/25GbE to 100/200/400GbE aggregation
- **5164 Platform:** cost-effective network slicing router implementing Adaptive IP and optimized for 10/25GbE to 100/200GbE aggregation

Ciena 5G Network Solutions
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The best way to cost-effectively support the continued coexistence of 4G and 5G transport networks is through an open, interoperable, and common transport network.

5G automation and network slicing

Although higher capacity and lower latency get most of the media fanfare, the significantly higher numbers of connections associated with 5G, and the speed at which they need to be created, place automation in a pivotal role. Traditional management systems and associated manual processes used in operating today's networks are simply inadequate for 5G. Extensive intelligent automation is required throughout the 5G service lifecycle, including network planning, design, and operations. Network slicing, in particular, is a key differentiator of 5G over 4G that directly builds upon NFV/SDN orchestration, and other automation concepts.

Automation allows for reliably and rapidly setting up physical and virtual resources required to guarantee end-to-end performance for a given network slice (such as urLLC service) across the RAN, xHaul transport network, and Network Functions Virtualization (NFV) cloud domains. This is a major change from existing best-effort 4G networks, and will unleash a new wave of applications, such as mobile gaming (eSports), Augmented/Virtual Reality (AR/VR), industrial automation, and more. Automation also plays an important role helping MNOs bring 5G to market faster by delivering an accurate, real-time view of network and service inventory.

As such, Blue Planet is launching new 5G-centric 3GPP-compliant network slicing and dynamic planning capabilities that facilitate the rollout of 5G NSA network buildouts, as well as 5G SA network slicing for highly differentiated eMBB, mMTC, and urLLC services for a specific group of applications, subscribers, wholesale opportunities, or price points.

Blue Planet 5G Automation
Download solution brief

RANs, and the transport networks that interconnect them to each other and the core, are already being upgraded today, initially to support eMBB applications in a 5G NSA configuration. To support mMTC and urLLC applications, further wireline network upgrades are required; they will start this year and continue for several more.

5G is a multi-year journey

There is no simple upgrade to enable Full 5G and the three categories of 5G services (eMBB, mMTC, and urLLC). Substantial upgrades from handsets to data centers, where accessed content is hosted, and everything in between will be required to support more users and bandwidth, lower latency, physical to virtualized function migration, and guaranteed end-to-end network performance. 4G is not going away anytime soon, so MNOs must continue supporting, and even expanding, associated services while migrating toward Full 5G services.

This is a complex journey, and every network operator has a unique path and migration starting point. Ciena's Services experts apply proven best practices and processes—along with the most effective tools for handling network complexities—to work with network operators from initial strategy consultation through implementation, as well as ongoing maintenance, to ensure success along all stages of the 4G to 5G journey.