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White Paper

What You Need to Know About 5G Wireless Backhaul

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If industry experts are correct, 5G is set to hit the streets at the very beginning of the next decade.

Despite some uncertainties, 5G is creating buzz among mobile operators and CSPs that want to get in on the ground floor. And while 5G isn't slated to be finished and commercially deployed until 2020, early trials should start in 2018. Smart operators and providers are learning all they can about 5G now.

In this white paper, we'll walk through what 5G is, and the challenges it poses for Communications Service Providers (CSP). We'll also cover the impact 5G will have on their wireless backhaul infrastructure, and how mobile operators can overcome these challenges.

5G—the known and the unknown

Many of the building blocks of 5G technology architecture are still unknown, or not well-defined. Access frequency, for example, is forecasted to migrate from the Decimeter-wave realm (sub 3GHz) to the microwave and millimeterwave domains (3GHz to 300GHz) to satisfy the exponential growth in capacity demand. Yet standardization of operating frequencies, as well as other technological and architectural specifications, are far from complete.

When looking at 5G services, however, one can see clear trends and characteristics of the underlying 5G networks that pose specific and well-defined challenges to network infrastructure.

Such 5G characteristics are:

More capacity per device

One of the main goals of the introduction of 5G services is to provide ultra-high capacity per end-device. GSMA[1] expects "*1-10Gbps connections to end points in the field (i.e., not theoretical maximum).*"

More devices

The exponential growth in the number of "standard" devices (e.g., smartphones, tablets, and computers) is expected to continue and increase the average number of human-controlled devices per person.

New types of devices

The mass introduction of IoT (Internet of Things) and M2M (Machine to Machine) services will create an explosion in the number of connected devices. This adds non-human-controlled devices to the mix, resulting, as forecasted by GSMA[1], in a tenfold to hundredfold increase in the total number of connected devices.

[1] Understanding 5G: Perspectives on future technological advancements in mobile, GSMA intelligence, December 2014

New services

The massive increase in infrastructure capabilities in 5G will enable new services. Services such as augmented reality (enhancement of a live view with layered infotainment applications via smart-glasses and other devices), tactile Internet applications (such as remote sensing, remote movement, and remote medicine), mobile XaaS (anything as a service), and virtual reality will enrich the service offerings provided by both mobile operators and over-the-top (OTT) service providers.

5G wireless backhaul challenges

The trends and services listed above illustrate both the drive towards 5G and its benefits. At least that is the theory. In reality, achieving these benefits will require huge changes in how mobile networks and their underlying infrastructures are built—especially for the wireless backhaul/transport layer. Here are some things to know:

Higher capacity density

Multiplying the increase in capacity per device by the expected growth in the number of mobile devices results in a huge increase in capacity density (the required capacity per a given area). This forecasted increase could be x1000 compared to the capacity density in current 4G/4.5G networks.

The clear effect of the increase is: **more capacity per cell site**—both at the radio access network (RAN) and at the backhaul layer.

However, since a site capacity increase of x1000 is not feasible, and since the forecasted move to higher RAN frequencies will also require smaller coverage areas per cell site, the **mobile grid will become far denser than it is today**.

This grid will incorporate the addition of macro-cells as well as small cells, on poles, towers, rooftops, but also **mass-deployment at the street level**, utilizing street furniture and light poles as physical infrastructure.

These issues will present wireless transport networks with the following challenges:

- Higher capacity wireless backhaul links per cell site: While current wireless backhaul links serve requirements of hundreds of Mbps, future links will be required to support tens of Gbps.
- Denser wireless backhaul links, due to denser cell site grid, will require better utilization of wireless backhaul spectrum, since frequency reuse will be highly limited as links get closer to each other.
- Mass deployment of street level sites will require high capacity non-line-of-sight wireless backhaul links, as well as quickly installed, low footprint, low-power consumption equipment.

Service and network virtualization

The need to improve operational efficiency and dramatically shorten time-to-market for new revenue generating services, together with the rare opportunity for a forklift change in network infrastructure, will drive mobile operators to massive virtualization of their networks and services. From cloud-based services to SDN/NFV infrastructure and even virtualized RAN (Cloud-RAN), networks will become heavily software driven. This will require the wireless transport infrastructure to accommodate the following:

- Wireless backhaul should seamlessly integrate into the SDN/NFV architecture to enable multi-domain, multi-vendor network resource optimization applications, as well as faster time-to-market for new services.
- Cloud-RAN will require cloud-backhaul (wireless fronthaul) to enable effective optimization of RAN resources.

Mission critical services

New service types, such as autonomous driving, tactile Internet, and many M2M applications must be served by mission-critical networks – the risks of failure are too great. “Five-nines” availability, as well as complete coverage, ultra-low latency, and tight security, will be standard requirements for public mobile 5G networks just as these are required in public-safety and utilities networks today. This will also require wireless backhaul infrastructure to:

- Serve as true mission-critical wireless backhaul, and include low latency, have high availability, and be tightly secured.

Redefining wireless transmission

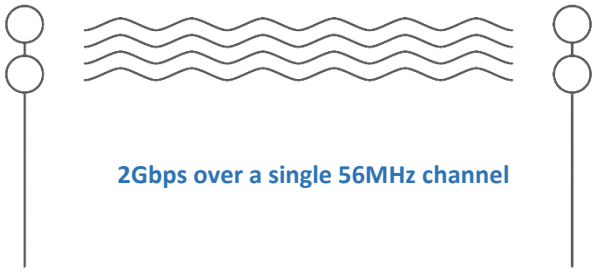
Wireless backhaul will increase its position as the most flexible and cost-effective backhaul technology for mobile networks when 5G arrives. That status will not be achieved without serious technical advancement. Ceragon is driving this innovation now by developing 5G wireless backhaul technology that moves the market forward and is capable of coping with all the challenges we’ve described.

The wireless transmission evolution will be driven by many new capabilities:

Ultra high-capacity wireless backhaul

High-capacity wireless backhaul will enable mobile operators to keep up with capacity demands and maintain excellent quality of experience for their customers. Meanwhile, operators will need to meet demanding operational efficiency targets by saving spectrum costs and avoiding costly and time-consuming fiber deployment.

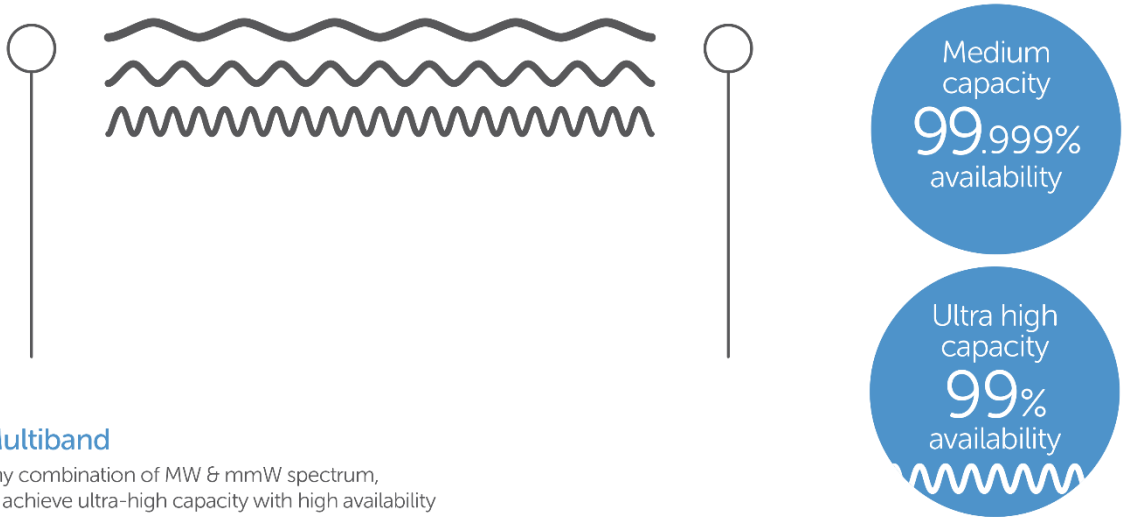
Traditional microwave bands (4-42GHz) will leverage both wider channel spacing (such as 112MHz and 224MHz) and higher modulation schemes (4096 QAM and up), as well as ultra-high spectral-efficiency techniques such as line-of-sight MIMO, to enable up to 10Gbps, and long and medium distance connectivity.



4x4 LoS MIMO

Short distance connectivity will heavily utilize higher frequency connectivity. E-Band and V-Band solutions will benefit from additional capacity-boosting techniques (currently more common in microwave solutions). Such techniques will include XPIC, LoS MIMO, and higher modulation schemes. This will enable rates of more than 20Gbps per link.

Combining multiple carriers in different frequency bands into a single link, sometimes referred to as Multiband or Carrier-Aggregation, will provide operators with the benefits of lower frequency ranges and availability alongside higher frequency band capacity. For example, a typical configuration might consist of a link created from an E-Band carrier planned for medium availability (99.9%, for instance, enabling longer range) and a MW carrier that increases the link's capacity while providing a "safety-net" whenever the E-Band link is unavailable, thus creating an ultra-high capacity link with the range and availability of a standard MW link.



Multiband

Any combination of MW & mmW spectrum,
to achieve ultra-high capacity with high availability

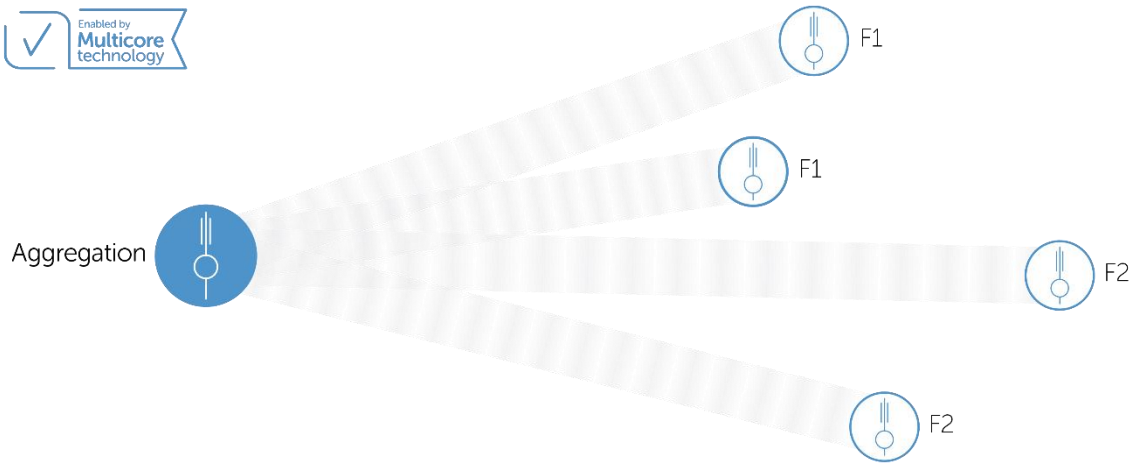
Because mmW spectrum will be heavily used for 5G RAN, additional, higher frequency ranges will also be allocated for wireless transmission. Above-100GHz bands such as W-Band and D-Band,

though not yet regulated, are already the subject of R&D efforts to create power-efficient, small-form-factor, ultra-high capacity wireless transmission solutions.

New frequency reuse scheme - deploying cellular base stations and small cells exactly where needed

Increasing the re-use of wireless backhaul spectrum will let operators meet operational efficiency targets by saving spectrum fees. This will also improve subscribers' quality of experience by placing their cell sites at the optimal locations, with no real constraints posed by wireless backhaul frequency allocation and planning.

Such higher frequency re-use is available thanks to a recently announced[2] Ceragon technology breakthrough, enabling inter-link interference cancelation to the level of re-using wireless backhaul frequency with links close together to the level of 15 degrees of angular separation. This technology enables massive re-use of wireless backhaul spectrum, which will be critical in the ultra-dense 5G cell site grid. It also enables wide channel adoption (112MHz/224MHz) by freeing adjacent channel spectrum in existing networks. This enables the combination of several narrow channels (56MHz or below) into a single side channel.



Deploy your cell sites where needed:
Deliver services anywhere, on time,
without backhaul spectrum constraints
(Advanced Frequency Reuse).

[2] Ceragon Removes Spectrum Bottlenecks and Doubles Capacity for Wireless Backhaul with Revolutionary New Advanced Frequency Reuse Technology - https://www.ceragon.com/thanks/item/1215-ceragon-new-advanced-frequency-reuse-technology

High capacity Non Line-of-Sight (NLoS) solutions - enabling fast deployment

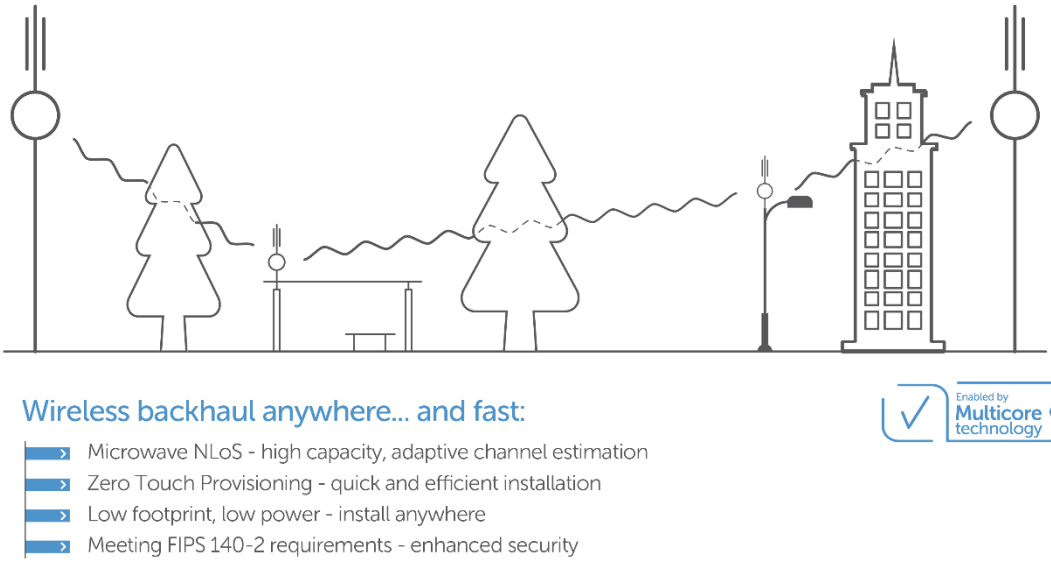
High capacity NLoS point-to-point wireless transmission solutions will enable true street-level mass deployment to accommodate capacity and coverage requirements in 5G dense urban environments.

While current sub-6GHz can overcome the limited spectrum channel widths to provide a fair backhaul solution for 4G/4.5G street-level deployments, 5G deployment demands capacities that are far beyond the scope of such solutions. Instead, 5G will call for high capacity, microwave and millimeterwave NLoS solutions.

It has been known for years that MW NLoS is theoretically feasible. Indeed, trials have successfully been performed on several occasions. However, in order to make it commercially efficient, Ceragon is driving MW and mmW NLoS implementations forward, creating an evolution that will incorporate adaptive channel estimation (similarly to the technique used by Ceragon in other implementations such as LoS MIMO and Advanced Frequency Reuse) in order to ensure capacity and availability of such solutions.

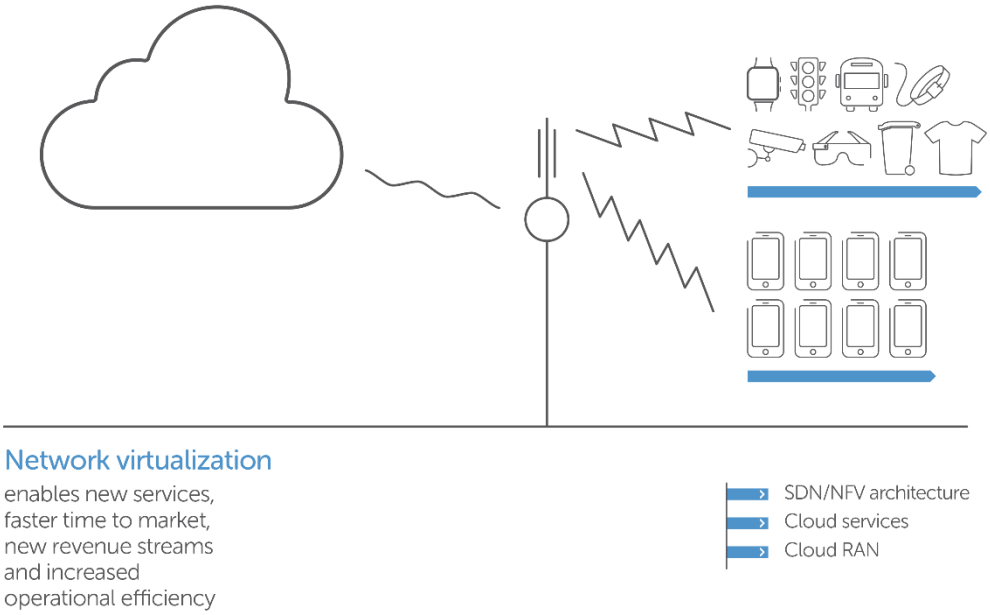
Moreover, Ceragon is pursuing a combination of NLoS adaptive channel estimation with MIMO implementation. This can increase link robustness, which is highly required in a NLOS environment.

In addition to NLoS operation mode, street-level backhaul will also feature low footprint, low power consumption, zero touch provisioning, and enhanced security.



Virtualized wireless backhaul - ensuring optimal use of network resources

Network virtualization enables operators to dramatically improve operational efficiency by making their infrastructure and resource utilization much more efficient and flexible. It also enables very fast introduction of new services and technology throughout the various network domains.

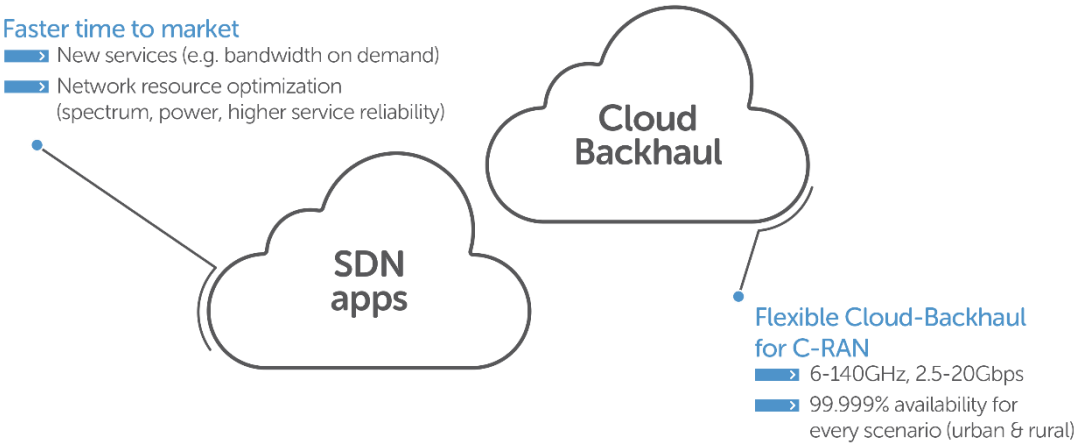


Wireless backhaul virtualization will serve two aspects of network virtualization:

1. **SDN integration:** Wireless backhaul will integrate, via open interfaces, with the end-to-end SDN and NFV infrastructure and enable SDN applications to achieve network resource optimization (spectrum, power), higher service availability (with smart re-route mechanisms), and faster introduction of services and technologies. All of these are applicable in the wireless transmission domain, as well as in multi-domain, multi-vendor environments (assuming vendor alignment to standard-based interfaces and applications).

   One application that will increase operational efficiency in the wireless transmission domain is the adaptive adjustment of power consumption at each site, according to the traffic running through the site in any given instance. Meanwhile, dynamic frequency allocation will be performed throughout the network based on required capacity weather conditions. This will offer considerable savings on spectrum and costs.

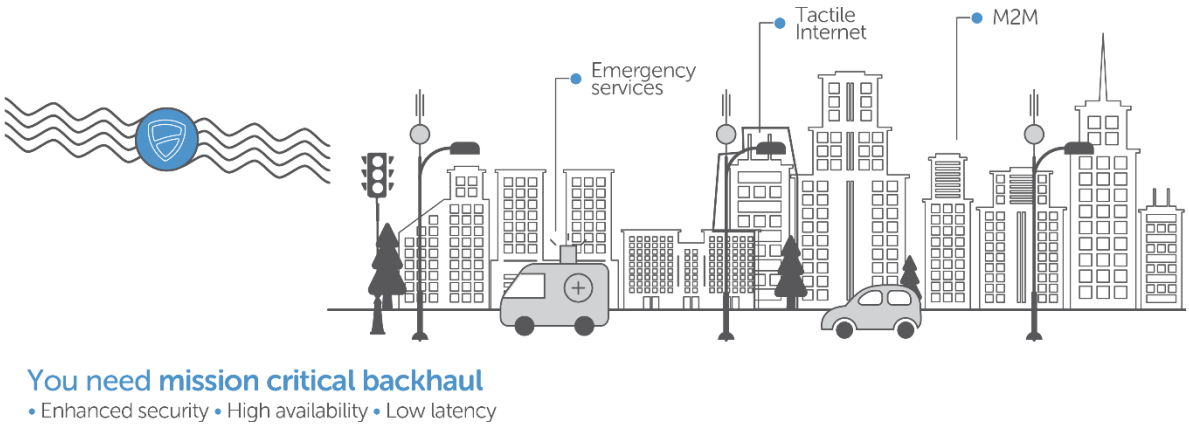
2. **Cloud-RAN support:** Separating baseband units (into BBU hotels at data centers) and remote radio heads will create significant benefits to mobile operators. However, such a model heavily depends on what is today a highly inefficient I/Q interface between the two elements (CPRI, for instance). This interface should be transported via wireless transmission (and not only over fiber) in order to create a cost-effective transition to C-RAN. This will be enabled by higher capacity wireless fronthaul, as well as highly efficient compression mechanisms incorporated at the wireless fronthaul nodes.



Mission critical backhaul

High-availability, low-latency, and highly secured wireless backhaul is common practice in today's public safety and utilities networks. By using multiple layers of redundancy, low-latency transmission technology, and physical and virtual security and encryption mechanisms, wireless transmission has been proven, in many cases, to be a more secured and reliable transmission method than fiber (plus it is inaccessible to vandals and hackers).

These standards will be widely adopted in 5G networks as mission-critical applications are introduced, demanding a high level of QoS, very good quality of experience, and five-nines of reliability.



Summary

5G offers huge and game-changing benefits to mobile users, and even more so to forward thinking mobile operators. The ultimate success of 5G is up to wireless operators and their technology partners, who together can overcome 5G's many challenges and build mobile networks for the future.

Mobile operators must understand and plan for higher capacity requirements, denser cell-site grids, street-level deployments, network virtualization and mission critical applications. Driving wireless transmission to a new era is a must in order to overcome these 5G challenges.

Ceragon is paving the way to this era with new technologies, some of which are already available (LoS MIMO, Advanced Frequency Reuse, SDN, and Cloud-RAN support) and others of which are under development, such as incorporating new frequency bands, capacity boosting techniques, NLoS operation, and virtualization. All this will help operators dramatically increase their operational efficiency, provide far higher quality of experience to subscribers, and achieve significantly faster time to market for new services and technologies.

About Ceragon

Ceragon Networks Ltd. (NASDAQ: CRNT) is the world's #1 wireless backhaul specialist. We provide innovative wireless backhaul solutions that help mobile operators and other service providers increase operational efficiency, ensure peace of mind, and enhance customers' quality of experience. We serve wireless service providers, public safety organizations, government agencies and utility companies, which use our solutions to deliver 4G, mission-critical multimedia services and other applications at high reliability and speed.

Ceragon's unique multicore technology provides a highly reliable, high-capacity 4G wireless backhaul with minimal use of spectrum, power and other resources. It enables increased productivity, as well as simple and quick network modernization. We deliver a range of professional services that ensure efficient network rollout and optimization to achieve the highest value for our customers. Our solutions are deployed by more than 460 service providers, as well as hundreds of private network owners, in more than 130 countries.