White Paper

CERAGON

A Guide to Building Flexible Wireless Backhaul Networks

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Introduction

5G is here. Two years ago GSMA announced the “year zero” for commercial 5G deployment.

In 2021, 5G is not everywhere, and not utilized to the full extent of its potential. But 5G is here.

With 5G comes a huge business potential. This potential derives from the capability to provide new services to new target markets and to create new revenues streams.

With this potential, however, come new types of network and operations challenges.

In this document, we will take a closer look at 5G challenges that are faced by operators seeking to unlock their 5G potential.

We will also describe Ceragon’s recommended approach to building a flexible wireless backhauling network, and allowing operators to overcome these challenges and to unlock their 5G potential.

5G challenges

These challenges hide within "dimensions" that are different than the ones we looked at in previous generations of mobile technology.

As we gear up for massive 5G commercial deployment, there are three main "challenge dimensions" we should explore:

1. **Target markets dimension** – multiple 5G use cases and services
2. **Architecture complexity dimension** – multiple 5G network scenarios
3. **Spectrum complexity dimension** – multiple 5G RAN frequency bands

The first dimension of target markets is driven by new use cases and new services enabled by 5G to address new target markets and create new revenue streams. These are, basically, the essence of 5G business potential.

As discussed before, there are two use cases that stretch existing 4G services to the limit: mobile gigabit broadband, via the enhanced mobile broadband (eMBB) use case; and gigabit broadband to the home, via the fixed wireless access (FWA) use case.

Additionally, there are two use cases which address new markets with new services: IoT, via the massive machine-type communications (mMTC) use case; and mission-critical applications, via the ultra-reliable low-latency communications (URLLC) use case.

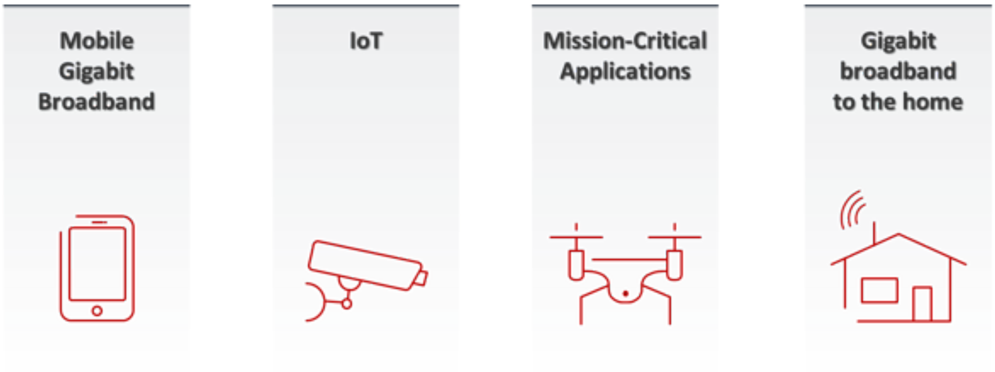

Figure 1 – 5G use cases

Those services pose several challenges to your network.

The first challenge derives from the fact that those services need to co-exist over the same network while each service has extremely different requirements from that network. This calls for service orchestration that is done with network slicing and software-defined networking (SDN).

On top of that, some of the services require much more capacity (specifically eMBB and FWA).

Other services require broader coverage that calls for more cell sites. This is the case, for instance, with an mMTC service that serves agriculture fields (with sensors deployed across them), which typically are not covered in current networks.

An additional challenge is the need for low latency. This is mainly the case in mission-critical applications utilizing URLLC, but could also be relevant in eMBB or FWA variants in which gaming or virtual/augmented reality applications are bundled (or run over-the-top).

The second dimension of architecture complexity is a result of an architectural revolution in 5G RAN. 5G actually allows massive horizontal disaggregation of the classic base station as it splits its functionality to no less than three separate functions: the central unit (CU), the distributed unit (DU), and the radio unit (RU).

This disaggregation brings huge flexibility, scalability and performance improvements to the network operator, but also creates several possible RAN architectures, which can all be implemented in different parts of the same network. Those architectures include: (1) cell site RAN, in which all three functions are co-located (the "classic" cell site architecture); (2) split RAN, in which the DU and RU are co-located and the CU is located in a central location; (3) central RAN, in which only the RU is deployed in the tail sites while the CU and DU are centralized; (4) and dual split RAN, in which each of the three functions is located in a different site.

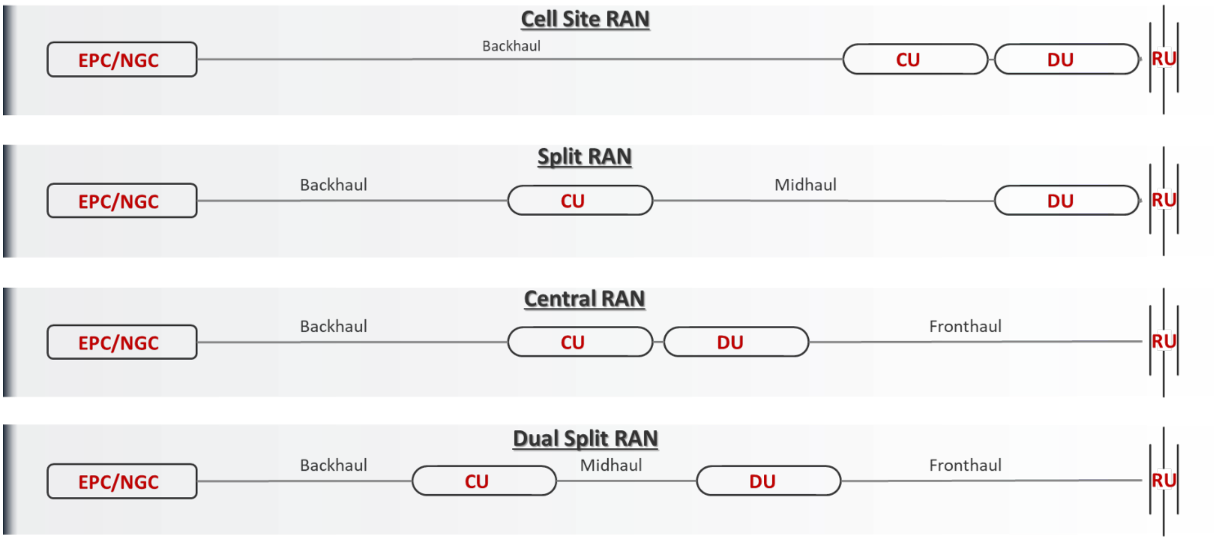

Figure 2 – RAN split options

These architectures introduce connectivity types or segments that did not exist in previous generations, like midhaul (between the CU and DU) and fronthaul (between the DU and RU). Both of these segments are actually an integral part of the RAN architecture (as opposed to backhaul, which connects the RAN to the network's core).

Choosing split, central or dual split architecture is typically done as part of network densification that calls for more cell sites. Midhaul and fronthaul have new low latency requirement as those transmission segments are actually a part of the base station. And fronthaul segments call for much more capacity than the equivalent backhaul or midhaul segments.

These new challenges that derive from network architecture come on top of the challenges mentioned earlier that evolve from the target markets dimension.

The last dimension of spectrum complexity is a result of using multiple RAN frequency bands for 5G radio access.

Low bands (<1GHz) and legacy mid-bands (1-2.6GHz) are used in 2G-5G networks, providing excellent coverage with limited channel sizes, and therefore limited capacity. Those bands primarily will be used for services such as eMBB and URLLC in a full-blown 5G network.

On the other hand, new mid-bands (3.5-6GHz) and, even more than that, high bands (a.k.a. millimeter waves, 24-40GHz, with even higher bands as candidates) are used in 5G and 4G networks. They bring ultra-high capacity by using ultra-wide channels (up to 400MHz), but lack in coverage and indoor penetration.

	Low bands <1GHz	Legacy mid bands 1-2.6GHz	New mid bands 3.5-6GHz	High bands (a.k.a. mmW) 24-40GHz (higher bands – candidates)
G	2G-5G	3G-5G	4G-5G	5G
COVERAGE	Ultra high	High	Medium	Low
CHANNELS	5MHz	20MHz	100MHz	400MHz
5G APPS	mMTC URLLC	eMBB URLLC	eMBB FWA	eMBB FWA

Figure 3 – RAN bands

Therefore, those bands call for more sites (due to poor propagation) and more capacity (as they enable massive capacity per site).

In summary, this complex picture of multidimensional challenges drives four main requirements from our networks:

1. More capacity
2. More sites
3. Low latency
4. Service orchestration

Those challenges need to be addressed at the network level across multiple network domains, and on the operational level.

Flexible wireless hauling – spectrum flexibility

With its flexible wireless hauling solutions, Ceragon allows operators to unlock their 5G potential by answering those challenges across multiple dimensions.

Operators are looking for solutions that will allow them to unlock their 5G business potential, launch new services, and address new target markets while overcoming the new dimensions of 5G network challenges – orchestration of multiple 5G use cases, multiple network scenarios, and multiple 5G RAN frequency bands.

Solutions addressing these challenges need to be, first and foremost, flexible. While this is true in all network domains, let's focus on the wireless hauling domain, and talk about Ceragon's flexible wireless hauling solution as an example of an optimized 5G network solution.

The first flexibility metric is spectrum flexibility.

The need for more capacity, lower latency and support of multiple network architectures calls for flexible hauling solutions with spectrum that spans well beyond the "classic" microwave domain.

True, the microwave domain (4GHz-42GHz) remains a cornerstone in cell site connectivity, as it provides long distance and high-availability connectivity to both macro and small cell sites.

Nevertheless, when it comes to multi-Gbps connectivity, the narrowband spectrum of microwave is simply not enough. This is where we expand our solutions to the more available (and significantly less costly) millimeterwave bands.

E-Band (71GHz-81GHz) is the current selection of choice for solutions that require up to 20Gbps connectivity over a medium distance (typically up to 5km). The short reach is a limitation, but the fact that the urban cell site network is becoming denser and denser usually means that the required distance is fairly short. And even if it is not, a multiband solution can be implemented to extend the reach of such high-capacity links.

In most cases, E-Band is enough to cover current challenges of 5G.

However, things change when we look down the road at central RAN or dual split RAN architectures in new mid-bands and high bands of the RAN. In such cases, we will face scenarios in which a fronthaul connection will have to accommodate traffic of wide RAN channels. This may result in capacity needs greater than 20Gbps.

These types of capacities, alongside the requirement for fast and cost-efficient deployment of new sites, call for wireless solutions that will range way above 20Gbps, to as much as 100Gbps over the air.

These kinds of solutions require wider channels. Since E-Band is usually limited to 1-2GHz channel spacing, higher frequencies such as W-Band (92GHz-114.25GHz) and D-Band (130GHz-174.8GHz) bring the possibility of using wider channels – in some cases up to 5GHz. Those wider channels will allow much higher capacity and a clear solution for all 5G capacity issues.

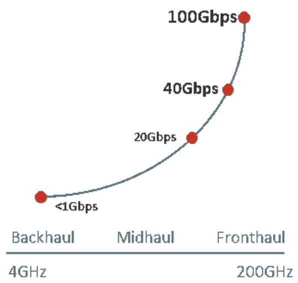

Figure 4 – Capacity scale

As we reach capacity targets, we also need to consider latency requirements.

Midhaul and fronhaul pose new latency requirements. While backhaul requires up to 10ms (10,000us) of latency, midhaul scales the requirement down to <1,500us, and fronthaul, depending on specific implementations, may require <25-200us.

This is a new scale that requires, once again, much wider channels that reduce connection latency. Millimeterwave is sufficient for 5G hauling in this aspect as well.

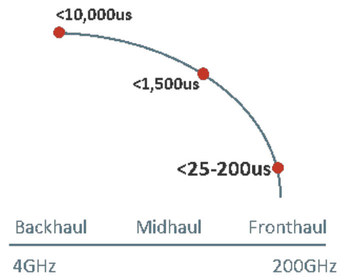

Figure 5 – Latency scale

To conclude, hauling spectrum flexibility, with solutions ranging from 4GHz up towards 200GHz, is essential to resolving 5G challenges and unlocking 5G potential.

Spectrum flexibility enables:

- **higher capacity** – up to 100Gbps
- **lower latency** – down to 25us
- **any hauling scenario** – backhaul, midhaul and fronthaul
- **flexible site acquisition** – with compact all-outdoor solutions that eliminate dependency on fiber, save time and reduce costs

Flexible wireless hauling – disaggregated wireless hauling

5G is a revolution as well as an evolution.

Advanced-generation mobile networks are usually built in layers, generation after generation.

The reason for that is that there are very few greenfield mobile networks in our era.

For 4G, the single significant greenfield, globally, was Reliance Jio Infocomm (Jio) that launched service in India late 2016 (and which has had amazing success, lately becoming India's largest mobile operator with over 370M subscribers).

For 5G, it appears there are two significant greenfield operators globally – Rakuten in Japan and Dish in the US.

In contrast to those few greenfield operators, brownfield operators look at the huge potential of 5G and the great 5G challenges ahead of them in the context of their network and service evolution. That is, how to evolve their infrastructure in a manner that will maximize the use of existing equipment and resources while leveraging their recent (and less recent) infrastructure investments.

This brings us, again, to the great need for flexibility. In our previous chapter, we discussed the first flexibility metric – spectrum flexibility

A flexible solution allows operators to overcome 5G challenges regardless of their opening point or installed base. Which brings us to the second flexibility metric in the Ceragon flexible hauling solution – disaggregated wireless hauling.

Disaggregated wireless hauling allows multiple dimensions of flexibility.

- You can upgrade any existing microwave link to a multiband solution (a single link, using layer-1 carrier bonding in an all-outdoor or split-mount configuration). Such a solution combines the ultra-high capacity of E-Band (up to 20Gbps with Ceragon's IP-50E) with the superior range and availability of the microwave carrier, without changing your existing microwave gear, no matter the vendor.

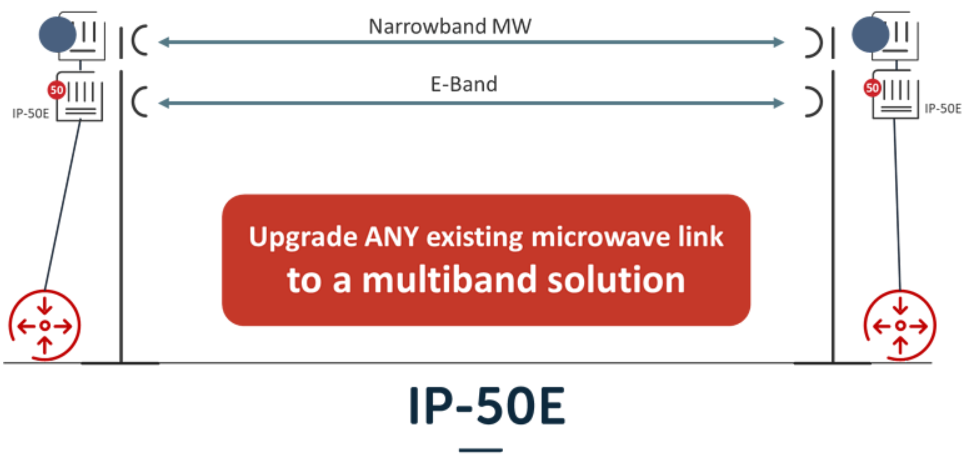

Figure 6 – Multiband

- You can also upgrade your existing narrowband microwave link to a wider-band microwave link, leveraging a different band, in which wider channels are available (112MHz and even 224MHz) with Ceragon's IP-50S universal radio. Once again you get a single link, using layer-1 carrier bonding in an all-outdoor or split-mount configuration, and there's no need to replace your existing microwave gear (regardless of vendor).

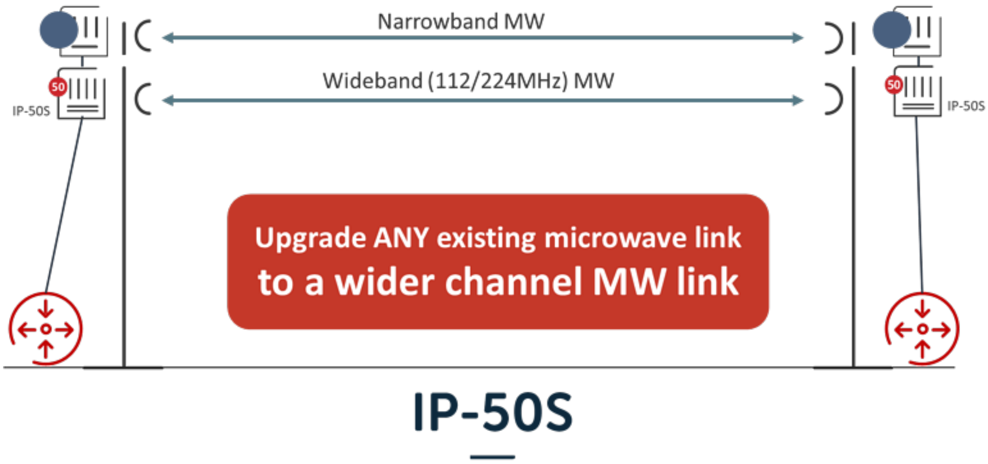

Figure 7 – Microwave upgrade

- If 2 carriers are not enough, but you still want to maintain your all-outdoor site, you can upgrade your existing narrowband microwave link to a 4+0 configuration with Ceragon's IP-50C universal radio. Once again, you get a single link, using layer-1 carrier bonding in an all-outdoor or split- mount configuration, with no need to replace your existing microwave gear (no matter the vendor).

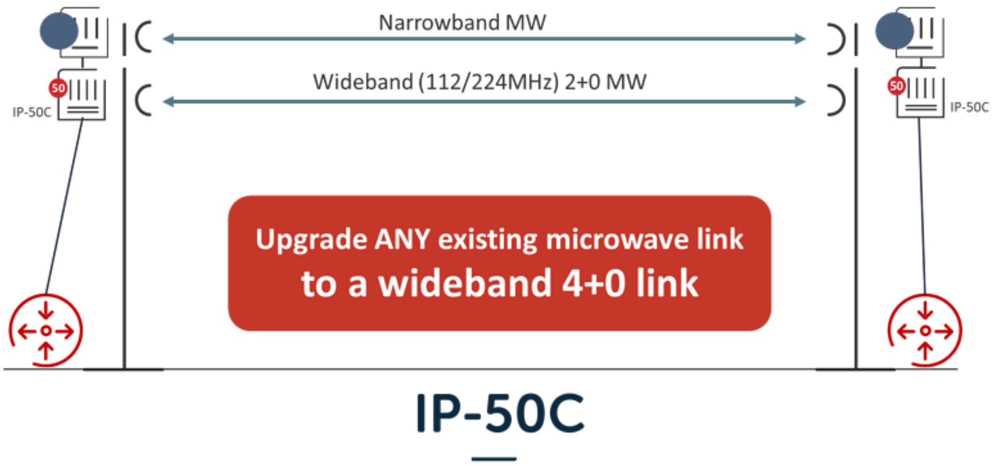

Figure 7 – Microwave 4+0

- The flexibility also allows you to use any existing routing infrastructure. Now, with your existing stand-alone cell switch router (CSR), you can leverage 4+0 configurations based on layer-1 carrier bonding.

Figure 8 – Standalone CSR

- And finally, as an alternative, you can integrate your CSR into your wireless hauling node, leveraging the IP-50FX.

Figure 9 – Integrated CSR

To conclude, when planning your 5G network evolution, your existing network infrastructure plays a major role. Here, flexible wireless hauling is required to make sure your past investments and current infrastructure are used optimally.

Flexible wireless hauling – SDN

When it comes to 5G, both its potential and its challenges are huge.

In order to unlock your 5G potential, you need a highly flexible infrastructure across all network domains. In the wireless hauling domain, this means a wireless hauling solution that is flexible enough to achieve any capacity in any spectrum and can evolve from any existing infrastructure.

It also needs to manage any level of complexity in your network. Adding sites, spectrum and services to the network make it larger, denser and much more complicated. Specifically, the support of new 5G use cases calls for service orchestration via network slicing.

As discussed before, there are two use cases that stretch existing 4G services to the limit: mobile gigabit broadband, via the enhanced mobile broadband (eMBB) use case; and gigabit broadband to the home, via the fixed wireless access (FWA) use case.

Additionally, there are two use cases that address new markets with new services: IoT, via the massive machine-type communications (mMTC) use case; and mission-critical applications, via the ultra-reliable low-latency communications (URLLC) use case.

While those latter use cases create the main 5G potential for new business, target markets and revenue streams, they also require extremely different resources and SLAs from the network, as described in the following diagram:

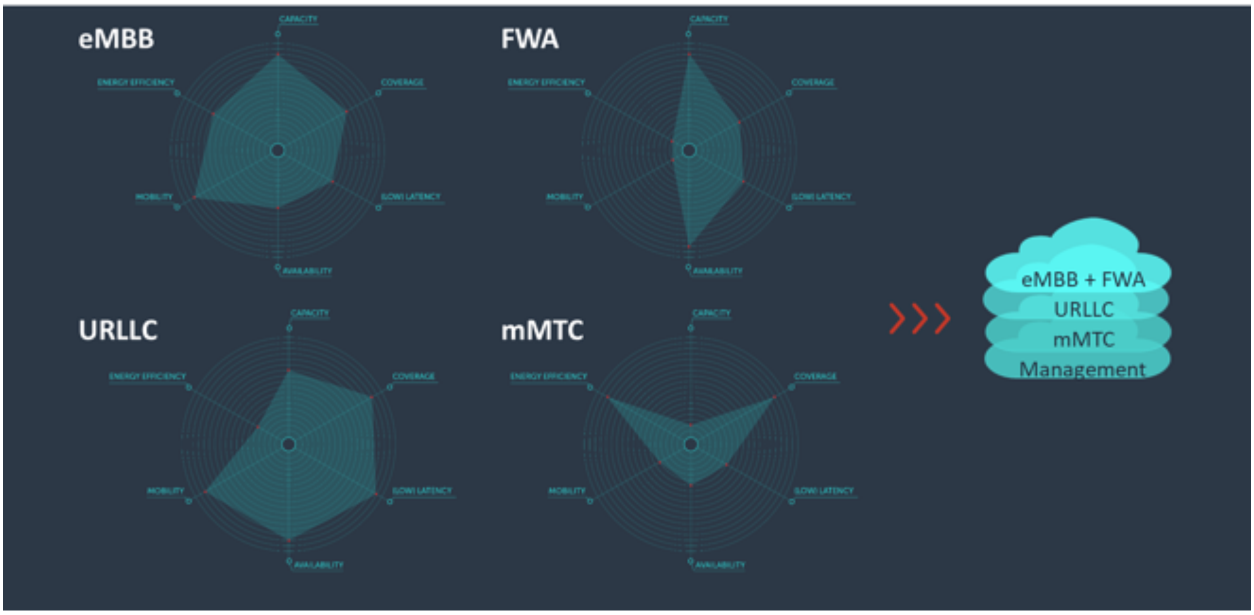

Figure 10 – Network requirements

Although service orchestration via network slicing is required, a sliced network is harder to manage, provision, optimize and troubleshoot.

That is why a key enabler to 5G network success is the use of software-defined networking (SDN).

SDN implementation across all network domains allows simple network slicing, as well as faster time to market for new 5G services, network optimization, and the simplification of operations tasks across all network domains.

SDN is typically implemented with a three-hierarchy approach. The top one is where you run the applications, end to end, with the network orchestrator / hierarchical controller.

In order to simplify the integration efforts among the network elements, and to overcome missing standardization and domain differences, a middle hierarchy is used – domain controllers. These controllers act as mediators for any network domain, be it RAN, IP/MPLS, optical, wireless, etc.

The domain controllers connect the SDN framework to the third hierarchy – the network elements.

Ceragon offers, as part of its portfolio, a wireless hauling domain controller called SDN-Master. This domain controller leverages Ceragon's support of standard-based northbound and southbound interfaces to make the wireless hauling domain an integral part of any cross-domain management and provisioning framework. This simplifies your 5G operations and allows you to unlock your 5G potential.

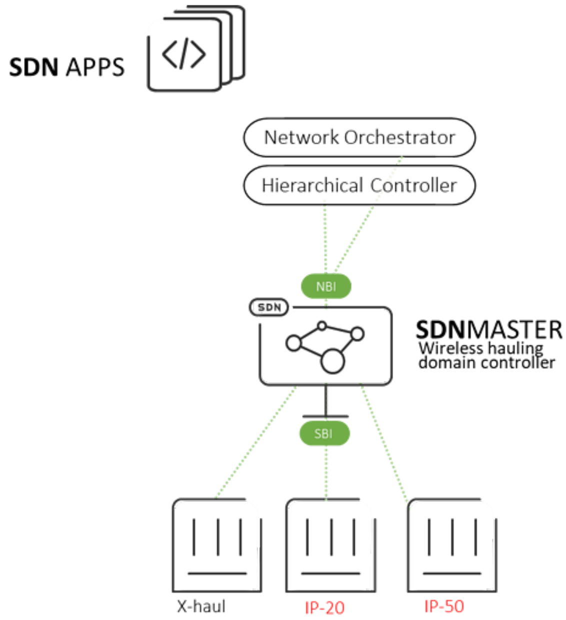

Figure 11 – Ceragon SDN offering

Conclusions

5G is a huge opportunity. It bring a great business potential for new services, new target markets and new revenue streams.

In order to unlock this potential, operators must overcome unique network challenges.

The solution for those, in the wireless hauling domain, is Ceragon's flexible wireless hauling.

Utilizing spectrum flexibility, disaggregated wireless hauling and SDN, Ceragon allow operator's to truly unlock their 5G potential.