WHITE PAPER

5G MACROCELL CONNECTIVITY

A FLEXIBLE APPROACH

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Introduction

5G infrastructure requires more capacity across all parts and domains of the network – access, core and hauling. This understanding is well established by network planners and solution vendors.

When it comes to the hauling network domain (backhaul, midhaul and fronthaul), network planners (and vendors) have come to another realization; in order to keep the needed flexibility for deploying new sites and upgrading existing sites when evolving networks and services to 5G, those hauling requirements must be answered (also) by a wireless solution. This enables operators to eliminate the dependency on fiber availability, feasibility, timing and cost when selecting a location for a new base station.

This paper focuses on macrocell connectivity, as this specific topic creates a unique challenge in terms of the combination of required capacity and distance – a challenge calling for a new type of wireless backhaul solution.

Addressing the 5G capacity challenge

Sizing the capacity required for 5G wireless backhaul, midhaul and fronthaul starts from determining the available RAN channels and the hauling architecture.

The following table provides a rough estimate for such capacity requirements, per the RAN band and channel spacing used:

BW	Frequency Band	MIMO Layers	Backhaul	F1 – Split 2	Split 7.2 /Compressed
50MHz	2.5GHz	8(DL)/4(UL)	2Gbps	2.01Gbps	11.3/3.5Gbps
100MHz	3.5GHz	8(DL)/8(UL)	4Gbps	4.02Gbps	22.7/7Gbps
400MHz	28GHz	4(DL)/2(UL)	6.4Gbps	6.44Gbps	35/10.2Gbps

Figure 1 – Typical 5G capacity requirements

Capacity requirements span from 2Gbps to over 30Gbps. Yet given the practice of fronthaul compression and the tendency to use midhaul rather than fronthaul in millimeter wave-based RAN, currently available E-Band solutions with 20Gbps capacity are more than adequate to cover all reasonable scenarios.

Multi-Gbps wireless solutions based on the millimeter wave (mmW) domain (currently E-Band, and in the future W-Band and D-Band) provide an excellent resolution to dense cell-grid connectivity. But we require an additional solution – one that will resolve the capacity challenges of macrocell and remote small-cell scenarios. Those scenarios call for a multi-Gbps solution (4-8Gbps) for distances over 10km, or even above 10 miles. Such distances are not feasible for a mmW solution, or even a multiband (E-Band + microwave) solution, with the required capacity and availability targets.

Achieving a solution that will answer the challenge of combined capacity and reach involves combining several methodologies for increasing the capacity of microwave wireless technology:

1. **Capacity-boosting technologies**: Such technologies increase the number of bits-per-second per hertz and include XPIC, 4x4 LoS MIMO and Advanced Frequency Reuse.
2. **Channel aggregation**: Once a wireless channel is exhausted, channel aggregation can be implemented in order to aggregate the capacity of several separated channels into a single stream. This can be done with channels in different bands (i.e. multiband). And in order to be efficient, it must include a layer-1 traffic distribution mechanism (aka layer-1 carrier bonding) to avoid the inefficiencies and operational complexity of hash-function-based mechanisms such as link aggregation (LAG).
3. **Wider channels**: Using wider channels is an add-on or an alternative to the above two methods. This is a trend we see in many technologies (wireless as well as wireline). One example for this was mentioned earlier in this paper – RAN channels. The move to 5G extended the typical Nx20MHz channel size to 100MHz, 400MHz and even 800MHz, allowing 5G NR to carry a significant amount of additional data. Another example is xDSL, evolving from 17MHz in VDSL1 to 35MHz in Vplus and to 106/212MHz in G.fast. This is also the case in wireless hauling.

In order to use wider channels, we typically need to work in higher bands. However, a combination of the three methodologies listed above is also feasible in lower frequency microwave bands.

Ceragon's IP-50C quad-carrier solution is a unique example of an efficient use of those techniques. A combined approach allows Ceragon to achieve up to 8Gbps for macrocell connectivity in distances far above 10 miles.

The IP-50C combines the use of ultrawide microwave channels (up to 224MHz channels) with a unique capability to aggregate up to four carriers (in two channels using XPIC, or even a single channel using 4x4 LoS MIMO).

This aggregation is done in layer-1, without the need for an indoor unit to split the traffic between the carriers, and without the inherent inefficiency and operational overhead of a layer-2 based technique (such as LAG).

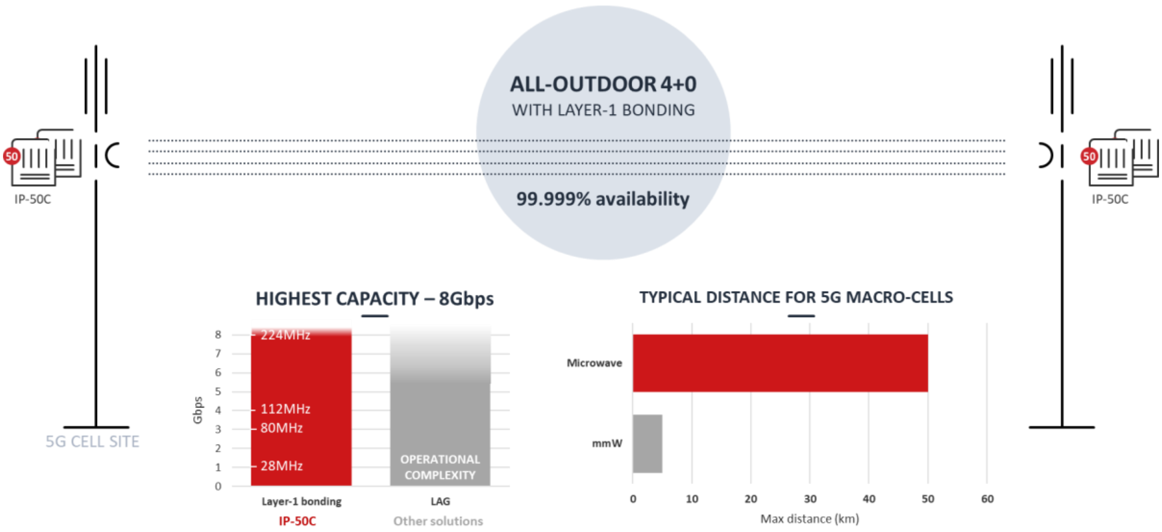

Figure 2 – 8Gbps capacity with 4+0 all-outdoor configuration

The above illustration highlights a 4+0 all-outdoor configuration, with two IP-50C boxes directly mounted to antennas, achieving up to 8Gbps. This configuration achieves the highest capacity for the available channel size and can evolve, over time, to wider channels.

8Gbps might be considered an "overkill" for current macrocell connectivity requirements. However, it is important to have this built-in scalability and flexibility when thinking beyond the short-term future to when 5G will kick in in full force.

Another key point worth mentioning is that a capacity growth plan can be implemented where three steps of doubling network capacity can be taken without site visits and truck rolls. As shown in the illustration below, a link can start with a narrow channel and single polarization. It can then grow, with implementation of a license only, to dual polarization and 4X the channel size. This requires advanced planning, of course.

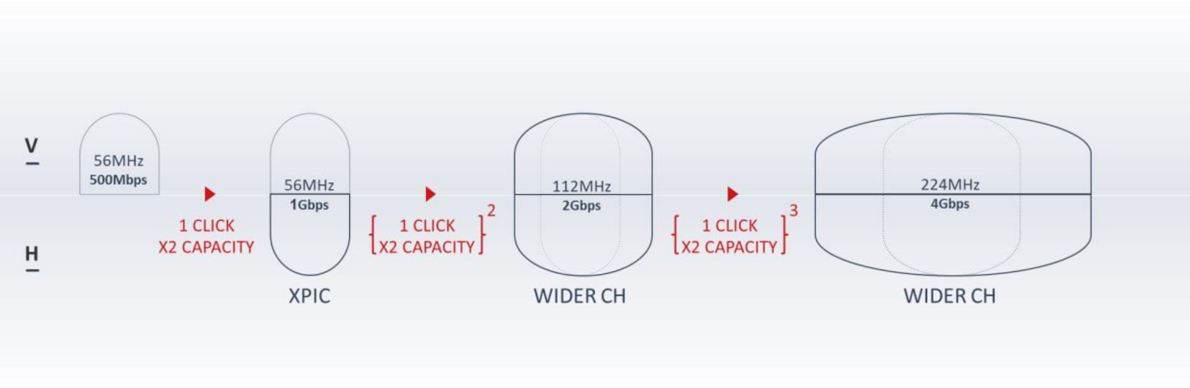

Figure 3 – Remote capacity upgrade process

In short, combining capacity-boosting technologies, widest microwave channels and a quad-carrier solution (like the IP-50C) is more than enough to address macrocell connectivity requirements for years to come.

Achieving faster 5G network and service deployment

Other than ultrahigh capacity, another major challenge associated with 5G network and service deployment is network densification.

Network densification is derived from the need to provide more capacity in a given area and from the use of higher frequency bands in the RAN. This calls (for propagation reasons) for shorter distances between the base station and the end device.

The process of densification requires the acquisition and deployment of new sites. The number of urban sites might grow to as much as 5X the number of current sites. That constitutes a major challenge in deploying many new sites in a time frame that will satisfy both time-to-market targets and, in some cases, regulatory requirements.

A key parameter that affects the site acquisition process is site architecture. There is a significant difference between all-outdoor sites (in which there is no shelter or indoor units) and a split-mount site. For all-outdoor sites, the site acquisition process is about 50% shorter than for split-mount sites, so the target is to have as many use cases as possible fit all-outdoor architecture.

In the previous chapter, we discussed the need for multi-carrier configurations for 5G macrocell backhaul. This calls for a 4+0 all-outdoor solution that will allow us to accommodate a multi-carrier 4+0 configuration in an all-outdoor architecture.

As mentioned, the IP-50C is a quad-carrier, all-outdoor, direct-mount solution with layer-1 carrier bonding.

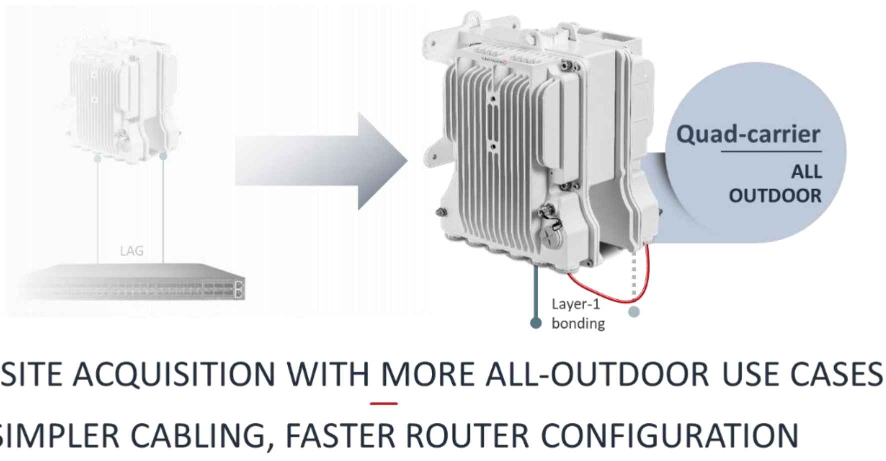

Figure 4 – Quad-carrier all outdoor solution

As such, the IP-50C allows more sites to be all-outdoor sites, thereby shortening the site acquisition process and, in turn, enabling the meeting of time-to-market targets.

Simplifying network upgrades

In most cases, 5G comes as an evolution to an existing, typically 4G, network. As such, the installed base is an asset that must be considered when planning the network evolution and upgrade process.

The flexible, scalable and simple way to approach such an upgrade is via a solution the maximizes the utilization of existing infrastructure. Such a solution provides significant reductions in total cost of ownership (TCO) as it eliminates the need to replace the existing infrastructure with a 5G-ready one.

Looking at a typical 4G wireless backhaul link, it generally uses a microwave band with a capacity of up to 1Gbps (based on XPIC configuration and a 56MHz channel).

A common case is that there are additional resources in the same band. In order to move to a wider channel and/or a quad-carrier configuration, a forklift upgrade is required that makes the existing infrastructure obsolete.

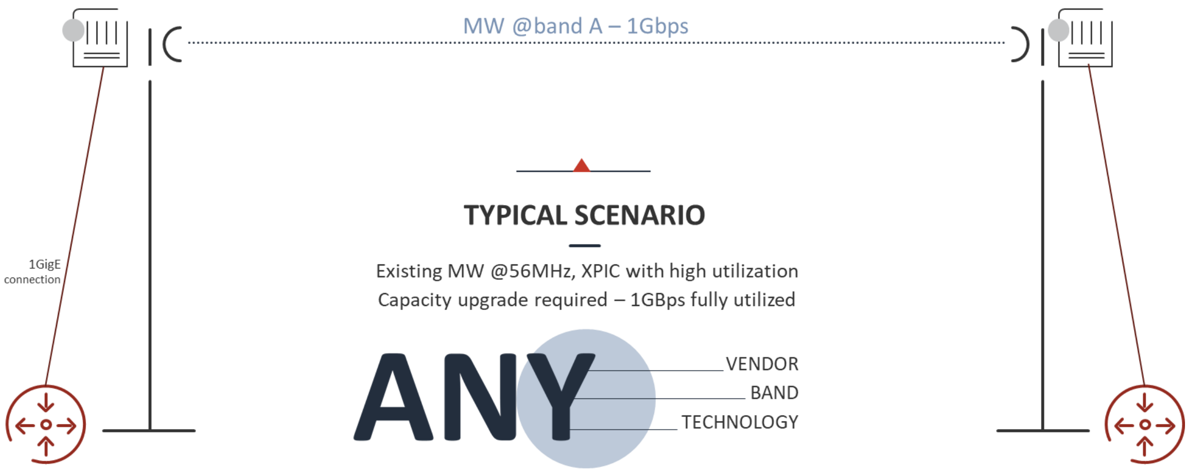

Figure 5 – Typical 4G backhaul link

A flexible 5G backhaul solution, however, allows an upgrade to this existing link while keeping the installed base without a change in configuration.

The IP-50C quad-carrier solution provides this benefit by utilizing all-outdoor, layer-1 carrier bonding and multiband capabilities, as illustrated below.

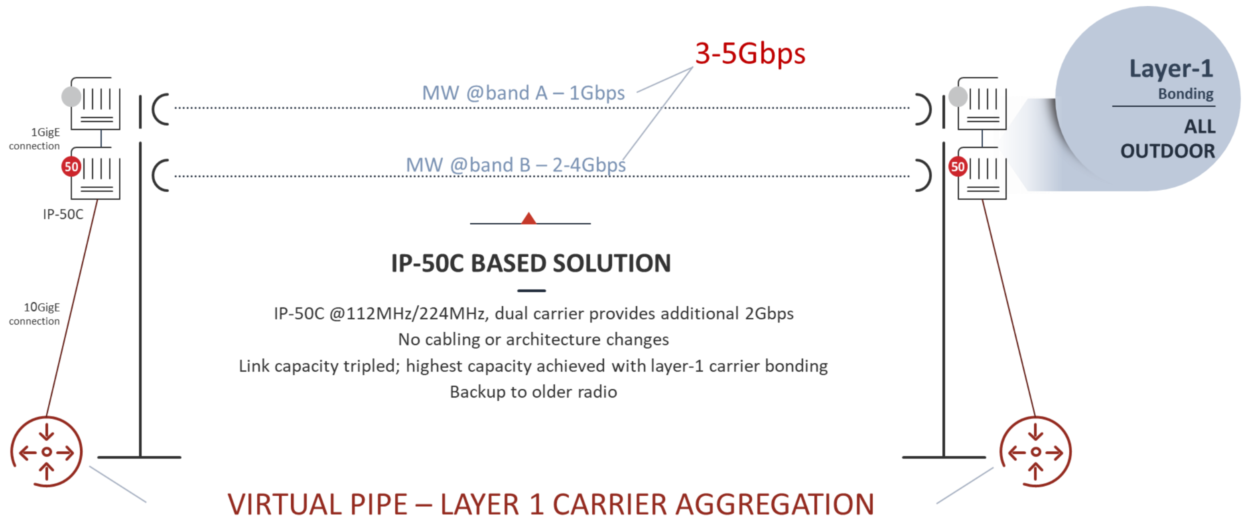

Figure 6 – Simple and efficient upgrade to 5G backhaul

The all-outdoor, layer-1 carrier bonding and multiband solution allows the operator to seamlessly combine the existing link with an additional link, which could be in a different microwave band in which wider channels are available. This allows the operator to add up to 4Gbps (in cases in which 224MHz channels are available) and to achieve 5X the original capacity with no change to the existing link. Also, no change is required to the router/base station configuration (which connects to the IP-50C with the same single 10GbE cable that is used to connect to the existing node).

It is also worth mentioning that the existing link does not necessarily have to include a Ceragon radio.

Conclusions

5G infrastructure requires more capacity across all parts and domains of the network – access, core and hauling.

In order to keep the needed flexibility for deploying new sites and upgrading existing sites when evolving networks and services to 5G, hauling requirements must be answered (also) by a wireless solution.

For wireless macrocell connectivity, a unique challenge in terms of combining required capacity and distance needs to be resolved. This is done by a new type of wireless backhaul solution, such as the IP-50C.