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An Iceberg Named Capacity

In today's transport networks, capacity is one of the most recurrent topics of discussion, especially when they are based over wireless media like microwave radios. Traditional licensed microwave radio solutions can offer several hundred megabit per second of uncompressed traffic although a newly available product architecture offers multi Gbps capacity.

siae microelettronica

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Introduction

Backhauling requirements have changed during the years, as access technology evolutions took place. Capacity however is a requirement that is always there and it still remains today's main driver. Users are consuming more and more capacity, and since the launch of LTE many mobile operators face a new scenario where the minority of the users, the LTE adopters, are consuming a staggering quantity of network capacity.

As reported by CISCO's Visual Networking Index VNI-2015, for the year 2014, global 4G traffic represents only 6% of mobile connections while accounting for 40% of mobile data traffic. In 2019 4G connections are estimated to increase to 26%, generating 68% of total mobile traffic. Currently in Europe we have analysed a network where 5 to 10% represented the LTE users consuming 25% of whole network access capacity.

Capacity is a clear requirement; more capacity equals more users and better service, resulting in better revenues. Capacity by itself however is not sufficient to operate the network successfully. Its strong visibility at times overshadows all the other requirements that are equally fundamental for the network to operate. We could say capacity is the tip of an iceberg, that once satisfied, shows everything else that needs to be addressed in the effort of continuing liaising over a flexible and durable transport network.

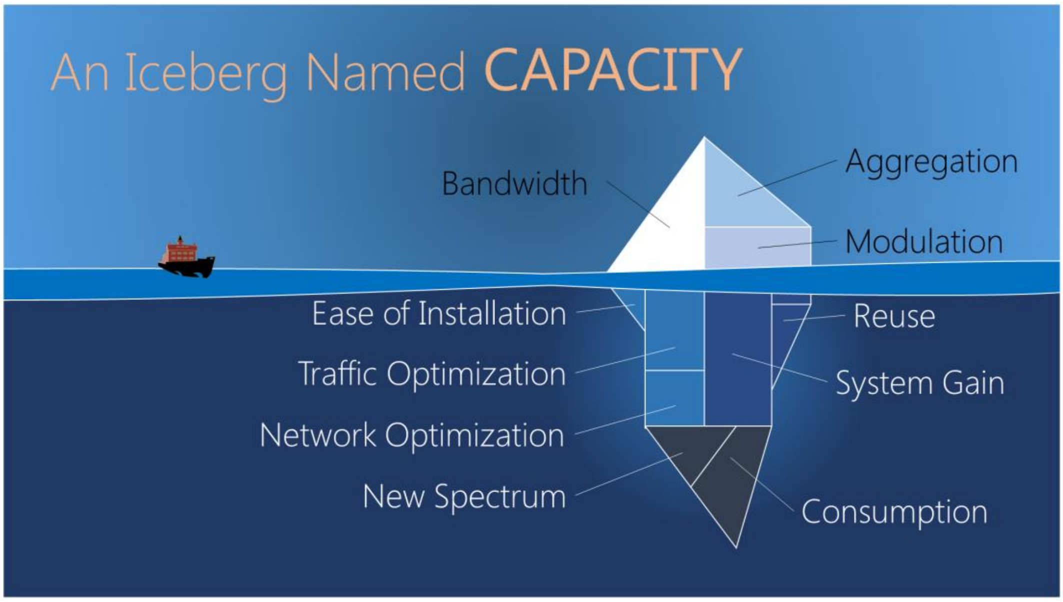
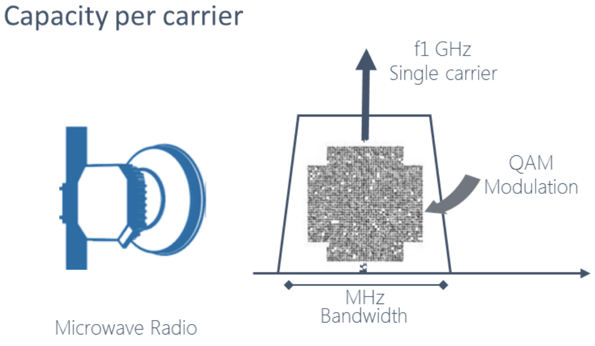


Figure 1: Network needs beyond capacity

CAPACITY: the tip of the iceberg

Capacity is a combination of a number of factors, namely: bandwidth and modulation. The mixture of these two aspects define the capacity per carrier, and in more complex configurations also by aggregation that results in the overall system capacity.



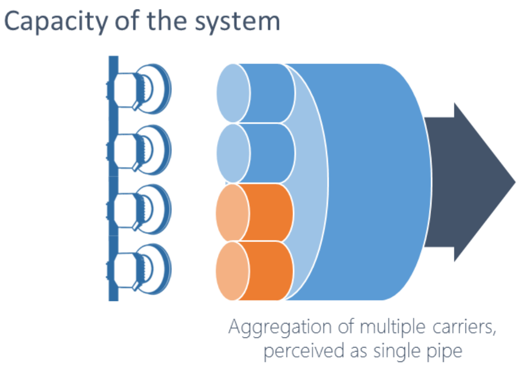


Figure 2: Capacity per carrier

While advances in modulation techniques beyond commonly used 256QAM have recently become more and more popular as reference for capacity, their real value is in improving spectrum efficiency, meaning transmitting the highest number of bit per Hz in a given channel bandwidth. The higher the modulation scheme, the higher the number of bits encoded per symbol. As we move to higher modulation schemes (to 1024QAM; 2048QAM and 4096QAM) the contribution we get in capacity diminishes (as shown in figure 3), while we augment the complexity of the system and the components sensitivity. Furthermore the higher the modulation scheme the greater the impact on the system gain of the link.

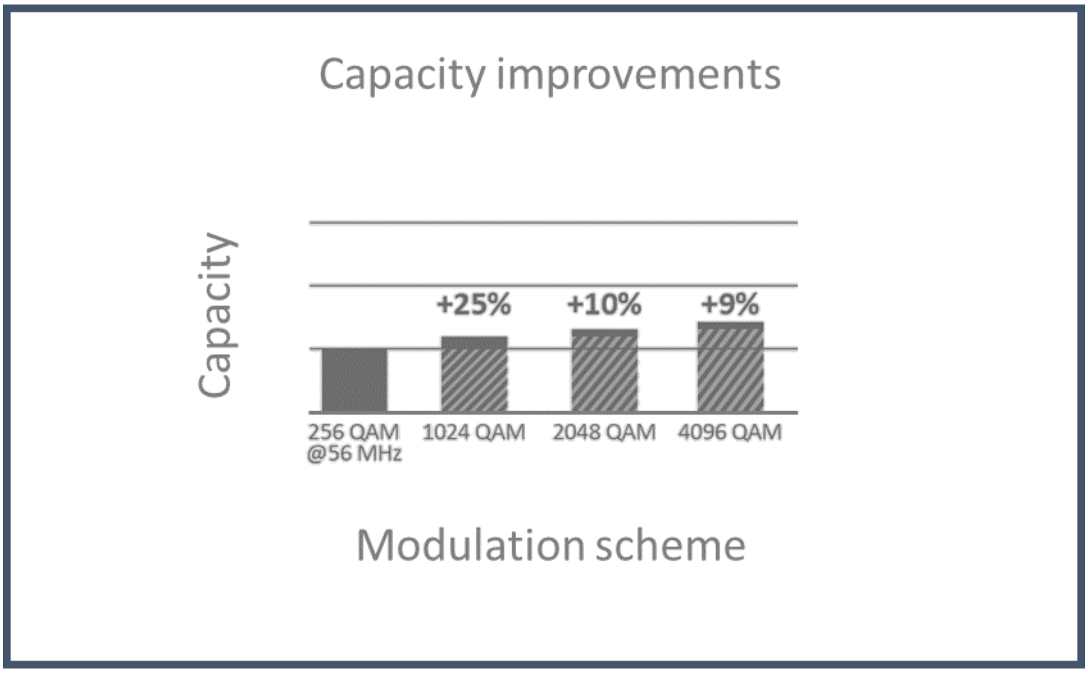


Figure 3: Capacity improvement by modulation scheme (+50% improvement from 4096QAM vs 256QAM)

Far more important to capacity is the contribution given by the use of larger bandwidth channels as shown in figure 4.

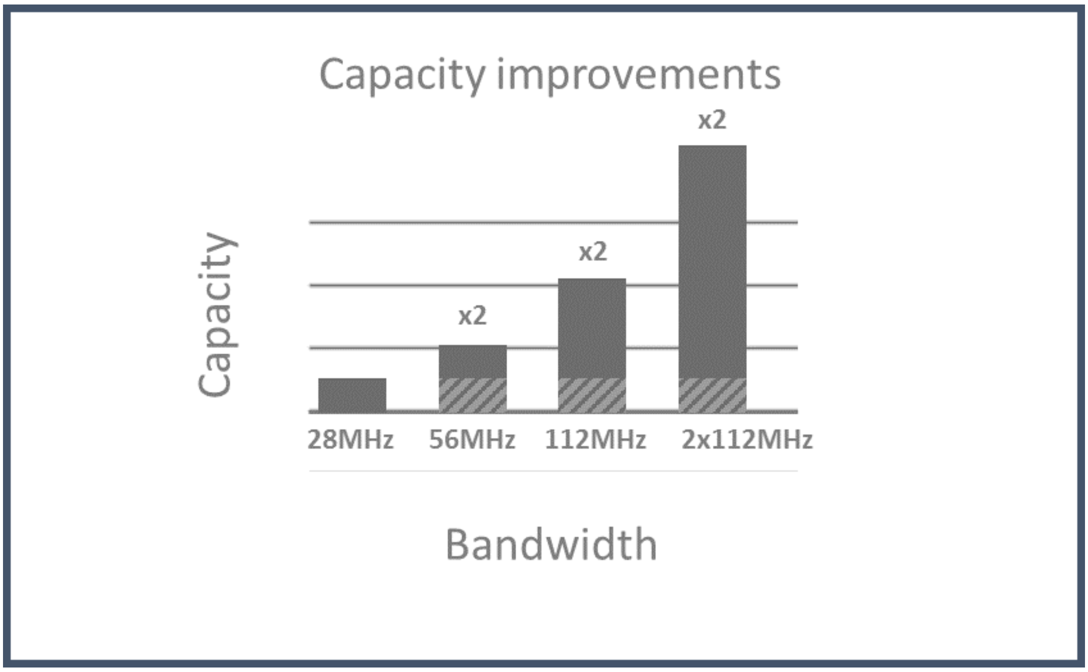


Figure 4: Capacity improvement by bandwidth and aggregation (x8 more capacity from 2x112MHz vs 28MHz)

The aggregation of multiple carriers is a way to logically show a single larger pipe that is physically composed by different radio links. The most efficient way to achieve this aggregation is by using a “Layer 1 link aggregation”, also known as L1-LAG, as shown in figure 2.

What is left underwater

Reuse

A way to improve spectrum efficiency while doubling the capacity with no extra licence costs is the use of X-PIC technology, using both the Vertical and the Horizontal polarizations of the spectrum of each carrier.

With X-PIC, we transmit two data streams over the same channels. If used together with L1-LAG, we combine the total capacity presenting it as a single high capacity pipe.

System gain

The system gain is one of the most important parameters in a microwave radio link. Higher transmit power and better receiver sensitivity are signs of a high performing system, contributing to the increase in the overall performance, as well as reduce overall link costs. With high system gain, we can maintain high link availability (99,999) when employing higher modulation schemes in a link, reaching the same distances as per lower modulation scheme links. An added benefit to utilizing higher modulation schemes is better spectrum efficiency. Alternatively we can use the budget to extend the reach of the link or on a given distance decrease the antenna size, lowering antenna CAPEX costs, as well as antenna OPEX costs such as transportation and installation and alignment.

Consumptions

Power consumption is a critical component to operational costs. Designing low power consumption solutions consequently represent a way to contribute to the reduction of the total cost of ownership of the network. Implementing automatic transmit power control (ATPC) and mechanism to control transmit power based over modulation scheme and propagation conditions are all ways to improve the bit/Watt. Another factor to consider is that the cost per bit as well as watt per bit grows as we process data at higher layers. Today’s highly-integrated silicon packaging (SIP) provides a combination of high performance and reliability, making Carrier Ethernet microwave radios a very cost effective solution.

New spectrum

With the introduction of millimetre wave radio links, telecom operators add a new technology to the portfolio of possible solutions to deliver multi Gbps capacity between sites. With these frequency bands we can access extreme channels ranging from 250MHz up to 2GHz of spectrum, delivering unprecedented capacity over the air.

V and E band, respectively 60 and 80GHz, are generally lightly or even unlicensed in some countries, offer almost 20GHz of addressable spectrum. The 80GHz frequency band has the potentials of offering tens of Gbps opening operators to new set of use cases like front hauling and “wireless urban fibre” applications.

Traffic optimization

To improve network efficiency and utilization several mechanisms for traffic optimization need to be taken into account while engineering traffic. With the introduction of LTE, networks need to be capable of efficiently handling TCP/IP traffic. Implementing WRED to handle queues at L2 is a commonly adopted measure, resulting in a better utilization of available capacity with an improvement of 24% in respect to system employing less effective mechanisms. Furthermore, to better compensate for TCP/IP traffic bursts, operators should implement traffic shaping from the network core to ensure network legs at the access are not overwhelmed. As this may result in expensive hardware and additional implementation queues, ensuring a dynamic buffer memory allocation in the backhaul allows the network elements to compensate for traffic bursts, while ensuring the latency of the round trip of the TCP/IP signalling is not heavily impacted as this would result in an actual reduction of total capacity.

Another trend taking place with packet microwave systems is the need to segregate the transport capacity, due to a network sharing strategy between multiple operators, or due to different services (e.g. enterprise and private) sharing the same infrastructure. Hierarchical Quality of Service (HQoS) as proven bringing benefit in fairly dividing the services over the network.

At times, it may be needed to increase capacity over an existing link. A way to boost the throughput is using multilayer header compression techniques. Multi-layer header compression can provide improvement between 2% to 200% depending on payload, protocol stack adopted and packet size.

Network optimization

As the backhaul network evolves and their topology becomes more complex, the network elements also need to learn to interoperate with each other to maximize transport efficiencies. In microwave networks, adaptive modulation represents a way of maximizing the available over-the-air capacity, therefore improving efficiency in the network. This technology however cannot be employed with ring protection mechanisms, as the networking devices are expecting to see fixed capacity between the ring segments. A solution called "microwave adaptive bandwidth" (jointly developed by SIAE MICROELETTRONICA and CISCO) enables signalling between the microwave radio and the neighbouring networking equipment, with messages about bandwidth changes. These inter-system messages trigger protection or traffic shaping, achieving a more intelligent use of the available bandwidth. This solution has enabled the standardization of this functionality that will be included in the updated version of the ITU-T Y.1731 Ethernet OAM protocol.

Ease of installation and maintenance

A significant way to reduce operational costs is to simplify and expedite the field installation and commissioning process and designing equipment for serviceability.

Although textual interface (CLI) is very common in the telecom world, when we address complex equipment configurations, especially in the microwave domain, a graphical user-interface (GUI) view is mostly appreciated from most operators and from service teams. A comprehensive and easy-to-use interface can streamline commissioning, expedite troubleshooting while reducing operational and maintenance costs.

During the physical installation of the equipment, a high level of integration results in a diminished number of physical items to carry, lighter load to lift, minimal to no assembly of the system. This results in reduction of time on-site as well as the reduction of installation deficiencies that could result in the malfunctioning of the link.

The advantages of a high level of integration become visible as more complex systems or configurations are at hand e.g. two radio in reuse to double capacity in aggregation links (2+0 XPIC), a configuration widely deployed in the microwave domain. The advantage of deploying a single unit (an RF Multicore solution) versus two discrete units, with external branching and cabling is a clear example of how installation time, skill, material and costs can be immediately reduced.

Summary

Microwave radio - enabler of future mobile networks

Microwave radio is today the most widely adopted solution for mobile backhauling, with as much as 70% of the radio access sites rely on this technology. Its role in the mobile space remains determinant to the success of mobile networks as it offers unmatched flexibility, cost effectiveness and time to service vs the next best adopted solution, fibre. Although fibre presence is growing also thanks to incentive like FTTH (fibre to the home), the wireless backhaul is the predominant solution when we look at the growing number of outdoor access deployment (e.g. small cells).

With the latest technology evolutions, any doubts about system capacity has also been cleared, with traditional licensed solution already offering capacities in the multi-Gbps range and millimetre wave in the 10s of Gbps, wireless transport offers today all the capacity needed to satisfy current and future mobile backhauling needs.

Melting the iceberg

The technical availability of a high modulation scheme is not necessarily equal to having high capacity available. In fact it is the associated system gain relative to that modulation that expresses what percentage of time, during up-time, that capacity can be made available.

If the system gain is inadequate, the link may not sustain the desired modulation, and therefore will deliver the expected high capacity only during a little portion of time. This is why SIAE MICROELETTRONICA has invested technologically to achieve high system gain in its products especially those addressing complex modulation schemes like 2048QAM or 4096QAM. (Our AGS20 utilizes a split mount architecture with modulation to 2048QAM, while our ALFOplus2 delivers exceptional spectrally efficient modulation utilizing 4098QAM in a compact, all-outdoor package.)

Several effective aggregation options are available to boost connectivity between sites. The best results are achieved when the basic building block (the spectral efficiency of a given channels) already offers the best in class utilization. SIAE MICROELETTRONICA has implemented 2,5Gbps connectivity in its Ultra-High capacity products to ensure no technical blocking when high modulation schemes like 4096QAM are employed associated to wider channel bandwidth like 56MHz, 80MHz, 112MHz, 2x80MHz or 2x112MHz. In this way Ultra-High capacities like 2,5Gbps over the air can be reached with simple solutions, offering better MTBF and cost efficiency.

Further, aggregation and better operational costs are realized when multiple radios can be combined into a single housing, relative to two separate ODUs and a combiner. SIAE MICROELETTRONICA's revolutionary ALFOPlus2 provides for RF multicore technology, enabling simultaneous transmission of two individual RF carriers on either the same or different frequencies. Unique RF branching solutions enable the cost –effective and simple integration of the ALFOPlus2 to a single antenna.

To reduce operational costs linked to the deployment of microwave systems, SIAE MICROELETTRONICA leads the efforts in realizing the lowest power consumption solutions in the market. This offers several advantages, from reduced carbon footprint, to lower energy needs and diminished costs of power, to longer hardware life as well as longer operational life in recovery operational modes. Also an effort to reduce physical size (e.g. only 12L volume for the split-mount transceiver) and high level of integration and innovation (e.g. unique advanced integrated flexible branching employed in ALFOplus2) are contributing in expediting time of installation and facilitating the ease of handling the products on site.

About SIAE MICROELETTRONICA ALFOplus2: go to web site

About SIAE MICROELETTRONICA AGS20: go to web site

Contents