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Breaking the 100 Gbps barrier

Extract from the Ericsson Microwave Outlook Report

October 2019

Breaking the 100Gbps barrier

The 100Gbps wireless transport barrier is broken by combining E-band radios with MIMO technology. Through this, 139Gbps over 1.5km was achieved, with high availability and low latency in a 2.5GHz channel.

Wireless backhaul's steady evolution over the last 40 years has been a response of continuous adaptation to the requirements of services enabled by new generations of mobile technology. The first commercial 100Mbps point-to-point links were available around the mid 90's; the first links supporting Gbps capacities emerged around 2010; and the first commercial links supporting 10Gbps recently became available. With this long-term trend in mind, point-to-point links supporting more than 100Gbps capacities are expected to be commercially available within the next 5–8 years.

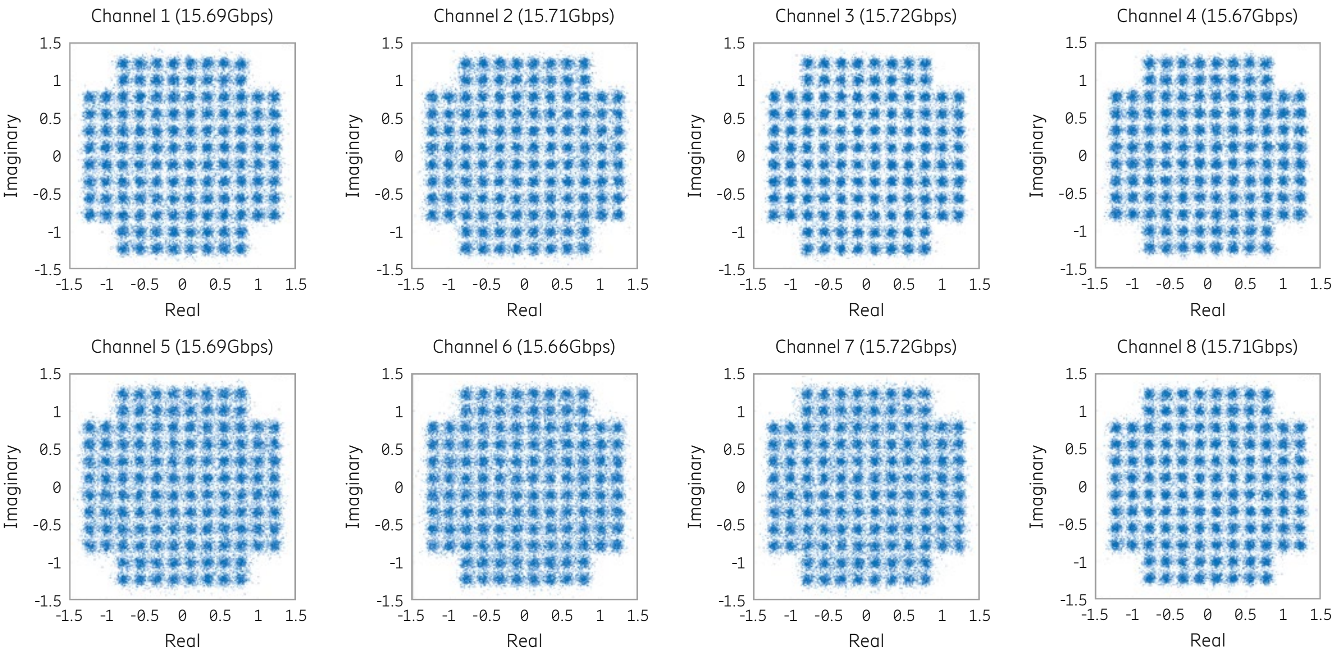
The key to increased capacity for previous backhaul generations has been accessing new frequency bands, wider channel bandwidths and higher modulation schemes. However, evolving along that path from today's 10Gbps links to 100Gbps would require a tenfold increase in channel bandwidth. This is not sustainable for large deployments of 100Gbps links, even with access to excessive spectrum beyond 100GHz. Due to this, new spectrum-efficient technologies such as line-of-sight MIMO will play a pivotal role in the commercialization of future ultra-high capacity point-to-point links. As described in the previous article on MIMO, this technology will multiply the spectrum efficiency, while maintaining or improving the system gain, enabling spectrum-efficient, high-capacity links over similar distances to today's backhaul links. To test MIMO in microwave fixed services, Deutsche Telekom and Ericsson jointly trialed a 100Gbps, 8x8 MIMO system using a single 2.5GHz channel in the E-band. The trial took place in April 2019 at the Deutsche Telekom Service Center in Athens, Greece.

This article was written in collaboration with Deutsche Telekom.

Deutsche Telekom is one of the world's leading integrated telecommunications companies, with some 178 million mobile customers, 28 million fixed-network lines, and 20 million broadband lines in more than 50 countries. They provide fixed-network/broadband, mobile communications, Internet, and IPTV products and services for consumers, and information and communication technology (ICT) solutions for business and corporate customers.

Figure 16: A 100Gbps hop at OTE Academy in Athens, Greece, stretching over 1.5km towards OTE headquarters

Figure 17: Measured throughput and constellation diagram per MIMO channel



Example of throughput and constellation diagram per MIMO channel at 128QAM and 5dBm output power in a single 2.5GHz channel. Error-free throughput is 126Gbps.

Source: Ericsson and Deutsche Telekom (2019)

A 1.5km link connecting the OTE headquarters (Hellenic Telecommunications Organization) in the Maroussi area with the OTE Academy (Figure 16) was used as the testbed. Four 0.6m parabolic reflector antennas were separated by 1.7m, which is the optimum antenna separation for a hop with a 73GHz carrier. Each antenna was deployed with two commercial Ericsson E-band radios in orthogonal polarization states. At the receiving end, the signals were received by a similar set of radios, recorded by a digitizer and evaluated offline.
The modulation scheme was changed from 64QAM to 128QAM and 256QAM, corresponding to a total bitrate of 105Gbps, 126Gbps and 139Gbps respectively in a 2.5GHz channel, and 84Gbps, 99Gbps and 113Gbps respectively in a 2GHz channel. The following experimental measurements were done in a 2.5GHz channel.

Figure 17 shows an example of the received constellation diagrams with 128QAM modulation, 5dBm transmitted power per radio and optimal antenna separation. The bit error rate for each channel is shown after error correction and the error-free throughput for all 8 channels combined is 126Gbps.

The left side of Figure 18 shows the antenna arrangement on the roof of OTE Academy, with the antennas arranged at optimum separation. The robustness of the antenna separation was tested by shifting the two lower antennas on one site towards the upper antenna row as shown in Figure 18 (right), first by 0.4m and then by 0.8m offset. Figure 19 shows measured throughput versus output power per radio for the three modulation formats. The power budget for 105Gbps throughput was higher than 25dB, resulting in a rain-limited availability better than 99.99 percent in Greece. This power budget would allow operation over long hop lengths with high availability in, for example, MBB configurations. Running a similar setup over a 7km hop would have resulted in 105Gbps capacity, with better than 99 percent availability.

The tolerance to reduced antenna separation is robust; a 0.8m offset results in availability estimated to be better than 99.99 percent for >100Gbps. A 135Gbps hop was reached with a power budget of 17.5dB, corresponding to availability of 99.97 percent.

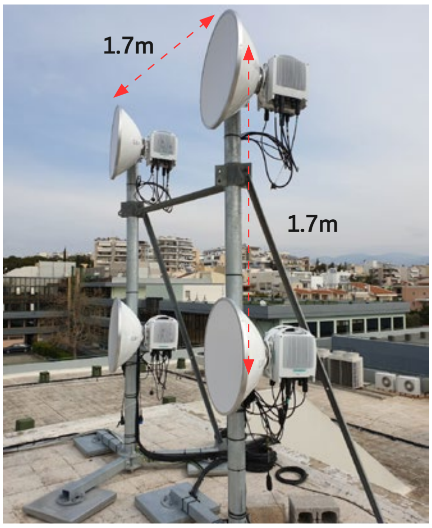
The high throughput will result in a latency reduction. We expect a linear latency decrease with increased bitrate, resulting in a round-trip time below 5µs at 100Gbps. The radio units used in the trial were commercial, off-the-shelf E-band radios, further demonstrating the potential of this band. When moving to new frequency bands beyond 100GHz, more channels will be available to handle bandwidths in the order of a few GHz and, in fact, the optimum antenna separation between the antennas will decrease. For example, operating the same 1.5km hop on a W-band (110GHz) or a D-band (140GHz) carrier instead of an E-band carrier would result in an optimum antenna separation of 1.4m and 1.2m, respectively. The individual antenna sizes will be reduced for the same antenna directivity, leading to an overall reduction of the installation footprint. For short hops up to 500m, it will be possible to put all four antennas within one box, thus enabling single-box 100Gbps links. These high-frequency bands are therefore well-suited for future 100Gbps installations.

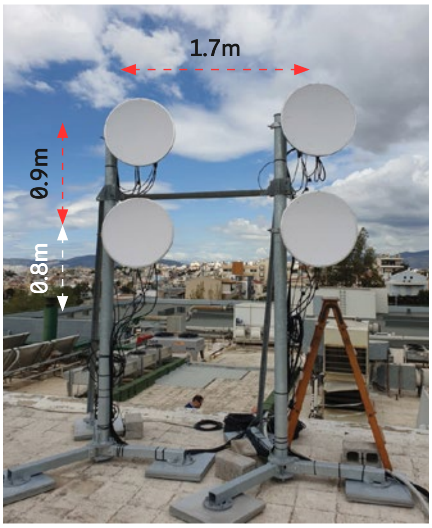
>99.995%

Availability of >100Gbps over 1.5km is more than 99.995 percent.

The work presented in this article shows the importance of applying spectral efficiency techniques, such as MIMO, on wireless backhaul. It demonstrates 100Gbps links with sub 5µs latency and telecom grade availability over hops measurable in kilometers with commercially available E-band radio technology. The need to process large amounts of high-speed data in parallel puts demanding requirements on cost and power consumption for the digital processors.

Figure 18: Antenna arrangement for the 100Gbps link at optimum antenna separation (left) and with 0.8m antenna offset (right)





Source: Ericsson and Deutsche Telekom (2019)

We expect the first 100Gbps links to be deployed in 5 to 8 years, given the technology development in this field but also depending on the potential market demands.

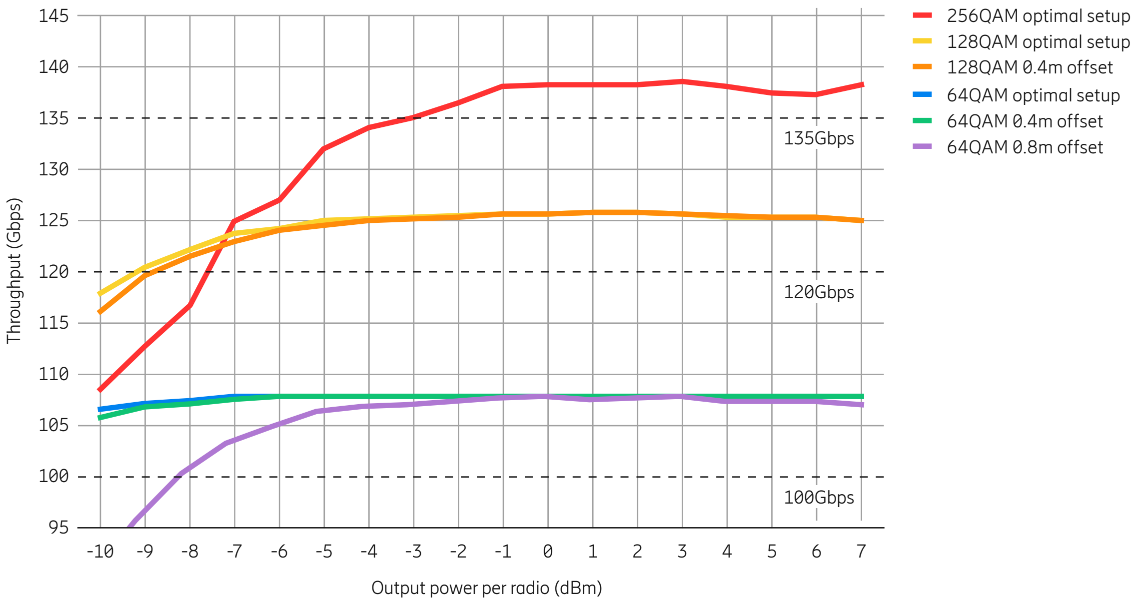
Market demand for increased capacity support continues to increase. Reaching 100Gbps and beyond is still far from today's capacity requirements in the access domain, which is typically in the order of 1Gbps, while ongoing capacity upgrades in advanced broadband networks are toward the 10Gbps milestone. However, in the aggregation networks (aka Edge/Core), capacity requirements are scaling from 10 to 100Gbps and this is most likely where we can initially expect these types of links.

These ultra-high capacity links will act as a cost and time-efficient compliment to fiber supporting ring closure, geographical redundancy in service provider networks or in private networks, such as campus and enterprise solutions. As a second phase, speeds in the pre-aggregation network segment and small cells fronthauling will drive up the last-mile capacities in multiples of 10/25Gbps. The single-box 100Gbps links may be used for ultra-high capacity connections in dense urban areas inter-site distances of a few 100m. It is evident that microwave is well prepared for the network evolution of 5G and beyond.

139Gbps

In the trial, 139Gbps over 1.5km with an availability of more than 99.9 percent was achieved.

Figure 19: Measured throughput versus transmitted output power per radio at optimal antenna setup and with 0.4m and 0.8m offset



Source: Ericsson and Deutsche Telekom (2019)

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EAB-19:006358 Uen
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