

CAMBIUM NETWORKS FORTIFIES ITS WIRELESS FABRIC WITH

Emerging Standards 5G and 802.11ax

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WHAT IS 5G?

At its simplest, 5G refers to fifth-generation mobile communications. In some contexts, it specifically refers to standards that meet the IMT-2020 requirements published by the ITU-R in 2012. In others, it is more about the associated advanced technology or the wide range of new services enabled by the 5G networks and related to avoid repeat of associated technology.

The IMT-2020 requirements extend to three main use cases: 1) enhanced mobile broadband (eMBB); 2) massive machine-type communications (mMTC); and 3) ultra-reliable low-latency communications (URLLC). 5G, by being flexible enough to address these different and frequently conflicting use cases, will enable a diverse set of new services.

The 3GPP LTE release 10 standard was recognized by the ITU-R as a fourth-generation mobile communications standard in 2010. While LTE continues to be enhanced and supports data rates of >1 Gbps as well as IOT (Internet of Things) applications, LTE was unable to meet IMT-2020 requirements. For this reason, 3GPP developed a new air interface, 5G NR. By combining 5G NR and LTE, 3GPP provides a composite standard meeting IMT-2020 requirements.

The dominant use case for 5G, at least for the short to medium term, will be mobile broadband delivered by MNOs. Anticipated revenues from this are driving investment in chip technology for handsets and fixed wireless access solutions.

HOW IS CAMBIUM NETWORKS USING 5G-LIKE TECHNOLOGIES TODAY?

An important use case for 5G is Fixed Wireless Broadband (FWB). Cambium Networks has nearly two decades of experience in providing successful FWB solutions to network operators around the world. Our accumulated domain knowledge is extensive, and there are numerous differences compared to Wi-Fi or mobile broadband communications. These include:

- Radio planning for fixed deployments
- Data traffic patterns for residential and enterprise subscribers
- Fixed wireless radio propagation
- Layer 2 networking
- Unicast and multicast messaging
- Quality of Service
- Affordable outdoor CPE antennas and packaging
- Outdoor residential and enterprise installation

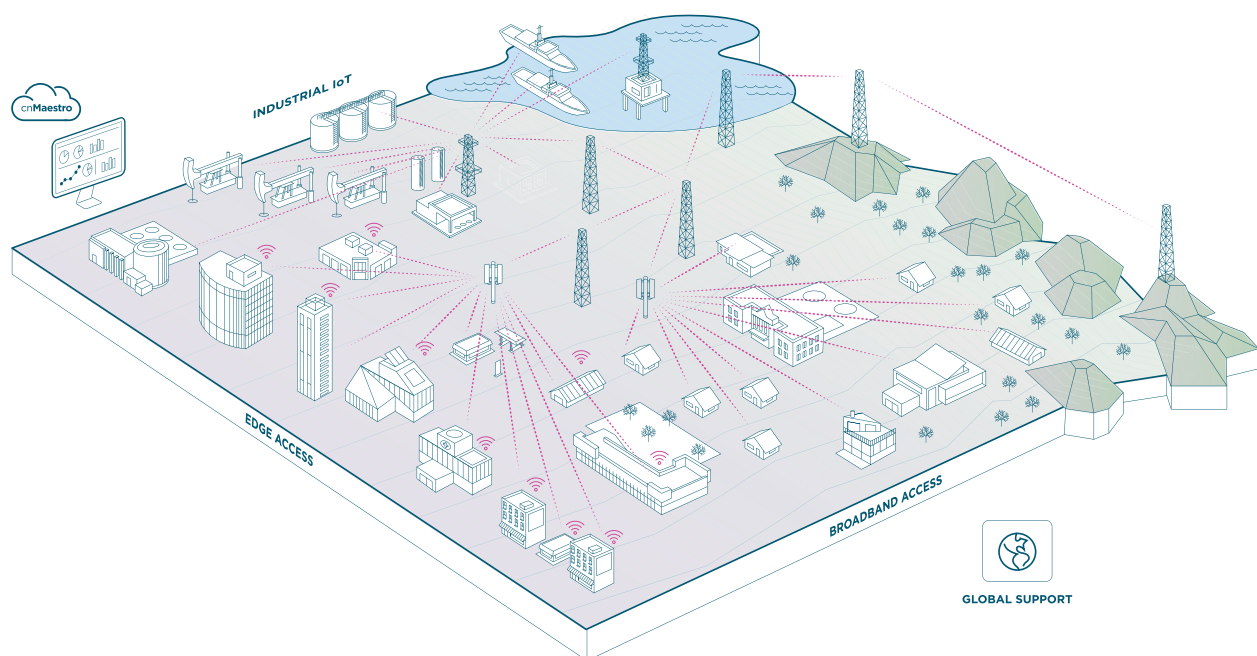
Key 5G technologies include beamforming and massive Multi-User MIMO (MU-MIMO). These technologies are integral to Cambium Networks' cnMedusa™ technology optimized for FWB. cnMedusa is used in the 14x14 MU-MIMO PMP 450m product brought to market in 2016 and has been widely adopted by Cambium Networks PMP 450 platform customers because of the dramatic performance gains it offers.

Cambium Networks' understanding and real-world experience of beamforming and Massive MU-MIMO are being applied to other Cambium Networks' products including the ePMP™ 3000 introduced in early 2019 and will be reflected in future products like the 802.11ax release of cnPilot™, Cambium Networks' Wi-Fi access platform.

HOW WILL CAMBIUM NETWORKS ADOPT 5G ALGORITHMS AND STANDARDS AS THEY EMERGE?

LTE is a crucial component of 5G. Cambium Networks has assembled considerable competence in LTE resulting in our first LTE product, cnRanger™. The cnRanger platform developed expressly for fixed broadband access is 3GPP air interface compliant. The cnRanger roadmap will evolve to support the 5G NR standard and bring 5G technology to the sub-6 GHz bands.

Cambium Networks is investing in 5G NR research and development, and the investment is influencing our development plans. In addition to MU-MIMO mentioned above, improvements to the PMP 450's forward error correction capabilities, sensitivity improvements, and analog beam steering are likely beneficiaries of the investment.



Cambium Networks is actively developing a 5G NR compatible 28 GHz FWB product. Here compatibility means that the Radio Access Network (RAN) will operate with qualified 5G NR CPEs when they become available. Cambium Networks 28 GHz, addressing 24.125 to 29.500 GHz, is focused exclusively on and thereby optimized for, FWB.

Cambium Networks is standards agnostic and has demonstrated a readiness to adapt to new technologies as new wireless networking options become available and business requirements evolve. Our adoption of standards will remain true going forward as we exploit the possibilities offered by 5G technologies.

HOW WILL OUR “SECRET SAUCE” OF DESIGNING AFFORDABLE, YET QUALITY FWB CONTINUE WITH THE EMERGENCE OF 5G?

Cambium Networks has demonstrated the ability to enhance standards based technologies to develop highly differentiated and commercially successful products. Examples of this in ePMP include applying TDD sync to 802.11 System on Chip as well as enhancing the interference mitigation. With cnRanger, Cambium Networks is optimizing Fractional Frequency Re-use (FFR) for FWB.

Early UE devices supporting 5G NR will be optimized for mobile broadband delivered by MNOs. This means they are designed for handsets or small terminals and have support for LTE and earlier mobile communication standards. They generally rely on access to sub-6 GHz licensed spectrum to ensure link availability under non-line of sight conditions. In contrast, there are many areas available for performance improvement and cost reduction when optimizing a product purely for FWB. These include:

- CPE antennas
- CPE power management
- Scheduler design for static deployments
- Absence of mobility support
- Reduced backward compatibility requirements and the necessary overhead to do so

HOW DO FWB AND IIOT APPLICATIONS GET A BOOST BY 5G STANDARDS?

LPWA (low-power wide area) networks driven by 5G will be the transport mechanism of choice for the IoT as long battery life, simplified provisioning, and long-distance connections drive new automation and analytics applications. The adoption of 3GPP standards like NB-IOT and CAT-M1 has started today, and these will migrate to 5G standards in the future. In parallel, networks based on the LoRaWAN protocol enable private networks to co-exist with public networks. The combination of LoRa private networks and 5G private and public networks gives industrial operators the flexibility to meet their objectives with criteria such as OPEX vs. CAPEX, licensed vs. unlicensed, power consumption, range, coverage area, capacity, and QoS.

Cambium Networks wireless fabric supports a broad range of industrial network operators today with both broadband and narrowband (below 1 GHz) network solutions. In addition to UEs developed expressly for residential and enterprise access, the cnRanger platform will also support M2M modems. Cambium Networks will build on this experience base in providing industrial solutions based on 5G and exercising the services embedded in 5G attributed to the aforementioned use cases: massive machine type communications (mMTC) and ultra-reliable low latency.

HOW WILL CAMBIUM NETWORKS SUPPORT ENTERPRISES AND WISPS WHEN 5G UNLEASHES?

Cambium Networks is actively working on mm-wave products for both the licensed bands available to our customers as well as the 60 GHz unlicensed bands. Together, these provide new affordable options for WISP and enterprise users to achieve higher data rates in access networks. New radio planning tools and installation features will be introduced alongside these platforms to address the alignment issues seen at these shorter wavelengths.

Cambium Networks is also working on products to exploit the new spectrum being made available below 7 GHz. The PMP 450 platform already supports the FCC's CBRS band in 3 GHz and will do so on cnRanger in 2019. As new spectrum availability is discussed, Cambium Networks continually evaluates the business opportunities and will create new platforms and adopt new technologies to provide additional leading-edge solutions for our customers. A positive example of this is the anticipated release of an additional 1.2 GHz of spectrum at 6 GHz by the FCC and ETSI.

IS 5G GOING TO REPLACE WI-FI?

5G is not going to replace Wi-Fi. Based on \$/Mbps data communication, using Wi-Fi for WLANs is much lower than that of LTE/5G NR and is likely to remain so for the foreseeable future. 802.11ax (also now known as Wi-Fi 6) has many advances in the Wi-Fi protocol that enhance performance, especially for applications commonly used by Cambium Networks' customers.

Reports of the death of Wi-Fi are greatly exaggerated. There are three reasons that 5G will not replace Wi-Fi in the foreseeable future:

1. Wi-Fi chipsets are low cost, delivering the lowest \$/Mbps ratio. Wi-Fi chips are used in everything from smartphones, to PCs and from enterprise devices to consumer smart home devices. Each year, over three billion Wi-Fi chips are shipped. The new enterprise network may very well be found in the consumer home as a host of connected "things" will increase demand for enterprise-grade connectivity and reliability. At the same time, traditional enterprise networks continue to prefer Wi-Fi as an access network for employees, company guests, and back-office devices like scanners, printers, environmental controls, and security.
2. The 802.11ax standard embraces and supports the same goals as 5G, chiefly greater spectrum efficiency, deterministic networking, and service slicing. 802.11ax and 5G share common goals and complementary implementations. Nothing in the foreseeable future will change the easy deployment and high-capacity networks that underly the success of the 802.11 Wi-Fi standards.
3. Public access Wi-Fi is a service-based economic model; whereas, mobile cellular networks are a fee-based economic model. Consider the number of hotels, coffee shops, restaurants, transportation hubs, and even public parks and urban cities that offer free Wi-Fi access. The services delivered over the top of the public Wi-Fi access more than pays for the cost of the network equipment. Mobile access networks based on 5G are fee based and cannot replace the service-based free network access offered by public Wi-Fi.

Cambium Networks has developed a Wi-Fi solution with pan-enterprise policy management and service delivery. Network architects and administrators look to Cambium Networks to deliver and manage a high quality of experience for Wi-Fi networks to support enterprise applications as well as public hotspot access networks.

IN CONCLUSION

5G's three principal use cases, and the services developed by the working group to address them, offer Cambium Networks a powerful toolset to create advanced network solutions optimized for fixed broadband access. Our practical and successful experience with 5G-like technologies such as Massive MU-MIMO and beamsteering, coupled with our deep understanding of the fixed broadband market, will allow us to accelerate the development of practical applications and solutions incorporating 5G services. We will apply these services across our Wireless Fabric, leveraging the strengths of PTP, PMP, LTE, and Wi-Fi network architectures and utilizing both licensed and unlicensed spectrum, to bring highly differentiated and cost-effective solutions to our customers.



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