



Intelⁱⁱⁱ 5G/mmWave Demonstrations

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Introduction to Intel Corporation Demonstrations

5G is a fundamental shift to a computing platform from the communications platform of 3G and 4G. It is the inflection point for connectivity and computing and will provide excellent intelligence and flexibility across networks, radio technologies and intelligent devices - enabling the full potential of billions of smart & connected things.

In order to make 5G a reality, Intel is in the forefront of the convergence of computing and communications connectivity by uniting the industry around new spectrum assignments, frequencies, standards, and innovative technologies such as mmWave, multi-antenna array, steerable beamforming, novel radio interface techniques, anchor-booster architecture and more. At the same time, we are working to define the scalable, virtualized radio networks, core networks and intelligent edge services that will make 5G a reality.

Below are descriptions of some of the work Intel is doing with its partners as the industry paves the path to 5G.

5G Mobile Trial Platform

As the industry looks to 5G to provide the higher data rates, lower latency and increased capacity to enable new services, user experiences and the Internet of Things, a combination of existing and new spectrum, network flexibility to accommodate different spectrum bands and silicon that can provide immense processing and communications power are required.

Intel's *5G Mobile Trial Platform* is designed to provide that flexibility and processing power. Created to reflect a holistic approach to 5G development based on input from our collaborators, this platform is configurable for use in both wireless access points (infrastructure) and end-user equipment (mobile devices).

This over-the-air 5G trial platform has been developed to prototype emerging 5G waveforms currently under development with operators and user equipment manufacturers.

The platform is a window into understanding what users can do with 5G technology and high data rates and will be helpful to Intel and its partners in understanding 5G network requirements.

Several advances in current 4G LTE technology, including a wide bandwidth of operation (100-800MHz), a resulting high peak data rate, and support for both sub-6GHz and 28GHz frequency bands are included.

Intel's 5G Mobile Trial Platform is only the beginning. Demonstrating the ease of reconfiguration, this platform is at the convergence of computing and connectivity, aiding in the development of prototypes for the new capabilities, user experiences and devices that will make 5G a reality.

Mobile Edge mmWave Backhaul and Access for 5G Densification

5G is the network that will enable the full potential of the upcoming billions of smart & connected devices and will require bringing together mobile broadband enabling technologies and spectrum with new access methods in order to expand services and increase capacity. At the same time, 5G networks are aiming to provide enormous throughput which will require technology advancements that manage backhaul traffic efficiently. Research and development on mmWave technology is one area Intel is innovating in order to meet the upcoming demands of the 5G network.

Backhaul performance will be crucial in 5G networks and the development of Millimeter Wave Capable Small Cells (MCSC), using the Modular Antenna Array (MAA) radio architecture with Mesh backhaul, will address the need for a massive increase in capacity, deployment flexibility, and affordability.

In addition, this demonstration shows the use of beam forming and beam tracking for very large mmWave antenna arrays. Intel's work in mmWave MAA demonstrates our fully adaptive beam forming and beam steering, 128-element, MAA proof of concept. Using a commercially available baseband and a uniquely architected MAA design, the MAA system architecture, using mmWave frequencies, provides a compelling solution for outdoor access applications in 5G cellular networks while the automatic beamforming and beam tracking capability maximizes link performance and minimizes interference.

Pre 5G Anchor Booster Concept with mmWave

Today's network technology and licensed spectrum, used for 3G & 4G services, are insufficient to meet the upcoming data demand and latency requirements of 5G networks. Intel's *Pre 5G Anchor Booster Concept with mmWave* demonstration shows what will be possible in 5G.

Anchor Booster network architecture uses LTE and 60GHz mmWave dual connectivity in an "Anchor/Booster" design concept to deliver more than 1 Gbps throughput and low latency for 5G systems. Utilizing an Intel® Xeon™ based eNodeB, an Intel® XMM™ 7260 LTE modem and an Intel® Tri-Band Wireless-AC 17265, this demonstration presents a complete pre-5G concept system that is fully integrated and optimized from the device to the network.

Intel's *Pre 5G Anchor Booster Concept with mmWave* represents an important milestone in the industry's development of advanced solutions on the road to 5G.

Narrow Band IOT

As the industry works towards 5G, solutions are already underway that will enable and set the stage for the upcoming 5G network. NB-IOT is a new narrowband, LTE-Based, radio technology designed for

markets with a mature LTE presence. It will capitalize on LTE availability to address IoT's need for deep indoor and wide area coverage while supporting low device complexity and power consumption.

Intel's NB-IOT demonstration is a joint proof of concept with Ericsson and Nokia that shows a 3GPP pre-Release 13 NB-IOT technology and illustrates the coverage enhancement benefits of an NB-IOT enabled client device compared to a commercial LTE client device - in both urban and rural use case scenarios.

Each scenario shows both devices starting in good cell coverage conditions and, using RF signal attenuation to simulate decreasing signal strength levels, highlights where the LTE device loses connection while the NB-IOT device remains attached.

NB-IOT operates in licensed spectrum and requires just 180 kHz bandwidth. This efficient utilization of spectrum and infrequent reporting from low data rate applications makes it well suited for large scale Machine to Machine deployments. Thanks to the characteristics of narrow channel bandwidth, NB-IOT will enable billions of smart "things" to connect to the Internet.

These are just a few of the ways that Intel is working to pave the path to 5G. Working in collaboration with leading manufacturers and service providers, we are creating the solutions that will enable billions of smart and connected things.

ⁱ Intel is a world leader in computing innovation. The company designs and builds the essential technologies that serve as the foundation for the world's computing devices. Intel also offers a portfolio of wireless communications solutions to connect a broad range of devices. Hardware and software products by Intel and its subsidiaries power the majority of the world's data centers, connect hundreds of millions of cellular handsets and help secure and protect computers, mobile devices and corporate and government IT systems. Intel technologies are also inside intelligent systems, such as in automobiles, automated factories and medical devices.

ⁱⁱ The devices described have not been authorized as required by the rules of the Federal Communications Commission. This device is not, and may not be, offered for sale or lease, or sold or leased, until authorization is obtained. Safety Certification, CE assessment and other country approvals not yet completed.

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