

eBRIEF



# Realizing New 5G Possibilities With the Intelligent Wireless Edge

PRESENTED BY:

**Qualcomm**

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# INTRODUCTION

By 2025, the number of connected devices globally is expected to exceed 74 billion<sup>[1]</sup>, and currently, more than 120 new devices are connecting to the Internet every second. For these devices, the processing of AI tasks has traditionally taken place in the cloud. As the number of connected devices continues to grow, there is a clear need to rethink the way intelligence is scaled. To support the proliferation of intelligent devices, processing must be pushed closer to where the data is being generated: at or closer to the device. 5G, the new generation of cellular technology<sup>[2]</sup>, provides the framework for scaling both connectivity and intelligence in this era of hyper connectivity.

Realizing the transformative potential of IoT — the internet of things — requires a shift away from the centralized cloud and toward a new model of distributed functions with on-device intelligence. Better connectivity, advances in artificial intelligence, and new ways to deploy the cloud for enhanced capabilities are the key ingredients. These developments will help establish the new generation of distributed computing<sup>[3]</sup>.



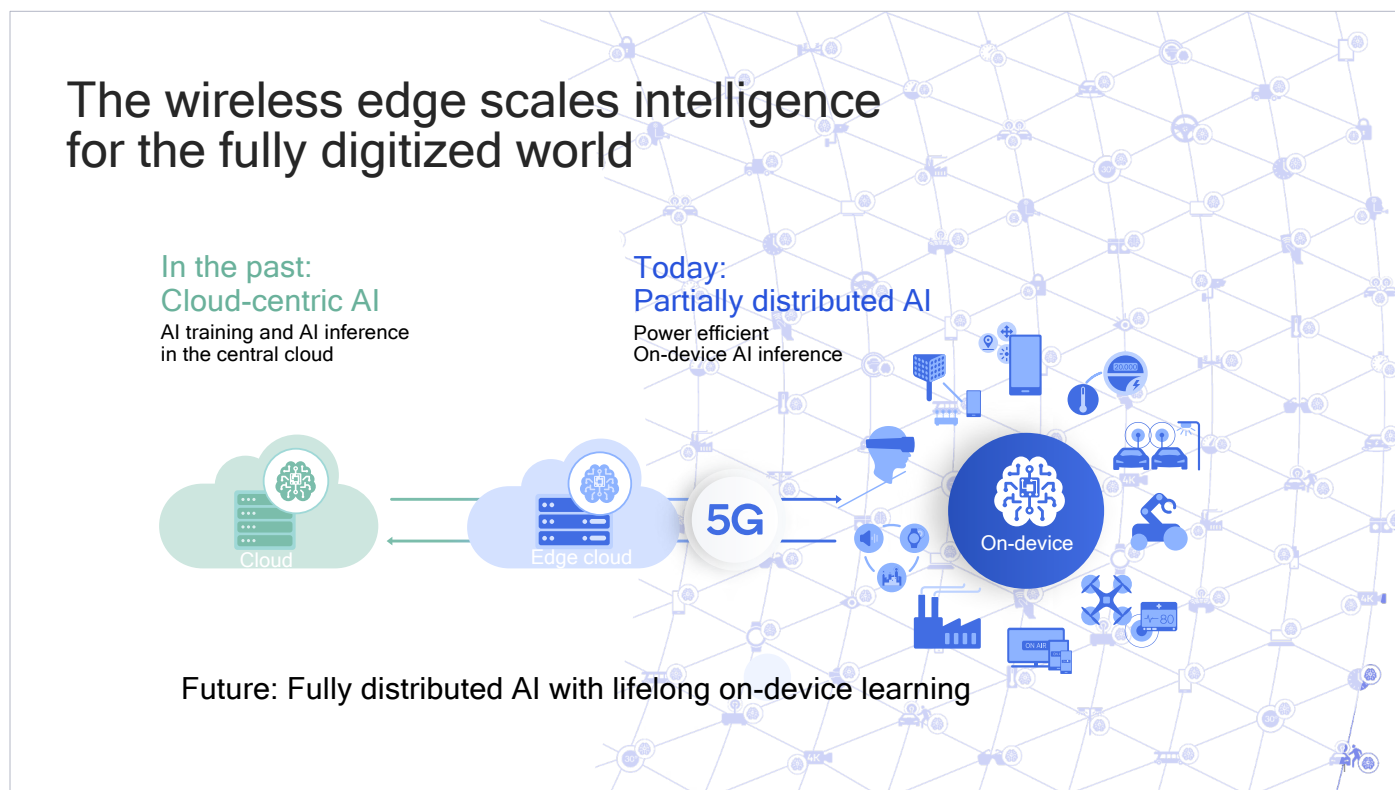


# THE 5G FUTURE: ENHANCED EXPERIENCES, GREATER EFFICIENCY, AND MORE

Devices like smartphones, smart speakers, and responsive sensors that monitor a patient's health are already “smart,” with varying models of on-device processing and data sharing via the Internet and cloud-based resources. Currently, many wide-area IoT devices are connected by 4G LTE, but more capable and efficient 5G connectivity will provide the framework for the future evolution of wide-area IoT.

Today, on-device AI can make local decisions, while these devices are also connected to the cloud for expanded capabilities. As the number of connected devices continues to grow, existing LTE networks and central clouds will need to keep up as well. Inherently, centralized clouds are often far away from devices, and this translates to higher latency—the amount of time needed for data to get from one point in the network to another. This is especially apparent when the network is congested.

In a world where virtually everything is connected, on-device processing will play a bigger role than ever. However, devices have intrinsic limitations, such as power, thermal, and form factor. To overcome them, a new, enhanced system architecture emerges — one that brings data processing capabilities closer to devices. This is the world of the intelligent wireless edge<sup>[5]</sup>, where on-device processing is augmented by edge cloud computing, and connected by ultra-fast, low-latency 5G.



Source: Qualcomm Technologies, Inc.

# 5G + AI AT THE INTELLIGENT WIRELESS EDGE

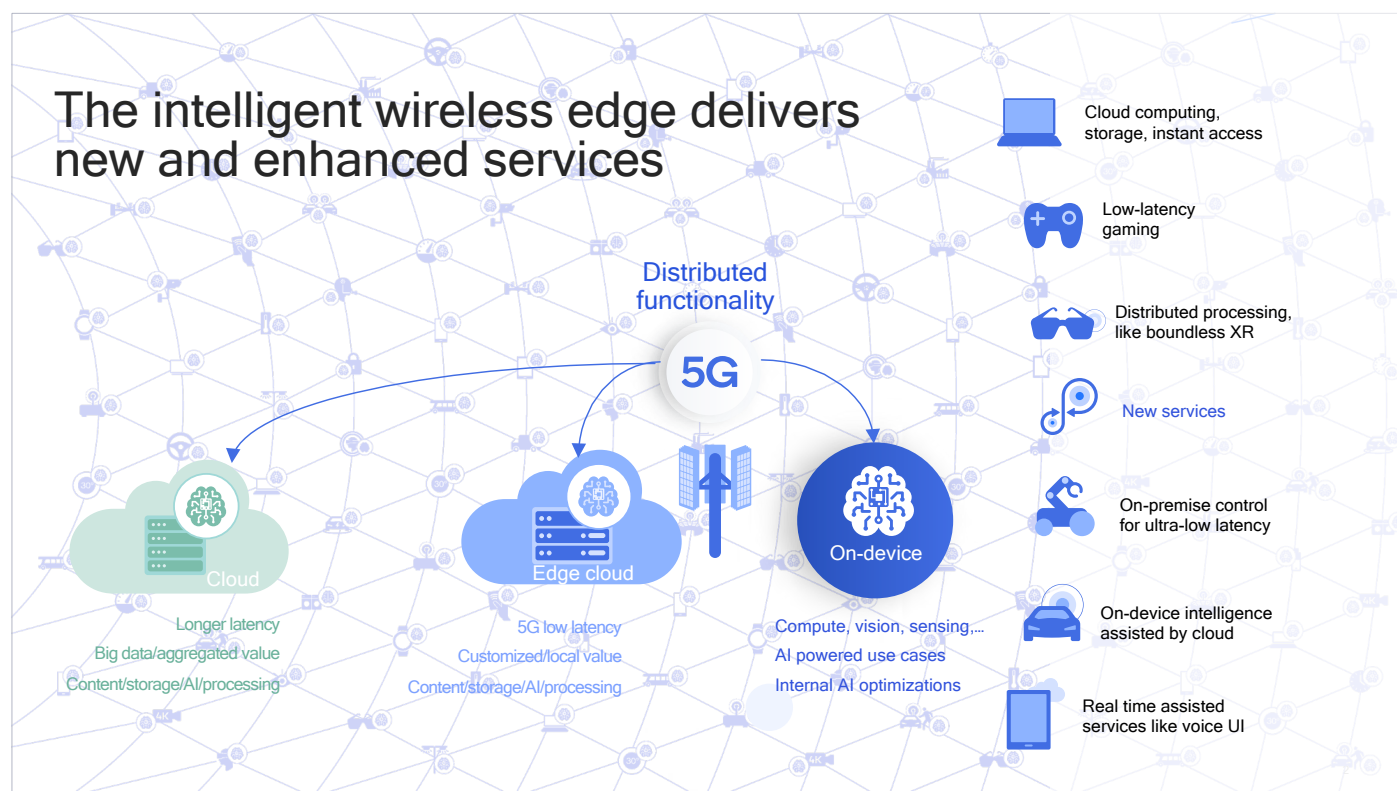
Today, on-device AI is already enabling a wide range of power-efficient use cases, such as computer vision and voice recognition. In the past, AI was predominantly cloud-centric, but in the future, the vision for AI <sup>[6]</sup> is to become fully distributed with lifelong on-device learning, bringing benefits like even better personalization and privacy protection.

While the training of data-intensive deep learning models primarily takes place in the cloud, inference — the act of responding to new situations using the predictive power of a trained AI model — should take place closer to the user in order to make decisions and take action in real-time.

Decentralizing the cloud in favor of a more distributed framework — using both edge cloud and on-device processing — also delivers lower latency, so devices can be more responsive. Today, inferences are increasingly processed on the devices themselves, and as this framework develops, AI training that has traditionally been handled in the central cloud will also become more distributed.

5G was envisioned to be the unifying connectivity fabric that can connect virtually everything and everyone, and it is being designed to support and expand the IoT ecosystem in previously unrealized ways. Not only is 5G capable of delivering extreme throughput and millisecond latency, it can also flexibly scale to efficiently support a large number of lower-performance IoT devices.

So, with the advancements in on-device AI, edge cloud computing, and 5G, the wireless edge will bring new and enhanced experiences and a wide range of use cases.



Source: Qualcomm Technologies, Inc.

# THE WIRELESS EDGE IN ACTION: NEW APPLICATIONS, NEW POSSIBILITIES

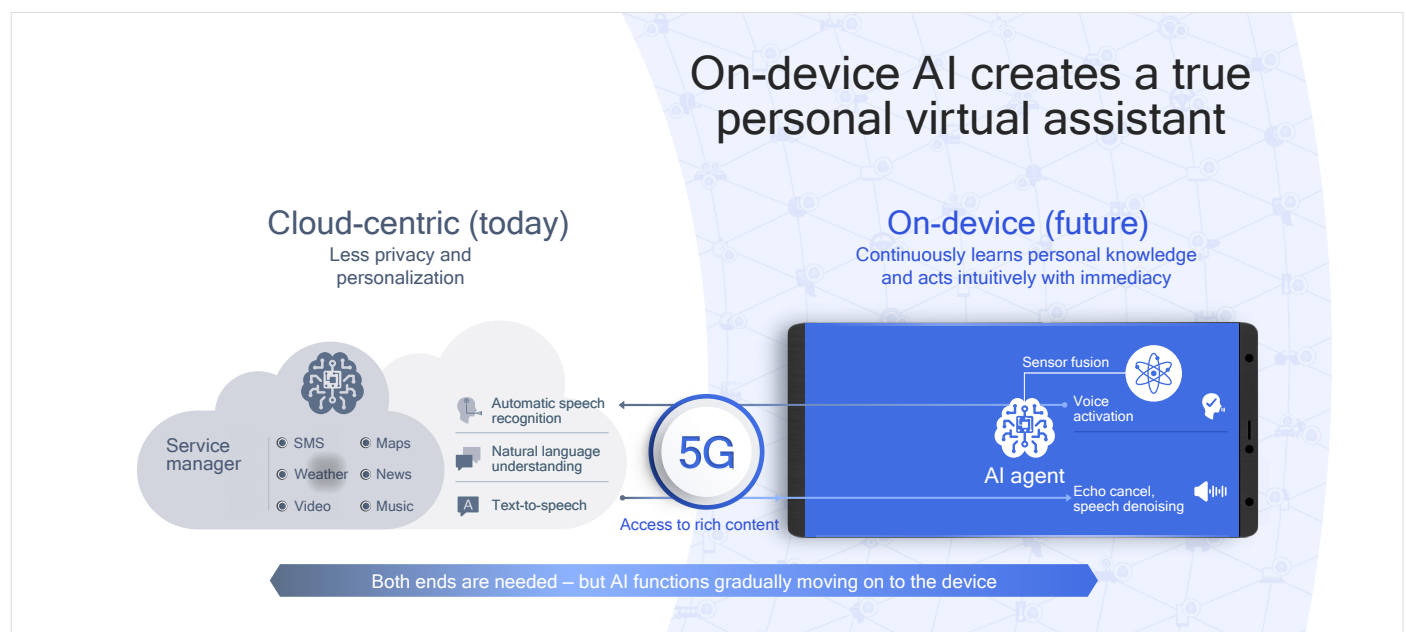
The intelligent wireless edge will become the cornerstone for powering next-generation user experiences. The seamless integration of on-device AI, edge cloud computing, and 5G networking will not only enable new devices and services, but also transform existing ones<sup>[7]</sup> for both personal and professional use. <sup>[8]</sup> 5G's wider bandwidth and low latency can enhance mobile experiences of all kinds, making video streaming, downloading, and browsing experiences better than ever. With the intelligent wireless edge, we can augment the capability of on-device AI with the edge cloud for new benefits, from higher-quality photography to more intuitive augmented reality experiences. The wireless edge can also enable many more new use cases beyond the ones we know today.

## Even Better Smartphones

5G is enhancing smartphone experiences with extremely high bandwidth and low-latency connections. With the intelligent wireless edge, 5G smartphones can also enhance a variety of use cases such as photography, mobile gaming and productivity. With AI-enabled cameras, new 5G smartphones can offer functionality equal to that of top-of-the-line DSLR cameras. AI enhanced features include low-light photography, bokeh effects, scene/people detection, and super-resolution.

## More Personable Voice Assistants

The combination of on-device intelligence, cloud computing, and 5G connectivity can also transform voice technology to create a true personal assistant that can be more responsive, proactive, and context-aware. Today's cloud-centric virtual assistants offer limited privacy and few options for personalization. In the 5G era, devices will be equipped with enhanced on-device intelligence that can continuously "learn" about the user and create a digital version of them that can act immediately and intuitively in various situations.

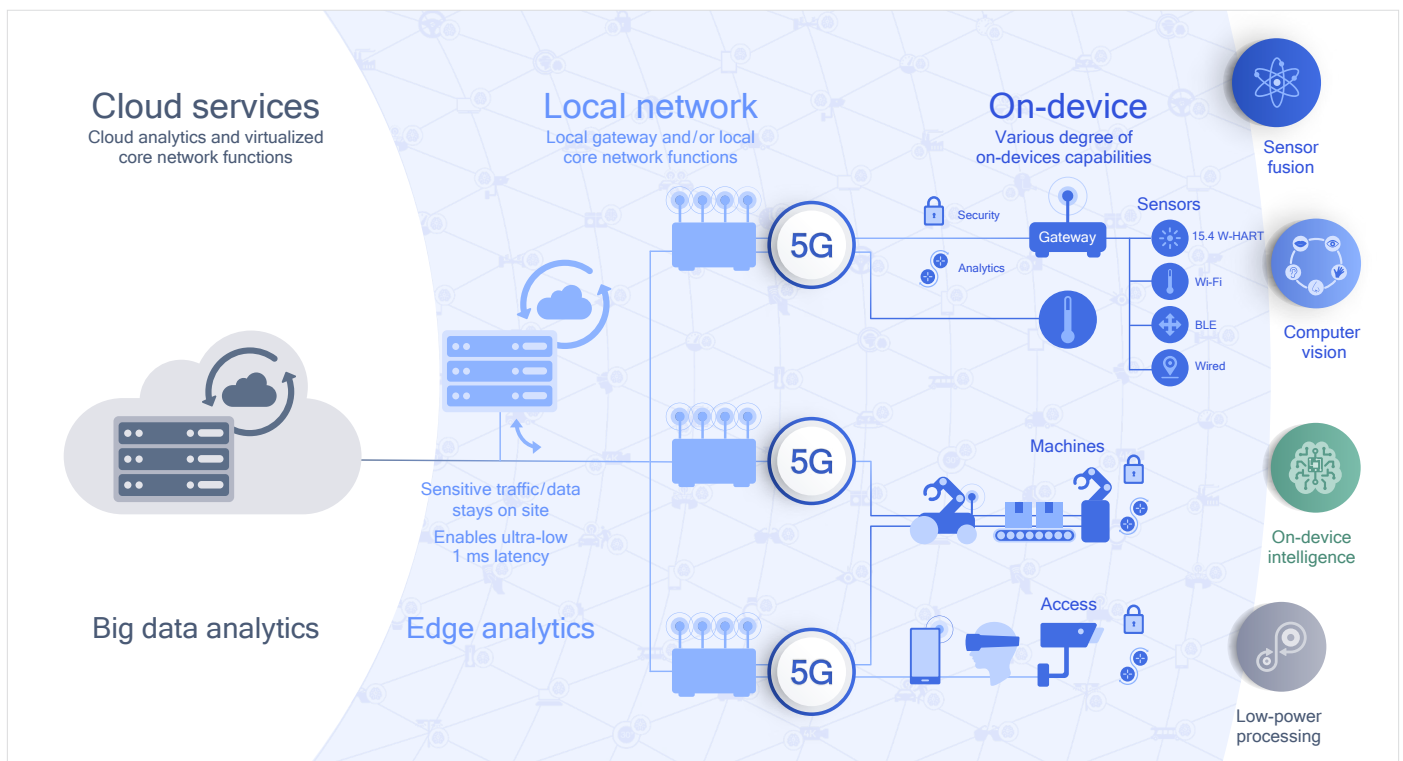


Source: Qualcomm Technologies, Inc.

## Expanded Industrial IoT Use Cases

Currently, only 49 percent of industrial organizations surveyed say AI is essential for manufacturing success over the next five years<sup>[9]</sup>. However, with the intelligent wireless edge, which can keep sensitive data inside a dedicated private network and address a wider range of industrial use cases, it is expected that the interest level will grow. It also opens doors to new opportunities that can enable the smart factory of the future.

The wireless edge will not only connect existing industrial IoT devices more efficiently (e.g., sensors and industrial handhelds), but it will also expand to new devices and services. High-performance industrial IoT can pose very challenging connectivity requirements, particularly for automation and robotics use cases. For instance, it is possible to replace today's wired industrial ethernet to make factories more dynamically reconfigurable. This requires the system to achieve reliability up to 99.9999% with an end-to-end latency as low as a millisecond — which is well within the reach on the intelligent wireless edge.



Source: Qualcomm Technologies, Inc.



## Better Road Safety and Automotive Applications

By 2021, all new vehicles sold for personal use will have some degree of AI-powered autonomous capability<sup>[10]</sup>. On-device intelligence paired with low-latency networks can improve driver performance and road safety, supporting the move to “smart” and more autonomous cars.

The wireless edge allows vehicles to respond immediately to current conditions, with no need to rely on the central cloud before responding. Complementing onboard cameras and other sensors, C-V2X (cellular vehicle-to-everything) acts as an additional sensor that helps on-device AI to drive autonomously. Since cameras cannot see beyond the line of sight, C-V2X can alert drivers to movement beyond the sightline, detect traffic light changes, warn drivers about pedestrians and road hazards, and more, eliminating the need to consult with a centralized cloud.

## More Immersive Experiences with Boundless XR

Extended reality, or XR, includes virtual reality (VR), augmented reality (AR), and everything in between. AR combines the real world with virtual objects while VR immerses you in a completely virtual world. XR can be experienced through a variety of devices, including glasses and headsets.

Current versions of mobile XR typically rely upon on-device processing, as the latency to communicate with the central cloud is too high to meet motion-to-photon requirements. In addition, mobile XR is also constrained by the power and thermal constraints of a slim and lightweight form factor that is worn on the head. In order to deliver truly immersive experiences in a sleek form factor, on-device processing needs to be augmented by the edge cloud. With 5G’s low latency and high capacity connectivity, XR experiences can become more photorealistic and completely immersive, with applications ranging from gaming and entertainment to education and healthcare.





# THE INTELLIGENT WIRELESS EDGE IS OUR FUTURE

The use cases outlined above are just some of the new possibilities unlocked by the intelligent wireless edge, and there will be many future use cases that we can't yet imagine today. The wireless edge will bring virtually unlimited opportunities, creating an intelligently connected world of the future that transforms how we compute and communicate.



At Qualcomm, our inventions are the foundation for life-changing products, experiences, and even industries. When Qualcomm connected the phone to the internet, the mobile revolution was born. Today, as we lead the world to 5G, we're making it possible for literally billions of objects to seamlessly connect and intelligently communicate with each other. And our history of sharing our foundational inventions will continue, allowing our customers to build the products that will change the lives of people everywhere.

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