WHITE PAPER

5G for an intelligent edge

5G unleashes the power of billions of connected devices living at the edge. Flex has the ability to deliver innovative technology with high reliability and efficiency that is necessary for a fully connected world to be realized.

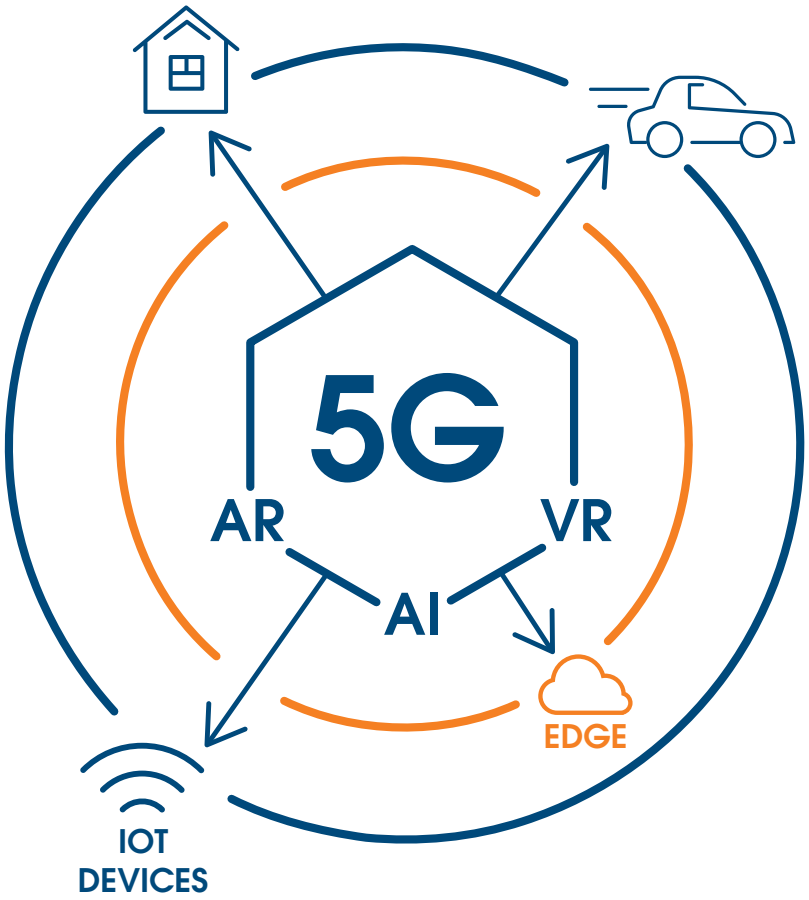
flex

As connected devices increase into the billions and become more intelligent, 5G technology enables a unified digital experience. 5G manages growing connection density, offers ultra-low latency and gigabit speeds and supports real-time processing near the devices.

5G supports the proliferation of devices at the edge

Previous wireless generations connected people to people and people to the Internet. 5G extends this to connect "things" to people, the Internet and other infrastructure and devices. By design, 5G can manage a growing connection density of one million devices per square kilometer. That density is compared to the 4G low-power wide-area (LPWA) standard, which supports only around 100,000 devices per square kilometer. 5G infrastructure deployments are essential in order to deliver high-speed, low latency, reliable and secure connectivity to the ever-growing number of edge devices.

Figure 1 – 5G supports edge device proliferation

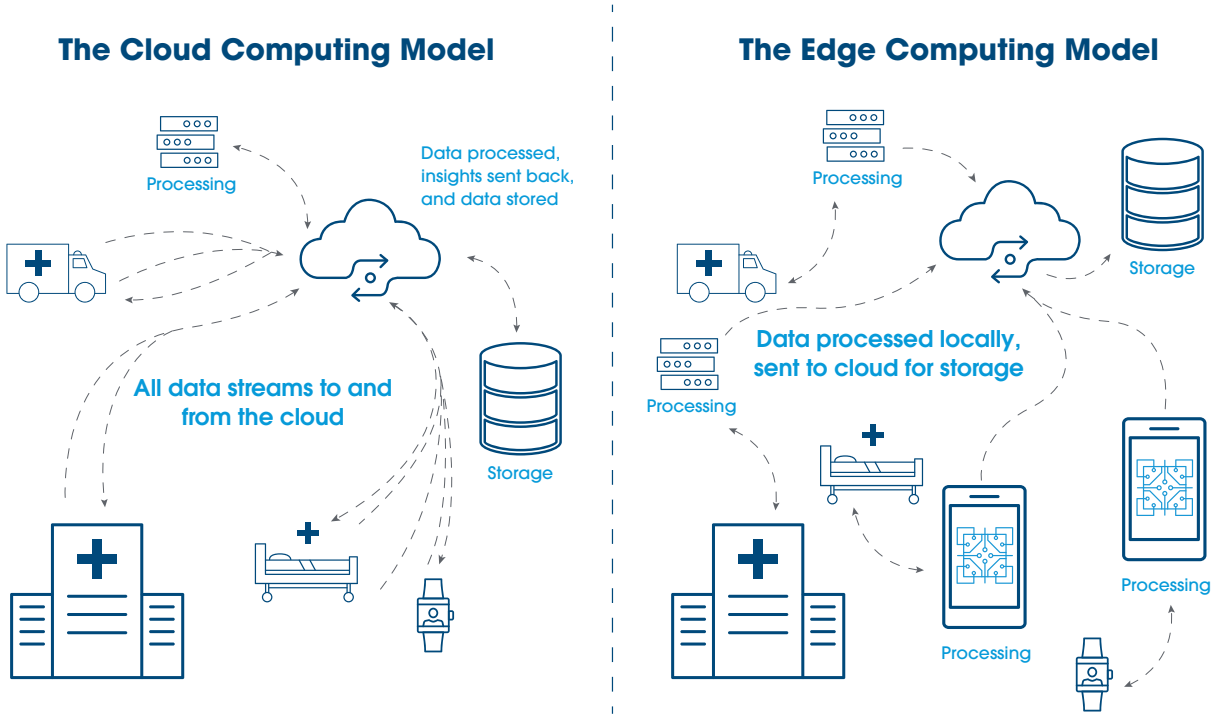


5G enables near real-time computing at the edge

5G supports a high density of connected devices – and it's 10-20 times faster. Peak data rates reach 10 to 20 Gbps and latencies are less than one millisecond. The high data rates and low latencies make 5G and edge computing an ideal match. When combined, they're perfect for applications requiring near real-time data collection and analysis. For example, artificial intelligence, augmented reality/virtual reality (AR/VR), vehicle-to-everything (V2X), smart-city and smart-manufacturing equipment require near real-time communications to deliver the data solutions of the future.

Figure 2 – 5G supports edge computing

Source: Business Insider

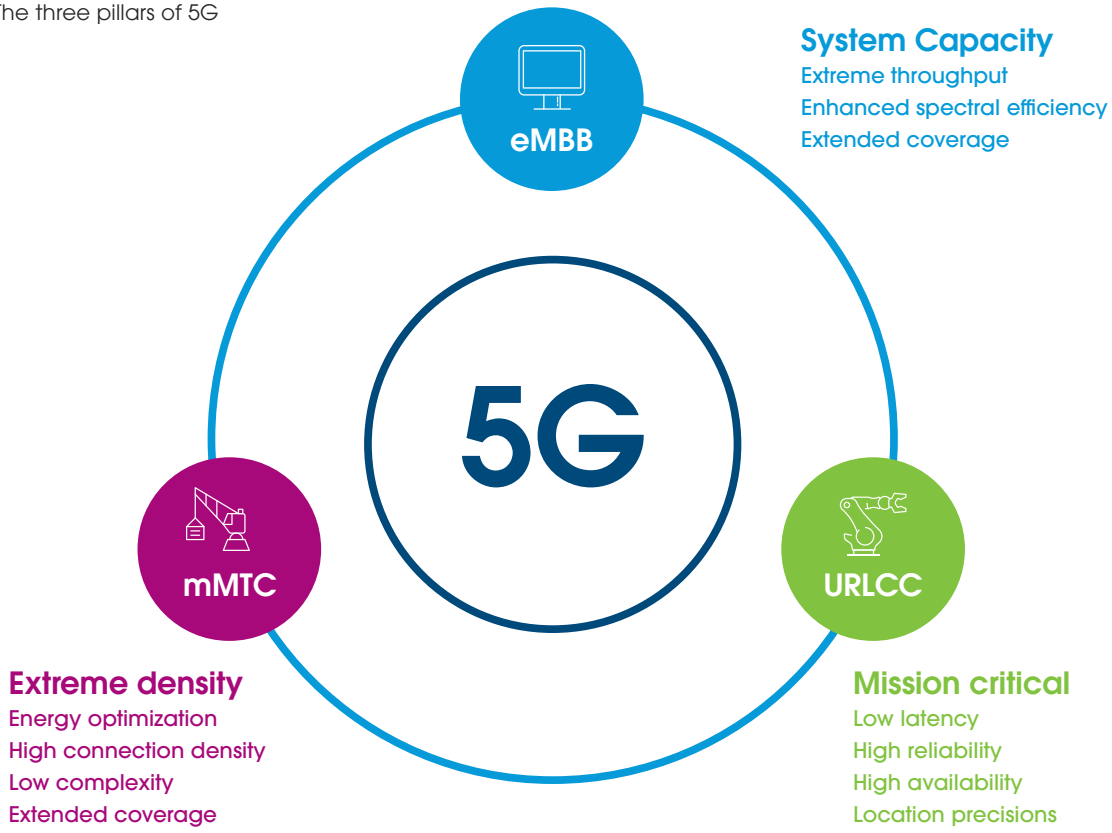


5G New Radio enables unprecedented use cases

The 3rd Generation Partnership Project (3GPP) published a study on 5G New Radio, as part of its New Services and Markets Technology Enablers project. It outlined more than 70 use cases that were grouped into three categories.

1. **Enhanced Mobile Broadband (eMBB):** Data-driven use cases requiring high data rates across a wide coverage area
2. **Ultra-Reliable Low Latency Communications (URLLC):** Strict requirements on latency and reliability for mission critical communications, such as remote surgery, autonomous vehicles or the tactile internet
3. **Massive Machine Type Communications (mMTC):** Must support a large number of devices in a small area, which may only send data sporadically, such as Industrial Internet of Things (IIoT) and Internet of Things (IoT) use cases

Figure 3 – The three pillars of 5G



Use case 1: Enhanced Mobile Broadband for lightning fast data rates

The advent of 5G technologies and applications pushes mobile networks to their limits. Enhanced Mobile Broadband (eMBB) can support extremely high data rates, 10-20 times what was possible with 4G/LTE. This provides significant performance benefits for the consumer such as lightning-fast browsing and up to 10x content download speeds. We also see ultra-HD, 360-degree streaming video and a seamless AR/VR experience. In addition to these consumer benefits, eMBB will enable exciting new uses such as connected cars, smart factories and smart cities.

All these data-thirsty eMBB applications require vast amounts of spectrum which is driving bandwidth scarcity in the low- and mid-bands and consequently driving up the cost of this spectrum. As a result, the focus has turned to millimeter wave (mmWave) spectrum above 24 GHz and Massive MIMO (mMIMO) technology which can utilize this precious spectrum more efficiently.

> Realizing that mmWave and mMIMO are key building blocks of 5G, we proactively developed reference designs for a mmWave phased array radio and a mMIMO antenna array which help customers develop products quickly and efficiently.

mmWave Radio

In the past, mmWave frequencies were not suitable for mobile applications due to their limited propagation distance. New technologies like phased antenna array beamforming make it possible to increase the range of mmWave radios and harness the power of this spectrum for mobile applications However, the cost of the mmWave chipsets and heat dissipation remain a challenge for our customers.

That's why we developed a reference design for a mmWave phased array radio to:

- Advance our 5G and mmWave design and development expertise
- Build partnerships with key suppliers of mmWave chipsets and materials, in order to utilize commercially available materials and keep costs down
- Maximize power efficiency and heat dissipation while keeping weight and size to a minimum
- Be ready to support our customers to develop future mmWave products, shorten time-to- market, reduce development costs and increase revenue

Our wireless design team developed a working prototype of the mmWave radio. The prototype operated at 28 GHz and featured two cross-polarized, electronically steerable, 16-element phased arrays. We constructed it using commercially scalable mmWave chipsets and PCB material. The 16-element array forms the foundation from which larger arrays with 64, 256 or 512 elements can be quickly and cost effectively developed for our customers. We fully tested and characterized the mmWave radio in an anechoic (echo-free) over-the-air test chamber to ensure design specifications were met.

The white paper titled "mmWave phased arrays for 5G applications" provides an overview of the mmWave reference design we developed which can be further customized to meet your product requirements. It also shows how mmWave meets consumer needs and ensure a step order increase in capacity is available.

White paper: mmWave phased arrays for 5G applications

We are investing in cutting edge technology building blocks to help our customers develop their 5G products.

Read white paper

mMIMO antenna array

mMIMO provides significantly higher data rates, capacity and coverage than traditional macrocell technologies. The increased performance is possible because mMIMO combines the radio and antenna elements into a single active antenna unit with 16/32/64/96 elements. This enables beamforming towards the user of interest, reducing interference with surrounding users and improving overall performance.

However, mMIMO units are often several times more expensive than traditional radio units, due to the generally higher bill of materials cost and increased manual assembly effort during production to attach the 16-96 antenna elements onto the main antenna board.

> Realizing that this was a major challenge for our customers, we developed a mMIMO antenna array reference design for cost efficient assembly during production. The design uses a single board for the antenna array, which means assembly can be automated, reducing production time and costs. We estimate it reduces assembly effort fivefold compared to traditional designs.

The mMIMO array consists of 16 dual polarized elements designed to operate at 2.5 GHz. The array can be quickly scaled to 32 or 64 elements. We can also customize the operating frequency, bandwidth, gain and power in accordance with your product requirements.

Read more in our Massive MIMO white paper describing our reference design, design process and test results for the prototype developed.

Use case 2: Intelligent transportation

We recently worked with Baidu, a large cloud-based service provider, to develop an outdoor vehicle-to-everything edge computing solution. The solution supports emerging use cases like autonomous driving vehicles in smart cities. We assembled a team of experts in mechanical, thermal engineering design, data transmission, cloud storage and system integration. The team developed the mechanical enclosure and thermo electric cooler to withstand extreme thermal variations and weather conditions. We provided leadership for the design and the selection of key system components, including the use of in-house power board design capabilities. The proof of concept was delivered in just one month and prototype units were delivered in four months, meeting an extremely aggressive time to market goal.

> Leading cities worldwide will employ intelligent roadside units (RSUs) to help smooth traffic flow, improve safety and emergency response, and provide additional services. Our cross-industry expertise makes us uniquely positioned to deliver solutions for these units and other intelligent transportation systems.

Case study: Intelligent transportation needs ruggedized design

We partnered with one of the world's leading cloud providers to bring a new edge server design concept to reality. Read how we collaborated to design and develop a volume manufacturing program solution.

Read case study

Use case 3: Industrial IoT

One of the main differences between 5G and previous generations of cellular networks lies in 5G's strong focus on machine-type communication and IoT. The capabilities of 5G extend beyond mobile broadband with high data rates and as smart factories become increasingly more automated, 5G will be essential for the mass number of precision, low latent, interconnected machines.

The IIoT is a network of sensors, instruments and devices used for applications such as manufacturing, energy and mining. This facilitates the exchange of data between devices for analysis and diagnostics, providing improvements in productivity, reliability, flexibility, versatility, usability, safety and efficiency for future smart factories.

Connectivity is a key component of IIoT and will support the ongoing developments by providing powerful and pervasive connectivity between machines, people and objects. We have developed a fully functional IIoT Development Kit (iENBL) integrating LPWAN, multiple sensors, and SW to quickly prototype IoT applications.

> Our iENBL development platform accelerates LPWAN and 5G connectivity for Industrial IoT applications. It is embedded in a ruggedized clamshell with the sensors required for most IoT applications. The rapid development platform helps you develop, verify and test your IoT ideas in the field without spending time or money developing custom hardware.

Case study: Managing and tracking off-highway machinery

See how we helped MachineMax take their machine analytics service from testing to global production in under a year, improving asset management and reducing cost with predictive maintenance.

Read case study

Use case 4: Surgery and patient care of the future

Remote surgery, which uses video and augmented reality along with advanced robotics, is an area of healthcare that can benefit greatly from 5G and edge computing. It is a great example of how very low-latency communications along with high reliability are critical in providing a potentially "life-at-stake" service. Virtual reality video streaming to support remote surgery is another compelling use case for 5G and edge computing.

Remote surgery is almost impossible using only basic data services provided by 4G/LTE networks. We are partnering with industry leaders to help bring these new use cases to fruition.

Drug delivery services for remote patient monitoring is another healthcare area with great potential for advancements. A broad spectrum of devices, ranging from drug monitors to autoinjectors, will require new technologies, including LPWANs. This technology enables device sensors to collect patient data and send it directly to the edge for processing, facilitating real-time decision making and critical action taking.

The future availability of 5G and its advanced wireless technologies that provide low latency and ultra-high reliability will enable new levels of personal medical devices. There are many considerations when selecting connectivity technology for drug delivery.

Article: Choosing the right connectivity for drug delivery and medical products

Learn about connectivity technology options for future medical devices including use cases, cost, range, RF performance and more.

Read article

We can help

As 5G propels intelligence to the edge, new solutions will require consideration of these factors:

- Total cost of ownership
- Power availability
- Location
- Design requirements
- Outdoor enclosure requirements

> We have the capabilities and experience to help you navigate these challenges.

Total cost of ownership (TCO)

This is often the first question asked when a company is considering edge computing infrastructure expansion. Capital expense and optimization of the server design are critical, but we must not overlook the cost of transporting data. The data produced in the 5G era will be more massive than we have ever seen. Intel estimates a typical autonomous vehicle will generate 4TB of data each day. Locating the edge closer to the source of the data minimizes transmission distance and cost.

We optimize our customers' edge computing infrastructure costs with a variety of supply chain offerings. And we deliver customized solutions. From hardware to system and rack integration to perfectly match your workloads, we simplify your supply chain and support your infrastructure needs.

Power availability

A traditional edge computing infrastructure typically has the luxury of purpose-built power systems, multi-grid feeds and backup. Edge computing infrastructures must consider the trade-off of available site facilities versus business needs. They may use an AC or DC system depending on what is available. Site locations and size may not allow for power redundancy.

In addition to designing power-efficient servers, we have a comprehensive power division, Flex Power. The team designs custom power supplies, backup and other solutions to meet the needs of the edge.

Location

For every edge computing infrastructure, there may be 100 or even 1,000 tethered edge computing infrastructures. These edge centers could be located anywhere from downtown office centers to rural locations, along highways, next to cell towers or even hidden in basements. Not all locations will be readily accessible, and some may be hazardous. This compromise is based on the need for ultra-low latency – which comes from proximity to connected devices.

The growth of services dependent upon the cloud means edge computing infrastructures will soon span the globe. With our presence in more than 30 countries, we are never far from your target deployment site. We advise on the lowest landed cost by utilizing our footprint, as well as the complex tax and tariff concerns. We maintain the most extensive global footprint of any supply chain solution provider in the industry.

Design requirements

Edge computing infrastructures will require new innovations. While these edge computing infrastructures conceptually require the same compute, storage and networking facilities, the requirements will differ to accommodate the uniqueness of edge environments. Optimization will ensure smaller servers perform well with various power environments, less redundancy, better physical security, many rack sizes and flexible cooling systems.

We have a long history of edge computing infrastructure customization. Our reference designs and deep experience in rack and systems integration help create a customized product in less time. And our architects and engineers will help design the optimal system to meet your requirements.

Outdoor enclosure requirements

Many edge devices will be located outdoors and must withstand harsh environments, such as extreme temperatures, sun, rain, snow, insects and high winds.

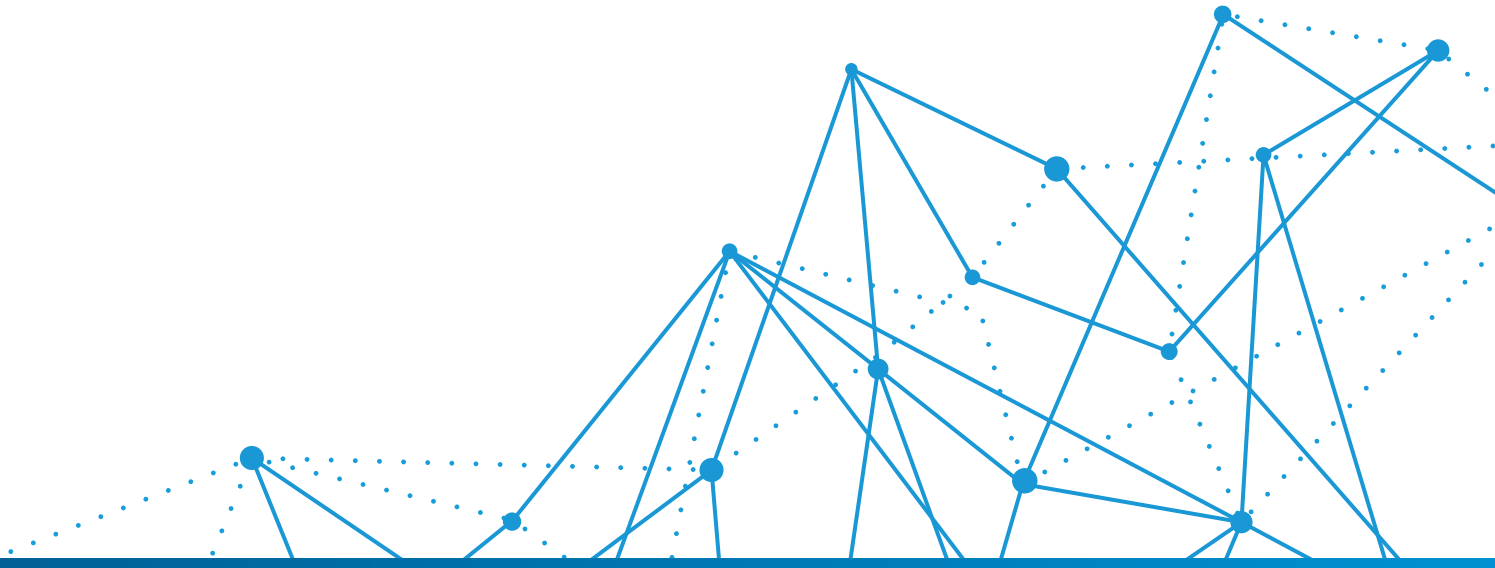
Placing edge equipment in an appropriate outdoor enclosure is always a challenge. Enclosures must protect edge gear from harsh environments created by weather and climate. We have the resources and knowledge to help you find the perfect enclosure for your application.

We help design and manufacture 5G and edge products like the roadside (edge compute) unit, mmWave phased array radios and Massive MIMO active antenna units. And we have the expertise to deliver smart connected devices for medical or manufacturing. We can help design your incredible products, navigate challenges and complexities, reduce development costs, bring products to market faster and significantly reduce time to revenue.

Conclusion

5G and edge computing provide a unifying connectivity fabric for society. We already see this through use cases like eMBB, URLLC and mMTC. With ultra-low latency, gigabit speeds, on-device intelligence, extreme reliability and virtually unlimited capacity, 5G and edge computing will permeate the landscape. And just like the air we breathe, consumers will expect 5G to be always available.

With our experience across industries in both 5G and edge, we are here to help you design, develop and manufacture your next incredible product. Through a joint design and manufacturing (JDM) partnership with Flex, we can work together to develop your 5G and edge product, scale to volume production and provide the supporting supply chain, forward/reverse logistics, and advice on tax, trade and duties.



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