



# The State of 5G

What to Expect from the New Generation of  
Information and Communications Technology (ICT)

ormuco



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# Introduction

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From the beginning, cell phones have been integrating core functions for collecting and sharing data in the form of text messages or calls. Users have been manually dialing numbers, entering text on these edge devices, and initiating transmission.

Over the years, cellular technology has evolved from simple GSM (Global System for Mobile communication) for voice and text transmission to LTE (Long Term Evolution) and similar standards. These enhanced technologies have enabled mobile phones to become "smart" by integrating IP (Internet Protocol) data transmission.

The result is, our mobile phones have turned into computers. Whether they run Android OS, iOS or else, loads of applications are now available with a tremendous variety of uses. Actually, smartphones have become autonomous. For instance, they can record GPS localization, itineraries, time spent on an activity, or sync with other devices.

As we notice, for many cases there is no longer need for the users to manually enter data and initiate its collection or sharing, as it is all automated. Moreover, smartphones analyze the information, do calculations and take actions accordingly. But that's not all.

Cellular networks have become so popular that they are now carrying totally different workloads. Thanks to the wide coverage of mobile networks and always-growing data transfer speeds, the industry 4.0 is born.

Not only machinery, but also different kinds of smart devices now integrate sensors that are connected to wireless and cellular networks. These collect data that is sent to edge servers or gateways for automated processing that can help make real-time decisions. This is the Internet of Things as we know it, with the need for ever more processing capabilities and connection speed. Big Data is now driving the demand and engineers are busy building solutions to respond. Obviously, the intelligent edge is in need of speed.

So here comes 5G, the latest in a long line of wireless mobile standards. It intends to close the gap on network latency issues that are currently holding the blossoming of edge computing applications back.

In this document, we will give you an insight of the 5G technology and its deployment.



# A Brief History of Mobile Networks

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5G is the subsequent generation of mobile networks that will replace the current 4G-LTE (Long Term Evolution).

A purple hexagon with a white border and the text "1G" in white.

1G

This is the very first cell phone network, which supported only voice signals. The very first 1G network was launched in Japan in 1979.

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A purple hexagon with a white border and the text "2G" in white.

2G

2G brought with it the development of the mobile cell phone as we know it, using the GSM standard. Voice and data signals could now be transferred over the network. It first emerged in the early 1990s. Over time, 2G developed to include EDGE technology and GPRS, allowing it to transfer data at speeds up to 374 kbit/s.

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A purple hexagon with a white border and the text "3G" in white.

3G

This was when mobile "broadband" was introduced, in the early to mid 2000s. HSDPA (High Speed Download Packet Access) was also introduced, boosting data transfer speeds to up to 14.0 Mbit/s.

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A purple hexagon with a white border and the text "4G" in white.

4G

This is, essentially, an extension of 3G technology, which supports extremely high bandwidth transfer speeds, even for streaming HD video. It was released commercially in 2010. The LTE standard is the most popular 4G standard, which can reach 100 Mbit/s download and 50 Mbit/s upload.

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A purple hexagon with a white border and the text "5G" in white.

5G

The 5G standard is still being developed, but is expected to be able to deliver download speeds of up to a gigabit, with lower latency, better energy efficiency, a larger wireless traffic capacity, and much more. Worldwide commercial launch is expected to begin in 2020.

# Who Is Coordinating the Efforts for 5G?

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There are several important standardization efforts underway for 5G. Two organizations are coordinating these activities.



The main actor in releasing this new 5G technology is 3GPP. The acronym stands for **3rd Generation Partnership Project**. This international taskforce has been in charge for a while and was key in developing the 3G UMTS and 4G LTE standards.

**The 3GPP produced its first global standard for 5G and it comprises:**

- ✓ 5G New Radio or 5G NR, as the new wireless air interface
- ✓ 5G NextGen, as the next-generation network architecture.

This specification is known as Release 15 and it enables commercial 5G deployments already.

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The International Telecommunications Union (ITU) oversees all standardization of mobile networks across the world.

The ITU has been gathering all specifications, including the work done by the 3GPP, into its official designation of 5G, known as IMT-2020. As its name implies, standardization will be sealed in 2020.

The IMT-2020 defines eight key technical capabilities.

➔ Figure 1: Technical Capabilities of IMT-2020

	<b>Peak data rate</b> <b>1 - 20 Gbps</b> <i>Total amount of traffic handled by a single cell</i>		<b>Latency</b> <b>1 - 10 ms</b> <i>Round trip time for a packet of data</i>
	<b>User experienced data rate</b> <b>10 - 100 Mbps</b> <i>Total amount of traffic experienced by the end-user</i>		<b>Connection density</b> <b>10k - 1 million devices/km<sup>2</sup></b> <i>Number of devices fulfilling a certain QoS</i>
	<b>Peak spectral efficiency</b> <b>15 - 30 bit/s/Hz</b> <i>Information rate that can be transmitted</i>		<b>Network energy efficiency</b> <b>90% more efficient</b> <i>Capability of a RIT (radio interface technology) to minimize energy consumption</i>
	<b>Mobility</b> <b>350 - 500 km/h</b> <i>Maximum mobile station speed at which certain QoS is achieved</i>		<b>Area traffic capacity</b> <b>0.1 - 10 Mbit/s/m<sup>2</sup></b> <i>Total traffic throughput served per geographic area</i>



# 5G Networks Deployment Schedule – When Will 5G Become Available?

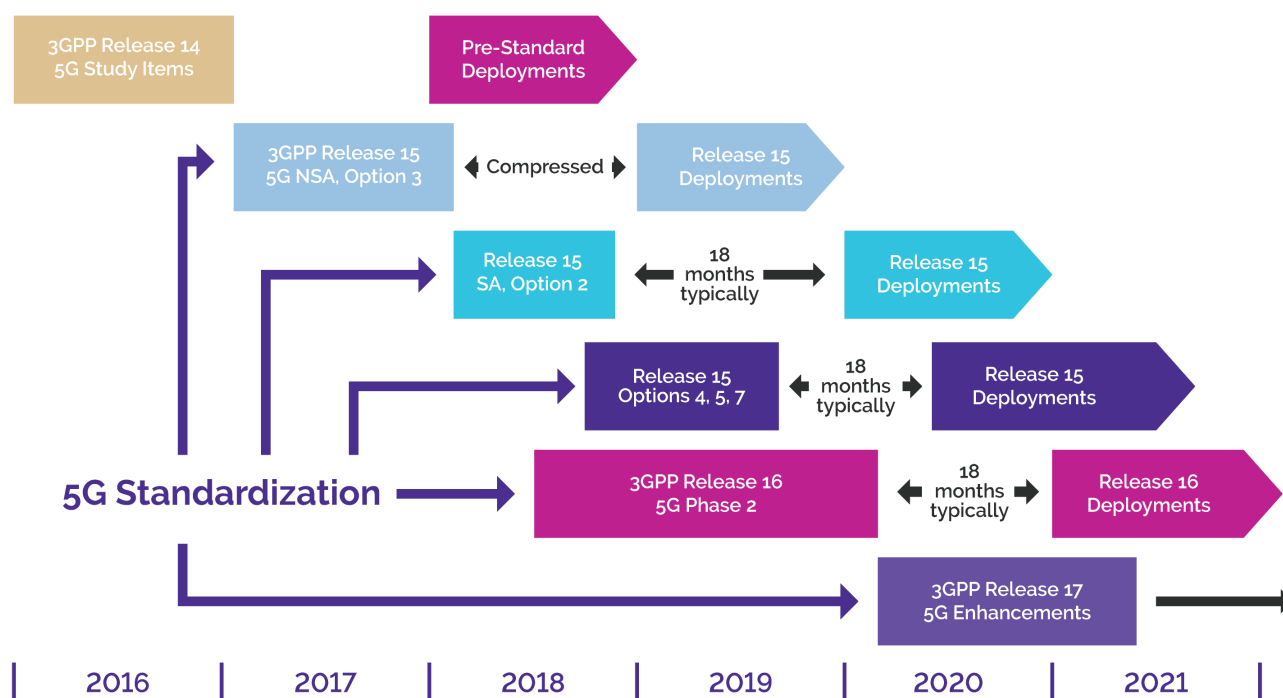
Ambitious 5G trials and pilots are currently being implemented in various parts of the world.

While the IMT-2020 will be finalized in 2020, there are already some commercial deployments of the 3GPP's Release 15 ongoing as well and they will continue into 2021 and beyond.

After this, it is expected that mobile operators will begin adapting their 5G networks to [3GPP Release 16](#), which defines higher performance standards and enhanced connectivity.

It's safe to say that a few mobile subscribers will have the ability to use 5G by the end of 2019 globally.

➔ Figure 2: 5G Timeline



NSA - Non Standalone

SA - Standalone

Option 2 (SA) - NR (New Radio) only radio access with 5G core network

Option 3 (NSA) - LTE (Long-Term Evolution) and NR radio access with LTE core network

Option 4 (NSA) and 7 (NSA) - LTE and NR radio access with 5G core network

Option 5 (SA) - LTE only radio access with 5G core network

3rd Generation Partnership Project (3GPP) is a standards organization which develops protocols for mobile telephony.

Source: Rysavy Research



# 5G Networks Speed Tests

5G brings a number of enhancements over 4G. These include high data speeds, low network latencies, increased reliability, lower power consumption and greater terminal device densities.

## In Theory

The 5G technology is meant to bring high data network speeds that can reach 10Gbps theoretically.



	1G	2G	3G	4G	5G
Theoretical download speed	2kbps	384kbps	56Mbps	1Gbps	10Gbps
Latency	N/A	629 ms	212 ms	60-98 ms	<1ms

As an example, a 4.5GB HD video would download in 4 to 40 seconds<sup>1</sup>.



<sup>1</sup> According to Canadian ENCQOR (Evolution of Networked Services through a Corridor in Quebec and Ontario for Research and Innovation)



## In Practice: Speed Tests in 2019

An early demonstration of 5G happened during the 2018 Winter Olympics in Pyeongchang where KT, Samsung and Intel deployed 5G SIG to deliver high-speed wireless broadband and low-latency live video streaming.

More tests have been conducted by mobile network operators in Asia, Europe and North America with encouraging results. Here are a few that were discussed during the World Mobile Congress 2019 conference.

✓ A test by Huawei of a 5G network achieved a speed of 1 Gbps, which is just as fast as 4G and fiber networks from leading telecom companies.

✓ Maxis, the second-largest mobile telecom operator in Malaysia, deployed a 5G network testing unit which reached maximum speeds of nearly 3Gbps, tripling the speed of the Huawei network.

✓ Qualcomm released results from a large batch of simulated tests, indicating that mobile phone users can expect speeds of 3Gbps and latency of less than 2 ms. While these are virtualized tests, they do conform to expectations of real-world 5G network architecture.

In contrast with these speeds, the highest speed reached by most 4G LTE networks usually approaches 100 Mbps at the upper limit, and typically hover below 50 Mbps.

In other words, at the low end, we can expect 5G networks to be somewhere between 10 to 20 times as fast as 4G LTE – and they could be up to 60 times faster.



# The Technical Innovations Behind 5G Networks

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## Network Softwarization

Among features expected from 5G networks, there is end-to-end flexibility<sup>2</sup>. It has been made possible thanks to "network softwarization" which is at the core of the innovation, transformation and acceleration of mobile networks.

Here are technologies that help "softwarize" networks.

### Network Functional Virtualization (NFV)

NFV replaces network functions on dedicated appliances – such as routers, load balancers, and firewalls, with virtualized instances running on commercial off-the-shelf hardware. This enables companies to reduce the cost of network changes and upgrades.

### Software-Defined Networking (SDN)

SDN allows the dynamic reconfiguration of network elements in real-time, enabling 5G networks to be controlled by software rather than hardware. This results in improving network resilience, performance and quality of service.

### Cloud-Radio Network Architecture (C-RAN)

C-RAN or simply RAN may still be in its early stages of development, but it is already essential to 5G networks. It is a technology that supplants the signal process units at mobile base stations with a distributed architecture (or "cloud") of processing nodes.

This technology will help reduce the cost of deploying dense mobile networks on small cells.

### Network Slicing

Network slicing separates a physical network into multiple virtual networks (logical segments) that can support different RANs or several types of services for certain customer segments.

This causes significant reduction of network construction costs by using communication channels more efficiently.



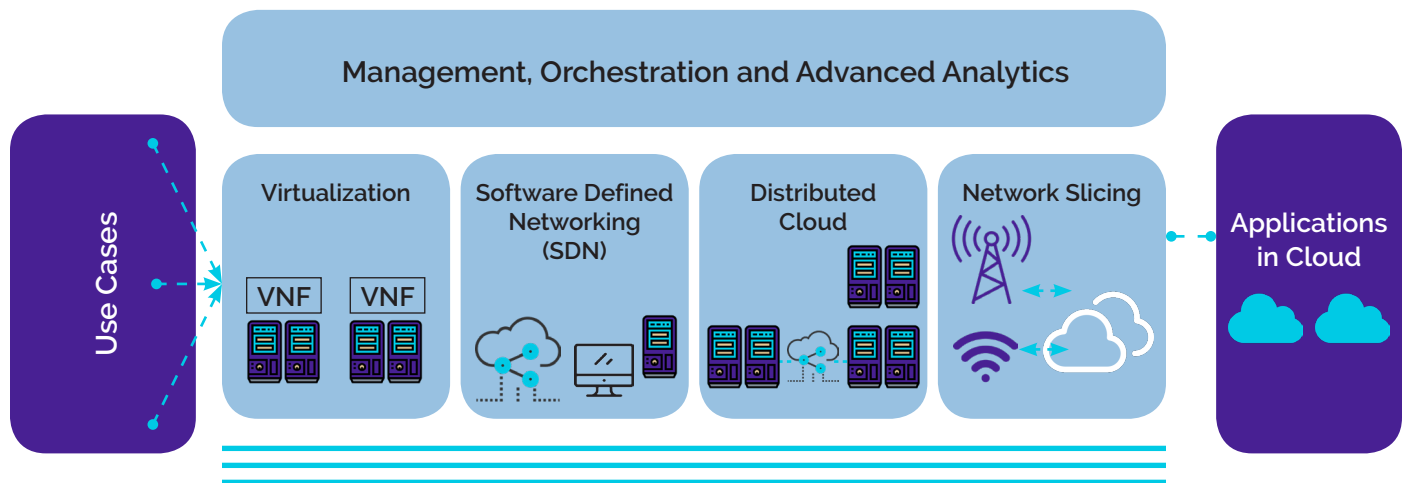
#### *Quick Note*

Network slicing introduces the ability to tailor mobile data services to specific use cases. For example, it will allow for infrastructure sharing between different companies. Or, it could help tune a single connection for different types of uses. On one slice, mobile operators would serve customers in need of high-speed connectivity, while on another, they would provide services that are not speed-dependent. This might force network operators to revise their charging models to adapt to capacity-based tariffication.

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<sup>2</sup> Source: ITU, "Setting the Scene for 5G: Opportunities & Challenges" (2018)

➔ Figure 3: Network Softwarization Technologies



Source: DotEcon and Axon, 2018

## Better Use of Spectrum Bands

Because of their popularity, mobile networks are highly used, which leads to performance issues such as latency or dropped connections. This is another issue 5G aims to fix.

Wireless communications networks use radio frequencies. Television, radio, and mobile

networks have been assigned different radio bands for their transmission needs. Over time, the decommissioning of previous versions of these services have left licensed spectrum bands unused. 5G is set to recycle those vacant frequencies to significantly boost network performance and capacity.

### 5G technology has defined two sets of frequencies<sup>3</sup>:

- ✓ The FR1 group is currently in use, with deployed services on 450 MHz to 6 GHz frequencies
- ✓ Research is still ongoing for the FR2 group that comprises extremely high frequency (EHF) or millimeter wave (mmWave) bands, ranging from 24 to 52 GHz.

Millimeter wave bands come with some drawbacks too: lower coverage and inability to travel through buildings and obstacles.

<sup>3</sup> Source: TechRepublic, 5G Mobile Networks: An Insider's Guide (2018)



# Combining Technologies to Improve Data Transmission

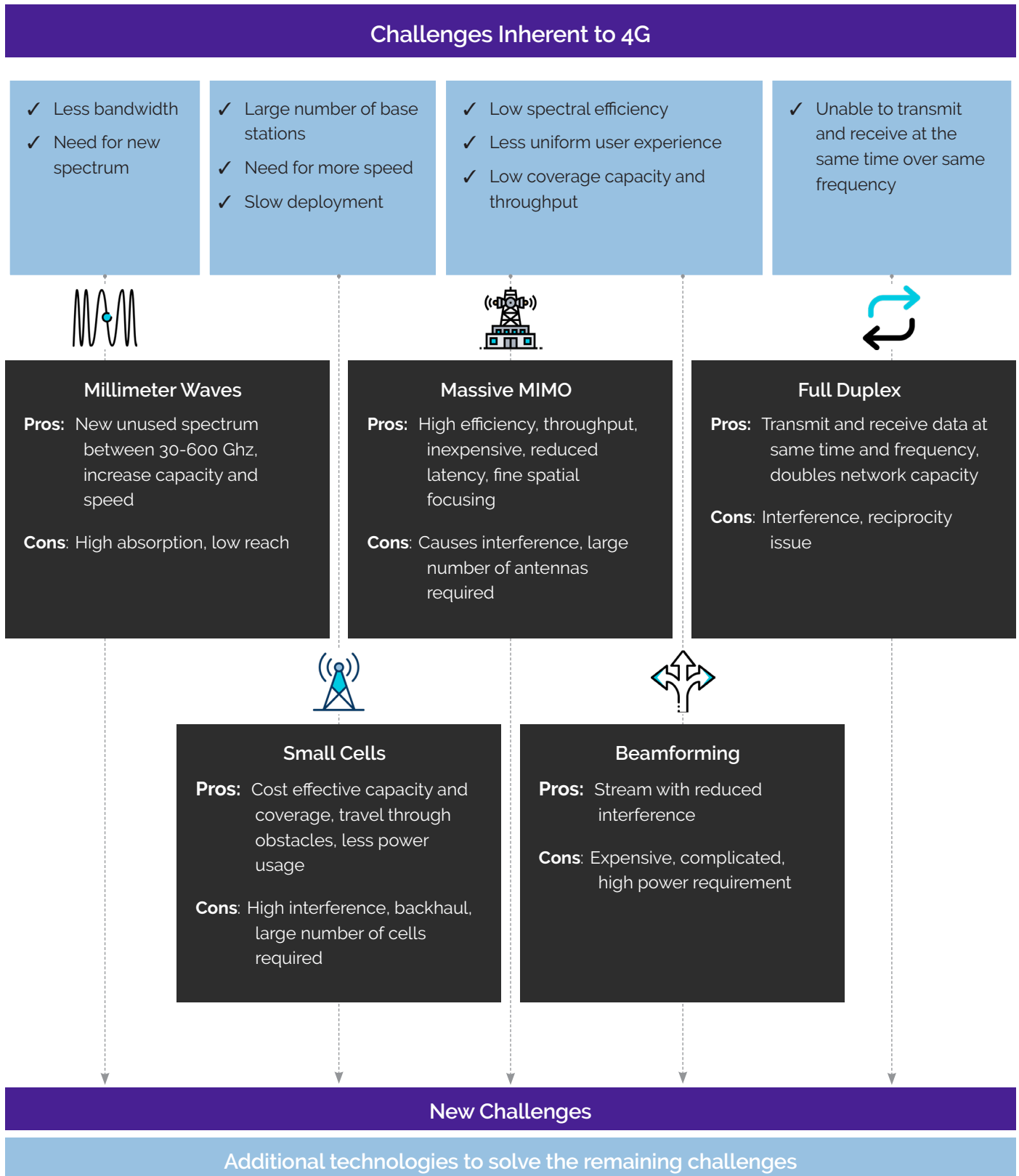
It takes different solutions to achieve 5G capacity. Many of them have already been explored and integrated into the architecture.

Small Cells	Massive MIMO	Beamforming	Full Duplex
Small cells make it possible to have hundreds of miniature base stations replace a single traditional one.	Massive multiple-input multiple output (MIMO) combines dozens of transmission antennas into one array.	Beamforming will use massive MIMO to carry more data from a larger number of users, with an improved signal and a data stream that can travel further distances.	The innovative and yet-to-come full duplex will make it possible for transceivers to use the same frequency for transmitting and receiving data simultaneously.

By combining these techniques, 5G can solve 4G inherent issues and augment propagation capabilities.



➔ Figure 4: Key technologies to enable 5G



Source: DotEcon and Axon

# Native and Enhanced Security

There are 5 properties that contribute to the trustworthiness of the 5G system<sup>4</sup>.



Source: Ericsson, 2018

## Resilience

5G resilience to cyberattacks and non-malicious incidents comes through a variety of complementary and partially overlapping features.

## Communication Security

The new Service Based Architecture (SBA) for core network communication takes threats from the interconnect network into account from the start.

## Identity Management

5G includes secure identity management for identifying and authenticating subscribers, roaming or not, ensuring that only the genuine subscribers can access network services.

## Privacy

Encryption protects data traffic, including phone calls, internet traffic and text messages. 5G also integrates protection for subscriber identifiers and detection of false base stations.

## Security Assurance

3GPP and GSMA (that represents the interests of mobile network operators globally) define the network equipment security assurance scheme (NESAS), which is suitable to the telecom equipment lifecycle.

<sup>4</sup> Ericsson, 5G security - Enabling a trustworthy 5G system, 2018



# Economy: New Revenue Streams and Benefits of 5G

## 5G Global Economy Input

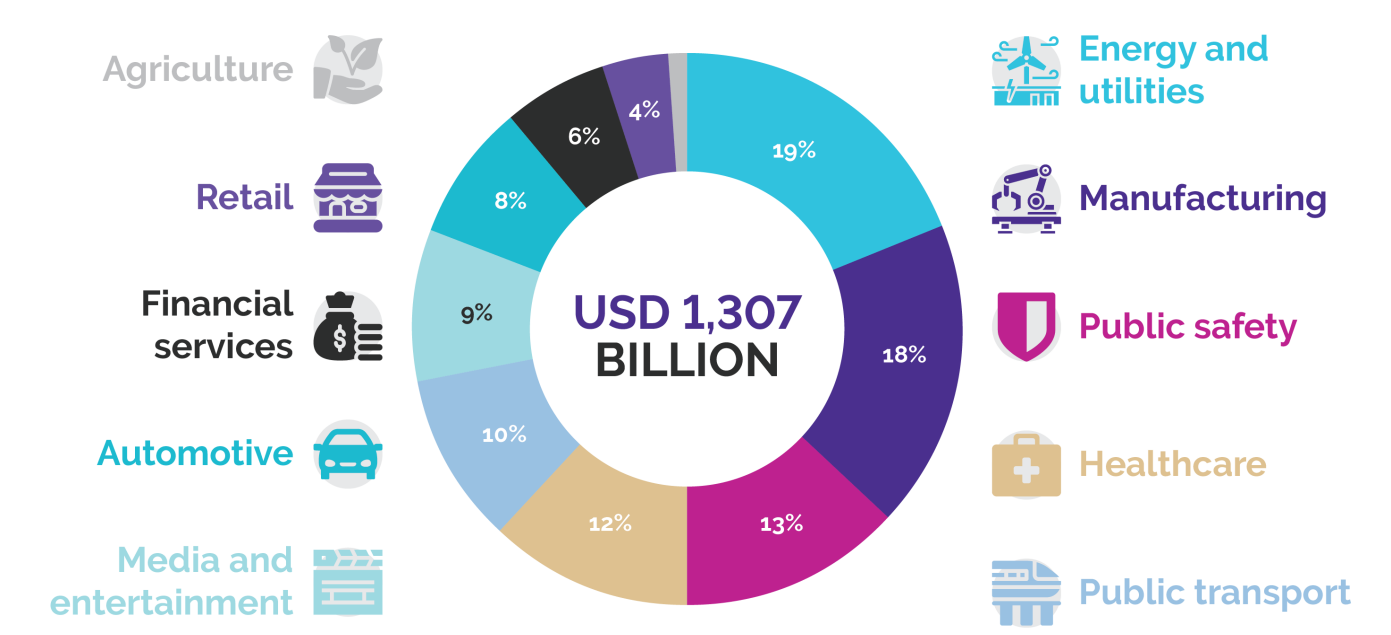
IHS<sup>5</sup> estimates that 5G will enable \$12.3 trillion of global economic outputs in 2035. This figure exceeds the combined 2016 consumer spending in China, Japan, Germany, the United Kingdom, and France.

The global 5G value chain will generate \$3.5 trillion in output and support 22 million jobs in 2035. This was the approximate cumulated 2016 revenue of the top 13 Fortune Global 1000 companies.

It is expected that 5G value chain will invest an average of \$200 billion annually for the expansion and reinforcement of 5G network and business application infrastructure.

From 2020 to 2035, the forecasted total of annual contributions to global GDP growth will reach US\$3 trillion.

➔ Figure 5: 5G-enabled industry digitalization revenues for ICT players, 2026<sup>6</sup>



Source: Ericsson and Arthur D. Little, 2017

5 IHS, "The 5G economy: How 5G technology will contribute to the global economy" (2017)

6 Ericsson and Arthur D. Little, The 5G Business Potential Second Edition, 2017

# Use Cases of 5G

When it comes to 5G, there are three categories of usage scenarios and applications, with less or more transformative economic impact.

## Enhanced Mobile Broadband (eMBB)

Extension of cellular coverage and network capacity improvement are both key to the adoption and value creation in the 5G economy.

eMBB encompasses all efforts towards the expansion of current 4G capabilities throughout 5G, that we find in the 3GPP Release 15.

Mobile operators are busy deploying small cells in industrial areas, shopping centers or any kind of building with high human density. This will result in massive mobile broadband availability indoors and outdoors, providing end-users with consistent experience globally.

**eMBB is essential to the success of rich and immersive media applications, such as:**

- ✓ Augmented and virtual reality (AR / VR)
- ✓ 4K and 360 degrees live video streaming
- ✓ Collaboration and education
- ✓ Digital signage

## Ultra Reliable and Low Latency Communications (URLLC)

URLLC covers scenarios that are highly latency-sensitive or mission-critical, and that require resilient, instantaneous and extremely secure connectivity.

These are emerging markets with revolutionary applications that are yet to be delivered, as 5G deployments and standardization projects are still ongoing. They will probably be available once 3GPP Release 16 is rolled out.

**Examples of URLLC use cases include:**

- ✓ Autonomous vehicles
- ✓ Drone delivery
- ✓ Telesurgery
- ✓ Smart grids
- ✓ Platooning

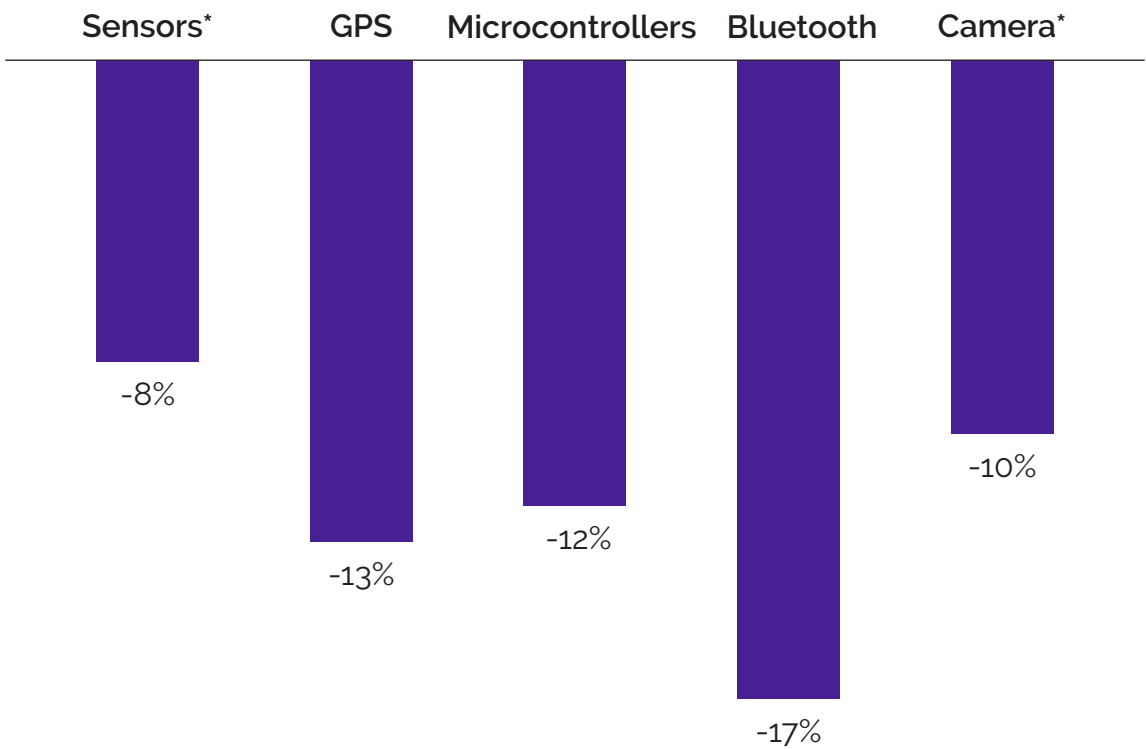
## Massive Machine Type Communications (mMTC)

Industry 4.0 is already at our doorstep, revealing high potential applications for any sector. Moore's law is more than relevant in this context, with manufacturers releasing faster semiconductor components that consume less power, at a lower cost.

This has a positive impact on economies of scale. It is becoming more affordable for companies of any kind to benefit from advanced sensing, metering, and monitoring applications that use intelligent sensors in machinery connected to wireless networks.

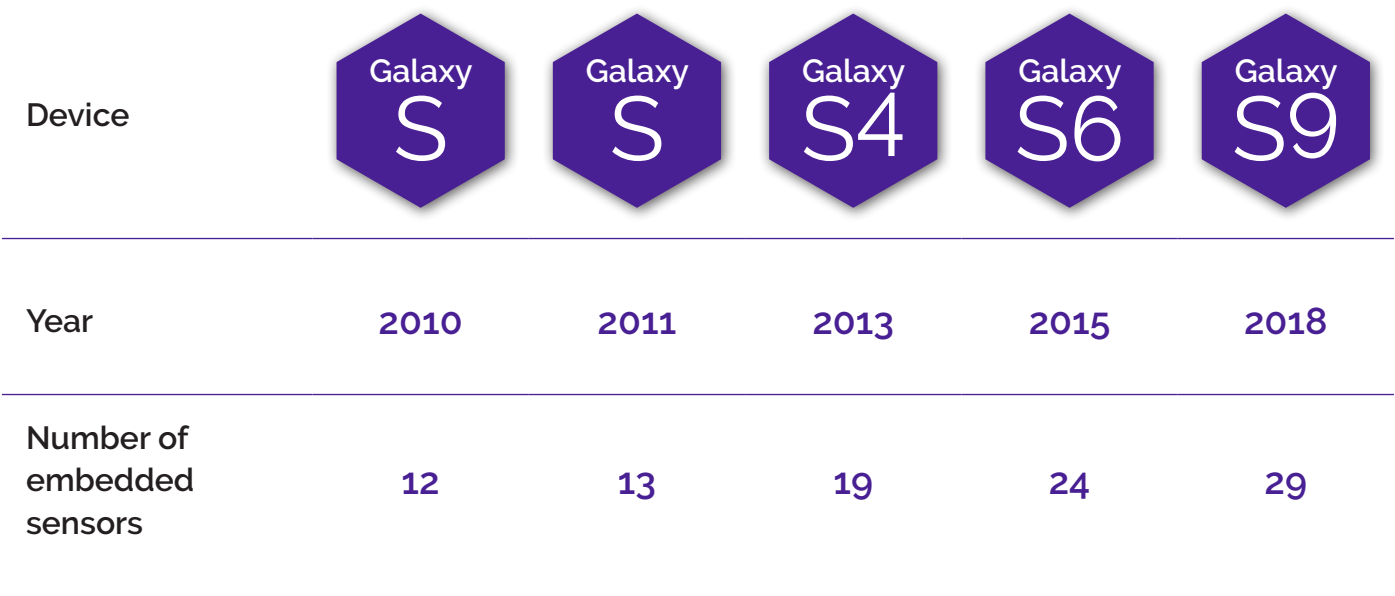
A study<sup>7</sup> revealed that the average selling price for such smart components decreased by around 12% year over year, from 2012 to 2016.

➡ Figure 6: Average selling price YOY change (2012 - 2016)



The following illustration inspired from the same study shows the number of sensors embedded in different versions of Samsung Galaxy S smartphones. While these are not industrial equipments, the figure still gives a clear example of the availability of sensors and how they have become more affordable.

➡ Figure 7: Evolution of the number of sensors in Samsung S devices



<sup>7</sup> Source: Gartner, ARM Holdings, and Raymond James research. Sensors refer to MEMS sensors and Camera refers 1.8 MP CMOS Sensor



Finally, it is likely that mMTC will leverage vacant frequency bands previously used by analog television or 2G/3G mobile communication to deliver these Internet of Things capabilities.

Here are examples of mMTC use cases:

✓

Precision farming

✓

Smart cities and homes

✓

Remote monitoring

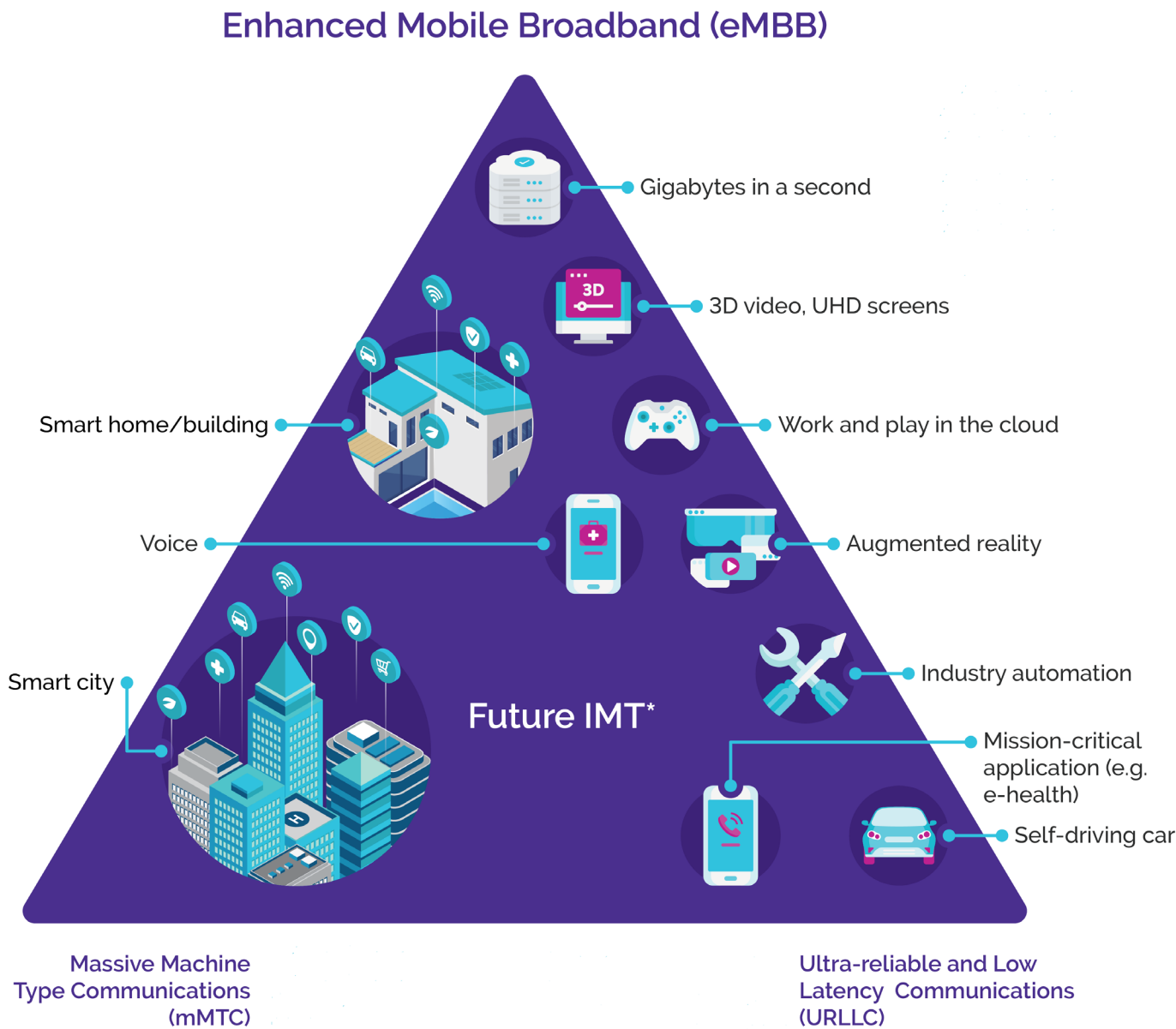
✓

Smart metering

✓

Logistic tracking

➔ Figure 8: IMT-2020 usage scenarios

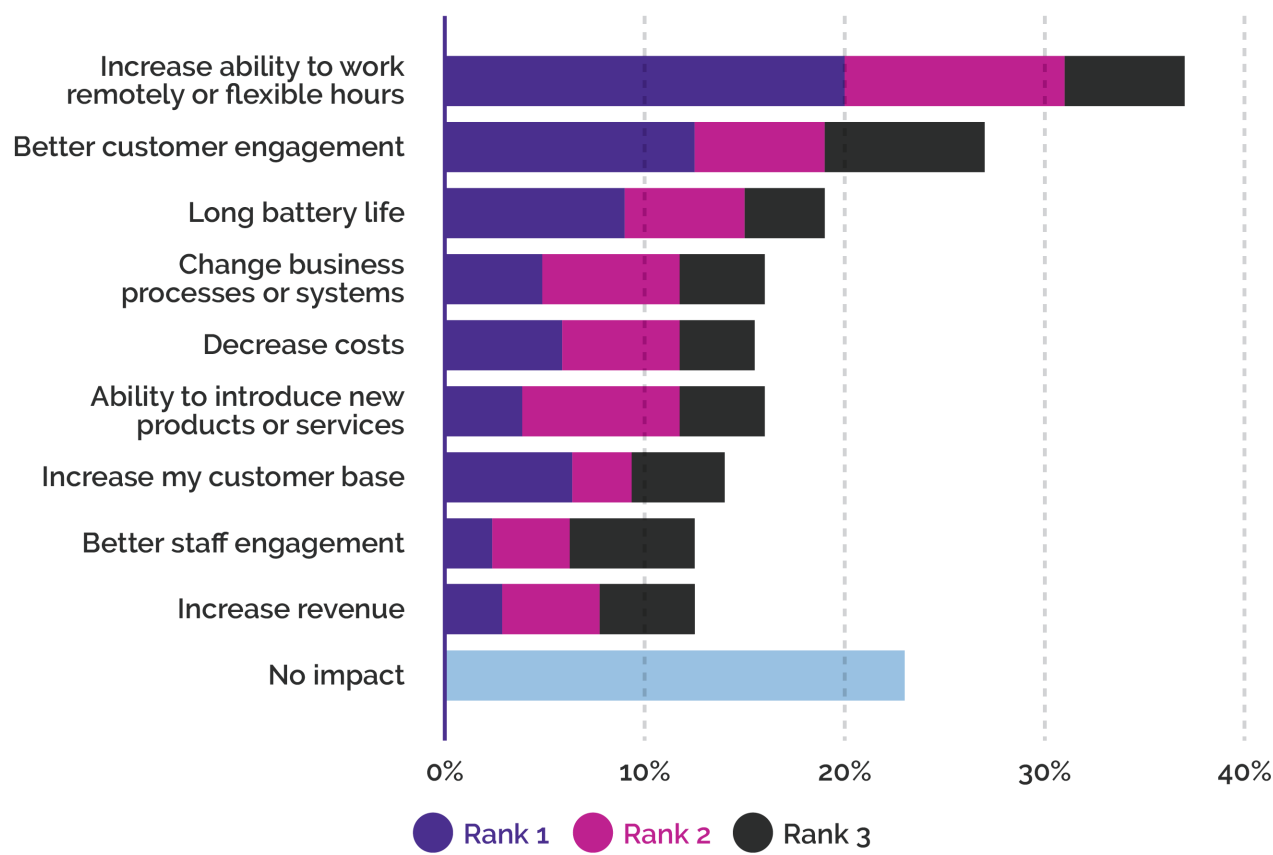


# 5G Benefits for the Economy

Whether it is through eMBB, URLLC, or mMTC, 5G technology will definitely contribute to the global economic growth with new business opportunities, augmented productivity and increased workforce participation.

A Deloitte survey<sup>8</sup> reveals that 12% of businesses list better customer engagement as the top benefit, while 6% believe 5G will enable them for lower costs.

➔ Figure 9: Benefits of 5G enabled technology



Source: Deloitte and Research Now

8 Deloitte, 5G Mobile Technology: Are Businesses Ready to Seize the Opportunity, 2018

# Getting Ready for the Killer Apps of 5G with Fog and Edge Computing

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As we have seen, almost all industries see an opportunity in 5G. Immersive applications such as AR/VR are the first wave of killer apps that will make the usage of this technology a reality.

Research for 5G is ongoing not only on the mobile network operators' side, but also on the information technology (IT) providers' side.

It is necessary for companies to quickly adapt their strategy so they can fully benefit from 5G. This requires a progressive upgrade of both their infrastructure and software solutions.

Fog and edge computing are important fields that are laying the foundation of the next generation of IT. They are a decentralized method of computing, that focuses on bringing processing capabilities closer to where the data is generated.

Fog and edge computing aim at leveraging the 5G infrastructure being deployed to host IT processing nodes. Technically, this would be done by deploying small data centers (or "cloudlets") along with or within transmission equipment.

Having processing power in different geographical areas will help handle a larger percentage of workloads locally and respond to real-time analytics needs. In other words, this will bolster the usage of the Internet of Things (IoT) and Big Data.

The main challenge for distributed or decentralized computing is to give companies the tools to manage geographically scattered infrastructures as one single, coherent architecture.

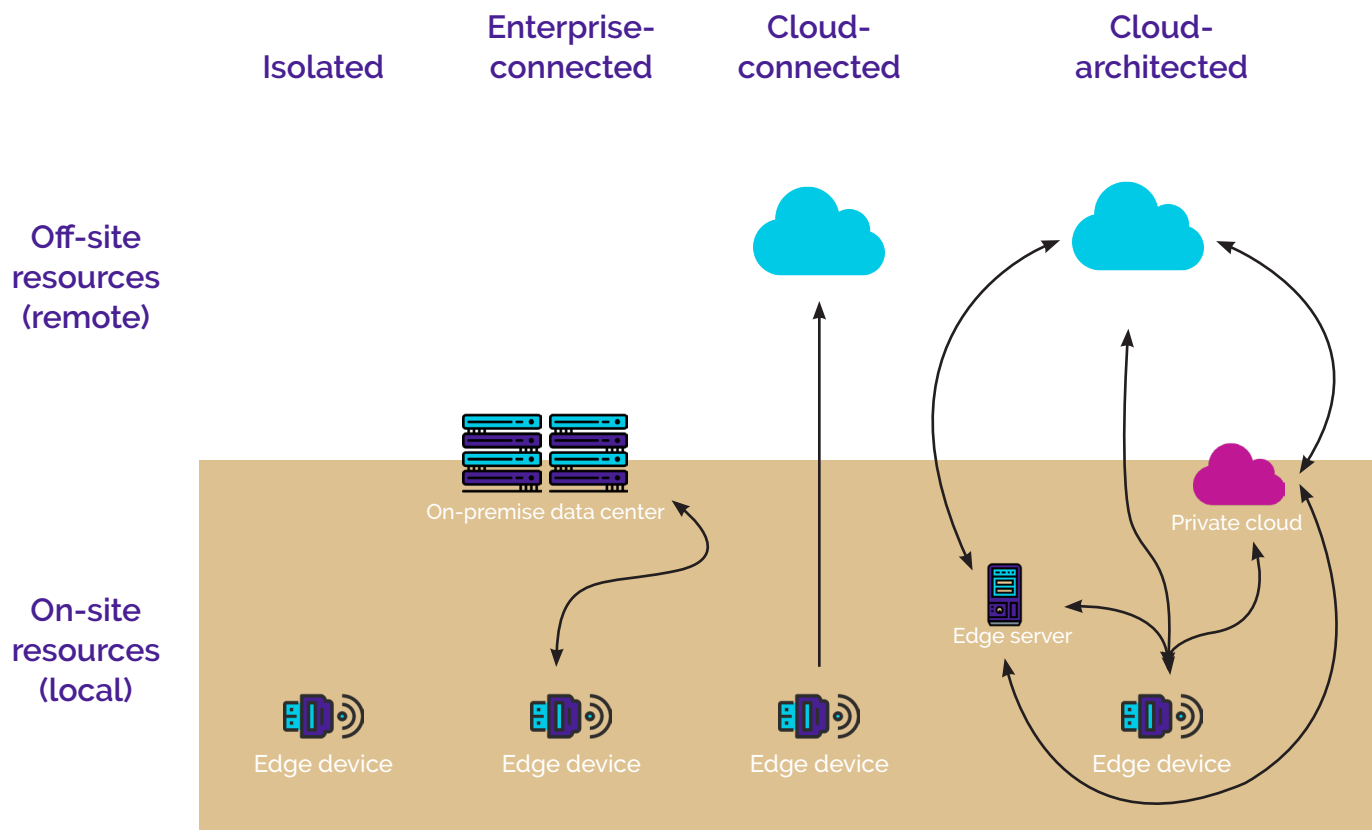
Fog and edge computing are addressing the shortcomings of the popular cloud computing technology. Clouds have failed to solve the critical issues of network latency, data privacy, scalability, ubiquitous mobility, and the decentralization of computing.

Cloud and distributed computing are meant to cohabit. Clouds will continue to provide centralized IT resources for heavy-load processing, archiving, and platform management. Fog and edge computing will focus on enabling eMBB, URLLC and mMTC use cases.





➔ Figure 10: Edge computing complements cloud computing by bringing cloud services to the edge



Source: Goldman Sachs, The Cutting Edge of Computing, 2018



## About Ormuco Inc.


Founded in 2008, Ormuco's mission is to be a leader in the deployment of edge computing as the preferred solution for data processing.

The company enables the delivery of real-time solutions based on innovative technologies such as AI and machine learning to businesses and users worldwide.

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