5G: THE NETWORK TECHNOLOGY OF TOMORROW

5G is the latest mobile network which is currently being deployed worldwide, stimulating many interesting discussions about the technology and its use cases. It has promised an increase in wealth creation opportunities due to its ability to provide wider network coverage, reliable network connections and faster data transfer.

REPLY specialises in the design and implementation of solutions based on digital media and new communication channels. Through its network of highly specialised companies, Reply partners with major European corporations in the telecoms and media, industry and services, banking and insurance, and public administration sectors, to devise and develop business models built on the new paradigms of big data, cloud computing, digital media and the Internet of Things. Reply's services include: Consulting, Systems Integration and Digital Services.

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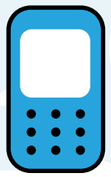
ENABLING SYSTEMIC TRANSFORMATION

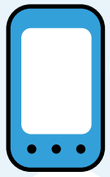
5G is much more than a linear evolution from 4G. Past mobile generations answered the need to connect people to other people first and then to data and services on the internet at a later stage.

5G is the answer to the **Internet of Everything** society where objects are smart and autonomous and connectivity must be pervasive, immediate, reliable.

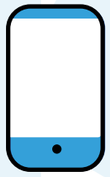
1980s
Analog voice
AMPS, NMT, TACS, JTACS



1990s
Digital voice
AMPS, PDC, GSM, CDMA



2000s
Mobile Broadband
WCDMA/HSP/ CDMA2000



2010s
Faster MBB
LTE, LTE

5G MAGIC TRIANGLE: SERVICE FAMILIES

The technologies that are an integral part of 5G networks can be grouped into three broad categories, usually represented in the following triangle.

EXTREME MOBILE BROADBAND (EMBB)

Provides **extreme high data-rate**, and **extreme coverage**. eMBB provides a more uniform experience over the coverage area, and graceful performance degradation as the number of users increases. eMBB will also support reliable communication for e.g. National Security and Public Safety (NSPS).

Key benefits:

- Extreme throughput
- Enhanced spectral efficiency
- Extended coverage

MASSIVE MACHINE-TYPE COMMUNICATION (MMTC)

Provides **wireless connectivity** for tens of billions of very simple network-enabled devices, **scalable connectivity** for increasing number of devices, efficient transmission of small payloads, wide area coverage and deep penetration are prioritized over data rates.

Key benefits:

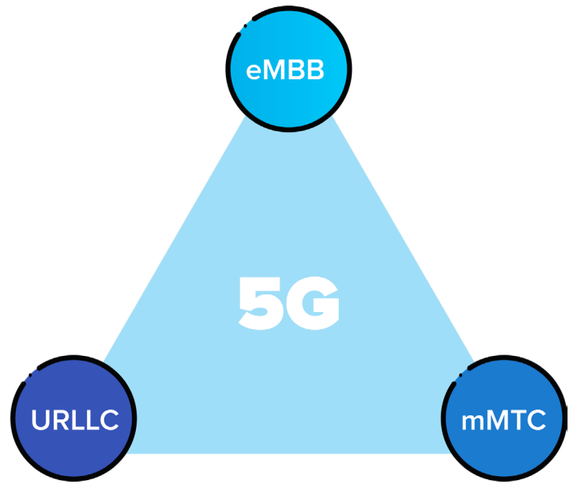
- High connection density
- Energy efficiency
- Low complexity
- Extended coverage

ULTRA-RELIABLE LOW-LATENCY COMMUNICATION (URLLC)

Provides **ultra-reliable** and **low-latency communication** links for network services with extreme requirements on availability, latency and reliability, e.g. V2X communication and industrial manufacturing applications. Reliability and low latency are prioritized over data rates.

Key benefits:

- Low latency
- Ultra reliability
- Location precision



5G NEW CAPABILITIES: PERFORMANCE & FLEXIBILITY

5G will bring new or enhanced capabilities to address the needs of many different industries, with the potential to transform or even disrupt some of them.

5G is mastering the magic triangle of bandwidth, latency and connection density while challenging the borders of physics and requiring a lot of engineering creativity and skills. This is reflected in the application of **numerous new technologies** - pictured below.

Network Slicing
Service differentiation, beyond Internet model

Ultrabroadband
20/10Gbps peak,UHD Media

Security
Natively embedded

Latency
<5ms on radio access

Device density
1 million per Km²

Device Relay
Extended coverage

Frequencies
mmWave (26-100Ghz)

MEC
Intelligence on Edge

Reliability
Fiber-like bit delivery

ULTRA BROADBAND & FREQUENCIES SPECTRUM

Network speed is the only feature that has been enhanced in past mobile networks, and 5G will improve it further to compete with fiber connectivity.

The Peak Data rate will be 20/10Gpbs in down/upstream allowing the **instantaneous transfer of huge amounts of data**, whether it's a NMR exam to share for a remote diagnosis by an expert or the party's avatars in an holographic call during call setup.

Other broadband KPIs will improve like the area traffic capacity reaching 10Mbps/m², meaning that under well designed coverage every spectator sitting in a stadium can view a live video streaming on their smartphone.

5G will benefit from the usage of a much wider frequency spectrum than previous mobile networks. There are 3 main ranges of frequencies involved.

<1 Ghz, mainly around 700Mhz: serve for **nationwide coverage**, with very large cells, but won't reach high throughput, and are suitable for IoT and pervasive communication.

3-6 Ghz, mainly around 3.4-3.8Ghz: they'll have smaller cells, are suitable for densely populated areas and will support **stronger throughput requirements** (best trade-off between coverage and throughput).

>25 Ghz, mainly around 26Ghz, 37Ghz, 64-71Ghz (TBV): cell size is very low (10-100m) and reduces transmission through walls, but reach peak data rates and are suitable for very localized and **dense use case**.

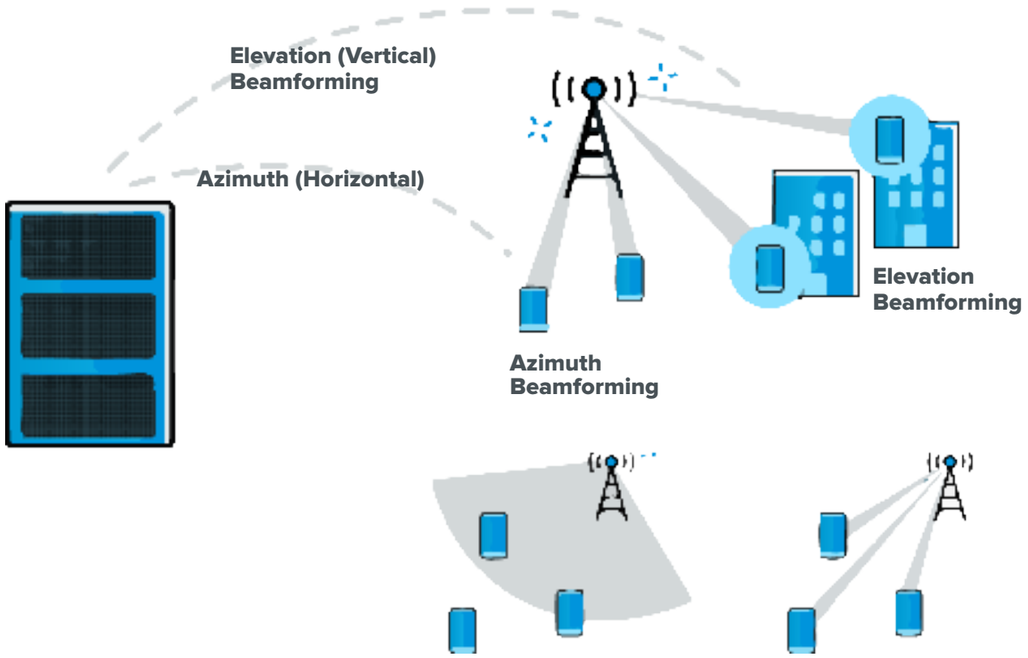
FREQUENCY RANGE 400 MHz - 1 GHz	FREQUENCY RANGE 1 GHz – 30 GHz	FREQUENCY RANGE 30 GHz - 60 GHz
EXTENSION Coverage	EXTENSION Macro capacity	EXTENSION Hotspot capacity
CELLS Large	CELLS Small	CELLS Ultrasmall

FREQUENCIES: INTELLIGENT ANTENNAS - BEAMFORMING

Beamforming leverages on constructive interference of existing antennas to send a single focused signal to each and every user in the cell coverage and monitor each user to make sure they have a consistent signal during time.

It maximizes the received signal energy resulting in significantly improved coverage wherever the user is, not only on ground but also in terms of elevation.

This will enable us to remotely control drones at elevations not made possible with today's mobile network and also create broad availability for a fixed-wireless access (FWA) scenario. It also contributes to the improved energy efficiency of 5G.



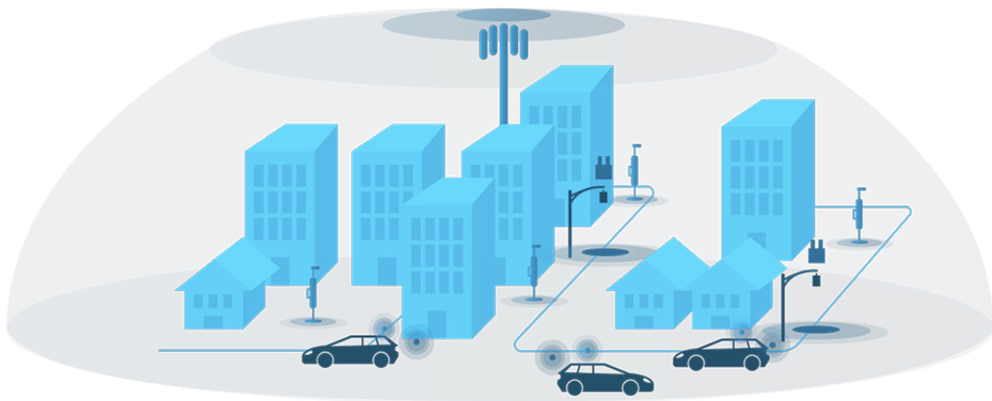
LOW LATENCY: WHAT IT IS AND WHAT IT IS GOOD FOR

If you need to connect autonomous and smart things, latency matters. While human reaction time is around 100ms, robots in a factory, vehicles on roads, drones and many other things move and react in a fraction of a ms.

For an **autonomous car** a few milliseconds delay in receiving info from other cars or vulnerable users can make all the difference in avoiding an accident. Industrial robots will be **wirelessly connected** to a central intelligence that will control them in real time. Machinery in dangerous environment will be **driven remotely** by experts who stay in a safe workplace, 5G latency will reach 1ms on the radio link.

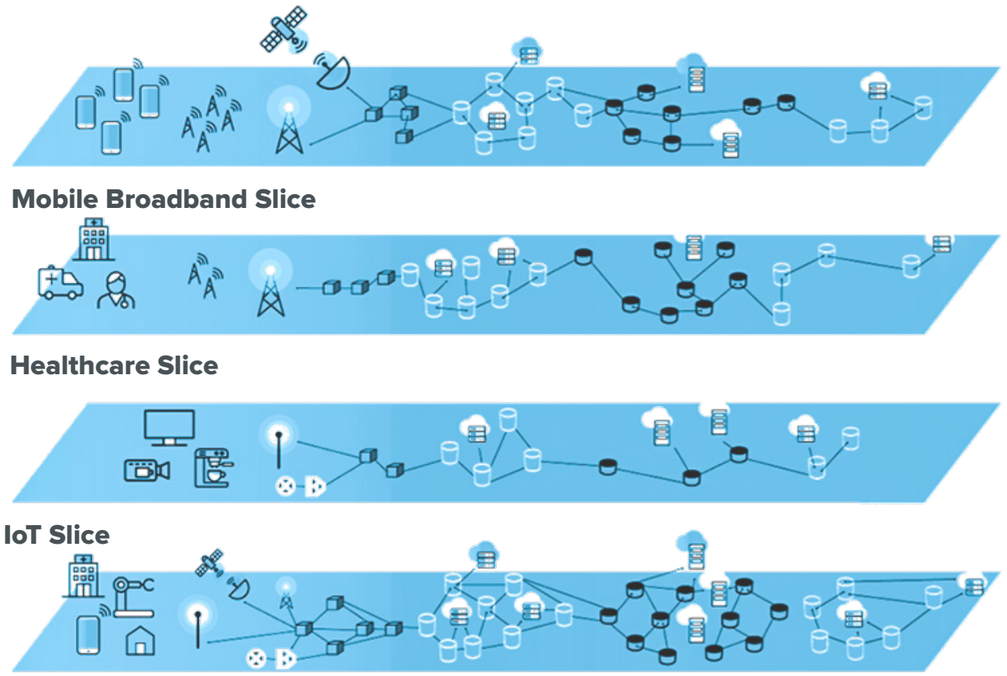
MEC - MULTI ACCESS EDGE COMPUTING

As 5G latency performance is on the radio link only, data needs to be processed "near" the antenna, to avoid losing any time to transfer data further. MEC offers application developers and content providers, cloud-computing capabilities and an IT service environment at the edge of the network. The edge keeps the traffic and processes local, with a key goal of granting **ultra low latency** and **high bandwidth** to applications.



NETWORK SLICING: SHAPING THE KPI YOU NEED

Network slicing creates a dedicated independent end-to-end logical network that runs on a single shared physical infrastructure, capable of providing an agreed and negotiated service quality.



Network slicing is a truly new concept in mobile networks and it promises to transform what was a “best effort” network into one which is much more reliable, at least somewhere and sometimes.

It will be possible to enable police offers to transmit **live video** from their wearable cams to the control room even from very crowded locations, and to grant the reliable latency to help them with supporting **monitoring with drones**.
Or a premium customer can watch their favourite sport match in 4K quality on mobile where others could not. By 2022, 20% of use cases will be derived from network slicing scenarios (service-driven, organization-delivered or event based slicing scenarios).

Network Slicing key features:

- Slicing **optimizes resource usage** (autonomous cars dont need Gb/s, HD streams dont need 1ms latency)
- Slicing enables **new business model**, reduces time to market, niche opportunities.
- Every slice includes requirements only for a subset of KPIs and at specific SLA.

DEVICE DENSITY: IMPACT ON SMART CITIES

Smart cities of the future will be very densely populated in terms of smart sensors, actuators and other kinds of objects. Every parking lot, street lamp, bench, traffic light, meters and much more will be connected as well as clothes, vehicles, buildings, etc.

Even if they exchange a few bytes a day they must be connected, that’s why 5G networks are designed to support up to 106 device per km², much more than today's mobile networks. Many of those sensors will only have an affordable business case if they are able to last years with a battery (parking sensors underground, gas meters, etc) and 5G will support low-power modes to enable this.

SECURITY AND RELIABILITY: MUCH MORE THAN 4G

5G leverages on 4G and will improve its security in different areas:

RESILIENCE
The resilience of the 5G system is achieved through a variety of complementary and partially overlapping features. For example, network slicing isolates groups of network functions. In addition, lower latency in mobility allows security-relevant functions processing in the base station.

COMMUNICATION SECURITY
The security design follows similar principles as the 4G system but has been further developed to better meet the requirements of new applications. In particular, the new SBA for core network communication takes threats from the interconnected network from the outset into account.

IDENTITY MANAGEMENT
At the heart of the 5G system is a secure identity management system that identifies and authenticates subscribers, regardless of their location, so that only the real subscribers have access to network services. It is based on strong cryptographic primitives and security features already present in the 4G system.

PRIVACY
Data traffic is protected by state-of-the-art encryption. Devices and networks authenticate each other and use integrity-protected. For example, 5G systems can detect the presence of incorrect base stations from the data in the measurement reports collected by the devices.

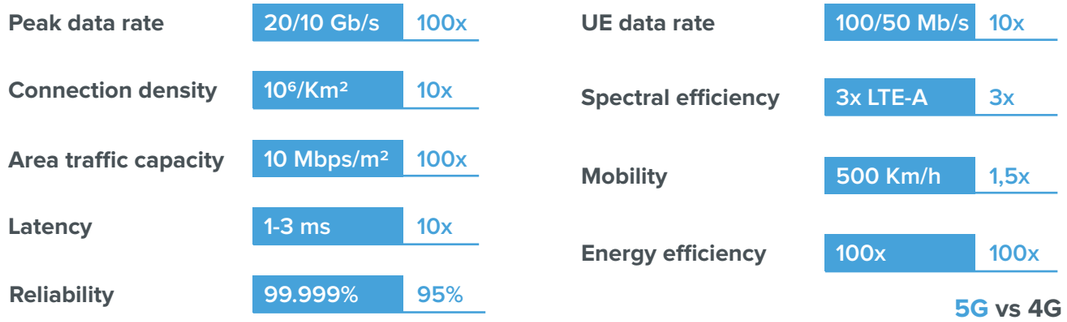
5G network reliability is defined as the capacity to deliver 99.999% of a data packet without errors in 1ms and it implies a 99.999% availability of the network itself.

Even if many protocols can recover data errors through retransmission either this will increase latency above a limit not acceptable for many use cases (autonomous driving, remote control, etc.) or it's not supported in some scenarios (real time video streaming, etc.). For these reasons reliability and availability are key features for all critical applications.

DEVICE RELAY: COOPERATIVE COMMUNICATIONS

Device relaying makes it possible for devices in a network to function as transmission relays for each other and realize a mesh network.

This is possible through **device-to-device** (D2D) communication, which allows two nearby devices to communicate with each other in the licensed bandwidth without a base station (BS) involved or with limited BS involvement. D2D communication can be of critical use in natural disasters replacing the damaged communication network, or simply allowing a device at the edge of a cell or in a poor coverage area to communicate. D2D can enable new kinds of services, but is dependent on how much operators will allow this new scenario.



HOW CAN REPLY SUPPORT YOU

Reply wants to become a point of reference for a real and rapid development of projects and services based on the 5G network.

Reply is working on the most relevant business opportunities for 5G by mainly analyzing the impact of 5G on different industries and designing different Use Cases for PoC or Trial, to offer to its customers. Use cases in analysis are for example, **360° live streaming**, **Smart Grid, Telecare, autonomous drones and AGVs**. 5g@reply.com