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CONFERÊNCIA

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# Tecnologia e Sustentabilidade


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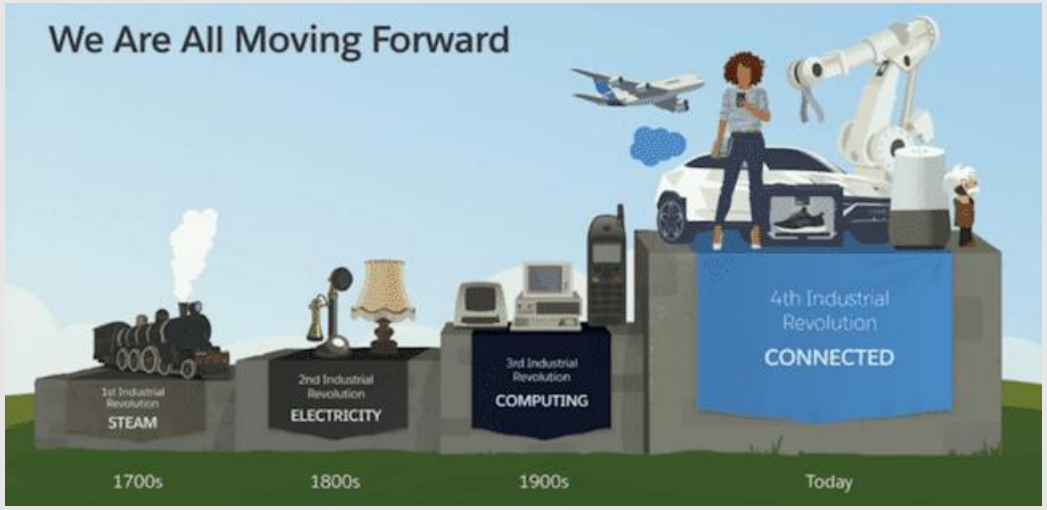
# 1. The Digital Transformation

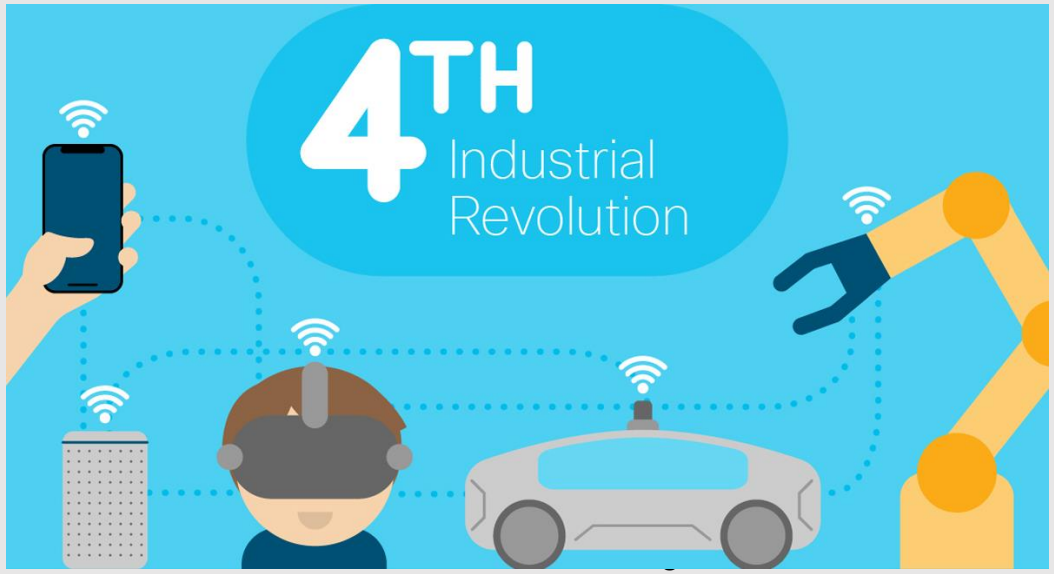
## What is “Digital Transformation”?

- Analog Electronics (Fourties)
- Phase 1: Digital Electronics (Eighties)
- Phase 2: All-over-IP
- **Phase 3: Automation** || 4rd Industrial Revolution (ecology vs technology – strategy of EU) – *Knowledge Age*

3rd Industrial Revolution

*Information Age*



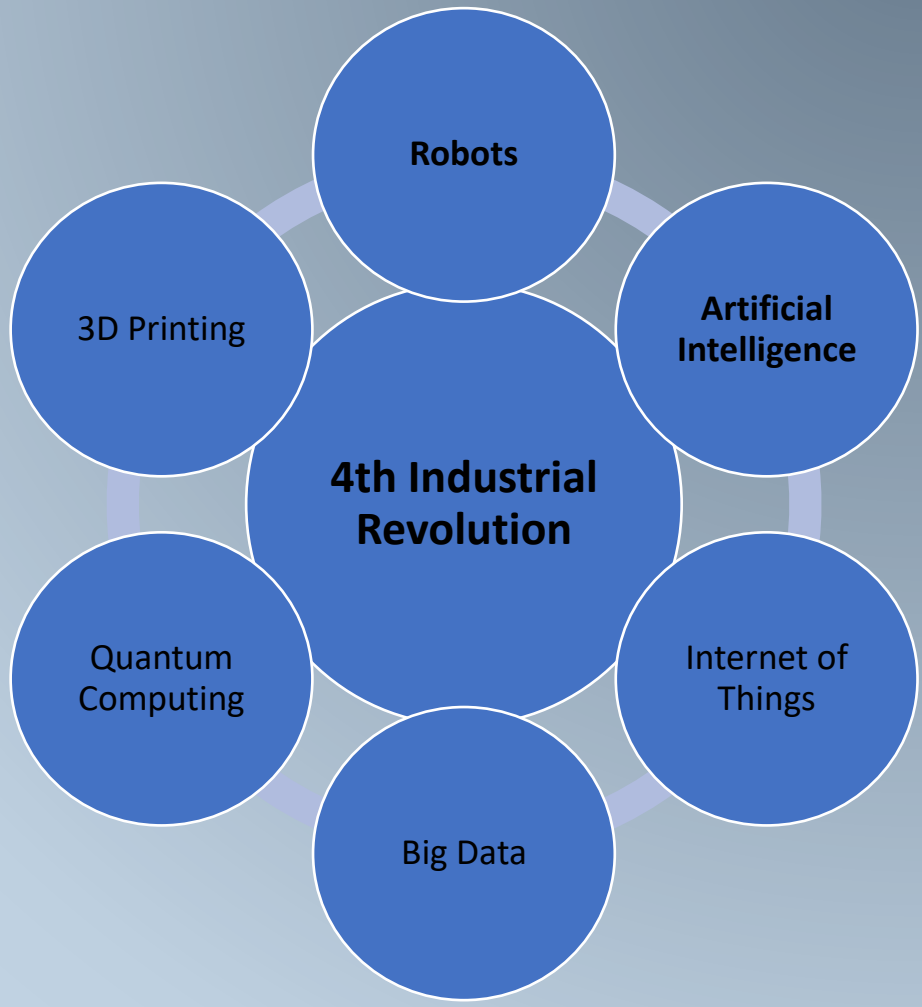
# 1. The Digital Transformation

The **4th Industrial Revolution** is characterized by the **massive use of Robots**, as well as **Artificial Intelligence, Big Data, Internet of Things, 3D Printing, Quantic Computing**.

More **eficiente use of the Resources**.

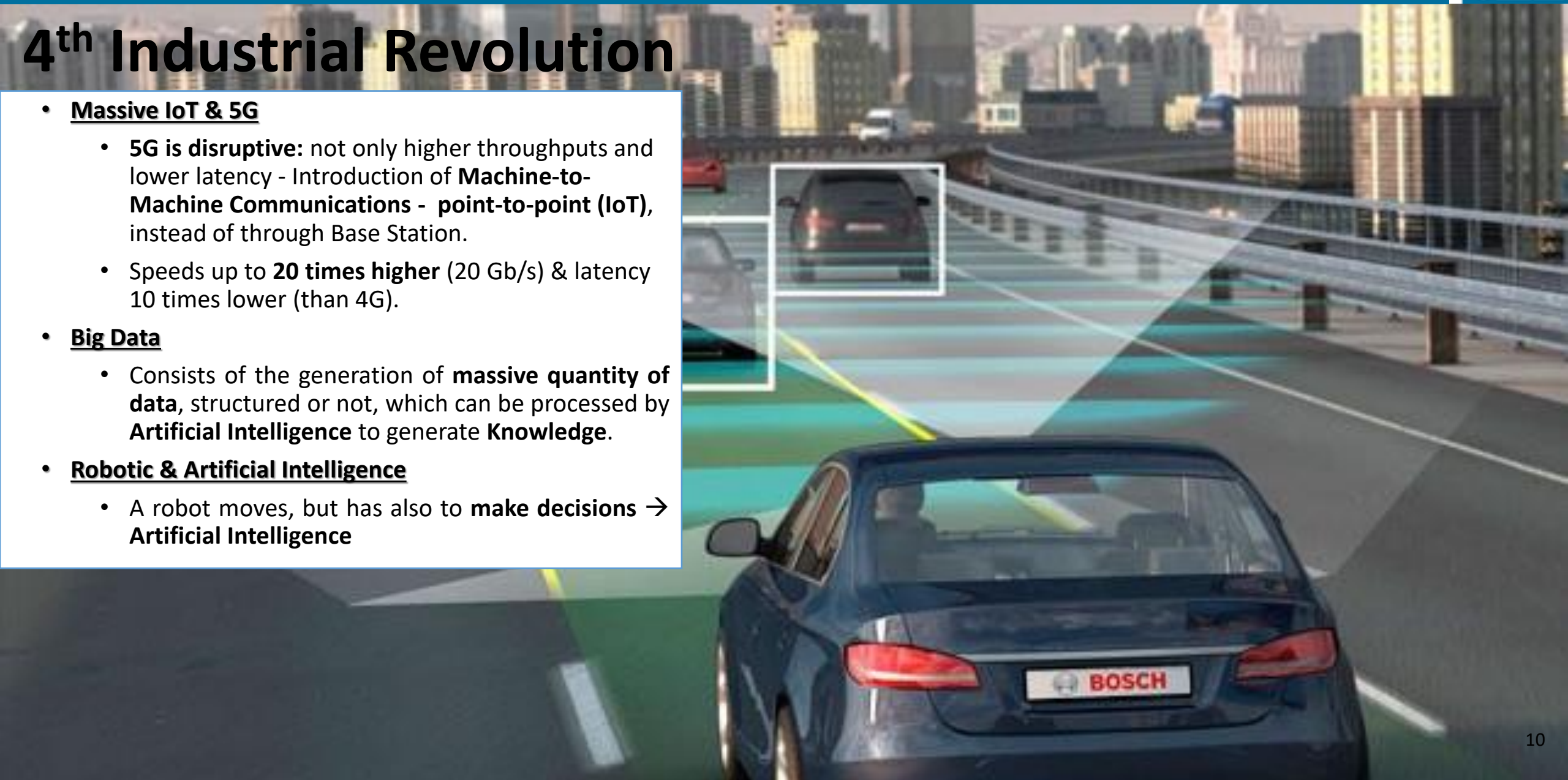
These technologies potentiate the **replacement of Humans by Robots** in diferent areas.

- **Some Jobs disappear, others are created**, requiring a great human **adaptation** to this new **Paradigm**.
- **Knowledge Age – routine decisions (or their support) are implemented by machines.**
  - **Scientific, technical and human skills**, critical thinking, emotional intelligence, abstract thinking, became more important assets than tangible goods.

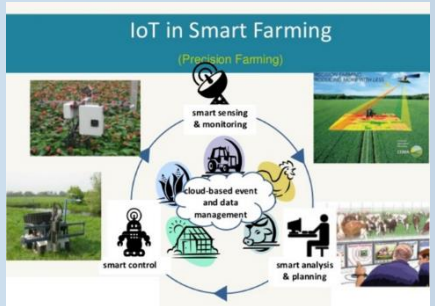


# 4th Industrial Revolution

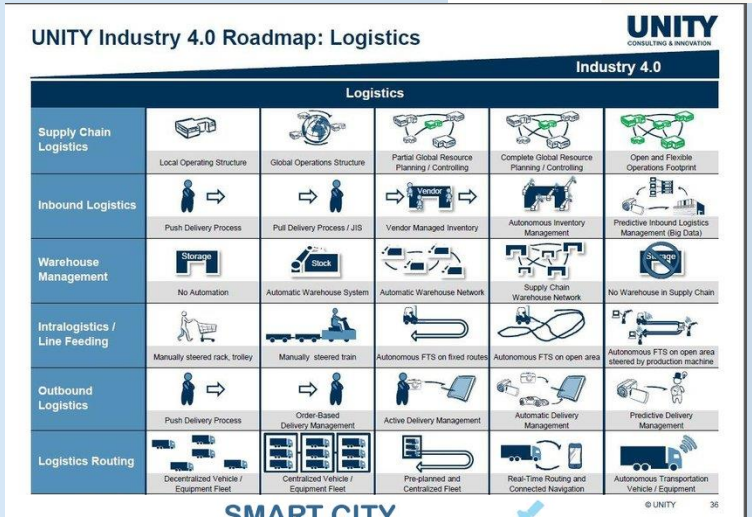
- **Massive IoT & 5G**
  - **5G is disruptive:** not only higher throughputs and lower latency - Introduction of **Machine-to-Machine Communications - point-to-point (IoT)**, instead of through Base Station.
  - Speeds up to **20 times higher** (20 Gb/s) & latency 10 times lower (than 4G).
- **Big Data**
  - Consists of the generation of **massive quantity of data**, structured or not, which can be processed by **Artificial Intelligence** to generate **Knowledge**.
- **Robotic & Artificial Intelligence**
  - A robot moves, but has also to **make decisions** → **Artificial Intelligence**



# 1. The Digital Transformation

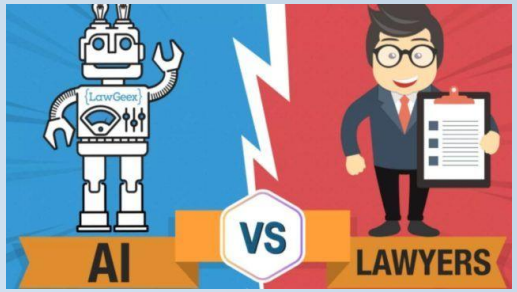



**Higher dependency from Cybersecurity, but with new Cybersecurity Solution**





Under the Skin Surveillance


# 1. The Digital Transformation

## Employability Post 4th Industrial Revolution (OECD):

- Automation **affects mainly industry and agriculture**, but trade and services are also vulnerable to automation;
- About **14% of existing jobs in OECD are highly automated**, while **32% of jobs can suffer a main change** on the way they are done;
- Higher risk is associated to **jobs with higher level of routines, lower skills and lower incomes**;
- **Younger people who enter the job market are more vulnerable to automation** than jobs developed by more experienced people;
- **Lower risk** is applicable to jobs related to **creation, maintenance and administration of technologies, creative intelligence, organizational manipulation, social intelligence**;
- **Not all the jobs technically automated will disappear**. Moreover, **other jobs will be created**, predicting that **employability will continue to rise**.

# 1. The Digital Transformation

## Artificial Intelligence

- Invented in 1956 (R&D)
- Bursted recently by:
  - **Increase of Processing Power**
  - **Increase of Data (Big Data) that can be used by Learning Algorithms**
  - Development of areas such as Neural Networks or Reinforcement Learning
  - Data: “The Petrol of XXI Century”
  - Sub-delegation in Machines to Decide:
    - **Ethical Issue** (Send or not to Prison? Kill or not to kill?)
    - Machines should have “awareness” of “good or evil”
    - Algorithms to take into account the **Awareness / Impact of Decisions** (not only to decide), considering factors such as **Altruísm & Empathy** .
    - **Altruísm & Empathy** had determinant impact in the survival and prosperity of humans.

# Environment vs Technology

Autónoma TECHLAB

Centro de Investigação em Tecnologias


- **Technologies** link with **Climate & Environment**, because they allow:
  - Generation of **renewable energies**
  - More **eficiente use of resources**
    - **Mobility**
    - **Energy**
    - **Industry**
    - **Smart Cities**
    - **Telework**
    - **eLearning**
    - **Robotis**

- Digital Transformation → Energetic Transformation → Ecological Transformation

- Transformations bursted by COVID-19 crisis.

# 2. 5G Communications

## Evolution of Cellular Communications

1G (FDMA) – Analog (voice)

2G (TDMA) – GSM – Digital, Introduction of data and Roaming

3G (WCDMA) – UMTS – Internet Access

4G (OFDM) – VTC (static, hard to equalize)

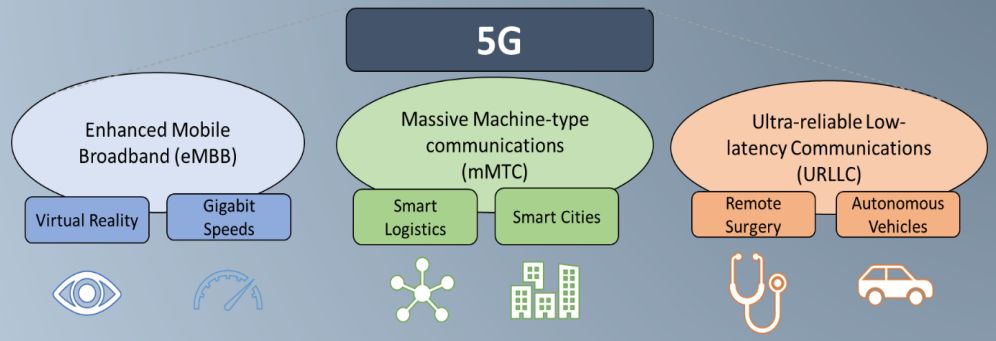
5G (OFDM) – Machine-machine Comm, VTC (on the move), Autonomous Driving, Point-to-point Comms (IoT), Virtual Reality, Artificial Intelligence, etc.

Leadership of European Standards in Cellular Networks

# 2. 5G Communications

- **Disruptive:** Not only **higher speeds**, but **increased Capacity** (massive IoT) and **lower lattencies** (autonomous vehicles or remote surgeries)
- **Massive MIMO, Millimeter Waves & V2V**
- **Capacity:** Up to **15 Tbps/km2** Indoor environment.
- **Spectral Efficiency:**
  - Downlink 30bit/s/Hz - services require more in the downlink
  - Uplink 15bit/s/Hz - uplink is the bottleneck, due to lower Tx Power, and lower number of Tx antenas, …

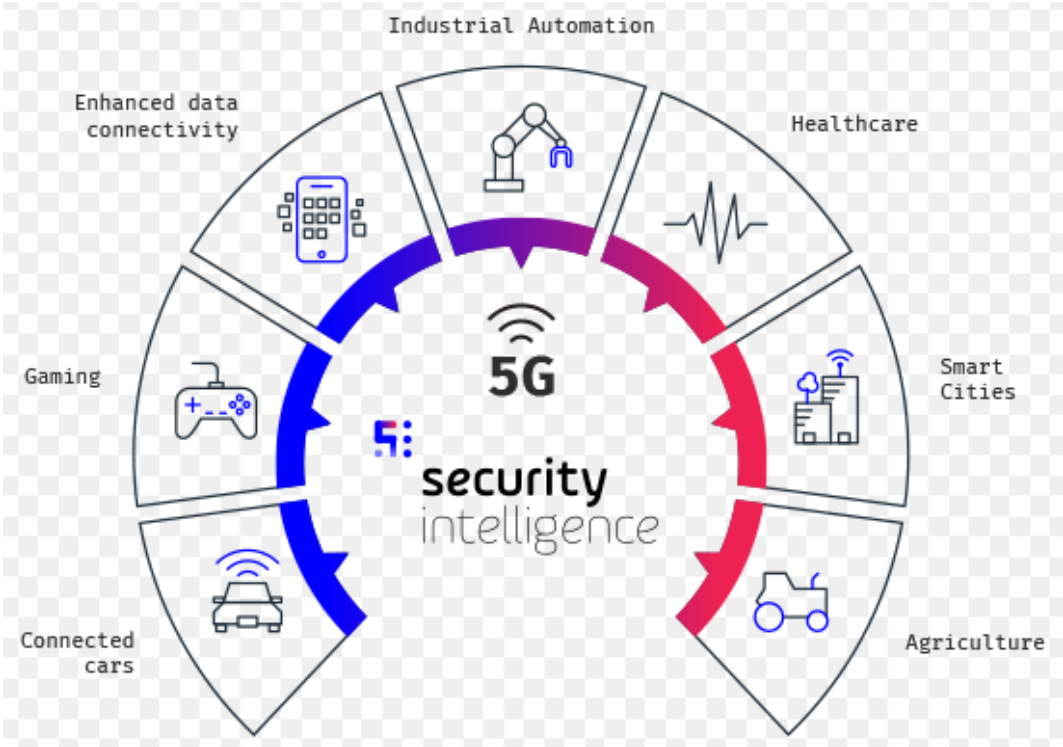
- **Main Differences:** 3 Use Cases – Improved Resilience of services (Network Slicing, ex: Virtual Reality, autonomous vehicles & smart cities):
  - (1) Normal + Higher Speed;
  - (2) Terminal-to-Terminal → Internet of Things & Security (Tetra)
    - [2.1] Sensitive to delay and very reliable (Communication & Sensors) → Edge Computing
    - [2.2] Smart Cities) → one million devices per square kilometer, and each device should have up to 10 years of autonomy or more [ITU]




| Capabilities | 5G | | 4G |
|---|---|---|---|
| Peak Data Rates | eMBB | 20 Gb/s (downlink) | 1 Gb/s (downlink) |
| Experienced Data Rates | | 100 Mb/s (downlink) | 10 Mb/s(downlink) |
| Mobility Speed | | 500 km/h | 350 Km/h |
| Connection Density | mMTC | 1 million devices per $Km^2$ | 100,000 devices per $Km^2$ |
| Latency | URLLC | 1 ms | 10 ms |

# 5G – Security Aspects:

1. Vulnerabilities from the Cybersecurity point of view;
2. Human Exposure from Electromagnetic Radiations;
3. Utilization of 5G Communications by Forces and Security Services (e.g., replacing TETRA).



# 2. 5G Communications

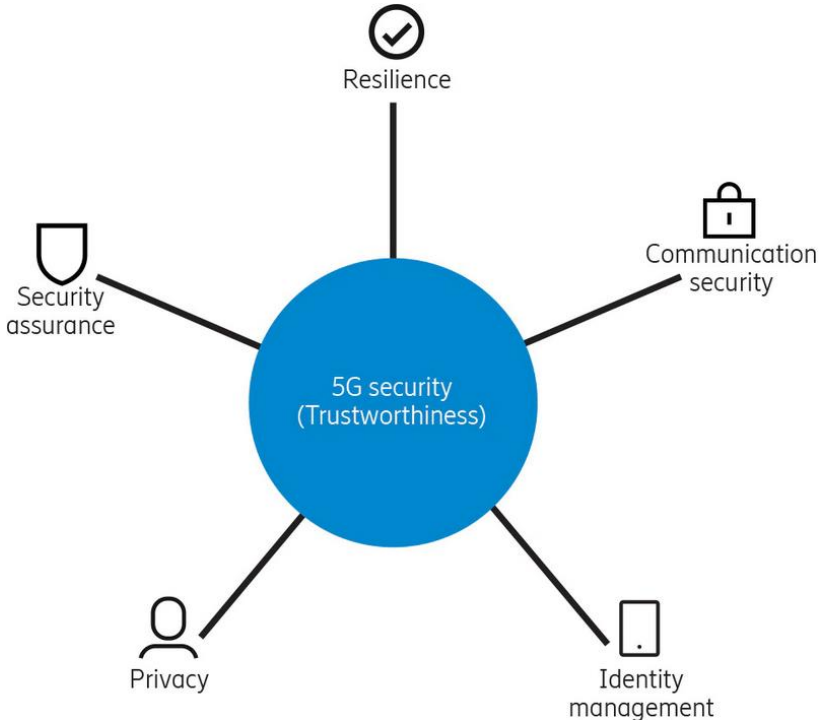
## 5G Security Aspects:

## 1 - Vulnerabilities from the Cybersecurity point of view:

- 5G connects billions of IoT devices. While PCs tend to be secure (Firewalls, anti-vírus, etc.), such concern is normally not taken into account in the majority of IoT devices developed by external entities but interconnected through 5G (WebCams, Smart TVs, Loudspeakers, refrigerators, smart lockers, Vehicles [autonomous]). These **devices act as an input** to 5G network, allowing reaching other devices.
- The extremely high number of 5G devices, with lower latencies and higher bandwidths, make monitorization of cyber attacks more difficult → Rethink Security.

- The extremely high number of IoT devices supported by 5G makes IPv4 address spacing unsufficient. 5G is typically associated with IPv6, where IPSec is embedded using Authentication Header (AH) or Encapsulation Security Payload (ESP).
  - AH: Protects from attacks against Authenticity and Integrity.
  - ESP: Protects from attacks against Confidentiality

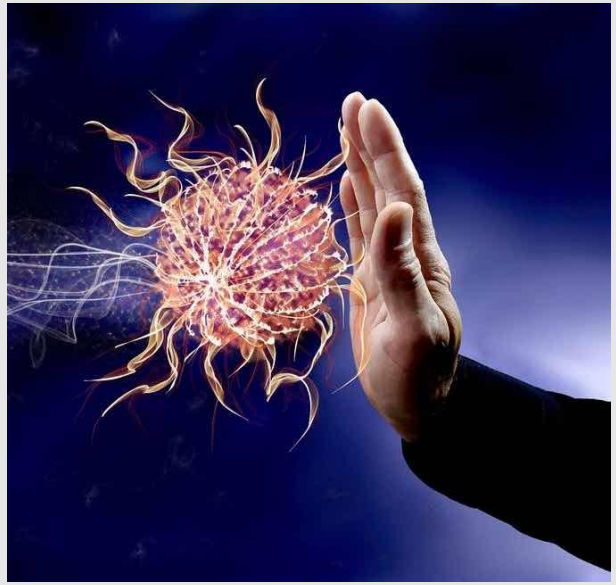
- What happens within the MANUFACTURER CLOUD? Which kind of data is stored, and for which purposes?



# 2. 5G Communications

## 5G Security Aspects:

### 2 - Human Exposure to Electromagnetic Radiations



- Special concern with millimeter waves due to extremely high Propagation losses.
- Existing legislation, based on studies, protects humans from Electromagnetic radiations:
  - Recommendation ITU-T. K-Series, "5G technology and human exposure to RF EMF," 2017
  - International Commission on Non-Ionizing Radiation Protection. Guidelines for limiting exposure to Electromagnetic Fields (100 kHz to 300 GHz), Health Physics 2020, 118(5), pp.483-524
  - Electronic Communications Committee (ECC), within the European Conference of Postal and Telecommunications Administrations (CEPT), Recommendation (02)04 (https://docdb.cept.org/download/d9aa1d17-0482/REC0202.PDF)
  - 1999/519/EC: Council Recommendation of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz) (https://op.europa.eu/en/publication-detail/-/publication/9509b04f-1df0-4221-bfa2-c7af77975556/language-en)

# 2. 5G Communications

## 5G Security Aspects:

### 2 - Utilization of 5G Communications by Forces and Security Services (e.g., replacing TETRA)


- TETRA is still a 2G System (very low data rates, used by policies, militaries, firefighters, etc.).

- Some Comms Requirements used by Security Forces:
  - ComSec (authenticity, integrity, confidentiality): IPv6: 5G OK
  - Direct mode of Operation [w/ relay]: Device-to-device Communication (without Base Station): 5G OK
  - Multicast & Broadcast: 5G OK
  - Priority of calls and fast setup

- 5G can also be used as a private network, such as Logistic Centers or Forces & Security Services.

- Network Slicing can be employed to reserve resources in public 5G network for creating private networks

- Virtualization and Software Defined Network (SDN), used in 5G, facilitates the customization of network, adapting to specific requirements.

# 4. 6G Communications

- 5G focus on the initial requirements of the 4th Industrial Revolution.
- 6G (2030) aims to improve such implementation.
- The digital society of 2030 and beyond, comprises more and more connected devices (IoT), including sensors, vehicles, aerial drones, and data.
- 6G aims to consider:
  - **Augmented Reality (AR) and Extended Reality (XR)**
  - **Artificial Intelligence (AI) infused applications**
  - Wireless Brain-Computer Interactions (BCI)
  - **<u>Holographic services</u>**
  - The integration of communications with localization, mapping and remote control
  - Emerging eHealth applications
  - **<u>Improved autonomous vehicles</u>**
  - More efficient support of IoT, namely smart cities and smart houses, supporting extremely high number of low-power devices
  - Support of flying vehicles and increased mobility speed

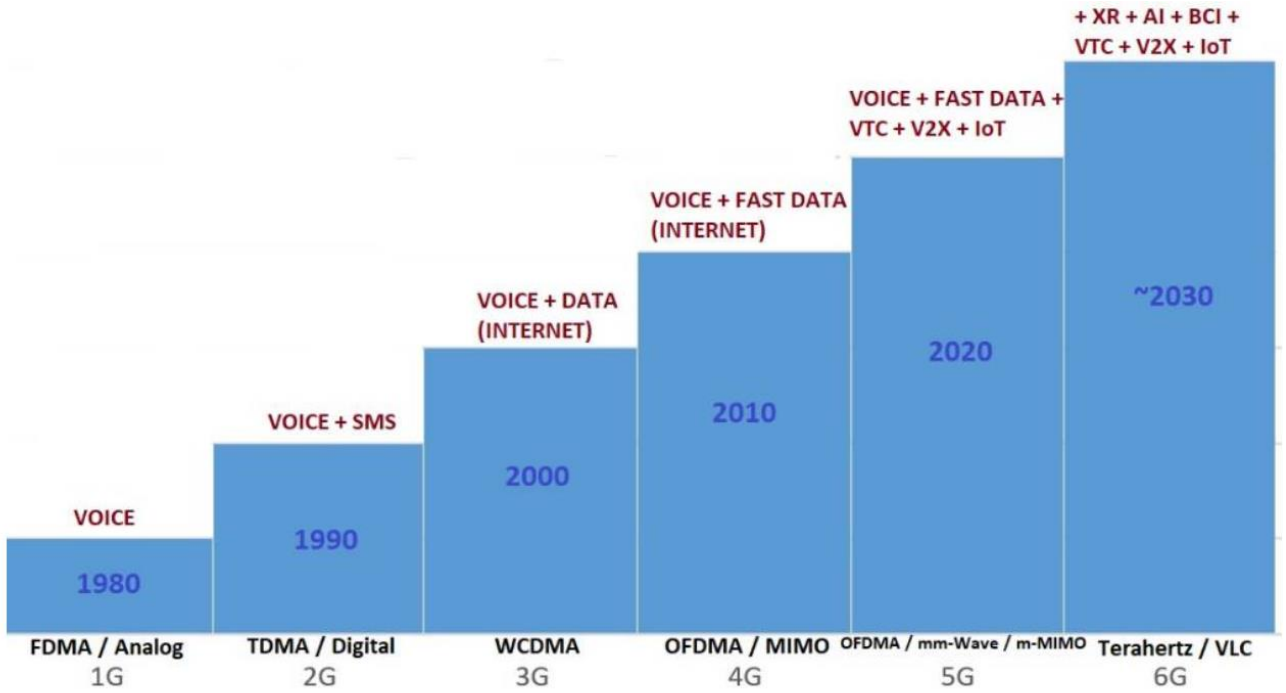
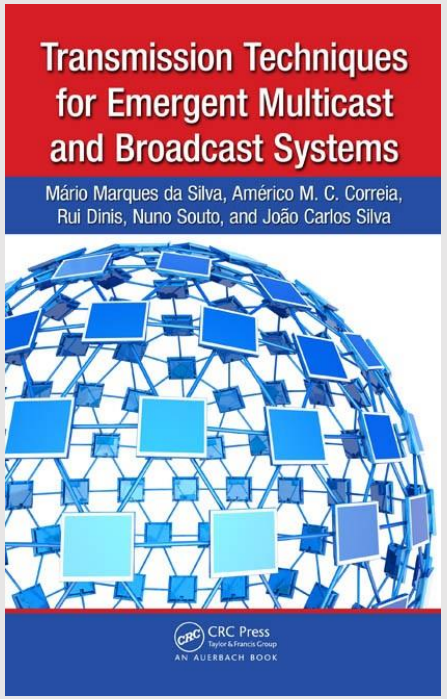



**Figure 8.** Evolution of cellular generations.

# Perspectives for 6G

- Some of the **foreseen requirements** for 6G include:
  - Nomadic peak data rate of at least 1 Tbps (100 times higher than 5G)
  - Mobile data rate of 1 Gbps (10 times higher than 5G)
  - Energy efficiency 10 to 100 times better than 5G
  - Spectral efficiency 5 to 10 times better than 5G
- While 5G requirements are achieved based on mm-Wave and m-MIMO, 6G must incorporate new concepts and frequency bands not yet considered for cellular communications.
  - This includes **Visible Light Communications** (VLC) and **Terahertz bands** (100 GHz – 10 THz).


Transmission Techniques for Emergent Multicast and Broadcast Systems
Mário Marques da Silva, Américo M. C. Correia, Rui Dinis, Nuno Souto, and João Carlos Silva
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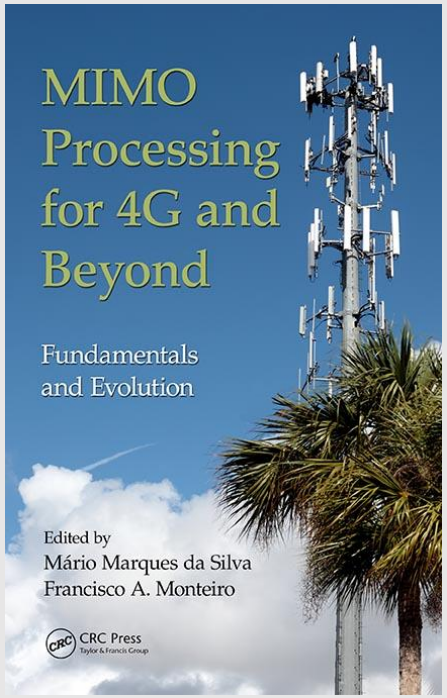
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Fundamentals and Evolution
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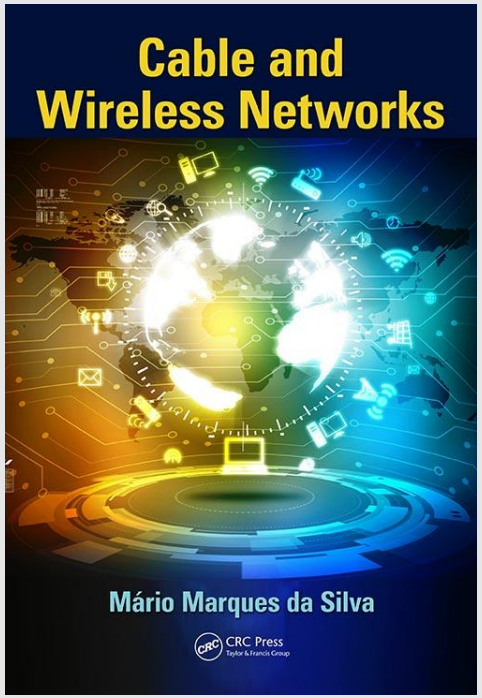
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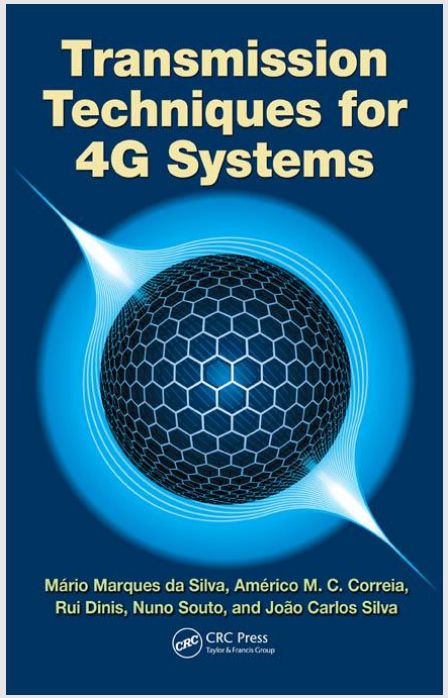
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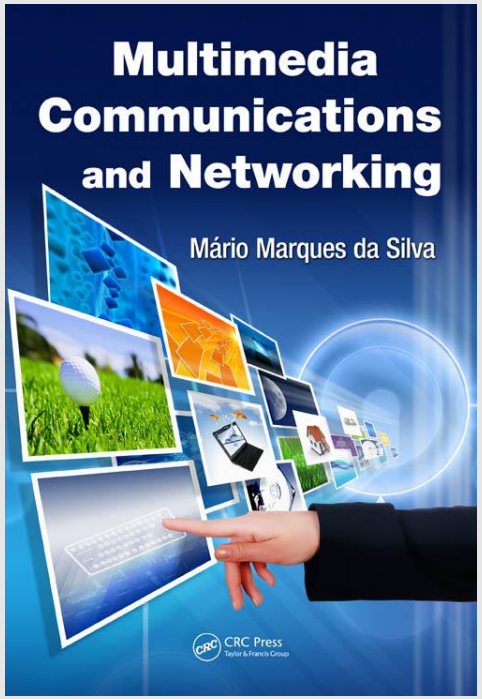
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