Wireless Communication Networks summary

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Artificial Intelligence & Information Analysis Lab

Wireless Communication Networks

- 4G networks
- Quality of Service in 4G networks
- 5G networks
- 5G technology components
- Quality of Service in 5G networks
- Internet of Things (IoT)

4G/LTE

- What is 4G/LTE
- Quality of Service for 4G/LTE

5G

- What is 5G
- 5G Types
- How 5G works
- How is 5G better than 4G?
- 5G technology components
- Quality of Service

Internet of Things

- What is IoT
- Characteristics
- Applications
- Baseline Technologies
- Sensors

FANET

- Drones
- Features
- Architectures
- Mobility Models
- Routing Protocols
- Safety and Security Aspects

What is 4G

- LTE → **L**ong **T**erm **E**volution.
- LTE is the next step for the **4**th **G**eneration of technology for cellular networks.
- It’s a global wireless standard after 1G, 2G and 3G networks.
- LTE is the access part of **E**volved **P**acket **S**ystem **(EPS)**

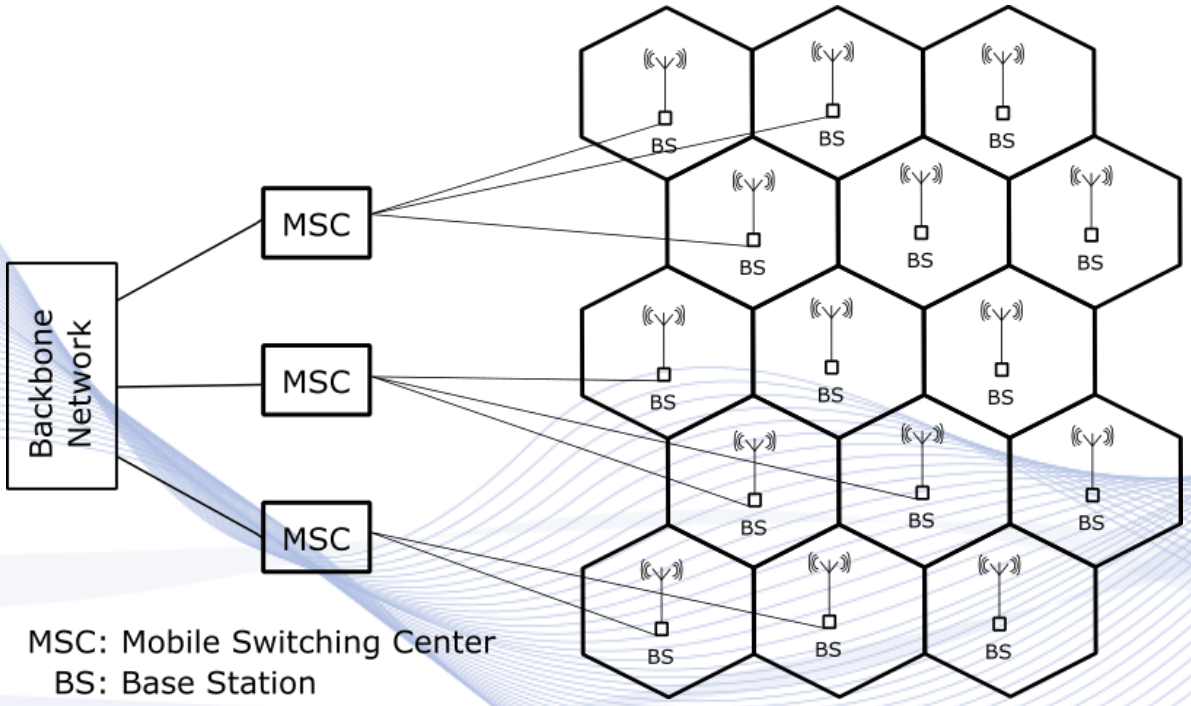
What is 4G

LTE brings

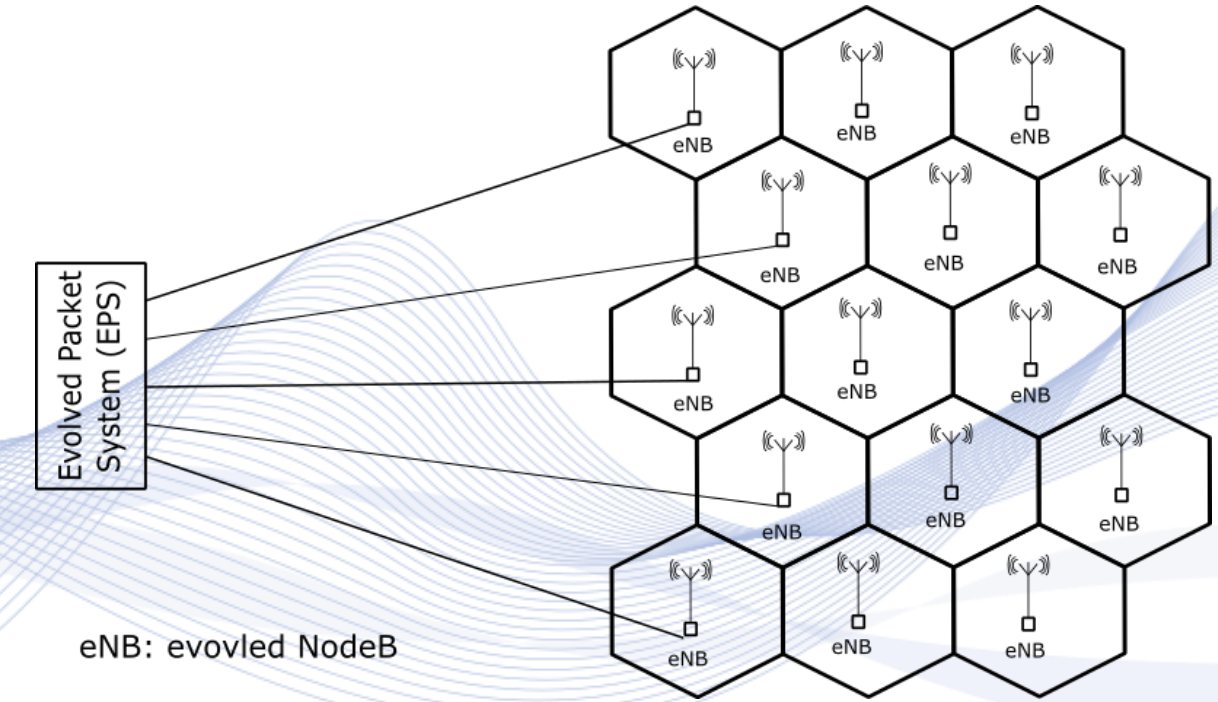
- High spectral efficiency
- High data rates
- Short RTT (**R**ound **T**rip **T**ime)
- High bandwidth
- Frequency flexibility

4G Network

Before 4G/LTE

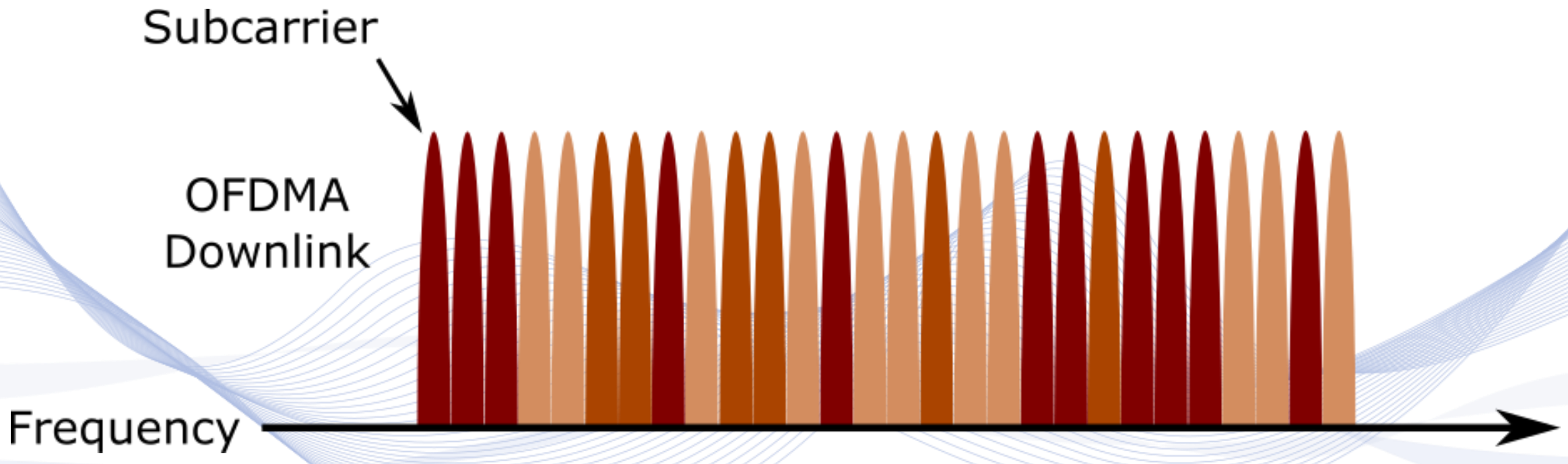


4G/LTE



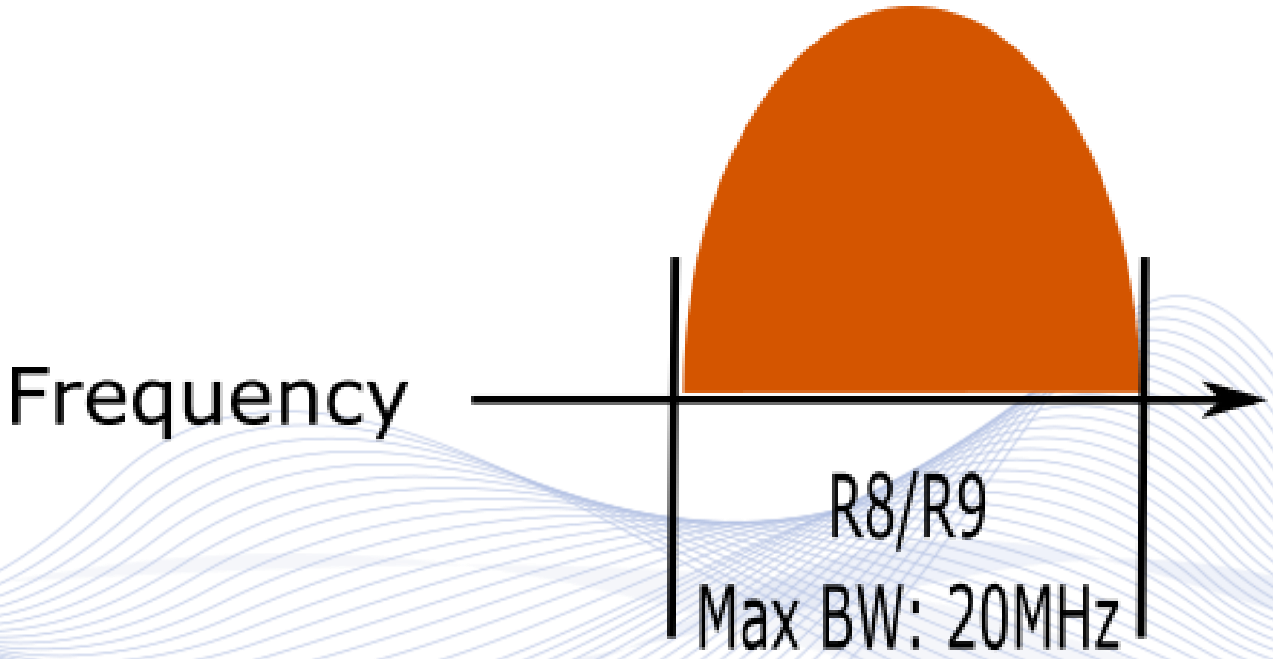
How 4G/LTE works

- **Use OFDMA for the Downlink**



How 4G/LTE works

- **Bandwidth**

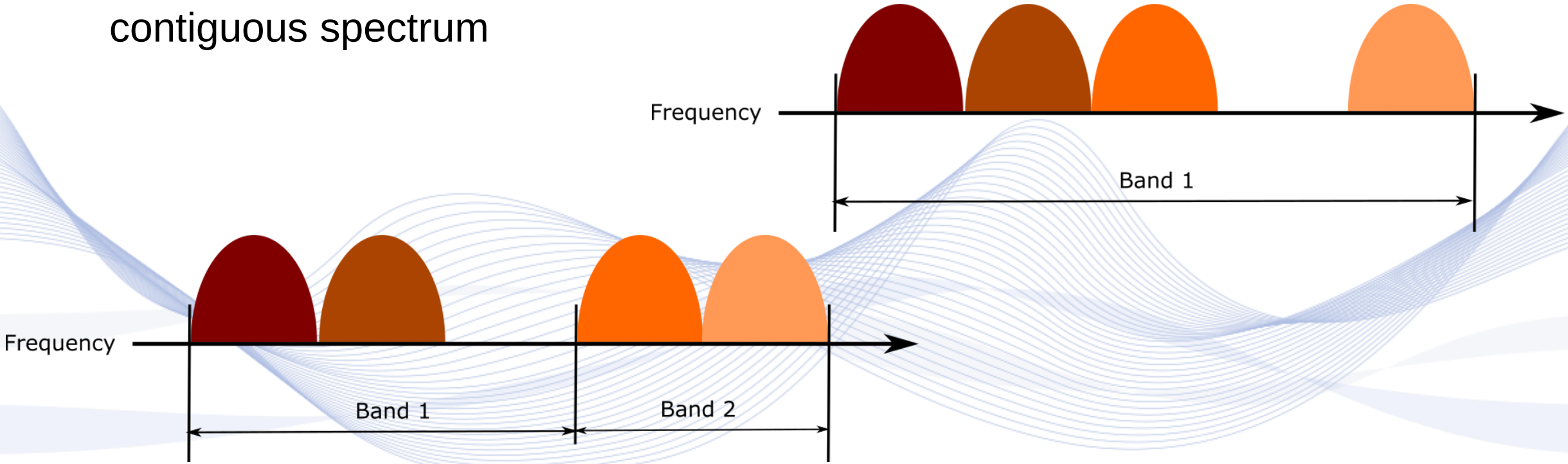


LTE-Advanced

LTE-Advanced (LTE-A)

LTE-A brings

- Spectrum use: Use of spectrum aggregation and scalable bandwidth for non-contiguous spectrum

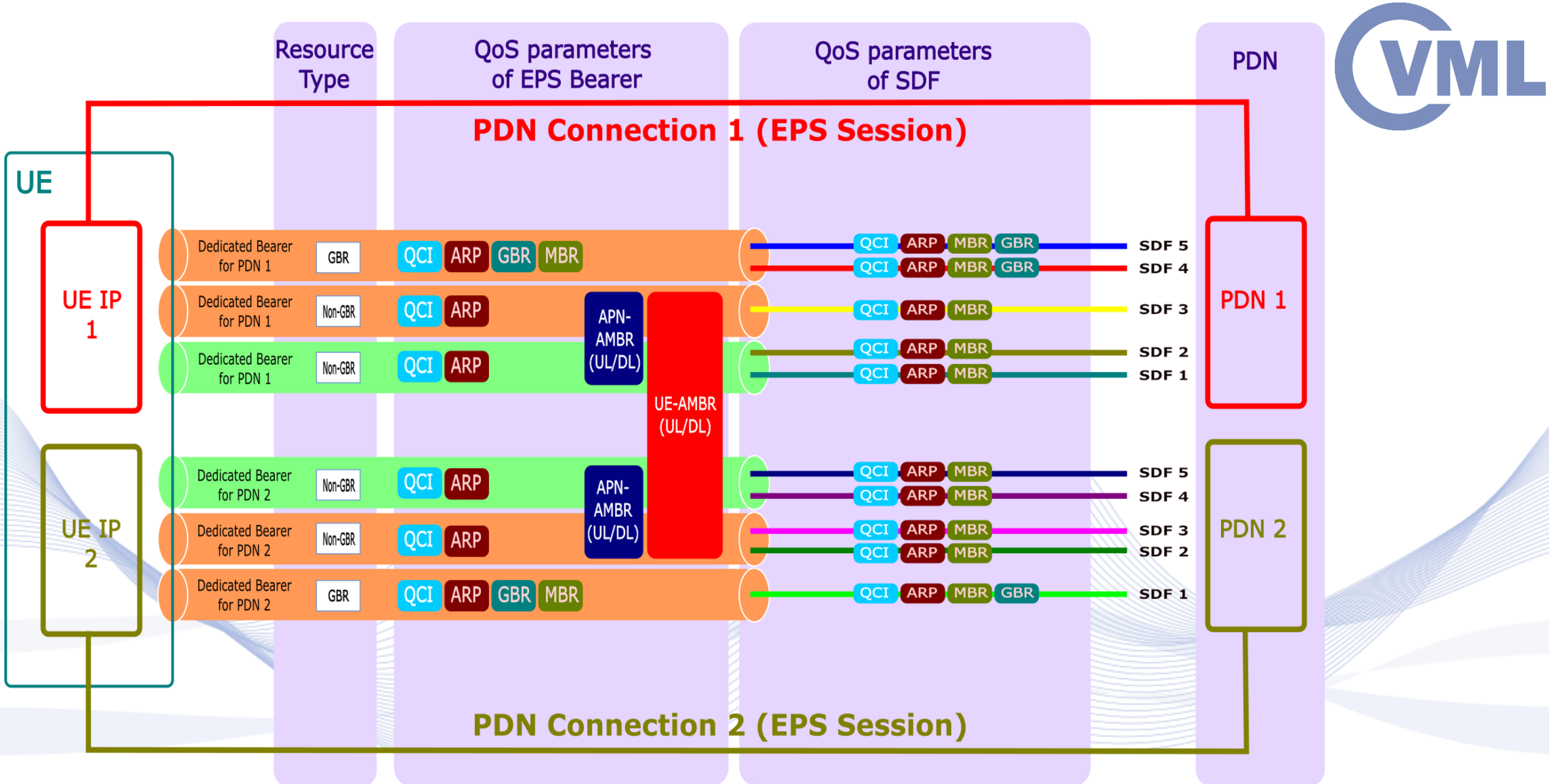


QoS for 4G/LTE

QoS for 4G/LTE

Quality of Service for 4G/LTE

- Based on **EPS bearer**
- Support **G**uaranteed flow **B**it **R**ate **(GBR)**
- Support **N**on **G**uaranteed flow **B**it **R**ate **(Non-GBR)**


Resource Type
QoS parameters of EPS Bearer
QoS parameters of SDF
PDN
PDN Connection 1 (EPS Session)
UE
UE IP 1
UE IP 2
Dedicated Bearer for PDN 1
Dedicated Bearer for PDN 1
Dedicated Bearer for PDN 1
Dedicated Bearer for PDN 2
Dedicated Bearer for PDN 2
Dedicated Bearer for PDN 2
GBR
Non-GBR
Non-GBR
Non-GBR
Non-GBR
GBR
QCI ARP GBR MBR
QCI ARP
QCI ARP
QCI ARP
QCI ARP GBR MBR
APN-AMBR (UL/DL)
APN-AMBR (UL/DL)
UE-AMBR (UL/DL)
QCI ARP MBR GBR
QCI ARP MBR
QCI ARP MBR
SDF 5
SDF 4
SDF 3
SDF 2
SDF 1
SDF 5
SDF 4
SDF 3
SDF 2
SDF 1
PDN 1
PDN 2
PDN Connection 2 (EPS Session)

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[3GPP-5G]

What is 5G

- 5G is the **5**th **G**eneration mobile network.
- It’s a new global wireless standard after 1G, 2G, 3G, and 4G networks.
- It’s designed to connect everything and everyone together including
  - Machines
  - Objects
  - Devices

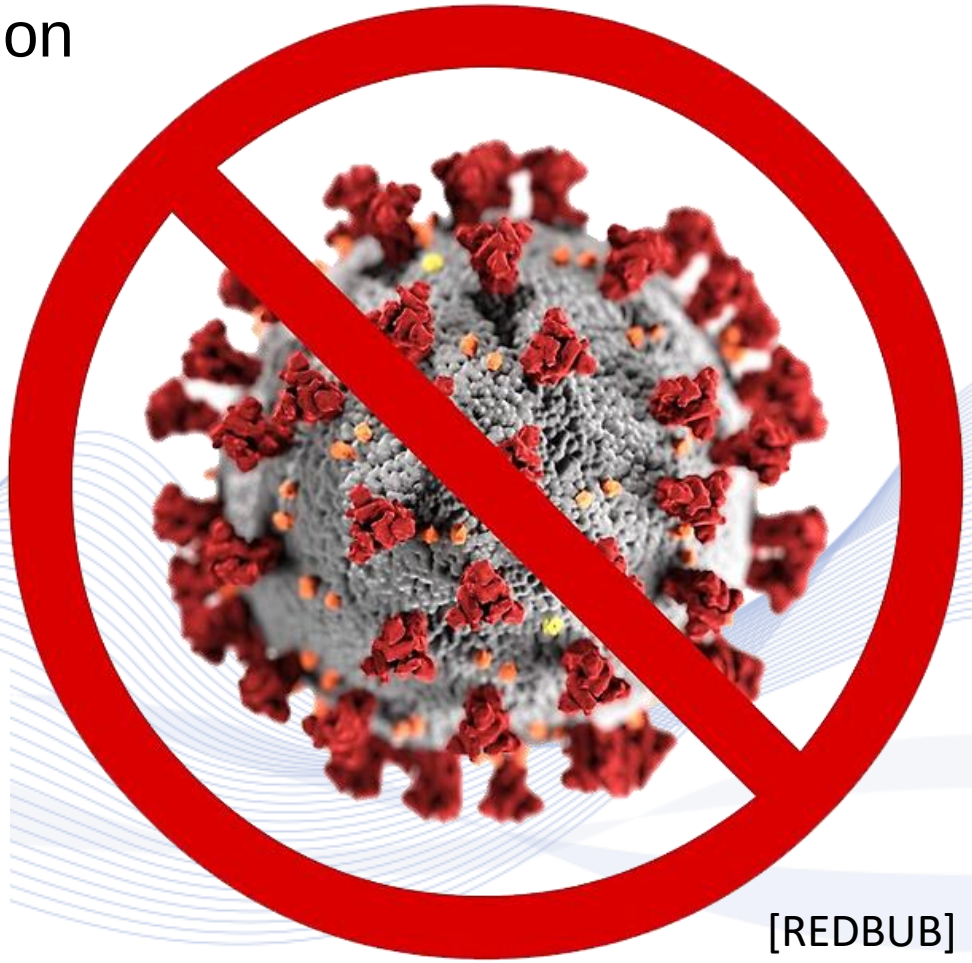
What is NOT 5G

- A massive attack weapon for humanity reduction
- Sars-Cov-2 carriage and spread technology

[BOL]

[1BP]

[LEROY]



[REDBUB]

5G Types

Non-standalone 5G

- **LTE anchor is required** for communication and mobility management
- Maximizes the use of the installed LTE base
- Add new 5G spectrums increasing the capacity and increase delivery efficiency
- 5G Evolved Packet Core
- Adaptor for 5G-enabled devices
- Enables video streaming, **A**ugmented **R**eality (**AR**) and **V**irtual **R**eality (**VR**)

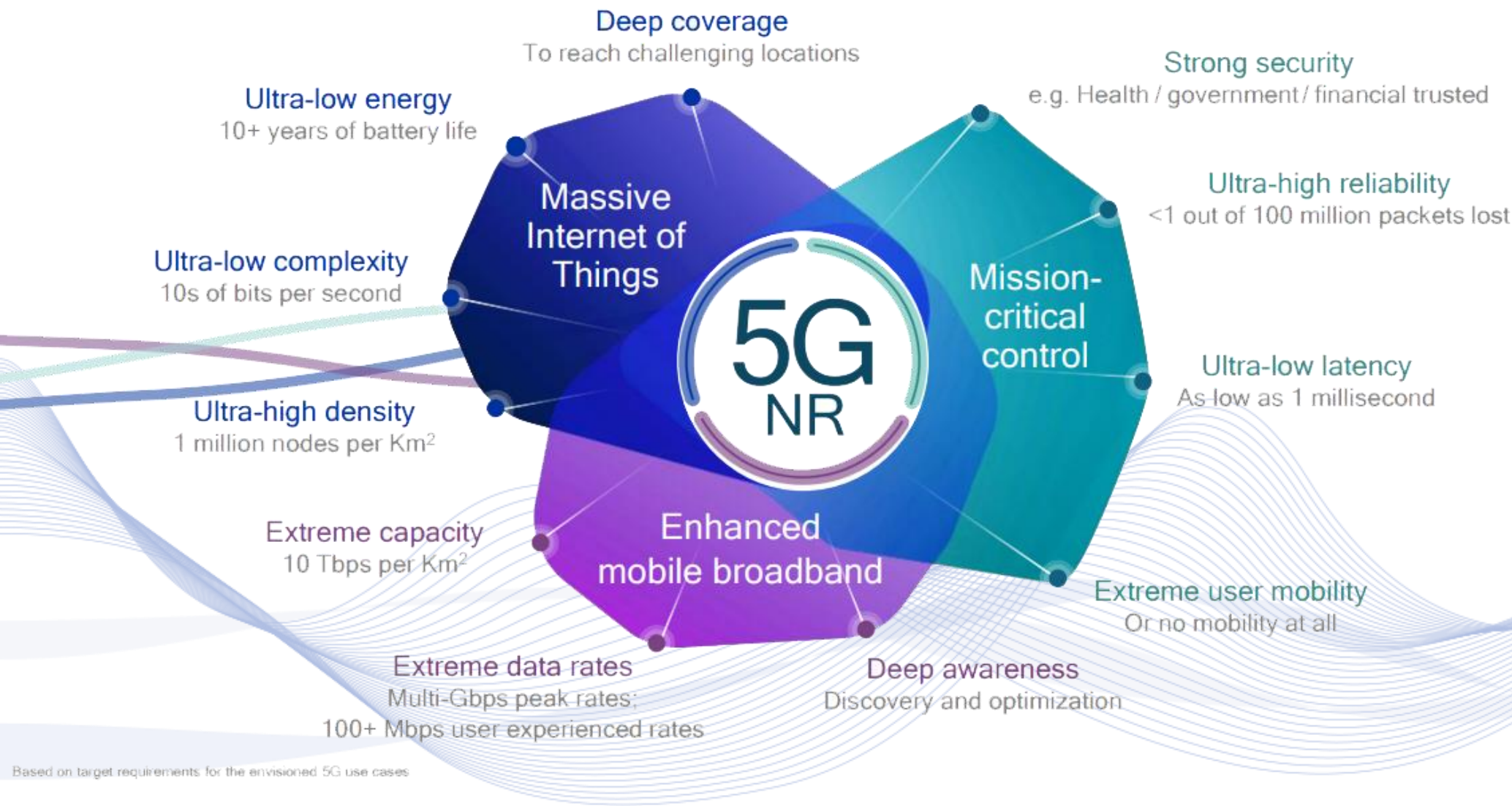
5G Types

Standalone 5G

- Target 5G architecture option
- Make RAN and device architecture more simple
- New cloud-native 5G Core
- Introduce ultra-low latency
- The only option to provide same 5G coverage for low band as legacy system
- Supports network-slicing functions
- Facilitates a wider range of use cases for new devices

How 5G works

- 5G is based on OFDM (**O**rthogonal **F**requency-**D**ivision **M**ultiplexing), a method of modulating a digital signal across several different channels to reduce interference.
- 5G uses 5G NR (**N**ew **R**adio) air interface alongside OFDM principles.
- 5G also uses wider bandwidth technologies such as sub-6 GHz (Bandwidth: **1GHz – 6GHz**) and mmWave (**m**illi**m**eter **Wave** – Bandwidth: **24GHz – 40GHz**)


Deep coverage
To reach challenging locations
Ultra-low energy
10+ years of battery life
Strong security
e.g. Health / government / financial trusted
Ultra-high reliability
<1 out of 100 million packets lost
Massive Internet of Things
Ultra-low complexity
10s of bits per second
5G NR
Mission-critical control
Ultra-low latency
As low as 1 millisecond
Ultra-high density
1 million nodes per Km²
Extreme capacity
10 Tbps per Km²
Enhanced mobile broadband
Extreme user mobility
Or no mobility at all
Extreme data rates
Multi-Gbps peak rates;
100+ Mbps user experienced rates
Deep awareness
Discovery and optimization
Based on target requirements for the envisioned 5G use cases

[QUALCOMM]

5G technology components

- **5G technology consists of the following components**
  - Spectrum – 5G NR

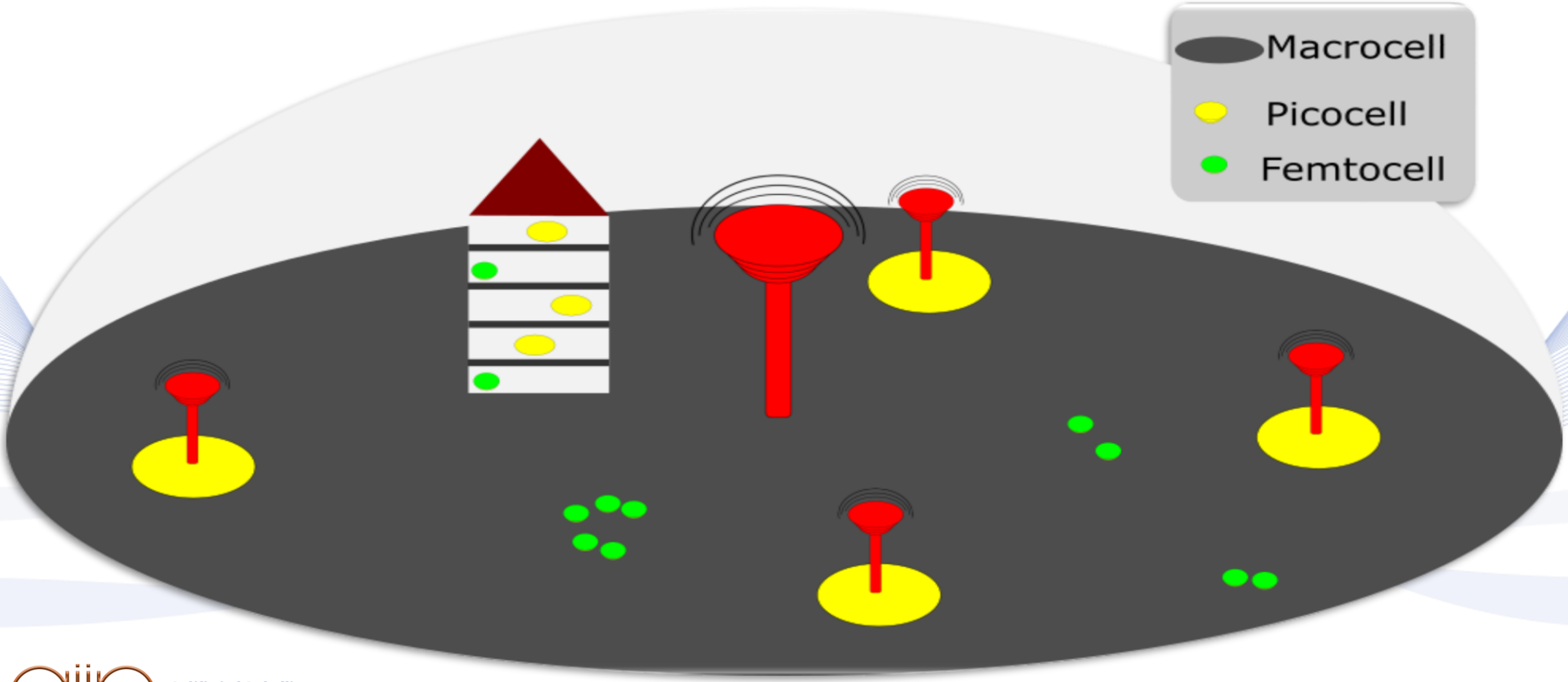
Low bands below 1 GHz: longer range for e.g. mobile broadband and massive IoT
e.g. 600 MHz, 700 MHz, 850/900 MHz

Mid bands 1 GHz to 6 GHz: wider bandwidths for e.g. eMBB and mission-critical
e.g. 3.4-3.8 GHz, 3.8-4.2 GHz, 4.4-4.9 GHz

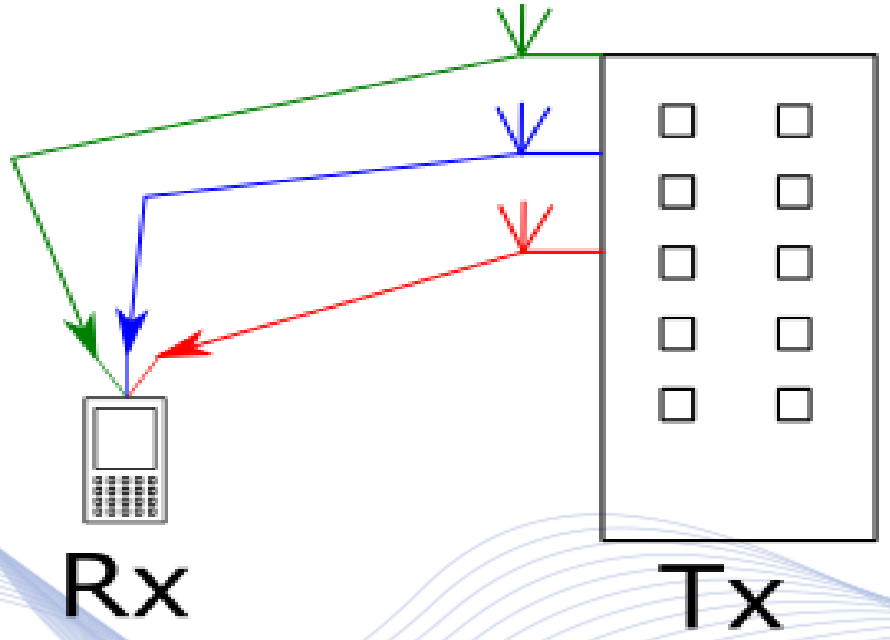
High bands above 24 GHz (mmWave): extreme bandwidths
e.g. 24.25-27.5 GHz, 27.5-29.5, 37-40, 64-71 GHz

[QUALCOMM]

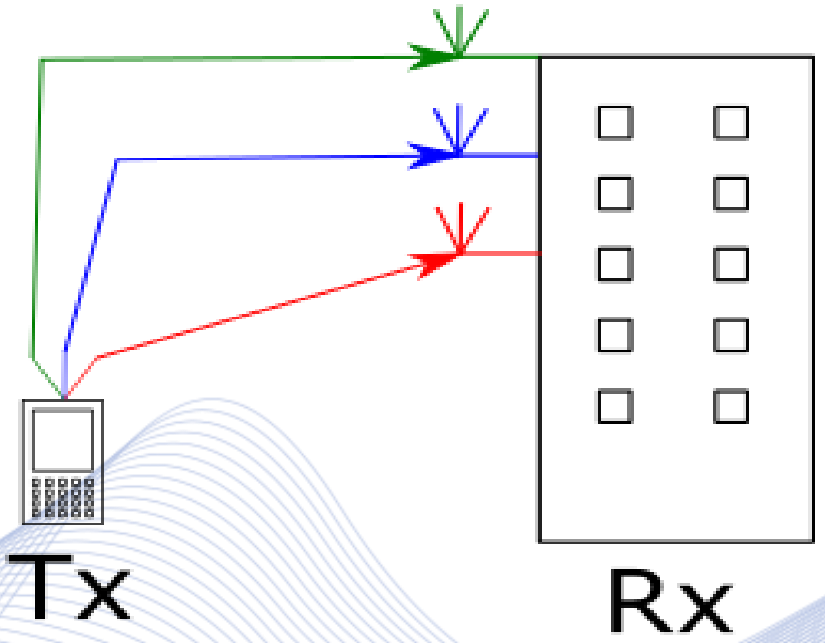
5G technology components



5G technology components

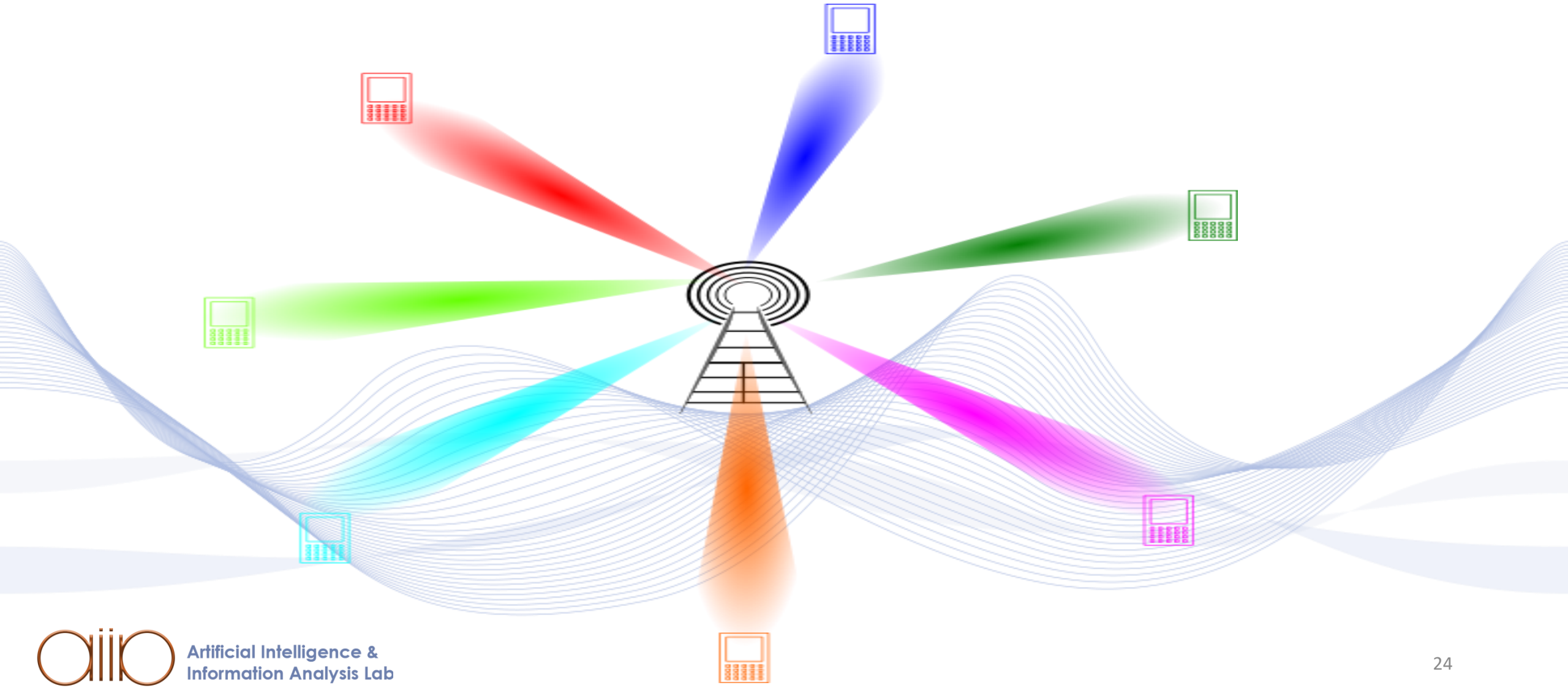


MIMO in download



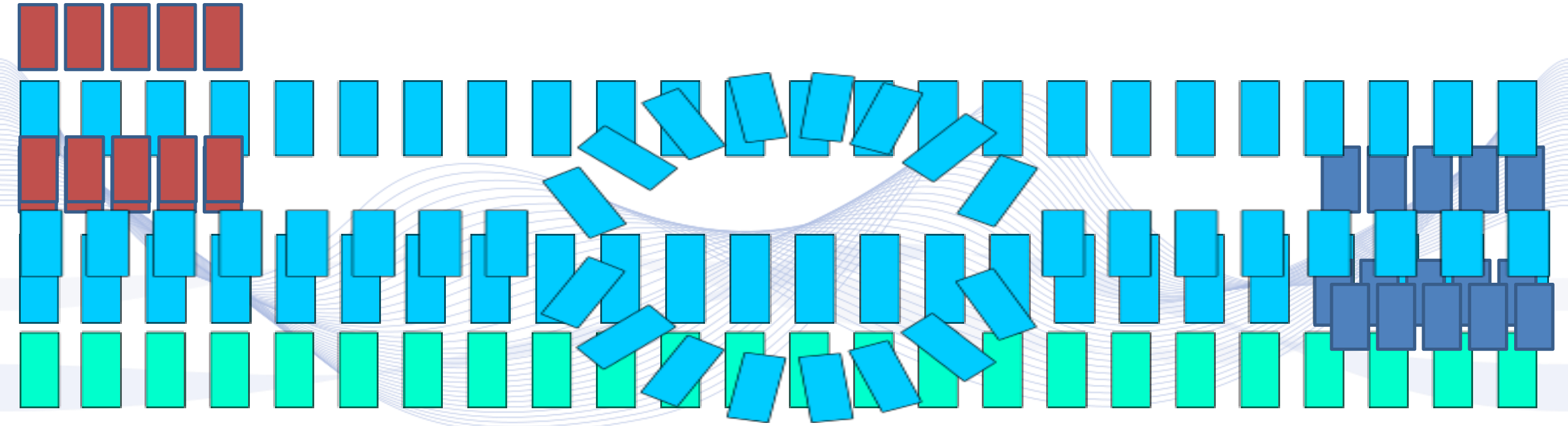
MIMO in upload

5G technology components



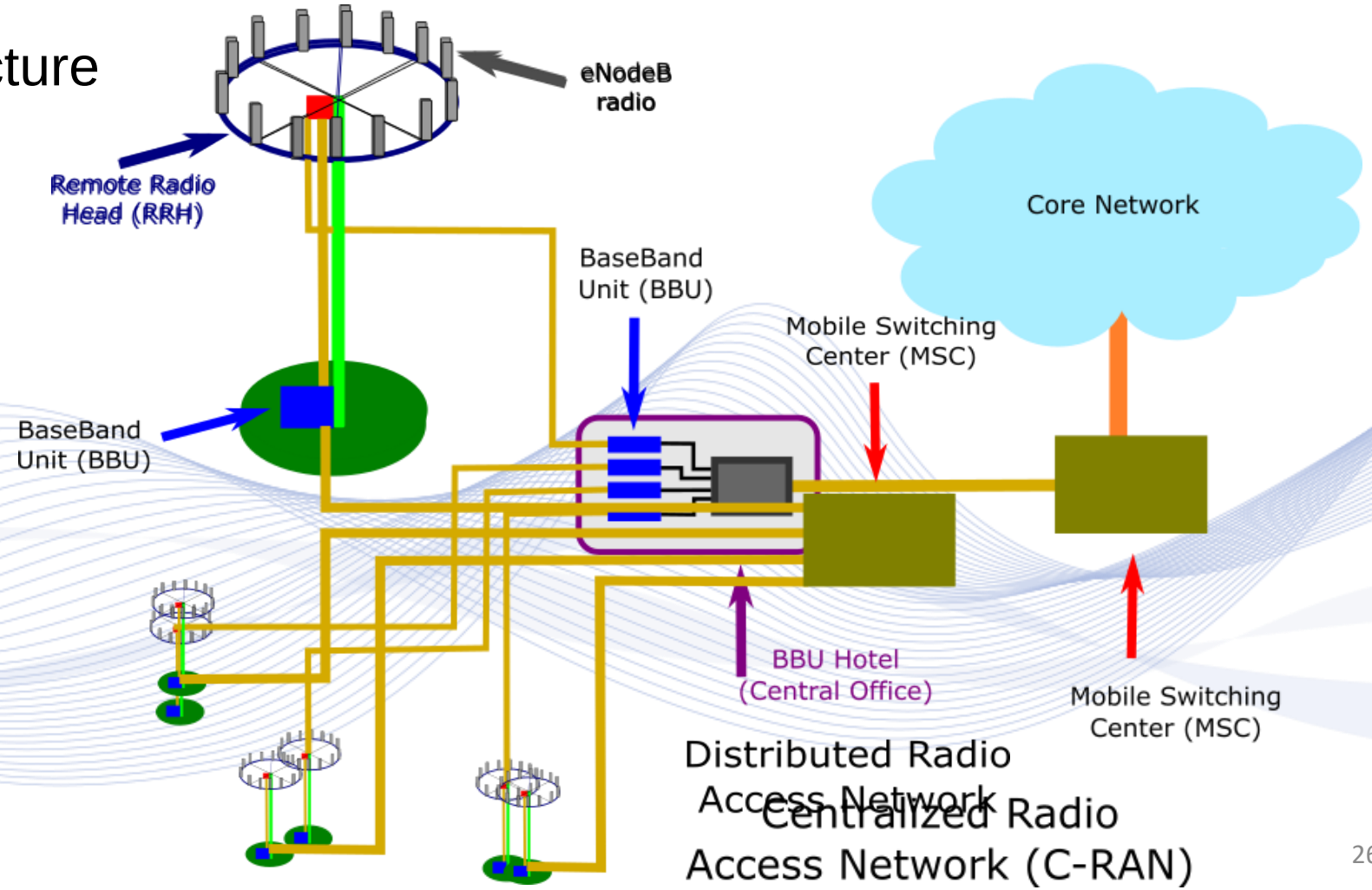
5G technology components

- **5G technology consists of the following components**
  - Full-duplex mode of transmission



5G technology components

- **5G technology consists of the following components**
  - C-RAN architecture



Quality of Service

Quality of Service

Quality of service (**QoS**) refer to the measurement of the overall performance of a service experienced by the users of the network. Many of the characteristics that we measure are:

- Packet loss
- Bit rate
- Throughput
- Transmission delay
- Availability

Quality of Service

Without Quality of Service

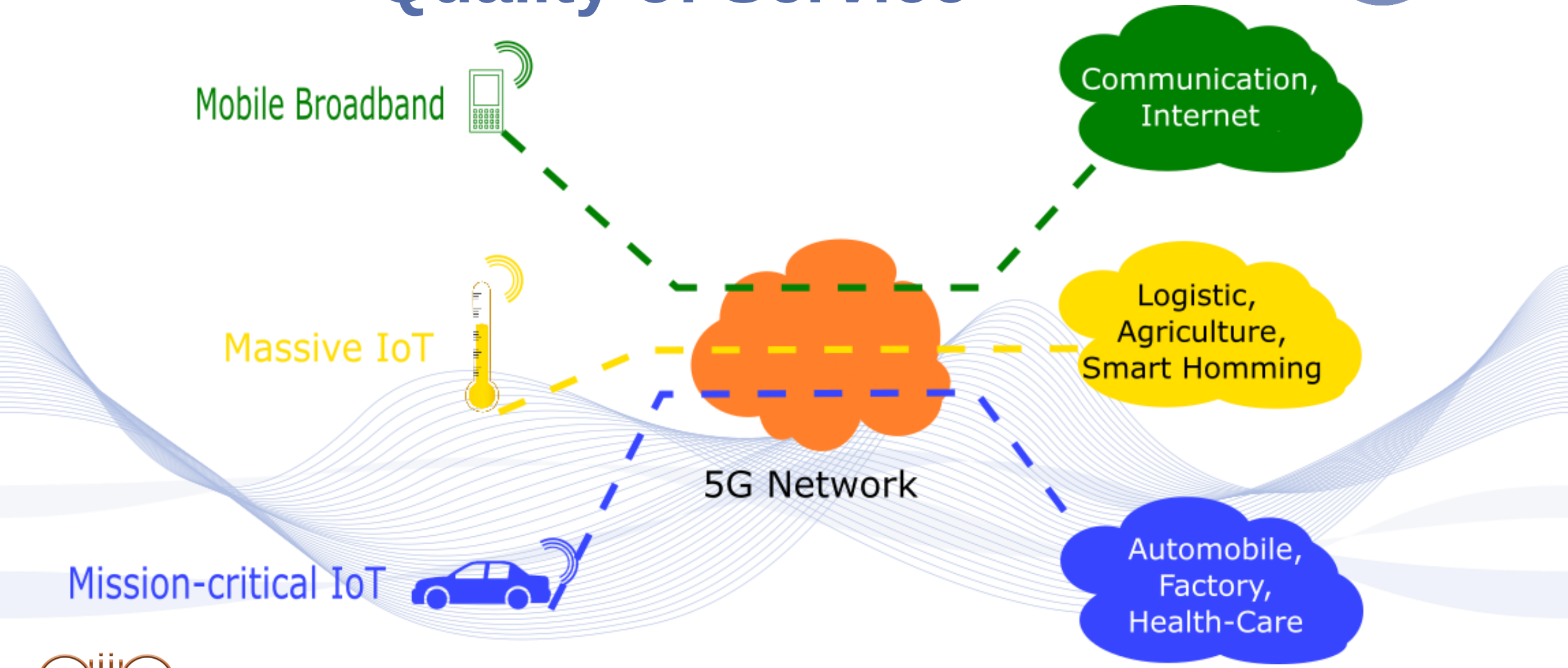
With Quality of Service

Mobile Broadband

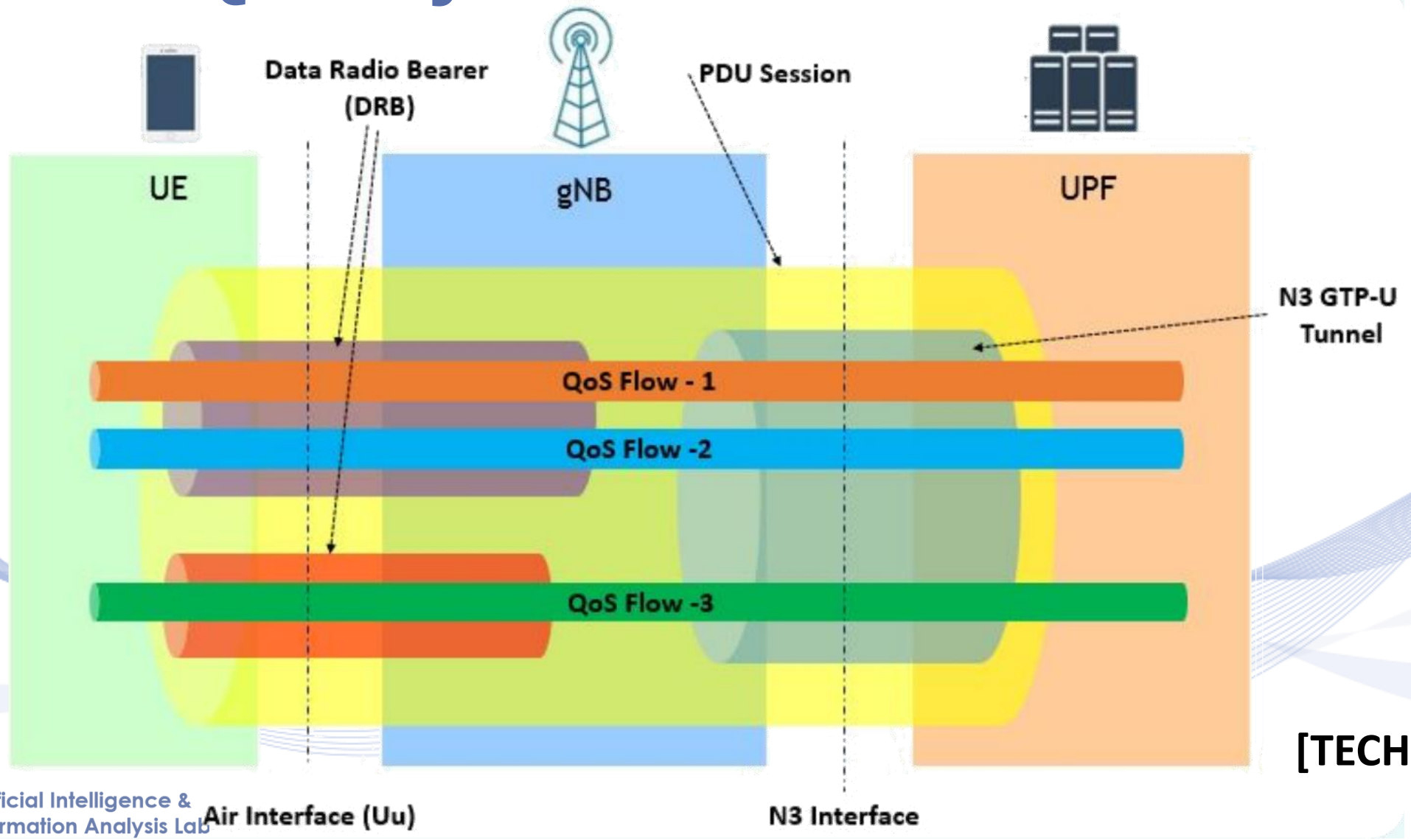
Massive IoT

Mission-critical IoT

Quality of Service

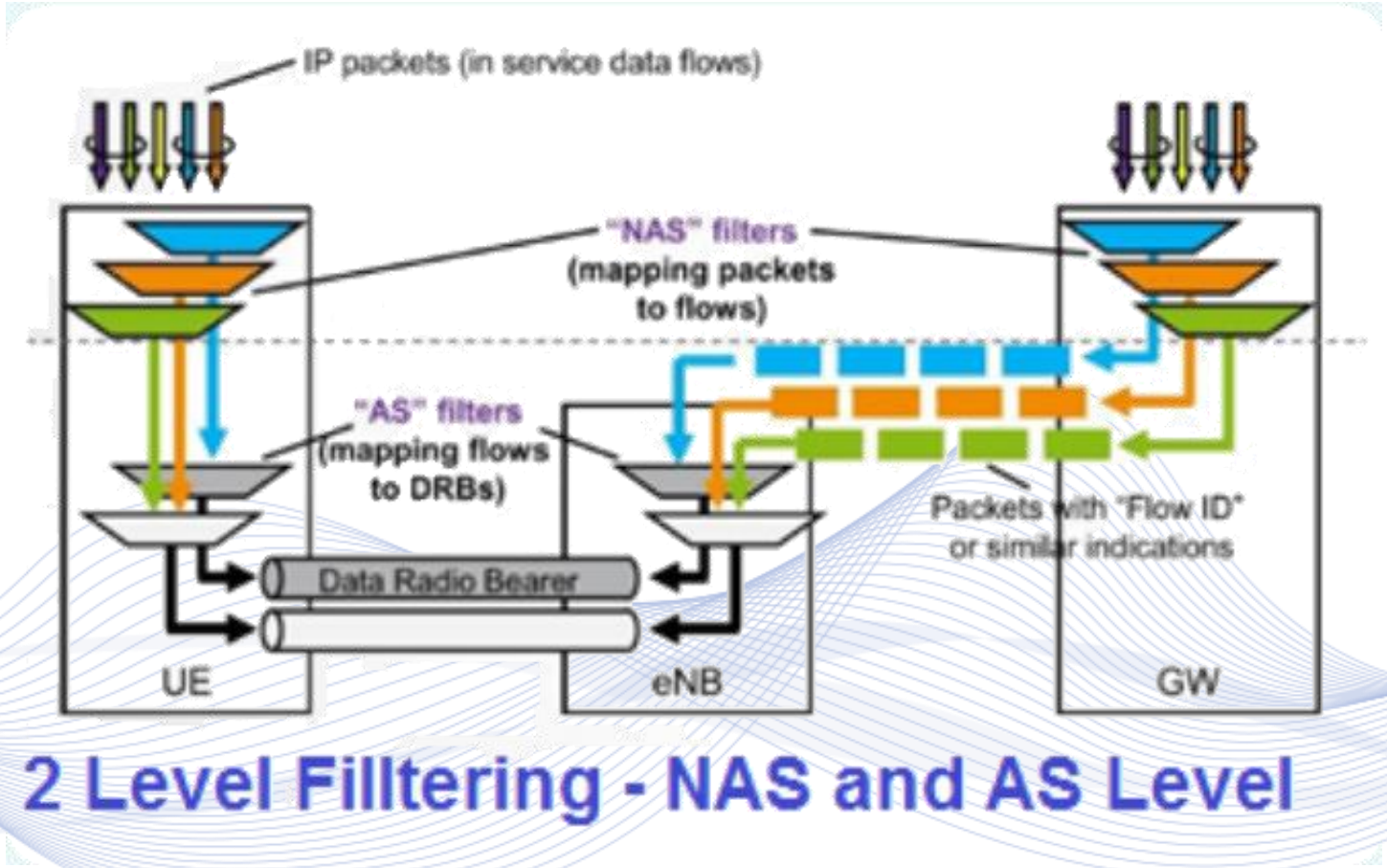


Quality of Service



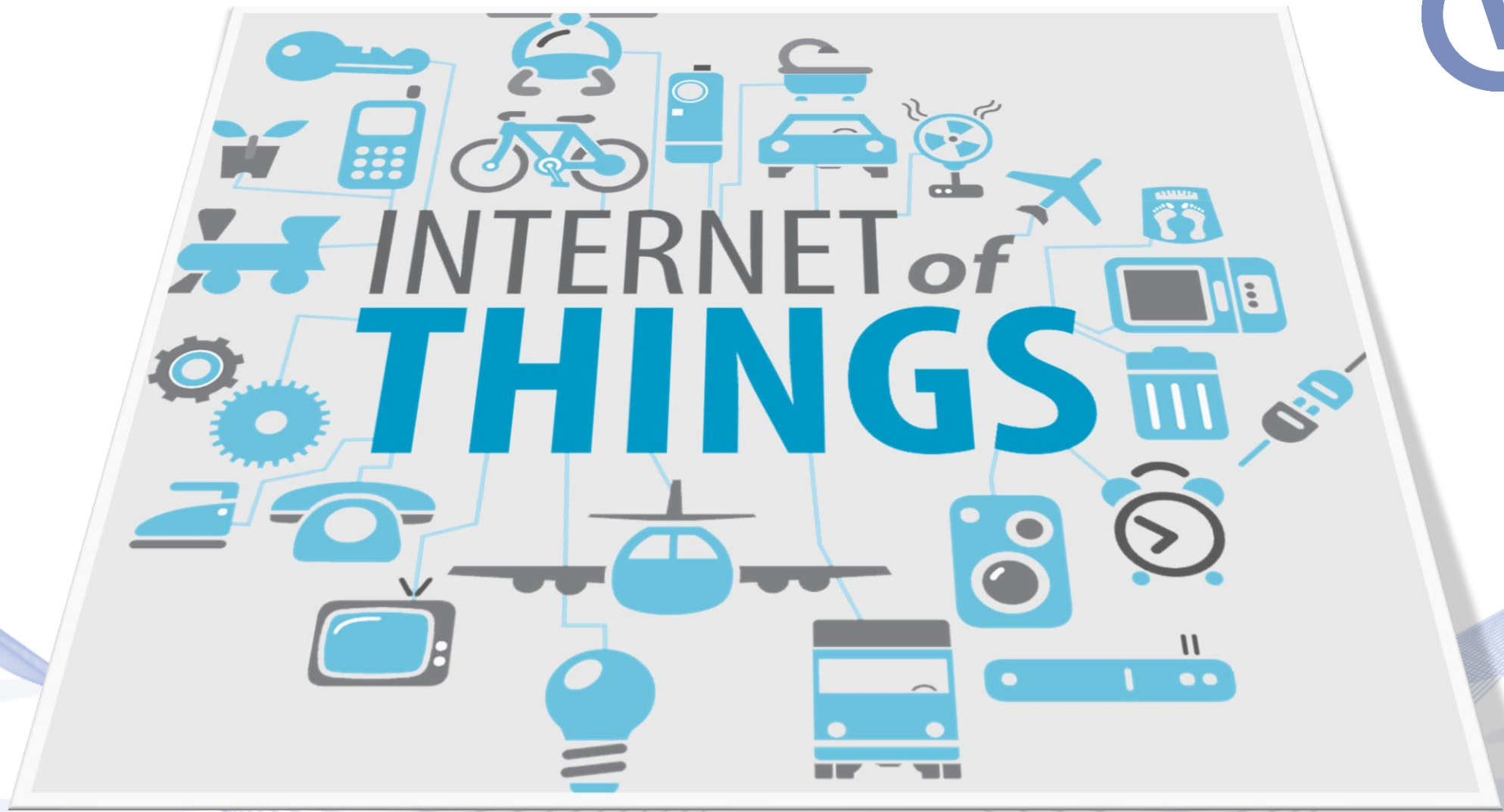
[TECH2020]

Quality of Service



2 Level Filltering - NAS and AS Level

[TECH2020]


INTERNET of
THINGS

Internet of Things (IoT)

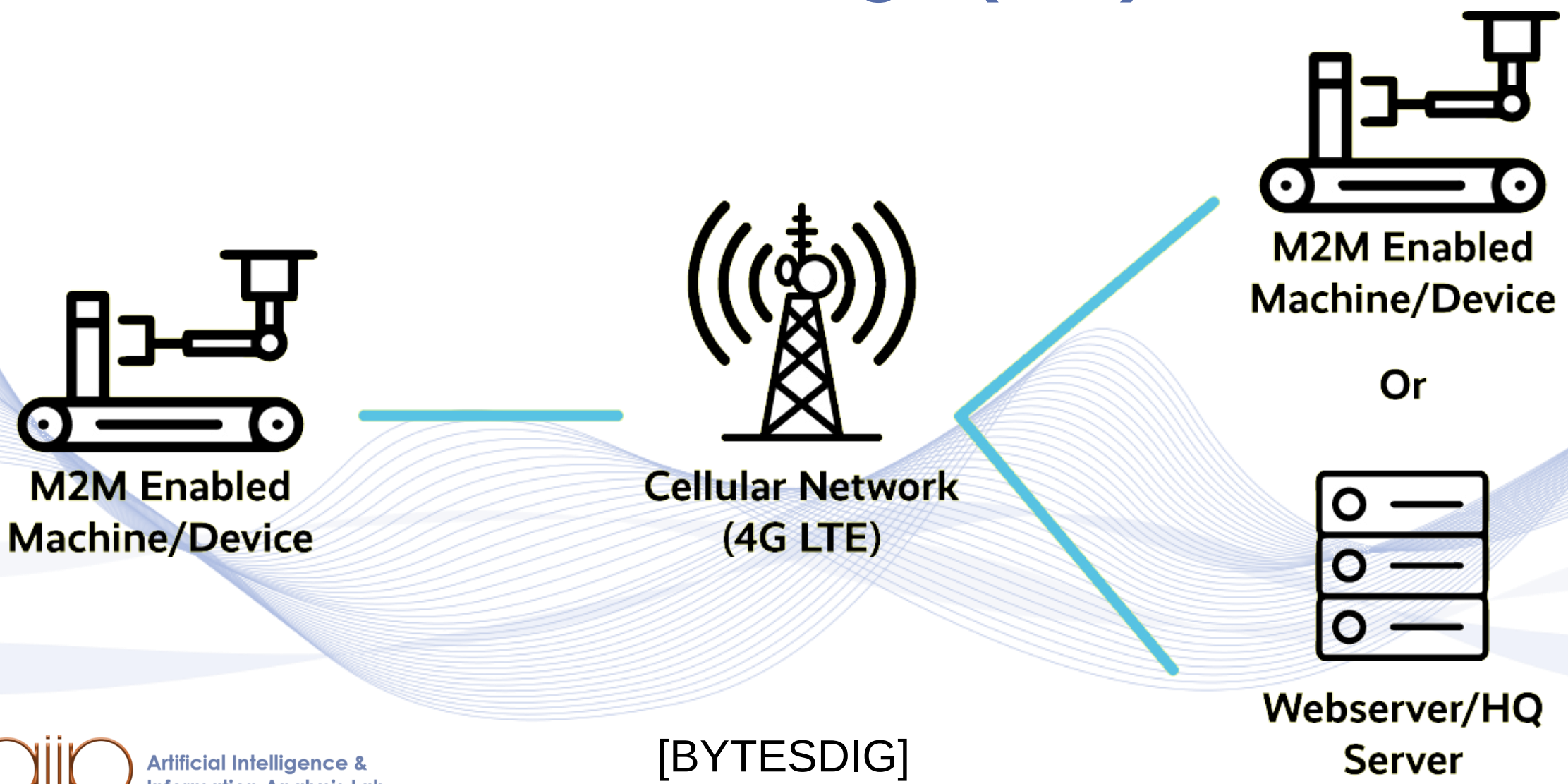
"The Internet of Things (IoT) is a network of physical devices, vehicles, home appliances and other items embedded with electronics, software, sensors, actuators and network connectivity which enables these objects to get connected and exchange data." [JOSE2018]

Internet of Things (IoT)

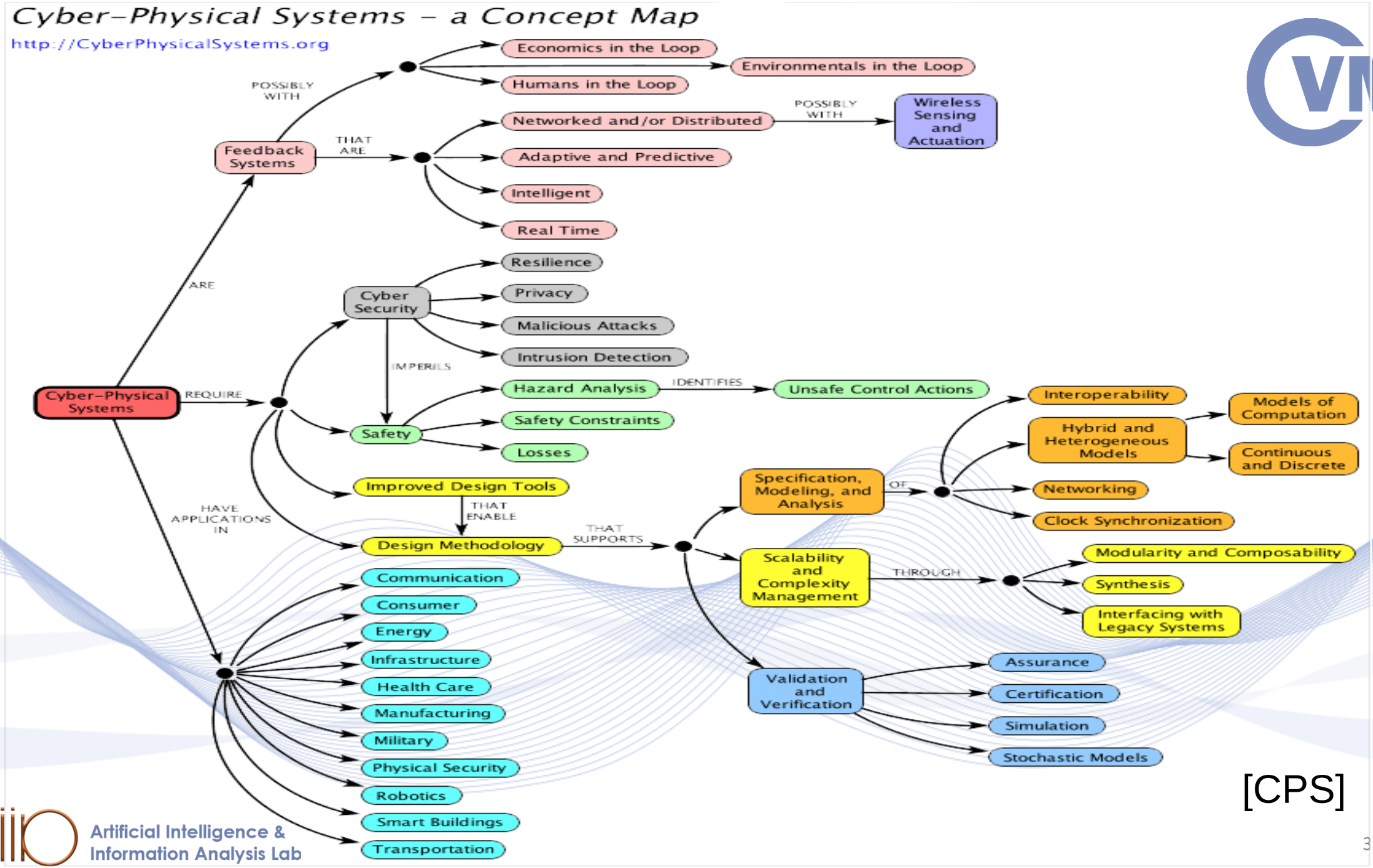
Applications of IoT

- Smart Home
- Smart Cars
- Smart Cities
- Smart Industry
- Wearables
- Smart Agriculture
- Smart Retail
- Energy Managment
- Smart Healthcare
- Smart Industry
- Smart Poultry and Farming
- Smart Dust

Internet of Things (IoT)

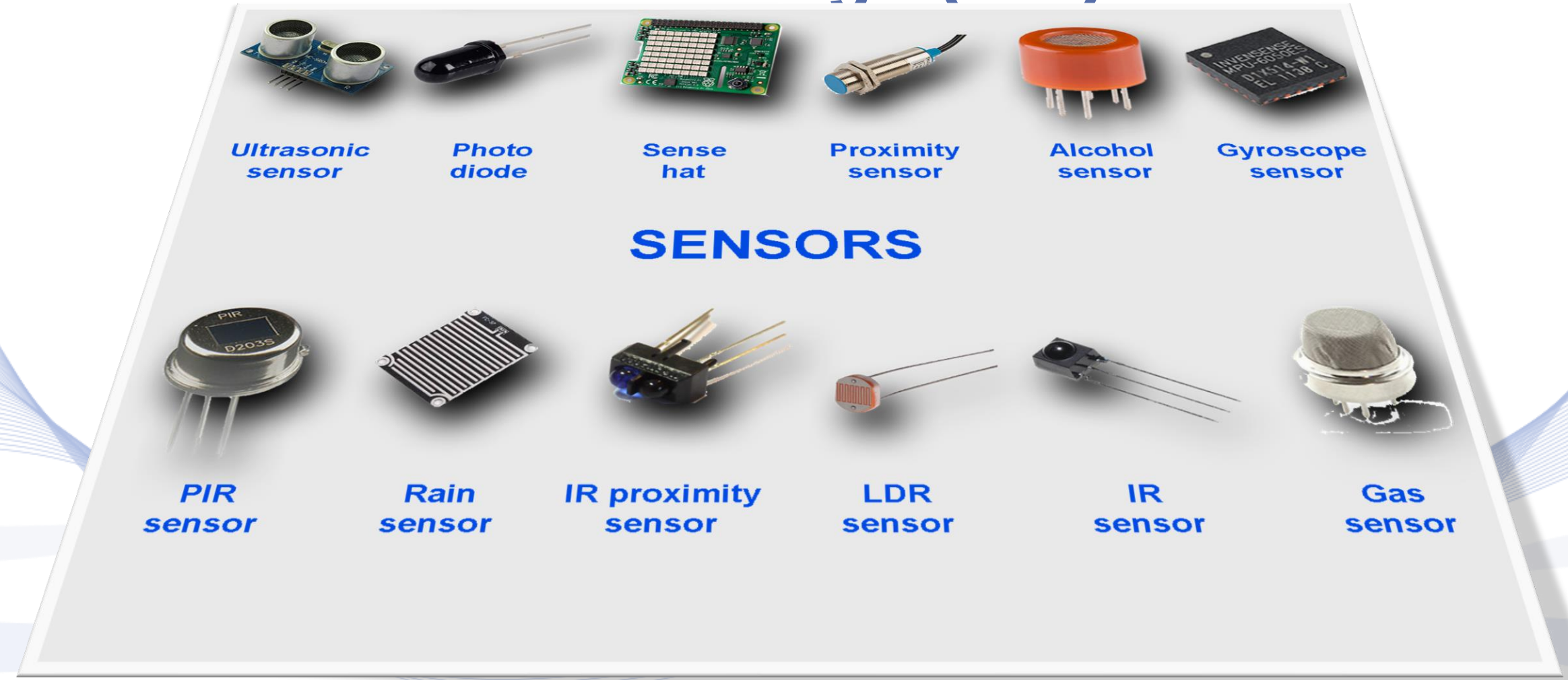


[BYTESDIG]


Cyber–Physical Systems – a Concept Map
http://CyberPhysicalSystems.org
Cyber–Physical Systems
ARE
Feedback Systems
POSSIBLY WITH
Economics in the Loop
Environmentals in the Loop
Humans in the Loop
THAT ARE
Networked and/or Distributed
POSSIBLY WITH
Wireless Sensing and Actuation
Adaptive and Predictive
Intelligent
Real Time
REQUIRE
Cyber Security
Resilience
Privacy
Malicious Attacks
Intrusion Detection
IMPERILS
Safety
Hazard Analysis
IDENTIFIES
Unsafe Control Actions
Safety Constraints
Losses
Improved Design Tools
THAT ENABLE
Design Methodology
THAT SUPPORTS
HAVE APPLICATIONS IN
Communication
Consumer
Energy
Infrastructure
Health Care
Manufacturing
Military
Physical Security
Robotics
Smart Buildings
Transportation
Specification, Modeling, and Analysis
OF
Interoperability
Hybrid and Heterogeneous Models
Models of Computation
Continuous and Discrete
Networking
Clock Synchronization
Scalability and Complexity Management
THROUGH
Modularity and Composability
Synthesis
Interfacing with Legacy Systems
Validation and Verification
Assurance
Certification
Simulation
Stochastic Models

[CPS]

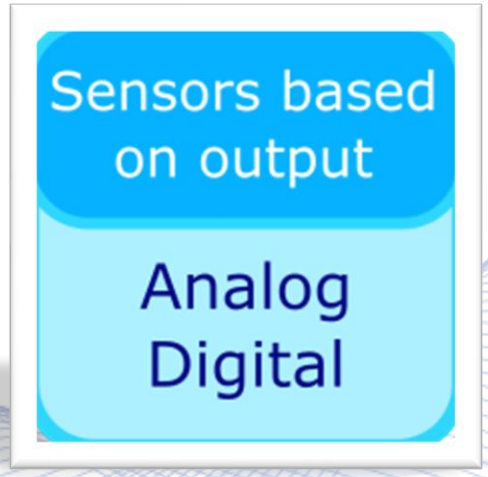
Internet of Things (IoT)

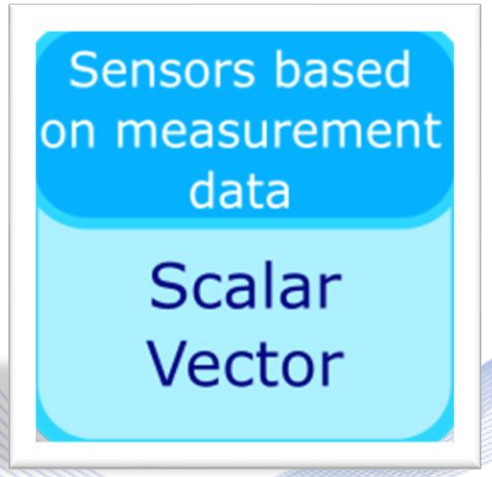


Internet of Things (IoT)

Sensors Classification

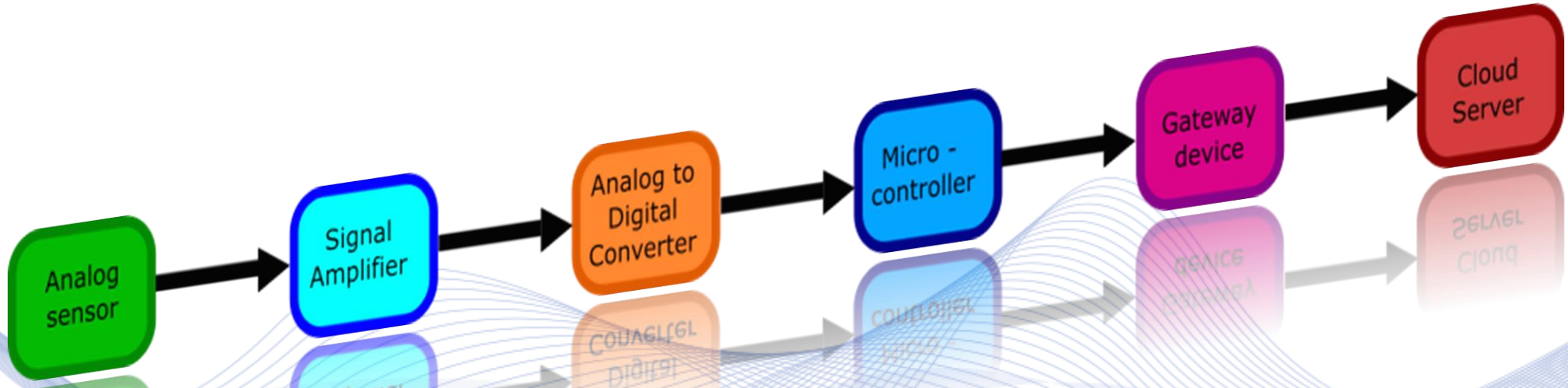
- Analog Sensors
- Digital Sensors
- Scalar Sensors
- Vector Sensors





Internet of Things (IoT)

How does the sensor works ?



Q & A

Thank you very much for your attention!

More material in
http://icarus.csd.auth.gr/cvml-web-lecture-series/

Contact: Prof. I. Pitas
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