

5G overview and first Pilots in Italy



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Agenda

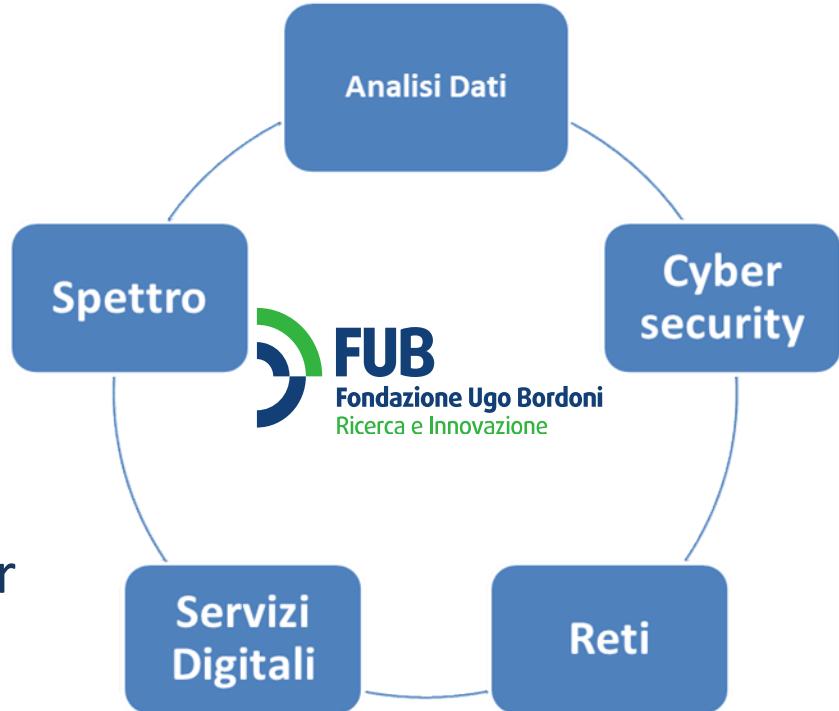
- **FUB short presentation**
- **5G overview**
 - roadmap
 - National stategy
- **New radio**
- **5G Core evolution**
- **Use cases (italian pilots)**

Fondazione Ugo Bordoni



100+ Researchers on technical-scientific application fields (Electronics, Telecommunications, Data Science, etc.)

Expertise 5 Research Areas for different scientific skills



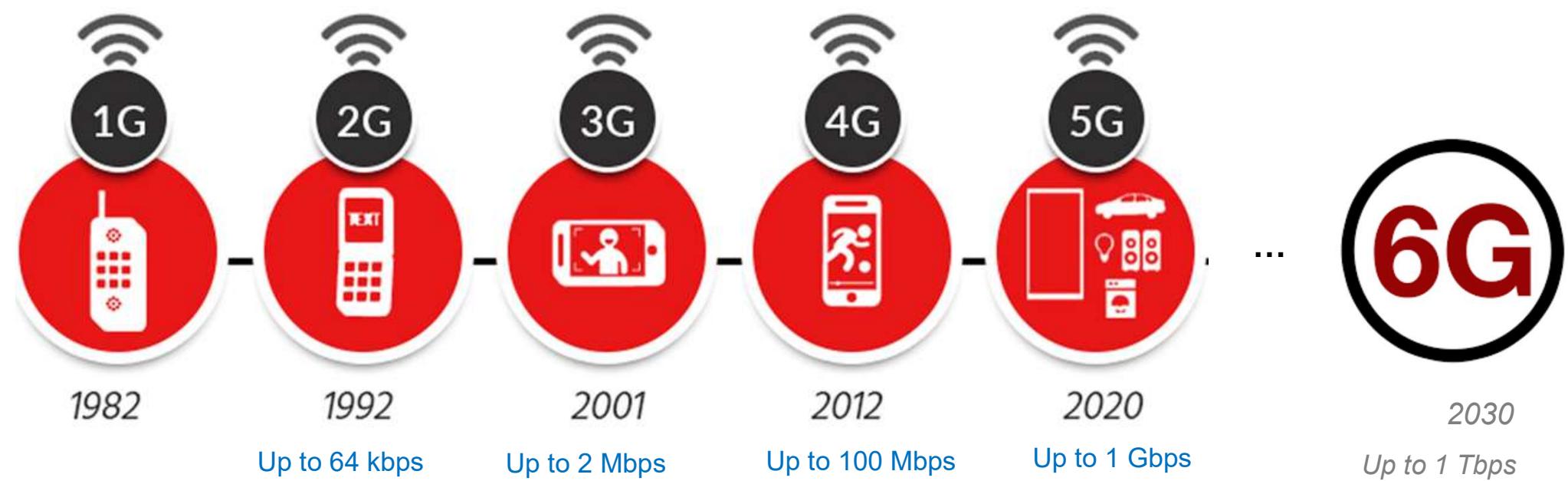
5G overview...what the say!

- **5G Overview – FUB (Fondazione Ugo Bordoni)**
 - <https://www.youtube.com/watch?v=ObegkknGkjI>
 - **5G User Pilots – MNOs (Mobile Network Operators)**
 - https://www.vodafone5g.it/5G-a-milano.php?icmp=landing_5g
 - <https://www.youtube.com/watch?v=93ahlJTGpfo>
 - <https://www.youtube.com/watch?v=eKSRiljY600>
- 

... vision

... just Ads ??

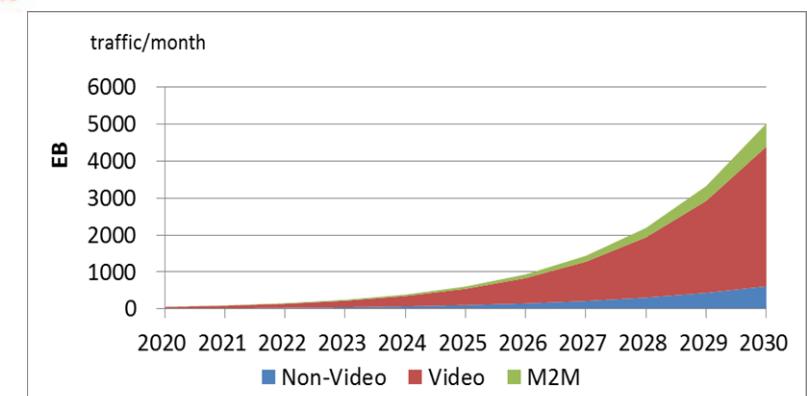
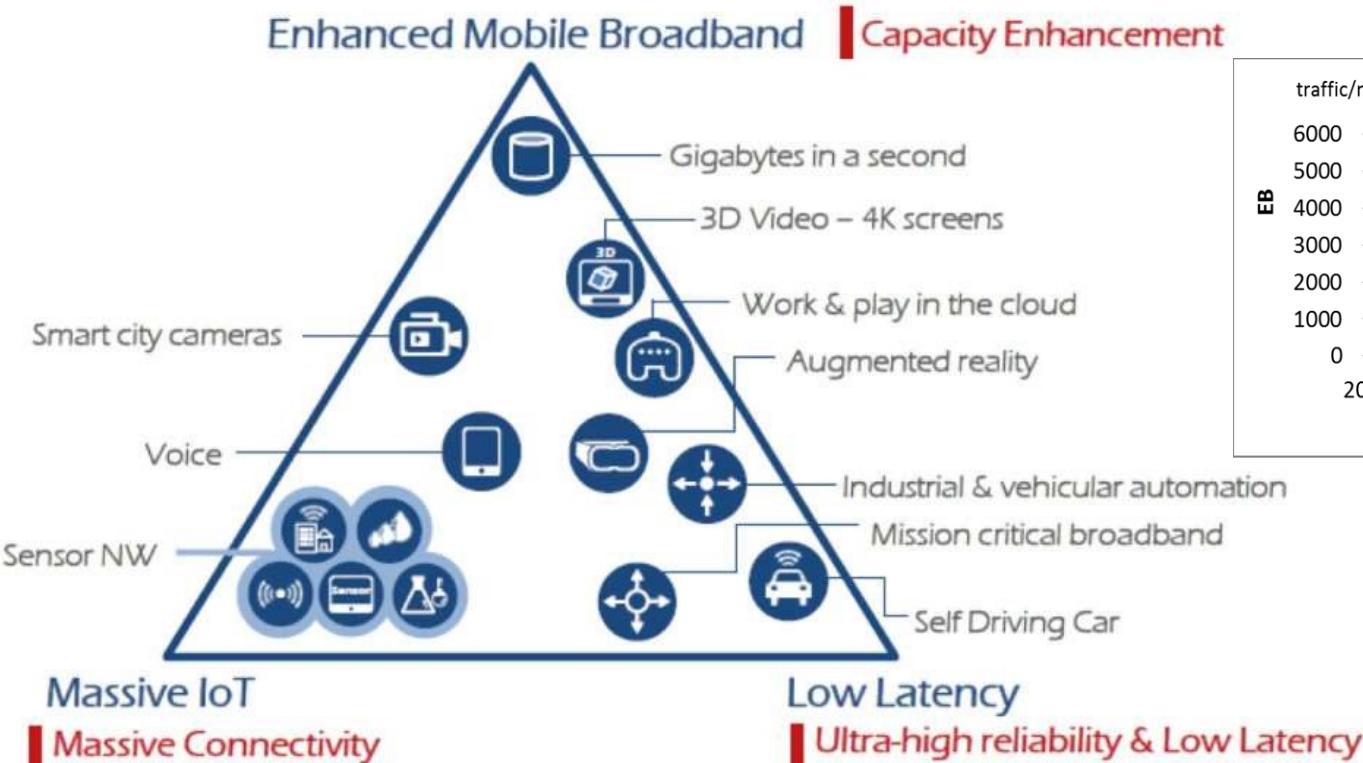
5G: only a Mobile Network Evolution?



5G Overview



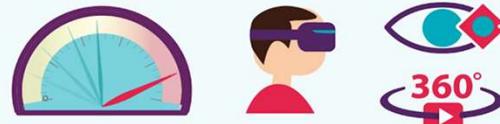
5G: a new communication Paradigms



(Source: ETRI graphic, from ITU-R IMT 2020 requirements)

What is 5G?

More data



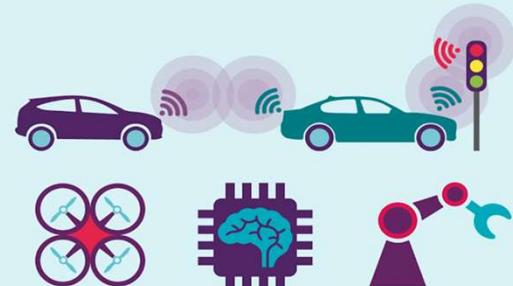
Improved consumer experience
More connected devices
Faster connection speeds
Virtual and Augmented Reality

More devices



e-health
Transport & logistics
Environmental monitoring
Smart energy networks
Smart agriculture, smart retail

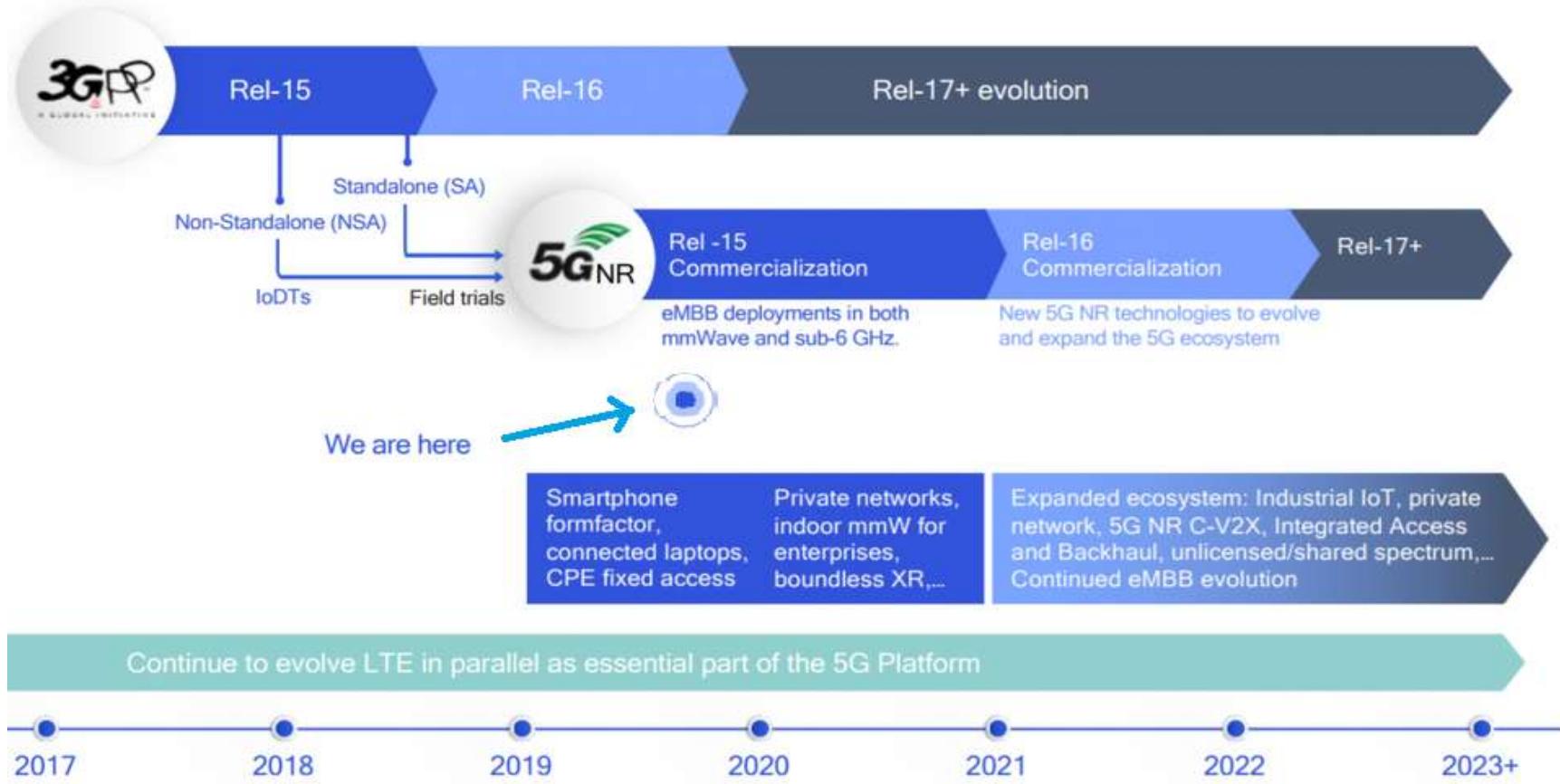
Instant response



Vehicle-to-everything communication
Drone delivery
Remote control
Smart manufacturing

Fonte <https://www.ofcom.org.uk/>

5G Roadmap



eMBB

Enhanced Mobile Broadband



- Peak Rate: 20Gbps (4G : 1Gbps)
- UX Rate : 100~1000Mbps

First commercial deployment by 2019 (eMBB)

Download of 15GB HD Video



240 sec

URLLC

Ultra Reliable & Low Latency Communications



- Latency : 1ms (4G : 10ms)

Reliable and Resilient Applications by 2022 (uRLLC)

Autonomous vehicles moving at 100km/h



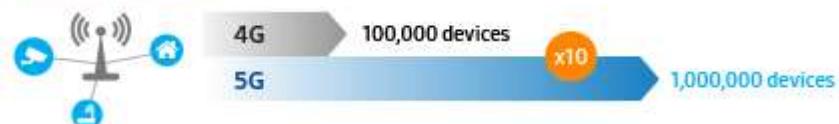
mMTC

Massive Machine-Type Communications



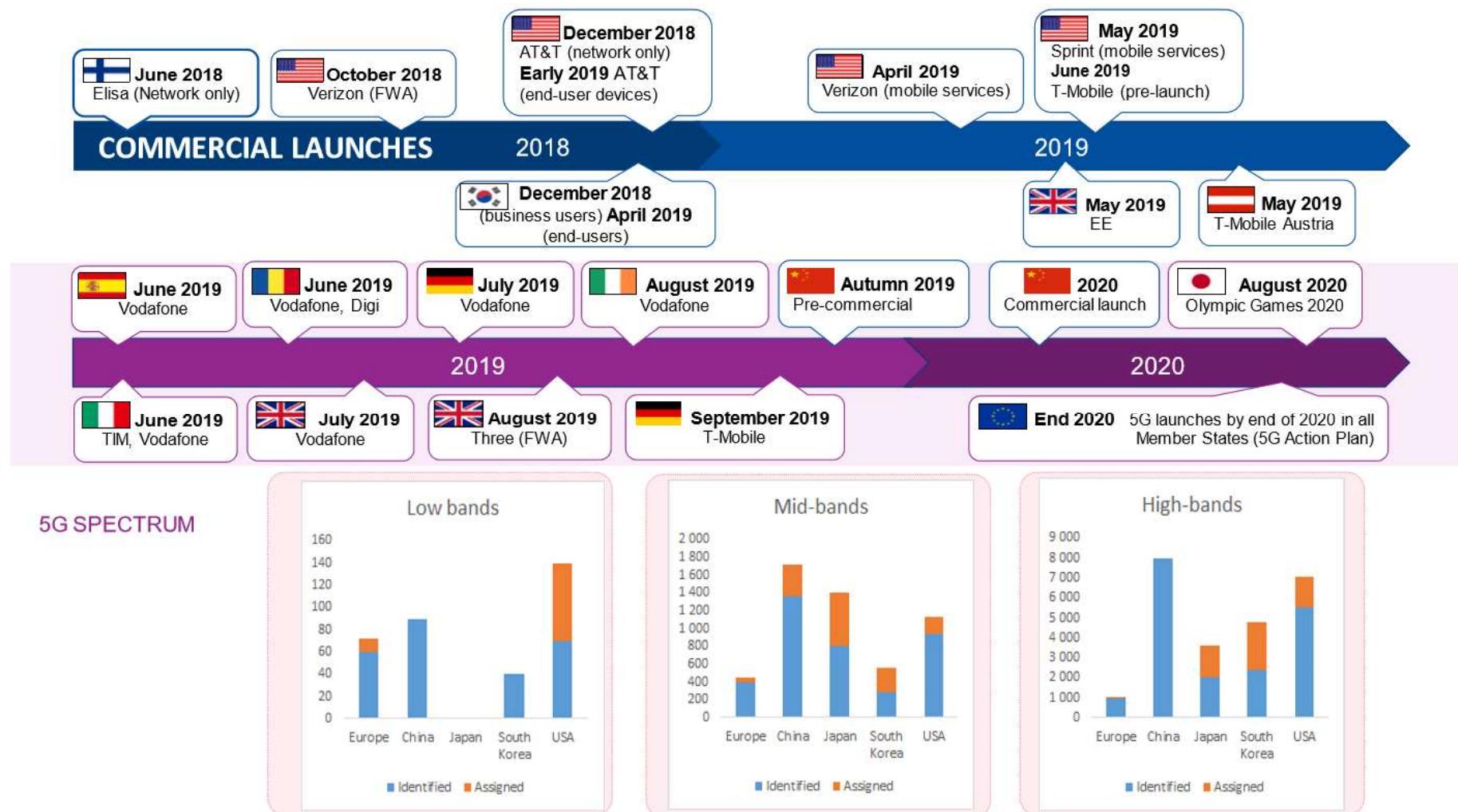
- Connection : 10^6 devices/km²
(4G : 10^5 devices/km²)

Within an area 1km²



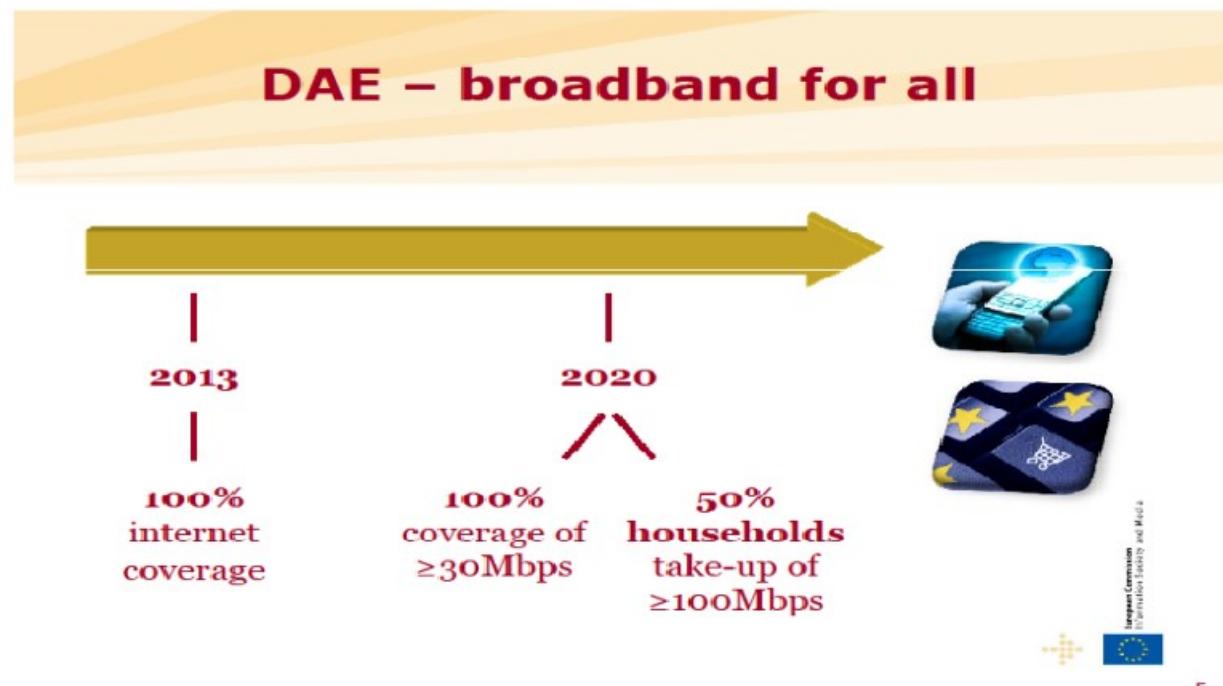
IoT massive Application by 2023 (mMTC)

Worldwide deployment roadmap



European Strategy : broadband for all

- European Commission has defined specific goals as defined in **European Digital Agenda (Com.2010/245)** in order to promote **social inclusion** in European Commission States



European Strategy: 5G roadmap

- *European Commission has developed a 5G Strategy by defining the “5G Action Plan”* in which a description of the 5G roadmap for all Member States is provided

Preliminary 5G pilots in selected area for each Member State

5G Commercial Launch in at least a Big City for each Member State

5G deployment in the main urban areas and in the main transport line (raillway, highway)

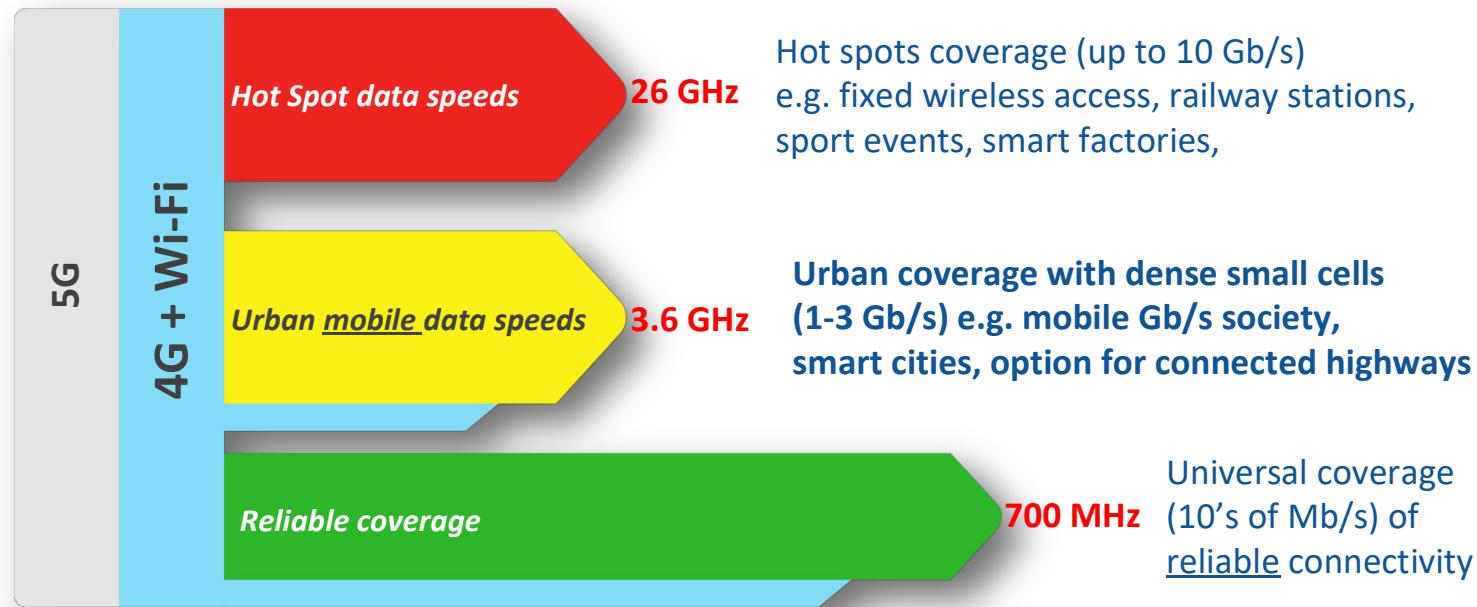
2018

2020

2025

European Strategy towards 5G

EU 5G 'Pioneer' Frequency Bands



Italian Strategy towards 5G

- «*Piano Banda Ultralarga*»: *UltraBroadBand Strategy*
 - 100% coverage of ≥ 30 Mbps by 2020
 - 85% coverage of ≥ 100 Mbps by 2020
- «*Sperimentazione 5G*»: *5G Preliminary Pilot*
 - *5 italian cities* has been selected in 2017
 - *Further cities* have been added in 2018/2019

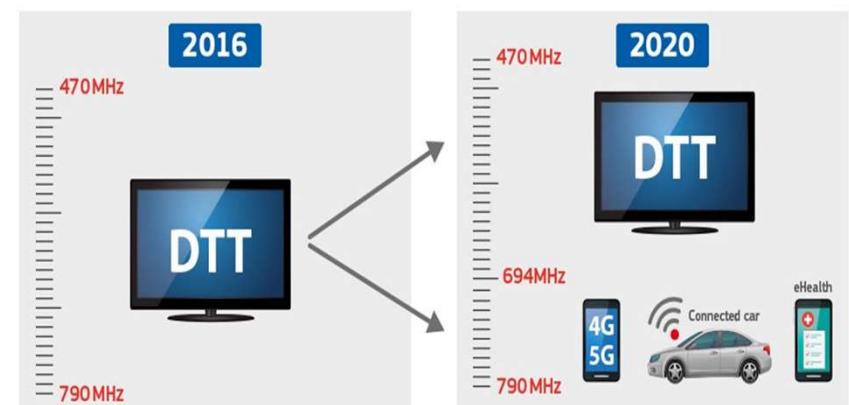


5G in 5 CITTÀ

Wired & FWA

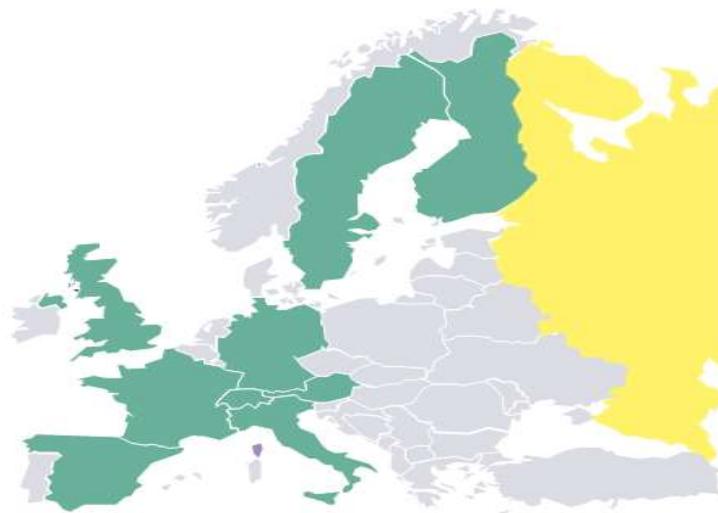


- «*Legge di Bilancio 2018*»: *Budget Law 2018*
 - 700 MHz Spectrum Band Harmonization
 - 5G Spectrum Auction



5G Spectrum Auction in Europe

	Band	Auction
• 3.4 - 3.6 GHz (150 MHz)	Done/2018	
• 3.6 - 3.8 GHz (116 MHz)		Q4 2019
• 26.5 - 27.5 GHz		2020
	Band	Auction
• 3.6 - 3.8 GHz		<i>Done/2018</i>
• 26.5 - 27.5 GHz		<i>Done/2018</i>
	Band	Auction
• 3.46 - 3.8 GHz	Q4 2019	
• 26 GHz		2020
	Band	Auction
• 3.6-3.8 GHz	Done/2018	
• 26.5 - 27.5 GHz		2020
	Band	Auction
• 3.4 - 3.8 GHz	Jan. 2019	
• 26.5 - 27.5 GHz		2022



Fonte: Qualcomm "Focus on mid-band (3.4–3.8 GHz) and 26 GHz (24.25–27.5 GHz) for 2018+", PIRMC 2018

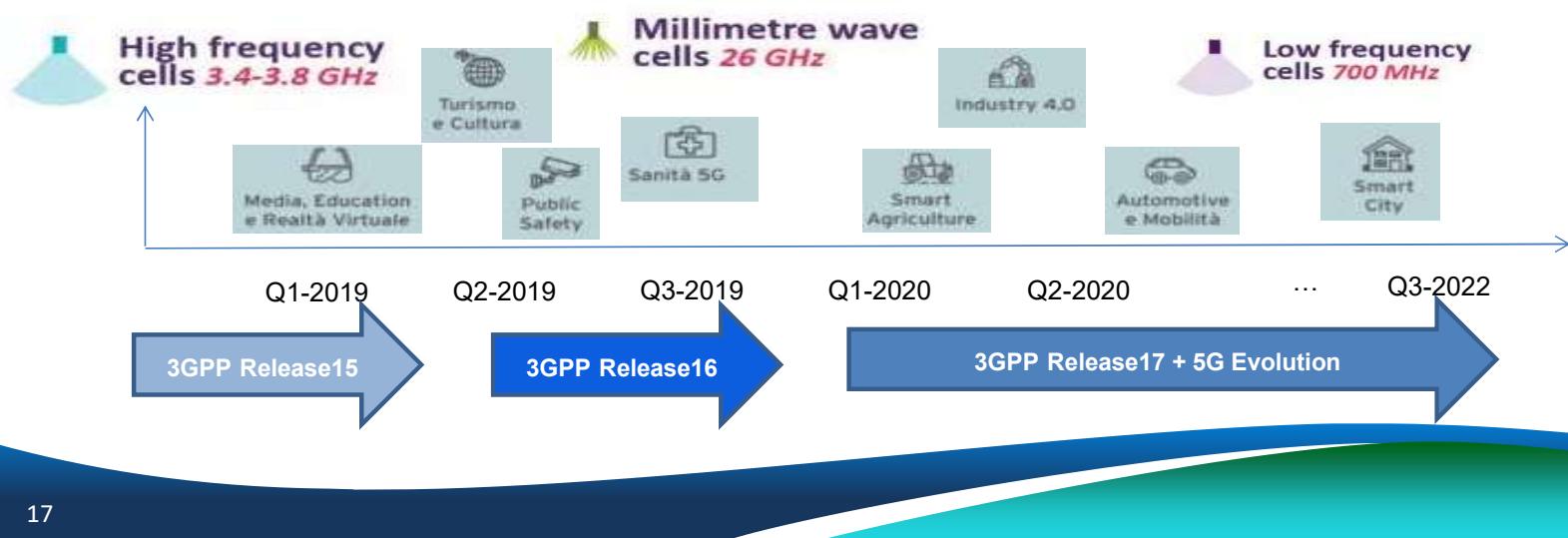
	Band	Auction
• 3.4 - 3.8 GHz		Q1 2019
• 26 GHz		2020
	Band	Auction
• 3.4 - 3.7 GHz	Q1 2019	
• 26 GHz		2019/2020
	Band	Auction
• 3.4-3.8 GHz	Rostelecom	
• 26 GHz		Q1 2019
	Band	Auction
• 3.4 - 3.8 GHz	Q3 2018	
• 26 GHz		2020
	Band	Auction
• 3.4 - 3.8 GHz	Q1 2019	
• 26 GHz		2020

Italy, is the first Country in Europe, and the second one in the World to have assigned *all 5G pioneer bands* (700 MHz, 3.4-3.8 GHz e 24-27.5 GHz).

Italy is the tenth Country in the World to have started pilots

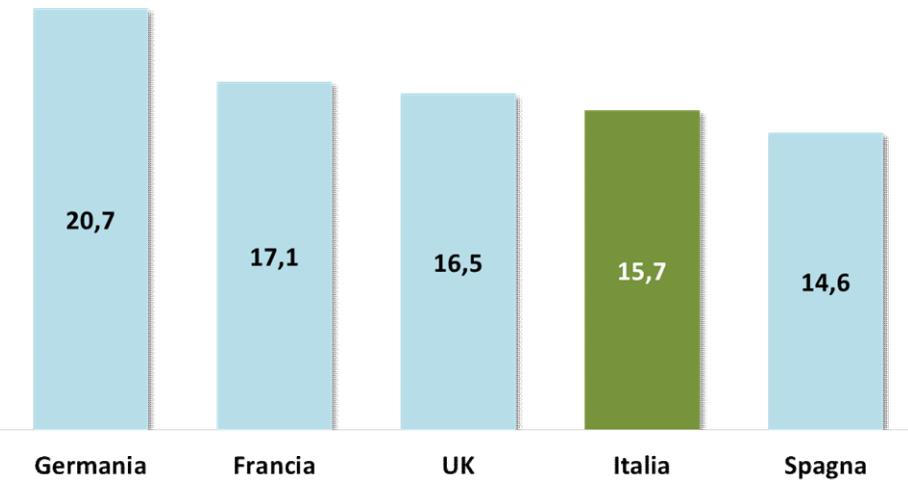
5G in Italy: Work in progress

- 5G Spectrum Auction in Italy has reached an amount of **6,550 billions of euros**
- The first commercial installations of the 5G will be scheduled by the **end of 2019/early of January 2020**, by using the first frequencies available, **3.6-3.8 GHz**, that will be those useful to realize services with a good compromise between capacity and coverage
- Subsequently, the **700 MHz bands will be available only in 2022** so massive IoT and ultra-reliable applications with high connectivity and reliability requirements will be gradually provided **in the next five years**



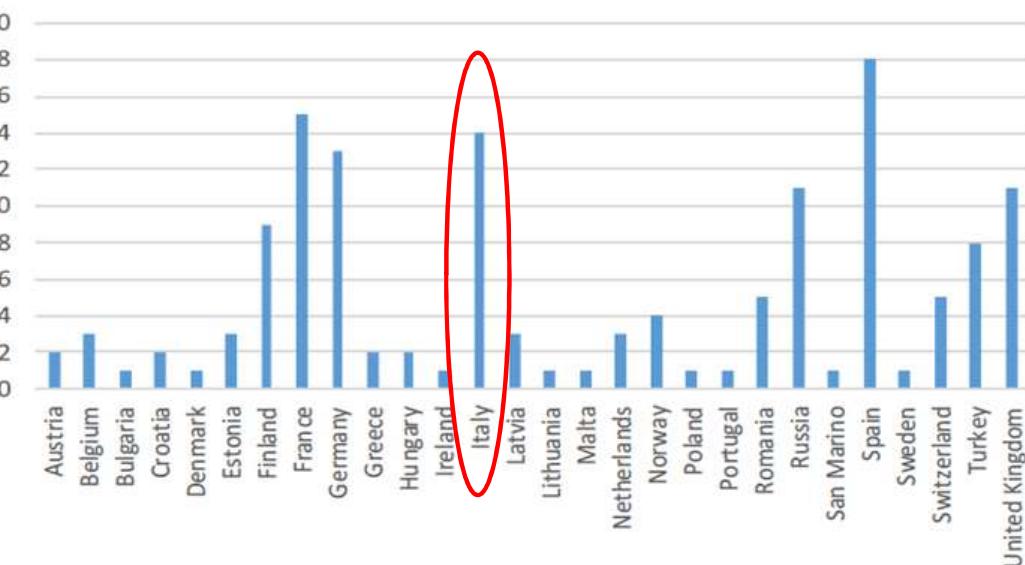
Economic 5G impact

Economic impact until 2025



actual Pilots

18



New Radio



5G Keywords:

ccess Networks

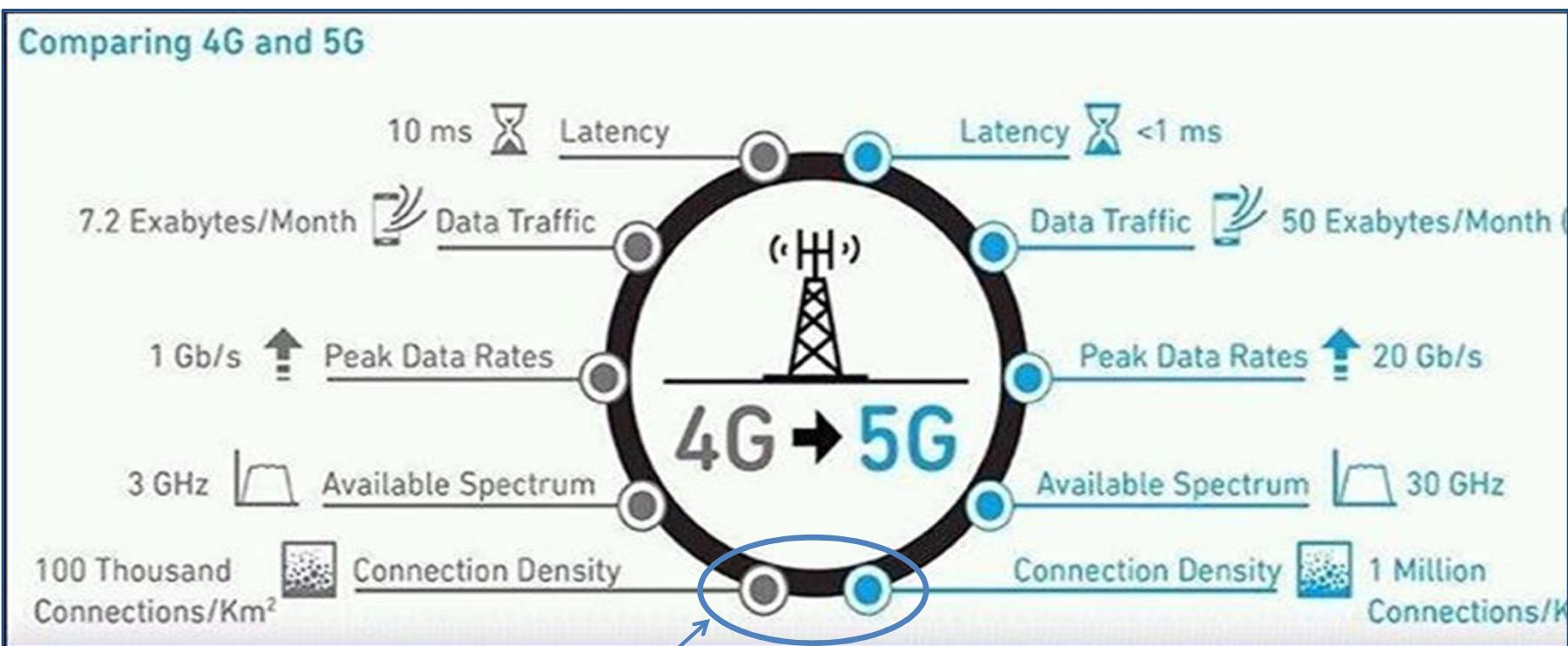
EC (Multi Access EDGE Computing)



- SDN/NFV
- Slicing



4G vs 5G



Basics: Legacy and 5G macro sites

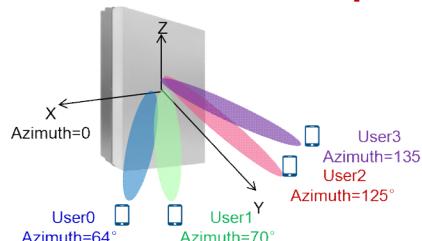
Traditional legacy sites



$$C = B \log_2 \left(1 + \frac{S}{N} \right)$$



5G sites with 3D MIMO with Spatial Multiplexing capability



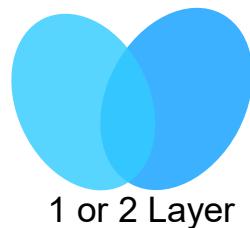
$$C_{M-MIMO} = \sum C_n$$

$$C_1 = B \log_2 \left(1 + \frac{S_1}{N_1} \right)$$

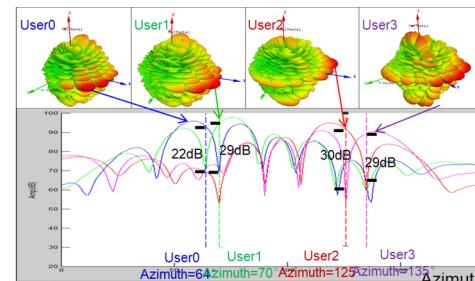
$$C_n = B \log_2 \left(1 + \frac{S_n}{N_n} \right)$$

TRX = 8/16/32/64/...

TRX = 2/4



Monitoring can be done at resource level (time and frequency) as radiation pattern are fixed

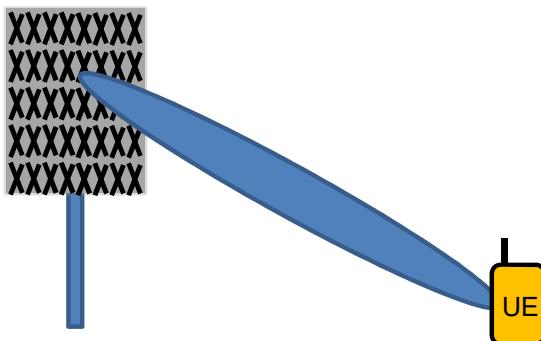


Traffic beams change in 3D space at every channel estimation: time, frequency + 3D space

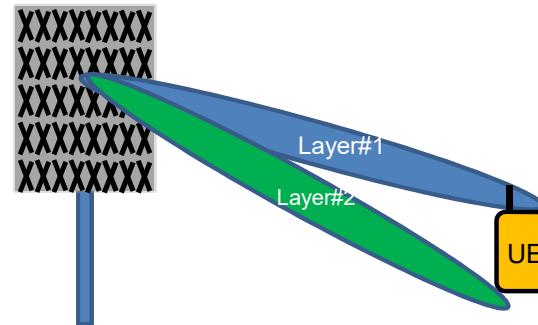
5G radiation direction is variable also in 3D space

Massive MIMO basic concepts

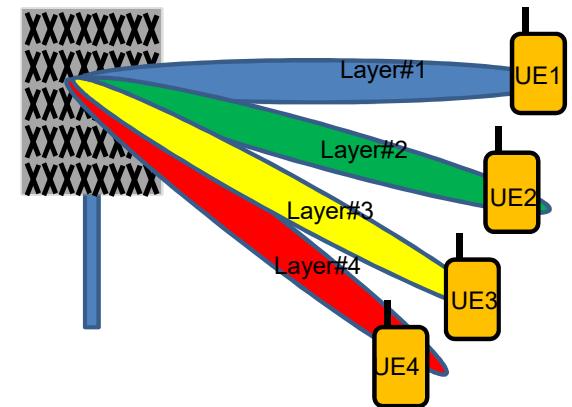
Beam Forming - BF



SU MIMO



MU MIMO

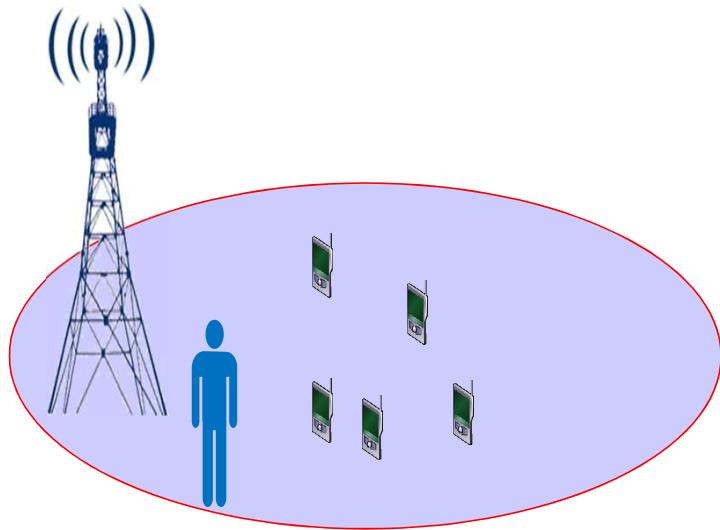


- Narrow Beam
- Traffic Channel Beam **Dynamic Sweep**
- Typical Beam:
 - High Gain: 24~25dBi
 - HBW: 10~13°
 - VBW: 6°
 - Sweeping Beam Period: 0.5/1ms
- System uses **multi beam** to provide service to **ONE UE**
- **One Layer = One Beam**
- Different Beams have same or different direction
- Each **Layer** uses **part of the total power**
- UE with 4 receiver antenna will receive 1~4 layer
- System uses **multi beam** to provide service to **MULTIPLE UEs**
- **One Layer = One Beam**
- Different Beams have same or different direction
- Each **Layer** uses **part of the total power**

BF can be seen as a SU-MIMO case in which all layers collapse in one direction

Differences Between 4G and 5G MM

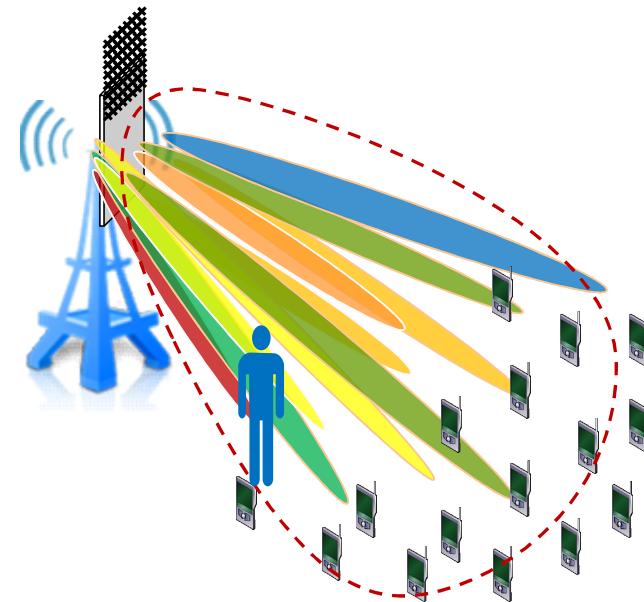
2G/3G/4G: Static Wide beams



Worst Case EMF = Total Power + Antenna Gain

Legacy sites: **No Beam Forming, No Dynamic Power Control**

5G Massive MIMO: Dynamic Narrow Beams



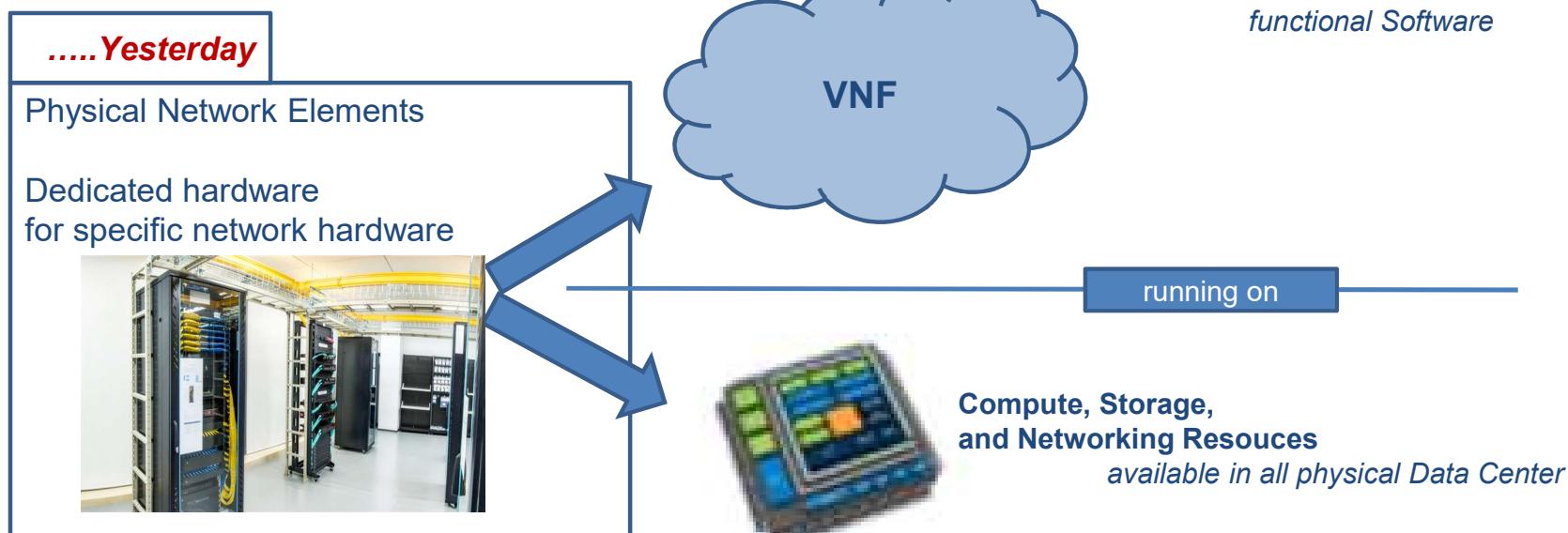
Worst Case EMF = Layer Power (1 or 2 layers same direction) + BF Antenna Gain

5G sites: **Beam Forming, Power Control, MU MIMO power is distributed in 3D-space**

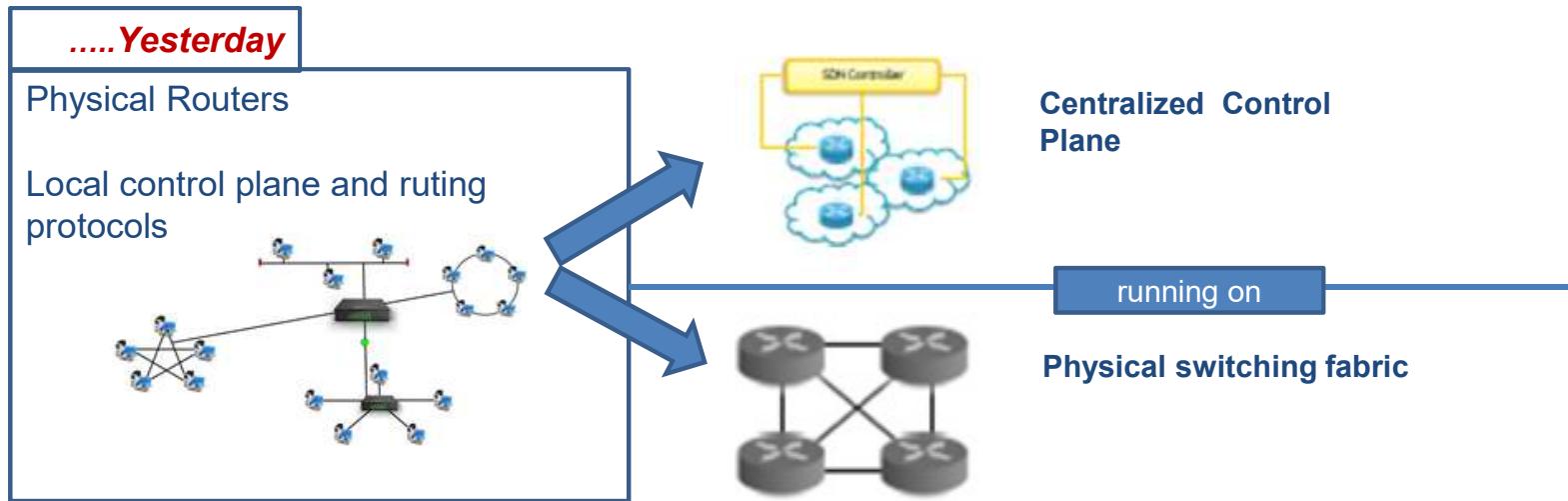
5G Core evolution



5G network Core evolution (I)

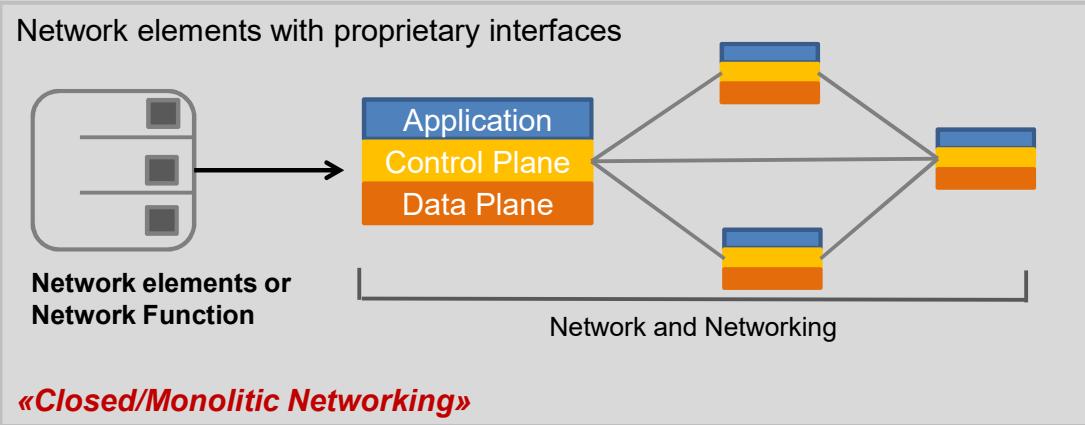


5G network Core evolution (II)

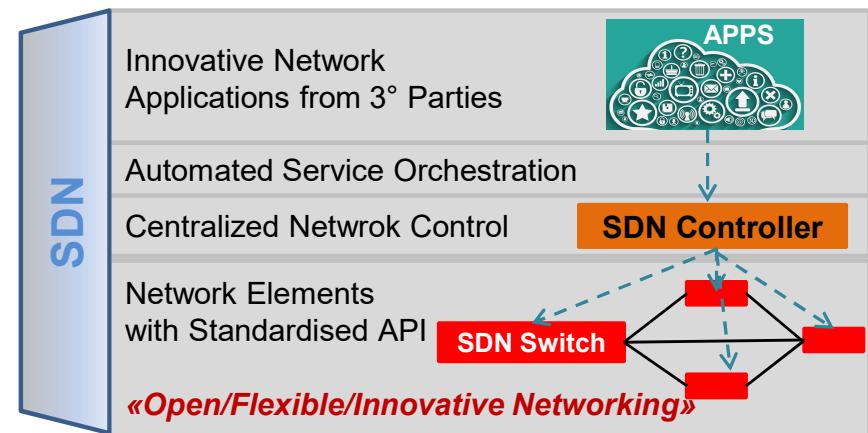


5G network Core evolution (III)

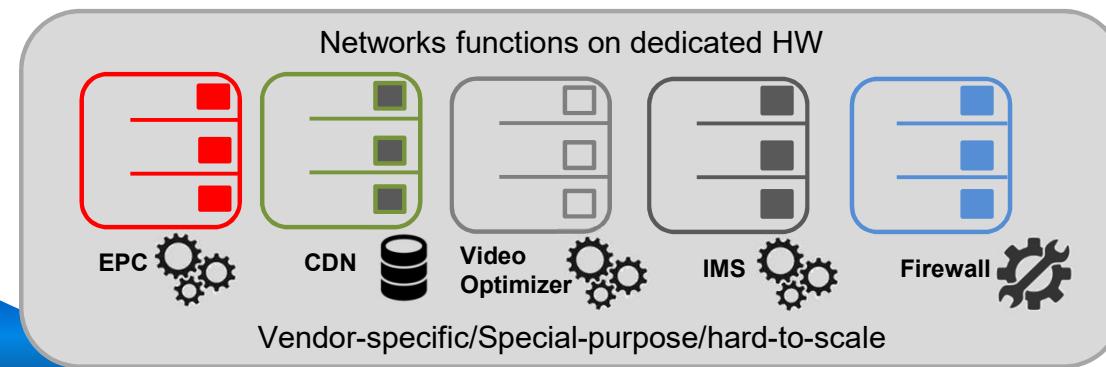
Traditional Networks



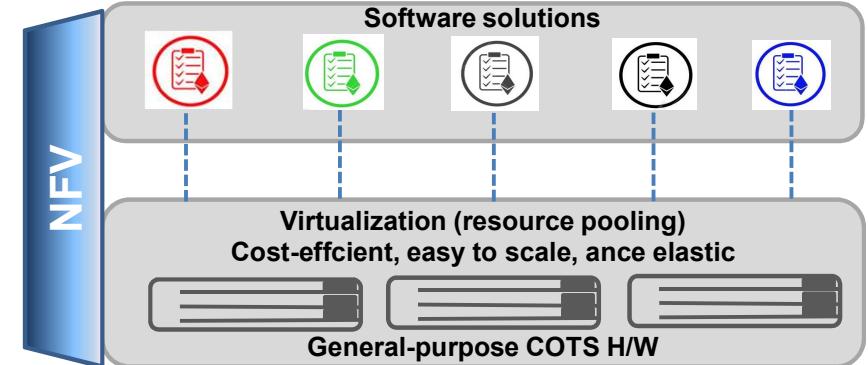
Networks with SDN



Traditional Networks

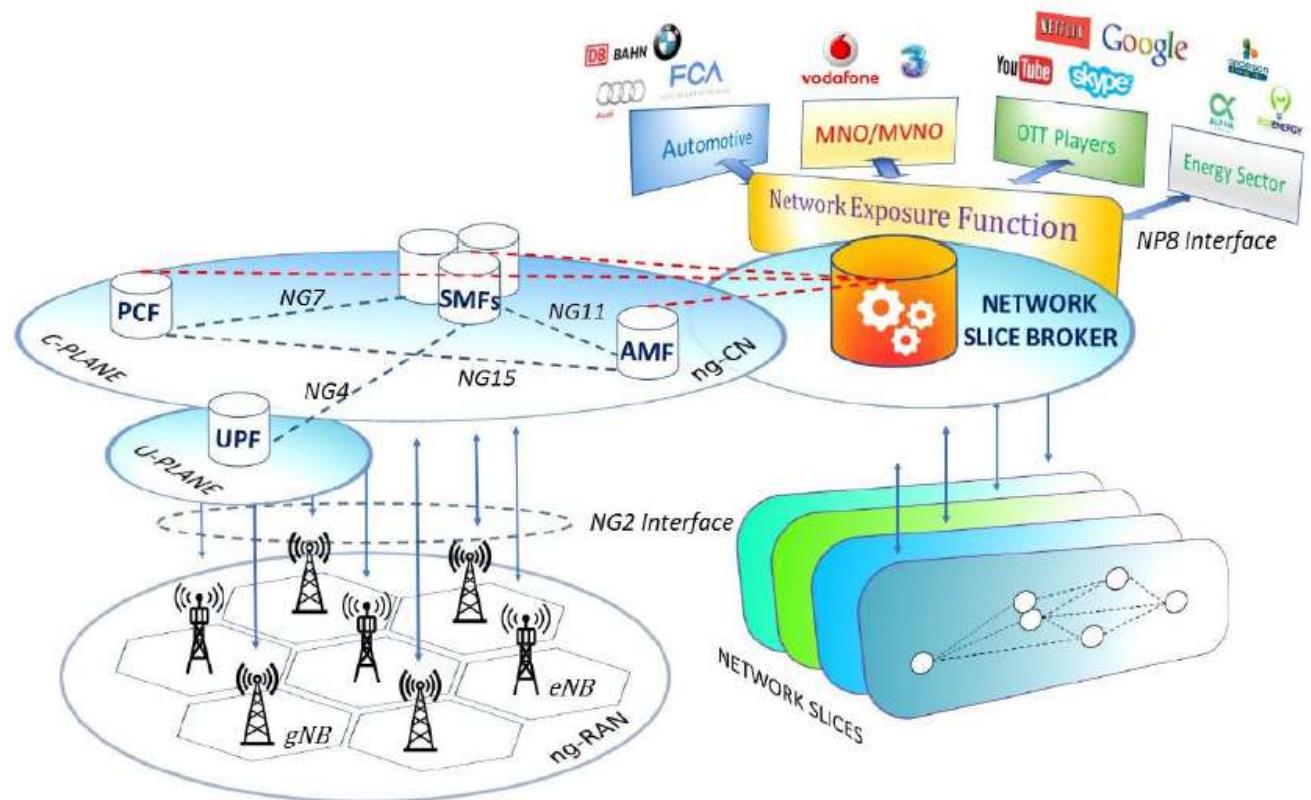


Network with NFV

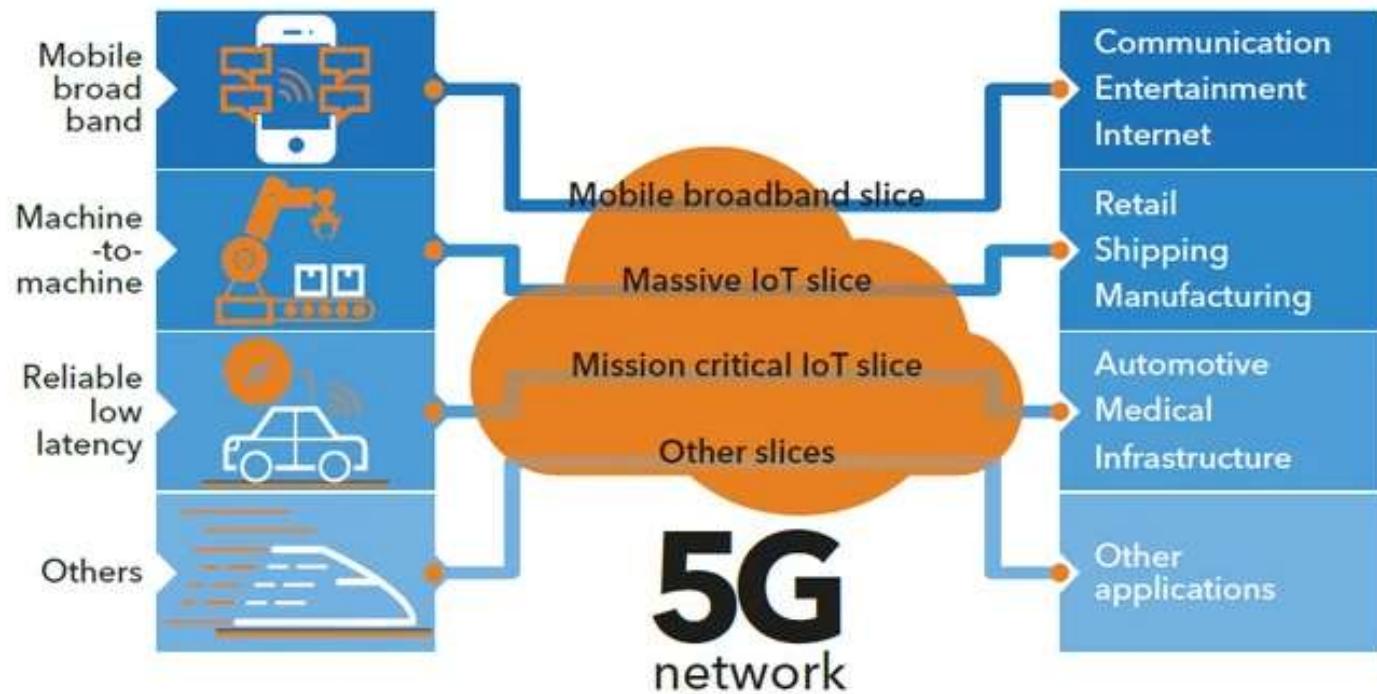


Network Slicing

- **Network Slicing:**
Software management able to create *optimal virtual networks* for each application



Network Slicing (II)



Previous network:
no flexibility

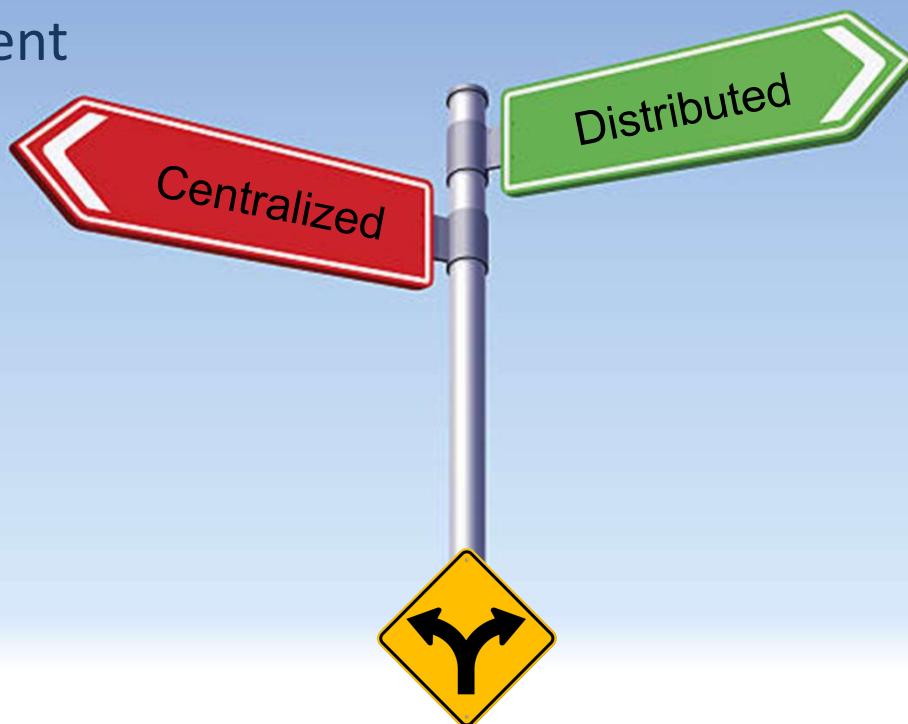
5G network: A *network slice* is a logic end-to-end network tunnel based on physical infrastructure and able to provide specific Quality of Service (QoS) for a specific application

Envolved Stakeholders



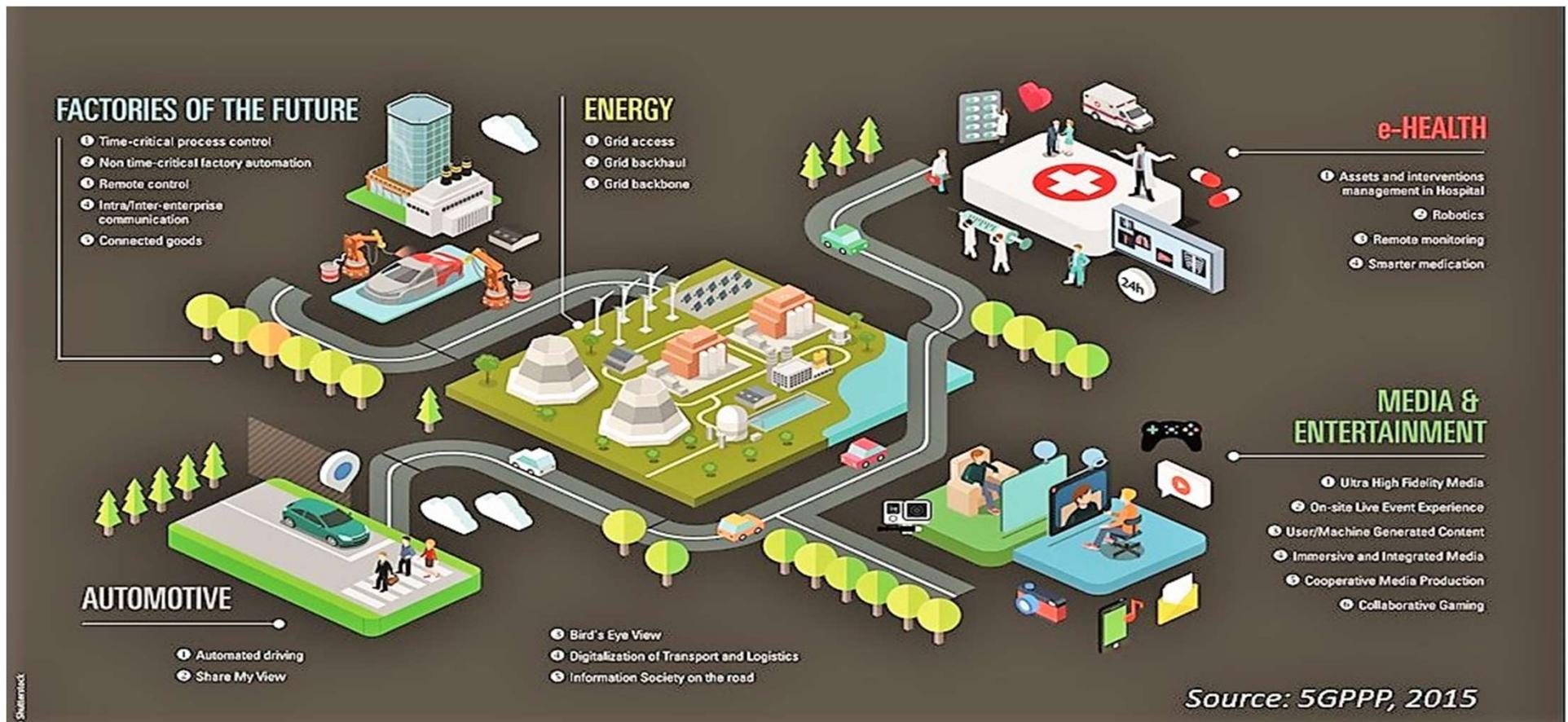
Open Issue (two-way fork)

- easier
- Service independent
- Minor resources
- statistic
- classification/
priority (?)
- Feasible



- complex
- Service dependent
- No limits resources!
- Fixed, mobile,
and...5G
- Classification/
priority (?)
- Feasible (?)

5G is not a simple upgrade of 4G



5G and Vertical Sector

5G Network will allow Verticals to definition of innovative services



TODAY

Capacity < 1Gb/s Data Traffic 7.2 Exabyte/mounth	Capacity Up to 20 Gb/s Data Traffic 50 Exabyte/mounth
Latency = 10 ms	Connected cars Latency 1 ms Localization accuracy <10 cm
Video surveillance	HD Video real time
Automation Process 1000 connected devices/Km ²	Industry 4.0 and Smart Factory 1 mln connected/Km ²
Electric Grid monitoring	Smart Grid development with real time applications
Telemedicine	Remote Surgery with latency < 1 ms High Reliability

Use Cases (Italian Pilots)



5G Pilots



5G Pilots (I)

- **"Sperimentazione 5G del Mise avviso pubblico (16 marzo 2017)"
for pre-commercial pilots in 3.6 - 3.8 GHz frequency bands**
- **Five cities**
 - **Area 1 – Area Metropolitana Milano**
 - **Area 2 – Prato, L’Aquila**
 - **Area 3 – Bari, Matera**

Area 1 - Area metropolitana di Milano

1°	Vodafone Italia S.p.A.	Punti 92,6/100
2°	Telecom Italia S.p.A., Fastweb S.p.A., Linkem S.p.A. e Ericsson Telecomunicazioni S.p.A.	Punti 79,7/100

Area 2 - Prato e L’Aquila

1°	Wind Tre S.p.A. e Open Fiber S.p.A.	Punti 74,3/100
2°	Vodafone Italia S.p.A.	Punti 71,5/100
3°	2bite S.r.L.	Punti 67,8/100

Area 3 - Bari e Matera

1°	Telecom Italia S.p.A., Fastweb S.p.A. e Huawei Technologies Italia S.r.L.	Punti 86,6/100
2°	Vodafone Italia S.p.A.	Punti 84,1/100

5G Pilots: Area 1

Milano: 41 use cases



e-heath: wearable,
connected ambulance,
telemedicine



smart city: smart energy,
culturare heritage, tourist 4.0

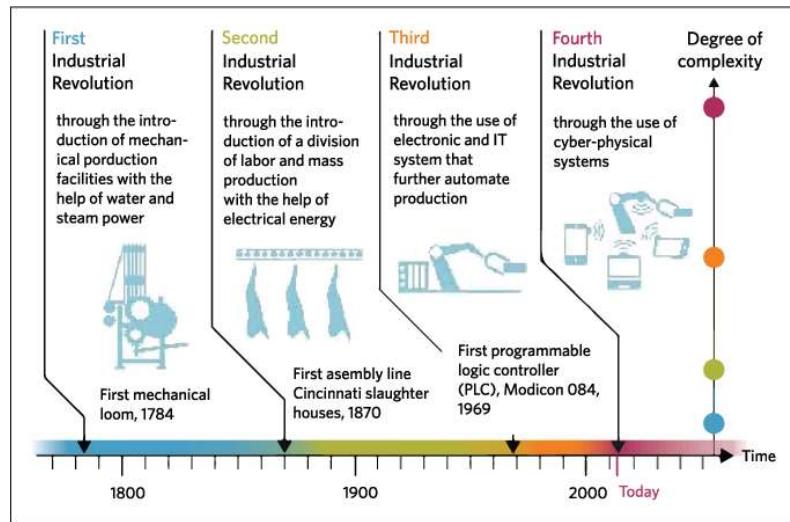


security: surveillance,
emergency services

5G Pilots: Area 2 - Prato

Prato: digital manufacturing use cases

5G pilots have been mainly focused on **digital manufacturing** and the implementation of **Industry 4.0 applications** due to the characteristics regional context based on a lot of SMEs of textile manufacturing



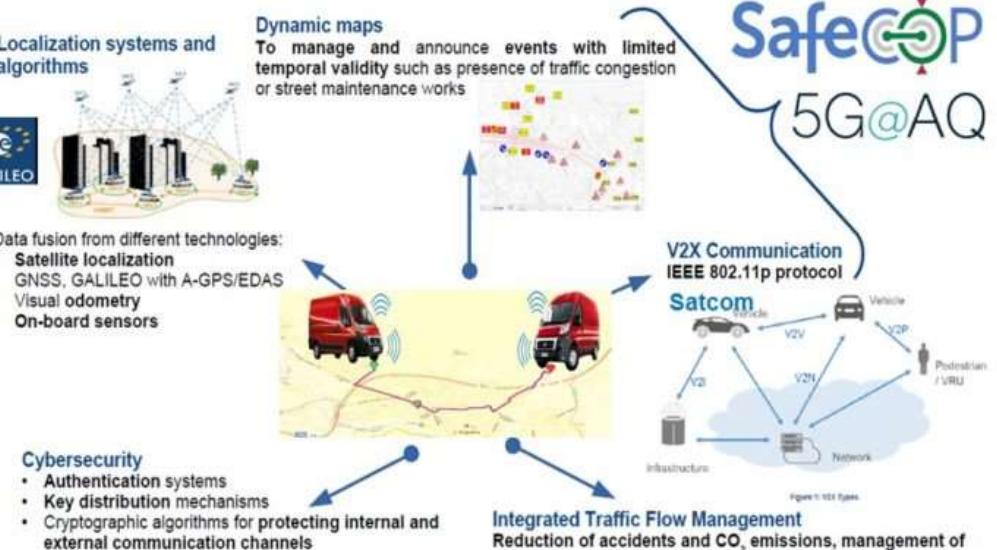
5G Pilots: Area 2 – L’Aquila

L’Aquila: critical infrastructure use cases



Structural Health Monitoring: to elaborate the state of preservation of monuments and to prevent seismic damage

5G security use cases and smart traffic management with satellite communication integration



5G Pilots: Area 3 – Bari Matera

Bari & Matera:

Innovative services on e-Health, Industry 4.0, Tourism, Automotive and Public Safety

Bari

5G is proposed to develop “*Port of Bari 4.0*” to efficiently monitor the maritime traffic of Bari

Matera

Cultural Heritage projects are part of the “*Matera capital of culture 2018*” where 5G is proposed to develop Culture & Virtual Visit using immersive reality and augmented reality to visit the Sassi of Matera

Bari Matera 5G



Other 5G Pilots: Roma

Virtual Reality and Augmented Reality

Adopted on Cultural Heritage sector was presented at the “**Terme di Diocleziano**” by using a virtual reconstruction of the no longer accessible or existing environments through special high-resolution viewers up to **6K for videos** and **12K for images**



Other 5G Pilots: Genova

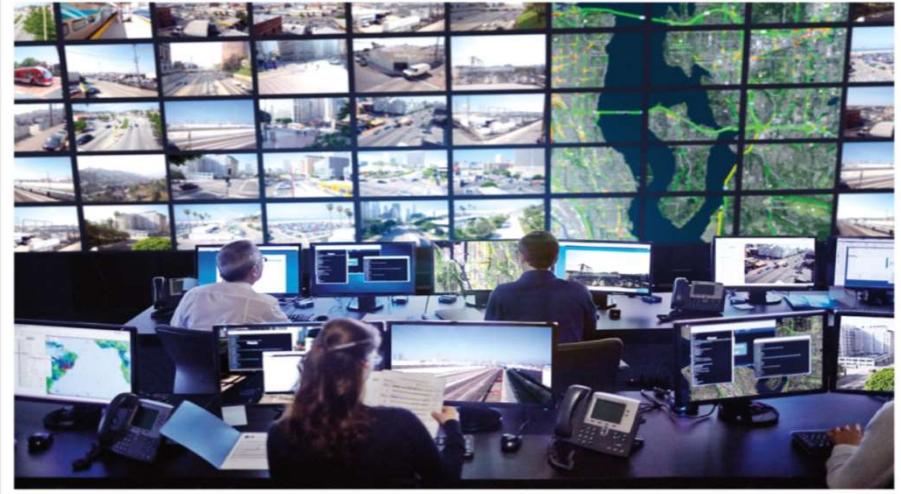
- Use of technologies for Augmented and Virtual reality for the development of innovative ***fruition applications at the “Porto Antico” of Genova***
- Definition of a digital ***IoT ecosystem for intelligent city management***, in order to develop new application services enabled by 5G, according to existing Wi-Fi platform deployed in the city for **Genova Smart City project implementation**



Other 5G Pilots: Torino

Torino: Automotive and Smart City 5G use cases

5G Automotive use pilot: connected car has been tested in Turin on 2019



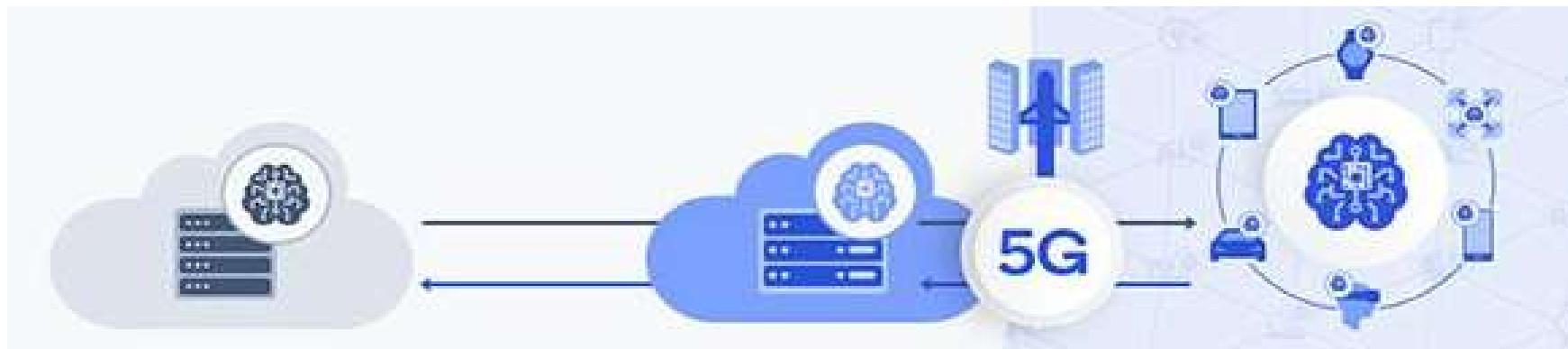
Smart City Control Room has been developed for innovative 5G services such as: smart traffic, smart lighting, smart waste, smart energy and advanced mobile video surveillance

Conclusion



5G: Conclusion

- The complexity of the future 5G scenario will require further investigation in several aspects
 - Telecommunication Networks management of all physical networks: fixed, mobile and satellite
 - Software management of Telecommunication Networks (*Network Slicing*)
 - Vertical Sector for new applications
 - Big Data, Artificial Intelligence, Blockchain, Cyber Security to develop future innovative services





Q&A



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