



**1<sup>ère</sup> Conférence Internationale de l'INT sur la  
Régulation des Communications Électroniques**

*"Les nouvelles tendances technologiques et  
régulatrices des réseaux du futur"*

13 & 14 mars 2018 - Hôtel le Palace, Gammarth, Tunisie

# Telecommunications evolution towards 5G

Francesco Vatalaro

Professor of Telecommunications

University of Rome Tor Vergata, Italy

Tunis, Mercredi 14 Mars 2018

Session 4: 5G, IoT, Big Data et Cloud: nouvelles opportunités technologiques et entrepreneuriale

# Mobile Generations



**2G – 1992**  
Voice  
Messages



**3G – 2002**  
+ Data  
+ Positioning



**4G – today**  
+ Video Conferencing  
+ 3D Graphics



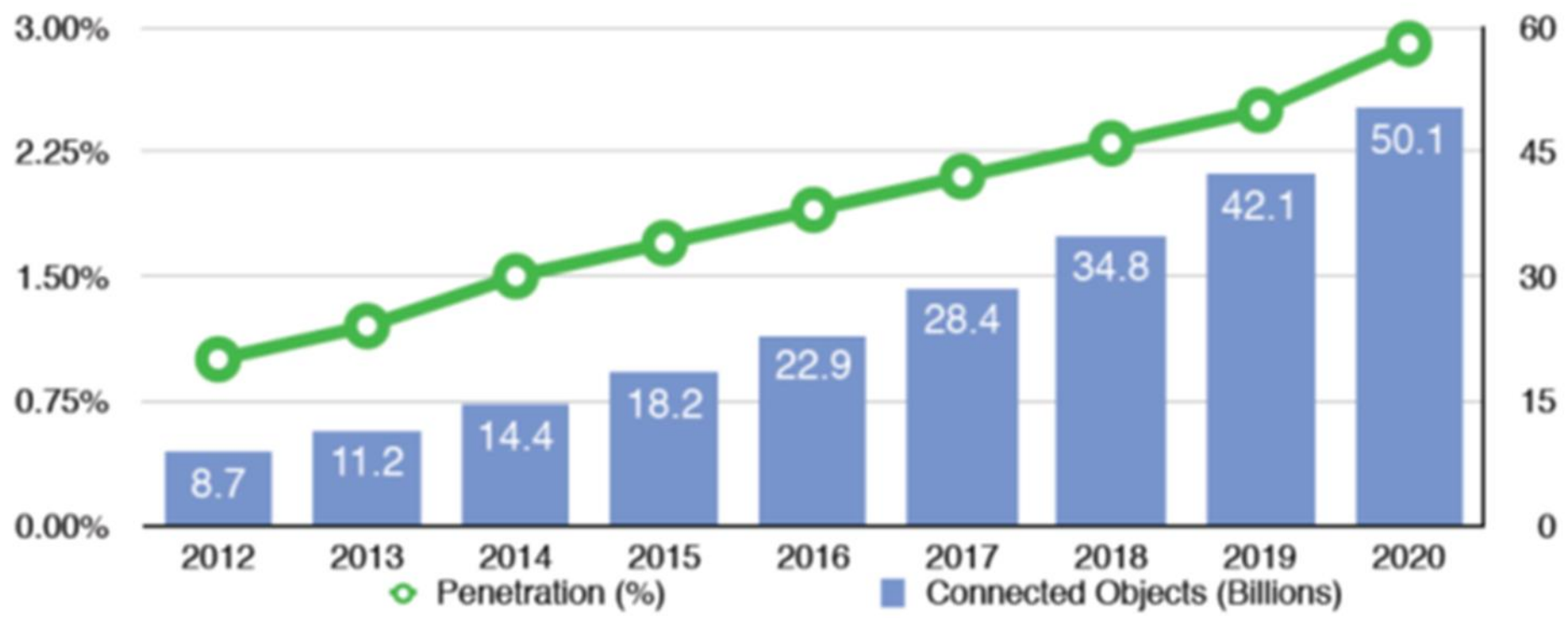
**5G – 2020**  
+ Control  
+ Things 2.0

# Overall 5G vision



Xiang et al. "5G mobile communications" Springer, 2016

# Projections for the Internet of Things



Source: Cisco 2016

# Internet of Everything

## IoE Vertical Solutions



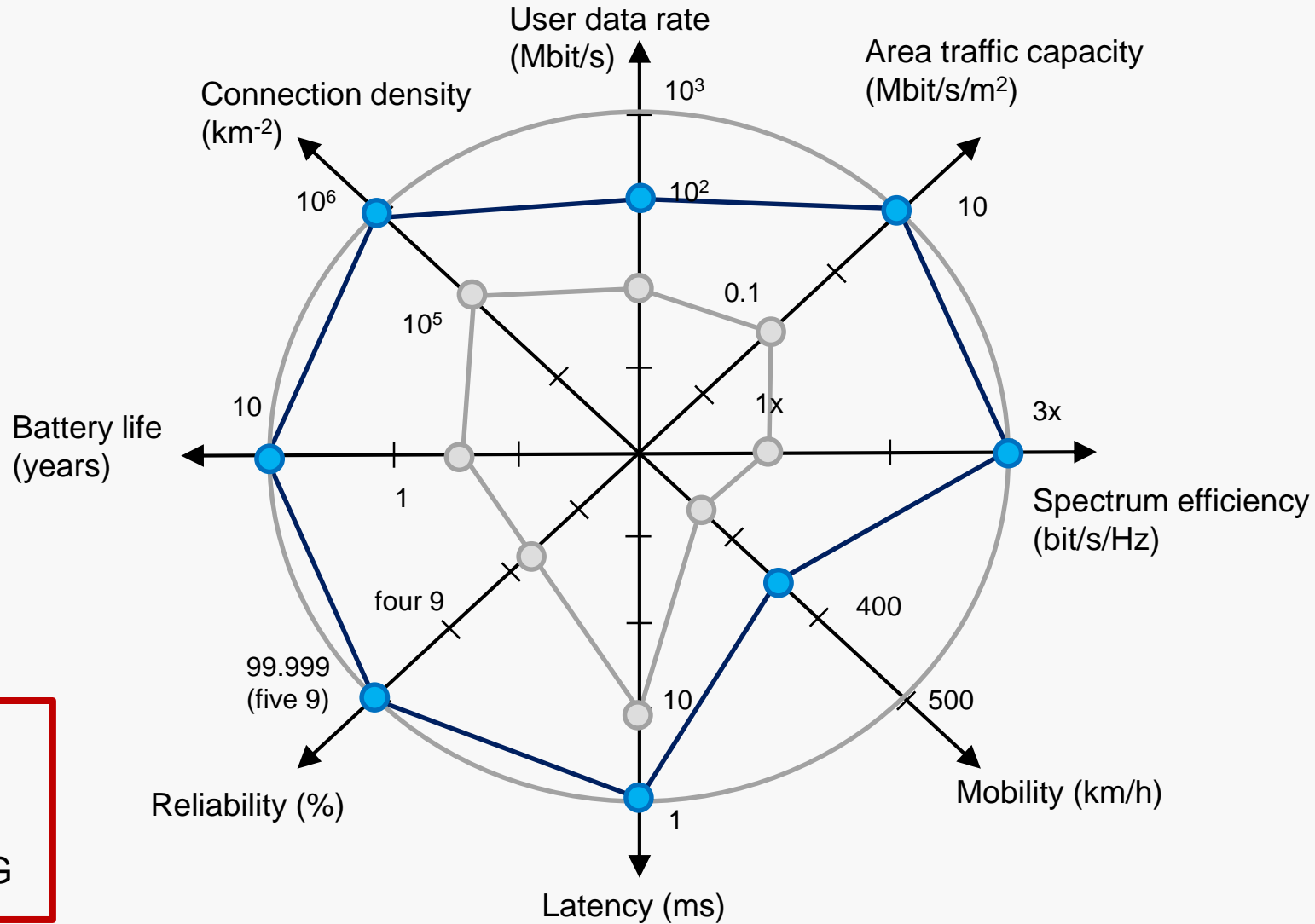
Connected Factory	Connected City	Connected Transportation	Connected Utilities	Connected Oil and Gas
Connected Factory Energy Mgmt.	SCC Infrastructure Management (City WiFi, Parking, Lighting, Location, Traffic, Safety & Security)  Workspaces (Smart Spaces & REGS)	Connected Roadways	Connected Mobile Workforce	Connected Pipelines
Connected Factory Wireless		Connected Trains	Connected AMI	Connected Refinery
Connected Factory Security		Connected Stations	Connected Substation Automation	Secure Ops
Connected Factory Automation		Connected Trackside	Connected Distribution Automation	Connected Oilfield

© 2013-2014 Cisco and/or its affiliates. All rights reserved.

Source: Cisco

Unlike in the past, the "silos" are virtual and reconfigurable.

# 5G requirements (comparison with 4G)



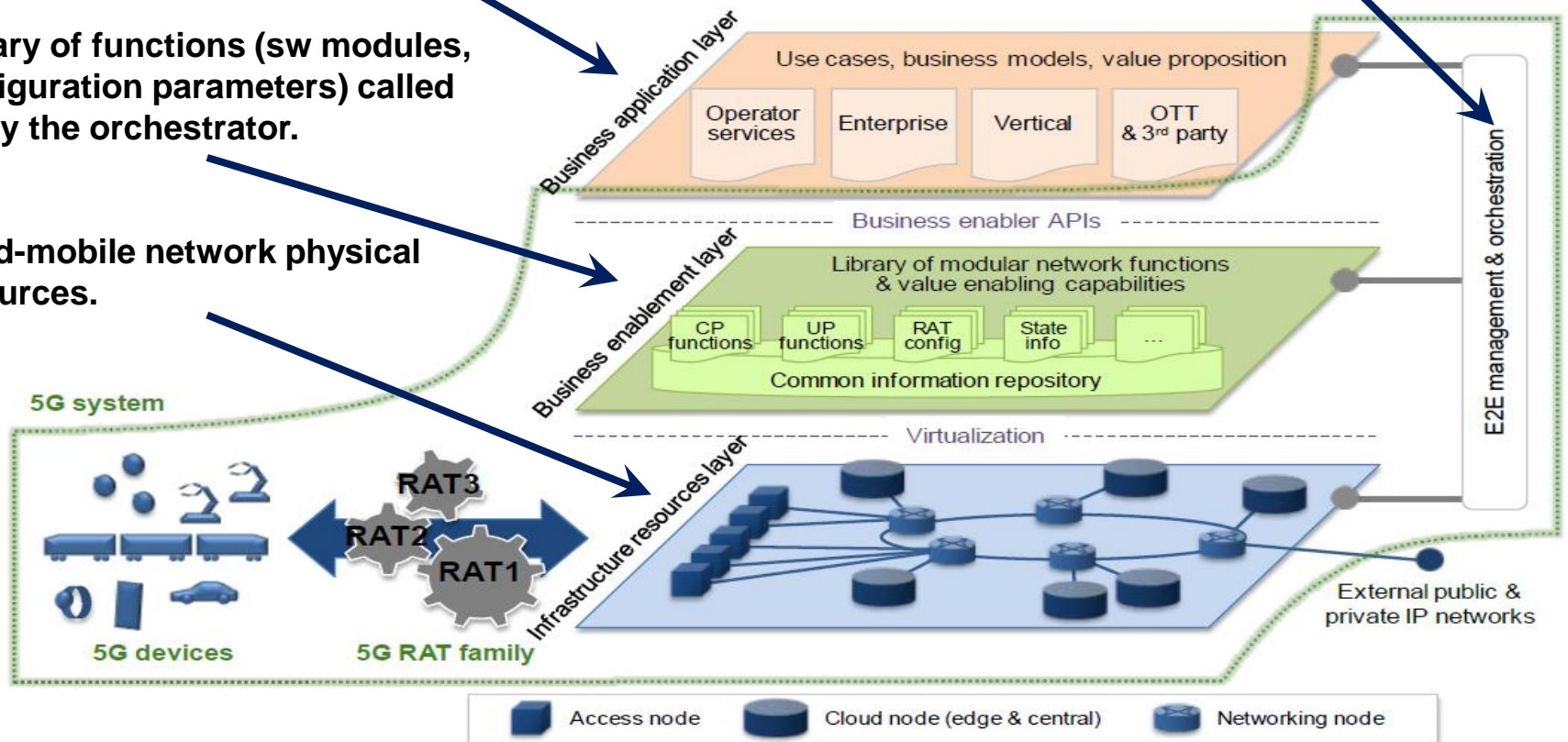
# NGMN 5G Network Architecture

Operator-specific applications and services, or those of the enterprise, or of third parties that use the 5G network (i.e., dedicated network slices).

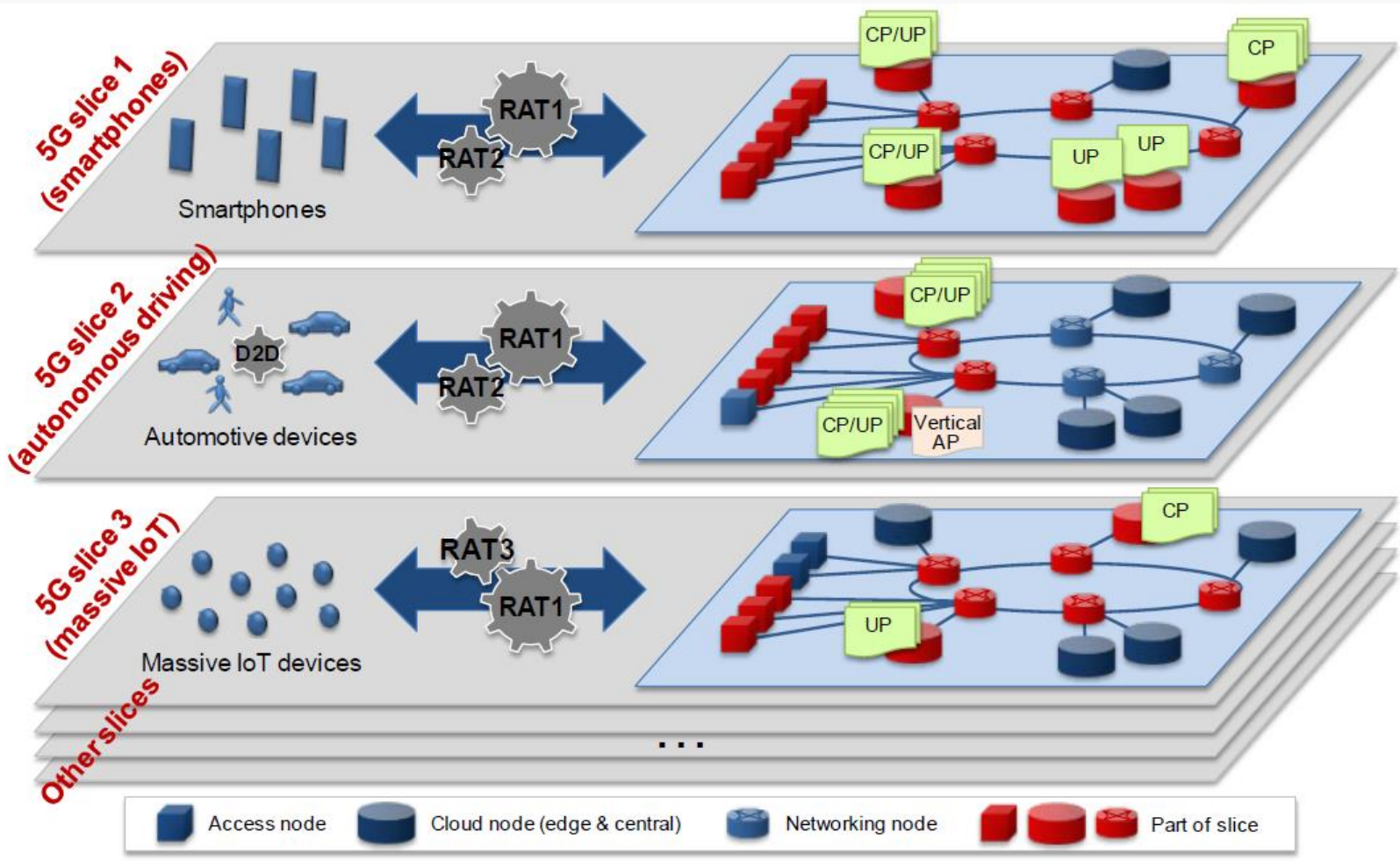
Orchestrator (translates use-cases and business models into actual network functions and network slices).

Library of functions (sw modules, configuration parameters) called for by the orchestrator.

Fixed-mobile network physical resources.



# NGMN Network Slicing Concept

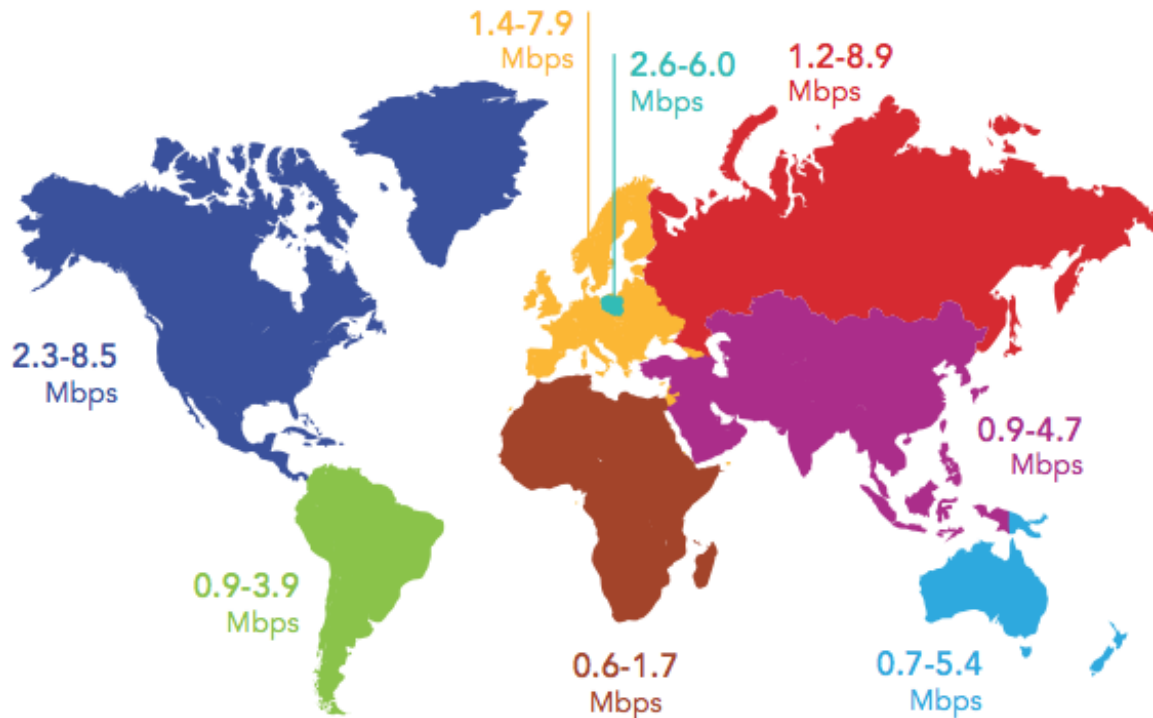


5G network slices implemented on the same infrastructure

# Bit rate vs Application Throughput

The main issue: today, mobile throughput is unsatisfactory (< 4Mbps).  
More importantly, throughput is believed to be **~35%** of Available Bit Rate

## Measured download throughput per region



- Mobile connections on average are four times slower than landline connections
- Around half of mobile users report speeds of less than 4 Mbps
- Mobile connection speed varies widely around the world, making it difficult to offer a consistent user experience

Average Throughput  
to Bit Rate ratio **~35%**

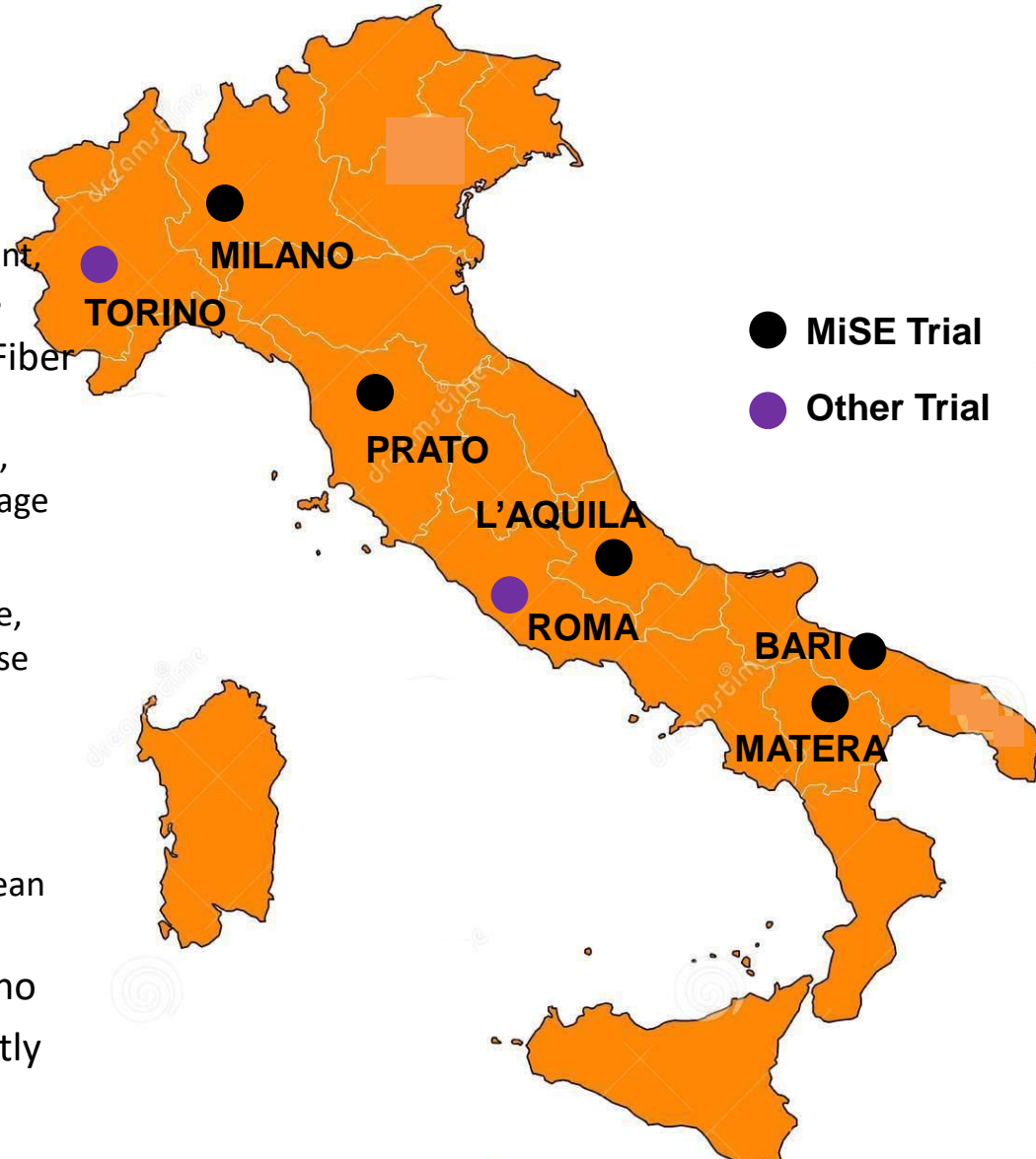
# Italy 5G trial projects

- **MiSE projects:**

- Milan: Vodafone Italia and Nokia
  - intelligent healthcare, traffic management, emergency and tourism-related services
- Prato and L'Aquila: Wind Tre and Open Fiber
  - healthcare, industrial applications, IT security, intelligent mobility, smart grids, video surveillance, AR and cultural heritage
- Bari and Matera: TIM-Fastweb-Huawei
  - healthcare, industry 4.0, tourism, culture, automotive and public safety (over 70 use cases expected)

- **Other 5G projects:**

- Turin: TIM
  - working to become part of a pan-European network of 5G interconnected cities
- TIM to bring 5G technology to San Marino
- ZTE and the Municipality of Rome recently announced one more 5G Trial.



# Conclusions

- 5G: both evolution and revolution
- Virtualization is a new paradigm which allows service segmentation without infrastructure property
- New services enabled by very short latency values and use of new frequency bands
- Virtualization can be introduced in an evolutionary way, so providing performance improvement and reduced cost (without waiting for 5G)
- Italy is a front-runner in 5G experimentation with several city trials ongoing