

The role of Artificial Intelligence in Telecoms

Prof. Ioannis Tomkos
Next Generation Networks

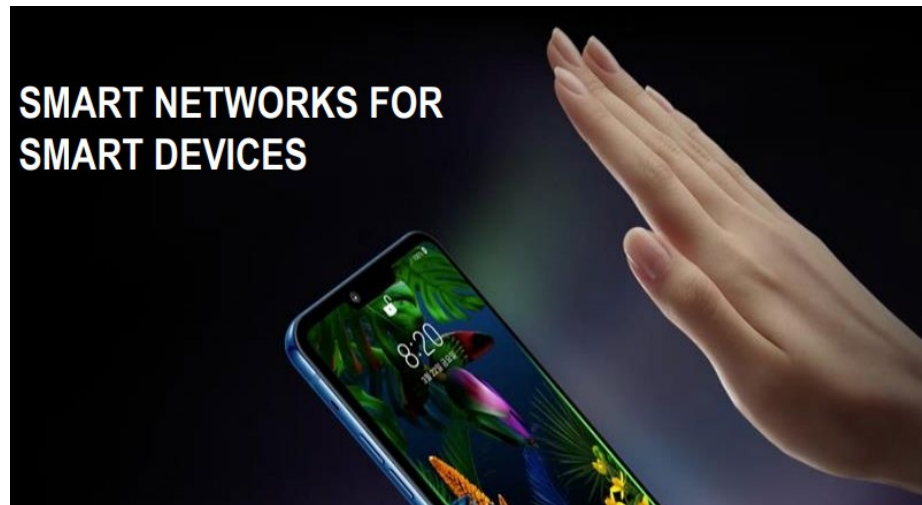
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Overview

- Introduction
 - Which are the key technology areas that introduce significant changes in our economy/society?
 - Next Generation 5G and IoT Connectivity
 - Artificial Intelligence
 - Edge Computing
- Evolution of advance 5G mobile networks towards 6G Smart Networks enabled by the Convergence of Key Digital Technologies
- AI for Telecoms and Telecoms for AI
 - Two sides of the same coin...
- Summary & Conclusions

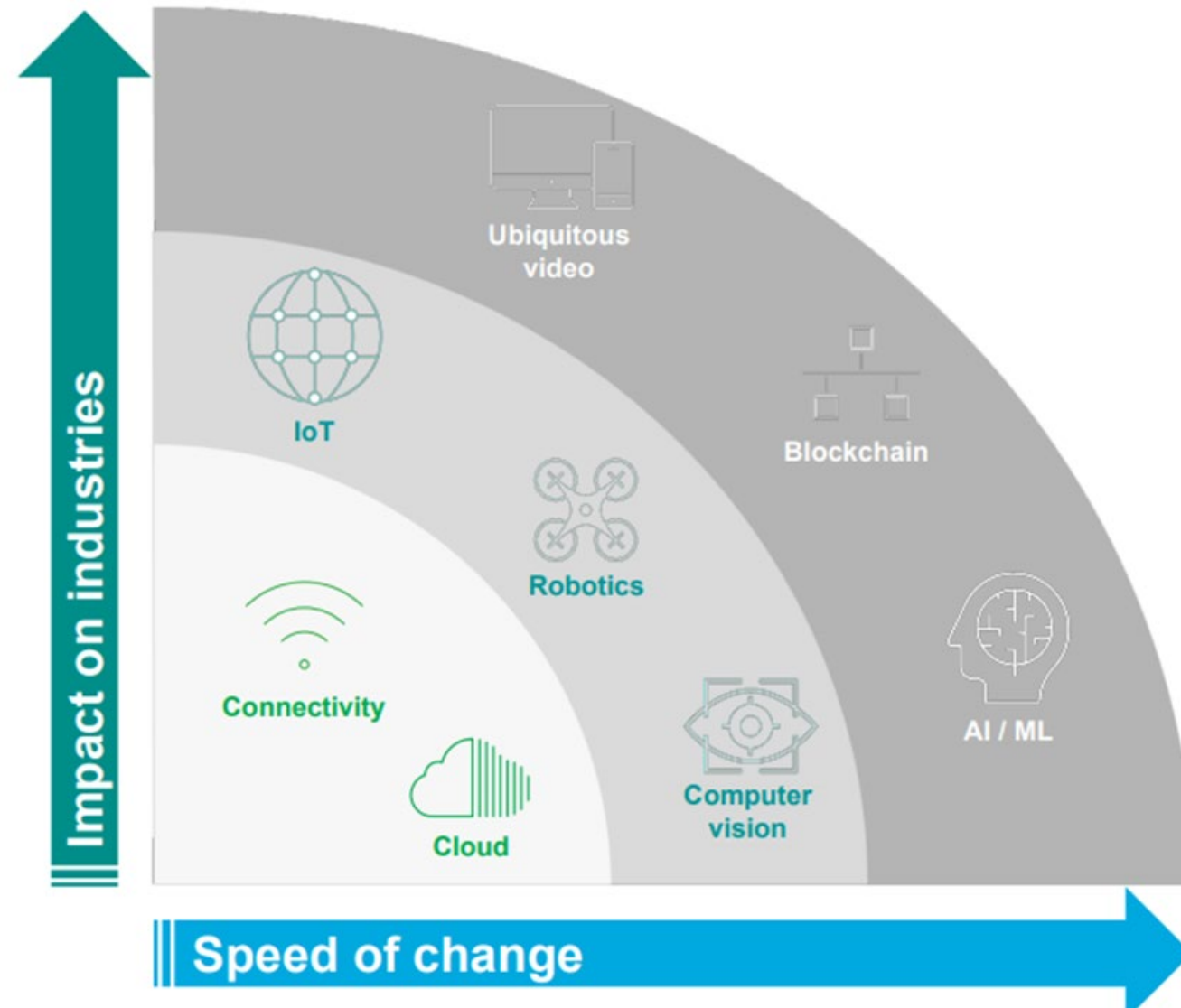
We live in a connected world

- The proliferation of smart devices has created a world that is connected more than ever!
 - How much data are we producing on a daily basis?
 - About **2.5 quintillion** (i.e. 2.5 followed by 18 0's) bytes of data are created daily
 - What is the average growth rate for the amount of digital data generated worldwide?
 - On average the estimated rate across all network segments is about of **50% per year**
 - What is needed?



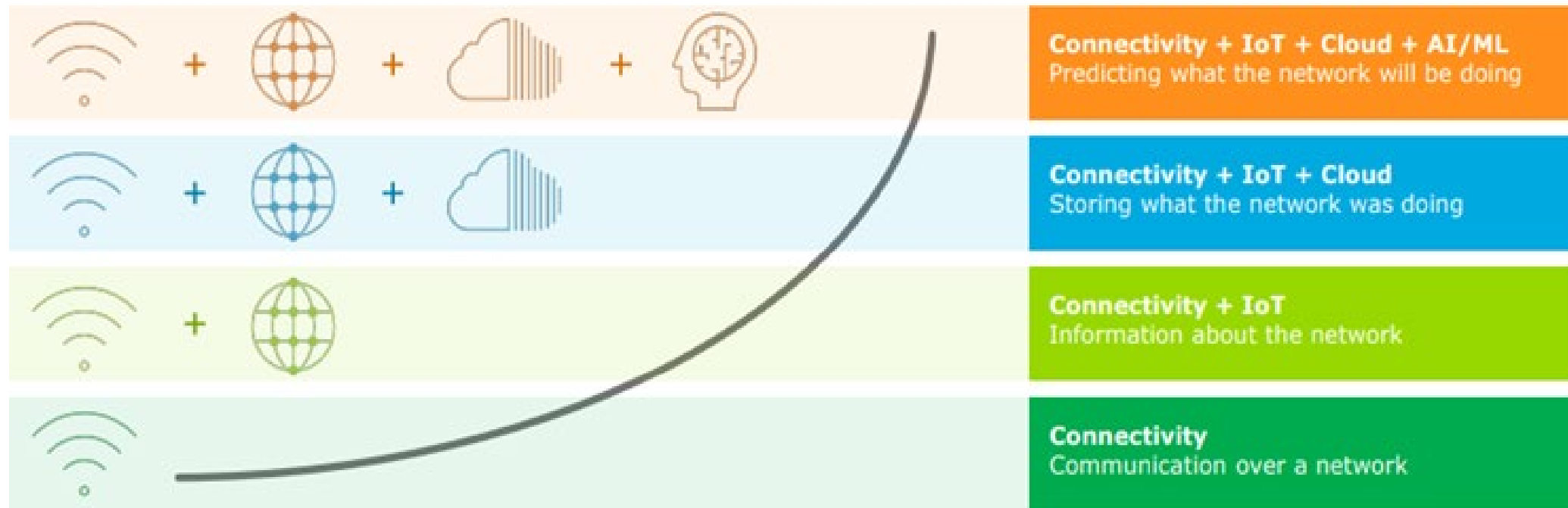
**Smart Networks
require AI!**

Besides 5G/IoT connectivity which are the technologies that introduce significant changes in our society?



The convergence of key technologies will drive exponential impact for our society

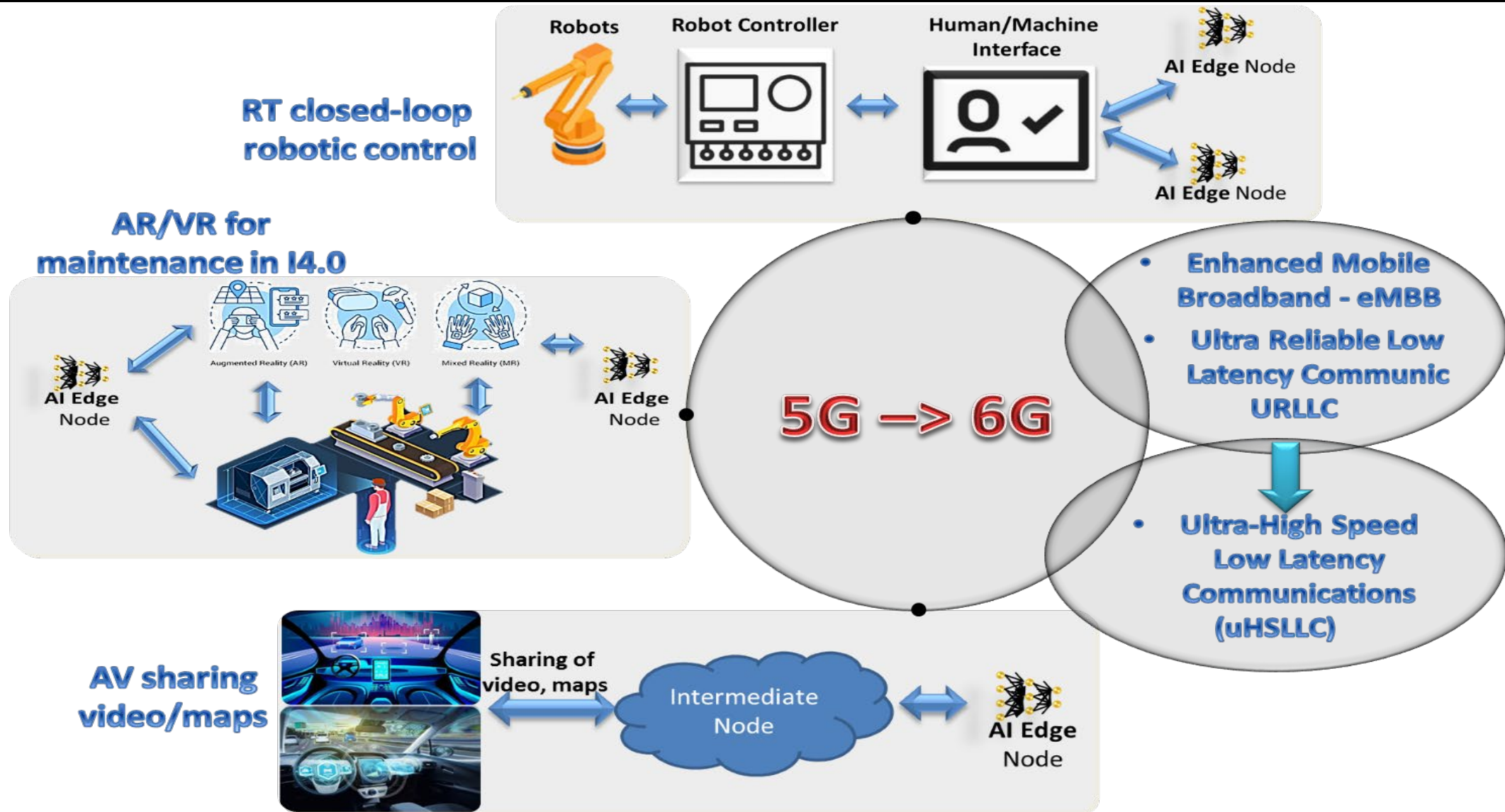
As different transformative technologies come together, impact goes from linear to exponential



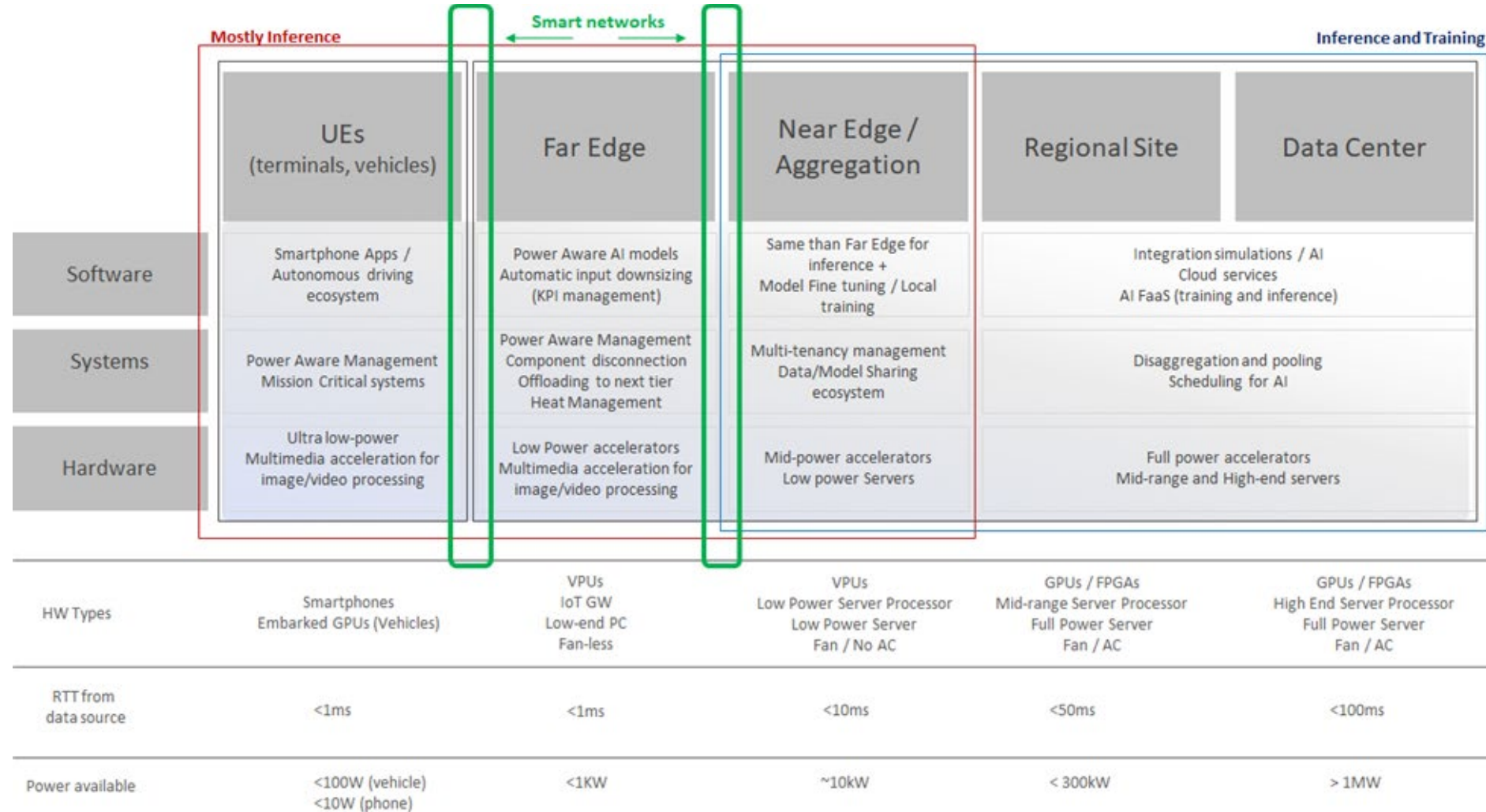
Vision for 5G evolution and convergence with NG-IoT and AI towards the 6G of communication systems

- As we move beyond current fifth generation (5G) networks, operating at low (sub-6GHz) radio frequency bands, towards mm-wave ones operating at higher and higher carrier frequencies, (initially at the high radio frequency window, above 20GHz, and then even higher towards optical frequencies in the visible and invisible electromagnetic waves spectrum), the true capabilities of 5G networks will be gradually revealed.
- In the subsequent evolution stage, the technologies of both 5G networks and Next-Generation Internet of Things (NG-IoT) will move towards some form of convergence where the use of mm-wave frequencies will become commonplace.
- Besides the evolution of wireless connectivity at the edge of the network, we anticipate major advances also on the control and management of the edge network that will be supported by the introduction of new technologies like Artificial Intelligence (AI) and Blockchain (BC), which in-turn will make the edge networks much more smart, trustworthy and secure

Novel and challenging use-cases towards 6G



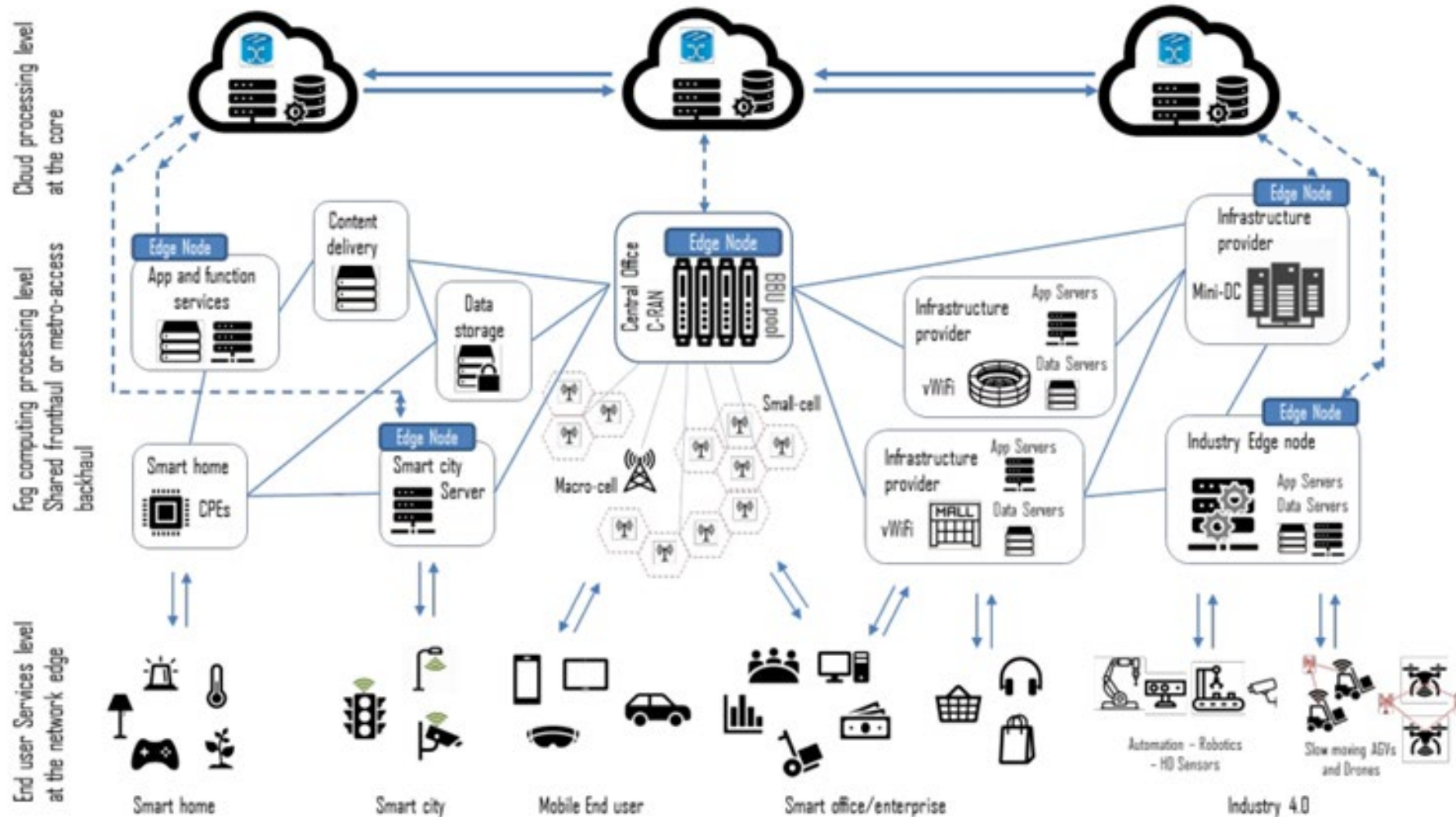
Requirements for evolving Computing paradigms: From Cloud Computing to Edge Computing



Towards AI at the Edge

- All the applications/use-cases of 5G networks, can be enhanced with the capability of cognition offered by computing systems that use the vast amounts of available data and Machine Learning algorithms
- The anticipated future requirements for introducing intelligence at the edge devices will lead to the evolution towards an AI-enabled platform that will be capable to offer intelligent services delivered over the access network to the edge devices.
- Such devices can include in the future computationally efficient dedicated hardware capable of running locally Machine Learning/AI Algorithms at the edge devices, deviating from the classical concept of ML/AI which focuses mainly on offline and centralized AI/ML, implemented by a cloud computing model.
- AI at the Edge is a nascent research field whose system design is entangled with communication and on-device resource constraints (i.e., energy, memory and computing power). Enabling ML at the network edge introduces novel fundamental research problems in terms of jointly optimizing training, communication, and control under end-to-end (E2E) latency, reliability, privacy, as well as devices' hardware requirements.

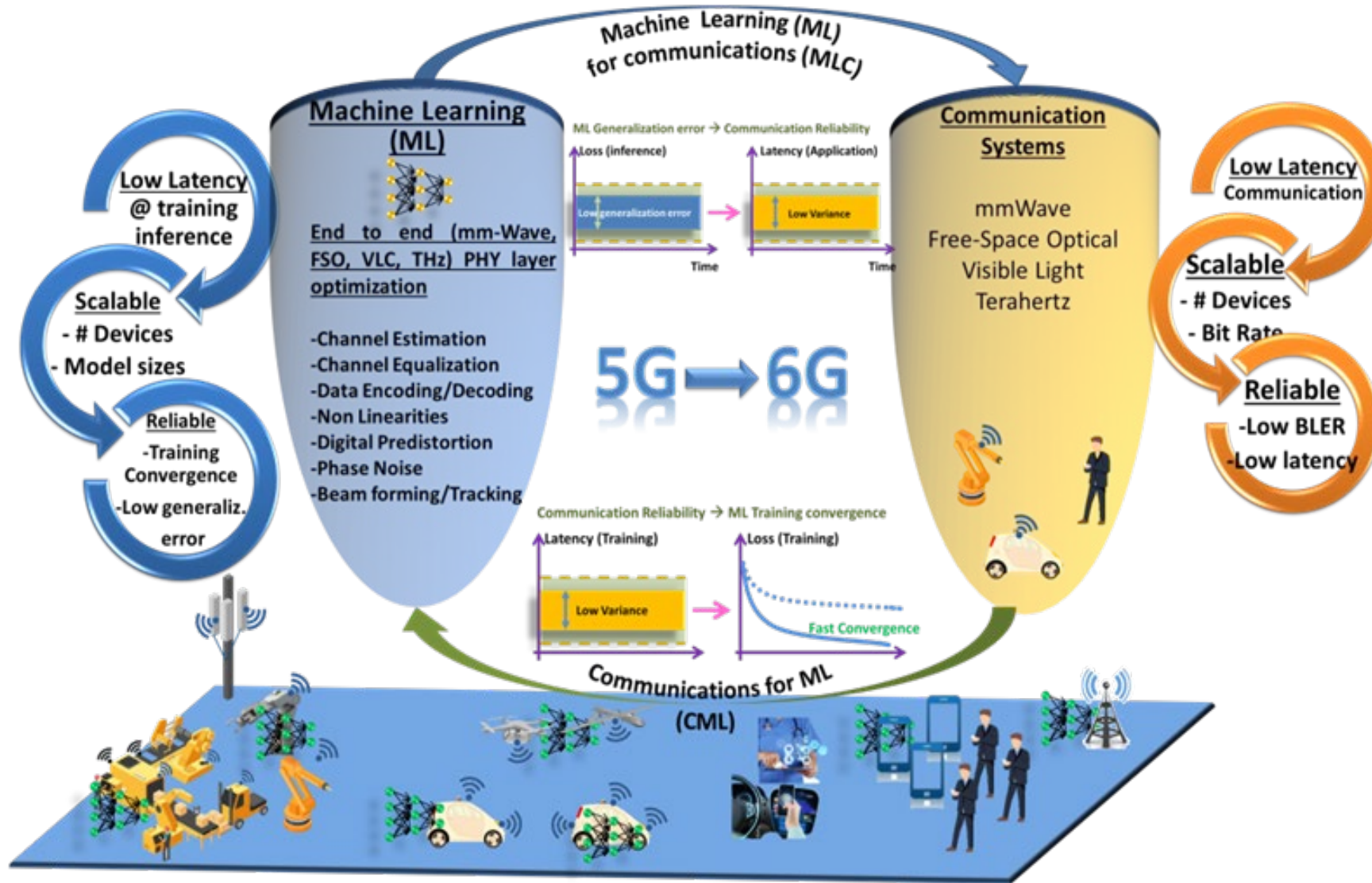
NG Networks enabling the hybrid Core/Fog/Edge Cloud Computing Paradigms for delivery of novel services



Smart Networks for AI at the edge

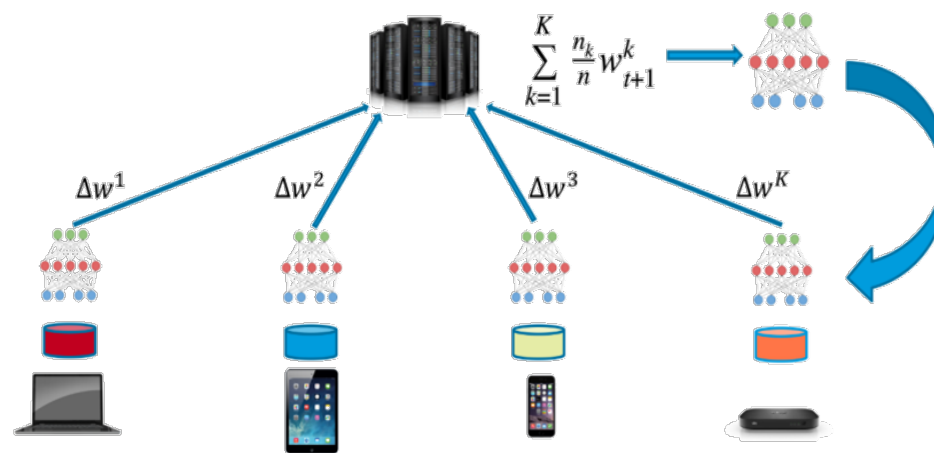
- Much of today's computation remains tied to hardware built for conventional centralized cloud-computing applications.
 - However, AI workloads are different from the calculations most of our current computers are built to perform.
 - Therefore, when used for AI targeting fog and edge computing applications, current platforms are power-hungry and inefficient.
- We need to pushing the physics and computer science of AI platforms in order to deliver radical improvements over the next decade, with innovations ranging from algorithms to systems to devices:
 - a) Algorithms and software platforms for AI-based edge resource allocation and services orchestration,
 - b) Dedicated computing hardware implementations for AI-based edge computing,
 - c) Programmable edge hardware and IoT infrastructures for AI-based edge networking

AI/ML for Comms vs Comms for AI/ML towards 6G capable of real-time learning

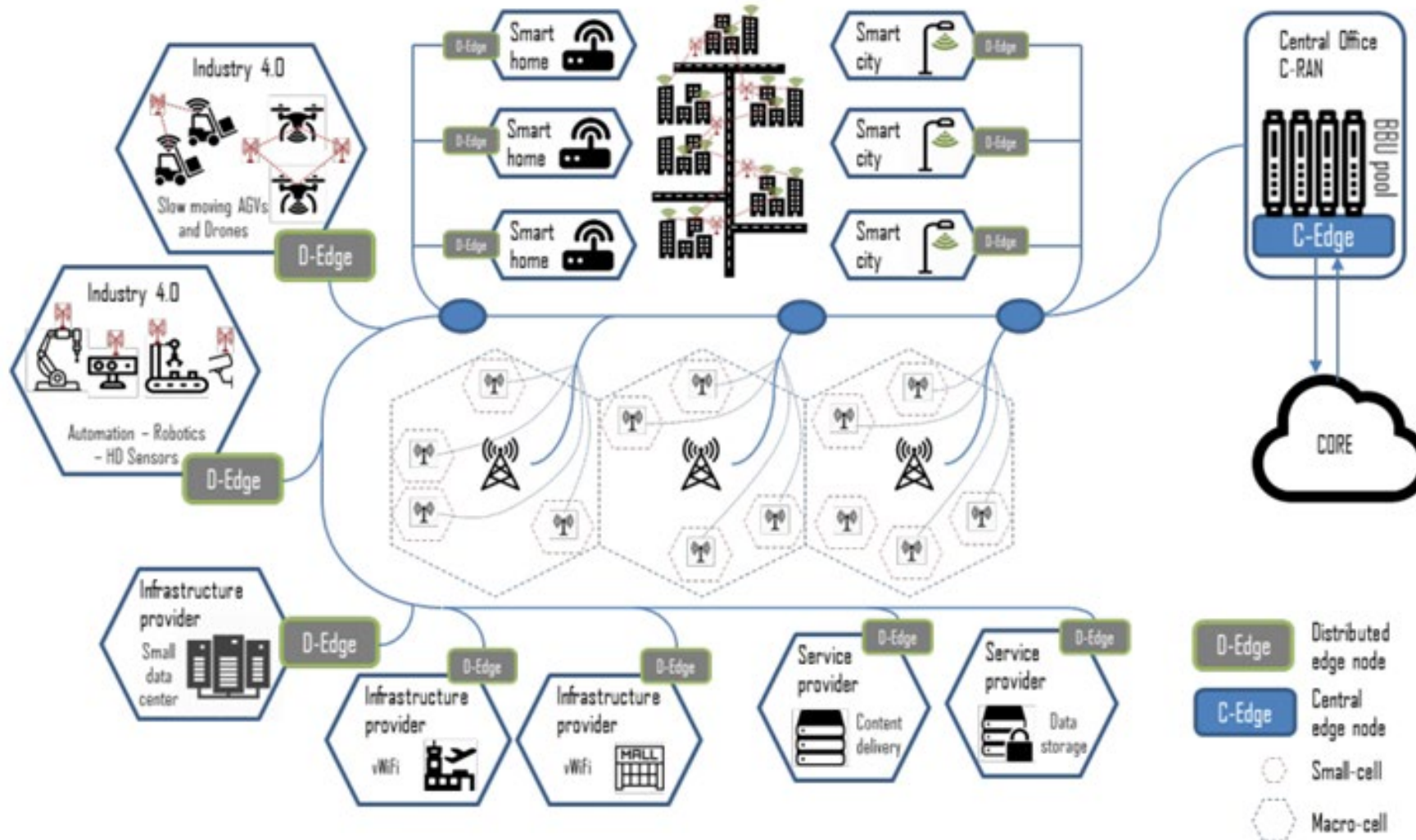


Federated learning (FL) approach for practical AI at the Edge implementation

- Enabling AI/ML at the network edge introduces novel fundamental research problems in terms of jointly optimizing training, communication, and control under end-to-end (E2E) latency, reliability, privacy, as well as devices' hardware requirements.
- For practical Edge AI/ML, online decentralized training can simplify the implementation and preserve privacy by exchanging not the entire dataset but key model parameters. Such an interesting ML architecture implemented with a decentralized approach and enabled by the edge-computing architecture is the *Federated learning (FL) approach*, in which mobile devices periodically exchange their weights and gradients during local training.



Towards Distributed Edge Computing



Conclusions

- The smart 6G networks of the future will integrate intelligent 5G and NG-IoT connectivity infrastructures, with advanced edge-computing hardware that will support the computational-resources heavy execution of the AI algorithms to bring new capabilities at the edge networks and services that will be offered over them to humans and machines that will be connected to this converged infrastructure.
- In such smart 6G network, the communications infrastructure connecting the foreseen billions of smart edge devices (collecting and distributing data) should be seen as its “nervous system”, while the edge computing hardware executing AI, BC and other algorithms over an SDN/NFV software control and management platform, should be seen as its “brain”.
- Such evolution, combined with the proliferation of smart (and even wearable) wireless devices at the edge will make the Internet of Everything (IoE) a reality, where billions of smart devices will be connected and managed by the smart converged 6G infrastructure that is expected to emerge after 2025 and will support the emerging 4th industrial revolution (Industry 4.0) in human history.

Thank you!

Dr. Ioannis Tomkos

itom@ait.gr

+30 6973 328 329