Workshop • 11 May 2023, Brussels, Belgium

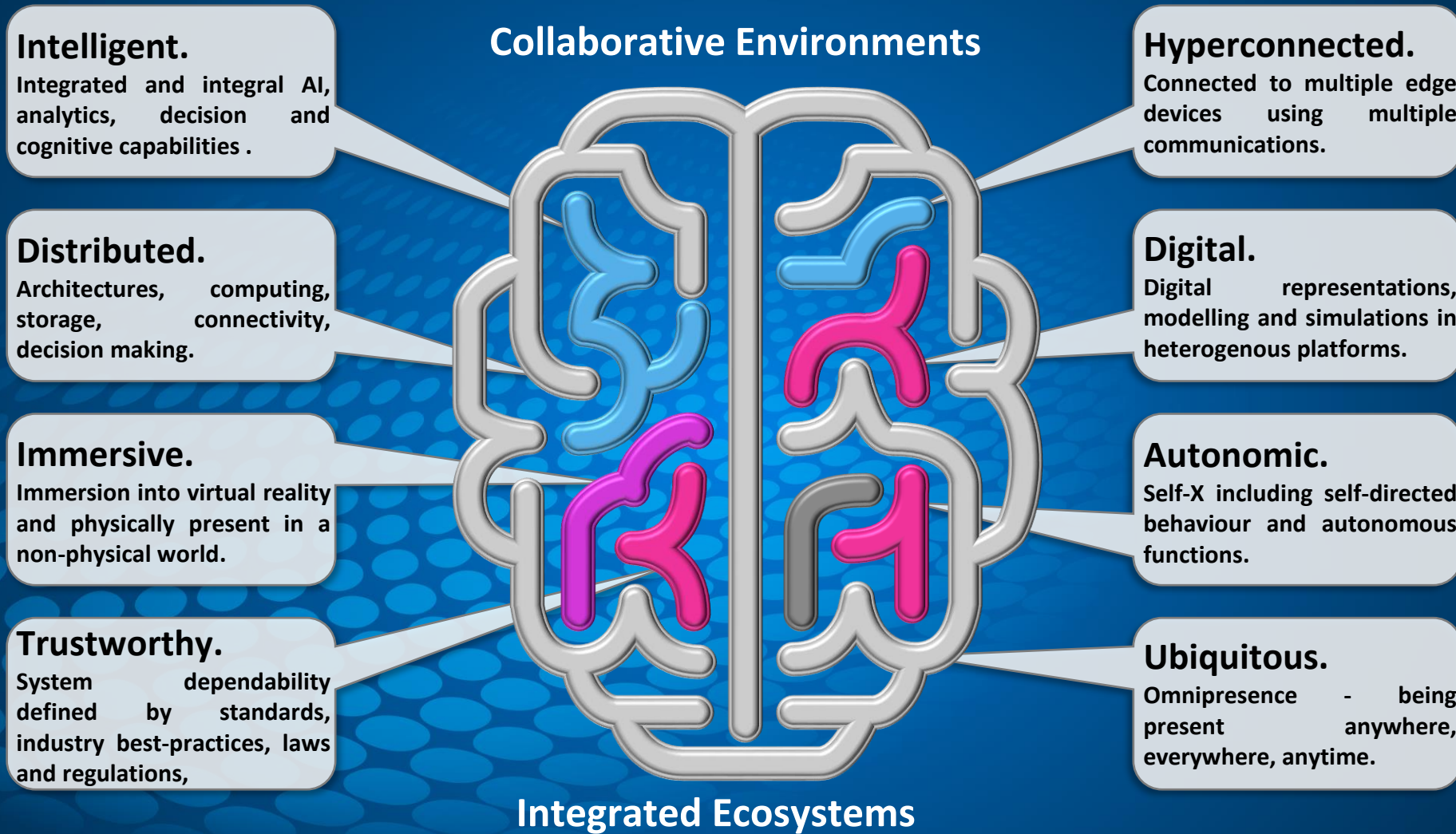# *Next-generation Intelligent Edge IoT Continuum*

Dr. Ovidiu Vermesan, AIOTI WG Research and Partnerships Chairman

Future Trends

Next-generation Intelligent Edge IoT Continuum

AI◎TI

Next-generation Intelligent Edge IoT Continuum

Collaborative Environments

Intelligent.
Integrated and integral AI, analytics, decision and cognitive capabilities .

Distributed.
Architectures, computing, storage, connectivity, decision making.

Immersive.
Immersion into virtual reality and physically present in a non-physical world.

Trustworthy.
System dependability defined by standards, industry best-practices, laws and regulations,

Hyperconnected.
Connected to multiple edge devices using multiple communications.

Digital.
Digital representations, modelling and simulations in heterogenous platforms.

Autonomic.
Self-X including self-directed behaviour and autonomous functions.

Ubiquitous.
Omnipresence - being present anywhere, everywhere, anytime.

**Integrated Ecosystems**

AI⊙TI

Research Challenges

- Advance meta-operating system features towards new web and edge IoT immersive technologies.
- Scalable and interoperable MetaOS - development of standardised interfaces and protocols that can be used to enable seamless communication and collaboration between various components of the edge IoT system.
- Data management adapted to the distributed edge IoT architectures.

AI©TI

Research Challenges
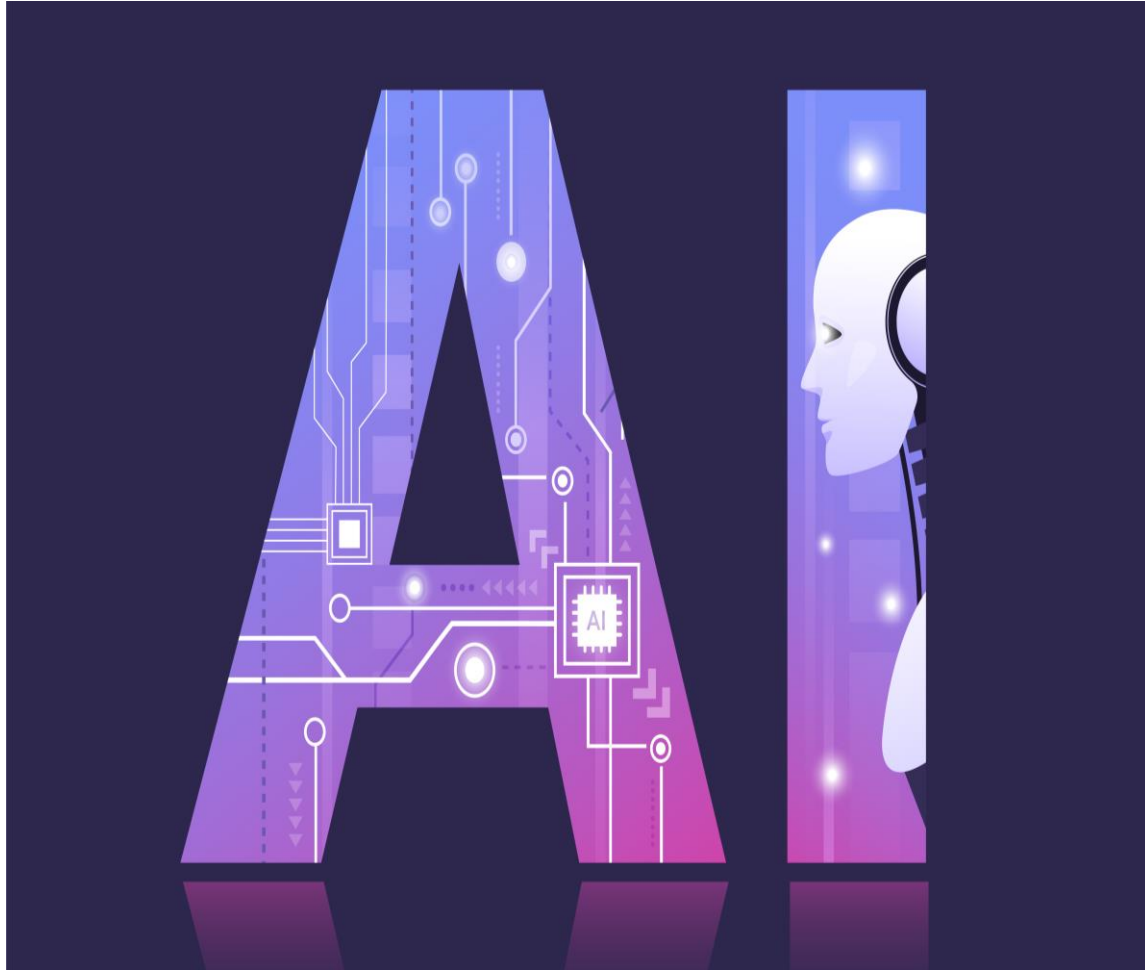
- New data management techniques, such as distributed databases, data mining, machine learning, and new programming models for processing and analysing data.

- New intelligent resource management techniques to dynamically allocate and manage resources across multiple intelligent edge IoT devices and applications based on real-time data and performance metrics.

- AI-based method, ML and RL to optimise resource allocation and management in real-time.

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Research Challenges

- Development of new architectures and programming models that can support high-performance embedded computing and low-latency communication across multiple intelligent edge IoT devices, agents and platforms.

- Human-computer interaction techniques, natural language processing, gesture recognition, generative edge AI for machine-to-machine, human-to-machine hybrid interaction enabling natural and intuitive interaction between intelligent edge IoT devices and humans.

- New distributed security mechanisms to address the real-time data exchange across multiple intelligent edge IoT devices and platforms. Development of passkeys like solutions for intelligent edge IoT devices.

AI◐TI

Intelligent Edge IoT Continuum

Summary
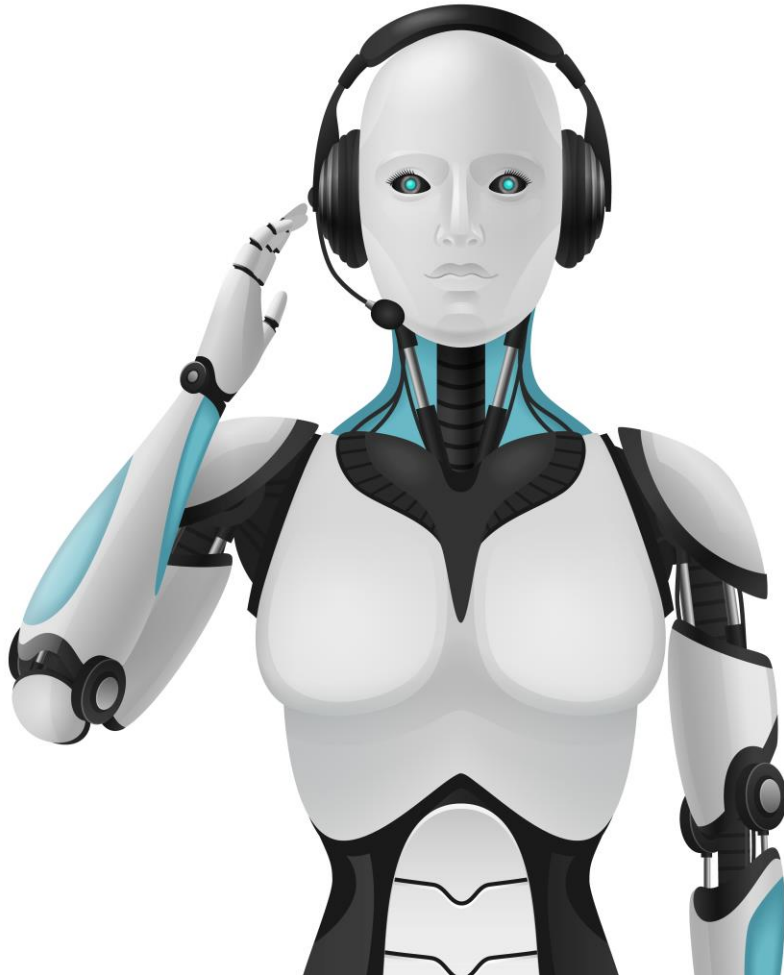
- More intelligent edge devices
- Distributed Intelligence
- Autonomous decision-making
- Edge-to-Edge collaboration
- Embedded immersive technologies
- New MetaOSs with extended functionality built on top of different OSs allowing different processes (nodes) to communicate with each other at runtime.
- Interoperability and scalability still a challenge.

AI TI

Thank you!

Ovidiu.Vermesan@sintef.no

AICTI

IoT as game changer in Industry

While Airbus pioneers sustainable and safe aerospace, grasping the levers for a more global system optimization is key to deliver more efficient and sustainable Products, Operations & Services

At each stage of the product life cycle, we look for data and models supporting informed decisions.

Product Life Cycle

| Research | Design | Manufacturing | Operations | End of Life |

With digitalisation and generalisation of smart devices,
interactions at the edge
between digital and physical worlds
are becoming **ubiquitous**

BUT, WE FACE

❑ A tremendous increase of the digital/physical interactions while data come from multi-physics frameworks and heterogeneous sources.
❑ A concentration of issues and risks at the edge

Our Digital Transformation and vision.

Future means should allow a very structured vision on edge usages, building a flexible decentralised digital architecture that will ease fast deployment and adaptations to the market.

New European ambitions should lead to

- **Organise** these interactions through new specific frameworks and standards. It is <u>crucial</u>.

- **Secure** the conceptual foundations enabling interoperability, digital continuity and cyber resilience

- **Develop** Generic Infrastructure for Edge Applications, Generic EdgeCell concept, EdgeCell Generic Services, …

Create Value
- Industrial **competitiveness**, due to fast, flexible & cheap evolutions of architectures,
- **Security** of data and advanced IT systems aligned with the **EU sovereignty objectives**
- **More eco-friendly and reliable products**, thanks to new knowledge captured in operations

The deeper integration of IoT technologies will be a strong leverage to the development and exploitation of the next generation of safe and net-zero emission aircraft

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RnT Cooperations and Business Development, Contract Manager for Horizon Europe.

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Concertation and Consultation on Computing Continuum:
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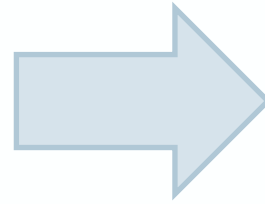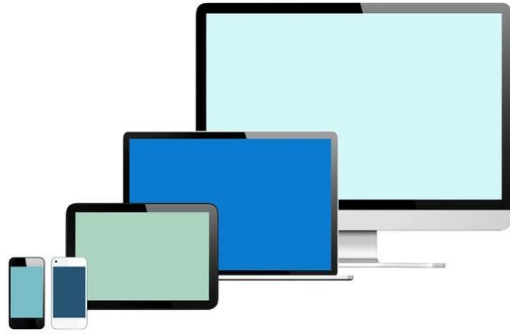Organized by: **Open Continuum |** Supported by: Unlock CEI and SWForum
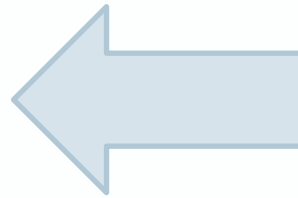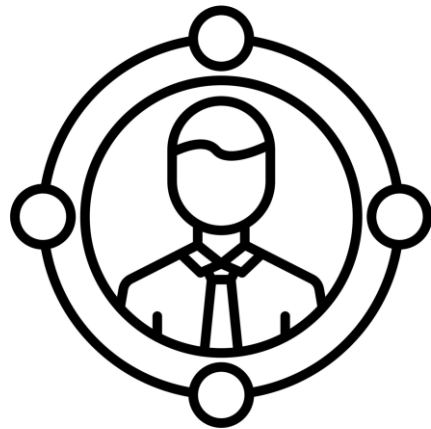
Pervasive Computing

Beyond ubiquity

Context

43 million

35%

> Data processing at device level
> Enhanced QoE
> Improved QoL

60%

~~Ubiquity~~
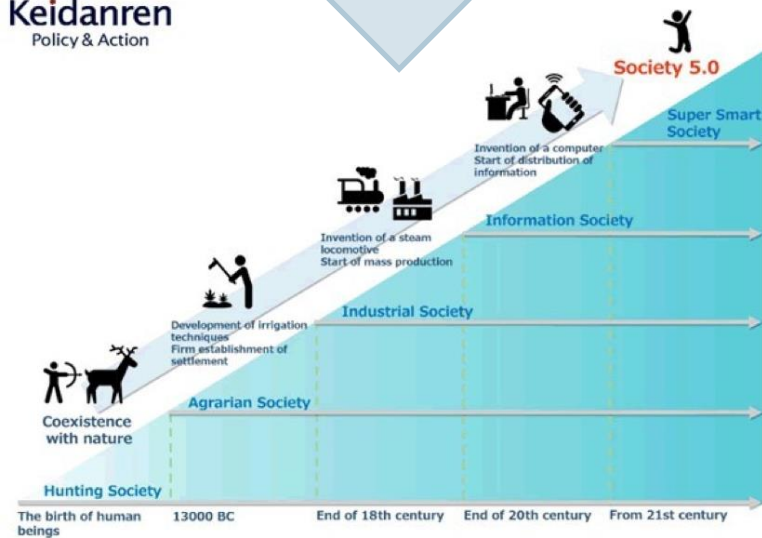
Challenges

Less human interaction

Intelligent and self-adaptive environments

Edge capabilities in a microprocessor

Embedded and dedicated networks

Embedded artificial intelligence

Dedicated trust models

Secured communication

Ad-hoc devices clustering

Decentralised management

Predictive behaviour
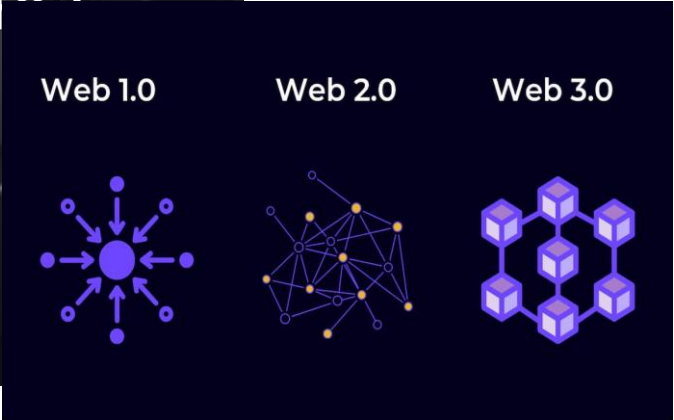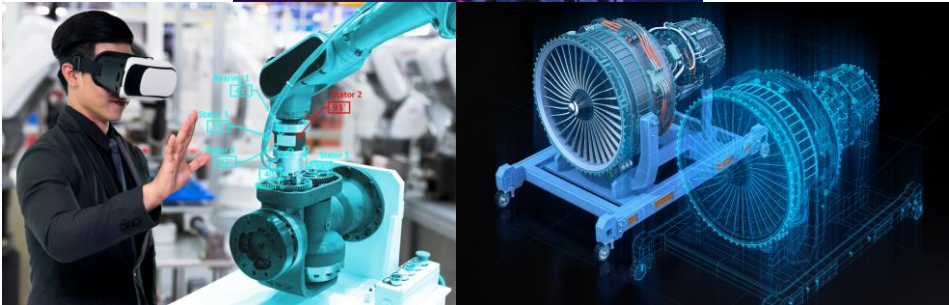
Energy consumption

Industrial Mediaverse

Between realms and worlds

Context

Industrial Metaverse is an emerging concept that leverages the power of data to create new opportunities for innovation, collaboration and efficiency.

Challenges

Digital twins for product design and engineering	Immersive training	Virtual (and remote) work
Fungible and non-fungible tokens	Permisionless use	Data management at the edge
Energy consumption & Carbon footprint	Holographic projections	Metaverse evolution

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Thanks for your attention!

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Network and infrastructure: key enablers for the industrial metaverse

Thibaud BIATEK – Nokia

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Industrial Metaverse : XR, Robots & Digital Twin

Demands of XR

A challenging mix of download surges with low latency high-bandwidth streams

3D asset downloads	**Up to 200 Mbps peak download**	Download surges of 3D objects and avatars before rendering
Cloud rendering	**20-70 Mbps Consistent 10–50 ms**	For high-quality visuals in gaming, collaboration, ecommerce…
User synchronization	**0.5 Mbps up and down 50 ms**	Object and avatar interaction (including voice) ~ multi-user gaming
Streaming volumetric video	**10-20 Mbps 50 ms**	3D video of people: performances, fashion, presentations
Cloud processing for world understanding	**1-20 Mbps upstream sessions of 1s-10min**	Upload of captured environment for positioning & advanced semantics that are too complex for local processing.
API	• Sandbox traffic simulation to elevate application performance before deployment • Secure coordination between network and multi-cloud resources	

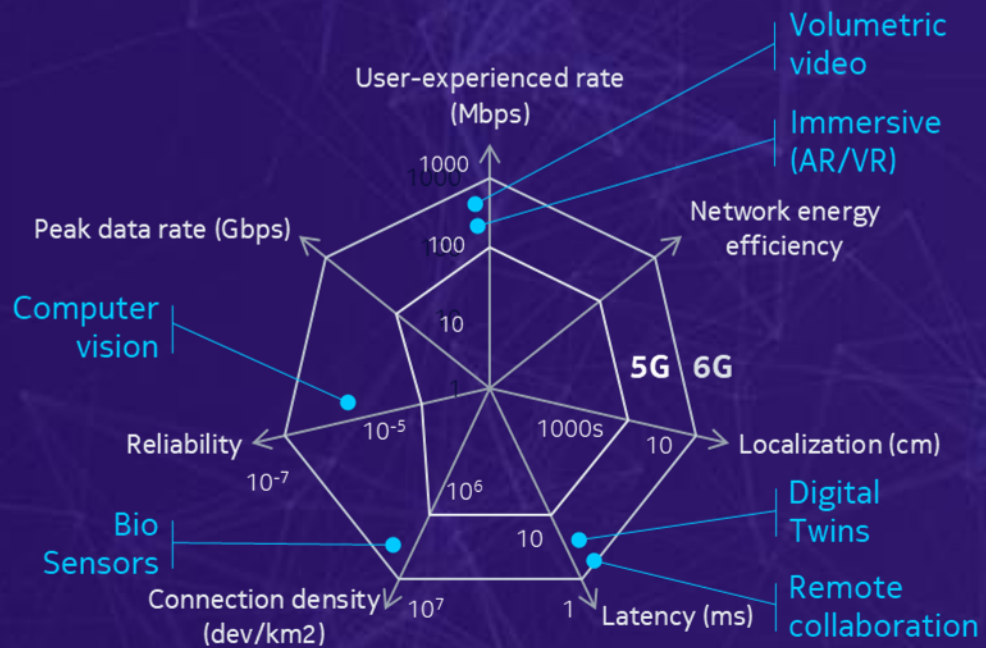## Demands of digital twin & robots

Substantial upload traffic for sensing and ultra-low latency streams for control

Low power sensors	**100 kbps UL connectionless**	Smart city parking and garbage bins, air quality monitoring, rural sensing
Robot world understanding	**1-20 Mbps UL 1 Mbps DL 50 ms**	Object recognition, motion/grasp/task planning
High bandwidth sensors	**5-20 Mbps UL 50ms**	Security and monitoring cameras in cities, factories, ports
Autonomous mobile robot fleet orchestration	**1 Mbps UL & DL 50 ms**	Traffic control, task allocation, live map mgmt.
Low latency sensors	**1-10 Mbps UL 1-5ms**	Automation control loops Robot safety and equipment anomaly
Haptic robot teleoperation	**5-20 Mbps UL 1 Mbps DL1-5 ms**	Remotely operated robots for inspections, production, emergencies, delivery
APIs	• Bandwidth evaluation/reservation • Latency-jitter evaluation/optimization • Real-time connectivity performance/coverage • Sandbox traffic simulation • Precision location <10cm • Device presence & connectivity mode • Passive sensing of people/objects • Energy consumption	

R&D orientations for Industrial Metaverse

Network will be key to realizing these opportunities

New service needs

- Volumetric video
- Immersive (AR/VR)
- Computer vision
- Bio Sensors
- Digital Twins
- Remote collaboration

User-experienced rate (Mbps), Peak data rate (Gbps), Reliability, Connection density (dev/km2), Latency (ms), Localization (cm), Network energy efficiency

5G 6G

New network capabilities

- Intent-based autonomy
- Enhanced symmetrical capacity
- Cloud and Network Convergence
- Distributed, flexible service instantiation
- Sensing, positioning and context
- Performance, resiliency & agility
- Industry-specific optimization
- Security & privacy focus
- Ubiquity & accessibility

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NOKIA

At Nokia, we create technology that helps the world act together.

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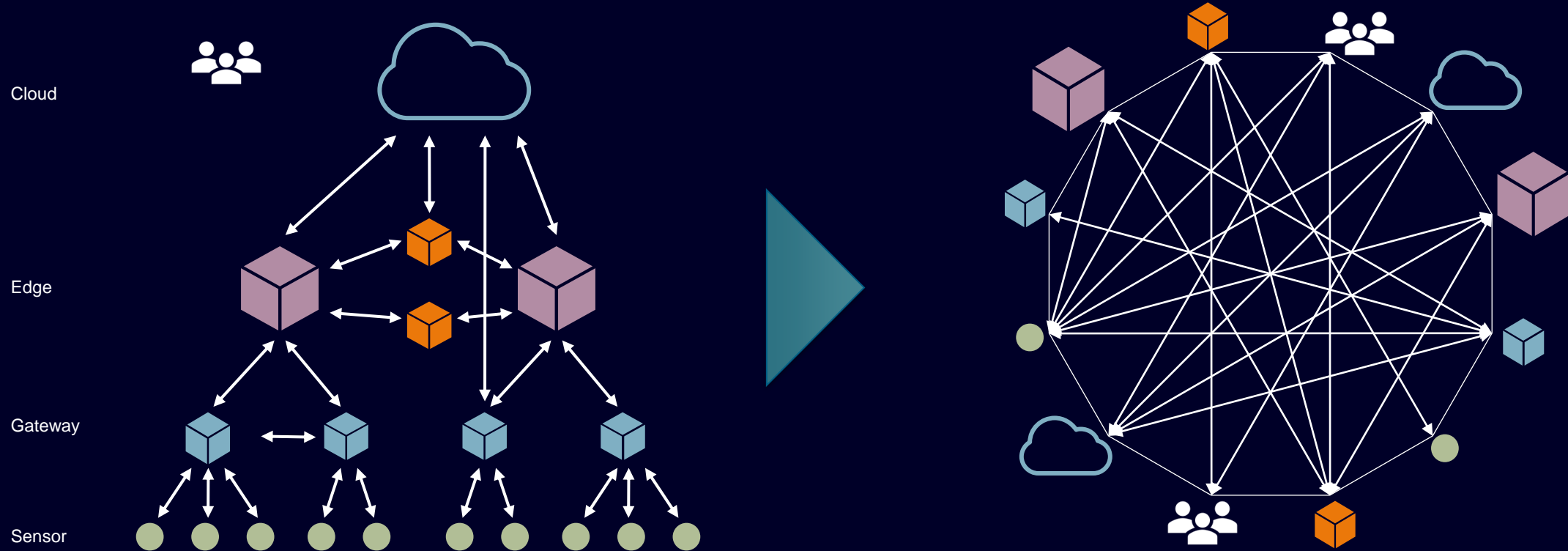# Autonomous Industrial IoT

Jochen Nickles – Siemens AG (T CED)

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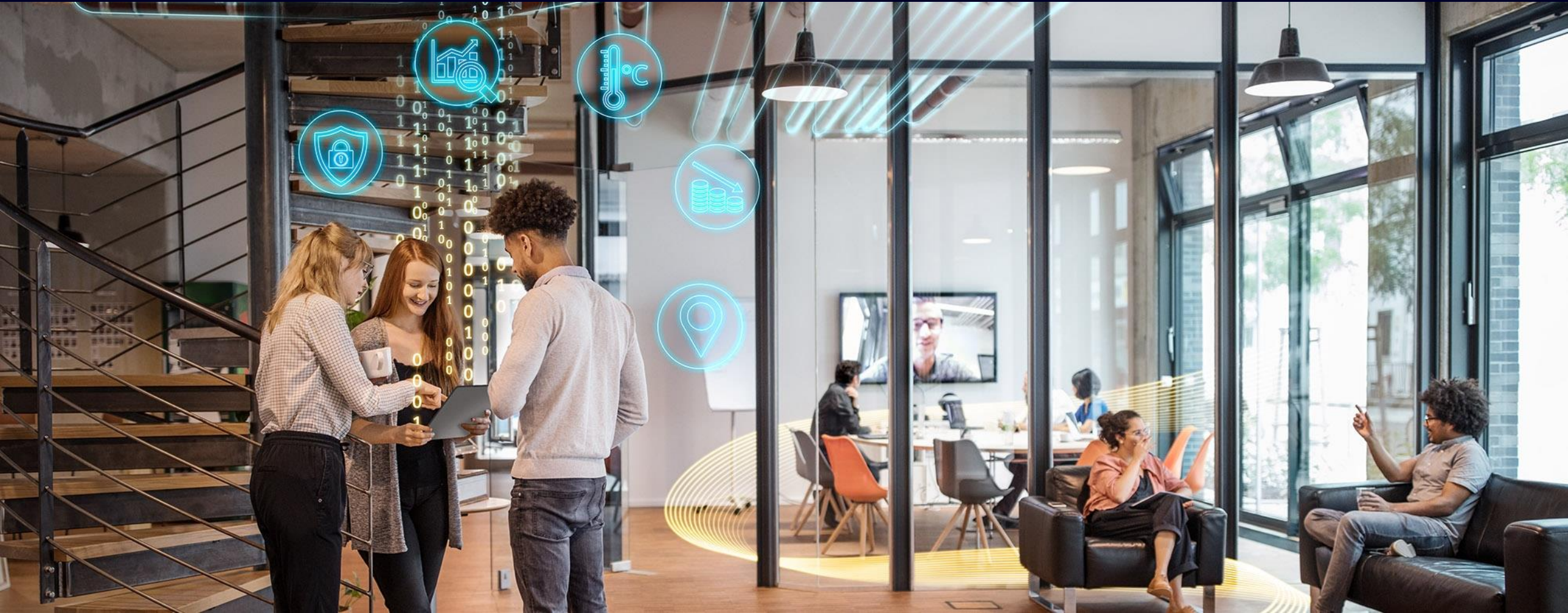
The Industrial IOT is getting smarter

From cloud-centric, hierarchical, orchestrated IOT, to decentralized, non-hierarchical, self-organizing Resource Networks
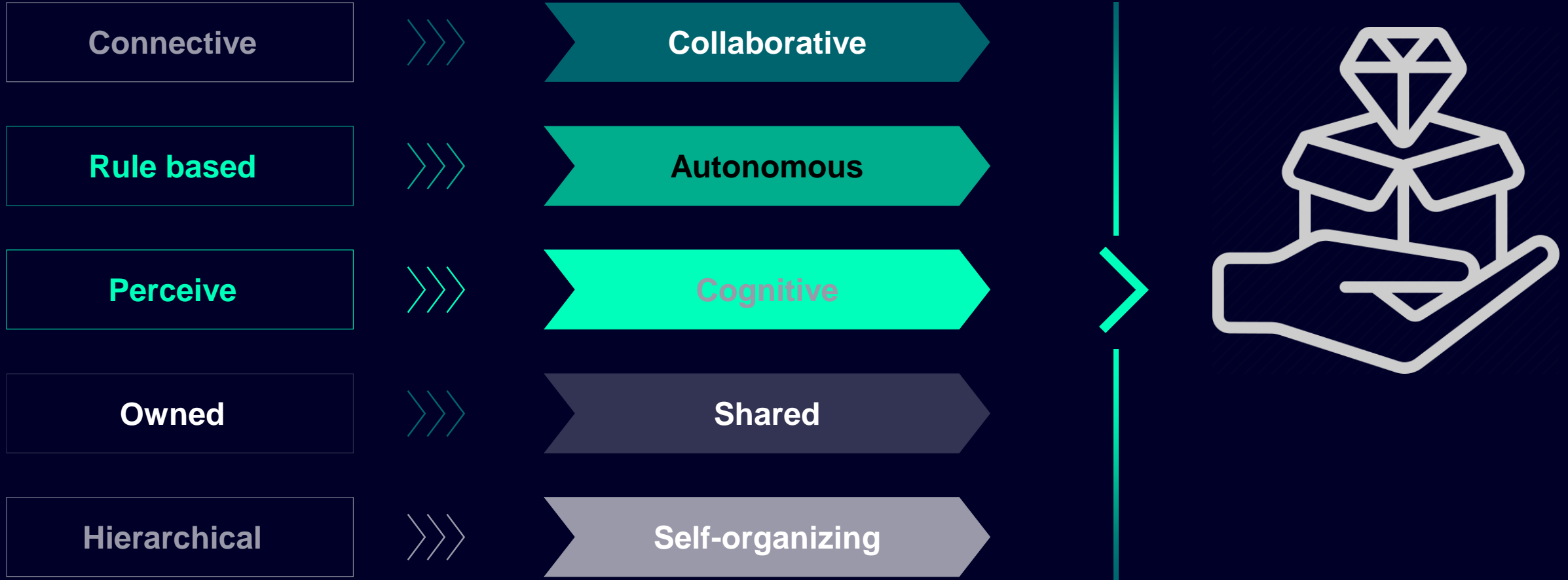
SIEMENS

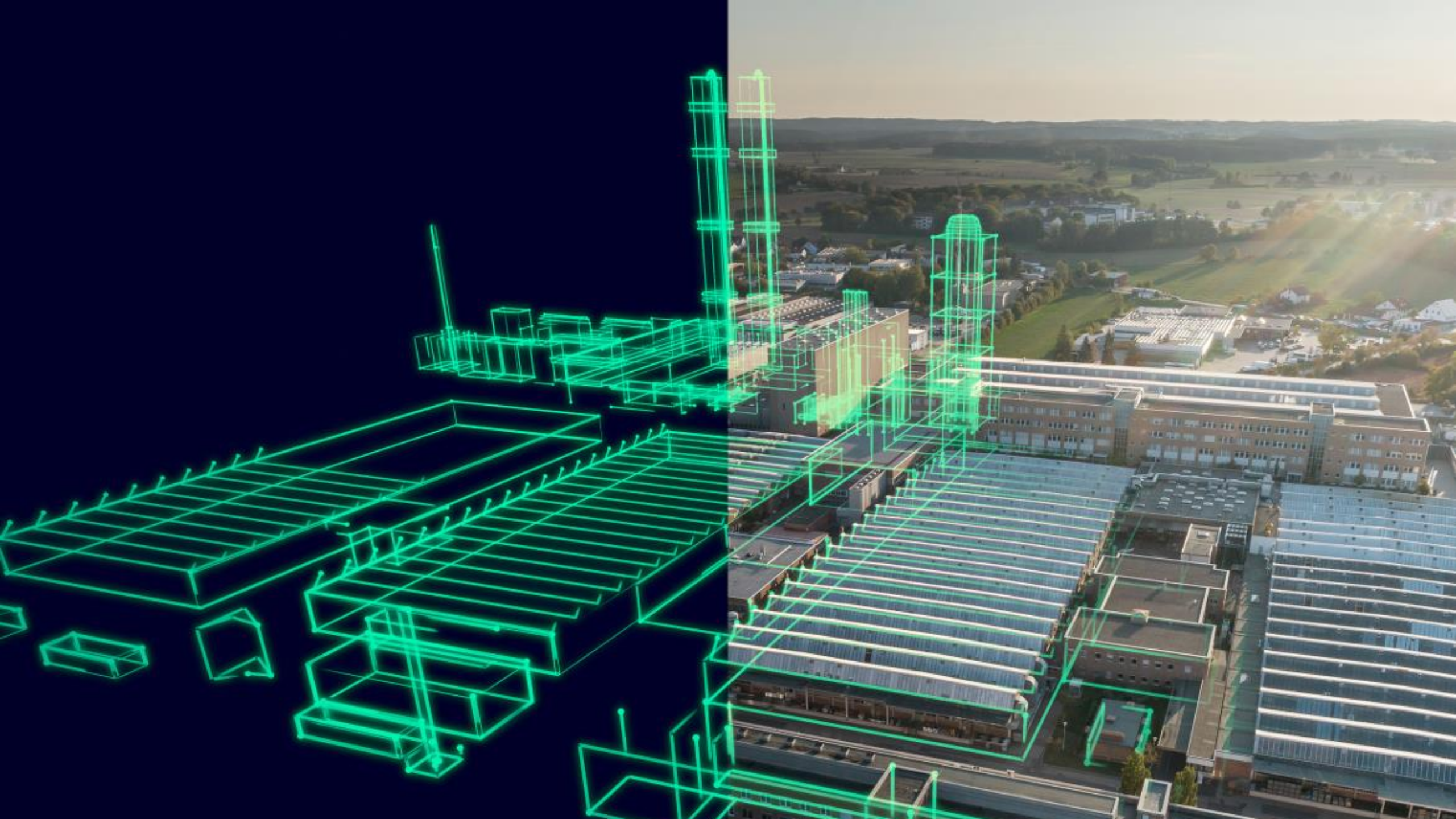**Most prominent autonomous 'Systems'**
Interacting Humans

SIEMENS

The AIIoT associated Paradigm Shift
Properties that generate new Value

Connective	>>>	Collaborative
Rule based	>>>	Autonomous
Perceive	>>>	Cognitive
Owned	>>>	Shared
Hierarchical	>>>	Self-organizing

SIEMENS

Industrial IoT Evolution

Vision Pitch: https://youtu.be/DjCNu7PZRz0

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Jochen Nickles

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SpaceOS: Secure and Efficient Cloud to Edge Computing with Type-Safe Unikernels

Miklos Tomka – Tarides, Paris

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Challenge and Achievements

Technology challenge: commonly used public cloud platforms do not scale well to edge / IoT: software stack is very powerful but also very complex and so

- there is a large cyber attack surface

- capable computing resources are required -> typically an issue for small, resource constrained IoT / edge applications

Additional challenge: most solutions used today rely on North American technology

Achievements so far by team include the development of a multiple award winning Unikernel toolkit (developed by Unikernel Systems in partnership with INRIA and the University of Cambridge – using OCaml, an open source programming language created by INRIA) – leading to executables with a size of 4% of similar systems while being much more secure (by design) and 10 times more resource efficient for cloud deployments. After Unikernel Systems was acquired by Docker, the founders created Tarides.

Objective of the project and key steps to get there

Objective of the project: Tarides intends to take its disruptive (and 100% European) cloud technology to build a world class OS platform for IoT / Edge applications with the following objectives:

- Very secure, using a "Secure by Design" approach, leveraging the type-safe / memory safe features of the OCaml language
- Highly efficient – make it accessible even on small footprint hardware devices
- Flexible – strong software isolation and easy and robust OTA upgrade features
- Broadly compatible – run on a range of hardware platforms, also bare metal
- Very user friendly: good documentation and easy to use toolkits to allow for smooth and rapid adoption

Steps to get there:

1. Demonstrate in a POC the value: status – complete: Space-OS has been successfully demonstrated in a POC for Thales Alenia Space as a platform for New Space
2. Take Space OS from POC to ready to deploy solution -> This is Tarides' current focus
3. After strong presence in the New Space sector roll out technology to other IoT / Edge computing use cases from energy to healthcare, mobility and more: for Europe from Europe

Your contacts if needed:

Miklos Tomka – miklos@tarides.com

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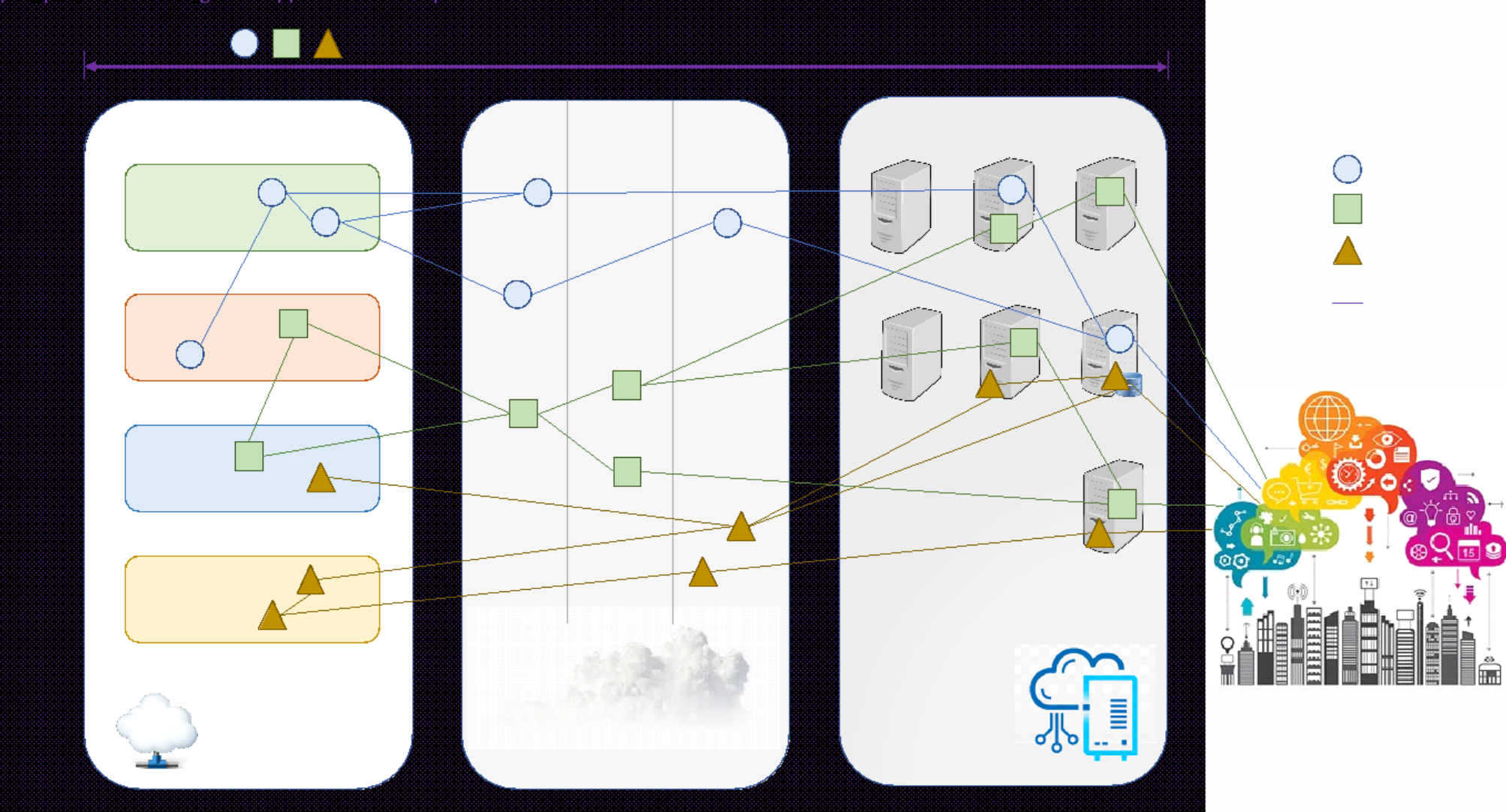
Decentralized Optimisation

Geir Horn – University of Oslo

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The motivation

Optimization

Current status

- Utility maximization
- MELODIC
  - Reactive
- MORPHEMIC
  - Polymorphic
  - Proactive
- NEBULOUS
  - Fog & edge resources
- Centralized optimization

- Distributed optimization
  - Global objective

Research challenges

- Multi-objective optimisation
  - Separate utility for each application
  - Conflicting application utilities
  - No global objective
- Discrete optimisation
  - Exponential time with problem size
  - Co-dependent optimisation
  - Local resource allocation
- Decentralized optimisation
  - Application components decide
  - Global emerging solutions

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optimize AI computations across the Cloud/Edge/IoT continuum

Prof. Alexios Birbas – University of Patras and π-NET

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- Motivation: Take advantage of the emerging 5G/6G infrastructure to support and optimize AI computations across the Cloud/Edge/IoT continuum
- Current Status: data on the cloud/edge/IoT continuum strongly dependent on 5G legacy infrastructure
- Main Challenge: accelerate cloud migration to the closest point of the edge where all data processing and connectivity occurs.
- Additionally:
  - Move from 5G enabled by AI (6G) to distributed (over Cloud/Edge/IoT) AI enabled by 5G/6G
  - Silicon - monolithic Integration of 5G Baseband, CPU and NPU into a single SoC (open processor i.e. RISC-V Based) for Concurrent Multi-RAT (4G, 5G), SA and NSA Modes and supporting Embedded Artificial Intelligence Multi-Access Edge Computing (MEC)
  - In-Line Acceleration Card for converged 5G/6G and AI acceleration card over Open RAN offering telco-class, multi-carrier, maMIMO performance. Virtualized RAN and machine learning for the Distributed Unit (DU).
  - Software programmability with high-speed, polymorphic interfaces which can serve as an all-in-one eNB/gNB disaggregated RAN (an elastic platform that dynamically scales and tailors across the rich broad range of 4G and 5G workloads) while also offers an AI compute platform for MEC use cases

EI : Statistical common-resources Deployment of 5G/6G (BBU) operation and edge applications

Dynamic Scheduling to exploit statistical multiplexing of applications
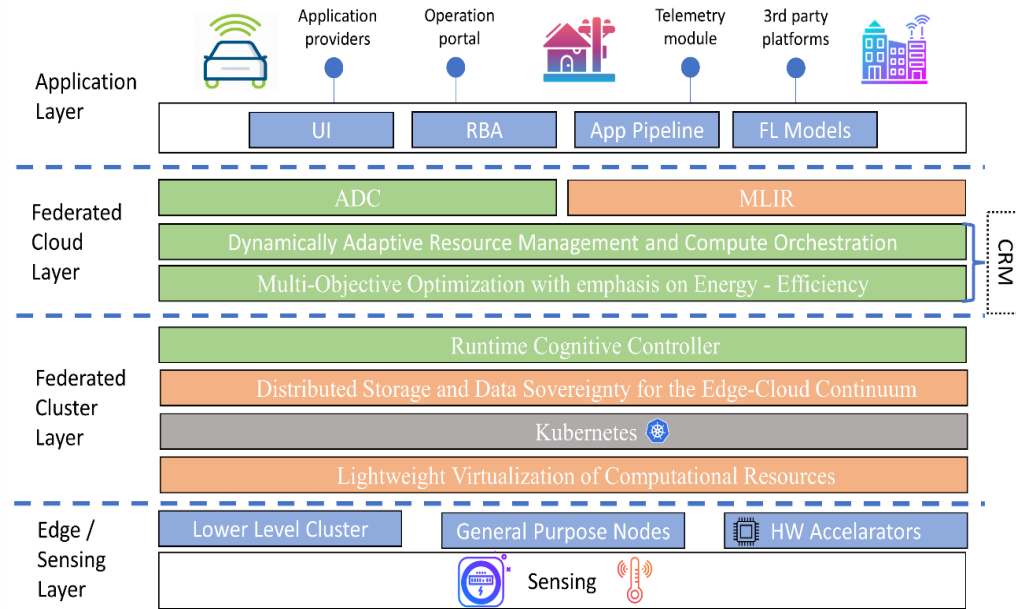
Sustained peak rates are inversely proportional to peak compute workloads

Many compute applications are relatively insensitive to short delays

Also possible to minimize energy consumption by reducing voltage in low activity periods
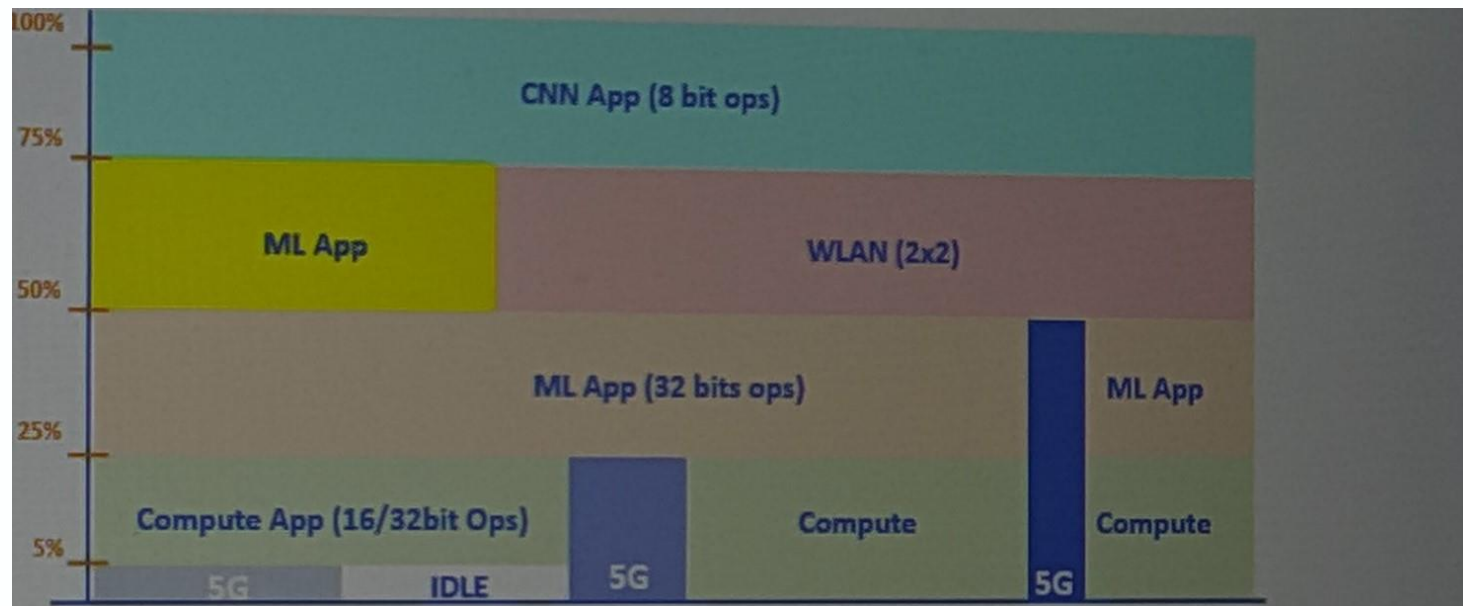
Infrastructure point of view: The application and federated cloud layers' functionalities are running on top of a Core Cloud system. The clusters (Federated Cloud Layer) are hosted on geographically distributed edge-cloud facilities which can expand to micro datacenters offering computing and storage and networking resources in a compact and portable package closer to the source of data. The edge device layer comprises a diverse set of IoT devices used for simple data collection from sensors and edge processing units of different embedded architectures (ARM, or RISC-V based).

Application-oriented programmability: From the perspective of application-oriented programmability, the developers utilize a method based on annotated code to explain the functionality of the app. The components of the applications are offered as code blocks expressing cooperating services. The application developer specifies operational parameters for each component (such as CPU, GPU, RAM, storage, etc.), as well as QoS parameters for the service, such as performance (e.g., latency), security, supported architectures, mapping restrictions, and operational regulations.
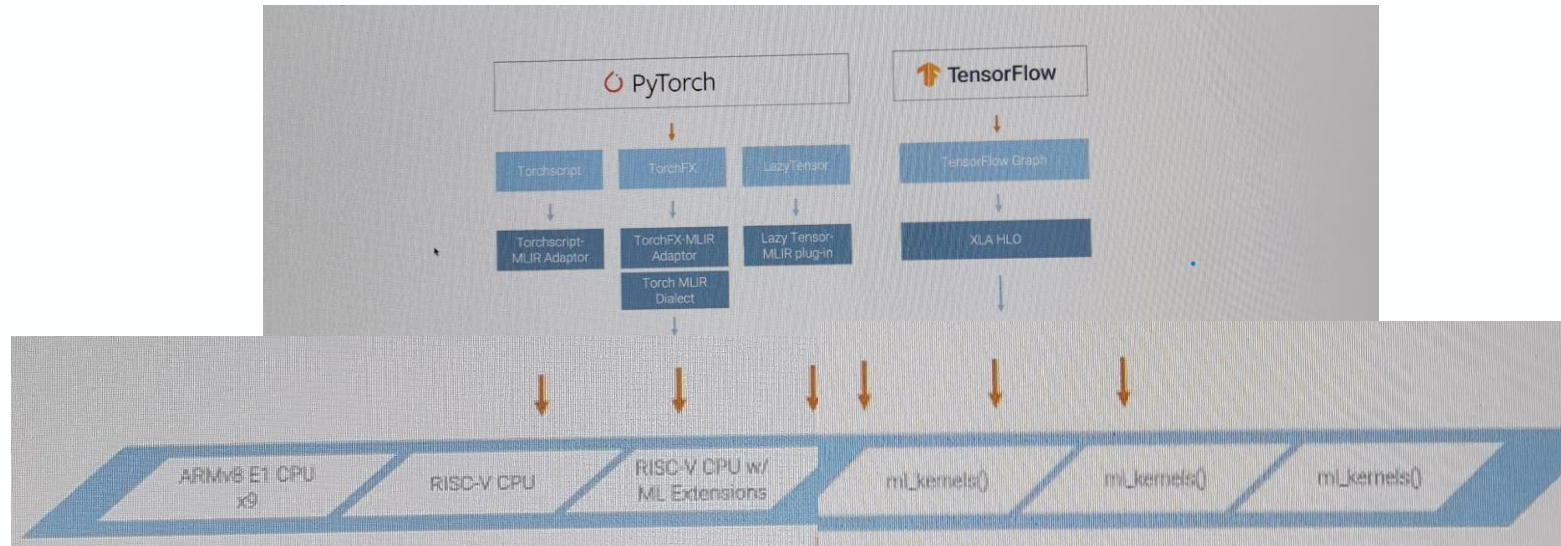
Federated cloud layer
        Application Descriptor Constructor (ADC)
        Multi-Layer Intermediate Representation (MLIR)-based compilation module
        Dynamically adaptive resource management & compute orchestration:
        Multi-objective optimization with emphasis on energy efficiency
        Distributed storage & data sovereignty
        Lightweight virtualization of the computational resources -Kubernetes:
Edge/ sensing layer
        General-Purpose Nodes
        HW Accelerators
        Sensing Devices.

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Prof. Alexis Birbas

Dept. of ECE. University of Patras and π-NET (5G competence Center of Greece)

birbas@ece.upatras.gr, +30 6944 265118

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Human-driven Industrial Metaverse

Karoliina Salminen – VTT Technical Research Centre of Finland Ltd

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Transformation of industrial work

Companies are looking for solutions to resolve the labour crisis prevalent in industrial nations with aging population and lack of appeal in industrial work.

Can industrial metaverse radically change the way of working?

Focusing especially on future industrial **hands-on tasks in different branches of industry,** could we renew the work with:

- next level of **autonomy**
- merger of **physical and virtual worlds**
- **location independent work**
- enriched multi-sensed **communication**
- novel **employment** models

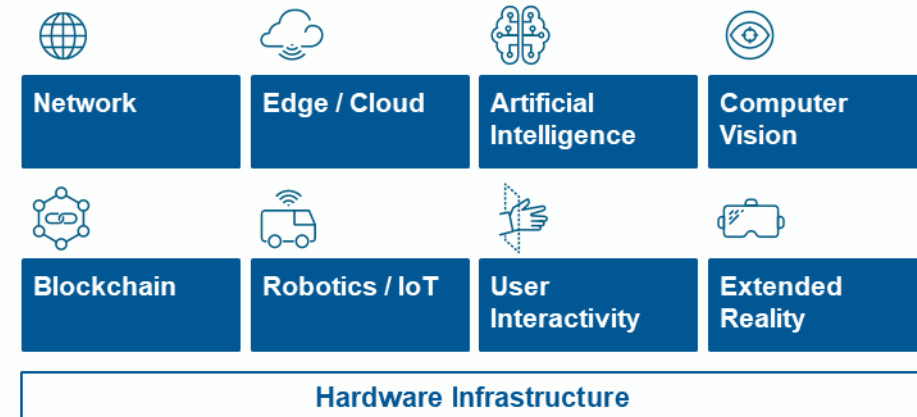Improve flexibility, productivity, safety and multi-profession collaboration across organisations

hybrid work

human-technology-AI teams

virtual collaboration spaces
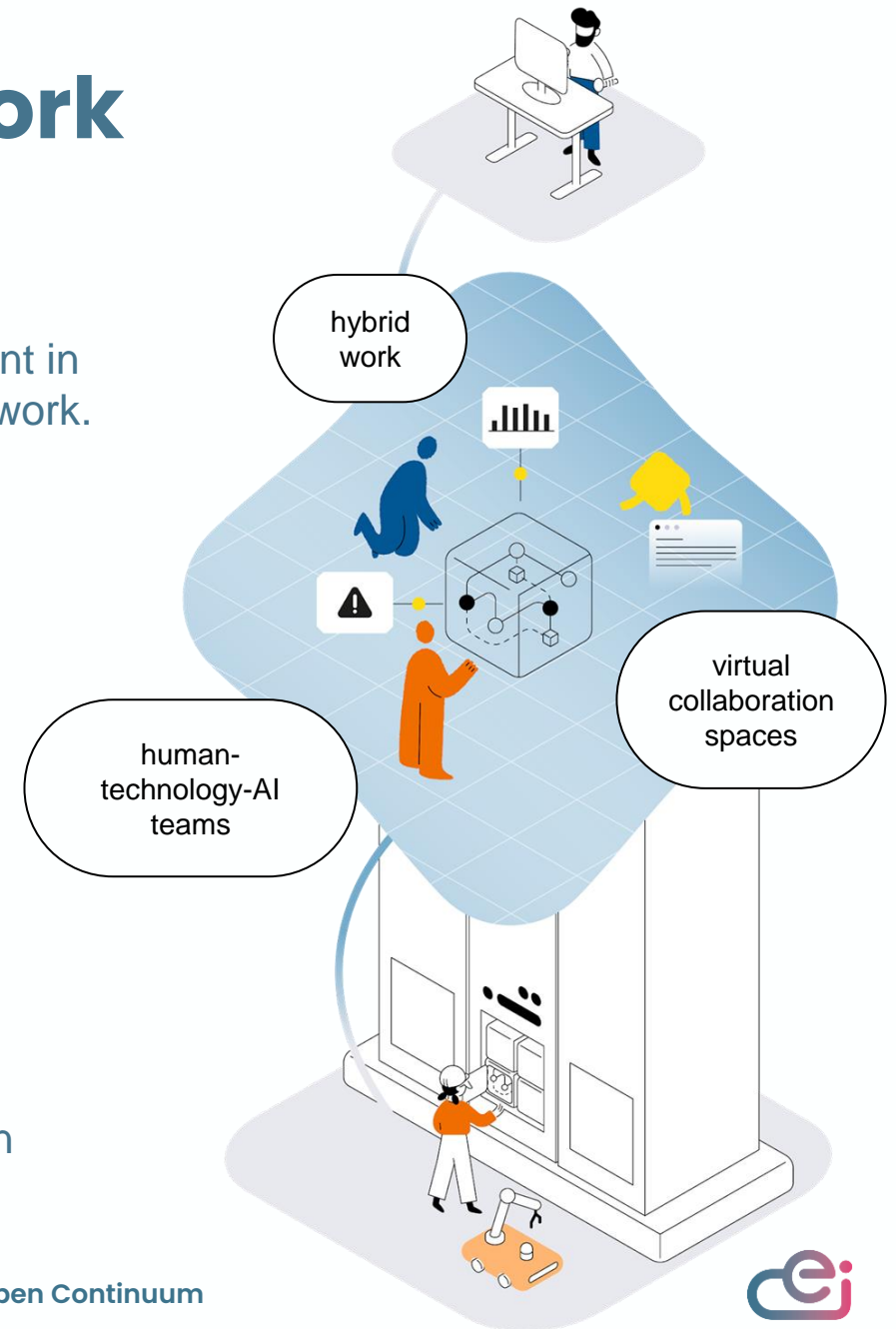
Human-driven industrial metaverse

✓ Creating human-centric, attractive and sustainable work concepts
✓ Offering interconnected spaces to support collaboration and individual work

1. Setting the **goal** of **Europe to be the forerunner** in the industrial metaverse, bringing industrial companies to the era of Industry 5.0.

2. Creating a **strategic research agenda** that focuses on multidisciplinary development of the metaverse initiative: **human, technology, and business**.

3. Preparing the needed **R&D investments** towards the shared goal.

Metaverse non-technology enablers

Regulations & governance	Content & identities	Virtual Economy	Security & Privacy	Work & Organisations	Social Acceptance

Metaverse technology enablers

Network	Edge / Cloud	Artificial Intelligence	Computer Vision
Blockchain	Robotics / IoT	User Interactivity	Extended Reality

Hardware Infrastructure

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