ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

Big Data e Digital Twinning

Webinar BI-REX

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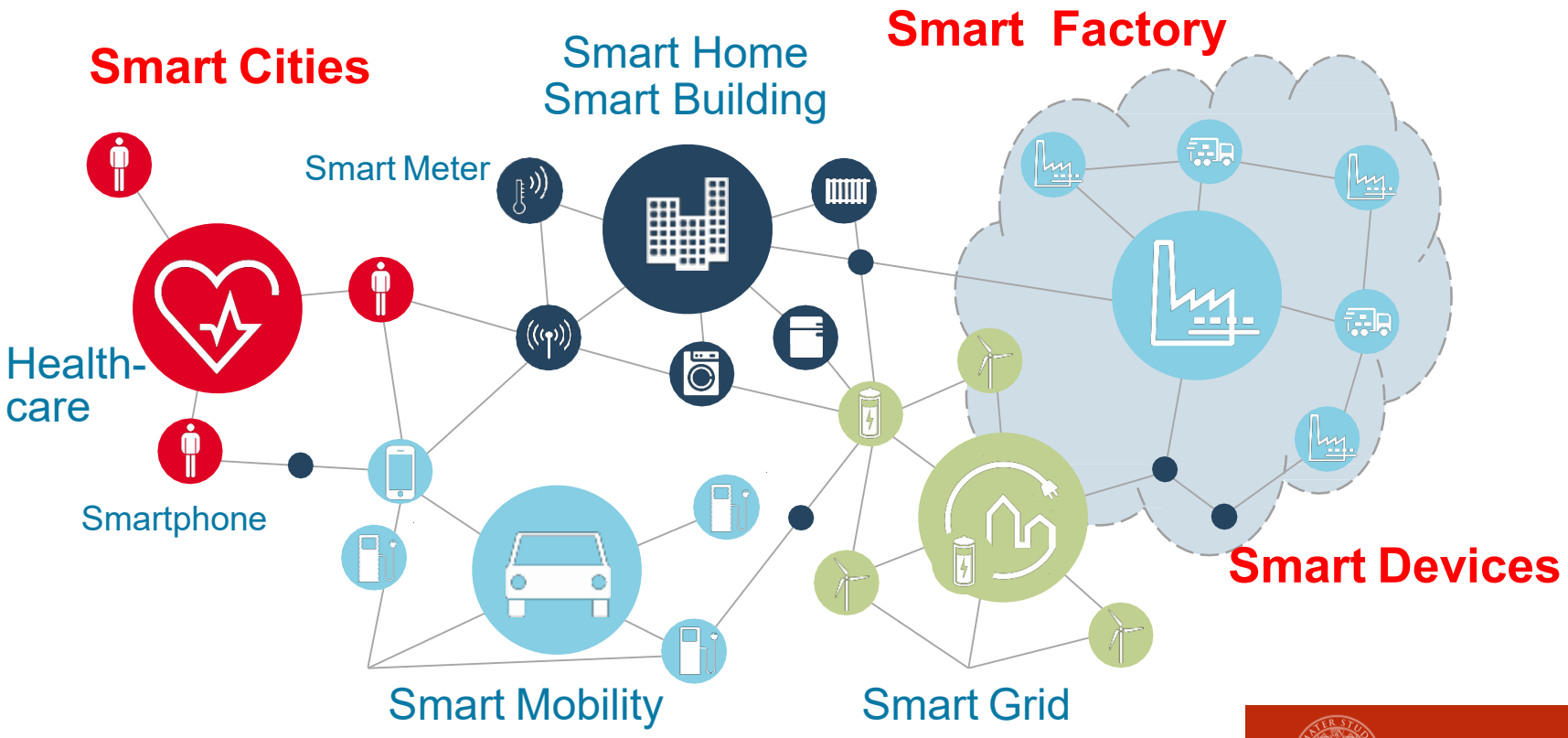
Paolo Bellavista

Dip. Informatica – Scienza e Ingegneria (DISI)
Alma Mater Studiorum - Università di Bologna

Mobile Middleware Research Group

http://middleware.unibo.it



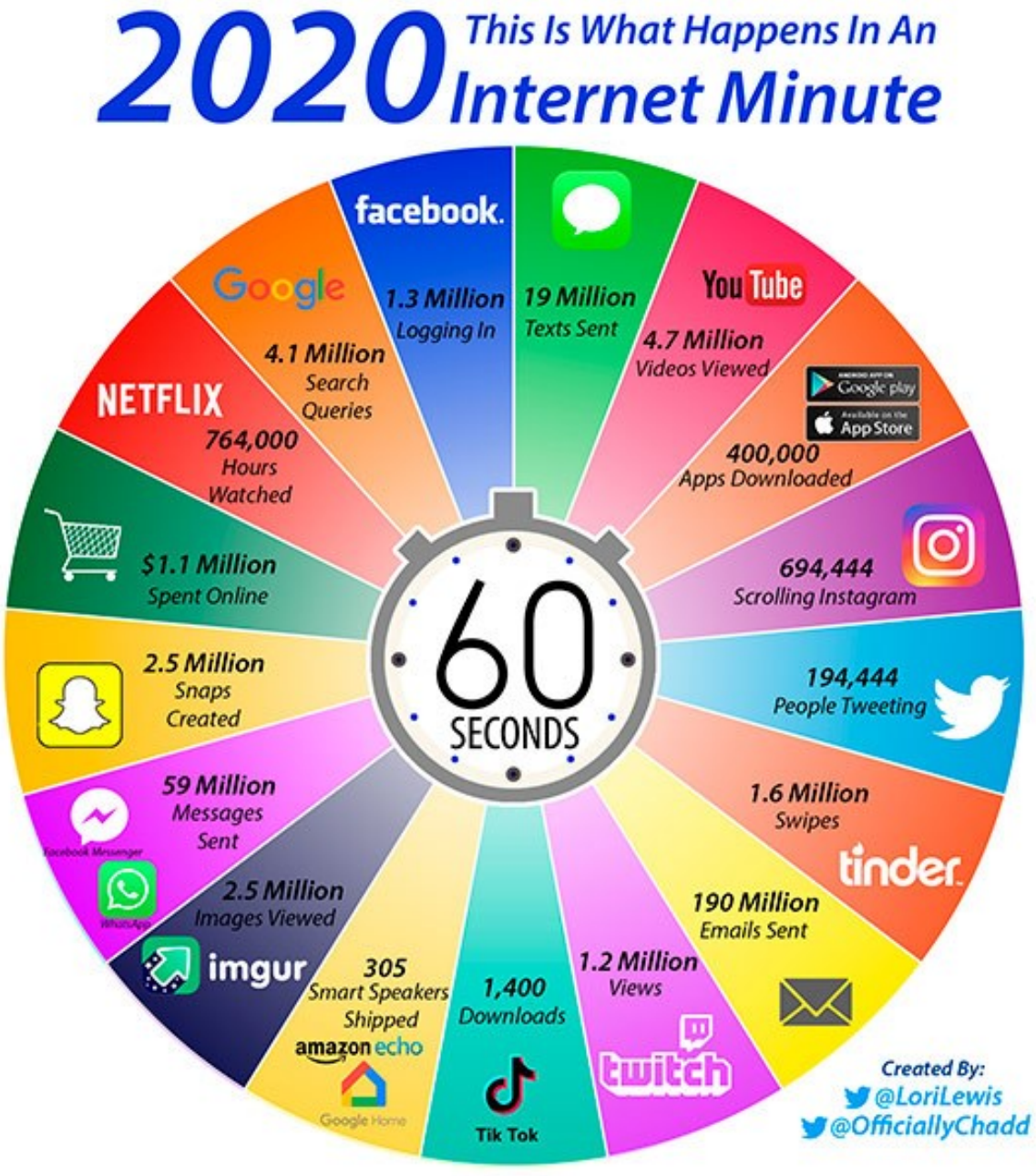
Agenda – Big Data e Digital Twinning nella Manifattura Avanzata

- «Quanto big» per essere efficaci ed efficienti?

- Un po' di chiarezza su:
  - ***tipologie di digital twin per Industria/Impresa 4.0***
  - infrastrutture sw di supporto basate su ***edge/fog computing***

- Big data for manufacturing nel progetto H2020 IA IoTwins https://www.iotwins.eu/

Real-world industrial data: is it really big?



Real-world industrial data: is it really big?

Che cosa significa «big»?

- Nel 2020 si raggiungerà la quantità totale di 40 trillion (10^{12}) GB di dati, ovvero 40 ZB (40 * 10^{21}); nel 2010 il totale era di "soli" 1.2 ZB), notare trend di crescita…
- 90% del totale dei dati ora disponibili è stato creato negli ultimi 2 anni
- Utenti Twitter inviano in media 0.5 milioni di tweet al minuto
- Entro la fine del 2020, ogni persona genererà 1.7 MB al secondo

Non sempre bigger is better…

- ***Similar but diverse***
- ***In similar operational conditions (context)***

Bigger is better?

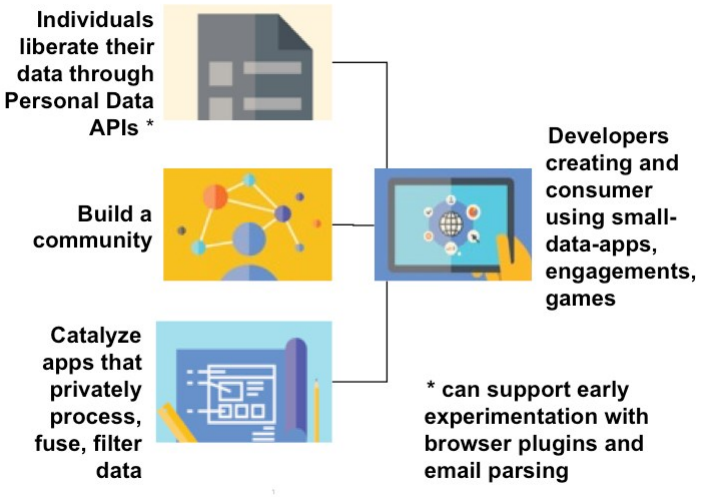
Non sempre…

- ***Similar but diverse***
- Esempio di grandi raccolte cv per job placement e sistemi automatici di talent management

- ***In similar operational conditions (context)***
- Esempio di fault detection e predictive maintenance ma in condizioni di «***contesto***» che possano essere considerate simili

Small Data

- **Extracting value also from "small data"** (D. Estrin, Cornell)
  by building and promoting the emergence of communities, ecosystems, … **fueled by companies in the manufacturing domain**



- Stimolare raccolta di dataset anche piccoli ma estremamente ***significativi per diversity, contesto simile***, …
- ***Segmentare utenti e datasource*** su base di profilazione con caratteristiche e obiettivi simili
- Creare una comunità di attori capace di ***estrarre valore*** da small dataset o da segmenti significative di dati
- Comunicare efficacemente il valore di questa opportunità vera di data sharing

Future opportunities

Business and technical challenges are future opportunities!

- **Extracting value also from “small data”**
  - Specialization national/EU districts and the emergence of communities, ecosystems, … which allow also SMEs to reach “the critical mass”
  - Big data for manufacturing in Emilia Romagna?

The many promises of Smart Industry

- Management
  - OEE performance
  - Factory improvements
  - Planning & Logistics
- Product
  - Better uptime
  - Less cost (effective/efficient/lean)
  - More automated, less manual
  - Predictive maintenance
- Design process
  - Validate design
  - Redesign op basis van feedback
- Production process
  - New insight in processes
  - Impact / influence of parameters
  - Establishing baseline
  - Fault analyses / diagnosis
  - Process optimalisation
- Quality
  - Automatic quality
  - Validated production
  - Automated reports
  - Digital passport
- Customers
  - Better services
  - Faster Quotes

We talk about this

But most companies are here

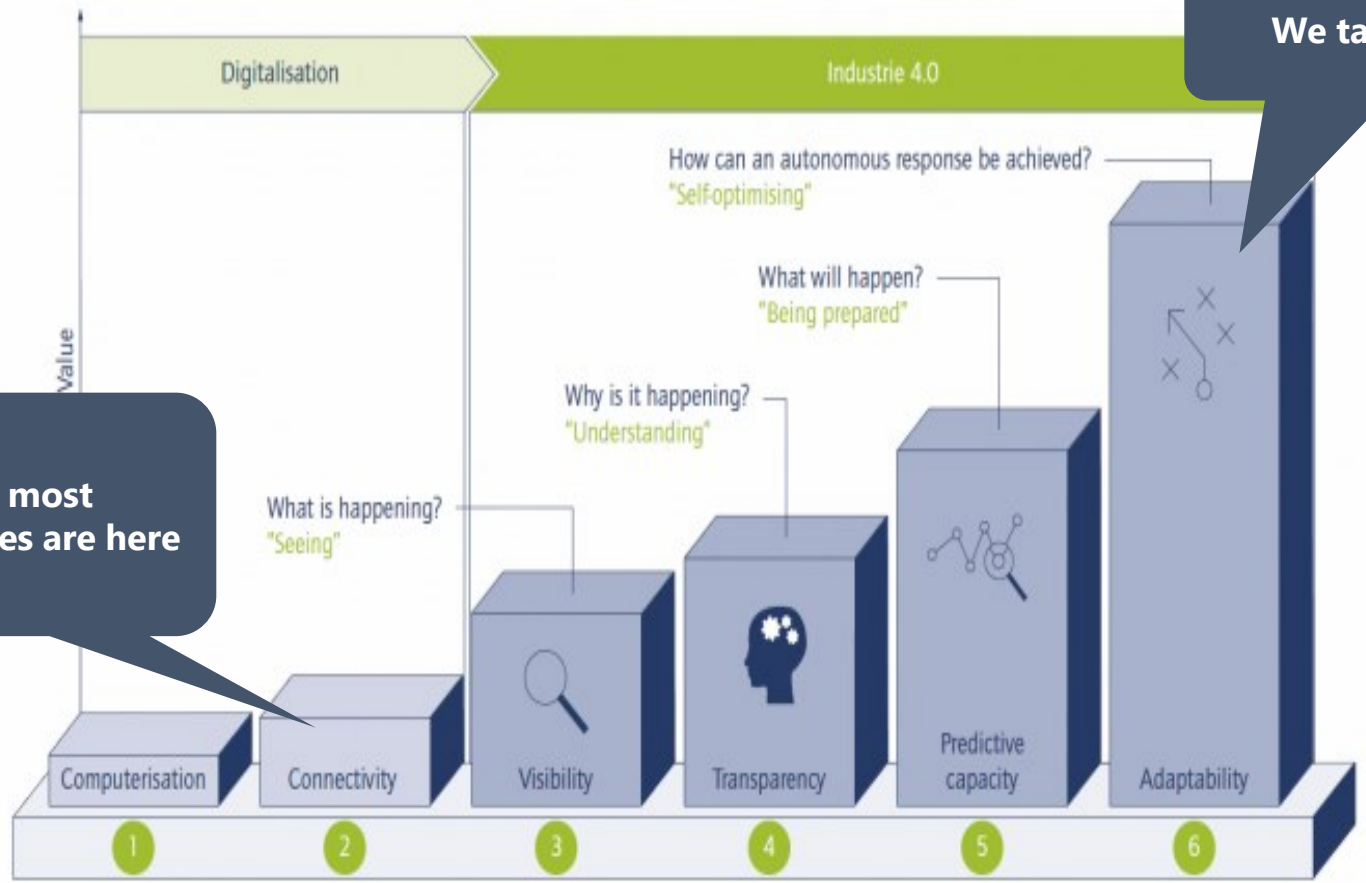


Figure 5: Stages in the Industrie 4.0 development path (source: FIR e. V. at RWTH Aachen University)

How do Digital Twins fit in?

Digital Twins are part of the digitization strategy, they require:

- a vision on digitization
- purpose in the processes
- the means to operate it
- the adaptivity of the organization

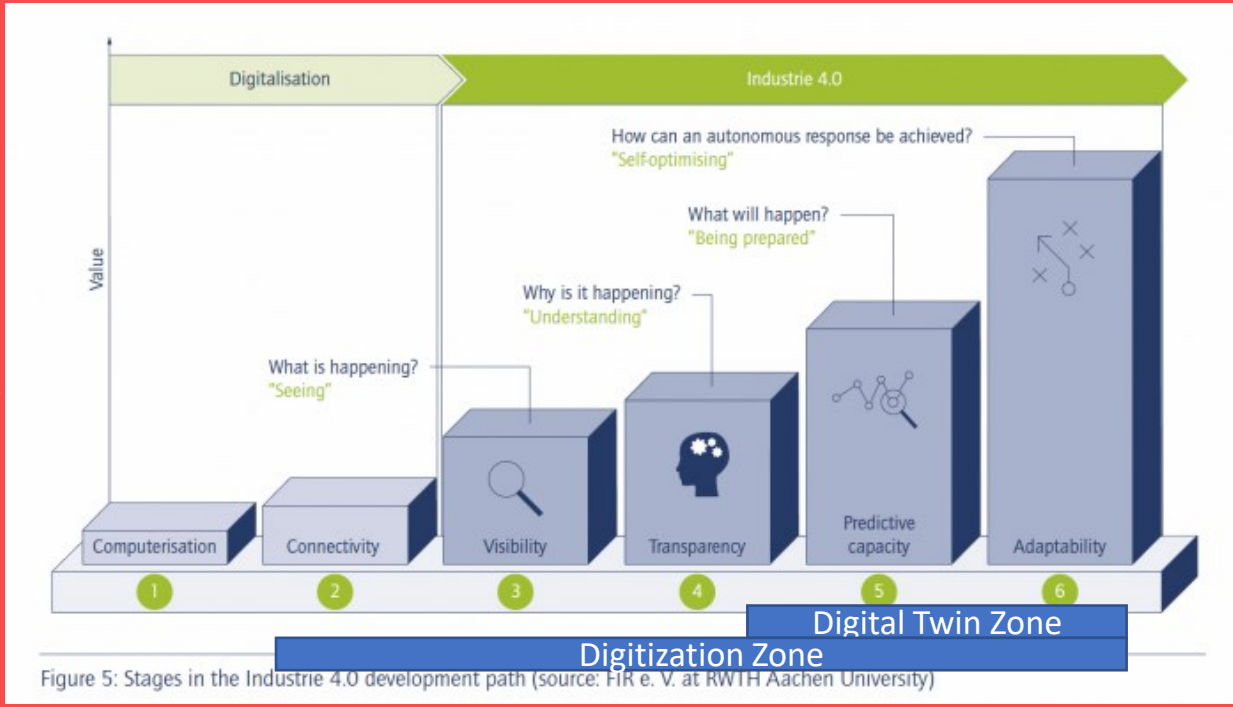


Figure 5: Stages in the Industrie 4.0 development path (source: FIR e. V. at RWTH Aachen University)

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Digital Twins - a definition:

A digital twin is a ***digital replica that is accurate enough*** that it can be the basis for decisions given a specific purpose

Creating value by linking data, models & processes

The replica is often connected by streams of data
The replica is aided by new IT infrastructures, e.g., edge/fog-enabled

Degrees of accurate enough

Level of abstraction

Company

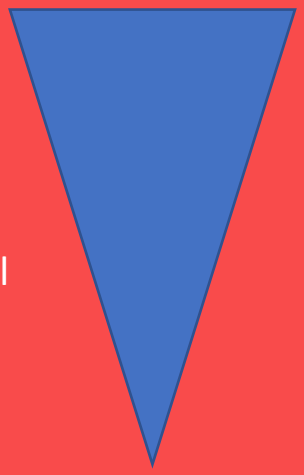
Factory

Line

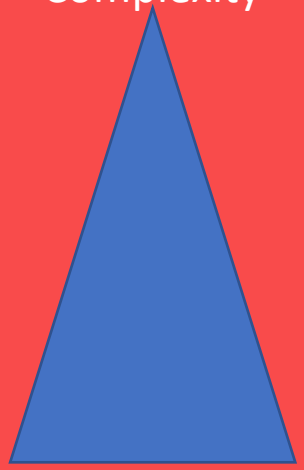
Machine/Cell

Component

Single part



Complexity



Description

Simple model

Validated model

Adaptive model

Full Physics simulation

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Obiettivi dei Digital Twin?

	Product	Production process
Design phase	• Virtual testing • Stress testing • Redesign based on user data	• Virtual commissioning • Bottleneck analysis • Process optimisation • Model-based definition
Operational phase	• Quality monitoring • Anomaly detection • Predictive maintenance	• Zero downtime • First-time-right production • Zero-defect production • Process optimisation • Control optimisation • Recipe optimisation • Anomaly detection • Root cause analysis

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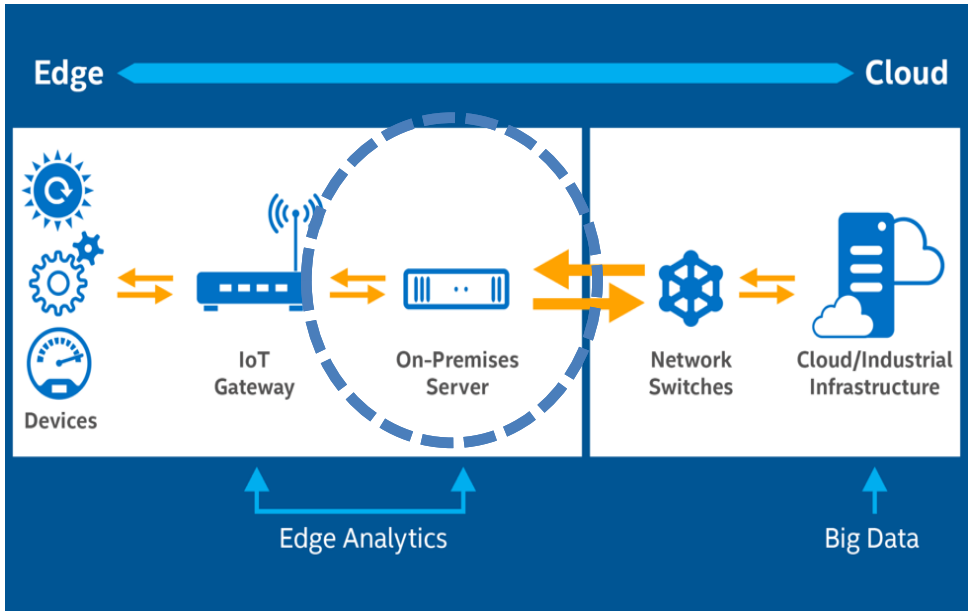
IoT: From Cloud Computing to Fog/Edge Computing



IoT Cloud Computing architecture

- most of the computation on the Cloud
- only gateways are deployed close to things
- gateways perform few and simple tasks

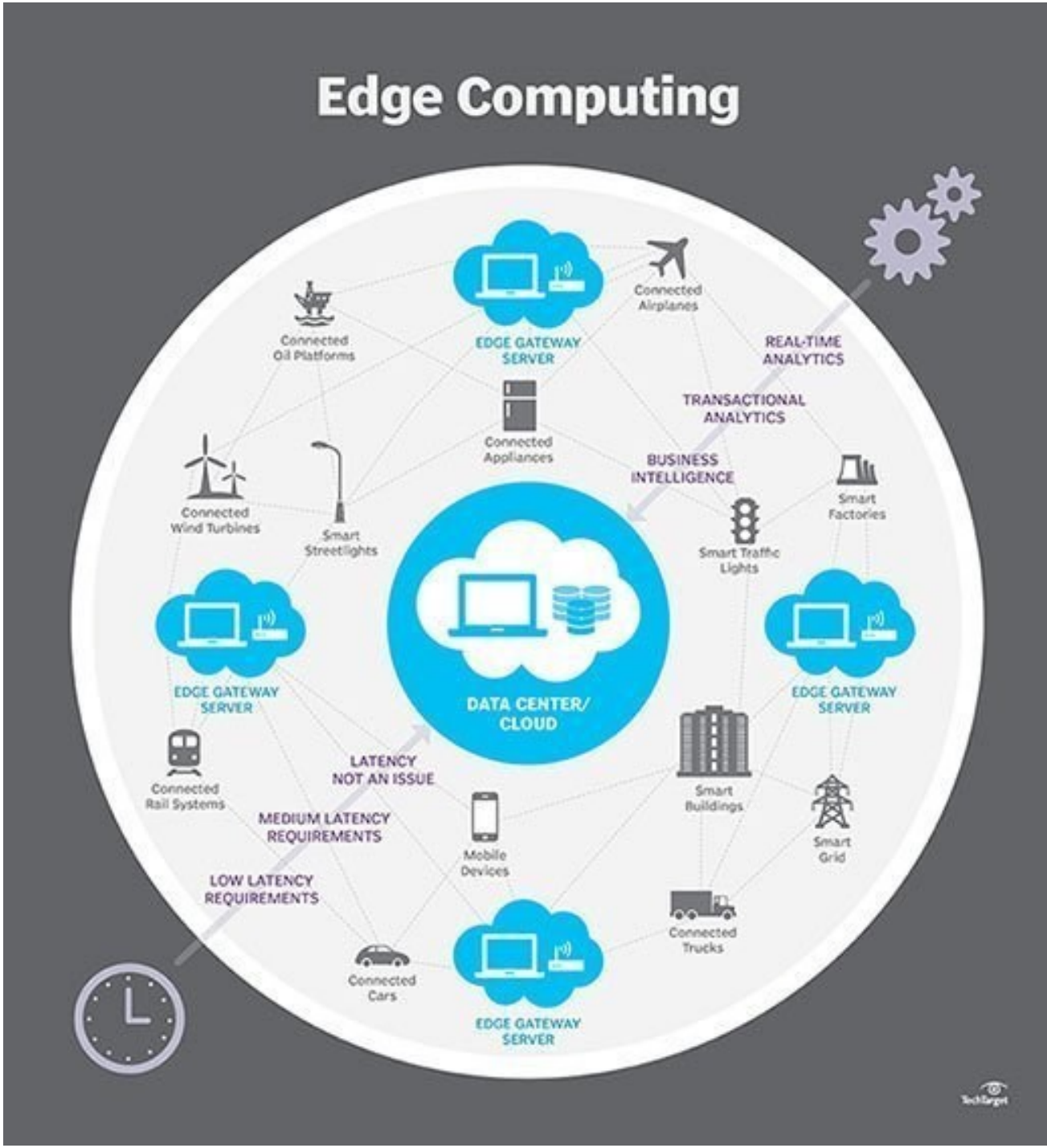
IoT **Fog/Edge** Computing architecture

- additional **relatively powerful devices**
- **close to things**, but between gateways and the Cloud
- **complex analytical tasks** on the client-side, before sending data to the Cloud

5G + Edge Cloud Computing

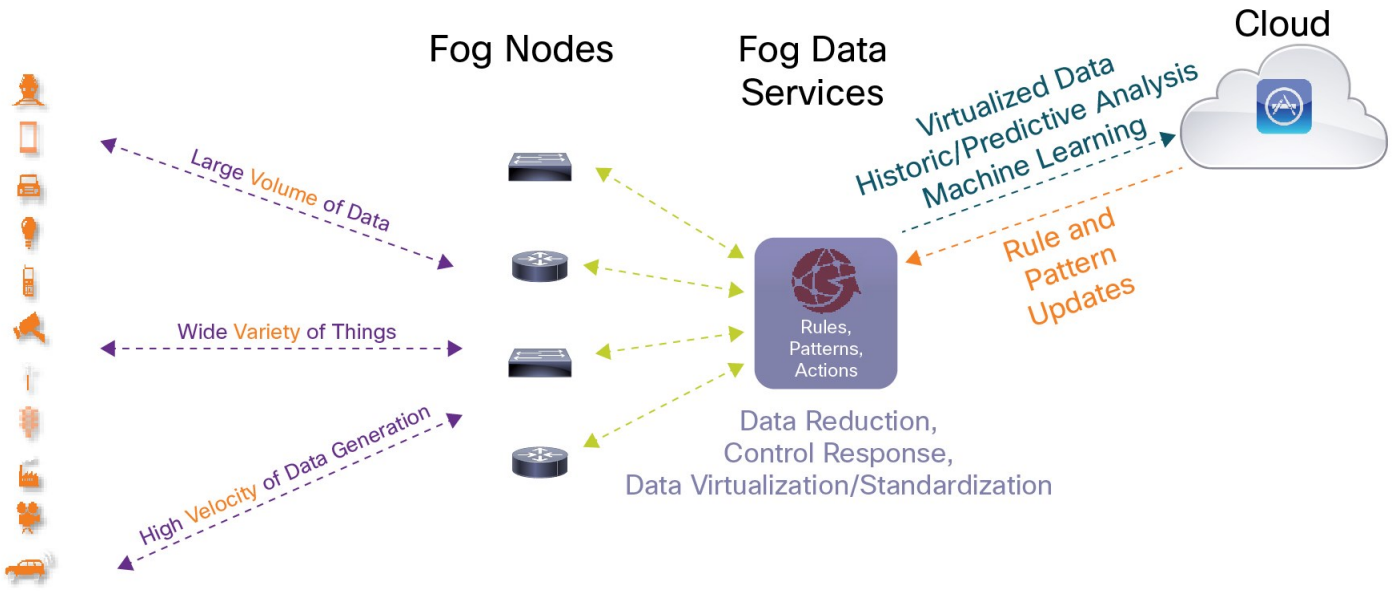
What is edge?

What is fog?



Fog Computing

Cisco: **the fog extends the cloud** to be closer to the things that produce and act on IoT data



An extremely valuable enabler:
5G + Edge Cloud Computing

5G-enabled edge cloud computing is a crucial enabler for many I4.0 applications:

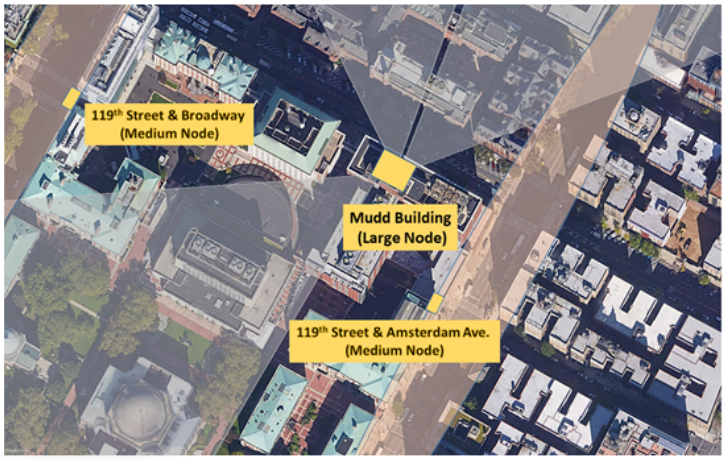
- Efficiency
- Low latency
- Low cost
- Scalability
- Interaction and collaboration (e.g., *tactile Internet*)
- Data sovereignty
- With customized properties of security, privacy, data protection, data aggregation/anonymization, …

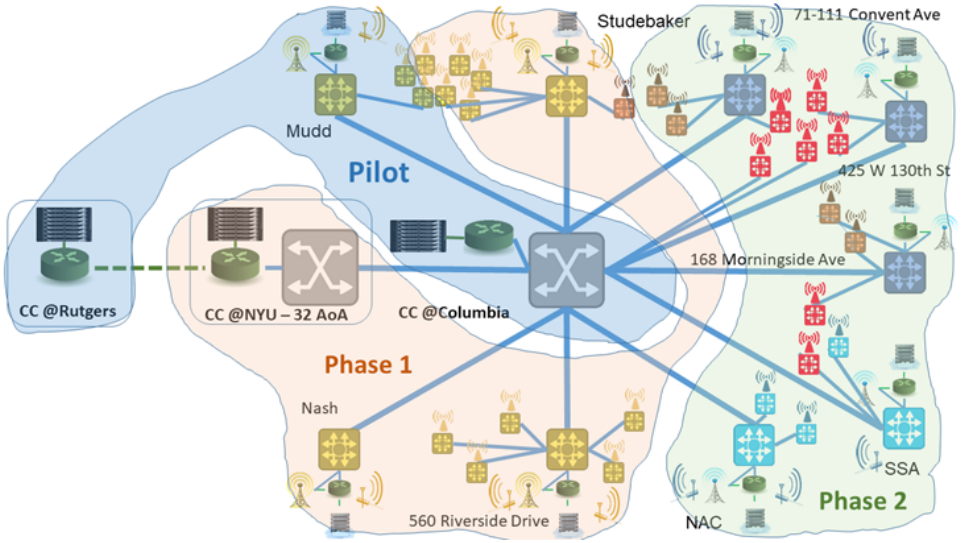
And not only for predictive maintenance!!!

5G + Edge Cloud Computing

COSMOS Deployment: NYC Coverage Areas

- Pilot – planned for end of 2018
- Phase 1 in 2019, Phase 2 by 2020





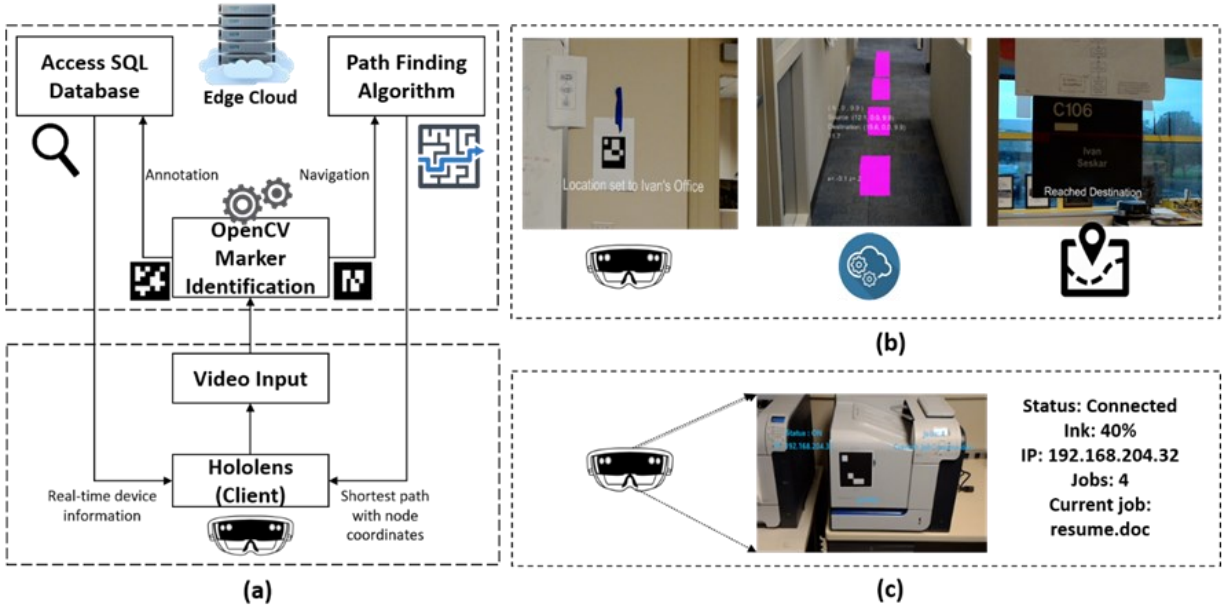

Mudd


Broadway


Amsterdam

- Phase 1 Columbia/CCNY – ~15-20 nodes
- Phase 2 – ~40 nodes

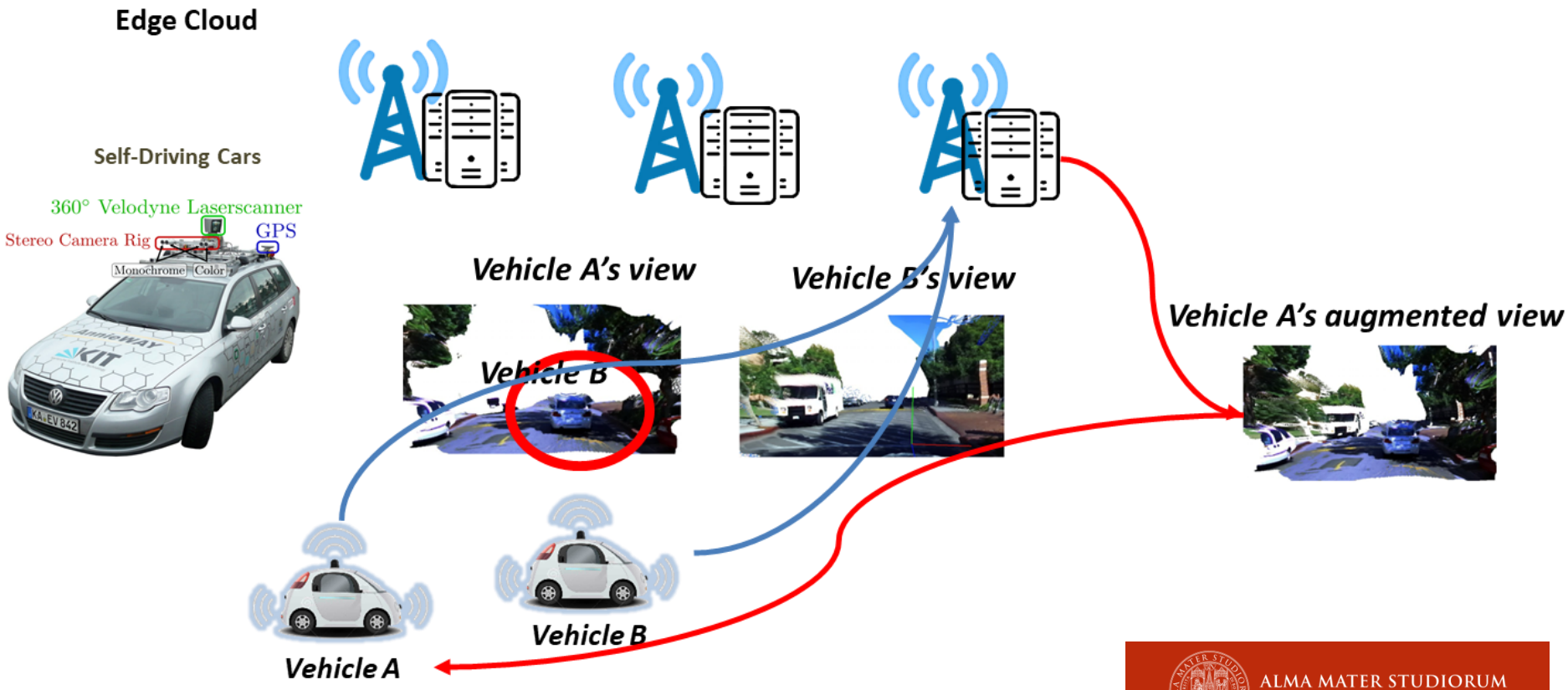
COSMOS Experiments: AR Applications



(a) AR application flow; (b) Smart meeting application using indoor navigation; (c) Annotation based assistance

5G + Edge Cloud Computing

COSMOS Experiments: Cloud Assisted Autonomous Vehicle



IoTwins

BIG DATA OPTIMIZE INDUSTRY AND SERVICES

TYPE OF ACTION
INNOVATION ACTION

PROJECT REFERENCE
857191

START/END
SEPTEMBER 2019 – AUGUST 2022

TOTAL COSTS
€ 20,029,818.75

EU CONTRIBUTION
€16,422,552.01

CALL IDENTIFIER
H2020-ICT-2018-2020

TOPIC
ICT-11-2018-2019 - HPC AND BIG DATA ENABLED LARGE-SCALE TEST-BEDS AND APPLICATIONS

COORDINATOR
BONFIGLIOLI RIDUTTORI

Concept and approach

- IoTwins is an EU project that will work to **lower the barriers for the uptake of Industry 4.0 technologies** to optimize processes and increase productivity, safety, resiliency, and environmental impact
- IoTwins approach is based on a **technological platform** allowing a simple and low-cost access to **big data analytics** functionality, **AI services**, and **edge cloud** infrastructure for the **delivery of digital twins in manufacturing and facility management sectors**
- The approach is demonstrated through the development of **12 large scale testbeds**, organized in three application areas: **manufacturing**, **facility management**, and **replicability**/scale up of such solutions

20	16	23	1	12	3
M€ total value	M€ EU Funding	Partners	Platform	Testbeds	Application areas

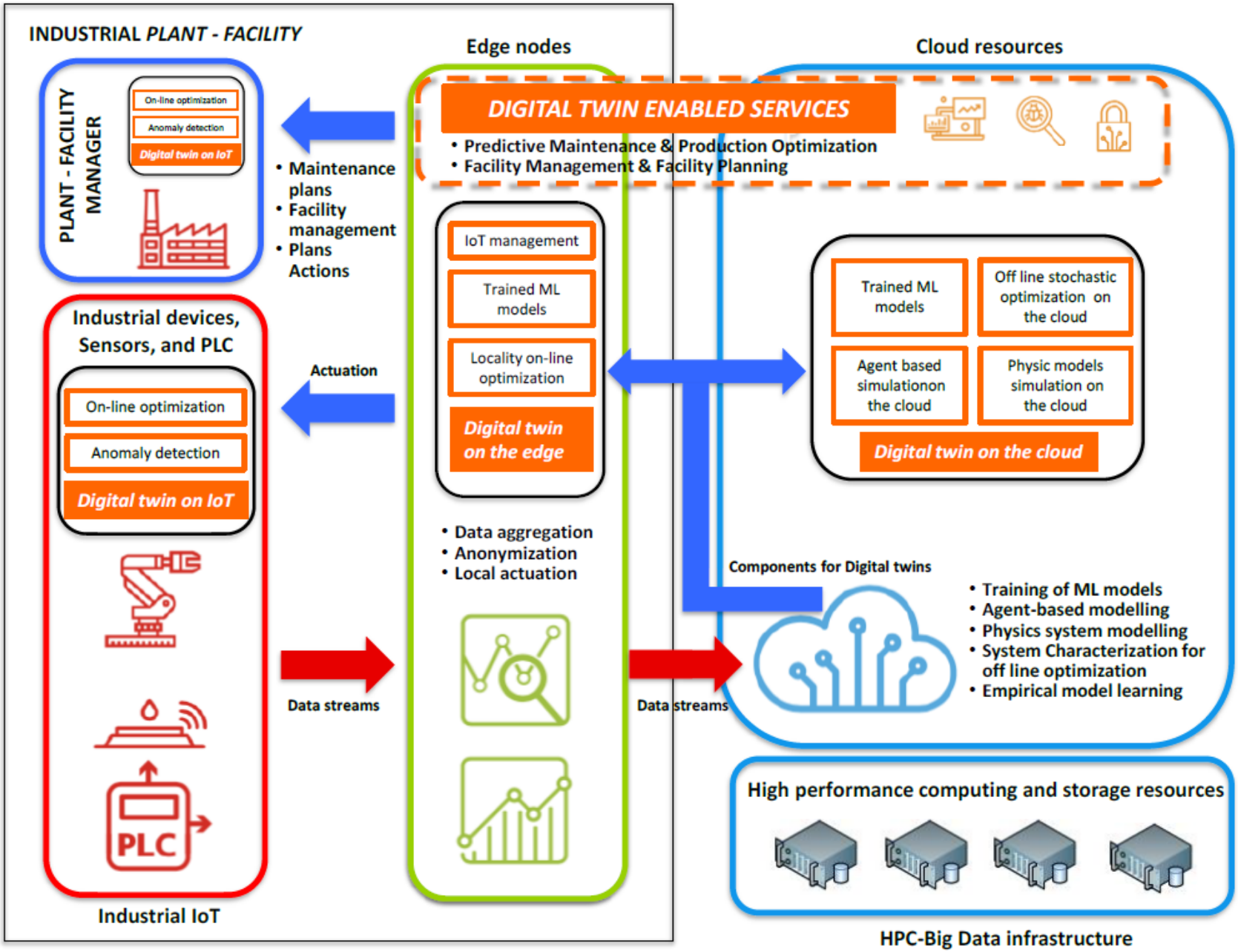
Platform and services

All the IoTwins testbeds share the same methodology, grounded on the concept of **distributed IoT-/edge-/cloud-enabled hybrid twins, to replicate complex systems**, with the ambition of predicting their dynamics and temporal evolution

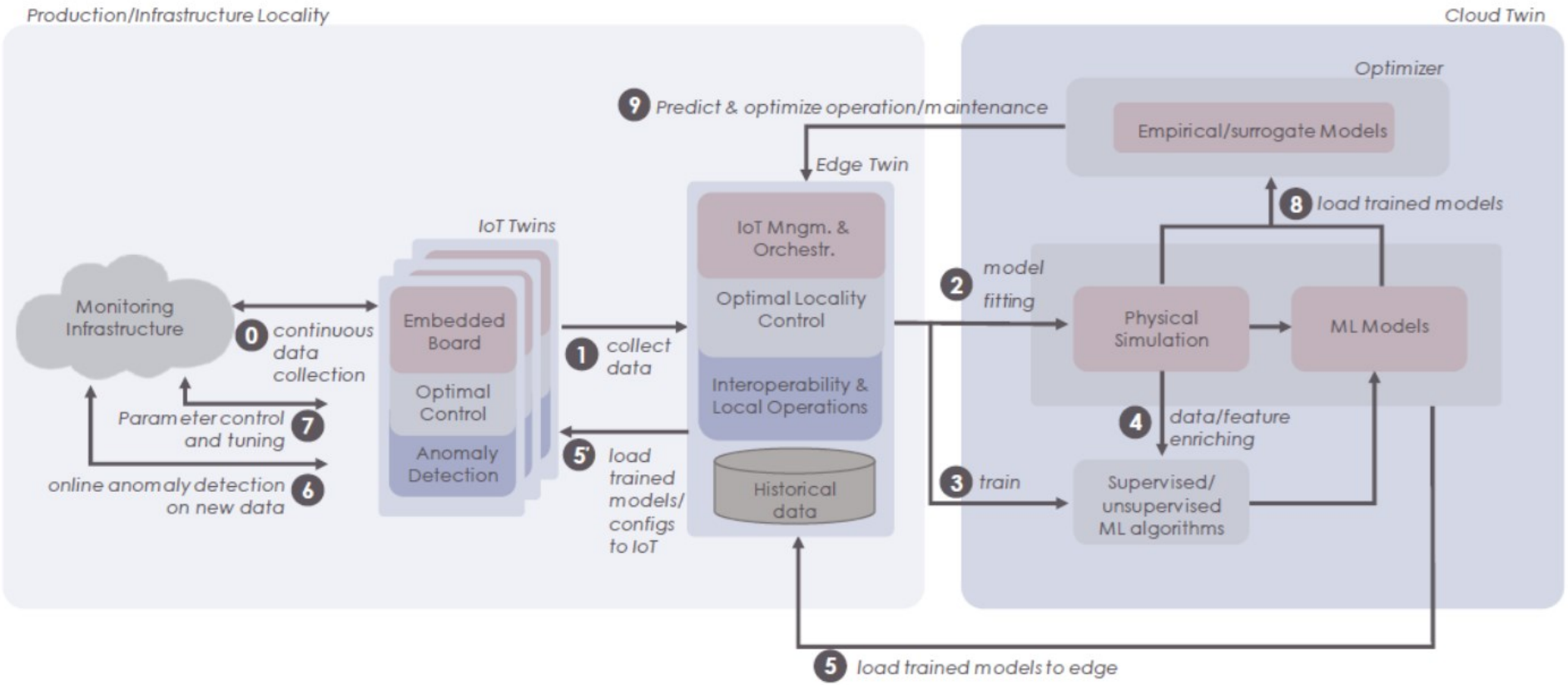
Key elements:

- A full-fledged platform enabling **easy and rapid access to heterogeneous cloud HPC-based resources** for advanced big data services
- **AI services** to simplify and accelerate the integration of **advanced Machine Learning algorithms, physical simulation, on-line and off-line optimization** into distributed digital twins
- **Advanced edge-oriented mechanisms, tools, and orchestration** to support **Quality of Service** in the runtime execution of the distributed digital twins

Digital Twins concept in IoTwins



Distributed Training and Control in IoTwins



Testbeds

manufacturing

4 industrial testbeds calling for predictive maintenance services (time to failure forecasting and generation of maintenance plans to optimize costs)

- Wind turbine predictive maintenance | **Bonfiglioli Riduttori, KK Wind Solutions**
- Machine tool spindle predictive behavior | **FILL**
- Predictive maintenance for a crankshaft manufacturing system | **ETXE-TAR**
- Predictive maintenance and production optimization for closure manufacturing | **GCL International**

Testbeds

facility management

3 testbeds calling for identification of criticalities, optimization techniques to provide efficient facility management plans, operation optimal schedules, and renovation/maintenance plans

- NOU CAMP - Sport facility management and maintenance | **Futbol Club Barcelona**
- EXAMON - Holistic supercomputer facility management | **CINECA**
- Smart Grid facility management for power quality monitoring | **SIEMENS**

Testbeds

replicability

5 testbeds to demonstrate the replicability and scalability of both IoTwins solutions and the former manufacturing and facility management testbeds

- Patterns for smart manufacturing for SMEs | **Centre Technique des Industries Mécaniques**
- EXAMON replication to other datacenters facilities | **Istituto Nazionale di Fisica Nucleare, Barcelona Supercomputing Center**
- Standardization/homogenization of manufacturing performance | **GCL International**
- NOU CAMP replicability towards smaller scale sport facilities | **Futbol Club Barcelona**
- Innovative business models for IoTwins PaaS in manufacturing | **Marposs**

Use case 1: Guala Closures

Target Plant: Spinetta Marengo (ITA)

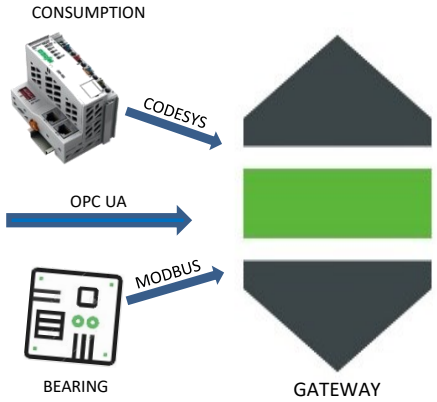
- More than 200 production machines

Identification of the use case

- Aim: ***prevent extraordinary maintenance*** through ***prescriptive maintenance***

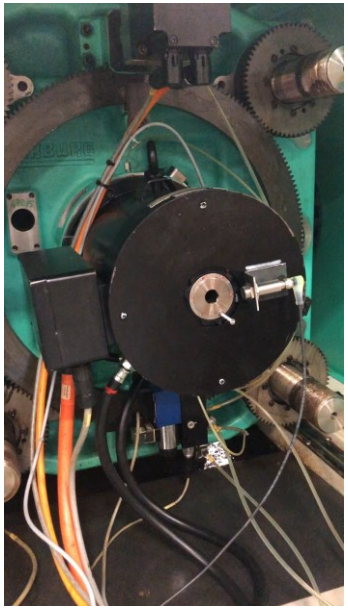
- Target machine: MOLDING press

Ongoing activities

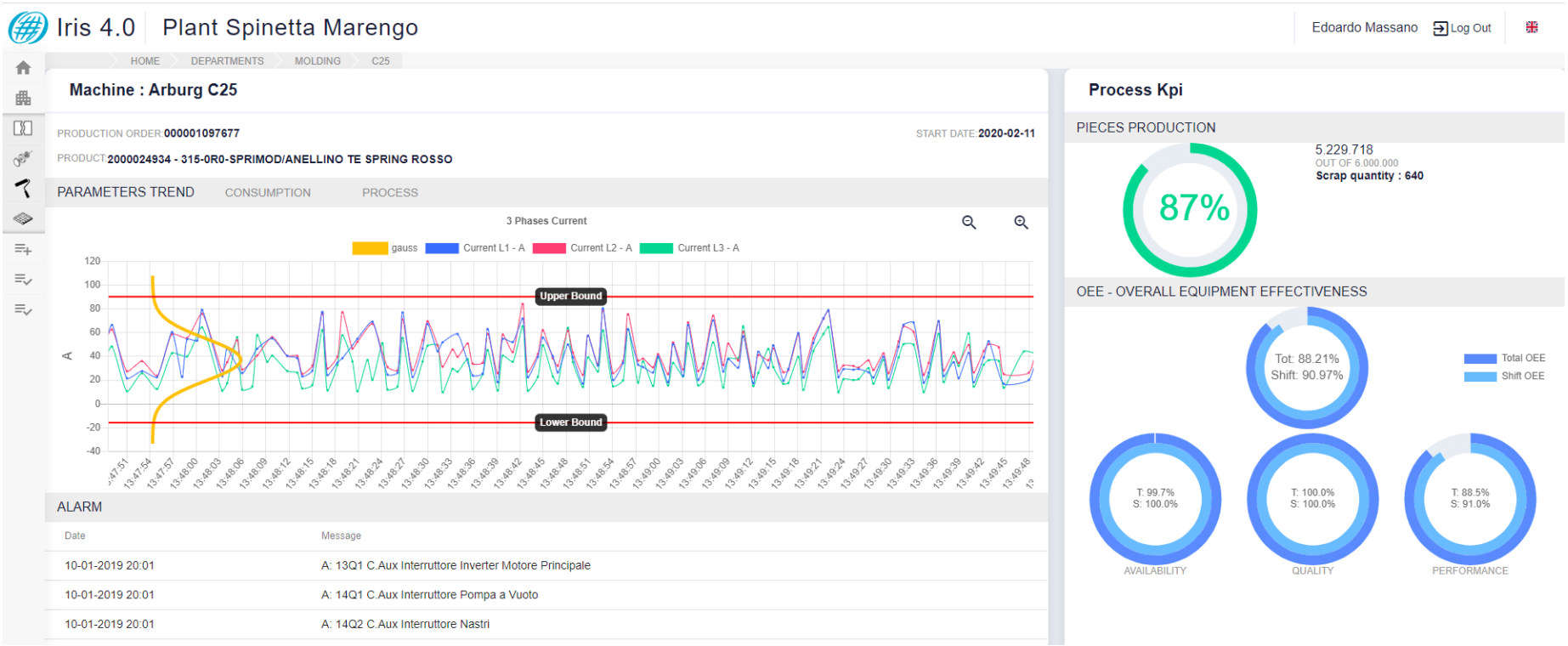


Identification of additional sensors

- Consumption
- Bearing Vibration/Temperature/Acceleration
- Bearing breakage event



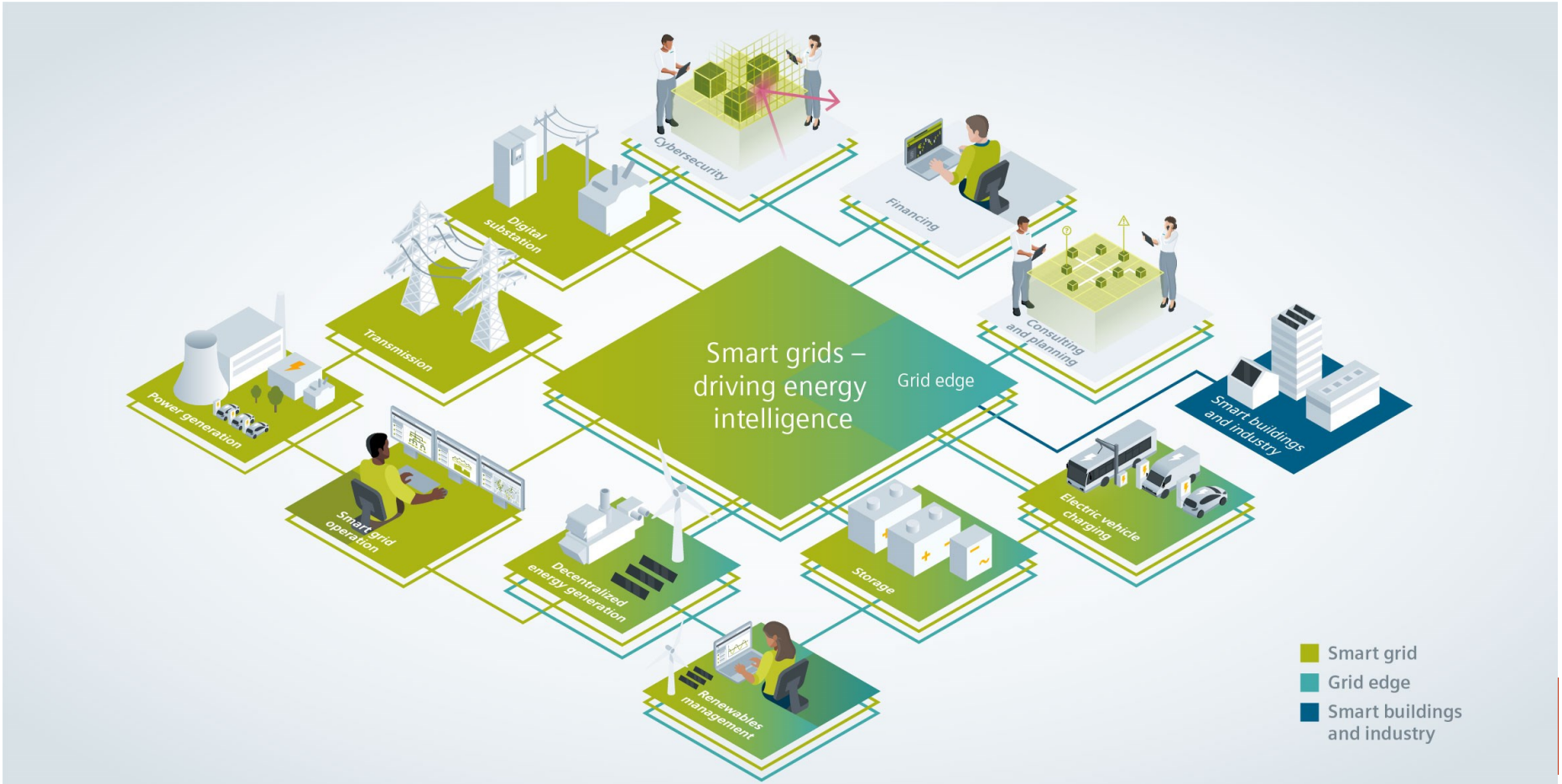
Trend prediction
based on modeling + unsupervised learning



Hybrid Digital Twins

Digital twinning for smart grid in Aspern, Wien

- State-of-the-art living lab project started 4 years ago
- 12 secondary substations with a total of 24 transformers (one of which is a tap changer) and grid monitoring devices that act as data sources
- 1.5M data points are processed by the associated datacentre each day



Digital twinning for smart grid in Aspern, Wien

The challenge of

FEDERATED LEARNING

- Edge devices based on ***CP-8050 energy automation device from Siemens***
- A use case in which edge devices are cooperating with the backend ***to locally identify global outliers***
- ***Power quality measurement*** devices are installed, but their raw data is NOT suitable to be forwarded to the backend, ***because of volume***
- ***Edge- and cloud-based digital twins to achieve an overall view*** on the state of the power grid
- Based on this generated information, ***new config parameters are extracted and forwarded to the edge nodes***
- Based on the local and global data, edge devices provide ***feedback for parameter tuning***
- and ***do anomaly detection locally***
- More in general, ***support to grid operation/planning***

Partners.

IoTwins

Bonfiglioli

Coordinator

ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA

ART-ER ATTRACTIVENESS RESEARCH TERRITORY

Barcelona Supercomputing Center Centro Nacional de Supercomputación

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ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

Paolo Bellavista

Dip. Informatica – Scienza e Ingegneria (DISI)
CIRI ICT
BI-REX Competence Center per Impresa 4.0

paolo.bellavista@unibo.it