Big Data e Digital Twinning nella Manifattura Avanzata

Webinar @ BI-REX

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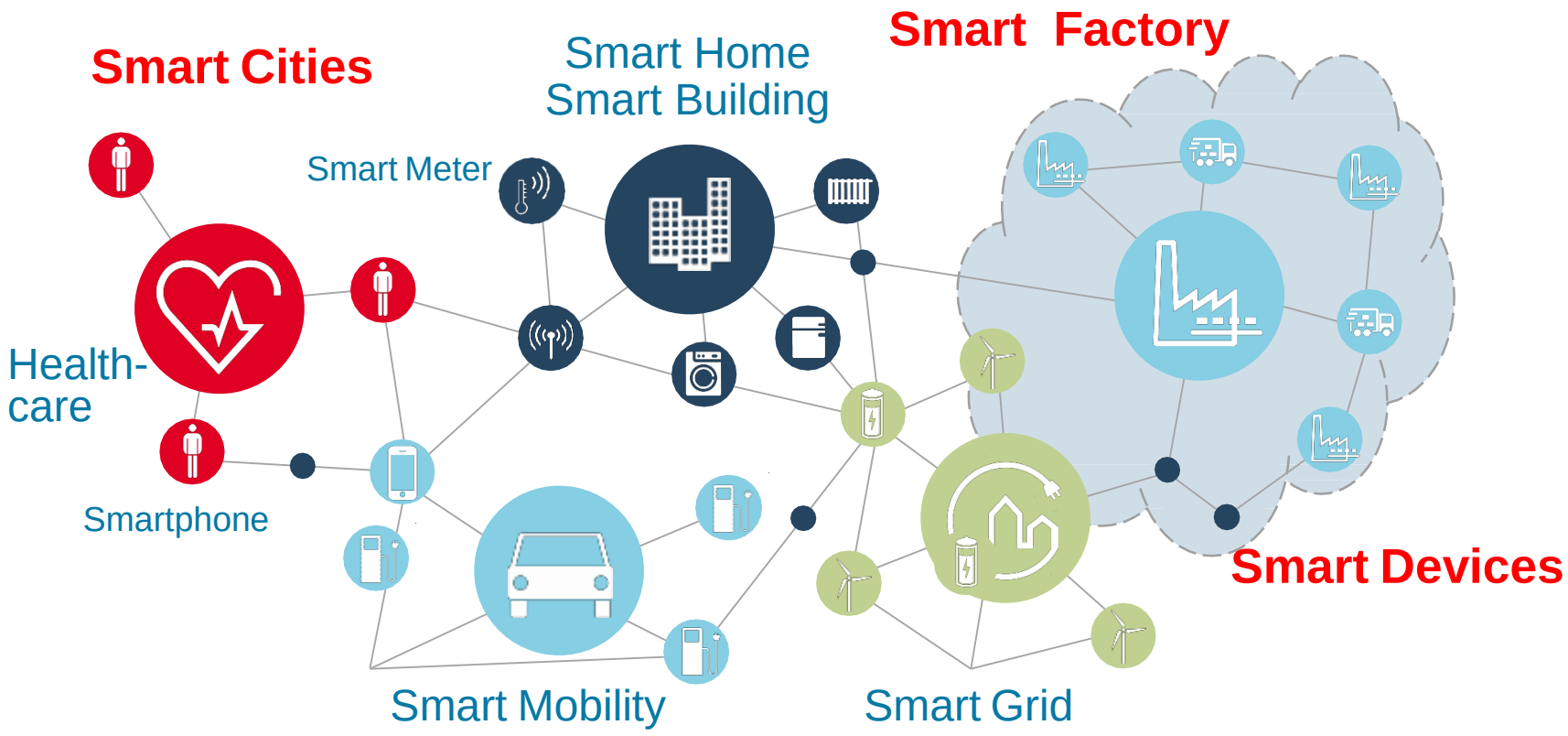
http://middleware.unibo.it



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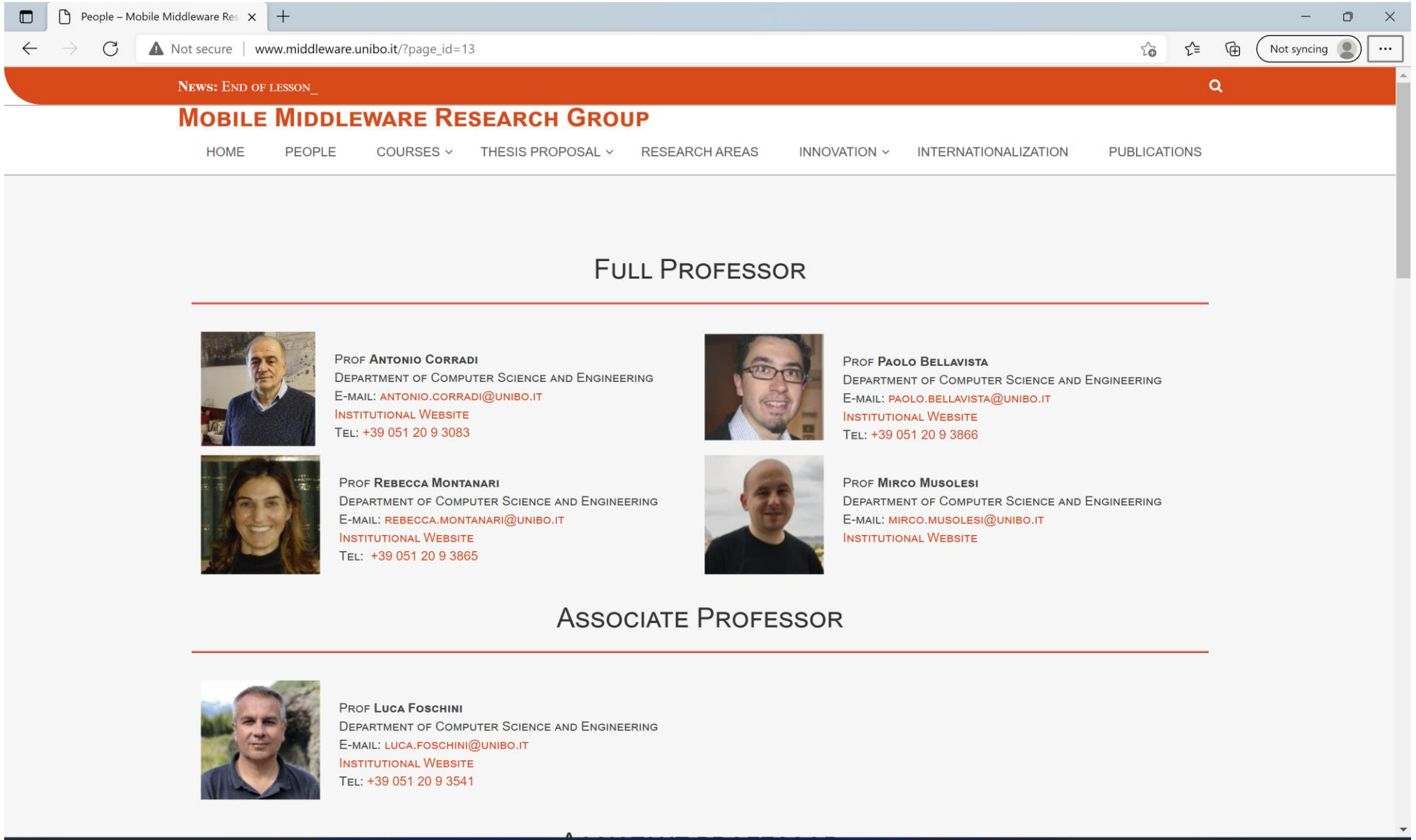

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Agenda – Big Data e Digital Twinning nella Manifattura Avanzata

- «Quanto big» per essere efficaci ed efficienti?

- Un po’ di chiarezza su:
  - ***digital twin per Industria/Impresa 5.0***
  - Innovazione in infrastrutture sw di supporto basate su ***edge computing e 5G***

- 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?

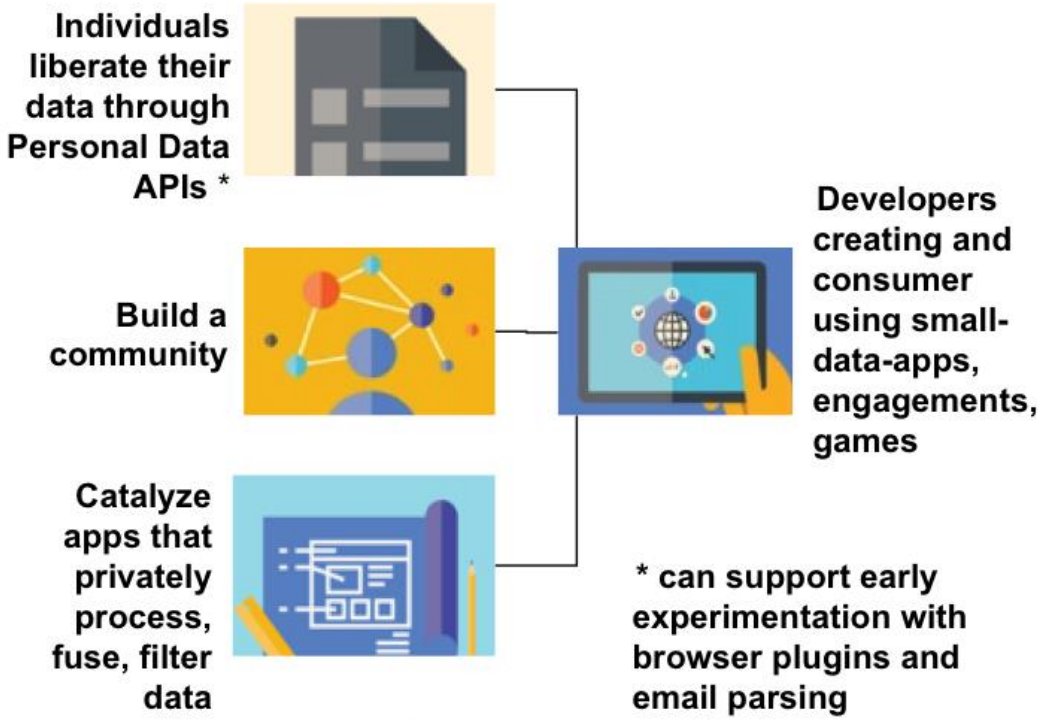
Non sempre bigger is better…

- ***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

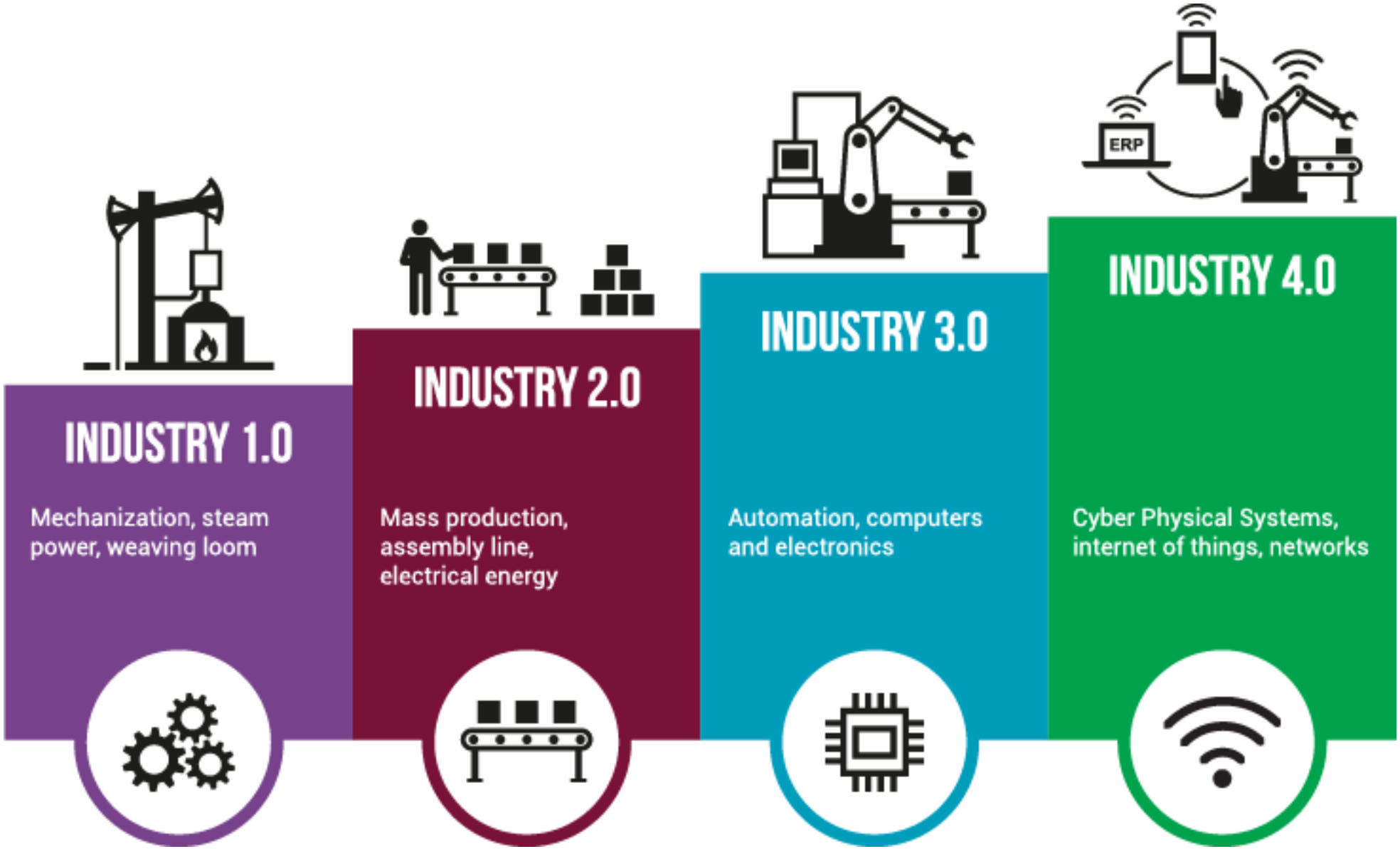
Small Data

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**

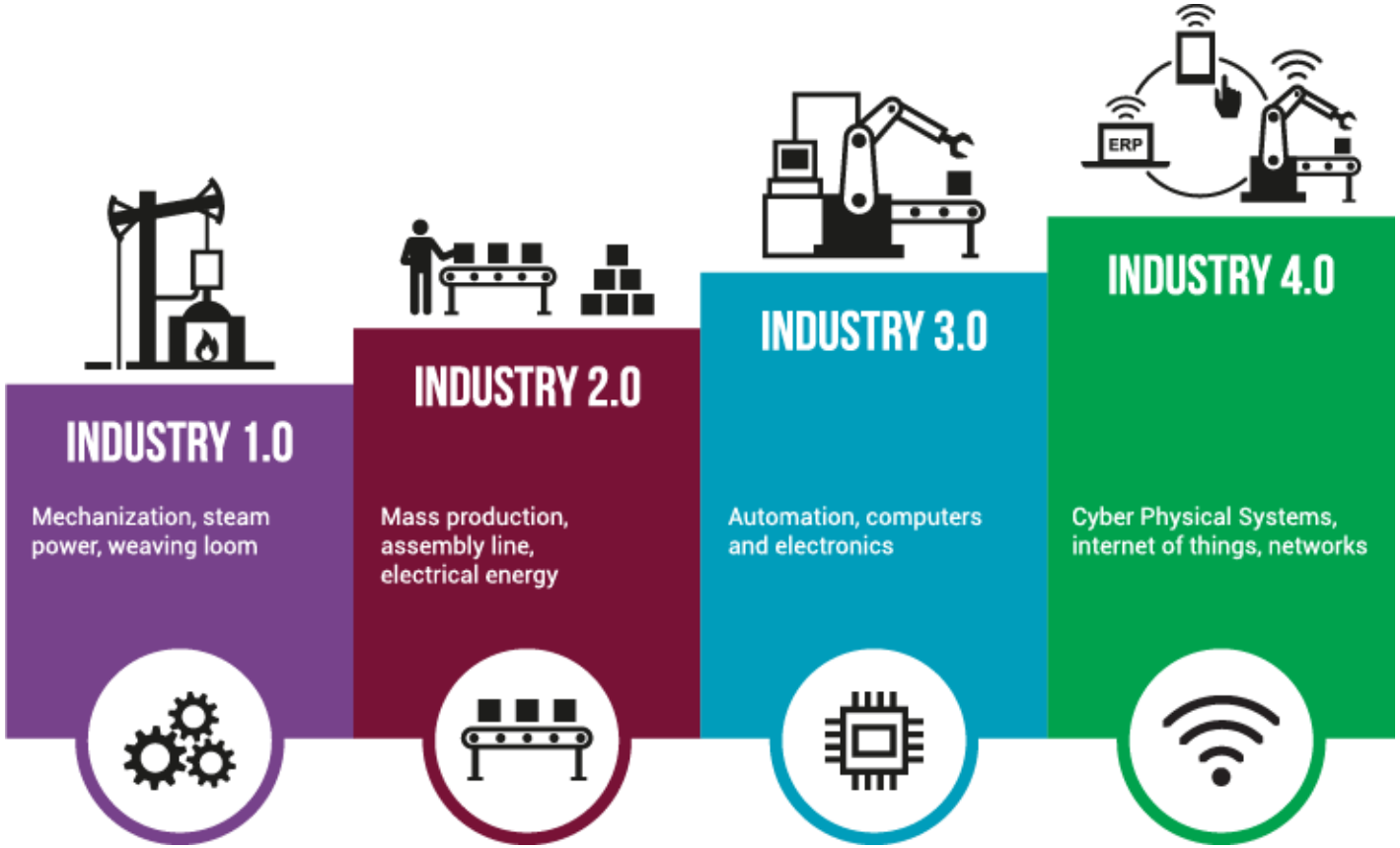


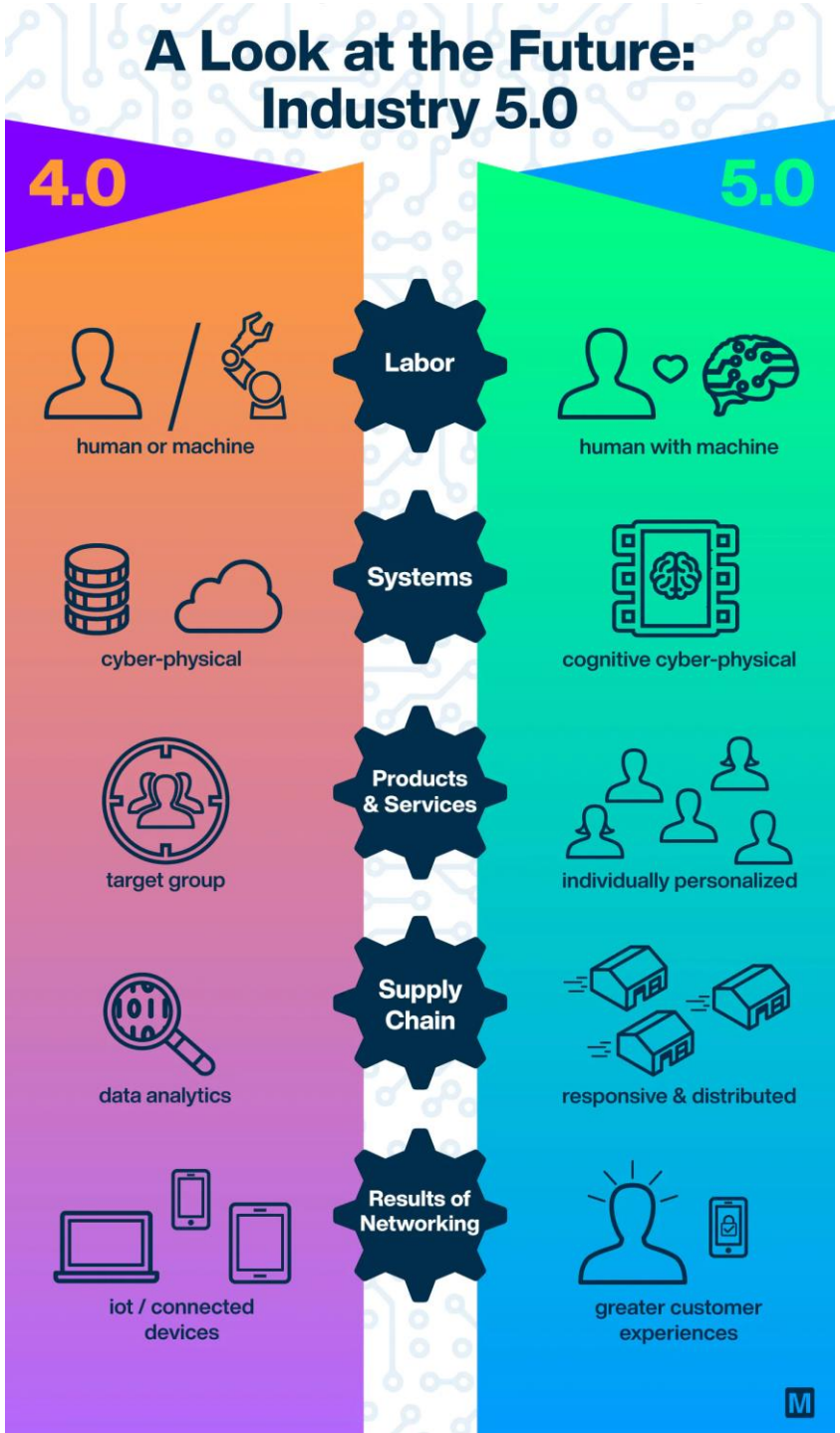
- Stimolare raccolta di dataset anche piccoli ma estremamente ***significativi per diversity, contesto simile***, …
- ***Segmentare utenti e datasource*** su base di profilazione con caratteristiche e obiettivi simili
- Creare una comunità di attori capace di ***estrarre valore*** da small dataset o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

Industry 4.0 and towards Industry 5.0…



Industry 5.0: which role for distributed intelligence and digital twins?





Digital Twins: towards a definition

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

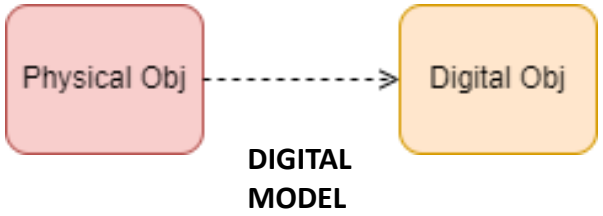
Creating value by linking data, models, and processes

- The replica is often connected to ***IoT big data streams***
- The replica is aided by new ICT infrastructures, based on the ***cloud continuum***

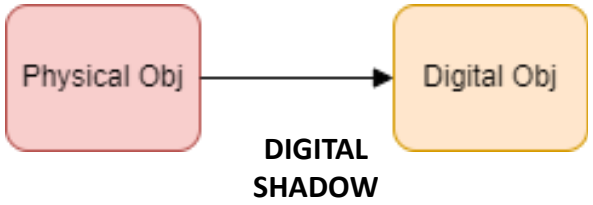
Digital Twins: towards a definition

- Digital counterpart of a physical object
  - Structure
  - Interaction
  - Global behaviour

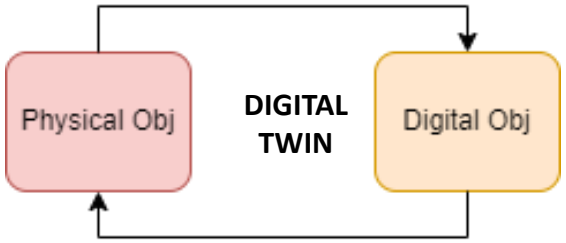
- Digital twin as bidirectional communication flow between physical and digital object



The digital object is a static reproduction of a physical one. Every change to the digital model has to be done manually

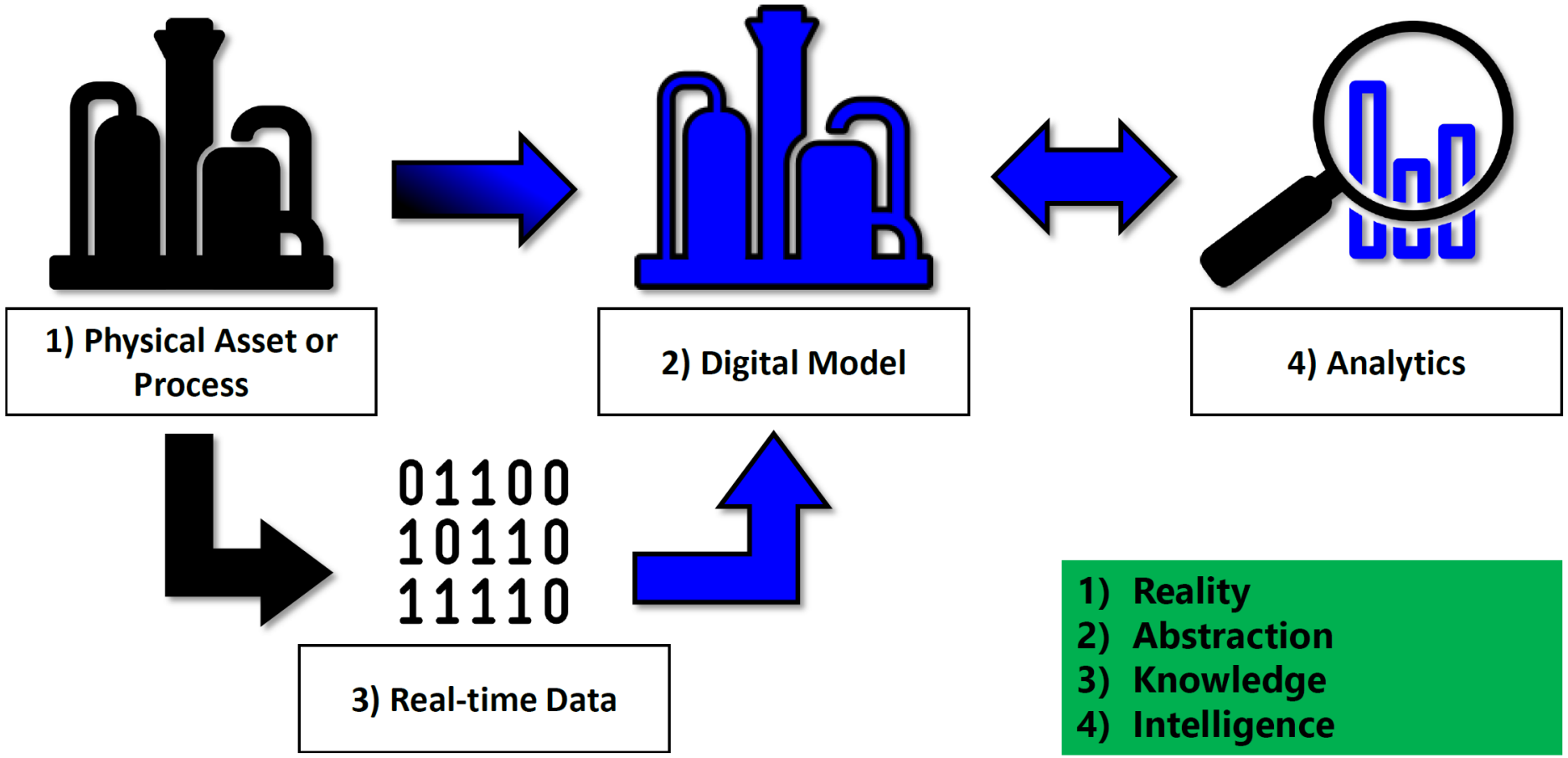


The digital object is a dynamic reproduction. The update of the digital model is automatic. Data flow just in one direction



The digital object is a dynamic reproduction. Data flow in both directions. Every change to the digital model has an effect on the physical one

Digital Twins: towards a definition



1) Reality
2) Abstraction
3) Knowledge
4) Intelligence

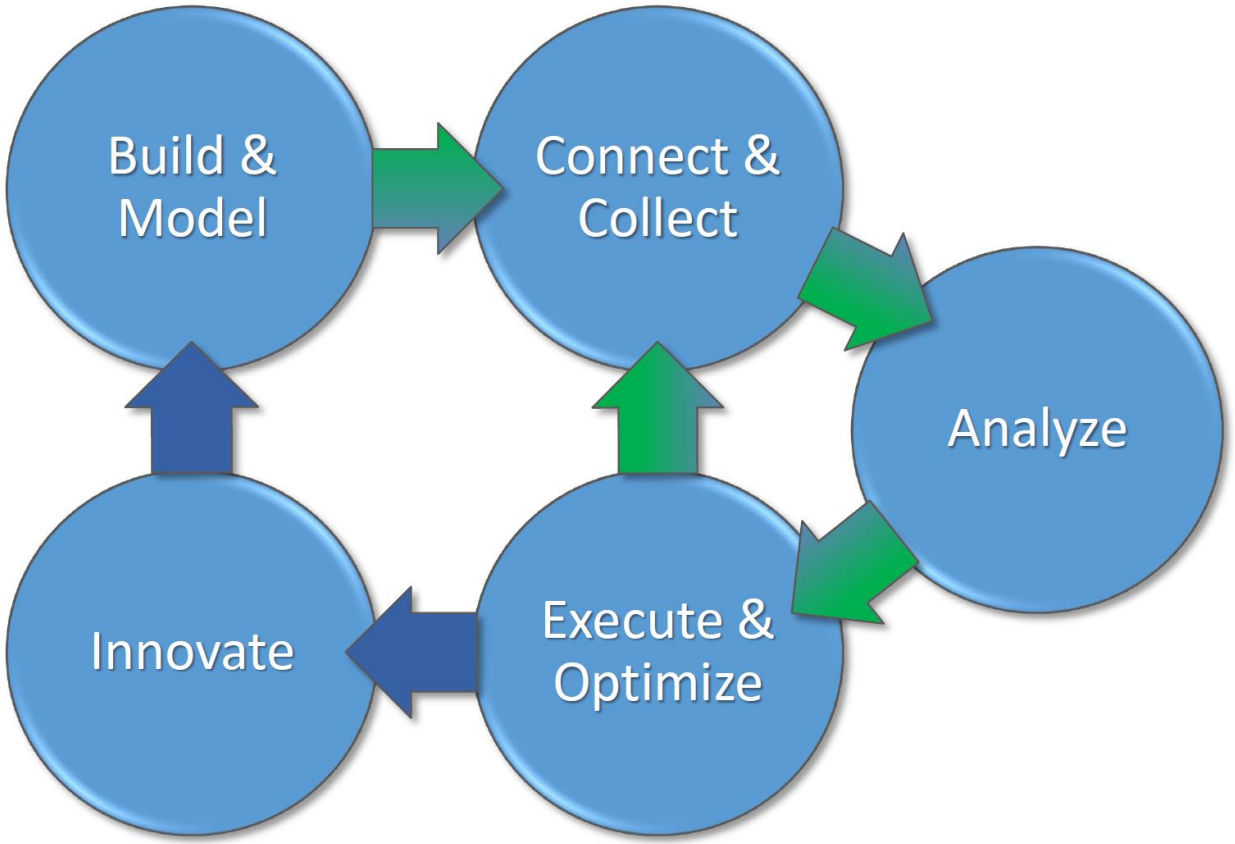
Which goals? Project vs Performance

Project Digital Twin

- Accelerate Program Timing
- Increase Product Fitness
- Provide Performance Baseline
- Close the Engineering Loop

Performance Digital Twin

- Optimize Operating Performance
- Create & Optimize Services
- Drive Project Decisions



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

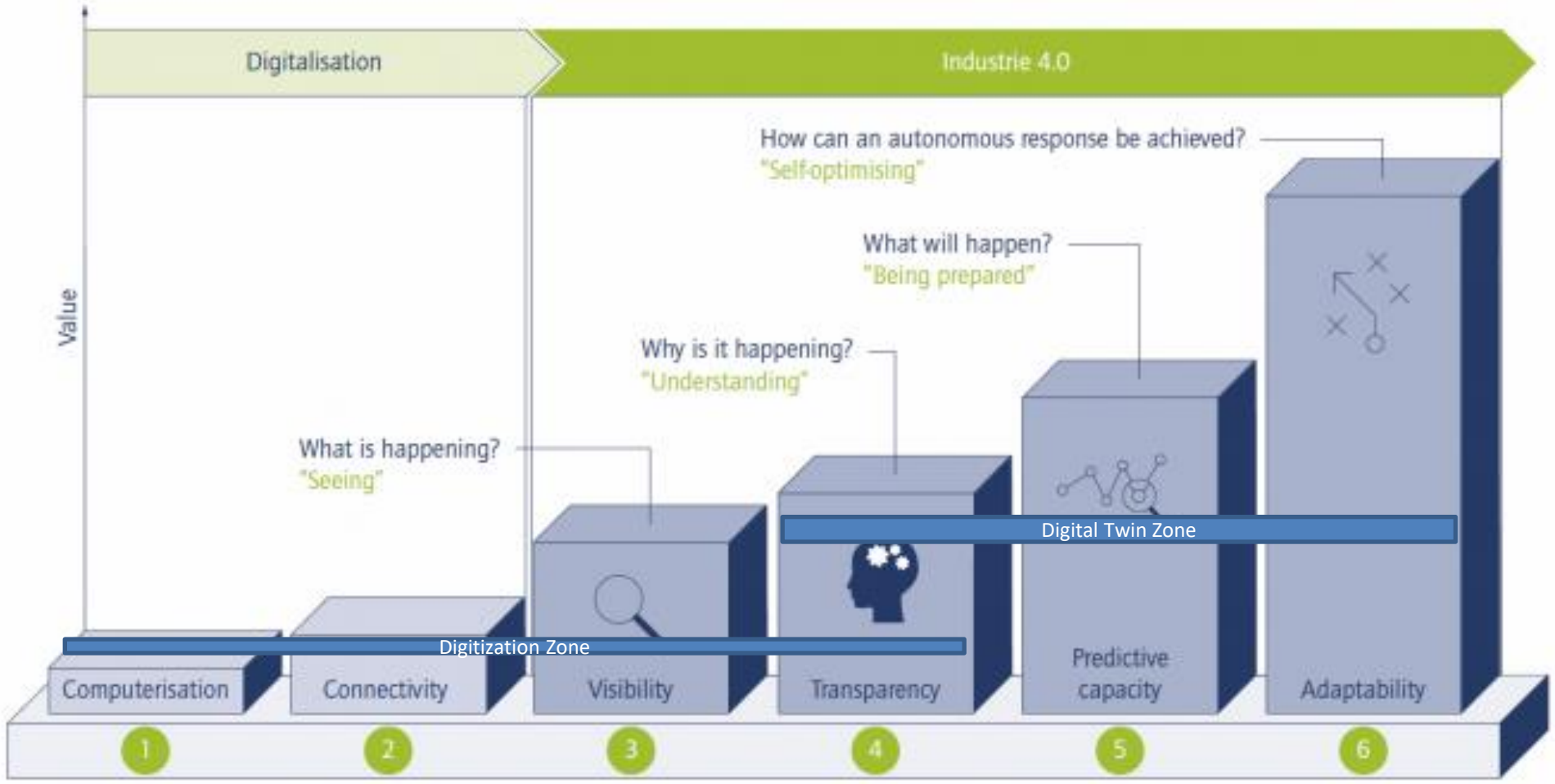
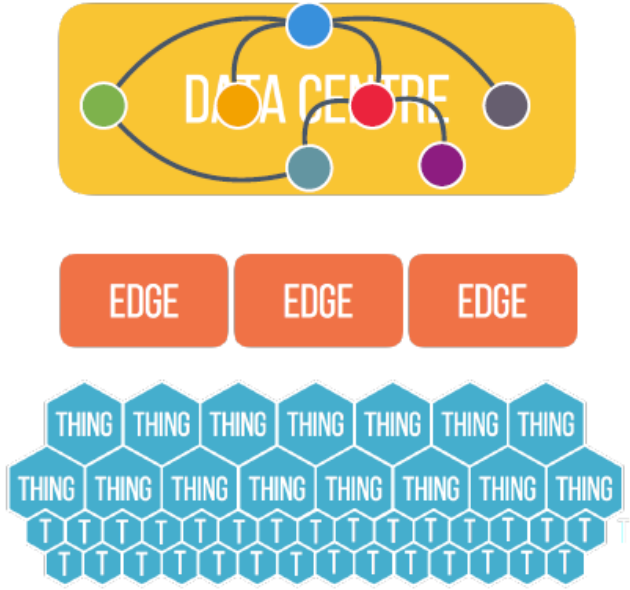


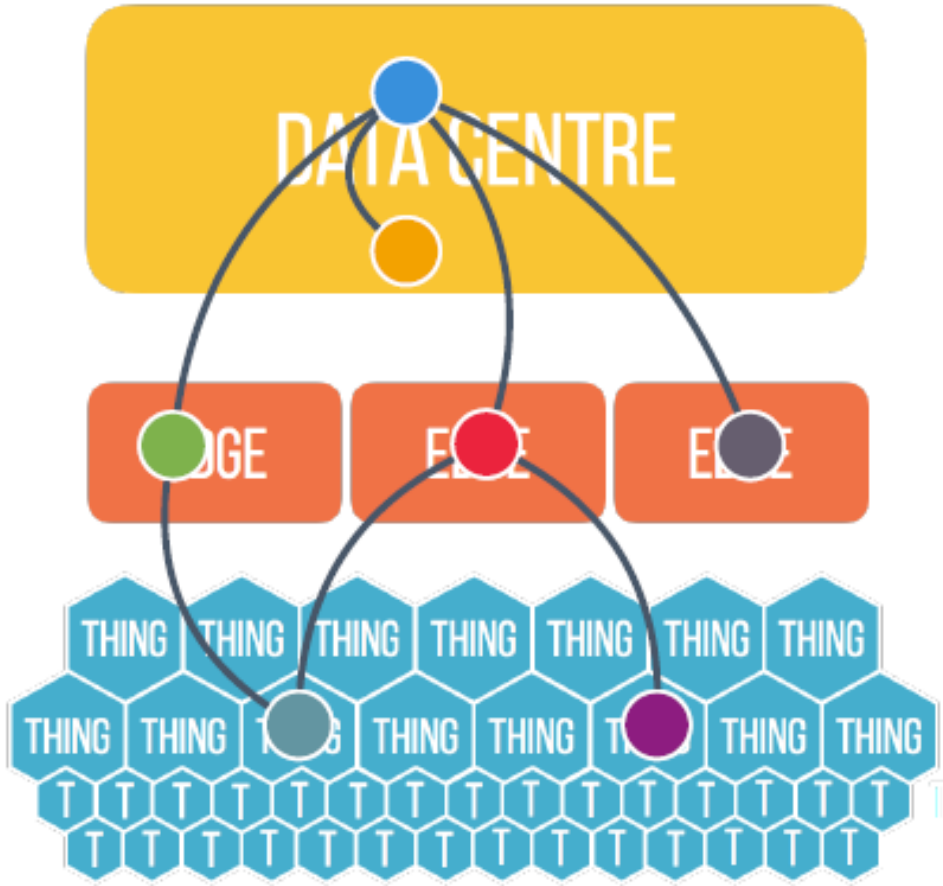
Figure 5: Stages in the Industrie 4.0 development path (source: FIR e. V. at RWTH Aachen University)

Towards Edge Computing and the Cloud Continuum for Big Data, IoT Applications, Digital Twins, …

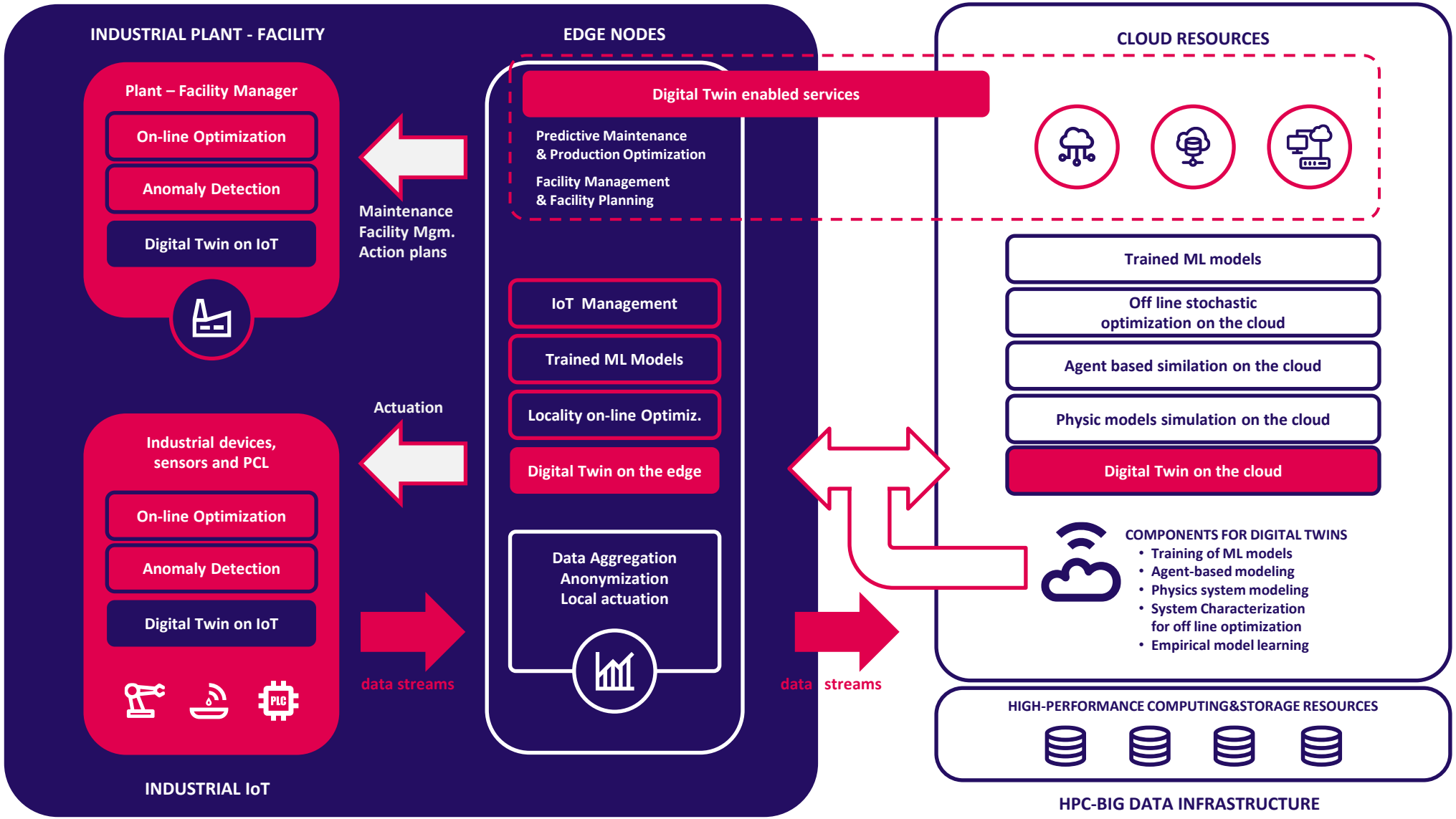
A Different Reality…

Due **latency**, **throughput**, **connectivity**, **cost** and **security** only a **restricted class of IoT/IIoT applications** that are **compatible** with the **cloud-centric mode**

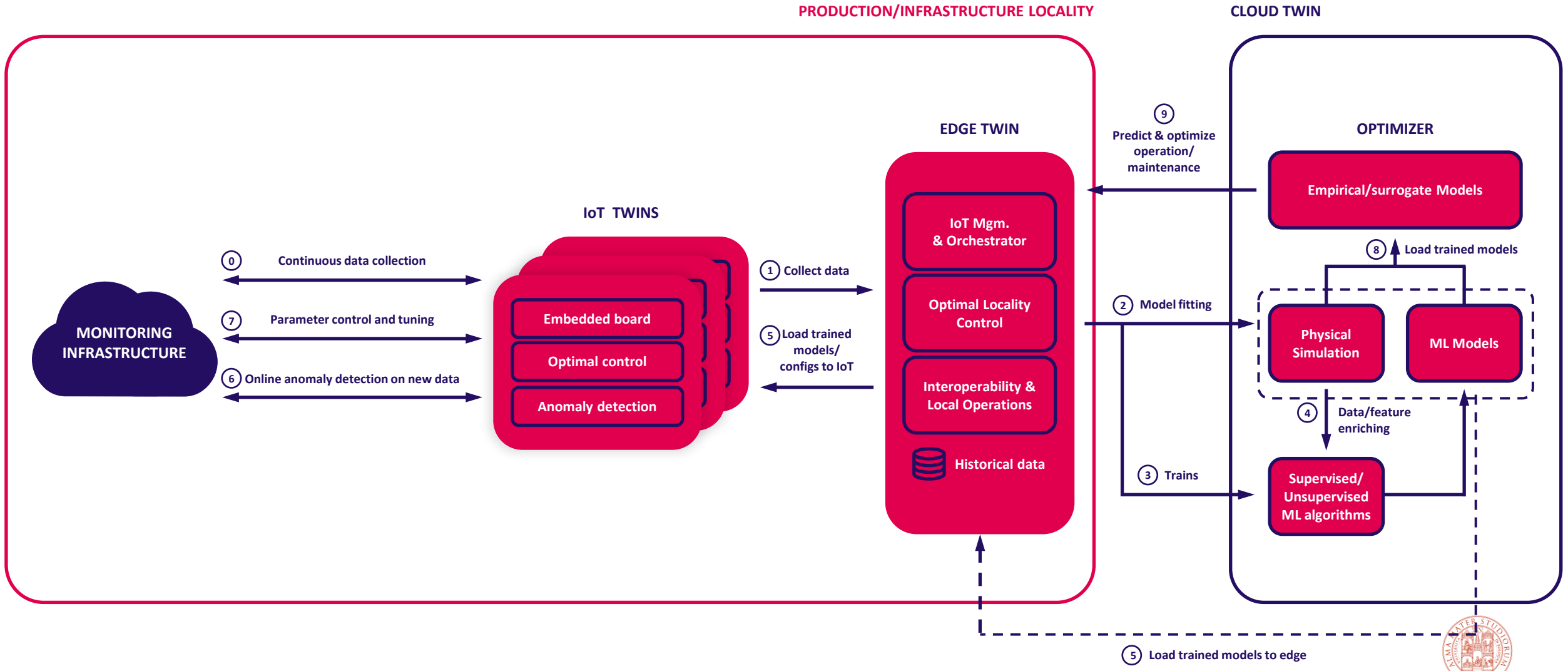




IL CONCETTO DI GEMELLI DIGITALI DISTRIBUITI (E IBRIDI)



TRAINING (MACHINE LEARNING) E CONTROLLO EFFICIENTE NEL CLOUD CONTINUUM



Distributed and Hybrid Digital Twins (for Industry 4.0 and not only…)

Goal:

To support industrial-scale distributed service provision under QoS constraints even in virtualized and containerized environments

Enabling technologies:

- ***Distributed and hybrid digital twins*** (integration with HPC/cloud-based simulation, distributed machine learning, federated/reinforcement learning, …)
- ***Edge computing middleware*** (e.g., Nerve platform, fog05 platform, Docker/LXC tools, …)
- ***Orchestration*** of distributed cloud resources (ETSI MANO, …)
- ***Online stream processing*** (Apache Spark, Geospark, Geomesa, …) and different types of application-specific optimizations
- ***Time Sensitive Networking***
- …

Extremely valuable enablers for Distributed Hybrid Digital Twins:
5G/6G + Edge Cloud Computing

5G/6G-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*)
- Distributed Machine Learning
- Data sovereignty
- With customized properties of security, privacy, data protection, data aggregation/anonymization, …

And not only for predictive maintenance!!!

Selected Ongoing EU Projects

- **IoTwins** (Innovation Action, 2019-2022, distributed and hybrid digital twins) - https://www.iotwins.eu/
- **Change2Twin** (Innovation Action, 2020-2023, digital twins for SMEs and replicability over different scales and scenarios)
- **TERMINET** (RIA, 2020-2023, edge cloud-enabled IoT for agriculture)

- **SimDome** (RIA, 2019-2022, integrated simulation and ontologies for material/component modelling) - https://simdome.eu/
- **OntoTrans** (RIA, 2020-2023, cloud-based platforms for ontology-based reasoners for I4.0 materials engineering) - https://cordis.europa.eu/project/id/862136/it
- **OntoCommons** (CSA, 2020-2023, material and component modelling)

- **Arrowhead Tools** (JTI Artemis, 2019-2023, open-source platform for IT/OT integration) - https://www.arrowhead.eu/arrowheadtools
- **EU Processor Initiative** (FPA, 2019-2022, low-power EU processors for big data) - https://www.european-processor-initiative.eu/

The IoTwins Project

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

HW Architecture Overview "Handle the Data"

Accelerometer (HighDataRate)
Thermometer/HR
SoundLevel Meter (HighDataRate)
Magnetometer (HighDataRate)
Tachometer (HighDataRate)
Torquemeter
Oil Sensor
IPC KKWIND (global WTG system)
Data Processed (AI&ML Models output)

Max Streaming Data: **1,6** Gbyte
Per Day
Per wind Turbine
(With **Data Compression Strategy)**

Cloud

REST API "push"

Cloud
IOTWins HPC

REST API "get"

IODS

Turbine Control System

SCADA

IPC

PLC

Switch Ethernet

LTE

Bonfiglioli Edge GW

Smart Sensors Nodes

Torque Sensor (Gearbox)
(Torque and Tacho)

Custom **Bonfiglioli** Sensor (MOTOR)
(Mic / Acc / Mag / Temp / IO)

Oil Sensor (Gearbox)

YAW DRIVE

Custom **Bonfiglioli** Sensor (Gearbox)
(Mic / Accel / Temp)

Cloud
3rd Party

Cloud
ESI

Cloud
KKWIND

Predictive maintenance for wind turbine

Bonfiglioli
Forever Forward

manufacturing

Testbed #4

Predictive maintenance and production optimization for closure manufacturing

TESTBED #4 PREDICTIVE MAINTENANCE AND PRODUCTION OPTIMIZATION FOR CLOSURE MANUFACTURING

manufacturing

In complex closures manufacturing (spirits closures can have up to 15 different components) several production phases occur and different technologies and machinery are used.

This testbed will optimize production management and implement predictive maintenance for operation improvement and cost reduction.

Key features will be

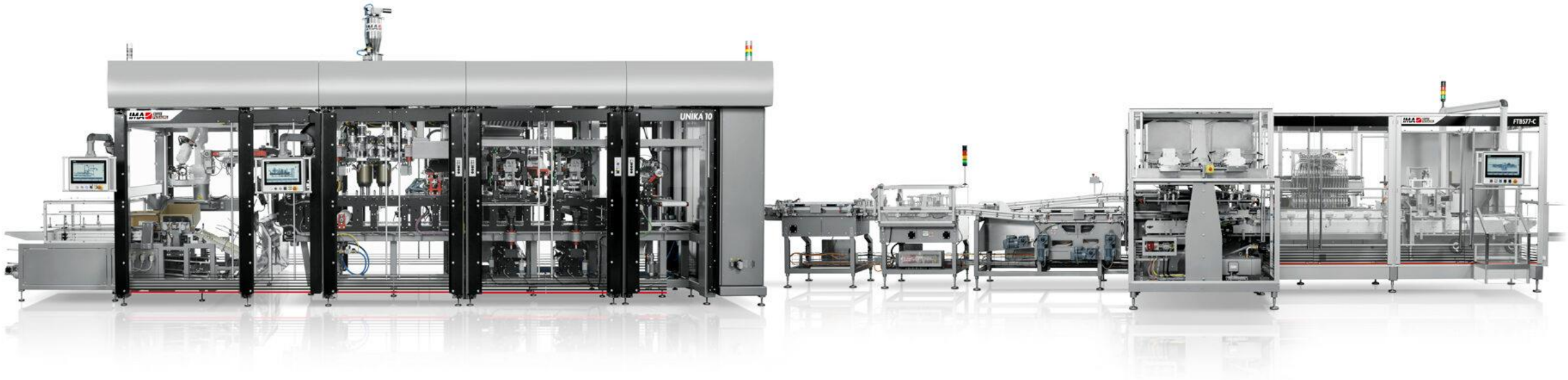
- **the remote and real-time performance and status monitoring** of all the industrial assets and the detection of anomalies;
- the **improved scheduling process** leveraging real-time data from the production floor, properly linking it to the scheduling **ERP system for production optimization**.

The testbed will foresee the design and deployment of **redundant IoT modules** able to

- **to log data** at high sample rates;
- **to fuse data** coming from a first pilot series of machines;
- to install a **new module of the industrial IoT platform ThingWorx** for predictive maintenance and performance improvement;
- to integrate **a data-driven anomaly detection system.**

INVOLVED PARTNERS

GCL International | CINECA | INFN



Anche importante ***riduzione difettosità e scarti***

con vincoli difficili e challenging su ***qualità di servizio e latenza***

Testbed #5

Camp Nou

sport facility management and maintenance

TESTBED #5 CAMP NOU SPORT FACILITY MANAGEMENT AND MAINTENANCE

facility management

CAMP NOU testbed focuses on the management of facilities involving the flow of large crowds, both during normal operation and during maintenance and construction projects. The digital twin is based on Machine Learning and Agent-Based Modeling for pedestrian simulation. Current crowd management systems are not capable of seizing large parallel computational power, and their usability for rapid question answering is limited. **This testbed will be performed during the renovation of Camp Nou, the home stadium of Football Club Barcelona** - the largest sport facility in Europe with a capacity of almost 100.000 seats.

FCB will reconvert all the area and facilities into the best sporting and entertainment complex in the world. The renovation plan foresees both the improvement of the football stadium, expanding its capacity, and the opening of all the private areas around the stadium (28.000 m^2) to the public, while integrating it harmoniously with the neighborhood.

This testbed aims to analyze how crowds move both historically and in real-time using a robust IoT and big data infrastructure to collect, transmit and process data in real-time

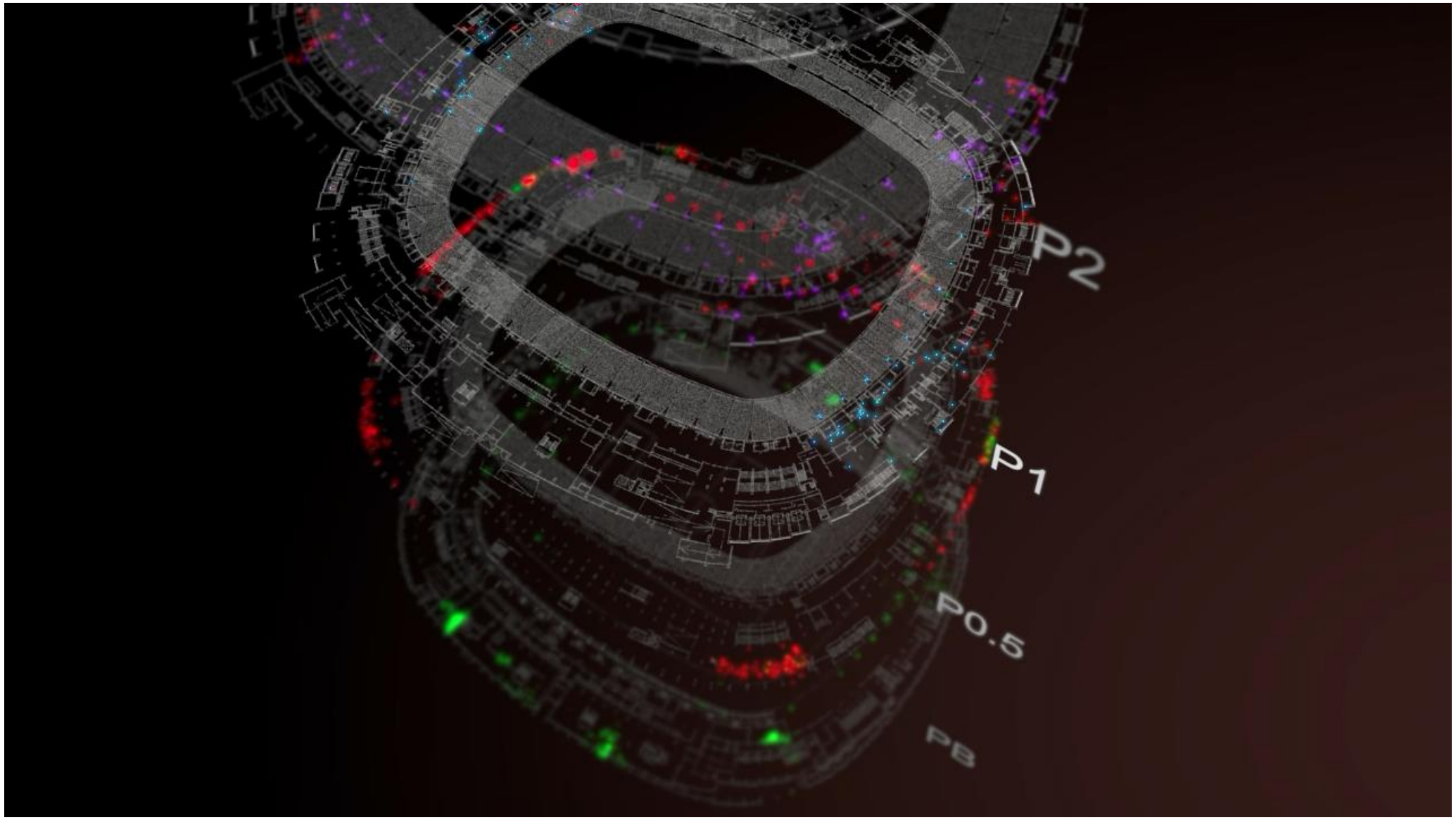
https://www.youtube.com/watch?v=5kxomB-UWqc (5:05 – 6:50)

INVOLVED PARTNERS

BARÇA INNOVATION HUB

Barcelona Supercomputing Center

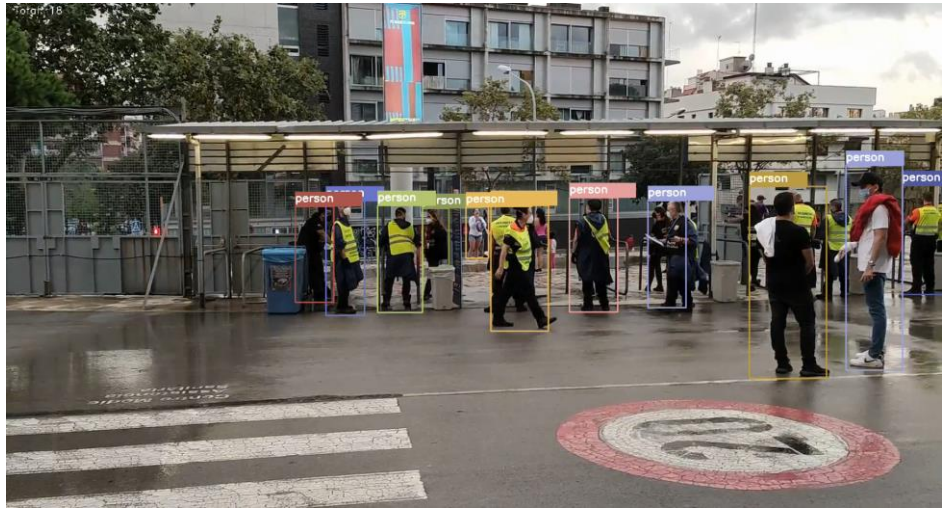
The Digital Twin of the Nou Camp Nou Stadium in Barcelona



The Digital Twin of the Nou Camp Nou Stadium in Barcelona

- WiFi data collection being transformed to use Indigo/IoTwins infrastructure in collaboration with INFN (now using an intermediate temporal solution)
- Cameras tested succesfully on a match, but delivery of full order pushed back until march 2022!!!
- Systems tested on stadium during match

Testing videos (phones)



NVIDIA Jetson Xavier NX

Device video (operational)

Course Outline

- Big Data applications => first significant success stories in the domains of users' behaviour

  prediction in terms of mobility and buying actions, ***predictive maintenance***, ***optimization of industrial manufacturing*** processes
- ***Models, solutions and frameworks for big data analytics in the cloud continuum***, with focus on support infrastructures for I4.0 applications
- ***Digital Twin solutions*** for manufacturing processes: innovative concept of ***hybrid and distributed digital twin***
- Modeling and concepts + success stories from companies + practical demos and exercises

Target Audience:

- Information Technology (IT) technicians
- Operations Technology (OT) technicians
- Quality & Sustainability Improvement technicians
- ***Middle Management***

and most relevant: INDUSTRIAL SUCCESS STORIES!

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