Workshop with ICT11 projects - HPC, Big Data, IoT and AI future industry-driven collaborative strategic topics

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IoTwins Project

Distributed Digital Twins for Industrial SMEs: a Big Data Platform

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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

IoTwins

The Project.

IoTwins

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

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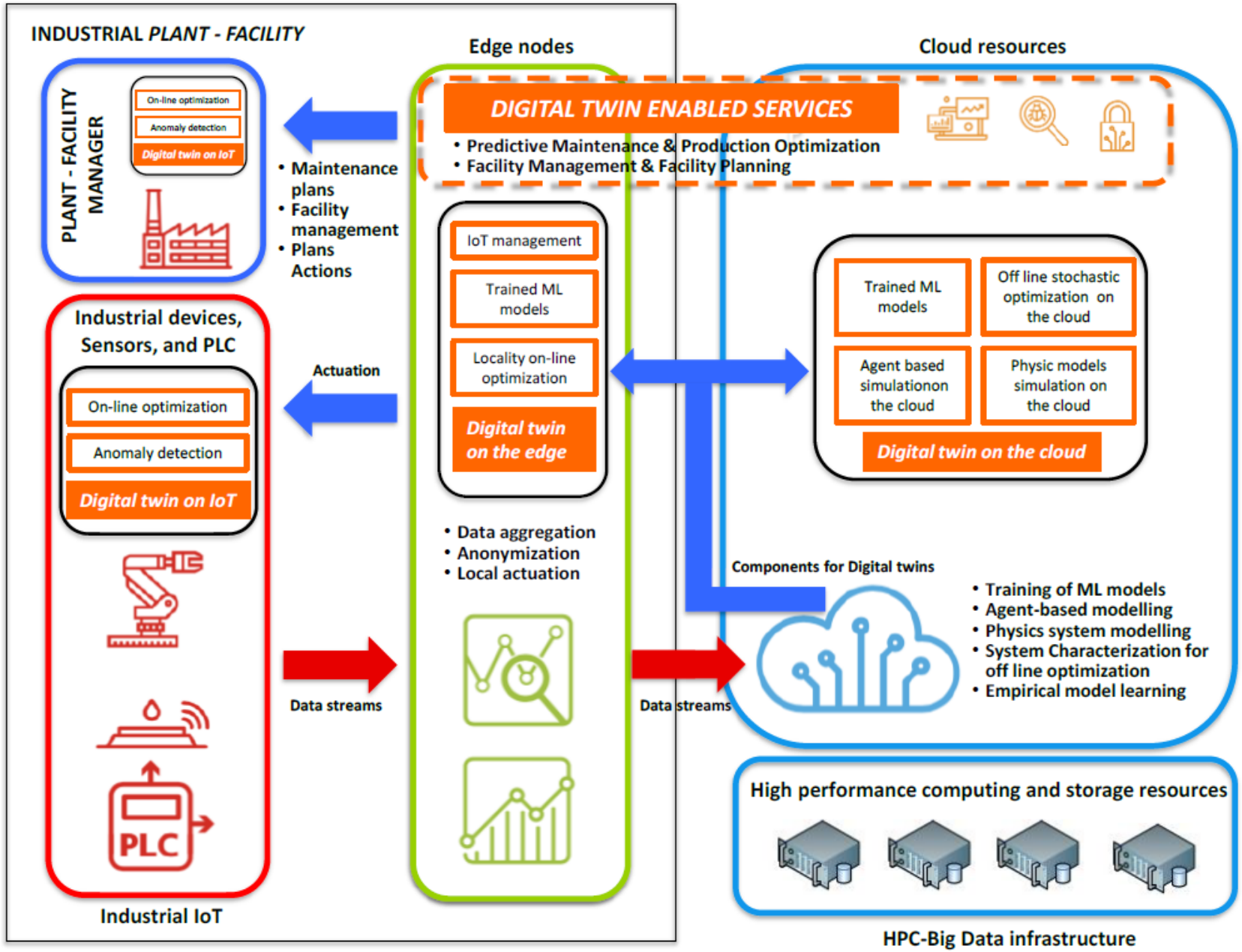
Platform and services.

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

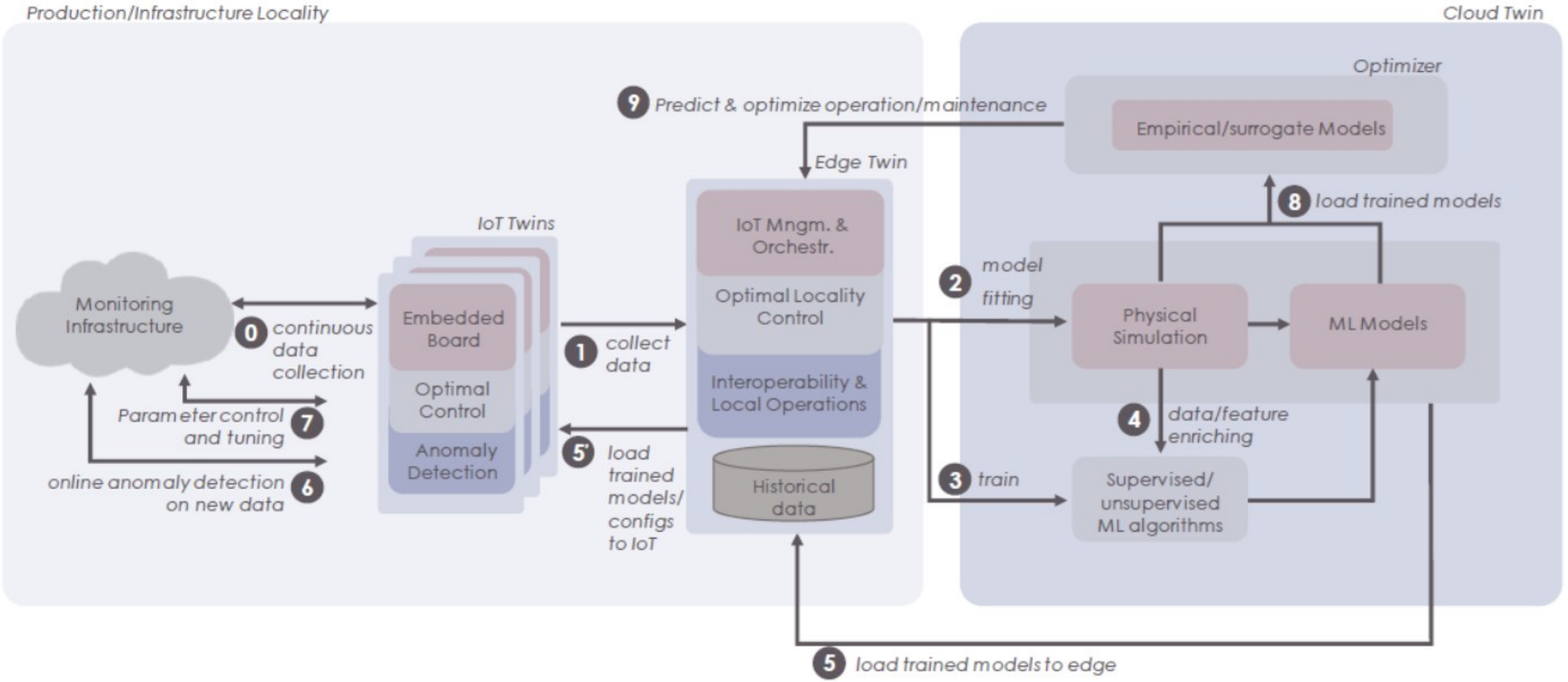
Key elements:

- 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**

Partners.

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Bonfiglioli

Coordinator

ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA

ART-ER ATTRACTIVENESS RESEARCH TERRITORY

Barcelona Supercomputing Center Centro Nacional de Supercomputación

beWarrant TINEXTA GROUP

cetim

CINECA

Arts et Métiers Institute of Technology

esi get it right®

Etxetar

FIM YOUR FUTURE

Fraunhofer FOKUS

BARÇA INNOVATION HUB Reinventing Sport

GCL International

INFN Istituto Nazionale di Fisica Nucleare

KK Wind Solutions

MARPOSS

SIEMENS Ingenuity for life

TU berlin

THALES

TTTech

WAVESTONE

Challenges and key research&innovation topics.

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Key topics, state of the art, and current limitations (1).

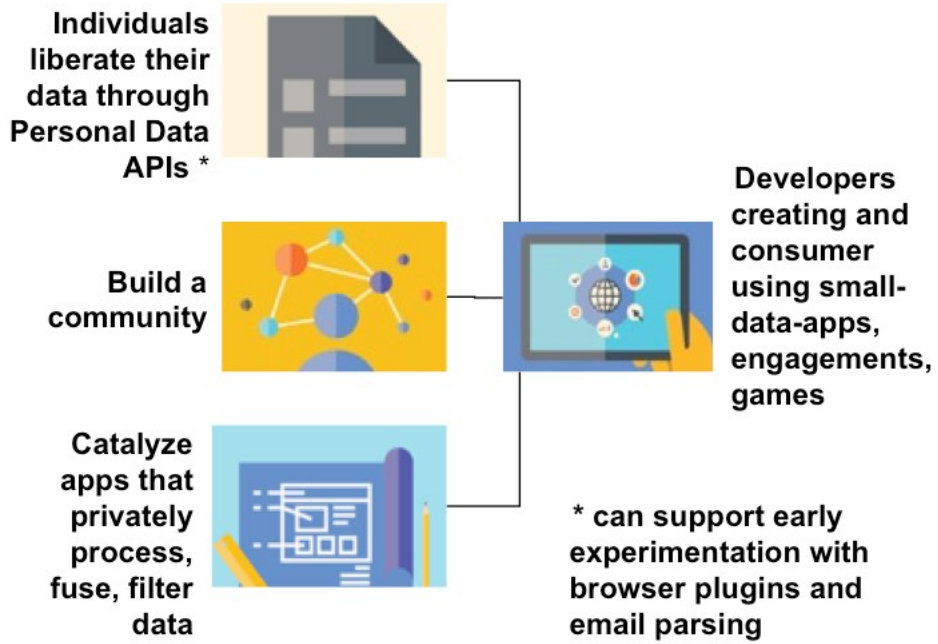
- **Big Data analytics and AI techniques** have an unprecedented chance to bring EU manufacturing companies (product companies, but not only…) into the world of services and digital business
- The Big Data impact and evolution could be extraordinarily amplified in manufacturing if coupled with **proper cloud continuum solutions**
  - to reduce **latency**
  - to support **prompt/reliable distributed control**
  - to improve **scalability**
  - to improve **sustainability**
  - to enable better **privacy and raw data ownership**
  - …
- Need for **more distributed and more explainable AI techniques**, first of all for distributed learning and distributed classification/anomaly detection/control

Key topics, state of the art, and current limitations (2).

- Short-term barriers that need to be reduced, in particular for SMEs:
  - Complex and rapidly evolving tools and techniques to be mastered ➔delays and costs in product/process design, deployment, test, and refinement
  - Deep learning require access to **very large sources of curated data**, as well as **significant computational resources for training**
  - **Need to be at the premises of the systems** generating the big data, e.g., to locally monitor, control, and adapt the components of a manufacturing production line under tight latency and reliability requirements, while preserving an adequate degree of data privacy
  - **Need of investments** in infrastructure at the server side (where relevant cloud/HPC resources are often needed for model learning and simulation), at the edge side (e.g., to extend manufacturing machinery and their gateways on the industry plant premises with edge computing functionality), at the communication infrastructure side (5G/6G, Time Sensitive Networking, …), and also in terms of integration efforts

Future challenges.

- **Making the cloud continuum an industrial reality**
  - Interoperability and common APIs
  - Distributed and portable orchestration
  - Generating trust around the idea of an EU-based cloud continuum, in particular in some specific vertical domains
- **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**



Future opportunities.

- Future challenges are future opportunities!

- **An EU-based cloud continuum, e.g., for the manufacturing industry**
  - Interoperability and common APIs
  - Distributed and portable orchestration
  - **Support for quality requirements, such as latency, reliability, scalability, …**
    - **Integration with resource slicing, 5G/6G, Time Sensitive Networking, …**
  - Generating trust around the idea of an EU-based cloud continuum, in particular in some specific vertical domains
- **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"

Impacts (1).

What happens if nothing happens?

- Loss of competitiveness
- Loss of centrality of the EU in the manufacturing sector

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Impacts (2).

In Industry 4.0 platforms, **off-the-shelf software is available, though it is hardly applicable** on certain sectors with a vast amount of different data being generated

High investments in R&D are needed to develop tailored solutions, but not all the companies have these resources, or the possibility to invest on them in the foreseeable future

IoTwins' main innovation is to bring a flexible platform that can adapt to different scenarios, based on open source software, based on:

- Edge computing and distributed digital twin services
- A flexible and scalable service-based PaaS layer simplifying access and integration between edge/cloud and Big Data resources, and providing privacy-preserving and secure access, fusion, interoperability, and management of Big Data sources
- An AI service layer enabling model learning, simulation, and optimization for digital twins
- Innovative business models to bring this platform to the market

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Impacts (3).

Quantitative evaluation of Impacts on IoTwins testbeds

Manufacturing:

- Reduction of down-time: **15%-25%**
- Reduction of unexpected breakdowns: **>20%**
- Reduction of machine set up time: **>30%**
- Reduction of maintenance costs: **>10%**

Facility management:

- Reduction of IT operation/cooling costs: **>20% with unbalanced workload; >10% for cooling**
- Reduction of IT unexpected breakdowns: **>30%**
- Sport facilities - Max percentage reduction of inflow and outflow of people on match game in reduced conditions: **<10%**
- Sport facilities - Crowd flow simulation accuracy increase (with regard to previous approaches): **>10 %**

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Concrete actions of IoTwins: benefits for companies/SMEs.

- an **architecture** (and its reference implementation) **for the coordination and interworking of distributed cloud-, edge-, and IoT-hosted twins**, specifically tailored to SME-oriented test-beds for industrial production processes and facility management operations
- a **PaaS layer** simplifying access and integration of cloud resources (also hosted on HPC-specific resources when needed) for industrial IoT, heterogeneous big data sources, and remote edge components, capable of providing application developers with composability and integration facilities for distributed digital twin functions
- an **edge computing framework** (compliant with emerging standard specifications) enabling dynamic deployment of edge twins, dynamic migration of pre-elaborated control models to them, and open orchestration of their control/reconfiguration actions with the cloud-hosted counterparts when needed
- **vertical, industrial, and distributed digital twins** for online quality management of production processes and optimization of facility management operations
- **a well-assessed methodology for replicability** towards companies even for different application sectors, for scalability, and for business models definition covering new forms of platform servitization, on premise deployment, and performance standardization/homogenization

More general and ambitious concrete actions.

- What the EU, the BDVA, our scientific community can do to **stimulate the emergence and consolidation of "small data" ecosystems**?
- Are we ready for an **EU-centric cloud continuum**?
- Which could be the role of national competence centers and EU Digital Innovation Hubs in that?
- …

More technically oriented:

- Support research on **federated learning and control applied to I4.0**
- Support research on **cloud continuum oriented to SLA on quality** requirements, integration with **Time Sensitive Networking**, virtualization/isolation with **guaranteed execution properties**, …

Definitely an open list for discussion…

Contacts.

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Thank you.

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