IoTwins

BIG DATA OPTIMIZE INDUSTRY AND SERVICES

BIG DATA PLATFORM FOR OPTIMIZED AND REPLICABLE INDUSTRIAL AND FACILITY MANAGEMENT MODELS

iotwins.eu

THE PROJECT: A BIG DATA PLATFORM

IOTWINS

IoTwins is an **European project** that aims to build a reference architecture for the development of **efficient and distributed digital twins** for specific manufacturing and facility management domains.

12 dedicated large-scale testbeds will collect large amounts of data to generate and refine the associated digital twins, including optimized models of resources, systems and processes involved.

IoTwins digital twins will be used to improve **the efficiency of production processes and of facility management**, as well as to demonstrate **the replicability of the achieved results** in similar scenarios and to determine new application areas and business models.

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.

TECHNOLOGICAL APPROACH IS BASED ON:

A full-fledged platform enabling easy and rapid access to heterogeneous cloud HPC-based resources for **advanced big data services.**

Intelligent services to simplify and accelerate the integration of advanced **Machine Learning algorithms, physical simulation, on-line and off-line optimization** into distribu ted digital twins.

Advanced edge-oriented mechanisms, tools, and orchestration to support **Quality of Service** in the runtime execution of the distributed digital twins

TESTBED #1
WIND TURBINE PREDICTIVE MAINTENANCE

Creating a **digital twin of a wind farm** by aggregating simulation and machine learning models of single turbines for predictive maintenance. Here, data are used to detect the health status of the turbine to predict failures and finally to plan wind farm maintenance operations for reducing unexpected breakdowns and downtime.

The testbed will produce a smarter wind turbine by integrating sensors, edge nodes and software components providing efficient data transmission solutions and control system; simulating the best orientation of blades to increase energy production and reduce mechanical stresses; developing predictive maintenance algorithms for each component of the turbine and for the whole farm, based on the information gathered and on the scenarios simulated at the cloud side.

INVOLVED PARTNERS

Bonfiglioli Forever Forward | KK Wind Solutions | CINECA | INFN Istituto Nazionale di Fisica Nucleare | esi get it right | Arts et Métiers

TESTBED #2 MACHINE TOOL SPINDLE PREDICTIVE BEHAVIOUR

A multiple target-oriented **digital twins of machine tools for the production of automotive components** based on simulation and machine learning models of machine tools, drives, and spindles for detecting their condition and behaviour to predict manufacturing-relevant and quality-influencing parameters (load, forces, vibrations etc.). The testbed aims at reducing unexpected rejects, break-downs and downtime, by optimizing load and performance indexes.

The testbed will produce smart machine tools with embedded digital twins for smart sensing and edge nodes with real time data processing. It will provide intelligent data transmission, optimized control system and a cloud-based digital twin to simulate the best performance of the machine tool both to optimize energy efficiency, cycle time, tool costs, quality, maintenance and spare part costs.

INVOLVED PARTNERS

FH YOUR FUTURE | TTTech | ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA | Fraunhofer FOKUS | TU berlin

TESTBED #3
PREDICTIVE MAINTENANCE FOR A CRANKSHAFT MANUFACTURING SYSTEM

High throughput crankshaft manufacturing system is a semi-autonomous CNC machine that produces an average of 1.000 crankshafts per day.
The machine is already IoT-ized and produces a huge amount of data which will be processed and exploited on the edge to develop real-time predictive maintenance solutions. Data will also be sent to the cloud to accumulate training data (towards optimal maintenance strategies and off-line machine degradation monitoring) whenever real-time conditions are not required.

The fusion of all the data/information will generate valuable knowledge of the process for the manufacturing line operator to achieve the "near future required" availability of 98%, by integrating with predictive maintenance as a key enabler.

The testbed aims at developing **a new big-data-enabled manufacturing framework** that integrates over the same hardware: sensor fusion at both IoT Twins and Edge Twins; application of predictive maintenance plans for specific parts; the possibility of fully benefiting from advanced big-data visualization techniques for operators.

INVOLVED PARTNERS

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TESTBED #4
PREDICTIVE MAINTENANCE AND PRODUCTION OPTIMIZATION FOR CLOSURE 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; and 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 log data at high sample rates; fusing 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; and the integration of a data-driven anomaly detection system.

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TESTBED #5 CAMP NOU SPORT FACILITY MANAGEMENT AND MAINTENANCE

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 (28.000m2) to the public, while integrating it harmoniously with the neighbourhood.

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. The models developed on the basis of data will be optimized towards preserving usability and safety of the building for visitors, and for aiding the decision process concerning the location of the flows of equipment, machines and workers at each construction phase.

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TESTBED #6
EXAMON
HOLISTIC SUPERCOMPUTER FACILITY MANAGEMENT

Examon is a distributed and scalable monitoring infrastructure which combines delocalized monitoring agents (SW and HW) and distributed databases. The testbed focuses on data-driven **prescriptive maintenance and optimization of large computing facilities.** Computing centres are today composed by thousands of computing nodes featuring parallel and heterogeneous computing elements. These computing nodes are aggregated in racks, and racks in computing rooms. In addition to the computing racks, computing rooms host storage racks and cooling equipment. To reduce their operational/maintenance costs, datacentres should embed holistic live monitoring support: monitoring data come from multiple heterogeneous sources, i.e., on-chip and on-board sensors integrated on the compute nodes, as well as sensors at the node, rack, and room level.

The Examon infrastructure will be enriched with machine learning for power and performance model construction for heterogeneous machines (CPU + Accelerator nodes). It will also be integrated with data-driven anomaly detection to enable proactive maintenance of the involved HPC nodes and sub-systems.

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TESTBED #7
SMART GRID FACILITY MANAGEMENT FOR POWER QUALITY MONITORING

This testbed focuses on the computation of smart grid KPI, performed close to the data sources. Having near real-time requirements, high data volumes, and distribution over a large geographical area, data needs to be (pre-)processed locally with regard to the needs of the processes which use the data. In industrial systems, power quality monitoring enables the possibility to identify short current peaks that, otherwise, may lead to system failure. Prescriptive analytics will help to set up a system that can automatically react to issues in the power grid.

This testbed is already active in the framework of the "Aspern Vienna's Urban Lakeside" (https://www.ascr.at/en/), i.e., a smart city environment of private apartments, a student home, and a school, as well as a supply area with about 6,500 inhabitants and small business, which IoTwins will be able to exploit for data collection and configuration tuning.
The installed edge devices are based on the CP-8050 energy automation device from Siemens, that allow runtime installation of the applications. **IoTwins will extend the existing framework with a more flexible edge platform** which can process power quality measurements (including the necessary management functionalities); with a cloud-based digital twin providing system-wide power quality assessments; and integrating off-line generated parameters into distributed twins running at configurable edges.

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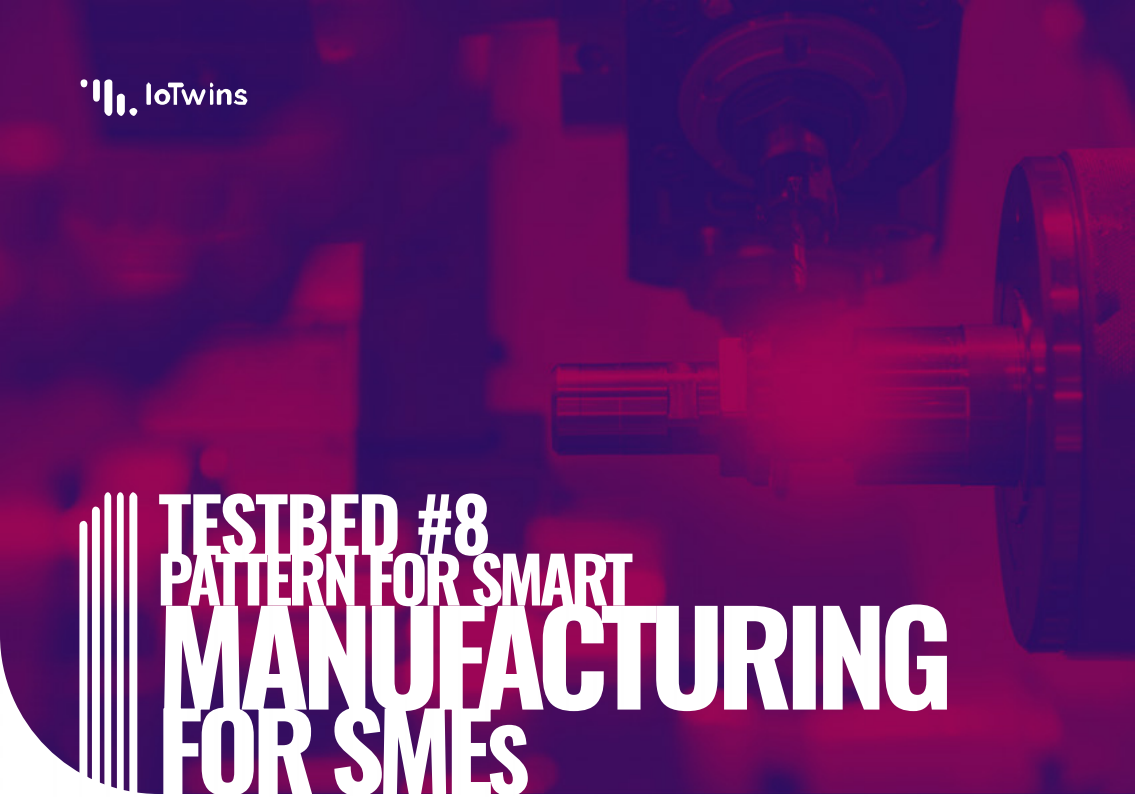
SIEMENS
Ingenuity for life



TESTBED #8 PATTERN FOR SMART MANUFACTURING FOR SMEs

This testbed is devoted to the definition of a general and replicable methodology for SMEs based on the convergence of data analytics, AI, IoT and physics-based simulation. In a first phase the testbed focuses on the development, adaptation and testing of the methodology, where the needed research/development competences and the infrastructure facility are already available. In the second phase, the methodology will be replicated and validated on two real industrial use cases, including turning and milling machines.

The testbed foresees the optimization of data processing; process learning and knowledge extraction, by combining synthetic big-data produced via efficient real-time simulations and AI techniques to emulate rich sets of possible defaults; real-time decision making techniques to control production quality (when machines allow online parameter tuning), including monitoring of surface defects (short-time loop), monitoring of small deviations (tool wear, corruption, tool breakage) for medium-time loop, and performing predictive maintenance for long-time loop. The distributed digital twins developed within this test-bed will be specific for each machine and will evolve in time.

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TESTBED #9 STANDARDIZATION/ HOMOGENIZATION OF MANUFACTURING PERFORMANCE

GCL has more than 20 plants operating in 5 continents.
Production performances in each plant are significantly different due both to external conditions and to different organizational levels (human and technical).
One goal of large international groups is to standardize/homogenize production quality and manufacturing performance across various plants, bringing them to world-class consistent levels.

This testbed aims at performance homogenization and standardization methodologies. It grounds on Testbed 4, focusing on production management optimization and predictive maintenance, and extends it to four GLC plants (three in Italy and one in Luxembourg), putting the basis for the deployment of IoTwins solutions in all GCL EU plants, with a deployment time of only 2-3 weeks.

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GCL International

TESTBED #10 EXAMON REPLICATION TO OTHER DATACENTRE FACILITIES

The Examon IoTwins-enabled management of Testbed 6 will be replicated on two data-centers located at INFN and BSC premises. The purpose is to define a methodology for the monitoring infrastructure reuse and deployment in new and different contexts.

Two different contexts are considered, heterogeneous in terms of data collection and monitored resources. INFN is already collecting data (tens of TB) on the production datacenter composed of high-end servers. Examon enables the collection of new data and it will be integrated in the current monitoring system (e.g., infrastructure control data, IT hw control, services) for troubleshooting and predictive analytics. In BSC, Examon will be deployed on an unconventional cluster composed of heterogeneous machines in terms of architecture, power consumption, form factors and configuration. These resources are not yet instrumented and provide a solid benchmark for the flexibility of the monitoring and predictive tools.

The testbed will provide a fast deployment of the Examon infrastructure in different contexts and adaptability models for different machines, with reduced time to train Machine Learning models on new machines.

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CINECA

Alma Mater Studiorum Università di Bologna

TESTBED #11
CAMP NOU
REPLICABILITY
TOWARDS SMALLER SCALE SPORT FACILITIES

This testbed focus on the replicability and scalability of TESTBED 5 to enable the IoTwins solution to smaller facilities. Futbol Club Barcelona includes several facilities, such as:

- The Palau Blaugrana, (next to Camp Nou) with a capacity for 8K spectators, that hosts basketball, handball, hockey and futsal games as well as social and cultural events;
- The New Palau Blaugrana, in development, that will have a capacity for 15K spectators;
- The Johan Cruyff stadium (8.5 km from Nou Camp), with a capacity for 6K spectators, which hosts 2nd Division, UEFA Youth League, and Women's football games;
- Around the Camp Nou stadium there are facilities like the FCBotiga store (with 4M yearly visitors), and the FCB museum, which receives 2M visits per year.

Excluding coverage and data formats, all these facilities are already instrumented with some of the key sensors needed for the replication and are equipped with Wi-Fi or and Bluetooth connectivity. More edge devices will be installed temporarily by using hardware developed for TESTBED 5 (e.g., NVIDIA Jetson-assisted cameras to provide anonymous crowd profiling on site).

Replication of TESTBED 5 to smaller facilities allows to improve crowd movements in the stadium (and in its premises), increasing safety and identifying infrastructure optimization knobs. Customer experience will also be enhanced, by improving the location of services, commercial and leisure stands/shops.

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TESTBED #12
INNOVATIVE BUSINESS MODELS FOR IOTWINS PAAS IN MANUFACTURING

This Testbed aims to **validate innovative business models** that bring resources, available in the cloud (e.g. High performance computing, Digital Twins, AI networks, etc..), accessible to applications, related to the machine monitoring business, running on manufacturing machines. This testbed wants to demonstrate that innovative technologies such as Deep Neural Networks (DNN) and cloud-based access to HPC resources can open new opportunities to more pervasive and transversal business models. That is to be achieved through techniques that speed up the training of a monitoring system (in its capability of recognizing and anticipating patterns of process degradation) and facilitate the access to the above services from edge twins, also to decouple implementation from IoT device-specific characteristics.

The proposed business model is based on a **SaaS Cloud solution** that the customer can use on a "pay-per-use" basis. All the data read from the manufacturing machine and commands sent from involved edge nodes are collected and stored on the cloud. The collected data are used to train a DNN to obtain a predictive model of the degradation of the monitored process. Training is accelerated by the usage of the cloud-accessible **IoTwins PaaS infrastructure**, which can also exploit HPC resources. Once a reliable degradation model is available, the trained IoTwins digital twin can be used to test the behaviour and effectiveness of several control algorithms. Once the test has identified the best control algorithm, it can be compiled, on request, by using the specific toolchain needed to generate the executable code for the specific destination edge hardware platform. Thus, different edge vendors can take advantage of the features and training acceleration made available by the use of our cloud-based infrastructure.

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IOTWINS TESTBEDS

MANUFACTURING TESTBEDS

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

FACILITY MANAGEMENT TESTBEDS

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

REPLICABILITY TESTBEDS

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

20M€
Project Total Value

16M€
EU Funding

23
Partners

1
Technological Platform

3
Application Areas

12
Testbeds

IoTwins

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Partners

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