I-LABS
INDUSTRY

LABS

SMART AND DIGITAL SOLUTIONS

INDUSTRY
INFORMATION
INNOVATION

i-Labs identifies four Technology Platforms in the Marche Region, with the aim of promoting both collaborative research projects and innovation to foster economic growth and the competitiveness of the regional system.

The HD3FLab project has been designed to structure and make stable over time the collaboration between the industrial world and the research one on the topic of Industry 4.0, in particular on technologies for flexible and customized production. The project acts as a collaborative environment, created to encourage the growth of local companies in an ecosystem where research and innovation are combined with the attraction of talents and the growth of new businesses.

The project is divided into different development activities and sees in the Laboratory its fulcrum.

Among the development activities there are two research projects, which aim at developing new technologies based on Collaborative Robotics and Data Mining and a Technology Transfer project, where knowledge, technologies and new production methods will be made available to enterprises for the improvement of their production processes.

i-Labs Industry Laboratory

The Laboratory, physical center of the Regional Collaborative Platform on the theme Industry 4.0, is located in spaces made available by the Jesi Municipality.

Within it, researchers, companies and technology coexist to develop, apply and share useful solutions for the improvement of production systems, in order to ensure a rapid evolution towards the paradigms of Industry 4.0.

Production aid systems such as collaborative robots and human-compliant automation systems are available in the Laboratory, but also IIoT systems and Data management and analysis systems, able to manage in an advanced way the production process, to analyze product and production data and automatically reconfigure the different production phases, from the individual processing, assembly and quality control, implementing the latest Cybersecurity technologies.

The technologies present can therefore be grouped into 5 macro areas:

- Collaborative robotics
- Virtual prototyping for Human-Centered Manufacturing
- Technologies for Cyber Physical Systems, traceability and predictive maintenance
- IIoT & Data Analytics
- Cybersecurity.

Collaborative Robotics

Technologies for Collaborative Robotics

The equipment available in the Laboratory for the collaborative robotics section is intended for process automation, according to the logic of the human-centered manufacturing, in which the robot coexists with the operators to relieve them of repetitive and tiring tasks, leaving the operators to higher added value operations. These are therefore robots that respect particular security requirements, making possible to share the workspace with the operators and, in some cases, physical cooperation with the operators in the performance of a certain task.

The collaborative robotics section is equipped with three types of robots:

· Collaborative robots
· Industrial robots equipped with sensors
  to use them in a collaborative perspective
· Mobile robots.

For mobile robots, integration with a collaborative robot is envisaged, carried out directly by the manufacturer or in a personalized way in the Laboratory, with the aim of obtaining mobile collaborative robots.
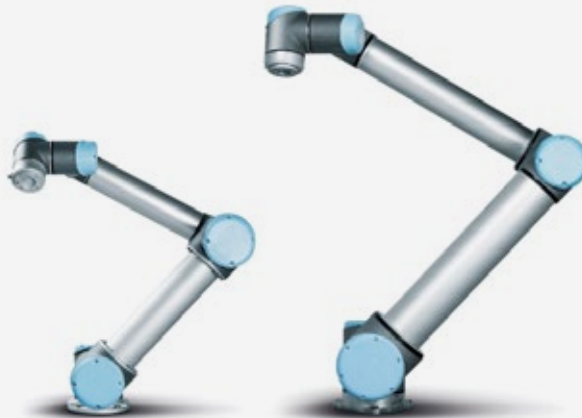
Two types of Robots are present, UR5e and UR10e, which differ in payload and arm size. Robots are equipped with intelligent Schunk grippers with position and strength control that are also collaborative and with the possibility of fast release.

There is also the possibility to install a Schunk load cell for precision force control for contact processing.

UR5e

- Payload 5 kg
- Reachability 850 mm
- Axes 6

UR10e

- Payload 10 kg
- Reachability 1300 mm
- Axes 6

Small collaborative robot. Dual-arm architecture with 7 axes per arm (redundant), ideal for complex kinematic tasks. Equipped with electric gripper and suction cup (arm 1) and electric gripper and camera (arm 2).

Dual-arm

● Payload	0.5 kg / per arm
● Reachability	560 mm
● Axes	7 / per arm

Traditional medium-large size robot. Equipped with SICK laser sensor and Safemove2 electronics to create a hybrid collaborative cell. Equipped with Schunk electric gripper with control of position and strength and integrated into the environment of Virtual Reality through RobotStudio.

● **Payload**	**20 kg**
● **Reachability**	**1650 mm**
● **Axes**	**6**

Mobile collaborative robot of medium-large size. Omnidirectional handling system. Manipulator architecture with 7 axes (redundant), ideal for complex kinematics tasks. Equipped with Schunk collaborative electric gripper.

Mobile platform with manipulator

● Payload	**14 kg**
● Mobile platform load	**170 kg**
● Reachability	**820 mm**
● Axes	**7**

AGV of medium-small size. Ready for integration with UR5e.

AGVs

● Dimensions	**890x580x352 mm**
● Payload	**200 kg**
● Towing	**500 kg**

End-of-arm modular system for robots with manual tool change system (master) for mechanical and electrical connection to the robot, including electric and pneumatic passages.

● **Dimensions X xY xZ**	**93,8 x 90,2 x 123 mm**
● **Min./Max. gripping force**	**35/140 N**
● **Recommended weight**	**0,7 kg**
● **Gripper weight**	**0,59 kg**

Collaborative robot that thanks to its reduced weight, can be easily installed in a wide range of applications, such as automated guided vehicles (AGVs). The robot can perform tipping movements highly functional in different applications.

● **Payload**	10 kg
● **Reachability**	1418 mm
● **Axes**	6

Collaborative robot that has already integrated a vision system that enables visual power assistance, inspection and measurement. Its ability to be integrated with mobile robots allows completely autonomous applications of machine tending and logistics management.

● Payload	4 kg
● Reachability	900 mm
● Axes	6

Offered Services

Feasibility studies commissioned by companies to automate certain operations of their production process, combining:

- **Simulations** using dedicated software provided by robot manufacturers where you can plan and verify work cycles by the use of manipulators and the integration of other equipments.
- **Experiments** by setting up workbenches using robots of the Laboratory and integrate additional equipment provided by the companies for physically implement the processing cycle and verify productivity and quality level. The same workbench can be used to train the company's staff in the future use of the system at the production plant.
- **Integration studies** in which companies operating in the field of automation can test their technical solutions by comparing them with the technologies present in the Laboratory and then decide which one better meets their needs.

Development of innovative technical solutions, not present on the market, on specific needs of companies, possibly integrated with research projects and innovation made in collaboration with centers of national and international importance, such as Universities and Competence Centers.

Training courses for company staff and students, given by the staff of the Laboratory and its partners, supplemented with contributions from the technological providers that taking advantage of the Laboratory, can offer specific training courses on their technologies.

Virtual Prototyping for Human-Centered Manufacturing

Virtual Reality Technologies

Simulation is an increasingly necessary tool in order to verify and validate a project before moving on to its execution phase. That's why Virtual Reality tools are increasingly widespread and used. In particular, it is possible to use this technology in the laboratory for the simulations of robotic cells using geometric models of the environments and geometric and kinematic models of robots.

In consideration of the flexibility that the Laboratory must satisfy and of the wide range of application areas and methods where they can be used, the Virtual Room available in the Laboratory is equipped with both an immersive fruition system (HMD viewer) and a semi-immersive system (stereoscopic 3D rear projection with tracking system).

- Proiettore 3D stereoscopico: Barco F50 WQXGA con ottica ultracorta
- Stereoscopic 3D projector: Barco F50 WQXGA with ultra-short optics
- Kit for active stereoscopic vision: 10 goggles Expand RF with its emitter
- Stereoscopic rear projection screen with Self-support structure: flexible screen 291x161 cm
- Optical tracking system: ART Trackpack
- Immersive 3D viewer: HTC VIVE PRO
- Graphics engine (graphics workstation properly configured): Workstat HP Z4 Professional Graphics
- Preview system: based on 2 monitors
- Audio system: two-channels system

Augmented Reality Technologies

The Laboratory has technological and computational systems in order to evaluate Augmented Reality (AR) solutions for the management and simulation of complex operational processes. With a view to Industry 4.0, AR technologies are of ever-increasing importance, both for simulation aspects than for those of advanced maintenance. The combination of AR technologies and those of Artificial Intelligence will be able to create advanced applications of image recognition that in the Laboratory will be applied to different productive areas.

At the level of computational instruments, in the Laboratory there is the possibility of access to reference libraries and development services that could also be accessible in the cloud on Azure / AWS: scalable environment both in terms of HW, bandwidth, resources and services to be managed on demand at modular consumption. Edge computing systems are also available for the deployment of image recognition algorithms.

There are many devices available on the market to support activities in the field AR; some of them are available in the Laboratory together with applications already developed for various application areas.

HoloLens 2 delivers mixed reality experience more comfortable and engaging, improved by the reliability, security and scalability of Microsoft Cloud and AI services. The version also improves the resolutions video, thanks to the new high camera resolution.

● Optics	**Holographic Lenses transparent (waveguides)**
● Display	**2K devices lighting (3:2)**
● Field of view	**52° (diagonal)**
● Battery life	2-3 hours
● User Interface	**Hand Tracking Eye tracking Voice commands**
● Weight	**566 gr**

Binocular display with transparent lenses ensures an Augmented Reality experience extremely engaging, 3D functionalities and stereo front camera with three-dimensional depth sensor that detects the size and location of more objects in space in relation to each other.

● **Optics**	**HTPS LCD**
● **Display**	**0.42'' panel wide (16:9) (960 x 540)**
● **Field of view**	**23° (diagonal)**
● **Battery life**	**4 hours**
● **User Interface**	**Controller Vocal Commands**
● **Weight**	**290 gr**

MOVERIO BT-300 uses the innovative OLED digital display technology (Organic Light Emitting Diode) based on Epson silicon, making it the lightest transparent lens binocular viewer with OLED display on the market, with high image quality. Allows you to live an experience of immersive Augmented reality, also thanks to the HD resolution and high contrast.

● **Optics**	**Si-OLED**
● **Display**	**0.43'' panel wide (16:9) (1280 x 720)**
● **Field of View**	23° (diagonal)
● **Battery life**	6 hours
● **User Interface**	Controller, Touch-pad pointing method
● **Weight**	69 gr

Technologies for the Human-Centered Manufacturing

In order to define and test new paradigms of human-robot collaboration (according to ISO/TS 15066 2016: "Robots and robotic devices: collaborative robots") that are able to guarantee higher levels of safety, in the i-Labs Industry laboratory, devices that can give robots advanced perceptive and cognitive capabilities are available.

In particular, activities will be carried out to monitor and improve the physical, cognitive and environmental ergonomics of the operator and the workstation work, such as:

- Implementation of shared processes to allow the robot to interpret the context (context awareness) and manage information locally
- Use of human detection, behavior prediction and/or gesture technologies recognition that makes possible the detection, systematization and information processing to enable "actions" at both the device and system levels
- Use of artificial intelligence algorithms that make robots capable to process data, predict operator behavior and react in real time.

The Smart Robots Device, thanks to the 3D vision, provides a mapping of the work area and recognize movements, actions and gestures of people in real time.

When connected to a cobot, the Smart Robots Device enables true interaction man-cobot, adapting and synchronizing the cobot programs with human actions. Below is a summary of the main features of the Smart Robots.

Human tracking: monitoring of the operator's movements and forecasting of the space occupied. The movement of the operator and his hands are tracked in real time. Human actions are information available to activate specific tasks of the robot.

Sequence control: the movements and actions of the operator are tracked in 3D and compared with the correct sequence of tasks providing real-time indications and feedback in case of errors.

Human gestures and commands: the robot can be controlled without the need for a physical interface; the operator can interact directly with the robot to modify its activities.

Object recognition: Recognition and classification of known objects based on matching with a 3D model. Inspection of objects to detect process errors. This feature can be customized for specific applications.

Intelligent scheduling: when used in connection with a robot, the system adapts in real time the actions of the robot based on the position and actions of the man and the availability of the pieces in order to effectively integrate human and robotic activities.

Avoid collisions: When used in connection with a robot, the system detects the 3D human-robot distance (body, arms, hands) in real time and slows down the robot before the collision occurs.

Captiks Movit System is a wearable system for motion measurement and analysis. The system consists of wearable wireless inertial devices and a wireless receiver connected to the PC via USB. Each sensor has been designed to be universal and applicable on the main parts of the body through wearable supports and a quick hook/release system.

The system allows you to record and export the following types of data: raw data from accelerometer, gyroscope, magnetometer and barometer; quaternions; animation bvh files; Joint angles and mp4 video files.

Electrooculographs Jins memes ES_R are glasses that integrate three sensors (accelerometer, gyroscope and 3-point electrooculographic sensor) able to provide in output the electrooculogram (EOG), which is based on the potential difference existing between the cornea and retina. Through the EOG, stress and visual fatigue can be assessed.

Zephyr BioHarness 3 is a chest strap made of conductive tissue (Smart Fabric patented) within which it is integrated a multi-parameter wearable sensor capable of simultaneously measuring: heart rate, ECG, respiratory rate, body temperature, activity, acceleration and posture.

E4 Wristband is a wireless wearable brace-let that allows you to monitor physiolog-ical parameters in real time. It consists of four sensors: photoplethysmograph (PPG), thermometer infrared accelerometer and EDA (electrodermal activity) sensor.

Offered Services

i-Labs Industry with its technologies described above, together with the skills of researchers and other qualified personnel, allows to offer the following services.

Consultancy

- **Study and/or experimentation** of new "human detection" techniques and "behaviour prediction" in different production scenarios so that human-robot interaction can take place safely and without reducing productivity

- **Study and/ or experimentation** of new techniques and methods of interaction/human-robot cooperation in different production scenarios so that operators are relieved of the most strenuous tasks and can devote themself to the most important value added activities

- **Study and / or experiment** with new techniques for the evaluation of the physical and / or cognitive ergonomics of the operator aimed at certification, to (re) design of the workstation to increase the operator's well-being and performance, comparing different production scenarios, etc.

- **Implementation** of Virtual Reality technologies for design of products, systems, workstations, human-machine interaction, etc.

- **Implementation** of Virtual Reality technologies for analysis and simulation in the robotic field with multiple purposes

- **Near real time analysis** of information and development of related architectures robust for decision-making applications (DSS)

- **Study and/or experimentation** of image processing & machine learning application platforms with the use of multi-brand viewers and tools/services specific applications to allow the appropriate developments

- **Staff training** using Virtual/Augmented Reality technologies.

Orientation: orientation events on research and technological development through the demonstration of strategic innovative approaches, methods and tools in relation to the technologies and thematic areas described.

Training: training courses on methods and tools for human-centered manufacturing (ergonomics, human-robot collaboration, social sustainability, etc.) and the implementation of Augmented Reality and virtual technologies (design, simulations, decision support, etc.)

Technologies for Cyber Physical Systems, traceability and predictive maintenance
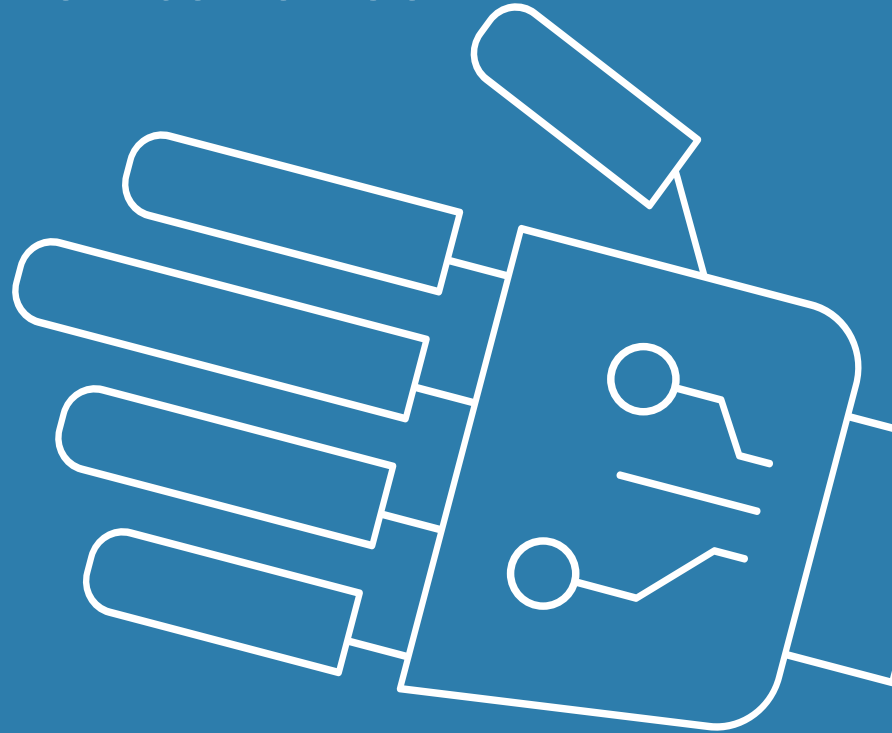
Hardware

The CPFactory consists of a set of machines that reproduce in a controlled environment, that is precisely the laboratory space, a real complete multi-purpose production plant, in compliance with the definitions used by i-Labs Industry and summarized in the now shared definition of Smart Factory (or equivalent to Cyber Physical Factory). Such a plant possesses characteristics of modularity, operational and functional flexibility, expandability, and is completely open with the aim of being able to be integrated at a functional level with other components of the Laboratory. The concept of modularity refers to the possibility of being able to functionally use the individual modules constituting the system both in stand-alone configuration and in network with others, with mechanical, electrical interfaces and standard protocols.

In addition, the Laboratory will be equipped with a Vertical Machining Center. It will be possible to carry out experiments to make pieces servoing via robots on mobile bases or do predictive maintenance of the machine, going to measure different quantities.

The concept of expandability refers to the fact that the functionality of the plant can be extended both by adding additional modules of the supplier; but also equivalently through the addition of "customized" modules acquired from the market, or designed ad hoc by our laboratory structure. This will be possible thanks to the use of ICT industrial standard interfaces used in the system.

The concept of operational flexibility is provided as inherent in the different modules and is in line with what is defined by the Industry 4.0 platform as a machine "Plug & Produce".

The CPFactory can operationally carry out a production cycle of real artifacts formed by several components, supplied in several points of the plant itself being assembled by human or robotic operator. Therefore, it is possible to have multiple variants of the finished product.

Software

The CPFactory is managed, at the level of machine configuration, management production, order and history management from a Manufacturing Execution System (MES), open and modifiable and updatable by the user.

There is also a software package for visualization in 3D simulation of complex industrial layouts, which also serves as an environment of design and development of new applications in Virtual Reality. The software package can also realize the Digital Twin of the system; it means that it can reproduce in Virtual Reality everything that happens on the real system.

It has a plugin that is able to handle the usual tools for Virtual Reality (using Hololens or other similar).

It is equipped with an educational software package that allows to gradually introduce less experienced users to the management of the plant, through the use in simulation of simpler and less structured systems.

There is also a software app in cloud mode, able to implement Augmented Reality methods aimed at the remote maintenance and inspection of the plant, of fundamental importance for the purposes of the Laboratory.
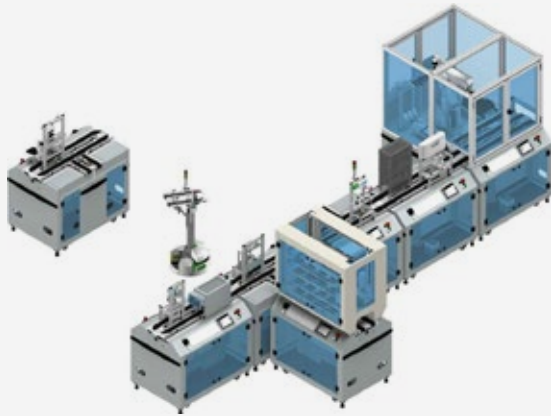
- A highly automated warehouse (ASRS, automatic storage & retrieve system) which acts as an initial storage of semi-finished products, and final for variants of finished products
- At least two local warehouse modules for distribution of components and semi-finished products to be processed/assembled
- At least two functional modules for automated assembly
- A functional module for manual assembly in order to test the human-machine interaction
- Two quality control modules by intelligent visual inspection
- A complete rework station, with defect routing
- At least two tracking modes (traceability) and recognition of products during transport on conveyor- transfer pallet system
- At least one software module for analysis and verification of production parameters
- A pair of mechanical and electrical interfaces with other external machines (e.g. cobot)

HAAS VF-2SS machining center. Haas' super-fast vertical machining center offering high spindle speeds, fast advances and fast change tools needed for production of large volumes with reduced cycle times.

The machine has a spindle in direct transmission line from 12,000 rpm, a side-mounted tool change ultra fast and fast advances to high speed on all axes. It is fully interfaced via ethernet to the local network of the Laboratory.

Offered Services

The availability of the CPFactory in the Laboratory, together with the skills of researchers and other qualified personnel, allows to offer the following services:

Feasibility studies commissioned by companies to automate certain operations of their cycles or production processes. Feasibility studies may be provided in different modalities.

- **Simulation:** simulations can be carried out using dedicated software provided by the manufacturers of the system in which you can plan and verify work cycles through the use of modules and the integration of other equipment.

- **Experimentation:** different processing cycles can be set up with the system available in the Laboratory and it will be possible to integrate additional equipment provided by companies to physically implement the processing cycle and verify productivity and performance or management level. The same system can be used to train the company's staff for future use of production lines at the production plant.

- **Integration studies** in which companies operating in the field of automation, hardware and software, can test their technical solutions using the systems present in the Laboratory. They can also test different solutions with the aim to comparing them.

Development of innovative technical solutions, not present on the market, on specific needs of companies; this activity will also be possible thanks to the participation of i-Labs Industry in research and innovation projects in collaboration with centers of national and international importance, such as Universities and Competence Center.

Training courses for company staff and students, given by the staff of the Laboratory or its partners, supplemented with contributions from the technology providers. The same providers can take advantage of the Laboratory to offer specific training courses on their technology, taking advantage of the presence of the machines at the Laboratory to carry out demos and practical courses.

IIoT & Data Analytics
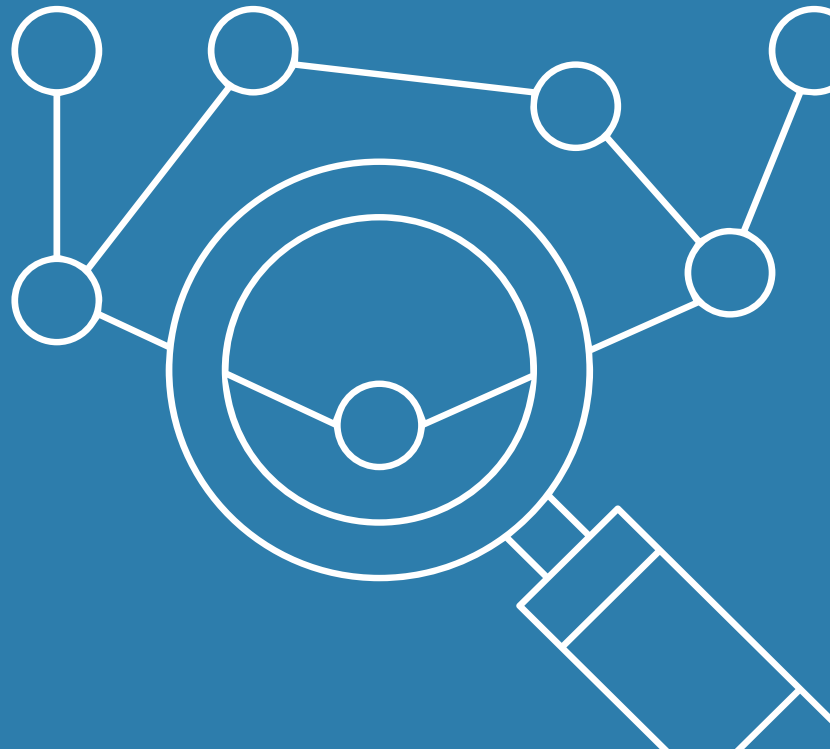
The application of Edge Computing in IIoT is extremely promising, as it allows the distribution and decentralization of computations, as well as devices – at the field level and at higher levels in the automation pyramid – involved in the production process, capable of supporting real-time interactions and fully scalable data analytics techniques.

Of particular interest is the development of protection techniques of the networks that need to be validated on real and specific data from IIoT devices used in Industry 4.0, allowing the identification of the most relevant threats to such systems. I-Labs Industry is equipped with cutting-edge solutions for the protection of digital infrastructures and offers the possibility to develop and validate innovative detection techniques.

Among these: identification in real time of malware and compromised terminals through Artificial Intelligence techniques aimed at profiling and countering the spread of botnets, the real-time identification of anomalies specific to the Industry 4.0 context through the analysis of network traffic.

Regarding the creation and management of a regional blockchain, taking advantage of the computation and storage capacity provided by the hardware available at the Laboratory, in the Marche Region will be implemented the first node of a blockchain. Other nodes can then be associated with this node, for example maintained by universities and consortium companies, with the support of the Laboratory staff.

This will allow to set up and provide a regional blockchain platform, able to offer the certainty that the data remains on the regional territory, and able to offer a reduction in the costs of use compared to public blockchains.

This infrastructure can be used by SMEs, regional and extra-regional bodies and institutions for projects in the field of Industry 4.0 and beyond, according to the fees for the use established by the Laboratory.

For the Data Analytics part, i-labs Industry provides processing capabilities based on Machine Learning algorithms and Deep Learning techniques that will allow to integrate new approaches to data analysis in predictive mode and diagnostics applicable in industrial contexts 4.0 (from predictive maintenance of machines, to energetic consumption analysis, etc.).

Hardware

- VXRAIL hyper-converged infrastructure for computation and storage, consisting of 4 drives for a total of 96 physical cores, 1.6 TB RAM, 38.4 TB storage
- DELL Intel Xeon Silver 4210 workstation with 10 CORES Physical, Dual Graphic Card Nvidia Quadro RTX6000, 2 TB SSD, MegaRAID SAS 9460-16i 12Gb/s

Software

- Software for the realization of the Blockchain such as Ethereum and Hyperledger
- Cassandra DN Database
- Data analysis tools such as Elastic Searc, TensorFlow, MatLab, Microsoft Azure

Offered Services

The described available technologies in the Laboratory, together with the skills of researchers and of the other qualified personnel, allows to offer the following services:

Blockchain as a Service: provision of services to local companies dedicated to the use of Blockchain systems to support the management of data related, for example, to the traceability of production and processing chains. With these services, companies will be able to take advantage of Blockchain technologies already configured and delivered by the Laboratory's infrastructure having the security of the confidentiality and of the tracked data, while at the same time reducing the costs that the company should bear in terms of IT infrastructure and the need for highly specialized people for the installation and configuration of Blockchain frameworks. In general, it can be estimated that at regional level at least 20 other companies can be interested by this type of services.

Big Data IIoT: the services will concern the management of IoT device monitoring data for people monitoring and production machines in the production context, such as services dedicated to the world of Health & Safety to increase safety levels in the workplace; services for predictive maintenance of machines through IIoT data analysis with AI techniques; energy management services to increase the efficiency and energy saving of companies.

Business Analytics: services are based on Big Data management to bring value from the data collected from industrial contexts. The Big Data services will provide the basis on which the Business Analytics services will provide to the companies transformation and evaluation capabilities of IIoT data and data understanding through usage-based functionalities of AI and Business Process Engineering techniques in order to improve and optimize the production processes themselves.

Proof of Concept IoT systems and Digital Workplace: services to companies of the territory interested in evaluating the application of innovative IIoT technologies and services offered by the Laboratory through practical demonstrations on specific use cases in the i-Labs Industry

User Profiling and Customer Analytics: transversal service for SMEs aimed at the analysis of their data for customer profiling. Analysis of customers' past purchases, any judgments issued by them on the products purchased and the services used, any complaints and questions to reconstruct their profiles and, therefore, their needs and desires. Support for the creation of new products / services that meet the needs / desires of the Customers. Intelligent data analytics support for coupling product sales/ services of different companies.

Training courses: training courses for company personnel and students, taught by the staff of the Laboratory and by the company staff with regard to the aforementioned technologies and services offered, presentation of products, evaluation demos with practical courses.

Cybersecurity
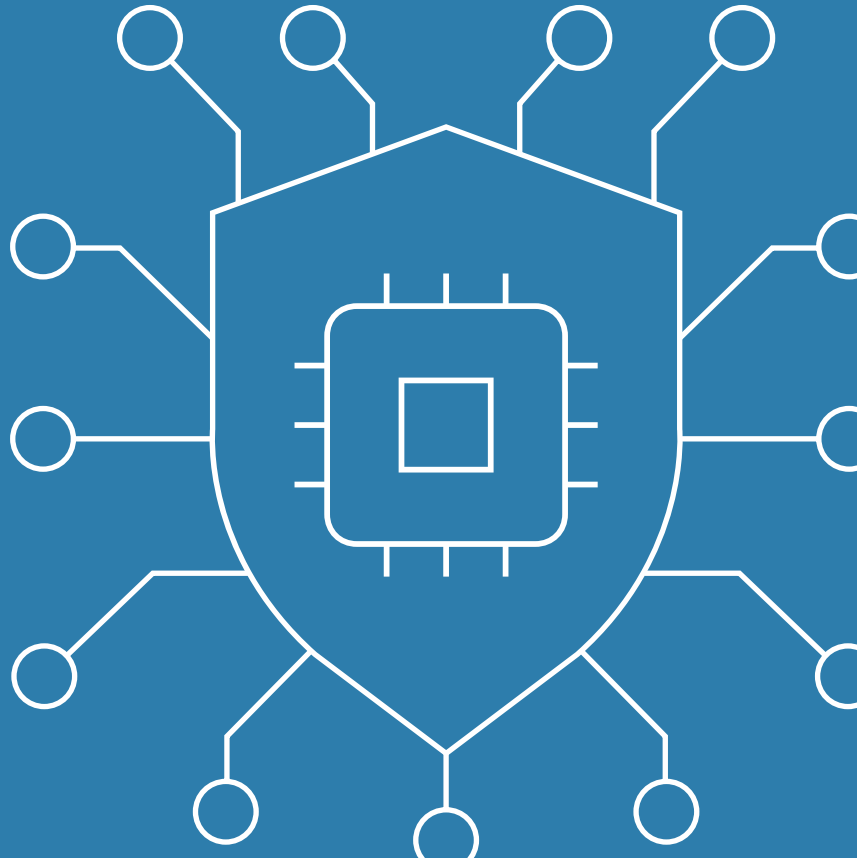
The Laboratory has a hardware and software equipment able to support both research and development activities and the provision of networks, digital infrastructures and data protection services, with particular reference to services for monitoring cyber events and preventing intrusions.

The hardware and software equipment of the Laboratory implement systems of Security Information and Event Management (SIEM) for the monitoring of the digital infrastructures of institutions and companies, the detection of cyber incidents and timely response.

Offered Services

Monitoring of cyber events: the Laboratory offers an automatic and supervised monitoring service of the ICT infrastructures of institutions or companies for the prevention and detection of cyber events, such as threats and attacks. This is also necessary for compliance with current regulations such as the GDPR, which requires the communication of any data breach within 72 hours from the event.

Companies and entities that use the service can provide the data automatically generated by their network equipment (routers, firewalls, servers, etc.) to the Laboratory, that analyzes them through its own systems. This allows the early detection of cyber events and the consequent generation of alarms.

Cybersecurity projects: the Laboratory represents a point of reference and competence in the field of cybersecurity of systems for Industry 4.0, which makes its technologies and expertise available, also making use of the academic staff involved, for specific projects on the cybersecurity of industrial infrastructures.

Training courses: the skills and hardware and software equipment of the Laboratory in the area of cybersecurity allow to offer training courses, practical courses and demonstrations of introductory or advanced level for company staff and students, making use of the staff of the Laboratory itself and of the partners involved, as well as contributions from technology providers.

I-LABS INDUSTRY PARTNERS

UNIVERSITÀ POLITECNICA DELLE MARCHE

UNICAM
Università di Camerino
1336

MECCANO

Gruppo Filippetti

Nautes

CADLAND

JOY TEK

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JESI
Comune di Jesi