BETTER FACTORY

Grow your manufacturing business

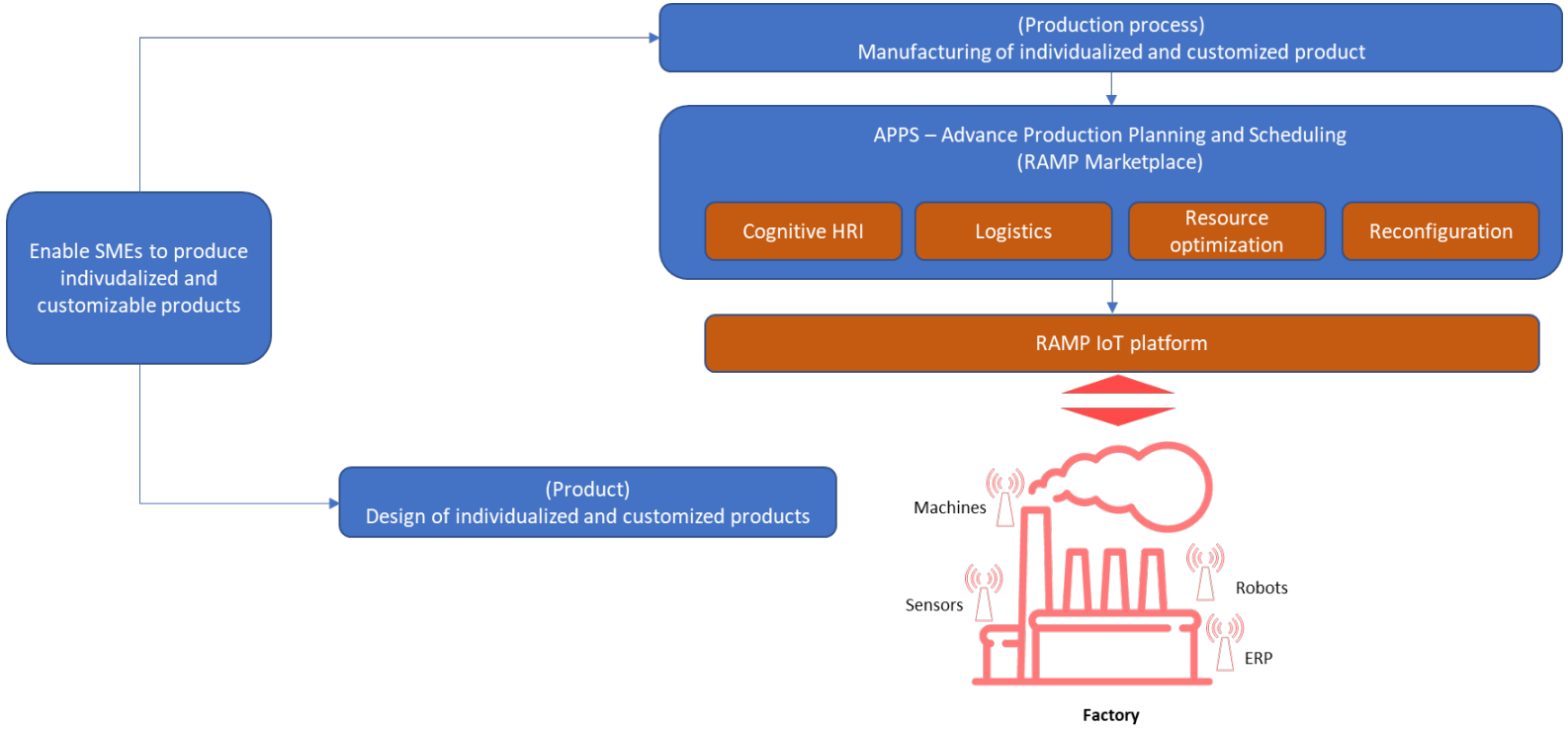
Technology solutions offered by Better Factory:
APPS
31st May 2021

Webinar Agenda

- Welcome (5 minutes) @Serena Albertario (HOLONIX)
- Presentation of APPS (Advance Production Planning and Scheduling) (10 minutes) @Serena Albertario (HOLONIX)
- Presentation of each APPS package and Use Case examples: (40 minutes; 20 minutes per block)
    1. Cognitive HRI @Thomas Staufenbiel (GESTALT)
    2. Logistics and Automation @Ladislav Korosi (NARODNE CENTRUM ROBOTIKY)
    3. Resource optimization @Kai Lehtinen (TOP DATA SCIENCE)
    4. Production reconfiguration @Panos Bouklis (EUROPEAN DYNAMICS)
- Q&A session (30 minutes) @All

APPS: what is?

APPS aims to provide a complete digital infrastructure needed by manufacturing SMEs to deploy cognitive HRI, logistics automation and optimization, resource optimization and production reconfiguration.



1st block: Cognitive HRI

The cognitive HRI module supports Human Machine Collaboration (HMC) aiming at combining human flexibility with repeatability of automated factory entities, such as cobots, for improving working conditions while pursuing better performances.

- Technologies involved:
  - FATIGUE MONITORING SYSTEM
  - INTERVENTION MANAGER
  - POSE RECOGNITION AND CORRECTION

2nd block: Logistics and Automation

The Logistics automation and optimization module optimizes routes, agents, and material flows in production.

- Technologies involved:
  - REAL TIME LOCATING SYSTEM
  - MATERIAL FLOW
  - AGENT OPTIMIZATION
  - TEMPORAL HEAT MAPS
  - LOGISTICS LIBRARY

3rd block: Resource optimization

Resource optimization package will be the module thought to guarantee, to companies joining Better Factory platform, optmization of resources in terms of energy, resources, waste. Data analytics tool will be provided to create optimal solution to minimise consumption, RAMP usage will guarantee real time data visualization and time/effort resource optimization. Tools proposed in this module will guarantee consumption of resources management.

- Technologies involved:
  - GRAPHANA DASHBOARD
  - BUSINESS PROCESS OPTIMIZATION
  - PRODUCTION OPTIMIZATION

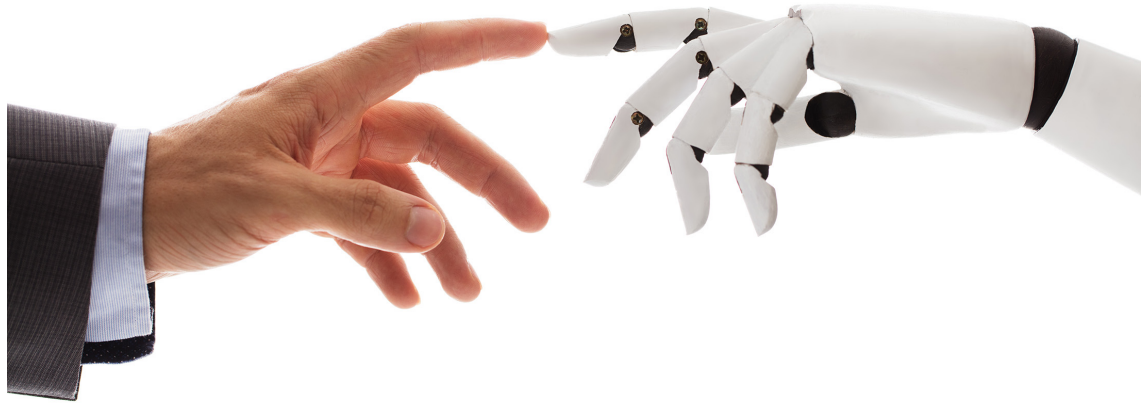
4th block: Production reconfiguration

The production reconfiguration refers to the reconfiguration of the production line and the tasks of the automated and human actors (equipment, robots, workers) in the production floor, in order to produce different variants / personalisations of a product.

- Technologies involved:
  - MANUFACTURING PROCESS MANAGEMENT SYSTEM
  - ADVANCED PLANT MODEL

1st block: Cognitive Human Robot Interaction

Nowadays working environments are marked by the presence of machines. In particular taking into account human robot interaction (HRI), the production paradigm consists of human and robots collaborations. Rather than thinking about replacing humans with machines, the aim is helping humans in performing certain tasks through cobots and other automated yet collaborative factory entities.



Cognitive Human Robot Interaction

THE MODULE

The cognitive HRI module supports Human Machine Collaboration (HMC) aiming at combining human flexibility with repeatability of automated factory entities, such as cobots, for improving working conditions while pursuing better performances.

USE CASE SCENARIO

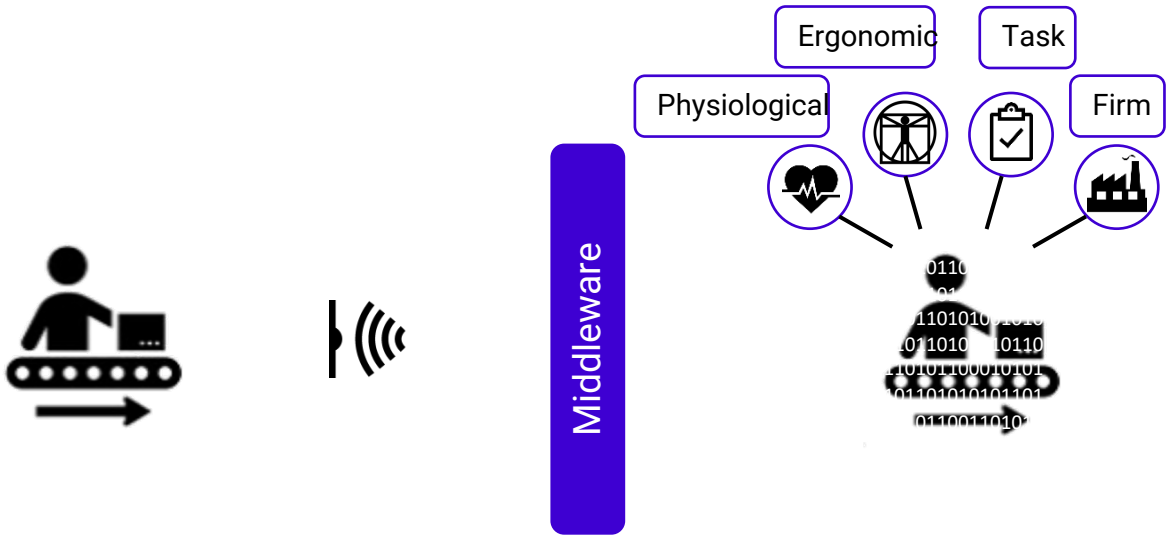
SUPSI and GESTALT provide software modules that monitor specific human parameters in order to detect both worker perceived exertion level (detected by the fatigue monitoring system) and posture (detected by the Ergonomic Module). This information could be used as input for a further decision making module, the intervention manager, in order to re-organize the working cell for improving worker conditions and getting better performances.

Cognitive HRI Assets Functioning Overview

Middleware

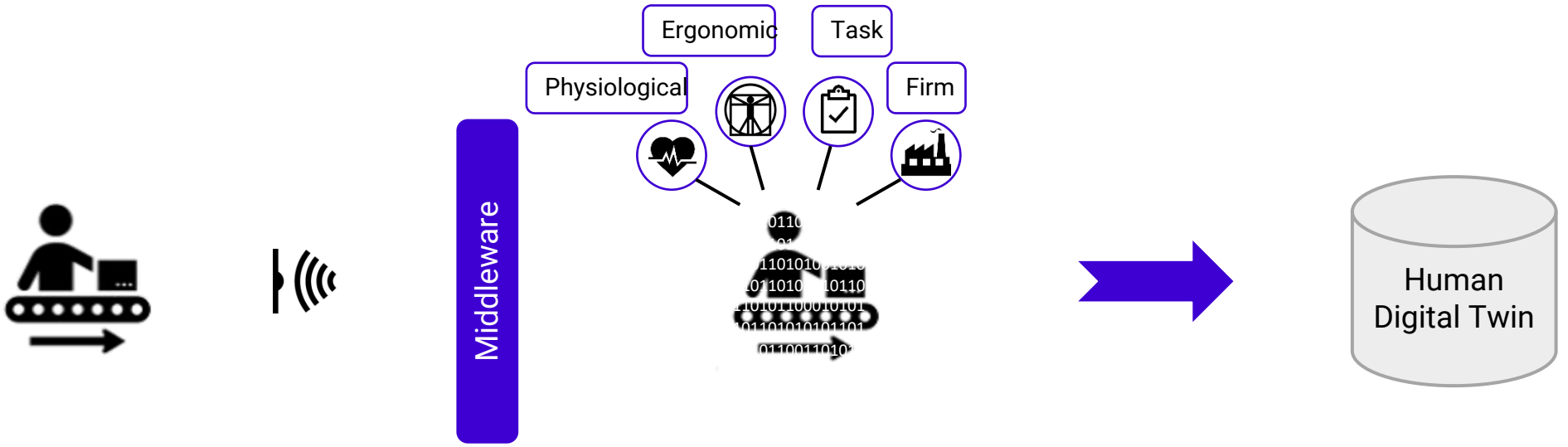
Implement a middleware which provides a standardized interface to existing or newly added sensors, in order to gather workplace relevant data

Cognitive HRI Assets Functioning Overview



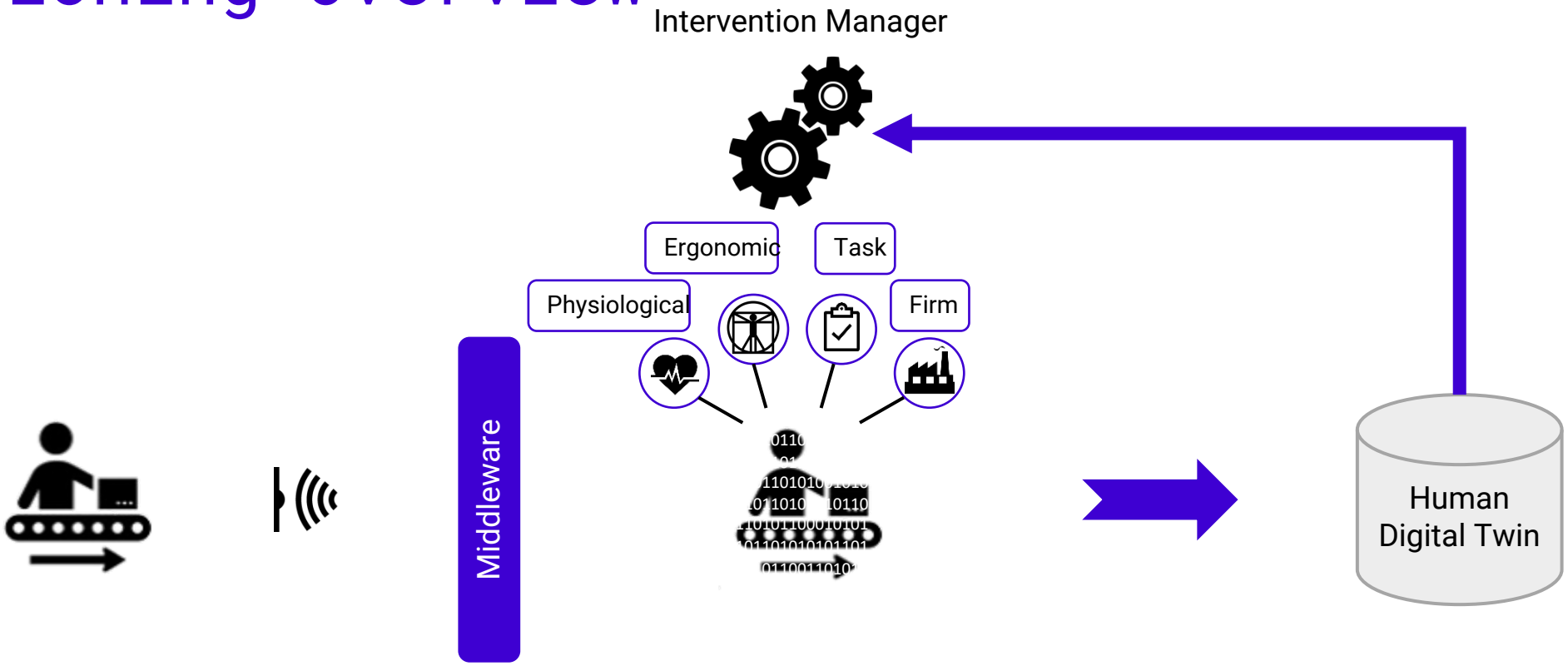
Create a digital workplace representation through a set of interconnected models capable of mirroring different aspects of the workplace

Cognitive HRI Assets Functioning Overview



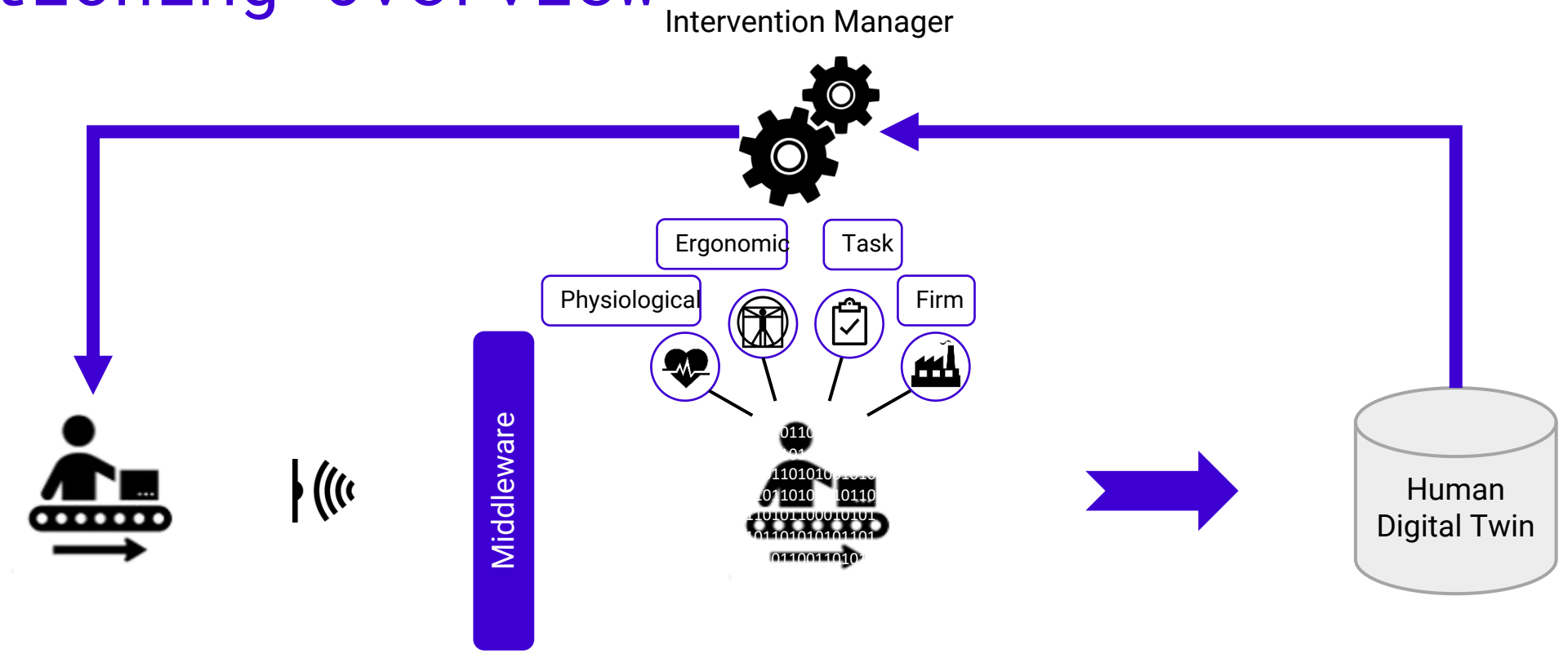
Synthesize these models into a unique holistic representation of the human digital twin

Cognitive HRI Assets Functioning Overview



Implement a reasoning engine, meant to interpret the work environment representation

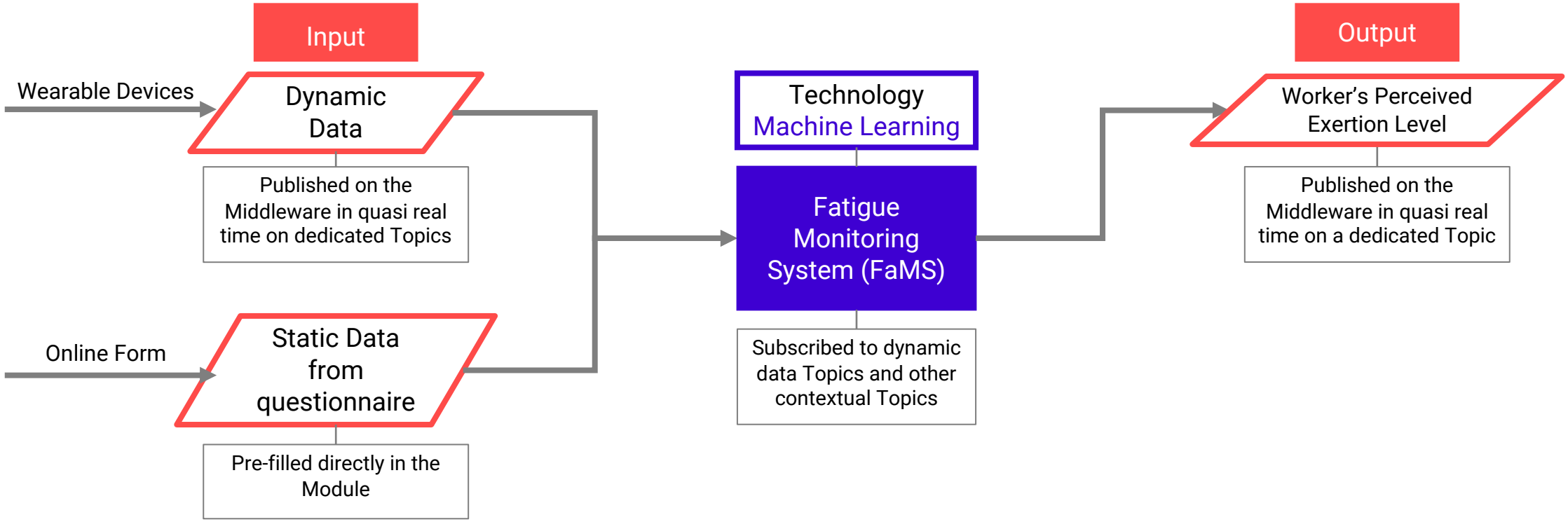
Cognitive HRI Assets Functioning Overview



Trigger interventions in real-time for supporting the worker and for improving production performance

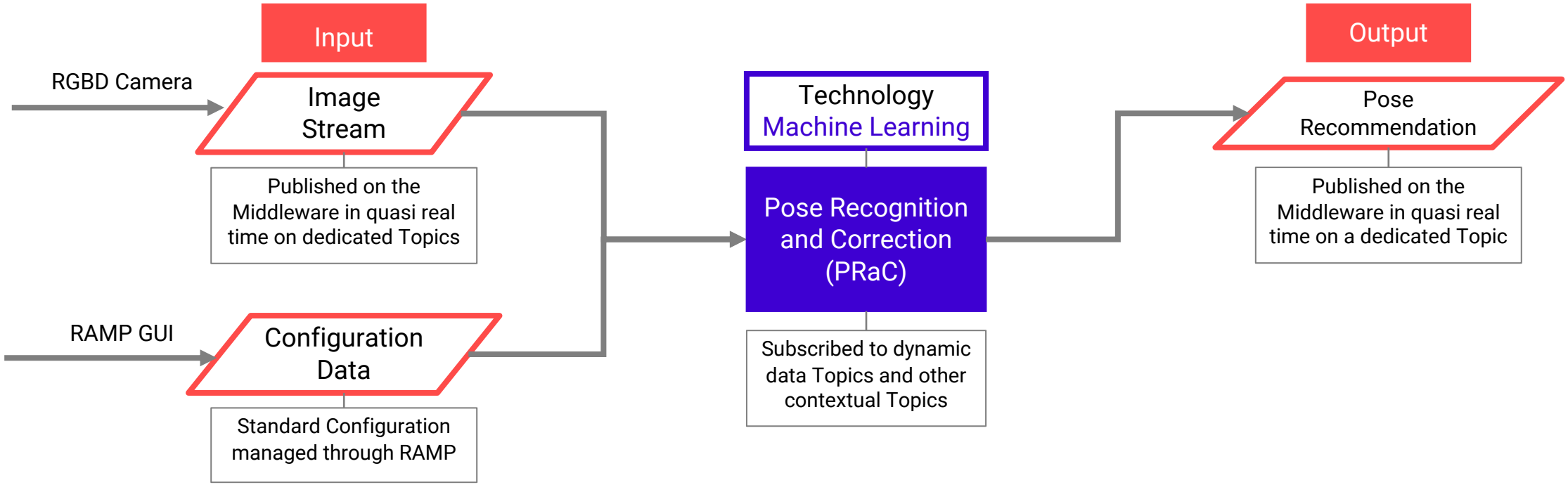
Fatigue Monitoring System

estimates exertion level of subjects based on static data (e.g. age, weight, height, hiring date, max HR, % body fat, sex, task experience, grip strength and others) and dynamically collected parameters (HR, EDA, skin temperature). The output of the model ranges from 0 - no stress to 10 - maximal stress. To this end, it uses an artificial intelligence (AI) model relying on machine learning.



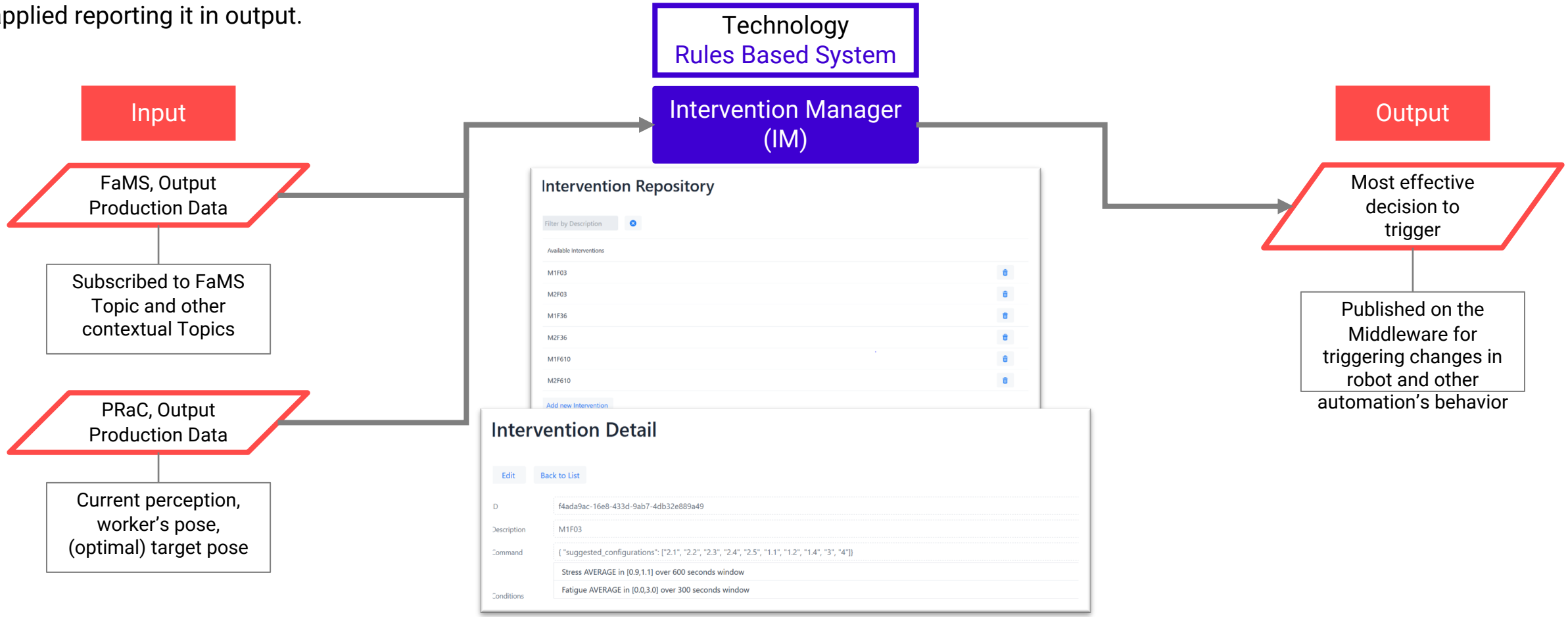
Pose Recognition and Correction

estimates the workers pose from image data and generates recommendations for ergonomic poses. The output can be transformed to robot poses automatically adjusting the workers pose. To this end, it uses an artificial intelligence (AI) model relying on machine learning.



Intervention Manager

acts as the orchestrator of the available solutions that can be offered to support the operator in better and most fruitfully interact with the workplace. It receives in input data from low-level components that reports the status of the worker at a given moment and identifies, from the pool of actions that has been configured by the Administrator, the best one to be applied reporting it in output.



SUPSI's Example: COMPLEMANT Experiment

GESTALT's Example: Robot integration Experiment

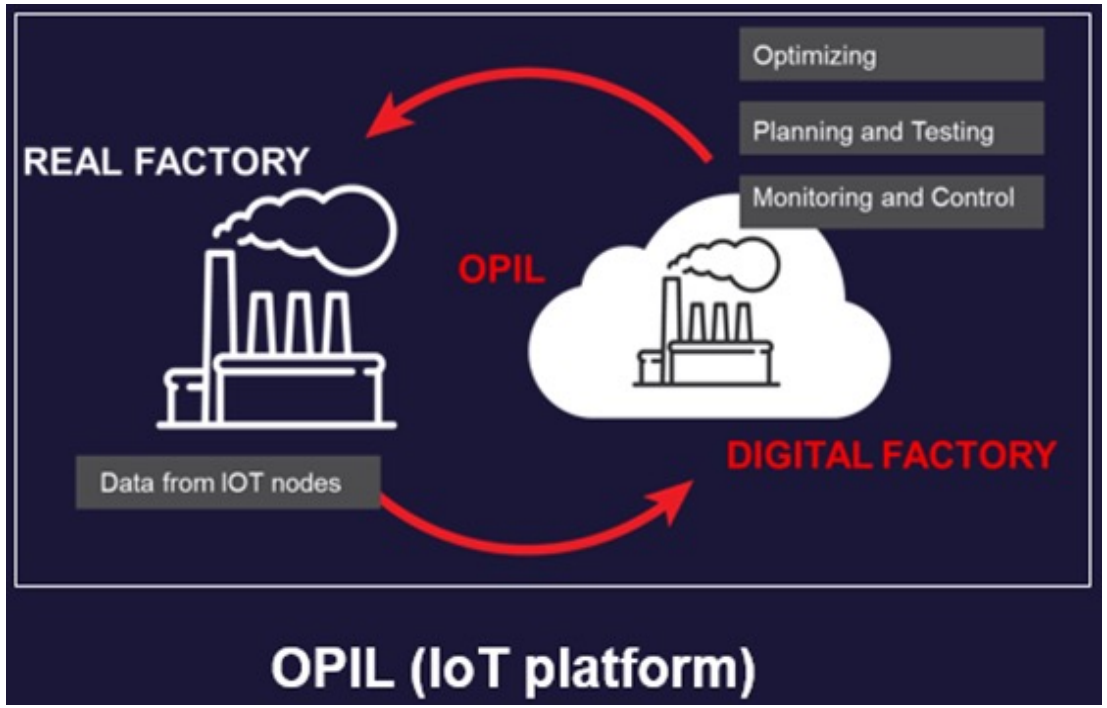
2nd block: Logistics and Automation

The Logistics automation and optimization module optimizes routes, agents, and material flows in production.

- Technologies involved:
  - REAL TIME LOCATING SYSTEM
  - MATERIAL FLOW
  - AGENT OPTIMIZATION
  - TEMPORAL HEAT MAPS
  - PERSON DETECTION AND TRACKING
  - LOGISTICS LIBRARY

2nd block: Logistics and Automation Logistics library (OPIL)

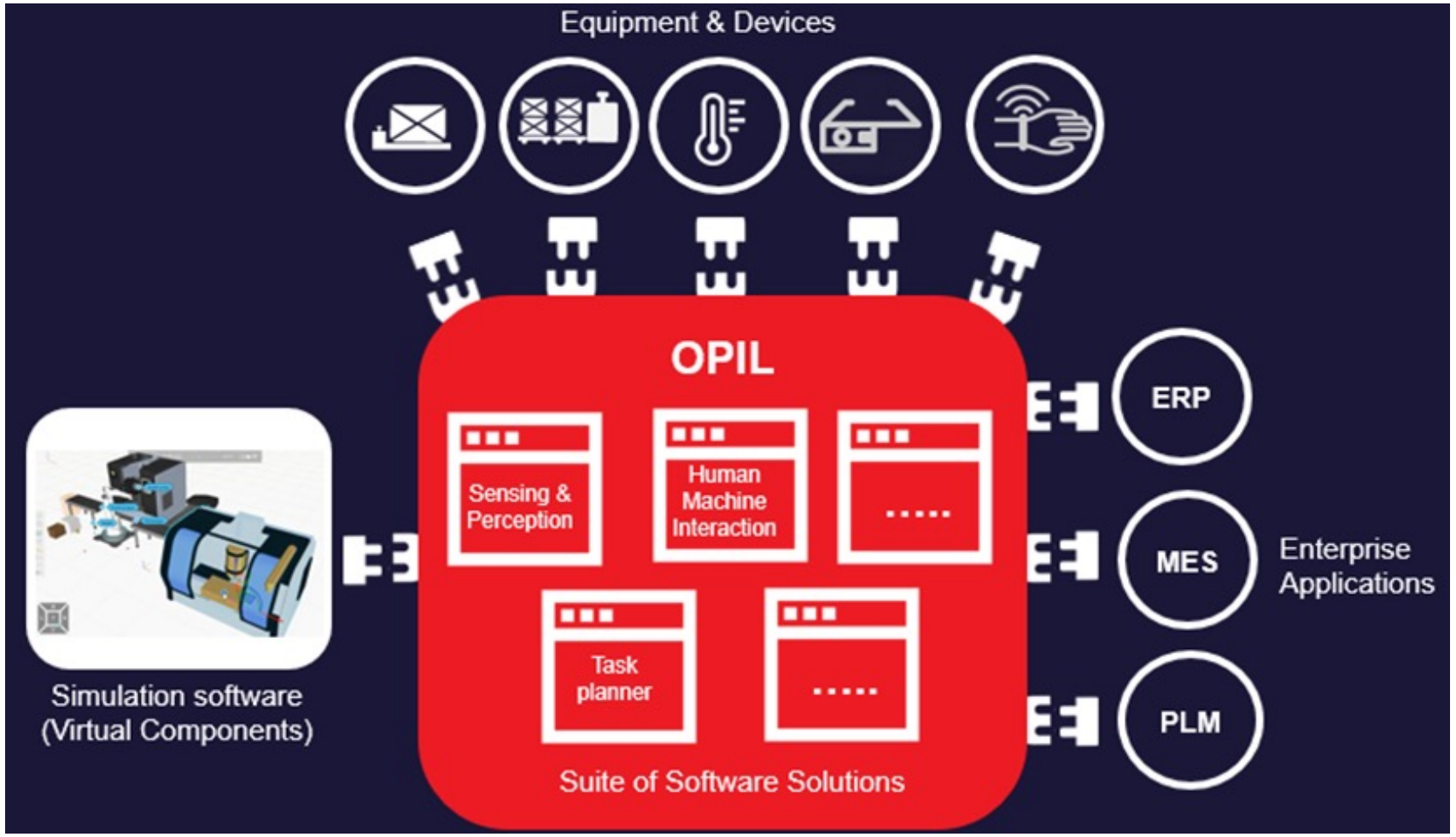
Logistics library is an IoT platform that exploits IoT paradigm to enhance communication among the different elements of the shop floor in order to create a flexible and responsive logistic system.



https://opil-documentation.readthedocs.io/en/latest/

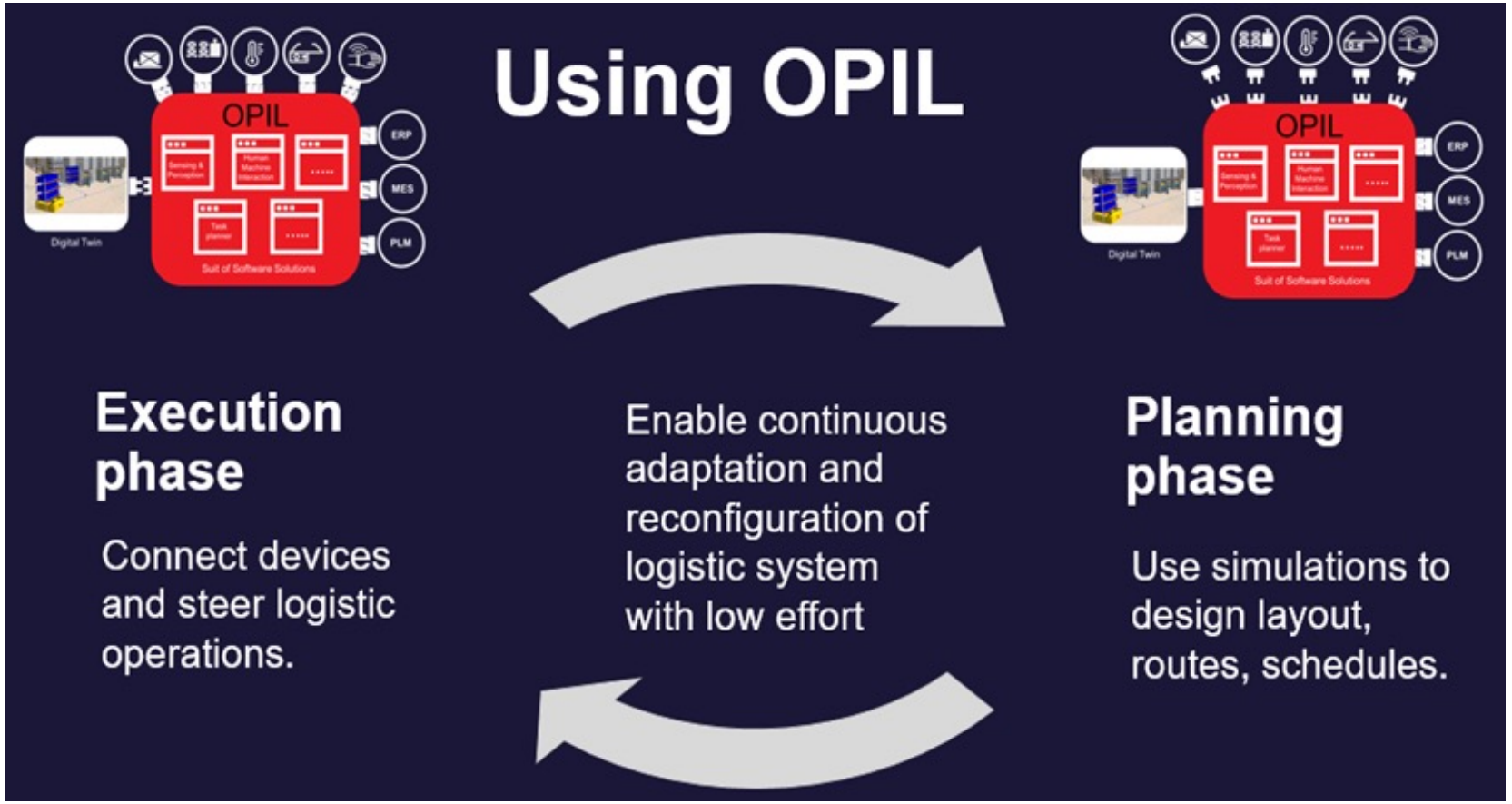
2nd block: Logistics and Automation Logistics library (OPIL)

Scheme of interactions



2nd block: Logistics and Automation Logistics library (OPIL)

Using OPIL



2nd block: Logistics and Automation Logistics library (OPIL)

Industrial challenges logistic automation

- Logistics
  - Staff capacity used in material handling
  - Material handling is a NON-value adding activity
- Common limiting factors for automating logistics
  - Uncertainty regarding future demand requirements
  - Uncertainty in future product portfolio
  - Layout changes required, especially during growing phase
- Automated Logistics
  - Traditionally have low adaptability
  - Integration costs due to software integration is high
  - System expansion is costly and time consuming

2nd block: Logistics and Automation Logistics library (OPIL)

Advantages & Benefits

✓ Production advantages of logistics library:

- Adaption to new layouts:
  - Design, redesign and optimization speed and precision (VC simulations)
- Adaptation to changing production volumes
  - Easy to include new AGVs, robots, etc.
  - Changes in Production Planning and Scheduling automatically considered
- Adaptation to new technologies:
  - Plug and Play functionality to sensors, ROS based AGVs.

✓ Economic advantages:

- Time and installation cost drastically reduced
- Time for system adaption drastically lower
- Standard interfaces

2nd block: Logistics and Automation Logistics library (OPIL)

OPIL Technical Tools

- Robotic Operation System (ROS)
  - Provides libraries specifically developed for robot control
- FIWARE Orion Context Broker (OCB):
  - Data distributed service
  - Every node of OPIL can write and read messages
  - The tool used by the nodes of the architecture to communicate

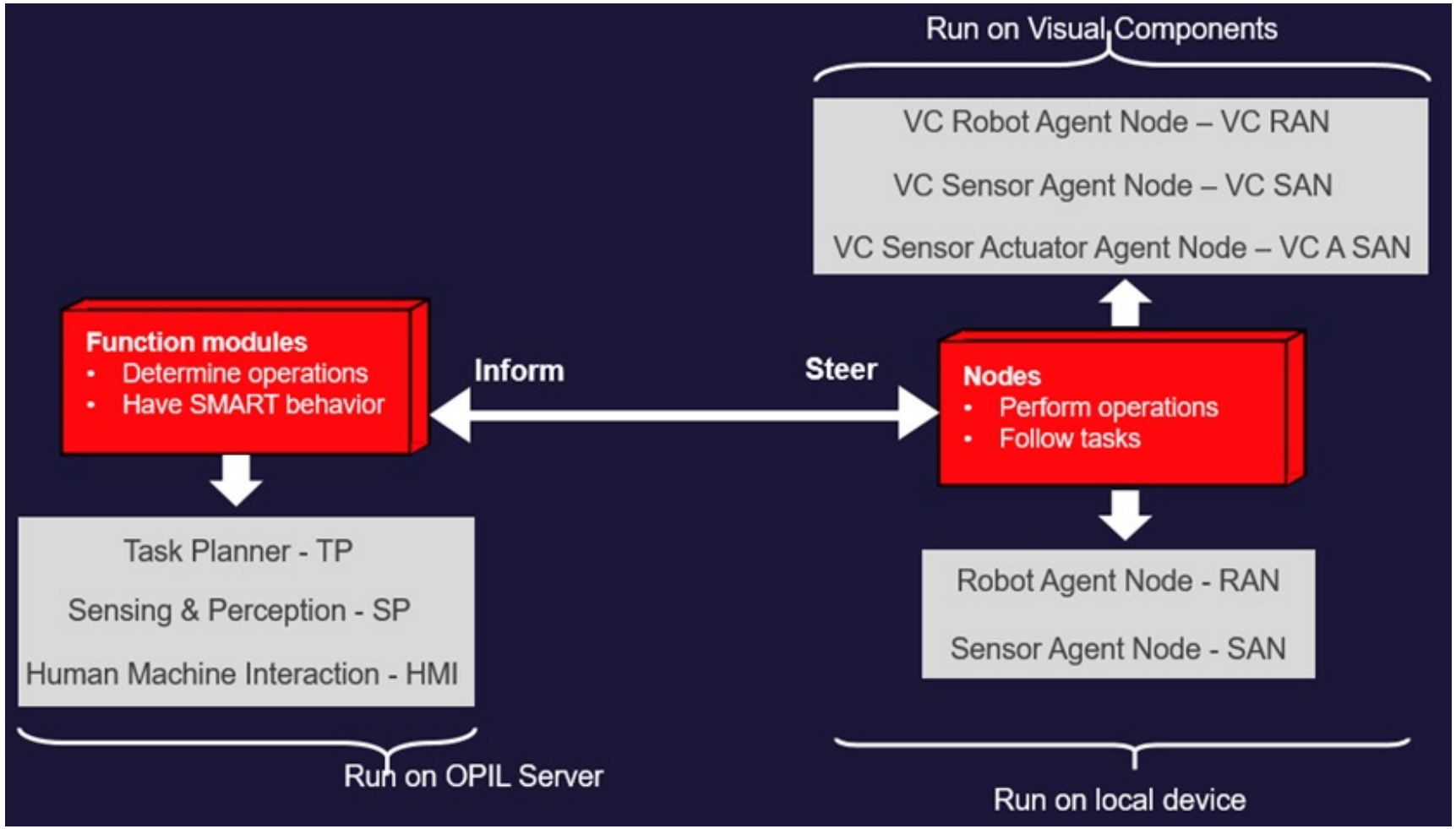
2nd block: Logistics and Automation Logistics library (OPIL)

OPIL Architecture

- Software System Layer
  - Logistics functionality
  - Simulation
- Cyber Physical System Layer
  - Middleware
  - Enables communication among different systems
- IoT nodes
  - Production floor
  - The ones that perform logistics tasks

2nd block: Logistics and Automation Logistics library (OPIL)

OPIL Functionality



2nd block: Logistics and Automation **Agent optimization**

- New module in existing logistics library

- Task / Output
  - Determine the optimal number of agents (AGV, human, …) for material transport

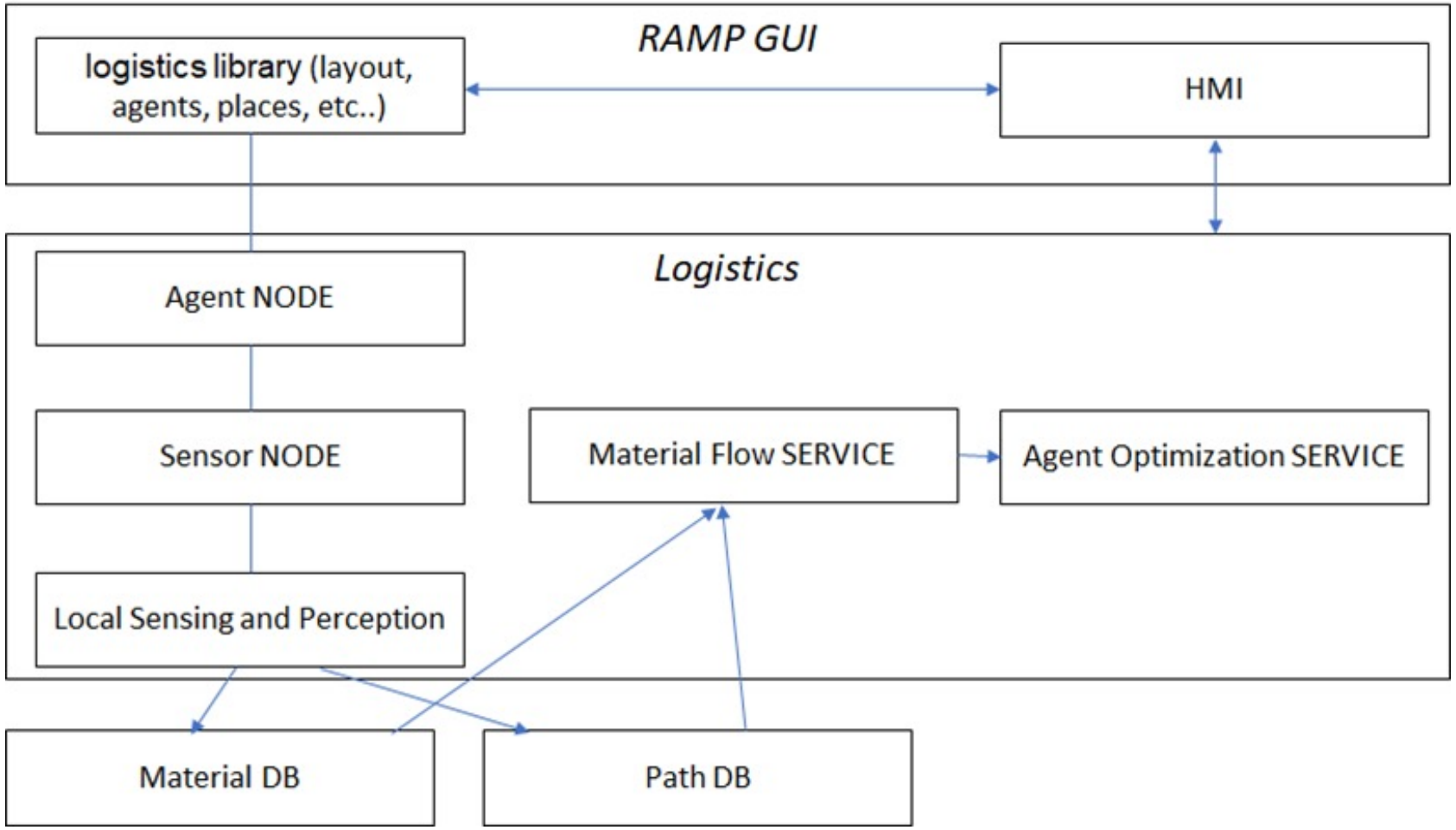
- Inputs
  - Distances matrix – distance from station to station
  - Flow rate matrix per agent type – representing material flow rate from station to station
  - Agent type parameters (speed, time to load, time to unload, traffic factor, …)

2nd block: Logistics and Automation **Agent optimization**

- Inputs defined by
  - manual entry (HMI / GUI)
  - or as input from **material flow** node
    - using existing agent node (logistics library)
    - using data logs from database

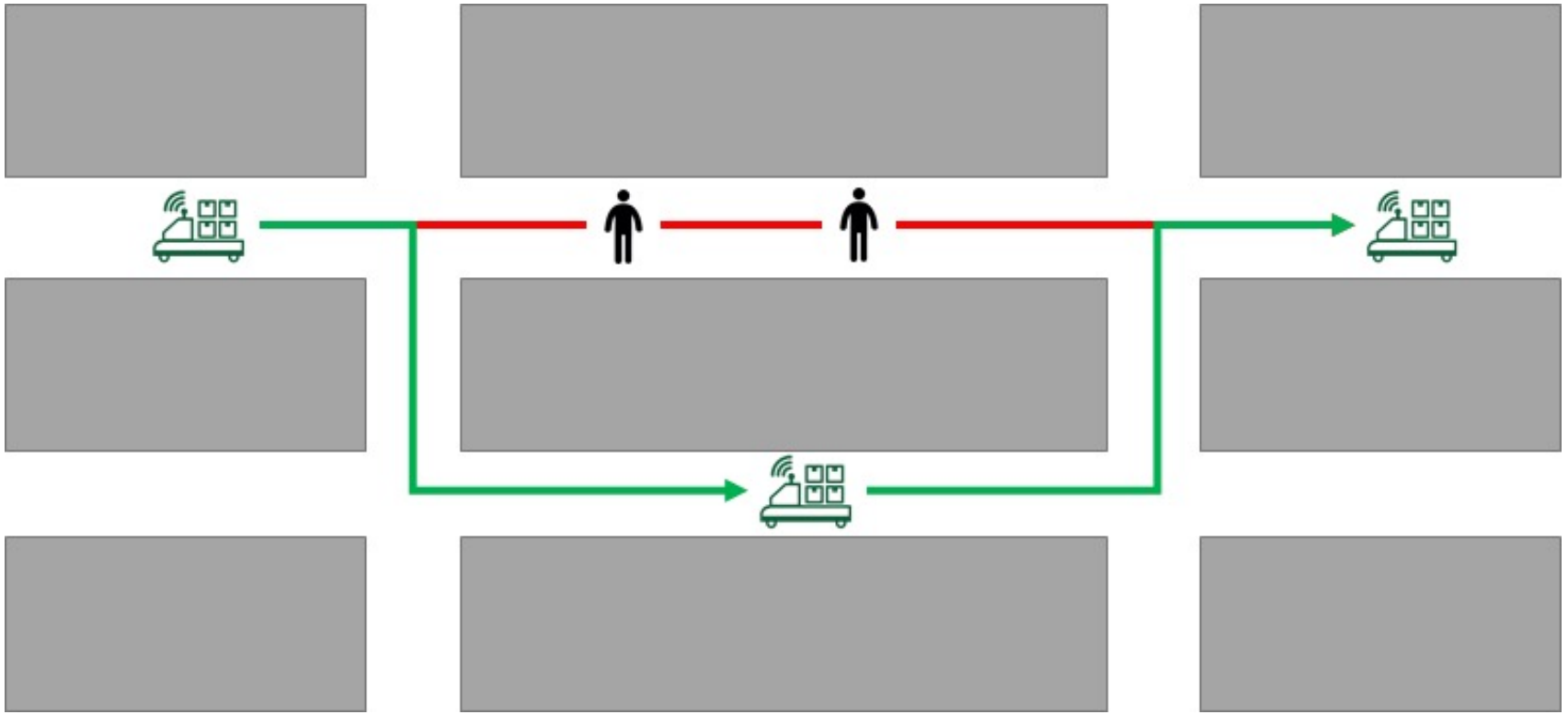
2nd block: Logistics and Automation Agent optimization and Material flow

Architecture



2nd block: Logistics and Automation **Temporal heat maps**

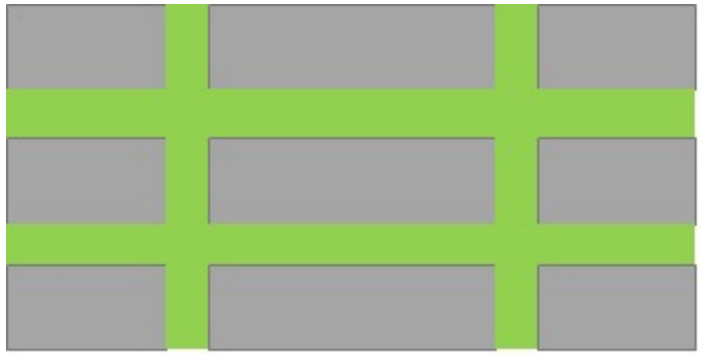
The shortest path ≠ fastest path for an AGV if humans are around!



2nd block: Logistics and Automation **Temporal heat maps**

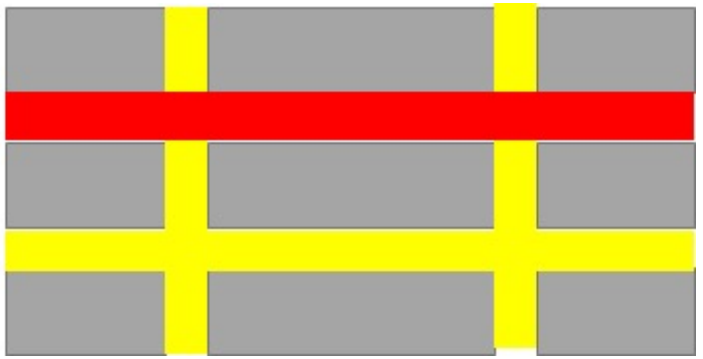
Using stationary lidars and AGVs, data about foot traffic is gathered during various work hours.

Data is aggregated in heat maps indicating the probability that a hallway will be occupied by humans.



10:00-11:00 local time

Not much traffic



12:00-13:00 local time

Much more traffic. One hallway especially (probably the one leading to the cafeteria)
AGV should avoid that hallway during lunch hour

Route Planning is not part of the Temporal Heat Map

2nd block: Logistics and Automation **Temporal heat maps**

We can provide you with 10 lidars to be installed in your factory hall for a period of 2 weeks for collecting data

- Will require access to WLAN or LAN to transmit data
- Will require access to internet for storing data

This results in a heatmap with the following resolution:

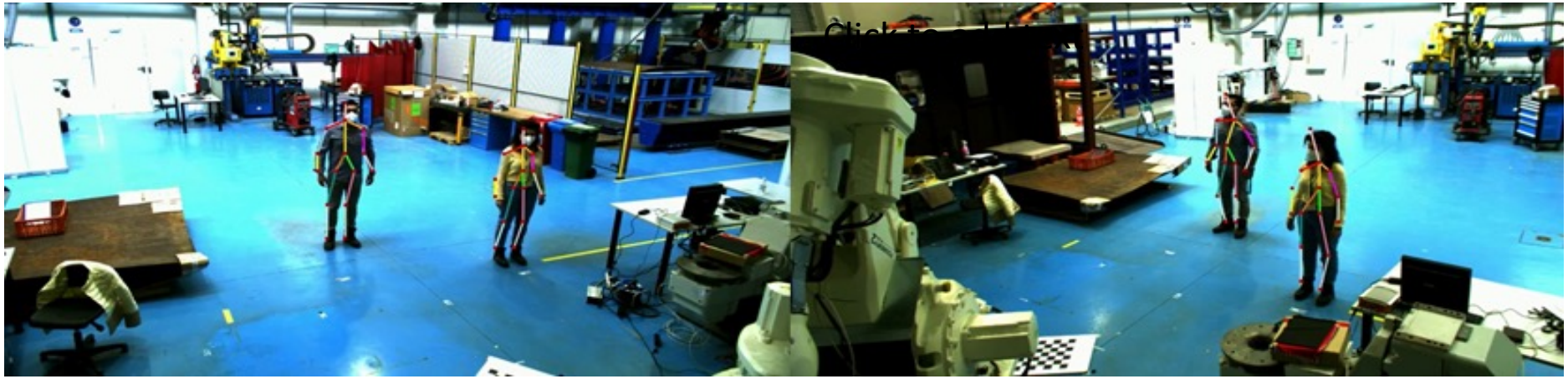
- Time: per 1 hour
- Space: per 1 m2

You could leave the lidars installed (1 x lidar + raspberry ~500 €)

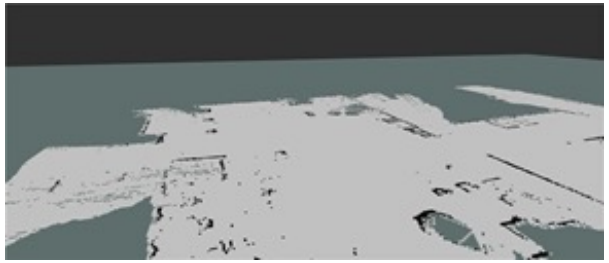
2nd block: Logistics and Automation Person Detection and Tracking

Monitor the occupancy in the shopfloor using stereo pairs from regular 2D cameras.

It is intended to be used in the shared space between robots and humans and allows for dynamic replanning when people is detected, either at global planning level or at robot local level.



Detection of workers and pose estimation using RGB cameras



Poses of the persons detected are included in the occupancy gridmap

Logistics and Automation – Use cases

Logistics library (OPIL) – Use case 1

#1 Challenge

PuntoArt is a small Italian company providing embroidery & trimmings to major fashion brands. The raw materials and half-finished products were carried in cases from workstation to workstation by factory workers. The process was spread on two separate floors, which meant workers were spending a considerable amount of time waiting for the elevator.

#2 Solution

Digital Twin was created to simulate current and future paths and also all functions of Jobot. The Jobot will pick up and deliver loads between workstations and use the elevator independently whenever needed. Workers will call Jobot with their tablets or smartphones and select its next task. The most important changes concerned the scheduling of the tasks assigned to Jobot and the interface with the lift.

#3 Result

The time spent on manually moving materials was reduced significantly. Before the experiment workers spent 20% of their time (Full Time Equivalent) moving materials manually between two floors. After the implementation this was reduced to approximately 2%.

Logistics and Automation – Use cases

Logistics library (OPIL) – Use case 2

#1 Challenge

Procalçado is a shoe component manufacturer operating in Portugal. By improving the indoors logistics, Procalçado wanted to reduce machine downtime and improve just-in-time delivery in the factory. The company also wanted to improve the safety of the workers during mould change operation.

#2 Solution

The solution was divided in 2 parts: Design Material handling solution where an AGV delivers the material boxes (raw material or finished product) to a set of gravity-based conveyors. OPIL was used to integrate each task as a mission, giving coordinates for each task as the infrared sensors detects a box. For the mould change, Ewen created a structure to help the mould change operation where OPIL serves the operator with the SAP orders of the day, identifying which what moulds are needed.

Logistics and Automation – Use cases

Logistics library (OPIL) – Use case 2

#3 Result

Productivity was increased by 5% with machines using AGV's, the number of accidents was reduced by 72% and zero accidents occurred during mould change. This helped to increase job satisfaction among the factory workers. The increase in net profit, on a yearly basis, due to quicker production is estimated to be over 9%.

Logistics and Automation – Use cases

Agent optimization – Use case 1

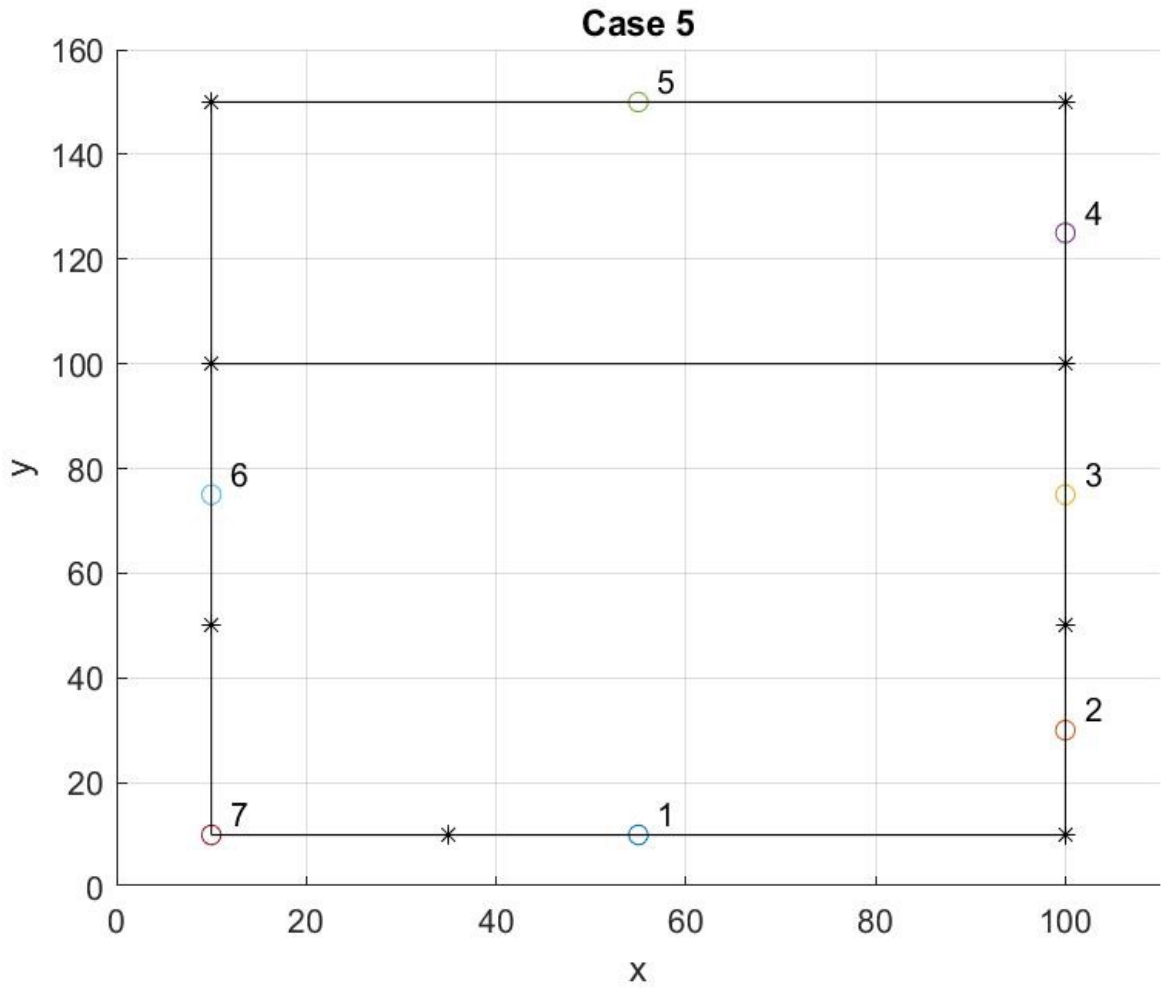
- Defining the position of stations, path between stations, agent parameters (load time, unload time, traffic factor, …) by
  - manual entry
  - or as input from **material flow** node
    - using existing agent node (logistics library)
    - using data logs from database

In the use case manual entry will be presented.

Logistics and Automation – Use cases

Agent optimization – Use case 1

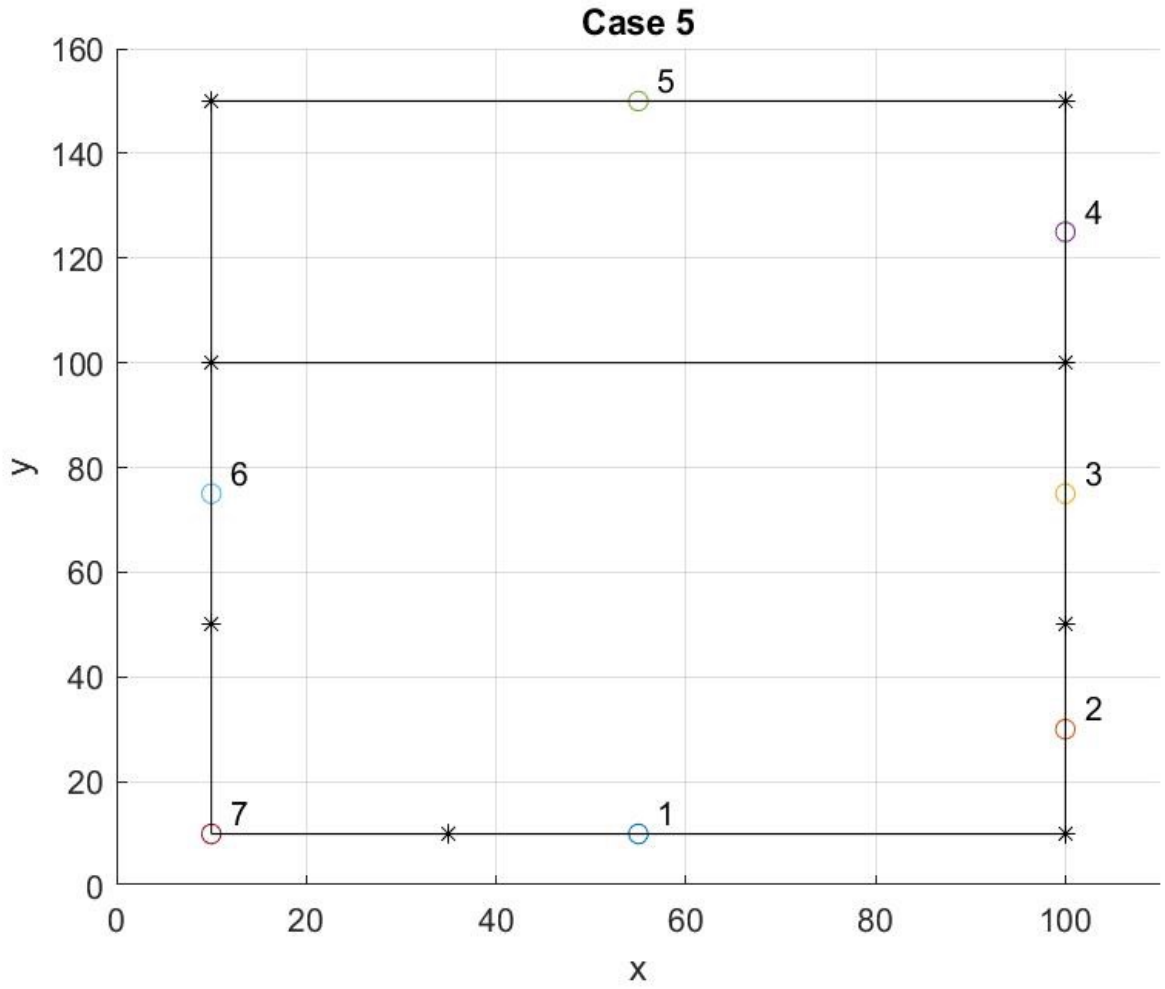
- Defining the layout
  - Scale 100m x 160m
  - Station positions
    - stations{1}.xy=[55,10]
    - stations{2}.xy=[100,30]
    - stations{3}.xy=[100,75]
    - stations{4}.xy=[100,125]
    - stations{5}.xy=[55,150]
    - stations{6}.xy=[10,75]
    - stations{7}.xy=[10,10]



Logistics and Automation – Use cases

Agent optimization – Use case 1

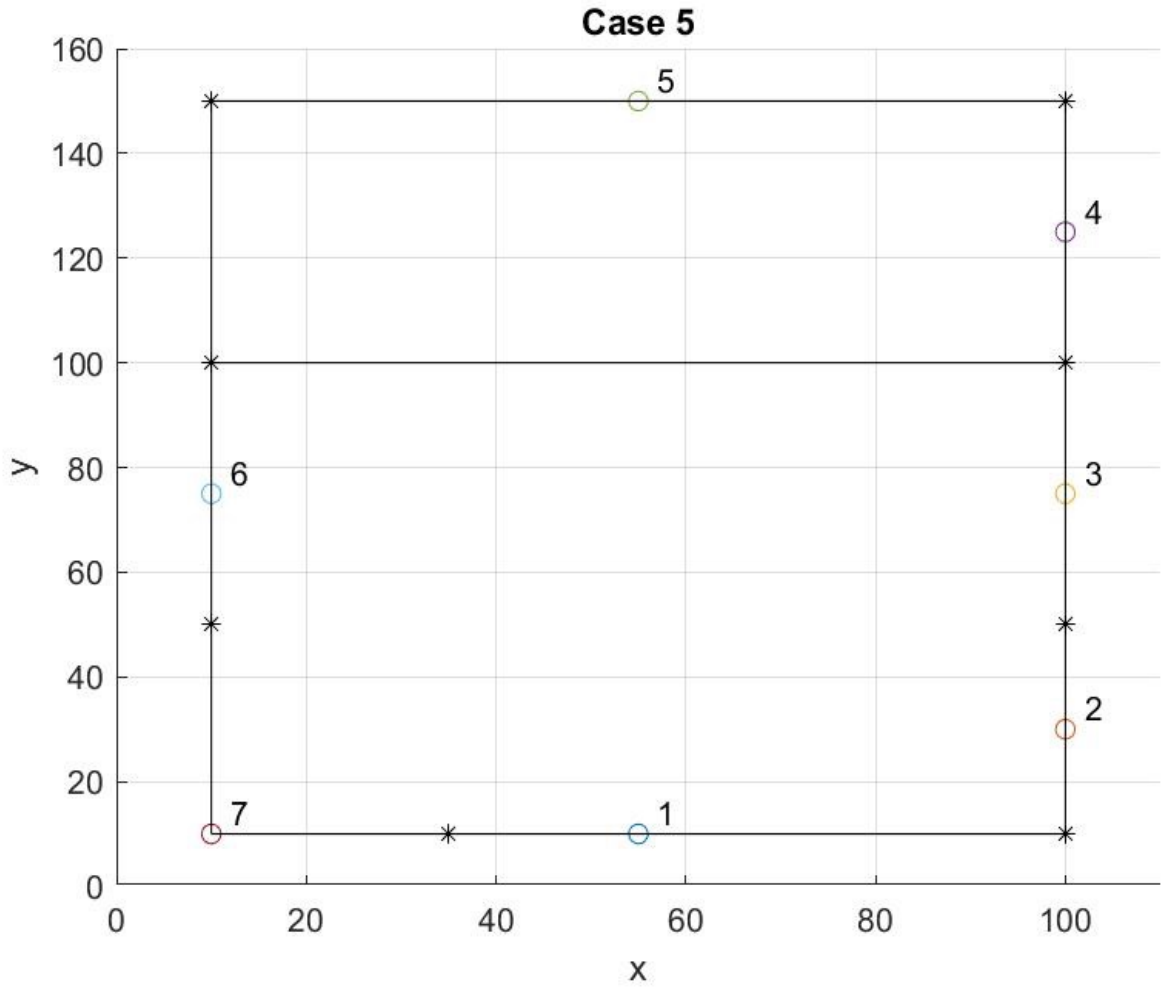
- Defining path between stations
  - stations{1}.pathto{2}=[100,10]
  - stations{2}.pathto{3}=[100,50]
  - stations{3}.pathto{4}=[100,100]
  - stations{3}.pathto{6}=[100,100;10,100]
  - stations{4}.pathto{5}=[100,150]
  - stations{5}.pathto{6}=[10,150;10,100]
  - stations{6}.pathto{7}=[10,50]
  - stations{7}.pathto{1}=[35,10]



Logistics and Automation – Use cases

Agent optimization – Use case 1

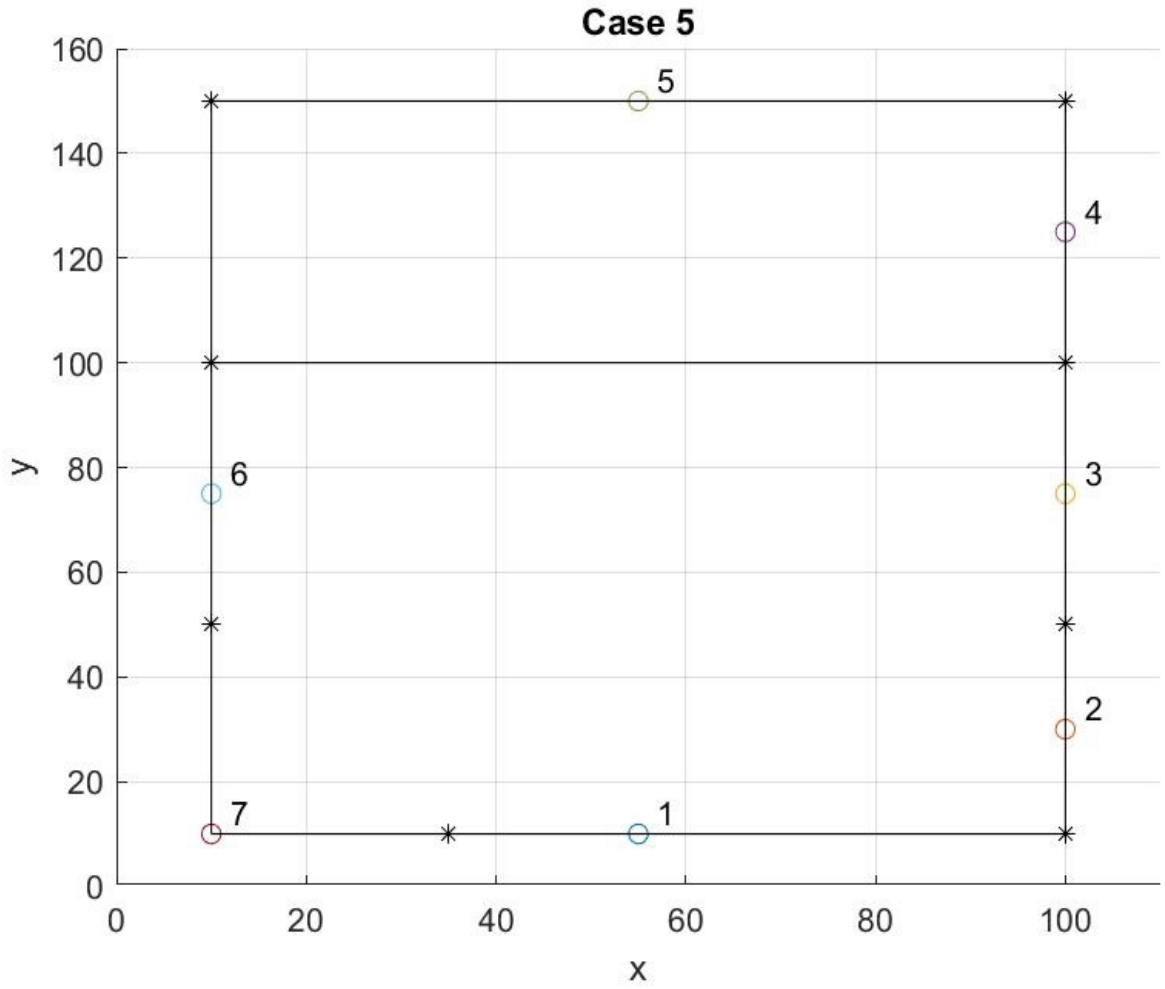
- Defining agents
  - Manual entry (**agent 1**)
    - agent speed (50 m/min)
    - load time (0.75 min)
    - unload time (0.5 min)
    - capacity (**1**)
    - availability (1)
    - traffic factor (0.9)
    - operator efficiency (1.0)



Logistics and Automation – Use cases

Agent optimization – Use case 1

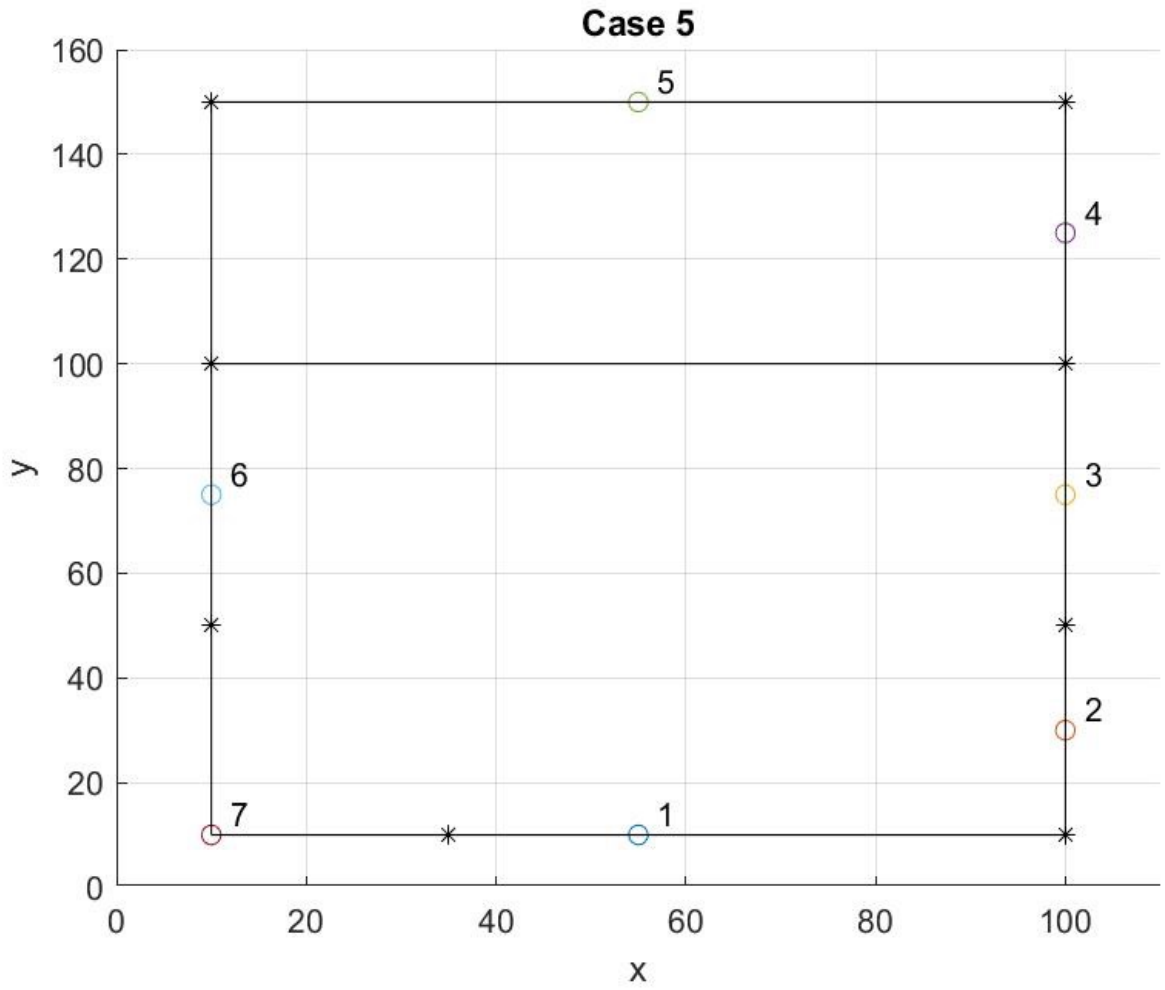
- Defining agents
  - Manual entry (**agent 2**)
    - agent speed (50 m/min)
    - load time (0.75 min)
    - unload time (0.5 min)
    - capacity (**100**)
    - availability (1)
    - traffic factor (0.9)
    - operator efficiency (1.0)



Logistics and Automation – Use cases

Agent optimization – Use case 1

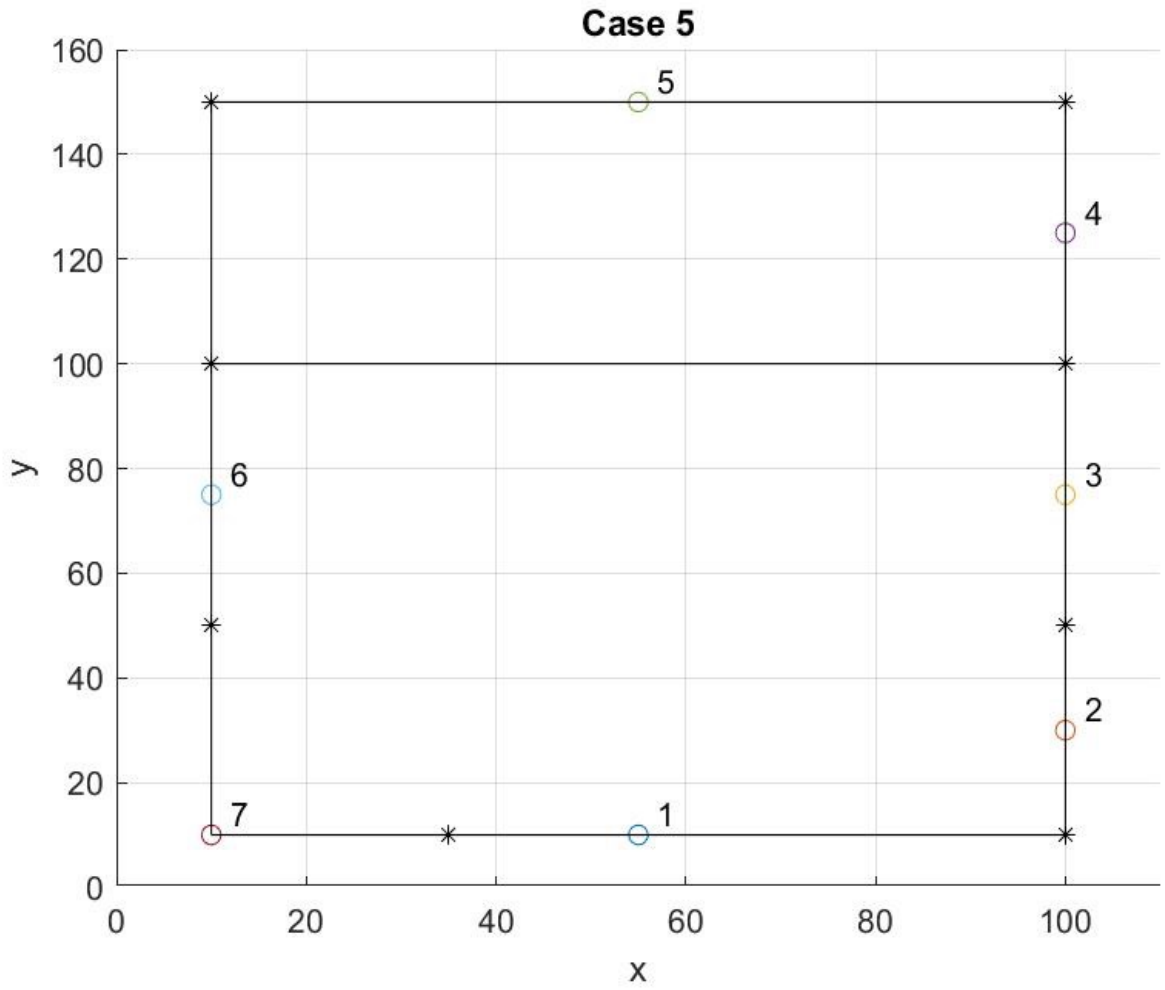
- Defining the flow rate
  - Manual entry (**agent 1**)
    - stations{1}.flowrate{1,2}=200
    - stations{2}.flowrate{1,3}=200
    - stations{3}.flowrate{1,4}=100
    - stations{3}.flowrate{1,6}=100
    - stations{4}.flowrate{1,5}=100
    - stations{5}.flowrate{1,6}=100
    - stations{6}.flowrate{1,7}=200
    - stations{7}.flowrate{1,1}=-1



Logistics and Automation – Use cases

Agent optimization – Use case 1

- Defining the flow rate
  - Manual entry (**agent 2**)
    - stations{1}.flowrate{2,2}=200
    - stations{2}.flowrate{2,3}=200
    - stations{3}.flowrate{2,4}=100
    - stations{3}.flowrate{2,6}=100
    - stations{4}.flowrate{2,5}=100
    - stations{5}.flowrate{2,6}=100
    - stations{6}.flowrate{2,7}=200
    - stations{7}.flowrate{2,1}=-1

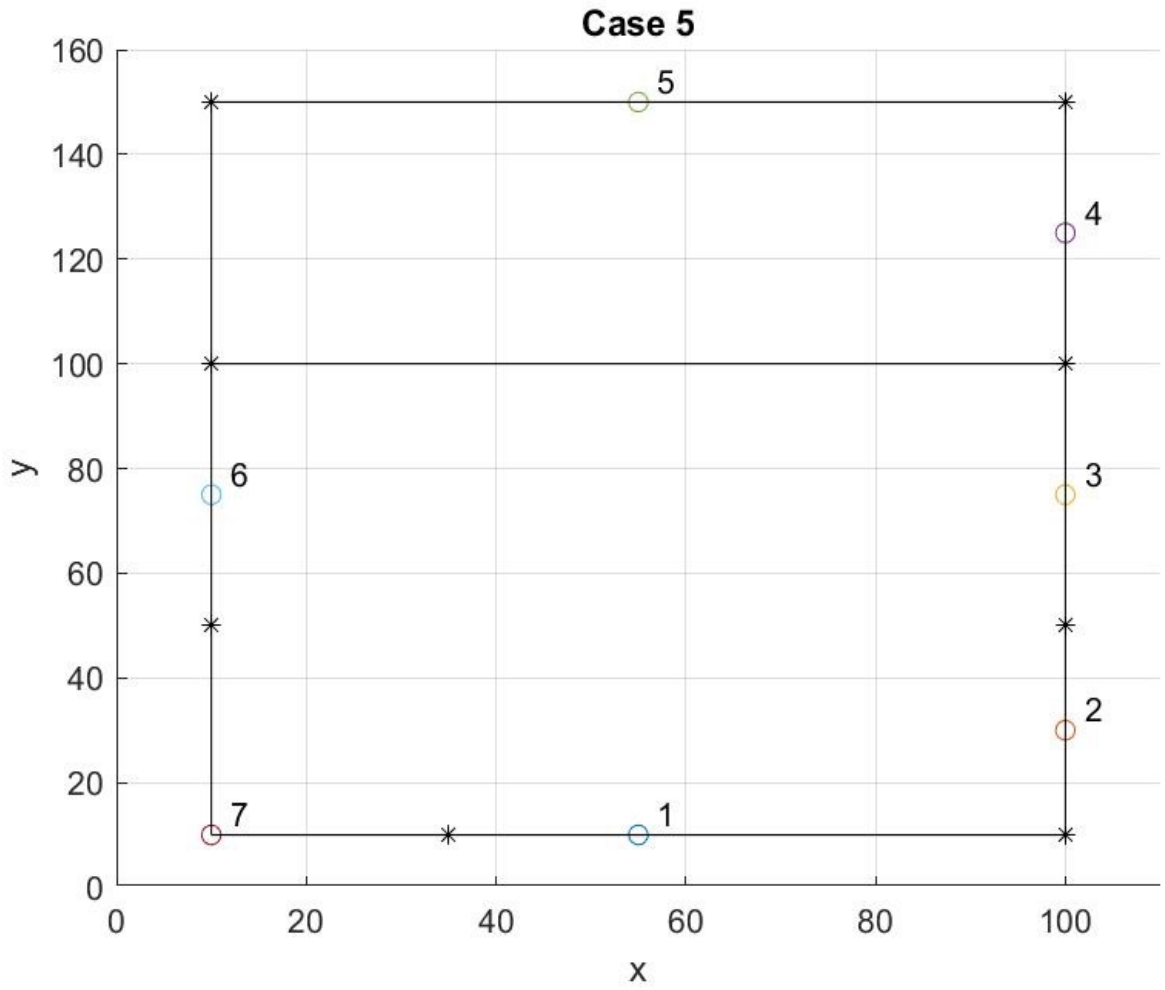


Logistics and Automation – Use cases

Agent optimization – Use case 1

- Calculating the distance matrix

0	65	0	0	0	0	0
0	0	45	0	0	0	0
0	0	0	50	0	140	0
0	0	0	0	70	0	0
0	0	0	0	0	120	0
0	0	0	0	0	0	65
45	0	0	0	0	0	0

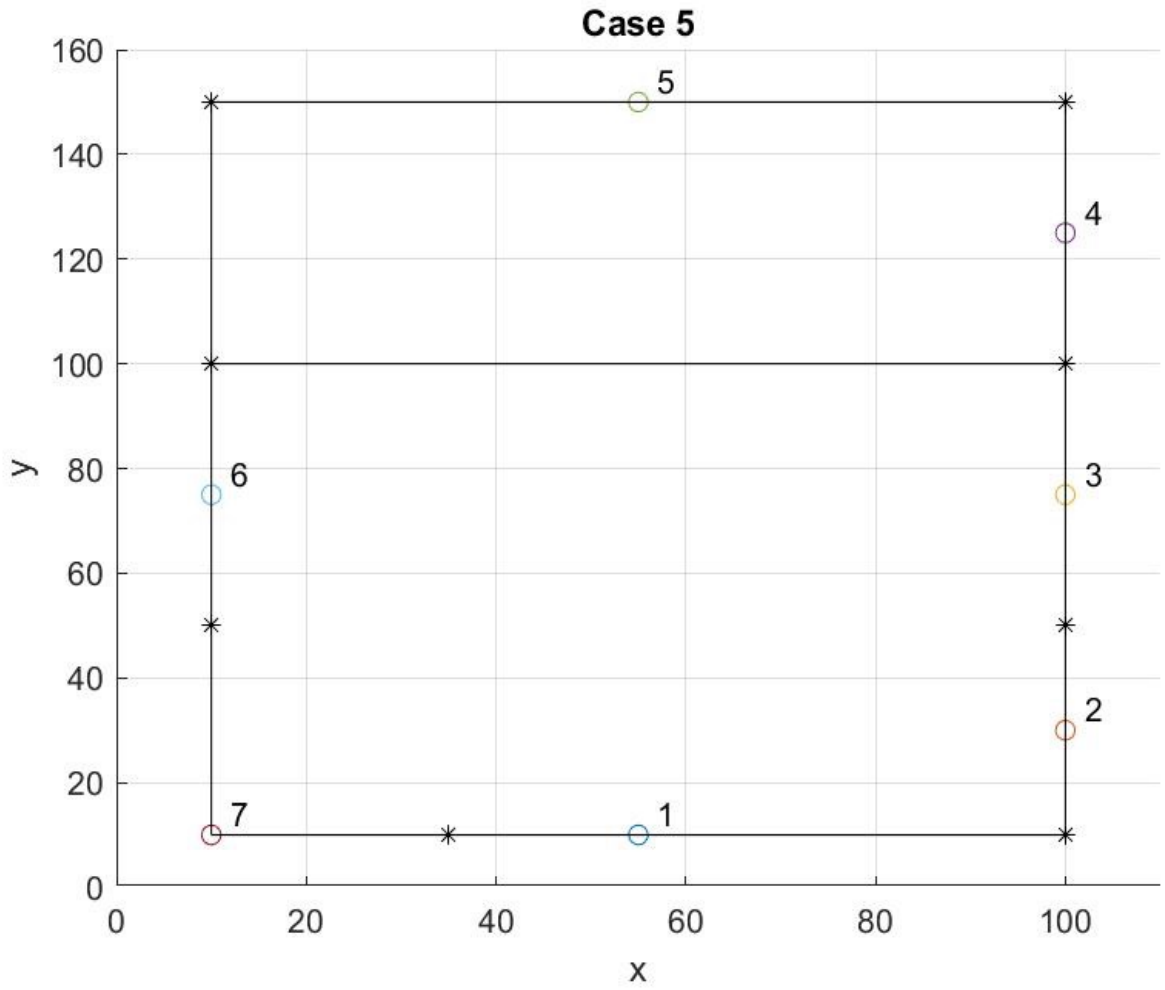


Logistics and Automation – Use cases

Agent optimization – Use case 1

- Calculating the flow rate matrices for agents

0	200	0	0	0	0	0
0	0	200	0	0	0	0
0	0	0	100	0	100	0
0	0	0	0	100	0	0
0	0	0	0	0	100	0
0	0	0	0	0	0	200
-1	0	0	0	0	0	0



Logistics and Automation – Use cases

Agent optimization – Use case 1

Agent 1 results

- Ideal cycle time per delivery per vehicle is 3.61 [min]
- Ideal cycle time per delivery per vehicle is 3610 [min / hr]
- Available time per hour per vehicle 51.3 [min / hr per vehicle]
- Number of required vehicles 70.37
- Rounded number of required vehicles **71**

Logistics and Automation – Use cases

Agent optimization – Use case 1

Agent 2 results

- Ideal cycle time per delivery per vehicle is 2.165 [min]
- Ideal cycle time per delivery per vehicle is 2164.6 [min / hr]
- Available time per hour per vehicle 51.3 [min / hr per vehicle]
- Number of required vehicles 42.195
- Rounded number of required vehicles **43**

3rd block: Resource optimization

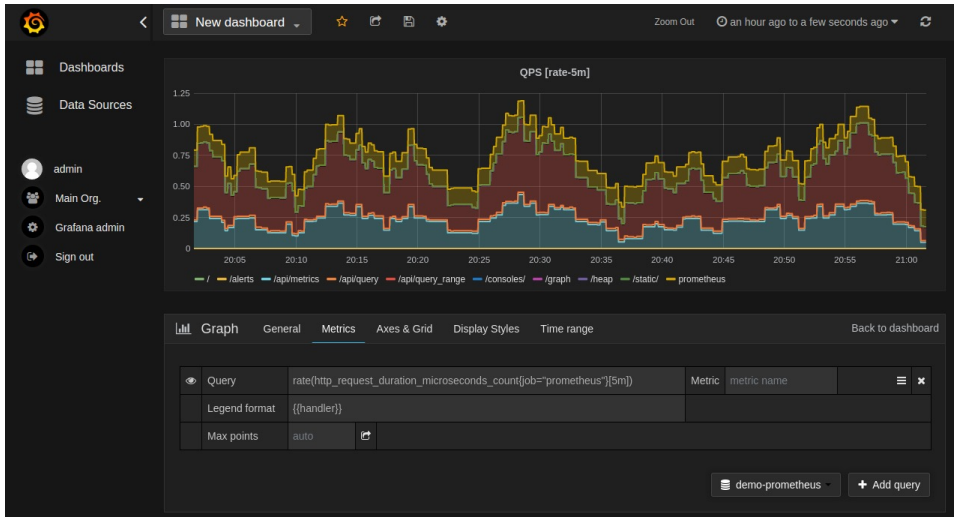
Resource optimization package will be the module thought to guarantee, to companies joining Better Factory platform, optmization of resources in terms of energy, resources, waste. Data analytics tool will be provided to create optimal solution to minimise consumption, RAMP usage will guarantee real time data visualization and time/effort resource optimization. Tools proposed in this module will guarantee consumption of resources management.

- Technologies involved:
  - GRAPHANA DASHBOARD
  - BUSINESS PROCESS OPTIMIZATION
  - PRODUCTION OPTIMIZATION

3rd block: Resource optimization

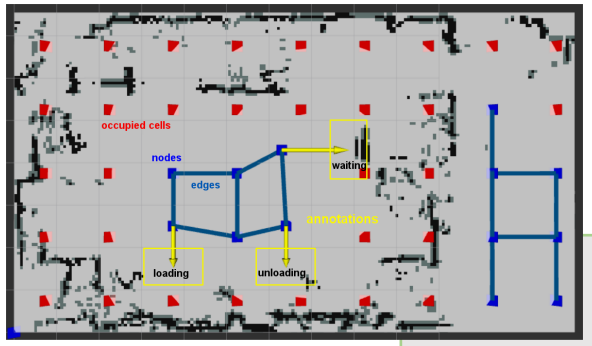
GRAFANA DASHBOARD

- Grafana is an open source software enabling graphics creations as docker images. Holonix will offer his experience in Grafana dashboard to configure graphics and connecting data sources, it will not be installed cause already present in RAMP.



Level 3: Functional element view
Resource Optimization

Topology (gridmap)



Task Specification

signifies the capabilities and constraints of the agents acting on the factory floor

```
{
   "Environment":{
        "locations":{...},
        "agents":{
                "robot_1", "human_1", "item_1" } },

   "Capabilitites":{
        "robot_1":{...},
        "human_1":{...},
        "item_1":{...}  },

   "Constraints":{
        "robot_1":{...},
        "human_1":{...},
        "item_1":{...}  },

   "Starting_point":{...},

   "Objective":{...}
}
```

Input data

Business Process Optimization

Task Planner

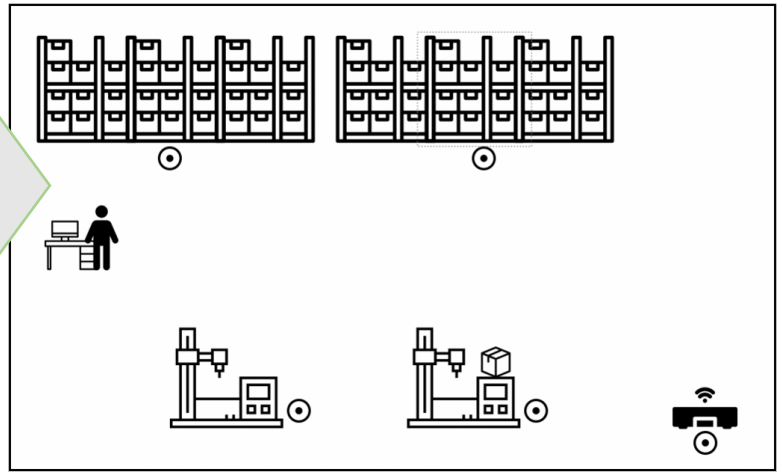
Task Specification Parser

Communication Stack

Output data

Optimal Task Plan

minimizes the logistics resources required and the total cost of the given task.



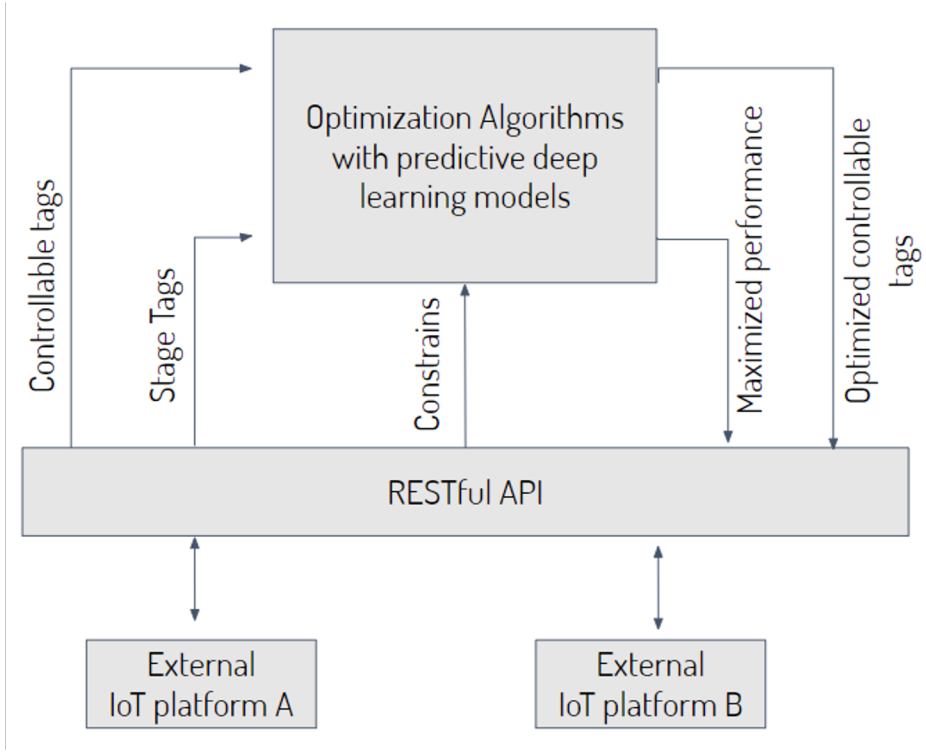
AI for Resource Optimization

- The focus areas for **Top Data Science** in Better Factory project is to further develop AI based optimization capabilities especially in the area of **Resource Optimization**
- The primary focus of the optimization so far has been the Paper & Pulp industry, but similar optimization approaches and technologies can be used in other industries as well
- The new AI technology approach in this context is to use **Deep Learning** in modeling and predicting the process performance

Optimization Concept & Approach

Top Data Science optimization architecture can be used to any optimization process by applying the following approach:

1. Defining the **process** and its stages
2. Identifying the **optimization objective**
3. Identifying the **input parameters** (tags)
    - Stage tags
    - Controllable tags
4. Selecting the **integration approach** and creating the **data pipelines**
5. Assessing to which extent **historical data** is available and needed for the specific optimization problem (customer own data, other similar process data, ready-to-use models)
6. Selecting the **optimization** deep learning model **approach** and creating the model
7. Testing the model with new process data to **verify** the **performance** and to finetune the optimization
8. Deploying the solution to **production**



As a **result** the optimization provides values both for estimated **optimal future process performance** and how that can be achieved through controllable parameters.

Aiya™- AI solution for High-Performance Industrial Processes

Aiya is a state-of-the-art AI solution that is used for optimizing and steering industrial processes

- Aiya utilizes historical and real-time data
- Aiya models the process performance and predicts its output with high accuracy
- Aiya enables steering and optimization of process output through an easy-to-use and robust application

Aiya™ - Key functionality

Optimizing the use of chemicals and raw materials

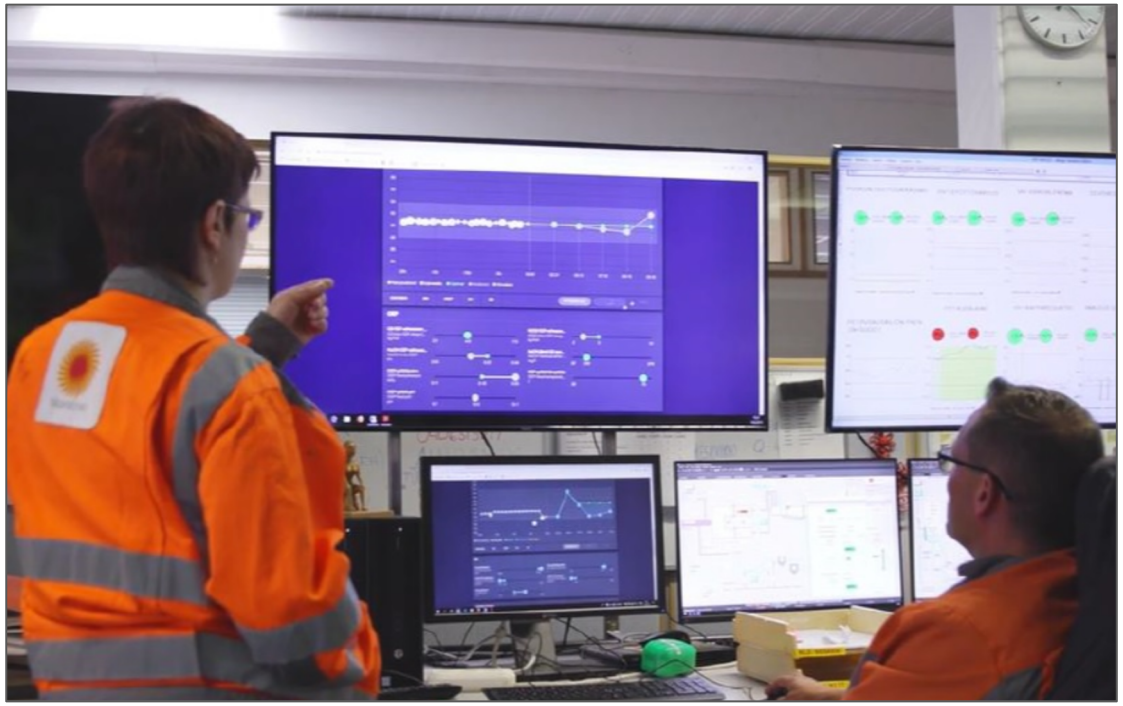
- Taking into account the target quality and the given production configuration
- Aiya is able to minimize the amount of chemicals needed to achieve production targets

Simulations to predict performance of different production configurations

- Aiya enables users to virtually modify process parameters
  and run simulations to create different production scenarios.
- Different configuration setups can be stored for future usage

Advisory tool to guide the daily operations

- Engineers and operators can provide instructions to colleagues or contractors for their work.



Aiya™ - Key benefits

LOWER RISKS AND HIGHER PREDICTABILITY

- Improved ability to forecast the process outcomes and the need of resources
- Scenario analysis and simulations to increase the reliability of the process

COST SAVINGS THROUGH MINIMIZED USE OF RESOURCES

- Significant cost savings are achieved as the optimization directly minimizes the use of chemicals and in-directly the use of energy

IMPROVED DECISION MAKING AND WORKING ENVIRONMENT

- Improved transparency, communication and clarity on process status, production plans and operative tasks
- Support for real-time decision making based on continuously updated information about process status

4th block: Production reconfiguration

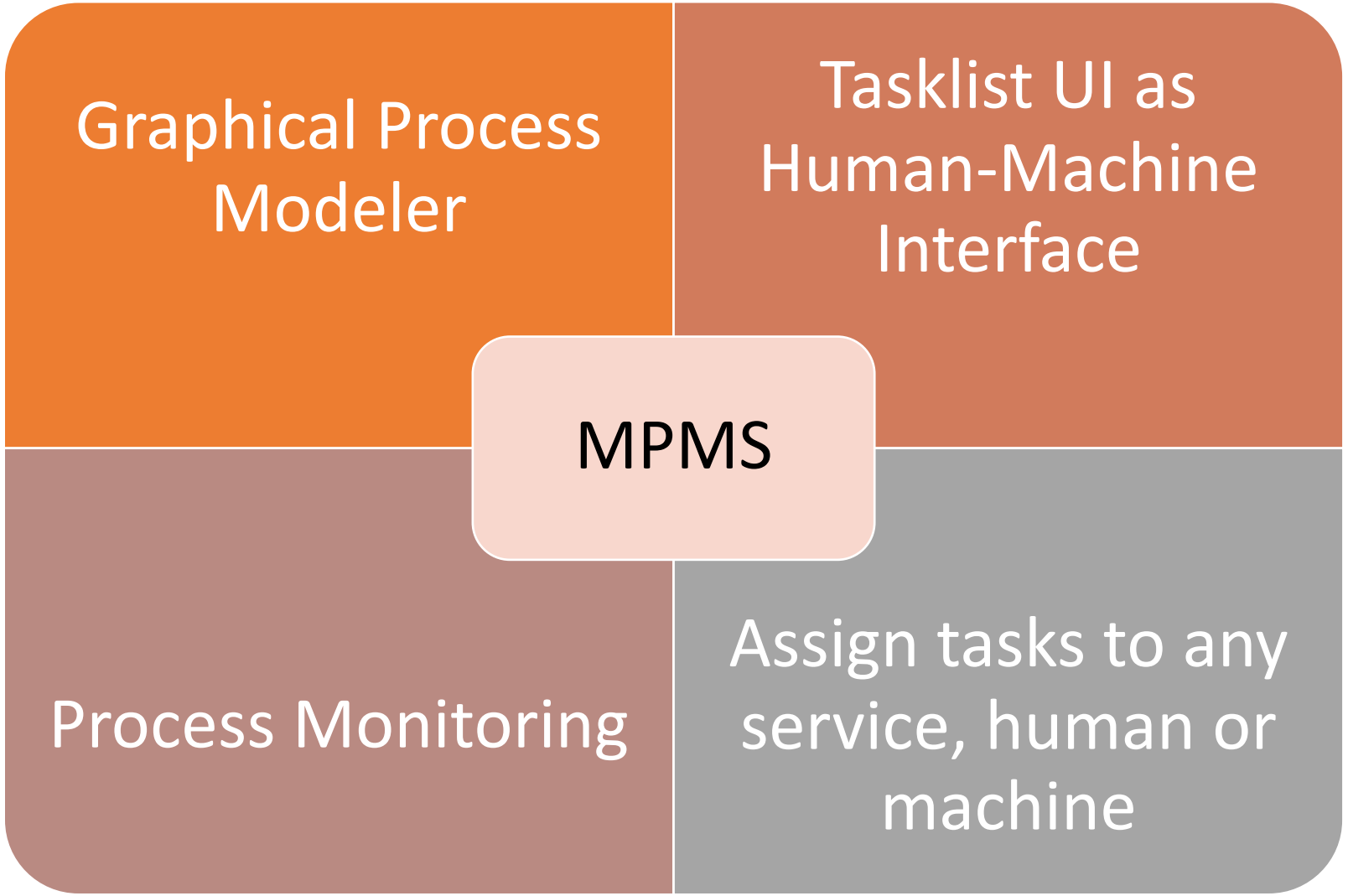
The production reconfiguration refers to the reconfiguration of the production line and the tasks of the automated and human actors (equipment, robots, workers) in the production floor, in order to produce different variants / personalisations of a product.

- Technologies involved:
  - MANUFACTURING PROCESS MANAGEMENT SYSTEM
  - ADVANCED PLANT MODEL

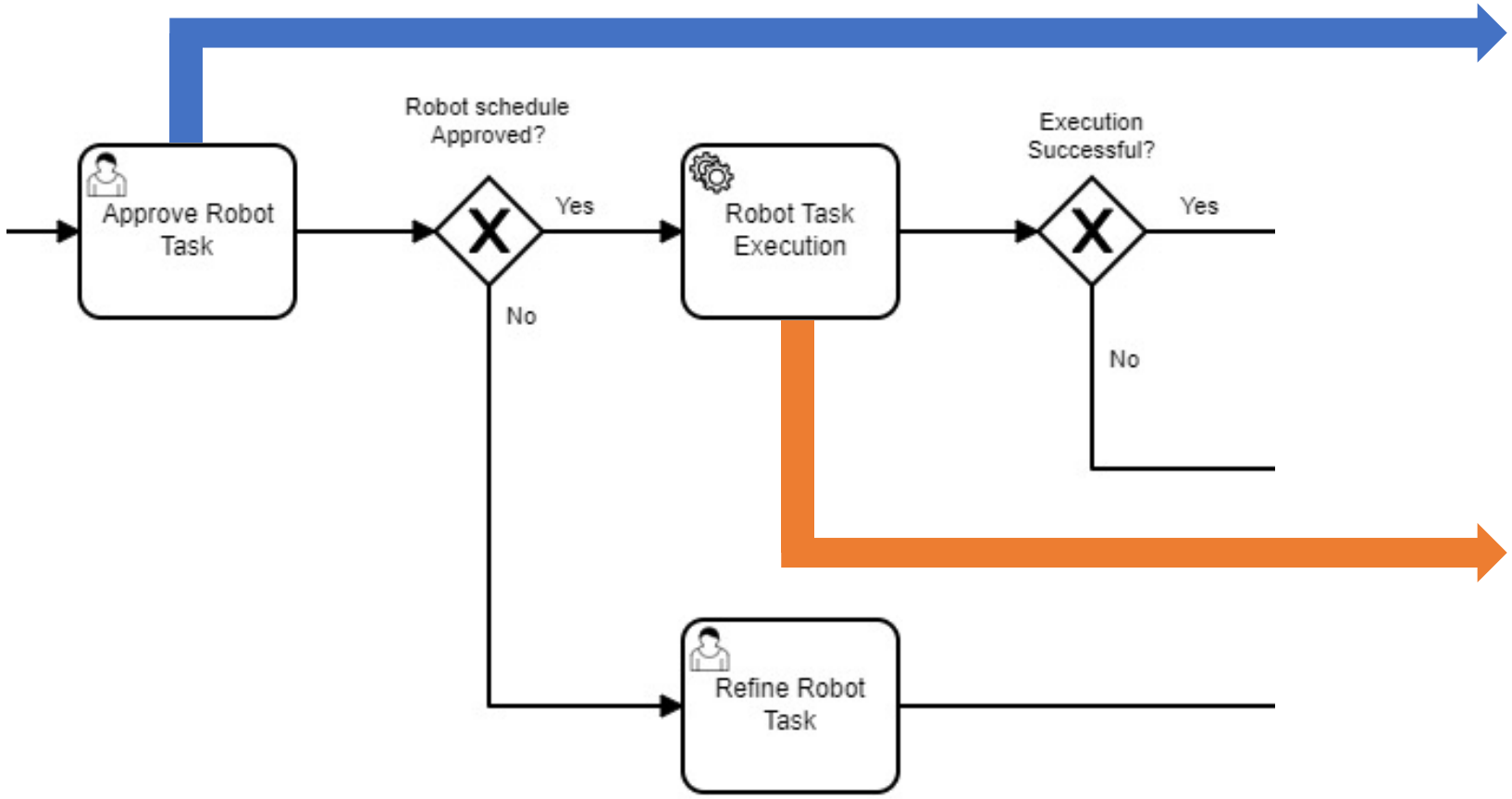
Production reconfiguration: Scope

- For the production of customized/personalized products
- Auto-Reconfigure the production line
- Assign tasks to equipment and workers
- 3D twin of factory line (both real-twin & simulation)

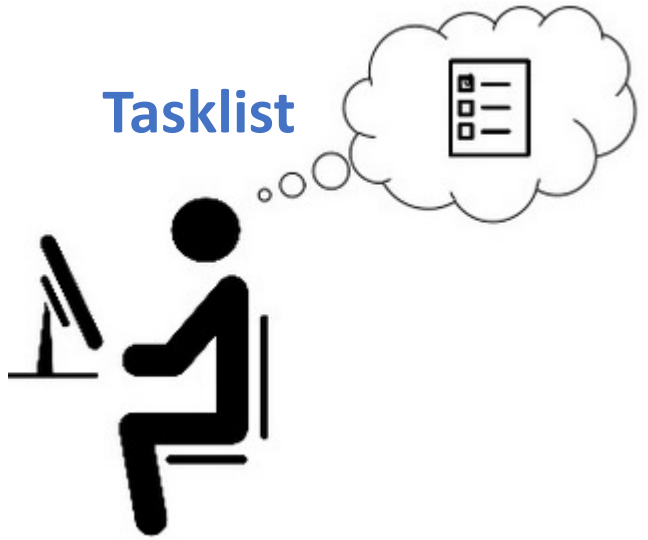
Manufacturing Process Management System (MPMS)



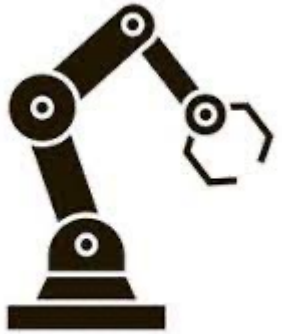
Design Manufacturing Workflows



Tasklist

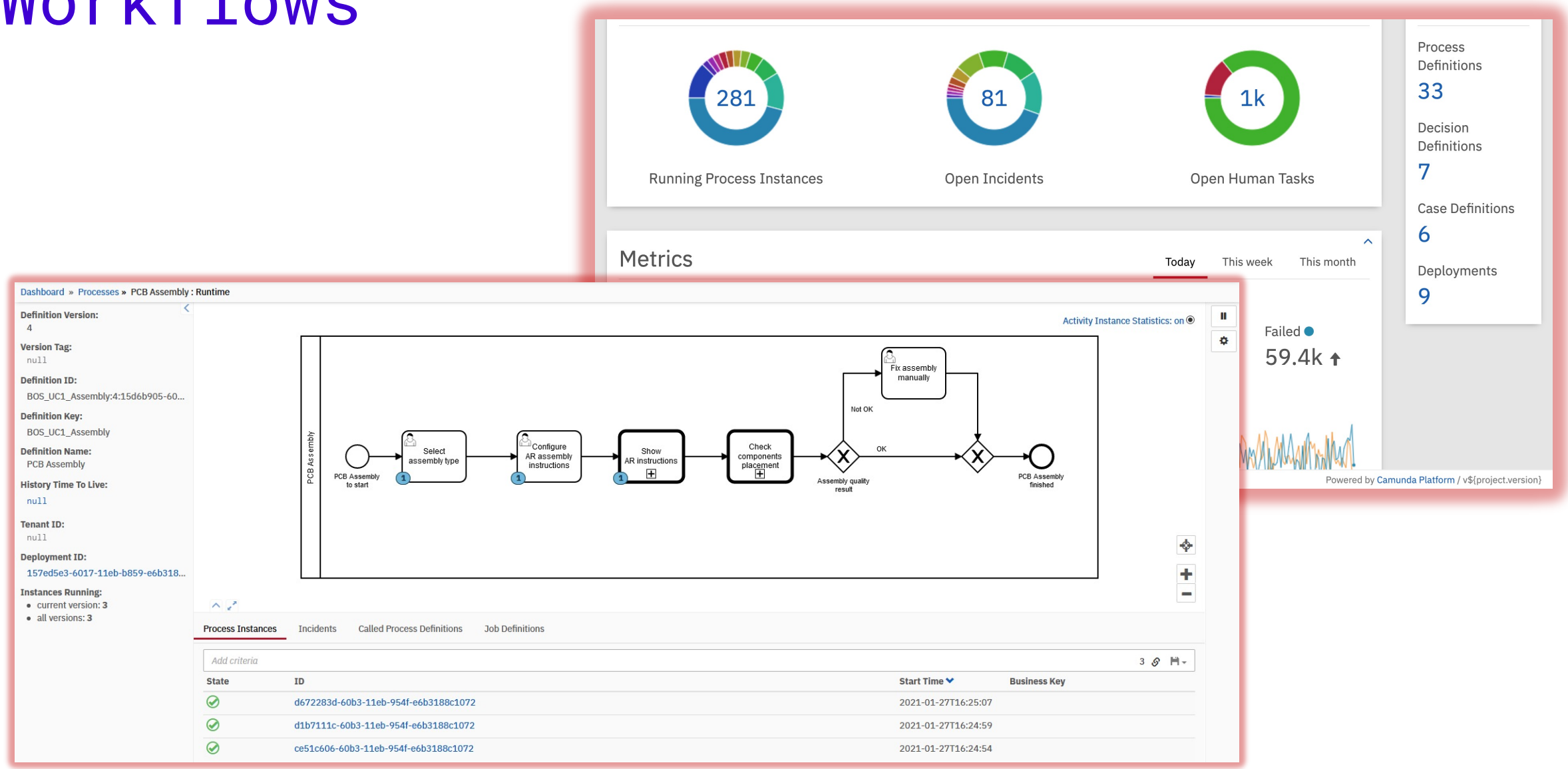


Robot Execution service



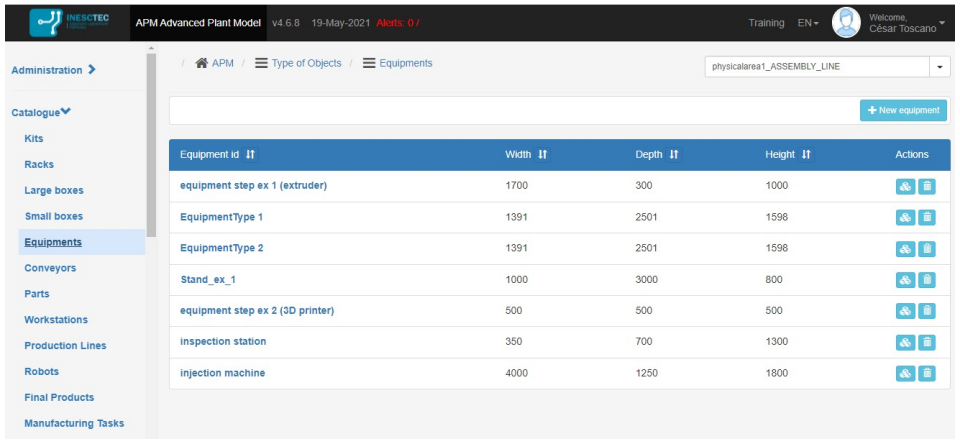
Monitor Multiple Running Workflows

BETTER FACTORY

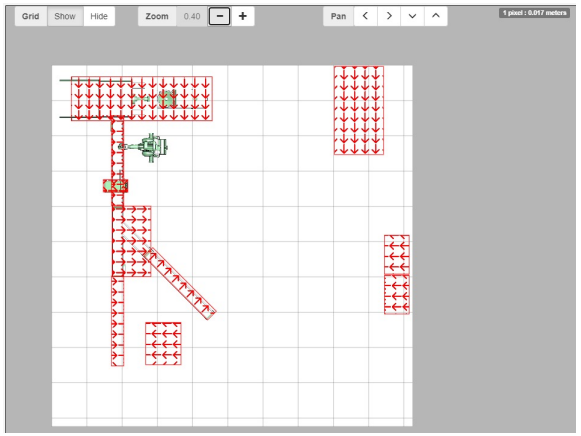


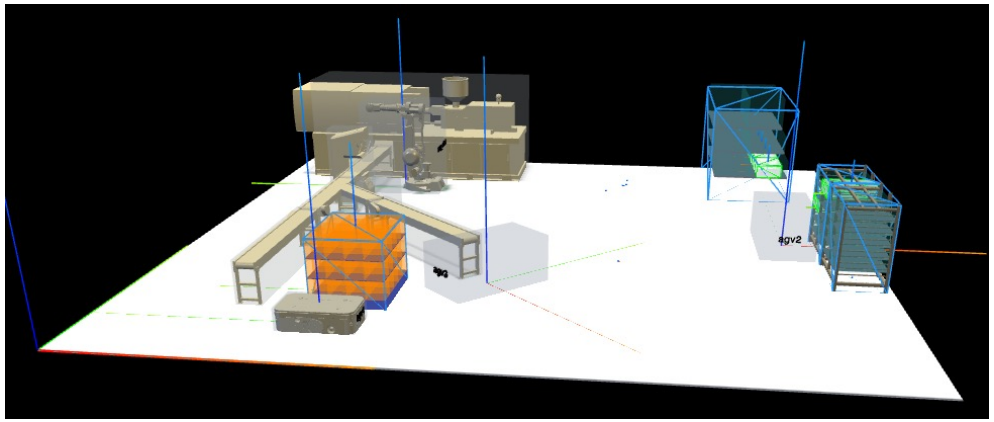
APM component

Build a Catalogue of 3D models for the relevant objects in your manufacturing area



Build a digital representation of your manufacturing area

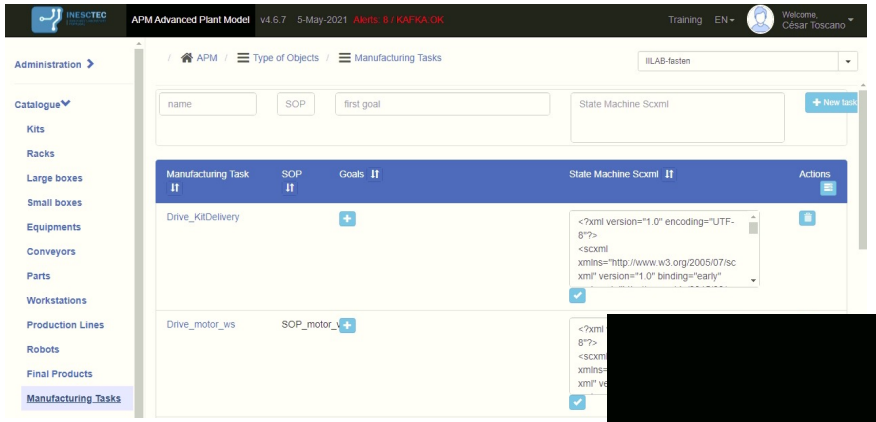


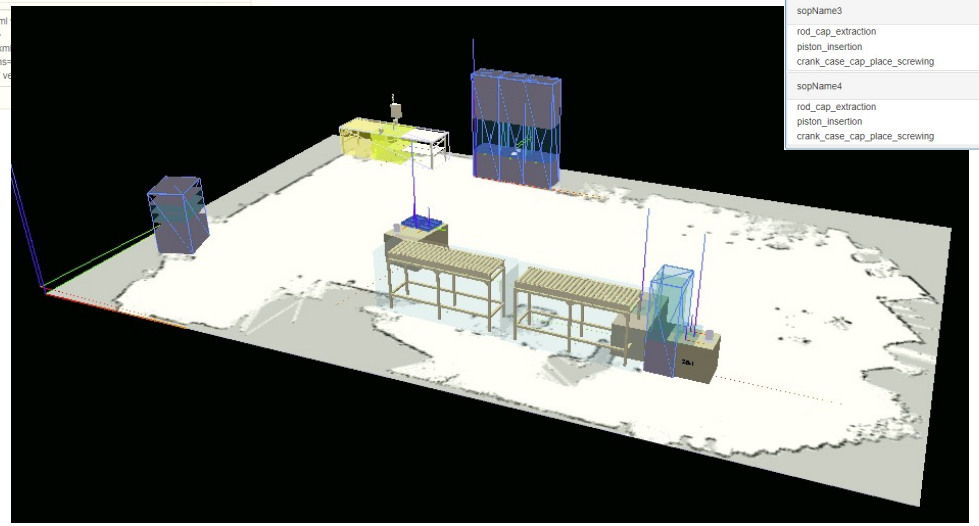


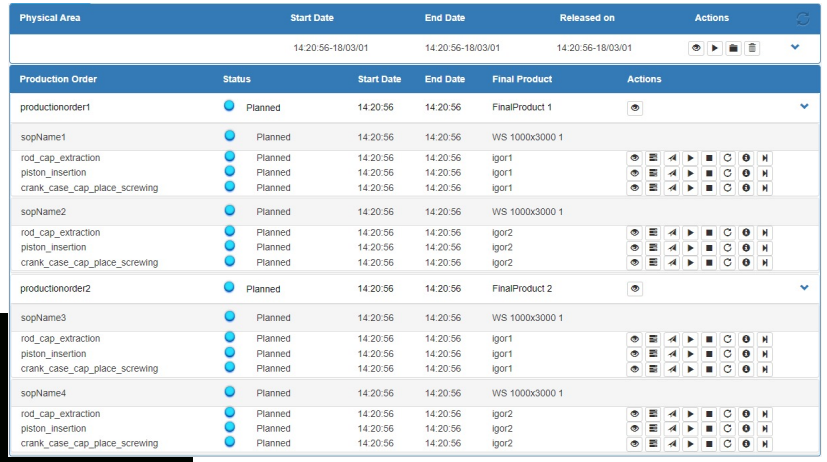
APM component

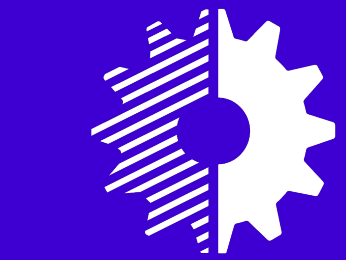
Specify the SCXML state machines for OSPS-compliant robots

Monitor execution of tasks (simulation or real operation)









BETTER
FACTORY