Towards AI powered manufacturing services, processes, and products in an edge-to-cloud-knowlEdge continuum for humans

Pilot 1 – Intelligent scheduling of production

FIIF event

14.03.2024

Parmalat Italy Operation: products/ plants matrix

UHT carton

UHT HDPE-PET

yogurt

Cream

Juice carton PET

MF milk

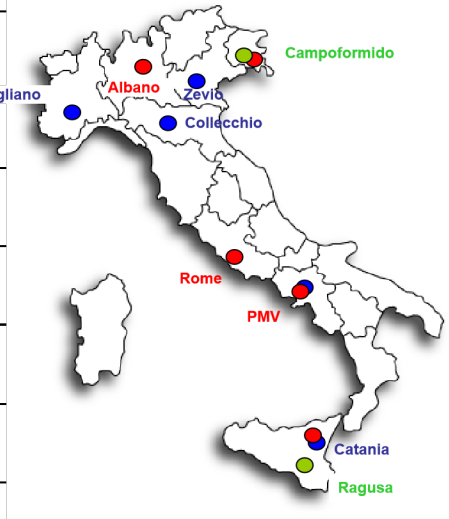
Pasteur. Milk PET Carton

ESI-UHT Cream

dessert

Mozzarella scamorza provola Montasio

	UHT carton	UHT HDPE-PET	yogurt	Cream	Juice carton PET	MF milk	Pasteur. Milk PET	Carton	ESI-UHT Cream	dessert
Collecchio	●	●	●	●	●					●
Zevio	●	●								
Savigliano	●			●					●	●
Catania	●			●			●		●	
Albano						●	●		●	
PMV		●					●		●	
Rome						●	●		●	
Ragusa										
Campoformido			●						●	



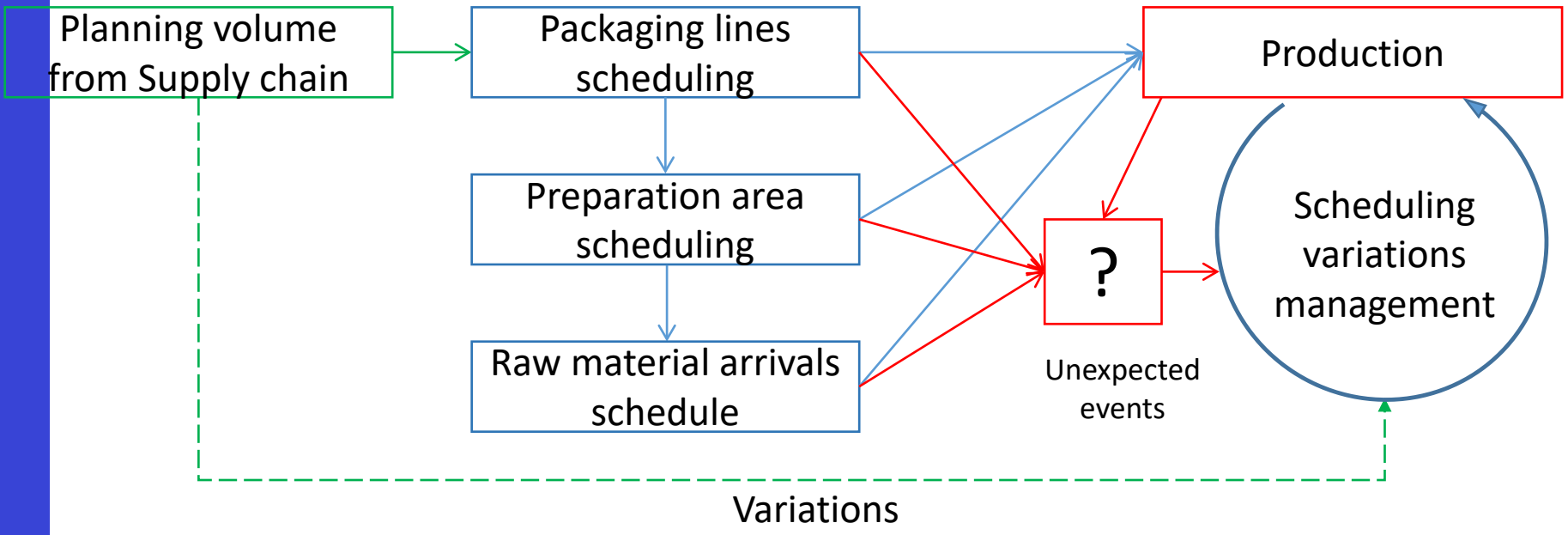
Collecchio Plant

- **Totale Area** **143.000 m²**
- **Totale Covered Area** **45.000 m²**
- **Warehouse (Distrib Center)** **29.000 pallets**

Current situation

cheduling process

The process of scheduling packaging lines with a finite capacity has many constraints and requires a lot of knowledge for operations to proceed at an efficient and possibly leveled pace within the plant, in order to eliminate bottlenecks and organize resources in the best possible way.



- SINAPSI is used to support the scheduling process, but all the constraints and optimizations are managed by human being
- Difficult to swiftly react to unexpected events

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KnowlEdge Contribution

- Our expectation is to create a **finite capacity scheduling tool**, able to optimize production sequences respecting constraints and limits of the entire production process, improving efficiencies and reducing losses.
- The connection with the field data and their analysis will offer a **realistic model of the production plant**, allowing to recognize in **real time the limits** of the plant's production capacity and therefore to react more promptly to changes.
- Through the use of **AI technologies** we would like to be able to carry out **predictive simulations** reducing human input to a minimum (prediction of demand for capacity planning)
- Provide convenient and **intuitive real-time** visualisation tools

What-if Production Scheduling

Parmalat AI-Scheduler

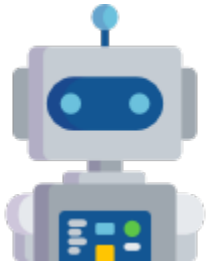
- The goal is to generate a production plan given a set or orders.

List of yogurts to be scheduled

List of machines Machine data

Yogurt cost info (scraps, time)

Compatibilities yogurt-machine



Scheduler

scheduling

Overview

- The plan minimizes the money loss generated by the scraps for fruit and mix yogurt types and the time from changing fruits.
  - Yogurt quantities are computed in minutes of work **using the kg and the speed of machines**
  - When starting an order, it starts on a single machine and does not stop until it is finished.
  - **Yogurt quantities are converted to the corresponding money loss**
  - **The sum of the different money losses is minimized**

model_v2.mzn

```
include "alldifferent_except.mzn";

% COMMON HEADER, probably independent of modelling.
enum MACHINE;
enum YOGHURT_TYPE;
array[MACHINE, YOGHURT_TYPE] of bool: compatibility; % Whether a machine can proc
array[MACHINE, YOGHURT_TYPE, YOGHURT_TYPE] of int: clean_machine_time; % How long
array[MACHINE, YOGHURT_TYPE] of int: yoghurt_speed; % Assuming yoghurt_speed repr

% Parmalat constraints
array[MACHINE, YOGHURT_TYPE, YOGHURT_TYPE] of int: kg_fruit_change; % kg of scrap
array[MACHINE, YOGHURT_TYPE, YOGHURT_TYPE] of int: kg_mix_change; %  kg of scraps
array[MACHINE, YOGHURT_TYPE, YOGHURT_TYPE] of int: monetary_kg_fruit_change;
array[MACHINE, YOGHURT_TYPE, YOGHURT_TYPE] of int: monetary_kg_mix_change;
array[MACHINE, YOGHURT_TYPE, YOGHURT_TYPE] of int: monetary_time_fruit_change;
%array[MACHINE, YOGHURT_TYPE, YOGHURT_TYPE] of float: monetary_kg_raw_change;
%array[MACHINE, YOGHURT_TYPE, YOGHURT_TYPE] of int: kg_raw_scraps; %  kg of scrap

% Different orders with different amounts requested and time to deliver (before e
int: num_orders;
set of int: ORDER = 1..num_orders;
array[ORDER] of YOGHURT_TYPE: order_type;
array[ORDER] of int: yogh_minutes; %yoghurt - free time unit
array[ORDER] of int: deadline;
```

Snapshot of the model

Model Output

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List of solutions sorted by loss

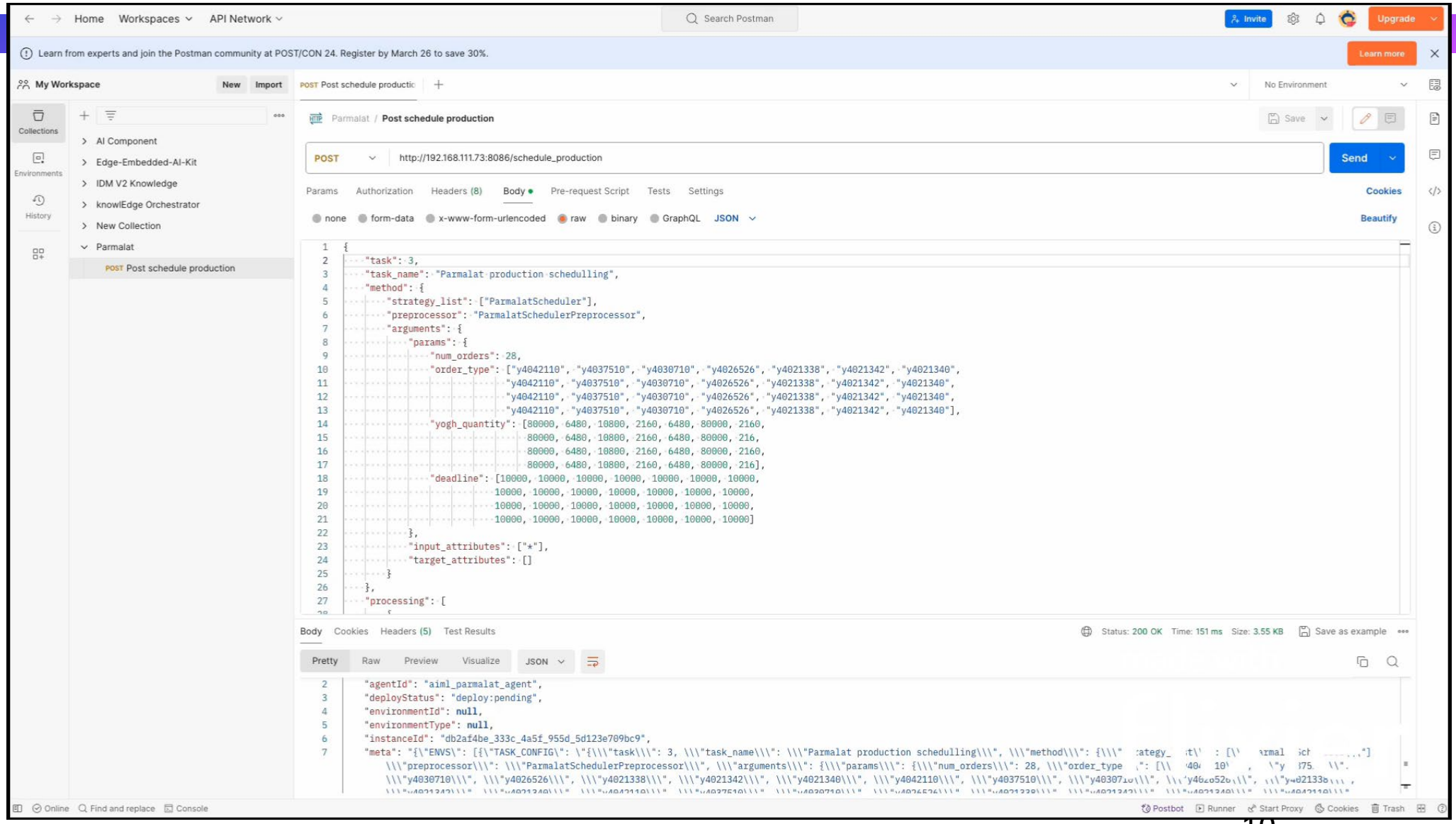
Per each solution:

- Per each machine:
  - List of assigned yogurt order, time start, time end
- Loss

```
----------
start time: [7657, 106, 6204, 6908, 6483, 285, 1
5699, 1097, 5735, 7193]
end time: [7876, 144, 6234, 6964, 6660, 669, 25
1274, 6119, 7194]
workers: [COMAN, HAMBA6, COMAN, ILPRA, HAMBA7, H
HAMBA6, COMAN, COMAN, HAMBA6, COMAN, ILPRA, HAM
Loss value: 48.0
----------
start time: [6659, 7905, 7704, 6624, 9496, 1394
5392, 6874, 5399, 4945]
end time: [6878, 8082, 7734, 6630, 9534, 1778, 6
5448, 6912, 5783, 4946]
workers: [COMAN, HAMBA7, COMAN, COMAN, HAMBA6, H
HAMBA4, COMAN, COMAN, HAMBA7, COMAN, ILPRA, HAM
Loss value: 47.0
----------
start time: [9692, 7277, 5616, 8553, 6163, 608,
2270, 2988, 2524, 6560]
end time: [9911, 7454, 5646, 8609, 6195, 1066, 5
2326, 3020, 2982, 6561]
workers: [COMAN, HAMBA7, COMAN, ILPRA, HAMBA4, H
HAMBA6, COMAN, COMAN, HAMBA7, COMAN, ILPRA, HAM
Loss value: 0.0
----------
```

Example of direct output from the model (* no postprocessing included

Demo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New
Import
POST Post schedule productic
No Environment
Collections
Environments
History
Parmalat / Post schedule production
Save
AI Component
Edge-Embedded-AI-Kit
IDM V2 Knowledge
knowlEdge Orchestrator
New Collection
Parmalat
POST Post schedule production
POST
http://192.168.111.73:8086/schedule_production
Send
Params
Authorization
Headers (8)
Body
Pre-request Script
Tests
Settings
Cookies
none
form-data
x-www-form-urlencoded
raw
binary
GraphQL
JSON
Beautify
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"method": {
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"preprocessor": "ParmalatSchedulerPreprocessor",
"arguments": {
"params": {
"num_orders": 28,
"order_type": ["y4042110", "y4037510", "y4030710", "y4026526", "y4021338", "y4021342", "y4021340",
"y4042110", "y4037510", "y4030710", "y4026526", "y4021338", "y4021342", "y4021340",
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80000, 6480, 10800, 2160, 6480, 80000, 2160,
80000, 6480, 10800, 2160, 6480, 80000, 216],
"deadline": [10000, 10000, 10000, 10000, 10000, 10000, 10000,
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10000, 10000, 10000, 10000, 10000, 10000, 10000,
10000, 10000, 10000, 10000, 10000, 10000, 10000]
},
"input_attributes": ["*"],
"target_attributes": []
}
},
"processing": [
Body
Cookies
Headers (5)
Test Results
Status: 200 OK
Time: 151 ms
Size: 3.55 KB
Save as example
Pretty
Raw
Preview
Visualize
JSON
"agentId": "aiml_parmalat_agent",
"deployStatus": "deploy:pending",
"environmentId": null,
"environmentType": null,
"instanceId": "db2af4be_333c_4a5f_955d_5d123e709bc9",
"meta": "{\"ENVS\": [{\"TASK_CONFIG\": \"{\\\"task\\\": 3, \\\"task_name\\\": \\\"Parmalat production schedulling\\\", \\\"method\\\": {\\\"
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Online
Find and replace
Console
Postbot
Runner
Start Proxy
Cookies
Trash

Monitoring and Proactive Reaction to Events

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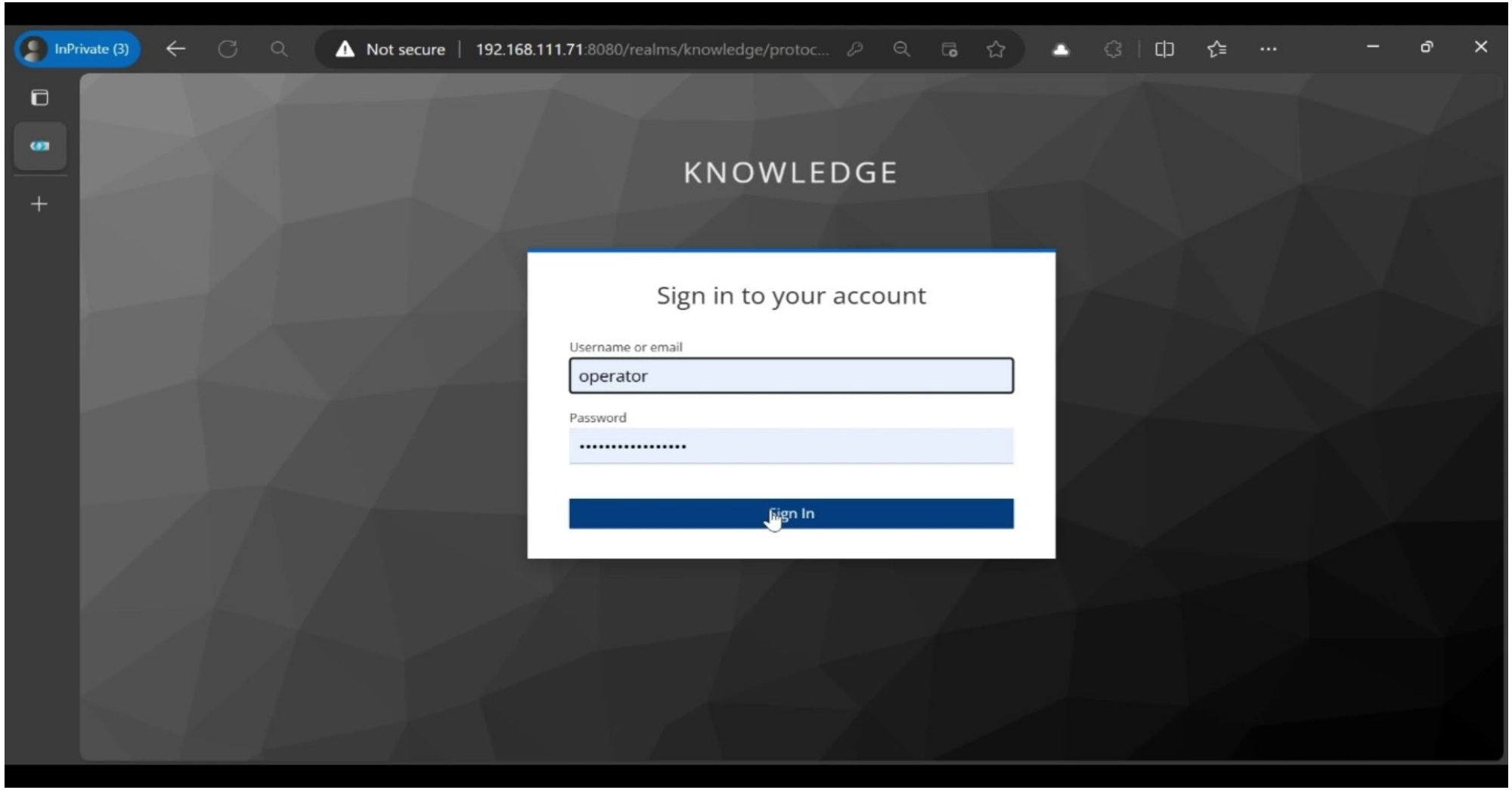

Impact

KPI	Goal
Scheduling hours	Decrease time devoted for production planning or scheduling.
Yogurt OEE	Improve the theoretical OEE of yogurt production
Response time	Time to create a new production plan responding to real-time changes/variations based upon real-time data will decrease more than 50%
Productivity	Decrease the number of man hours needed to produce one ton of product
Downtime	Decrease the time of downtime and setups
Scrap	Decrease the amount of scrap