Enabling Business Analysts to implement CPS solutions using a Model-Based approach

A PhD research activity project developed with AISE contributions

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- Dr. Ivan Famoso, System Engineer/Service Manager RHEA Group;
- Dr. G. Telleschi, Chief Systems Engineer, MBDA;
- Prof. Andrea D'Ambrogio, Tor Vergata University.

AISE-INCOSE MBSE WG

Associazione Italiana System Engineering - International Council on Systems Engineering Model Based System Engineering Working Group

Mission

The AISE-INCOSE MBSE Working Group would like to become, in the next 6 years, the primary reference for the Italian SE that would like to adopt the MBSE approach.

Main Topic

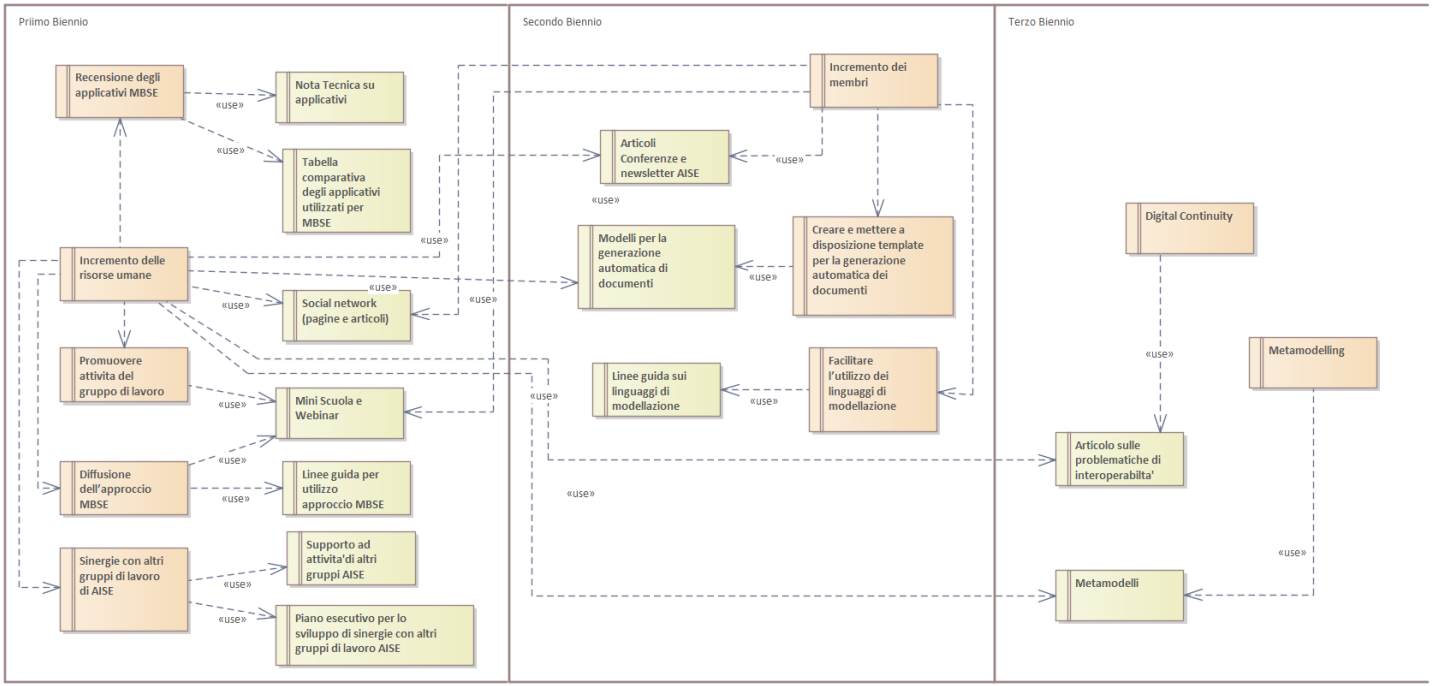
The WG MBSE will deal with:

- MBSE approach adoption,
- Metamodeling for a specific context (e.g. sector, project phases, etc.),
- Effective usage of the modelling language,
- Benchmarking of MBSE Tools,
- Digital continuity

AISE-INCOSE MBSE WG

Numbers

- Officially started end of 2020
- 11 Active Members belonging 6 different Companies spread over 5 Sectors
- 3 meeting organized in the 2021
- 8 activities currently ongoing
- 12 different type of deliverable



AISE and Tor Vergata cooperation in the PhD research project

The project is framed as part of a PhD research activity carried out at the **Tor Vergata University**, **Department of Enterprise Engineering** (PhD candidate T. Panetti, Tutor Prof. A. D'Ambrogio) and takes advantage of **AISE** activities.

In particular, **AISE enables the PhD research activity to validate the resulting model** and to contribute to the results **dissemination**.

The reference context analysis

The **industry 4.0 plan defined by the MISE in the 2018** aimed at getting the following benefits from the adoption of enabling IoT technologies by the industry:

- **Greater flexibility**
- **Greater speed**
- **Greater productivity**
- **Better quality**
- **Greater competitiveness**

The reference context analysis

From personal experience as Innovation Manager and by reviewing related works in literature, it is perceived that **Cyber-Physical Systems (CPS) solutions still have to provide their peak in terms of social and market benefits**.

In addition, market available solutions do not allow business analysts **evaluate easy-to-understand process descriptions at design time**, **before committing the resources for process implementation**.

In this context our **vision** consists in **enabling Business Analysts to implement CPS solutions using a Model-Based approach and increase the level of automation through model transformations**.

Background

In **CPS** the **computer system continuously interacts with the reference physical system.**

The project research generates a new paradigm where **processes, containing both cyber actors and humans, are integrated and collaborative**. In this new paradigm, **the business process models can be directly mapped to the corresponding CPS implementation using transformation rules**.

Business process modeling is an activity devoted to make process description easy-to-understand to both Business Analysts, from a process-centric viewpoint, and IT developers, from a technology-based viewpoint.

Main research guidelines

- To place the logic of execution of CPS solutions at process layer, in a **process-centric** organization;
- To use an **ontology** for abstracting the process layer from the physical layer;
- To introduce **Digital Twin (DT) technology,** in order to get a quick set-up of the solution before physical implementation;
- To **enable a new low-code approach**, based on model transformations, where the solutions can be easily implemented starting from the design level.

Research question areas

We focused our effort on the following **main research objectives**:

1. To define an innovative **methodology for enabling new solutions implementation in the CPS field**

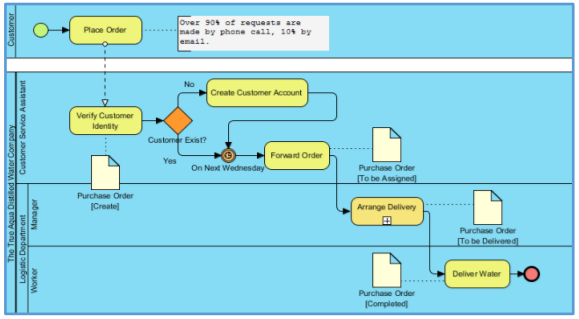
2. To define a **formal language complete with transformation rules for the automated mapping of Business Processes models to IoT-solutions**

3. To define a **reference architecture** for solutions in the CPS domain devoted to ensuring a new life cycle of process-driven CPS solutions

Research project big-picture

PATTERNS BPM-CPS

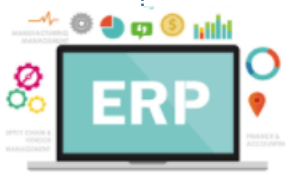
SIMULATION



CPS MODELS

Analytics

IMPLEMENTATION



MDE

```
// Receive input from requestor.

        portType="client:BPELProcess" operation="initiate"
        variable="inputVariable" createInstance="yes"/>



        query="/client:BPELProcessProcessRequest/client:input"/>

        query="/client:BPELProcessProcessResponse/client:result"/>
```

IoT Resources

Digital Twins

WEB PORTAL – CLOUD – MICRO SERVICES

Research project highlights

The research project contains the following pillars:

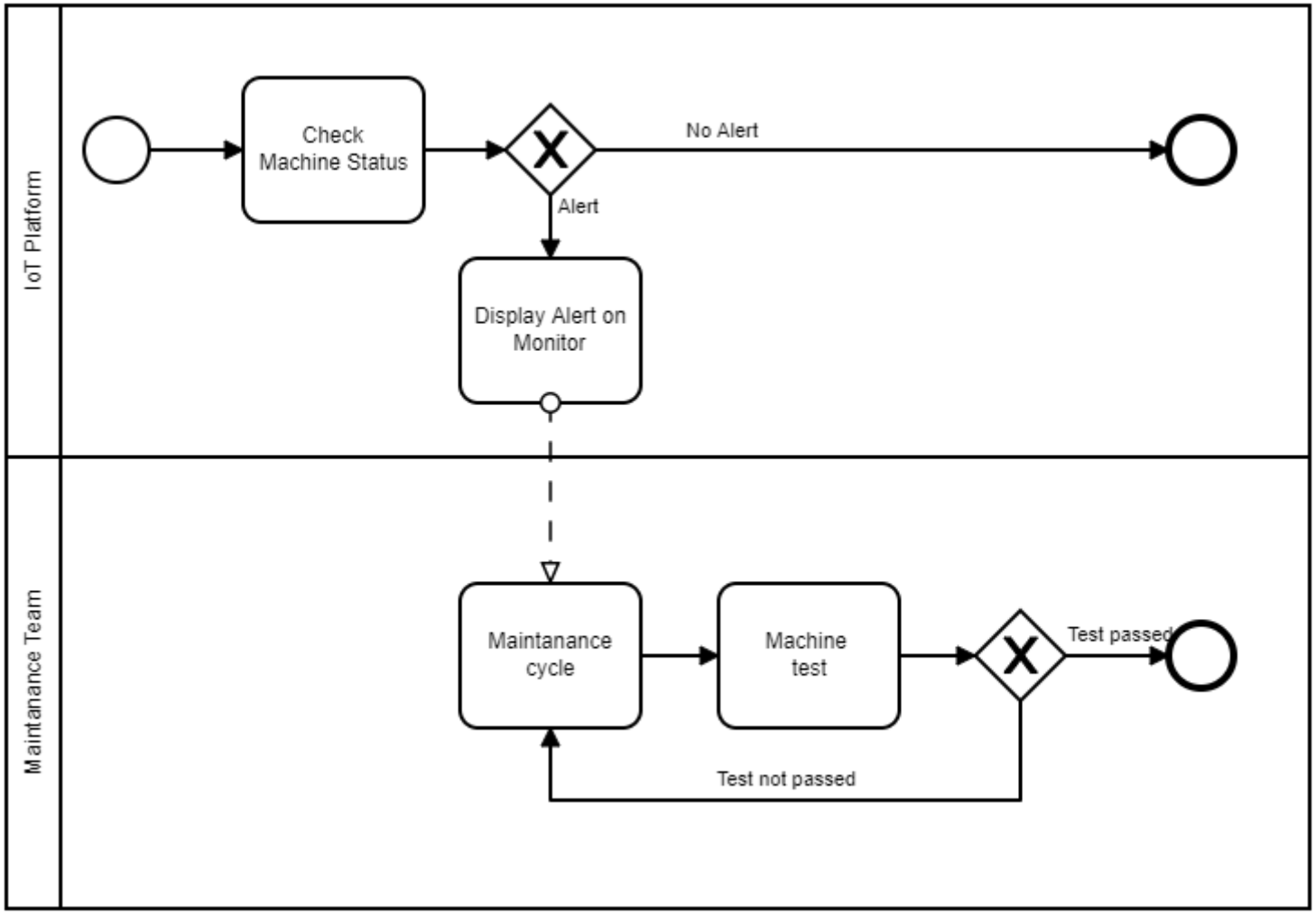
- A non-technology expert must be able **to design the CPS solution on a diagrammatic form (modeling)**;
- The CPS solution is expressed by the analyst at **Business Process Management (BPM)** layer, thus obtaining **process-centric solution**;
- **During the modeling phase, it is not required to know the technical aspects of the physical layer**;
- A set of **automated model transformation rules generate the implementation level**;
- A **CPS ontology is used for decoupling the conceptual level and the physical level,** and to gain compatibility with a wide variety of sensors and actuators.

The **research project is still in progress. Results will be published in the short-term**.

Expected benefits

- The possibility to easily **share the advantages of the designed CPS solutions**, using Business Process modeling
- The possibility to **reuse** CPS solutions using solution patterns available as libraries of Business Process models
- The **low-code approach** and the run-time auto-generation of syntactic and semantic links between the business process and IoT components
- The Digital Twin introduction in emulation mode, so to enable system integrators to **simulate** the process before building the physical layer
- The system integrator **focused on the business solution** rather than on technical aspects
- The Business Process execution engine continuously **monitoring and optimizing** the developed IoT solution
- The Business Process centric view used to **address disruptive technologies** such as **IoT, M2M and AI**.

An example application



An example application

Predictive Maintenance scenario

The **business analyst builds a Business Process maintenance model containing IoT components**, onboard sensors, **and human operators**, the "Maintenance team".
The maintenance model is then used in a predictive way, in order to avoid uncontrolled machine downs and start maintenance activities before failures occurrence.
The model is finally used, along with a set of **transformation rules**, to automate the generation of the corresponding implementation.
The transformation rules are executed on a **technology enabler layer** that is developed as part of the research project.

Thanks for the attention!

MBSE Linkedin Group

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