Simulation and Virtual Commissioning of a Production Line in a Digital Factory

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The Czech Institute of Informatics, Robotics and Cybernetics at the Czech Technical University in Prague is a research facility focusing on Industry 4.0. One of the research topics at the institute discusses virtual commissioning of a digital factory using a testbed in the laboratory. The testbed represents a toy car production line with five workstations, each equipped with a KUKA robot and a Montrac transportation system. The master's thesis aims to transfer the physical installation into a virtual simulation and virtual commission the installation into production.

The process of the research goes through four main phases. The first phase contains determining the physical setup of the testbed. Next, the physical installation is modelled in a virtual world using Tecnomatix Process Simulate software of Siemens. In the third phase, again, software of Siemens is used. This phase mainly defines the creation of a production sequence. The last and fourth phase is the virtual commissioning of the simulation model.

Phase 1: Production Line

The production line exists out of five workstations and one transportation system. Every workstation is equipped with a KUKA robot. Three different KUKA models are used:

- 3 Agilus KR 10 R1100-2
- 1 LBR iiwa 14 R820
- 1 Cybertech KR 8 R1610-2 arc HW

Figure 2: Workstations equipped with Agilus [1]   Figure 3: Workstation equipped with iiwa [1]   Figure 4: KR 8 Cybertech [1]

Montrac of manufacturer Montratec is a monorail transportation system using multiple shuttles to deliver products between different workstations.

Figure 5: Montrac mono-rail shuttle [2]

Figure 6: Montrac TracSwitch used to redirect shuttles [2]

Figure 1: Testbed at CIIRC laboratory (Czech Institute of Informatics, Robotics and Cybernetics) [1]

Phase 2: Tecnomatix Modeling

In the second phase of the research, a virtual replica of the testbed is modelled in Tecnomatix Process Simulate of Siemens. The model contains all the components of the physical installation, including safety components. Each robot gets its joint movement assigned along with trajectory paths to enable production movements in the software. Assigning these kinds of operations are called 'Events' in the software. Using LineSimulation of the software, which is an event-based simulation, it is possible to simulate the first virtual commissioning.
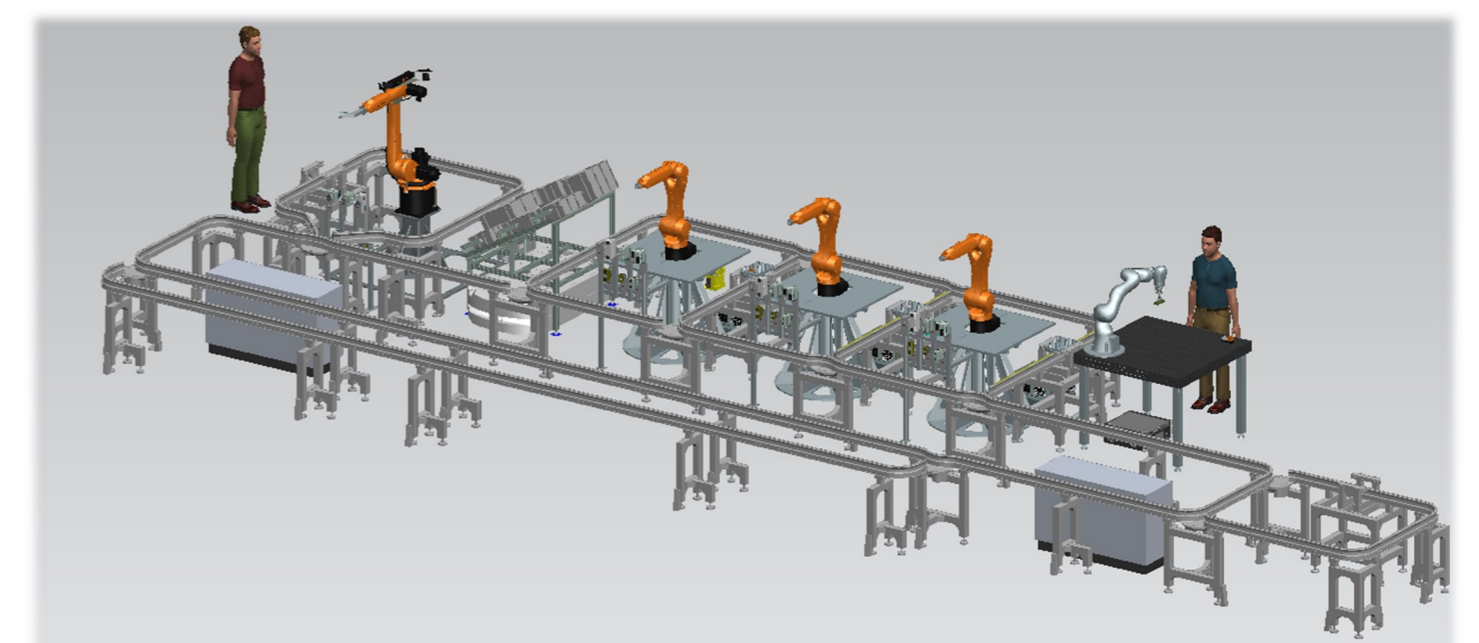

Figure 7: Production line model in Tecnomatix Process Simulate

Phase 3: TIA Portal - PLC SIM

Once the virtual model in Process Simulate is successfully operational without errors or collisions, this phase begins. In TIA Portal, a Sequential Function Chart (SFC) is responsible for the production operations and replaces the event-based LineSimulation.

In TIA Portal, all the desired hardware will be configured in the software. The software PLC Sim Advanced V3.0 simulates the chosen PLC. The simulated PLC is one out of the 1500-series. The PLC with this particular Central Processing Unit (CPU) is one of the few models that can be simulated in the software.

Additionally, an human-machine interface (HMI) panel is also configured in TIA Portal. The chosen HMI is a TP700 comfort panel.
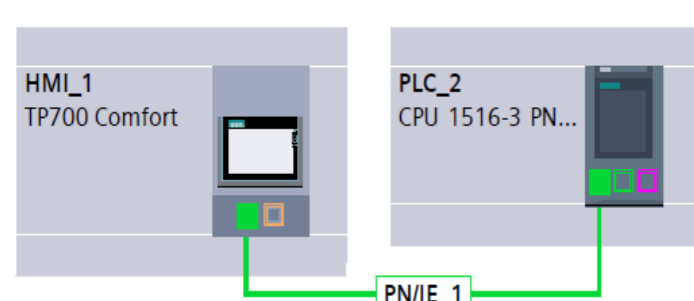

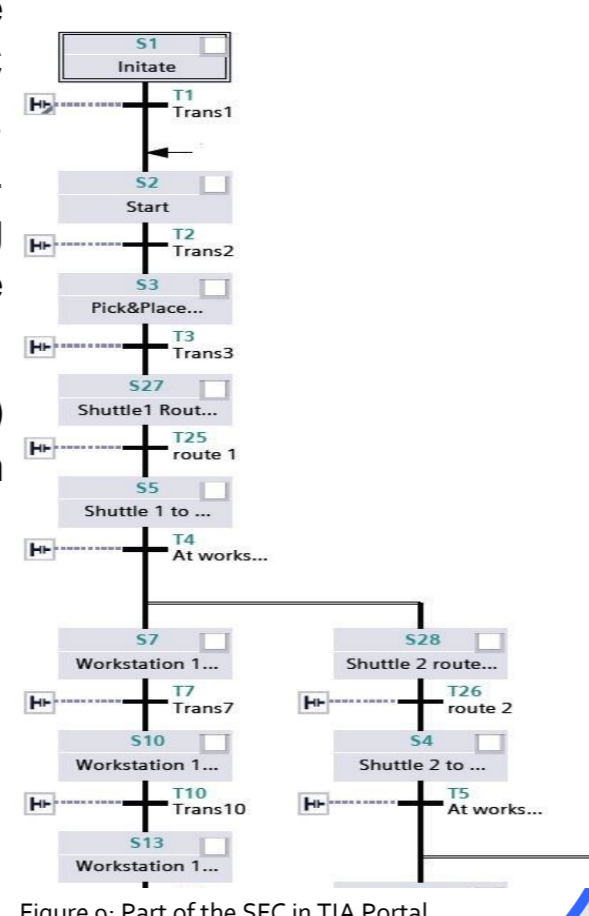Figure 8: HMI panel and PLC virtual interface connected by PROFINET connection

Figure 9: Part of the SFC in TIA Portal

Phase 4: Virtual Commissioning

The last essential phase is the interface between Process Simulate and TIA Portal software. Process Simulate has optional settings configured to be controlled by PLC SIM. The event-based simulation will no longer control the model in Process Simulate. The eventual interface is created with PLC Sim advanced V3.0 simulating the PLC and Process Simulate recognising this device. Figure 10 shows how the virtual PLC is connected and controls the model.
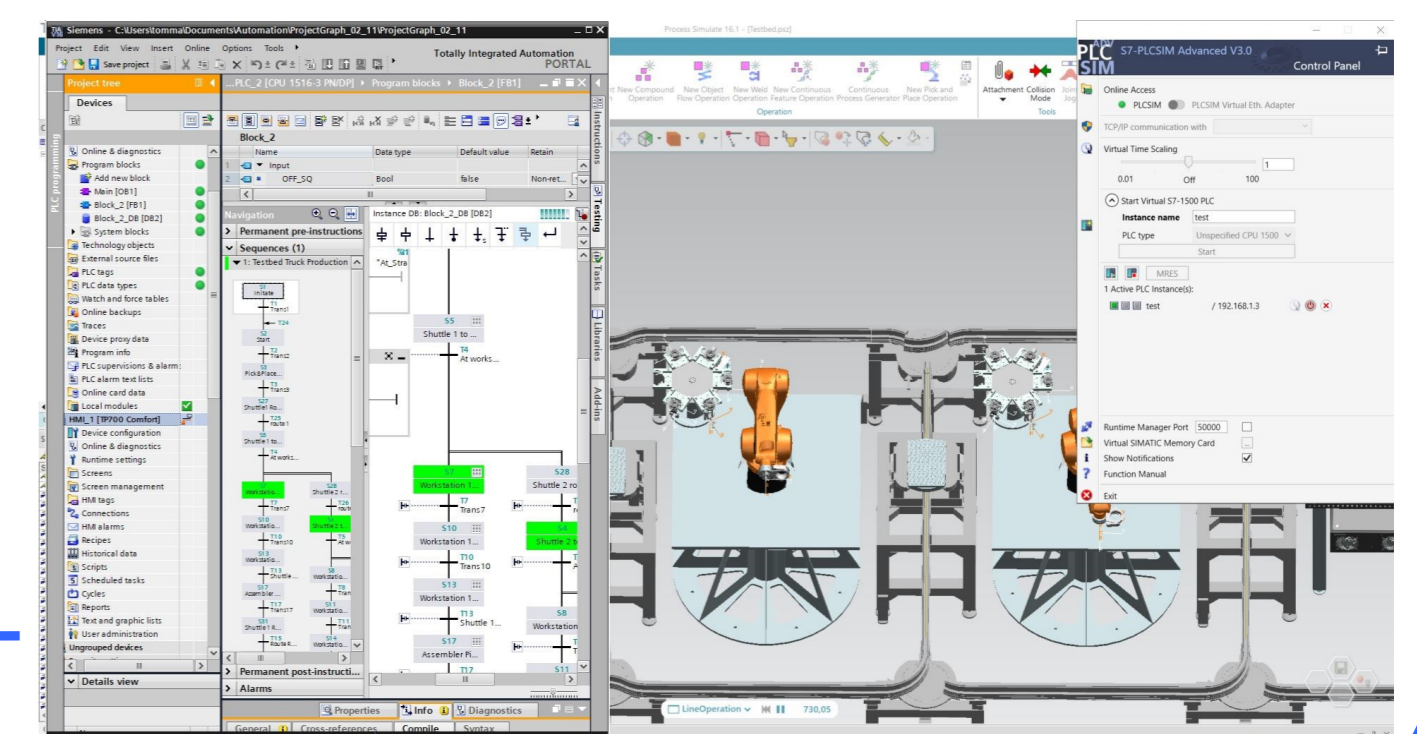

Figure 10: The interface between PLC and Process Simulate enables the SCF operating the model

Result

After the four phases and different steps, the result is a simulated and virtual commissioning car toy production line, also known as a digital factory. The benefits of this work are listed as follows:

⇒ Early discovery of errors or collisions in the designing phase;
⇒ Possibility to innovate production processes and explore new business models;
⇒ More efficient use of factory space;
⇒ Reduce of material and time costs in the manufacturing phase.

[1] Robotics and Cybernetics Czech Institute of Informatics, "Testbed for Industry 4.0: How to produce innovative products in a flexible and effective way?", 2020

[2] Montratec GmbH, "montrac - INTELLIGENCE IN MOTION", 2017