

# Effective Research Data Sharing during the Plant Evolution in the automated Production Domain

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1. Introduction to the research plant xPPU
2. Sharing research data with ontology
3. Ontology for describing research data during plant evolution
4. Summary and outlook



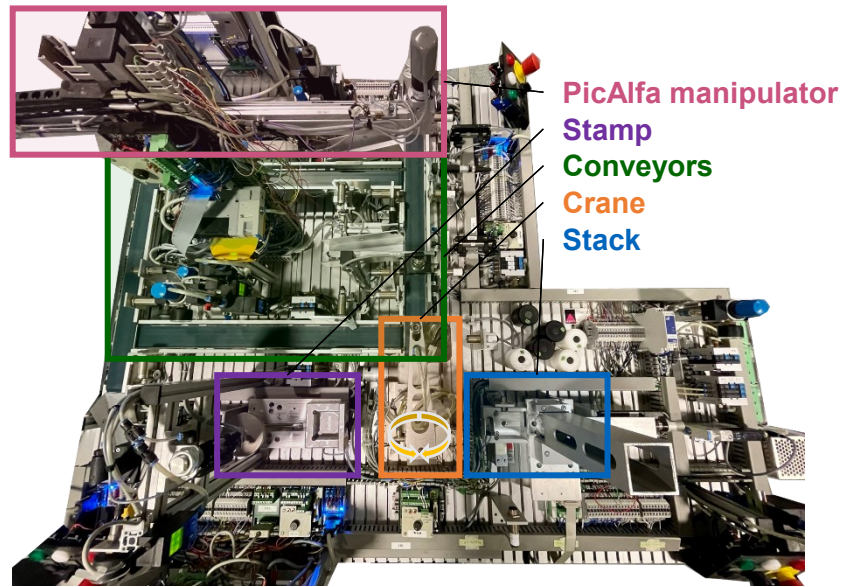
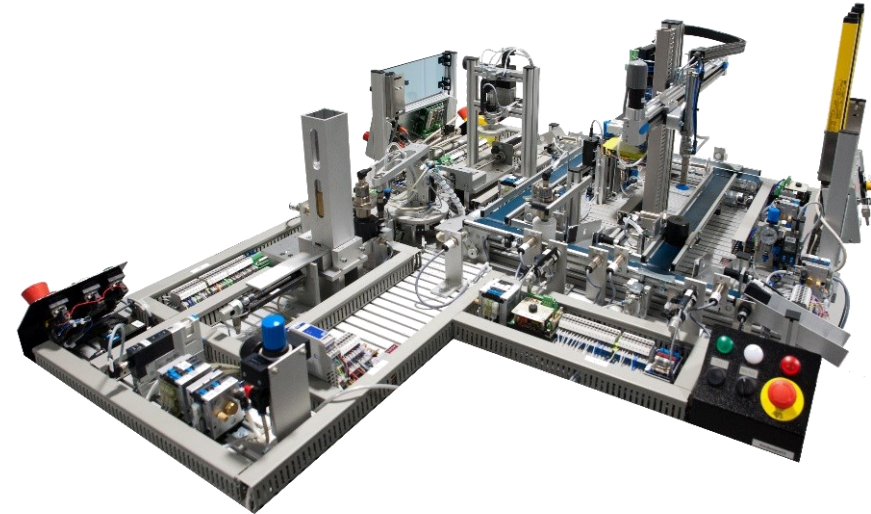
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# Introduction of the Research Plant

## The extended Pick and Place Unit (xPPU)

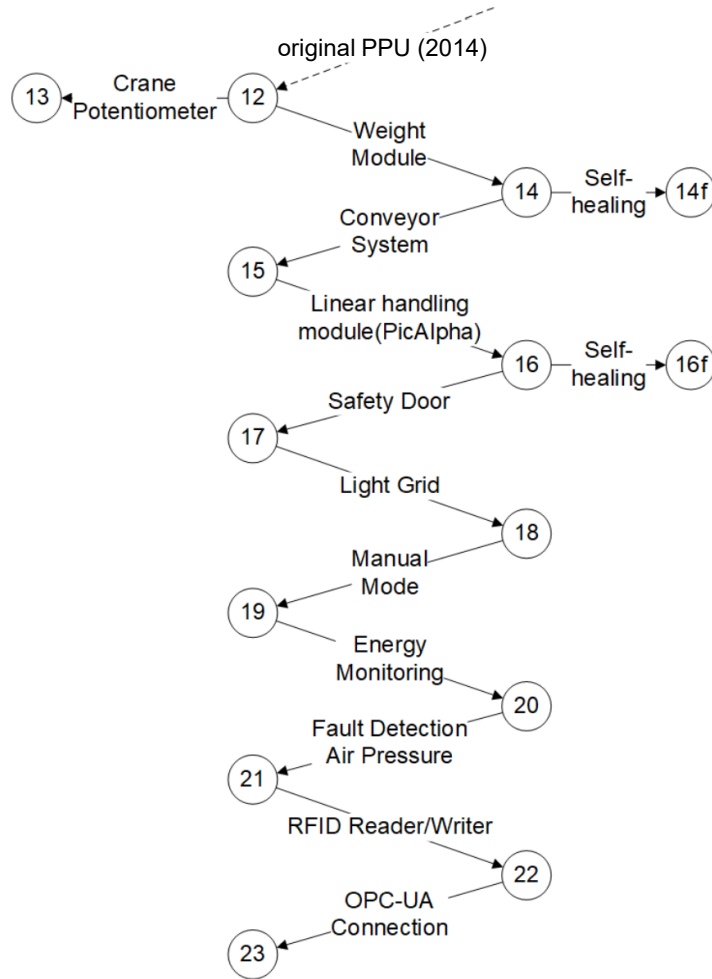
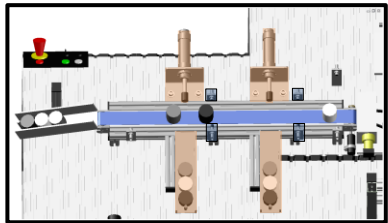
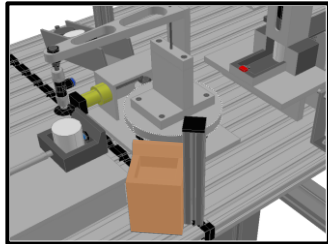
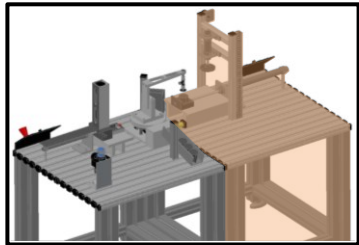
- Demonstrator for manufacturing engineering
  - Pneumatic actuators (pushers, grippers)
  - DC motors (no servos or steppers)
  - Optical, inductive, pressure, ... sensors
  - RFID readers / writers
  - Safety system (light barrier, safety door, emergency stop)
- Workpiece **stack** provides new workpieces
- **Crane** distributes them to **stamp** / **conveyors**
- **Conveyor system** for refeeding transport
- **PicAlfa** to manipulate workpiece order
- High redundancy → suitable as a reconfiguration testbed
- Different workpiece types to consider in control scenarios



Github: <https://github.com/x-PPU>

# Research Plant Evolution Scenarios

## The extended Pick and Place Unit (xPPU)

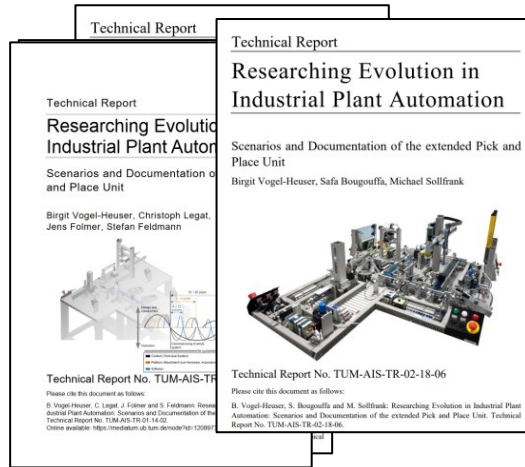


- (extended) PPU as a **case study of evolution** in manufacturing industry
- Scenarios of increasing complexity incorporate new components and functionality
  - **Variants** (13, 14f, 16f) exist independently
  - **Versions** up to Sc23 replace their predecessors
- Hardware and software **structured modularly** for easier reusability

Vogel-Heuser et al., "Researching Evolution in Industrial Plant Automation: Scenarios and Documentation of the extended Pick and Place Unit," Institute of Automation and Information Systems, TU Munich, 2018.

Vogel-Heuser et al., "Researching Evolution in Industrial Plant Automation: Scenarios and Documentation of the Pick and Place Unit," Institute of Automation and Information Systems, TU Munich, 2014.

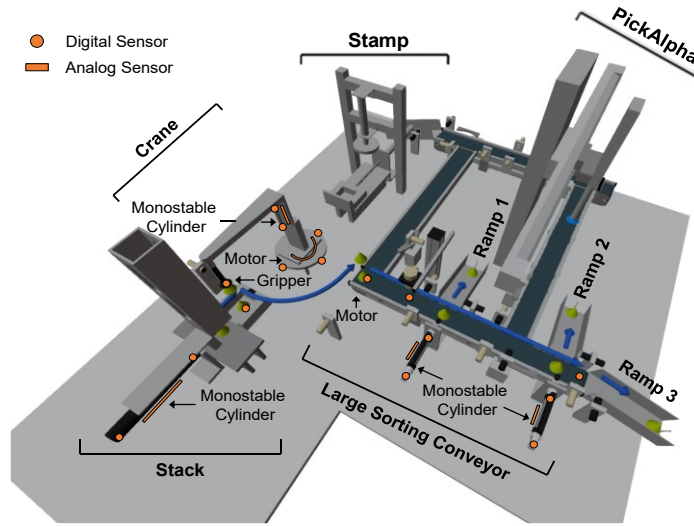
Documents, e.g., different versions of technical reports



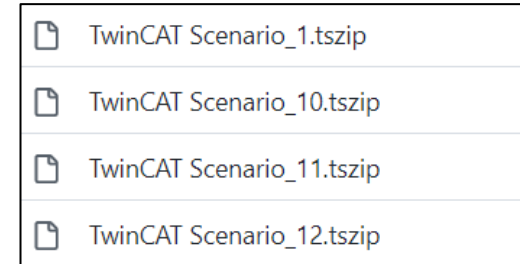
contains e.g., plant resource information

Table 2. Component list of the stack in Scenario Sc14

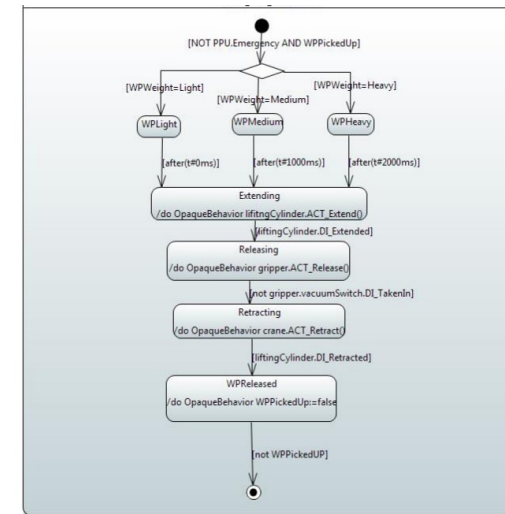
Position	Resource	Clamp	Description	Component	Type
1	100	X1	Stack		
100	100A1	X1.1	Extend separator (Valve)	Stack	DO
100	100B9	X1.2	Separator is extended (Reed Switch)	Stack	DI
100	100B8	X1.3	Separator is retracted (Reed Switch)	Stack	DI
100	100S11	X1.4	WP is available (Micro Switch)	Stack	DI
100	100B10	X1.5	WP is metallic (Inductive Sensor)	Stack	DI
100	100B11	X1.6	WP is light (Optical Sensor)	Stack	DI
100	100B12	X1.7	Weight of the WP (Weight module)	Stack	AI



Models/program code developed for each evolution scenario



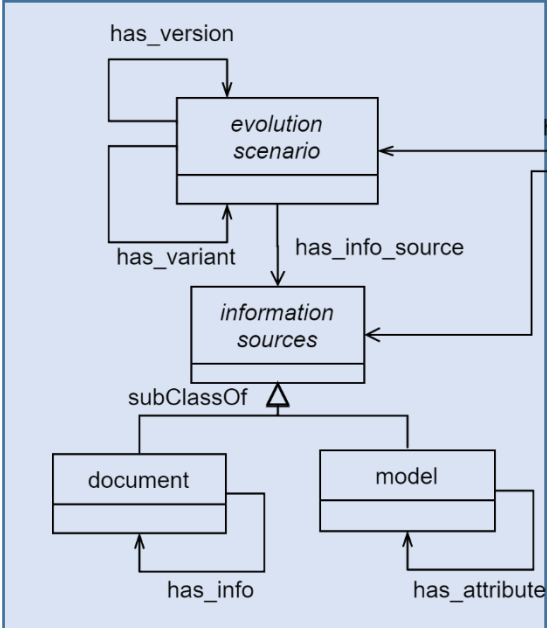
contains e.g., process information



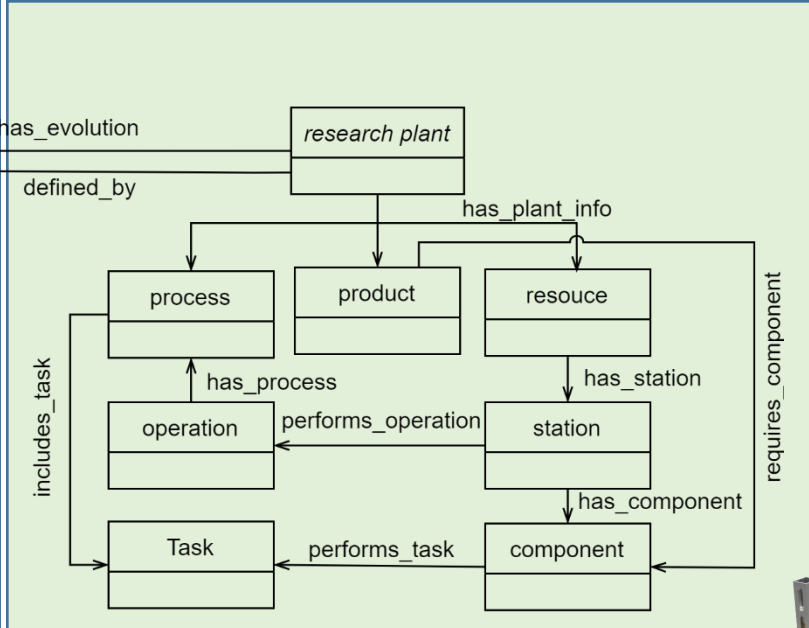
Challenges

- How to improve the interoperability of shared research data during plant evolution?
- How can different types and variants / versions of shared research data be better used?

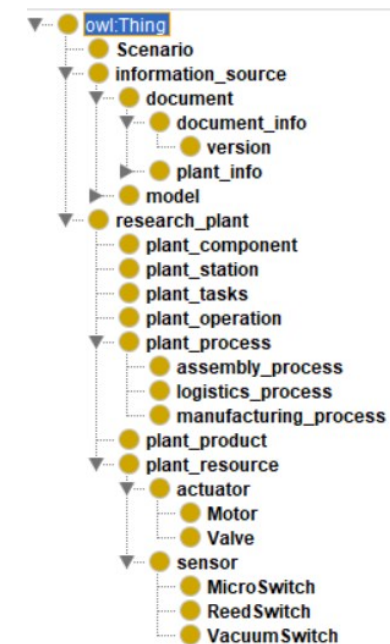
Terminologies of shared data and data sources



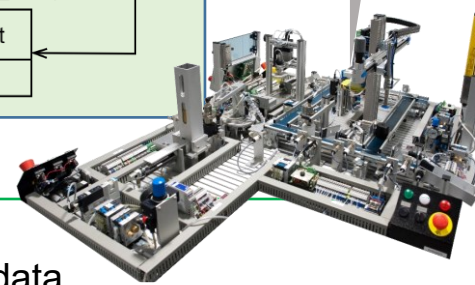
Terminologies of research plant information\*



Ontology



- Instances +
- ◆ xPPU\_Sc00
  - ◆ xPPU\_Sc01
  - ◆ xPPU\_Sc02
  - ◆ xPPU\_Sc03
  - ◆ xPPU\_Sc04
  - ◆ xPPU\_Sc05
  - ◆ xPPU\_Sc06
  - ◆ xPPU\_Sc07
  - ◆ xPPU\_Sc08
  - ◆ xPPU\_Sc09
  - ◆ xPPU\_Sc10
  - ◆ xPPU\_Sc11
  - ◆ xPPU\_Sc12



Instances for evolution scenarios

## Benefits

- Providing overview for shared documents, models and research data
- Automatic generation of research plant information based on the latest information sources (e.g., technical reports, control program)
- Information changes between evolution scenarios can be traced, e.g., changes in hardware components or software functionalities

\* Ferrer, Borja Ramis, et al. "Product, process and resource model coupling for knowledge-driven assembly automation." at-Automatisierungstechnik 64.3 (2016): 231-243.

Sharing ontology for describing data created during plant evolution

Name	Last commit
..	
inputs	importing PLCOpenXML models in ontology
outputs	importing PLCOpenXML models in ontology
query	importing PLCOpenXML models in ontology
LICENSE	Create LICENSE
importPLC.py	importing PLCOpenXML models in ontology
importTR.py	importing PLCOpenXML models in ontology
info_query.py	generating xPPU-ontology from files/models in each
onto_main.py	importing PLCOpenXML models in ontology

Visualization of plant information in each evolution scenario

assets	Fix: Doku of sparql_query_viz.py updated
datasets	Fix: a view minor version corrections
__init__.py	Fix: version set to 0.1.0
layout.py	Fix: Library Panel is now shown when Abox visu is off
sparql_query_viz.py	Fix: Library Panel is now shown when Abox visu is off

## Overview of shared xPPU Data

The screenshot shows a GitHub repository overview for 'xPPU Data'. It lists several repositories:

- Evolution-Ontology** (Private): Updated 7 days ago.
- xPPU-AML-PPR** (Public): Updated on 11 Nov 2021.
- PLCOpenXML** (Public): Updated on 12 Oct 2018.
- Incremental\_Changes** (Public): Updated on 10 Oct 2018.
- I4.0\_Interface** (Public): Updated on 2 Oct 2018.

Interface with other research plants

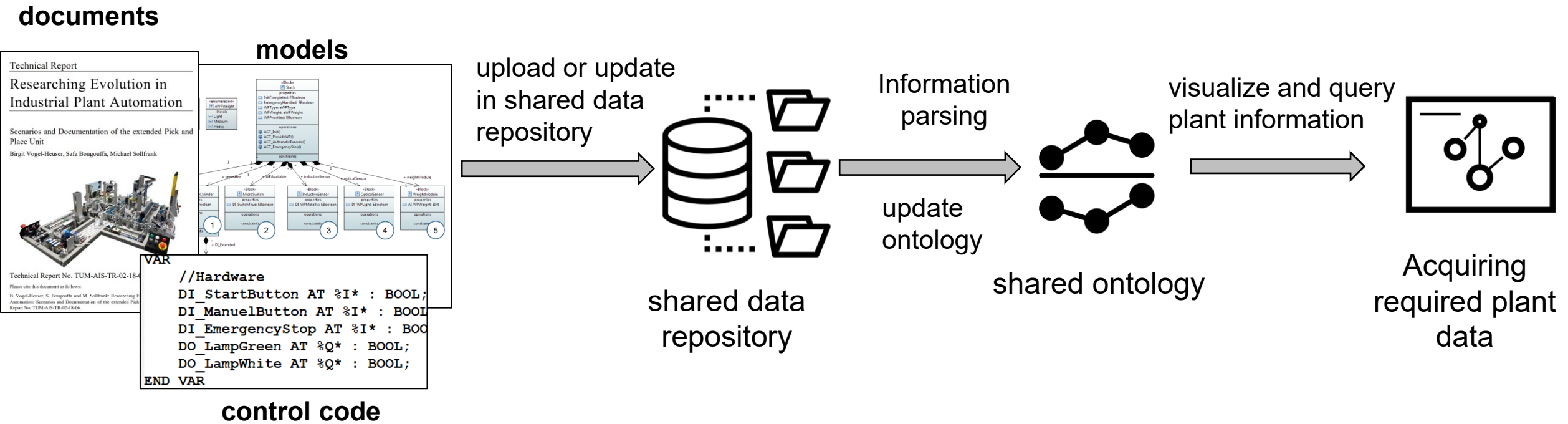
Sharing documents, models and control code developed for each evolution scenario

The screenshot shows a file upload interface for 'xPPU'. It is divided into two main sections:

- Control code**: Includes files like LICENSE, PLCOpenXML\_Scenario\_1.xml, PLCOpenXML\_Scenario\_10.xml, and PLCOpenXML\_Scenario\_11.xml.
- SysML Model**: Includes files like LICENSE, Papyrus - Scenario\_01.zip, Papyrus - Scenario\_02.zip, Papyrus - Scenario\_03.zip, Papyrus - Scenario\_04a.zip, Papyrus - Scenario\_04b.zip, Papyrus - Scenario\_05.zip, Papyrus - Scenario\_07.zip, and Papyrus - Scenario\_08.zip.

Github: <https://github.com/x-PPU>

- Required plant data is automatic parsed from the uploaded or updated documents
- Shared ontology is updated with the extracted data from the new information sources
- Visualization of scenario-based plant data and information changes during the evolution



Select the data to be visualized based on the plant terminology and evolution scenario

- Query templates are saved in the query-library (SPARQL Library)
- Users select the queries in the library and see the visualized results
- These templates include queries for changes in plant data between scenarios and for specific categories of information in a specific scenario (e.g., getting the sensors along a transportation process in Scenario 2)

Customization of the visualization

SPARQL Query Viz  
xPPU\_onto

The screenshot shows the SPARQL Query Viz interface for the xPPU\_onto ontology. The interface is divided into several sections: a search bar at the top left, a 'Select Scenario' dropdown menu, a 'Select Termonology' dropdown menu, and a 'Select' button. The main area displays a complex network graph with nodes and edges, colored and sized according to the selected options. The interface also features a 'Search' section with 'Un-/Freeze' and 'Search node or edge in graph' fields, and a 'Selected Edge' section with 'Hide/Show' buttons. A 'Color' section with 'Hide/Show' and 'Legends' buttons, and a 'Size' section with 'Hide/Show' buttons are also visible.



## Summary

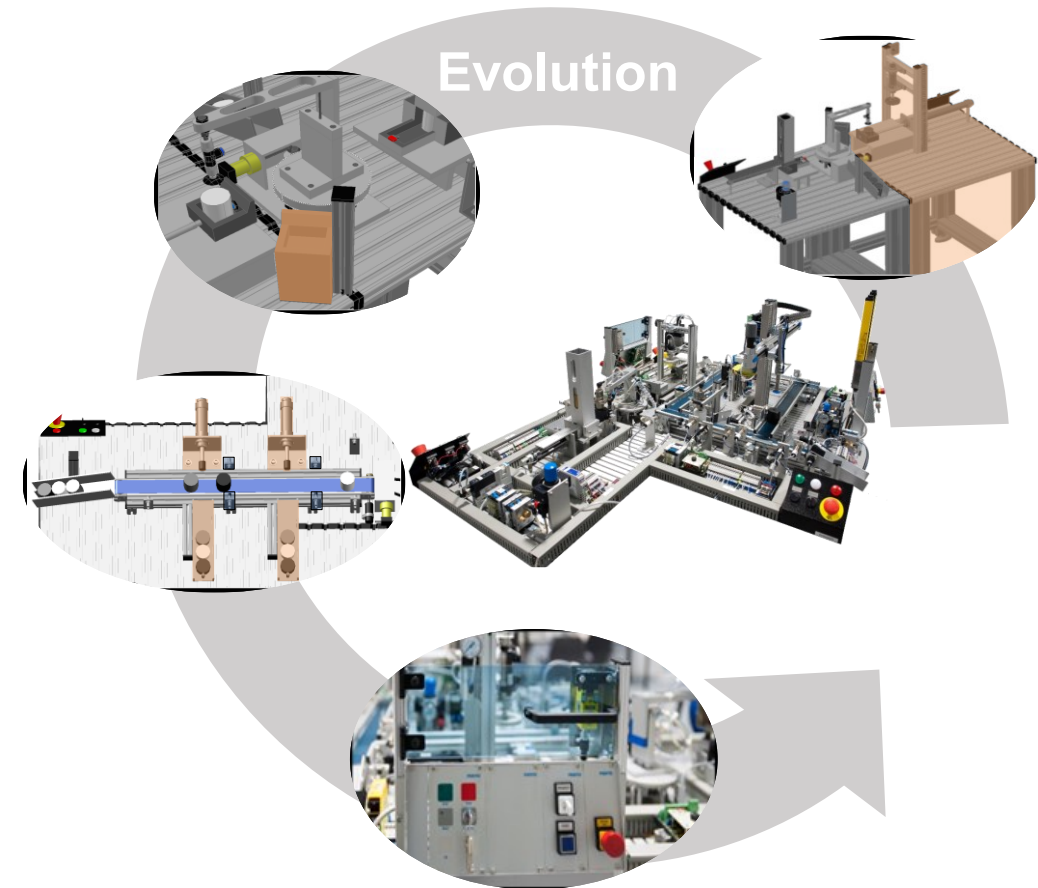


- Sharing research data of automated production plant with ontology improves the data interoperability
- Changes along the plant evolution can be better traced with the developed ontology
- Visualization of research data and query templates help users to efficiently access the needed plant data

## Next steps



- Supporting user-defined information query
- Further enriching the terminology of automated production plant
- Increasing the flexibility of information extraction process



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**Thank you for  
your attention!**



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