Multi-Robot, Multi-Machine Interoperability

ROS-Industrial Consortium Americas 2021 Annual Meeting
The Interoperability Problem

Current Landscape for Robot Systems in Manufacturing

Dimensions to achieve Interoperability

In blue, the focus of this project.
Why is Interoperability between Automation and Robotic systems difficult?

- **Custom Integration Software upfront cost can be 2x to 5x the hardware costs**
  - Small/midsize manufacturing companies may opt out from investing altogether

- **Communication protocol bridging is challenging (or even impossible)**
  - Introduces a high risk from the beginning

- **Every integration is a custom one-off solution**
  - Resulting in Non-Recurring Engineering costs every time
  - Only experience itself is reusable

- **Technology can be very intimidating**
  - Small/midsize manufacturing companies may lack the internal technical resources to take on the tasks
  - Software is not plug&play, lacks documentation and extended support

Source: [https://www.youtube.com/watch?v=hnDKqr-g3t4&t=1s](https://www.youtube.com/watch?v=hnDKqr-g3t4&t=1s), MTConnect Institute
ARM 18-01-F-25 Seamless Multi-Robot, Multi-Machine Interoperability

Cloud

ROIS-I

ROS 1

ROS 2

DDS

T1

T2

T3

T4

T5

MT Connect

OPC-UA

Automation Systems

Hardware

Robotic Systems

Robot Simulation

Hardware Demonstration

Cloud

Siemens Future of Automation Lab Schlumberger Manufacturing Center

Technology integration, enhancement and demo in this project & associated task name
Vendor specific drivers
Gateway between robotic and automation systems
Tech module transferable to ARM members

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### Key Contributions

#### OPC UA / DDS Gateway
- Initial implementation
- Uni-directional comm.
  - Linux
- Robustified implementation
- Bi-directional comm.
  - Linux and Windows

#### DDS and ROS2 Interoperability
- Partial ROS2 ↔ DDS Interoperability
- Freedom to Mix and Match ROS2 and DDS applications

#### MTConnect High-level Task Coordination
- Rigid MTConnect Implementation
  - HTTP Transport
- Flexible standalone MTConnect Python package
  - DDS Transport

#### Cloud and Simulation (OPC UA)
- Cloud Plug&Play devices collect OPC UA and proprietary protocol signals
  - Industrial Simulation Software uses OPC UA external signals
- Cloud Plug&Play field devices collect OPC UA and DDS signals
  - Industrial Simulation Software uses OPC UA and DDS external signals.
Integration under MTConnect Orchestration

Possible configurations under the MTConnect Orchestration scheme
Siemens Demo: Use Case

- Complex Industrial Environment
  - Industrial Simulation Software
  - Cameras and Sensors
  - Robotic Arms
  - Industrial Controllers
  - Transportation Systems

- Manufacturing Process
  - Supply
  - Mill
  - Weld
  - Polish
  - Inspect Quality
    - Raw material
    - Finished material
Siemens FoA Lab Hardware Demonstration
Orchestration over MT Connect

Legend

<table>
<thead>
<tr>
<th>MTConnect Interface</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ProcessItem</td>
<td>for tasks involving performing work such as milling</td>
</tr>
<tr>
<td>MaterialHandler</td>
<td>for tasks involving material handling (e.g. load)</td>
</tr>
<tr>
<td>MaterialTransport</td>
<td>for tasks involving moving objects between devices</td>
</tr>
</tbody>
</table>
Live Demo: Supply Station (PLC)

MTConnect on DDS

DDS Subscriber

RTI's OPC UA/DDS gateway

Siemens S71500 PLC + I/O with Native OPC UA Server

Work piece Supply Station
Demo: Welding Station (Berkeley, CA)

Optimizing the robot motion to maintain uniform temperature profile on the surface with simulated sensory input.

MTConnect on DDS
Domain 1

MTConnect Orchestrator

Welding Path Optimizer + Robot Control

TCP/IP

To be deployed on FANUC robot

Domain 0
MTConnect on DDS

PulseSecure VPN

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Recorded DEMO
How have we lowered the bar for Interoperability of Automation and Robotic systems?

- Developed/hardened Open-Source Software or based on Open Standards
- Successfully derisked OPC-UA / DDS / ROS / ROS 2 communication
- Developed reusable software (MTConnect Python Package, RTI OPC-UA / DDS Gateway)
- Plug&Play software accompanied by Tutorials, documentation, and samples for all core software contributions
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