ACADEMIC SALON ON TIME-SENSITIVE NETWORKING AND DETERMINISTIC APPLICATIONS

DYNAMIC CONFIGURATION OF TSN FOR INDUSTRIAL APPLICATIONS IN THE KITOS PROJECT

Dr. René Guillaume

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Dynamic Configuration of TSN for Industrial Applications

Motivation

Status Quo

- IT
  - ERP
  - MES
  - SCADA
- OT
  - PLC
  - Field Device

Factory of the Future

- Ethernet
- Industrial Ethernet

Vision:
- Machine functions migrating towards Edge/Cloud
- Modular / flexible production lines
- No vendor lock in through open standards
- Network convergence, i.e. IT/OT applications sharing a common substrate network

➡️ Diverse non-interoperable standards w/o convergence
➡️ Need for new standards addressing future requirements

ERP: Enterprise Resource Planning  MES: Manufacturing Execution System  SCADA: Supervisory Control and Data Acquisition  PLC: Programmable Logic Controller
IT: Information Technology  OT: Operation Technology

Source: Rexroth
Dynamic Configuration of TSN for Industrial Applications
BMBF Project KITOS

Goal
Equip industrial networks with mechanisms to support self-healing & optimization facilitating the required agility & reliability for future production processes.

Approach
- Methods for dynamic configuration of TSN
- Adaptation and integration of configuration tools
- Development of a platform for assisted configuration
- Analysis and evaluation of relevant algorithms

Consortium

www.dfki.de/web/forschung/projekte-publikationen/projekte-uebersicht/projekt/kitos
Dynamic Configuration of TSN for Industrial Applications
ctrlX Core – The Embedded Control Platform

Major Goals:
- Enable & evaluate TSN capabilities of ctrlX Core
- Achieve integration into multi-vendor industrial network
- Identify novel network configuration & management concepts

ctrlX Data Layer

- Provides access to any real-time and non-real-time system and app data
- Supports the most important software protocols (e.g. REST HTTPS, OPC UA)

Source: Rexroth

Dynamic Configuration of TSN for Industrial Applications

Use Cases – Methodology

Valuable sources for use cases & requirements in context of time-sensitive communication, e.g.:
- Use Cases IEC/IEEE 60802
- 3GPP TR 22.804
- 5G-ACIA Whitepapers

Lots of relevant use cases, yet not focusing on management of volatile TSN networks.

Our approach:

<table>
<thead>
<tr>
<th>Problem Statements</th>
<th>Use Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS 1</td>
<td>UC 1: Scenario 1.1</td>
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<tr>
<td></td>
<td>PS 2: Scenario 1.2</td>
</tr>
<tr>
<td></td>
<td>PS 3: Scenario 1.3-1, Scenario 1.3-2</td>
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Problem Statements
- Initial configuration: To find appropriate TSN configuration parameters.
- Reconfiguration & optimization: To find optimal TSN configuration options.
- Extending networks: To adapt the configuration to new requirements & constraints.
- Heterogeneous networks: To address fragmentation in network topologies & infrastructure features.
- Condition monitoring: To detect performance degradation & predict failures.

Our approach:
Dynamic Configuration of TSN for Industrial Applications

Use Cases – Control-to-Control

<table>
<thead>
<tr>
<th>Source</th>
<th>Target</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLC (Master)</td>
<td>PLC (Slave)</td>
<td>Isochronous</td>
</tr>
<tr>
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</tr>
<tr>
<td>PLC (Master)</td>
<td>PLC (Slave)</td>
<td>Acyclic</td>
</tr>
<tr>
<td>PLC (Slave)</td>
<td>PLC (Master)</td>
<td>Response</td>
</tr>
<tr>
<td>Engineering tool</td>
<td>Ctrl. / Dev</td>
<td>Acyclic</td>
</tr>
<tr>
<td>Ctrl. / Dev</td>
<td>Engineering Tool</td>
<td>Response</td>
</tr>
<tr>
<td>Sync master</td>
<td>Sync slave</td>
<td>Cyclic</td>
</tr>
</tbody>
</table>

Switch B represents a network infrastructure
Dynamic Configuration of TSN for Industrial Applications

Use Cases – Other Examples

- **Switch A**
  - Machine Module
    - PLC
  - Switch B

- **Switch B**
  - Machine Module
    - PLC
    - **Switch A**
      - Machine Module
        - PLC
  - Engineering

- **Switch B**
  - Machine Module
    - PLC
    - Edge Control
    - **Switch A**
      - Machine Module
        - PLC
  - Video Camera

- **Switch B**
  - Machine Module
    - PLC
    - **Switch A**
      - Machine Module
        - PLC
  - **Non-TSN device**
  - **Non-TSN device**

- **Switch B**
  - Machine Module
    - PLC
    - **Switch A**
      - Machine Module
        - PLC
  - TSN Domain 1
  - TSN Domain 2
Dynamic Configuration of TSN for Industrial Applications
Examples for Dynamic Configuration

Adding / Removing Machine Modules

Migrating Edge Applications
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Conclusion

There is a strong need for new standards like, e.g., OPC UA FX & IEC/IEEE 60802 addressing future requirements.

Interoperability enabling multi-vendor industrial networks is an end customer requirement.

TSN comes with lots of opportunities for future use cases, but complexity needs to be addressed.

Research projects like KITOS are targeting at flexibility in configuring industrial networks.
Thank You!

Still Curious?

Dr.-Ing.  
René Guillaume

Corporate Sector Research and Advance Engineering
Distributed Systems (CR/ADA1.2)

rene.guillaume@de.bosch.com
Tel.: +49-711-811-54610