ETFA2020
Deterministic ethernet use cases in injection moulding

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Introduction

Matthias Konnerth

- Teamlead software @ Engel
- Representing Engel within Euromap79 standardization
About ENGEL
Our world is injection moulding

We are one of the leading plastics machinery manufacturers and offer injection moulding machines for any kind of application, innovative technologies, robotics and customized system solutions from a single source. We are world market leader in generating added values and are 100% customer orientated.
About ENGEL
Facts & figures

Founded 1945 in Austria by Ludwig Engel

100% family-owned in the 4th generation

6,500 employees worldwide (FY 19/20)

1,3 billion Euro turnover worldwide (FY 19/20)

over 500 Mio. Euro Investment volume (FY 2018 – 2022)

70 Mio. Euro R&D investment per year
Scope of products & services
Innovative machines, technologies and solutions from a single source

INJECTION MOULDING MACHINES
SYSTEM SOLUTIONS & ROBOTICS
PLASTICISING TECHNOLOGY
DIGITAL SOLUTIONS / SMART FACTORY
PROCESS TECHNOLOGIES
GLOBAL SERVICE & SUPPORT
Injection moulding production cell

Overview

Cartesian robot

Injection moulding machine

6-axis robot

Tempering devices, dosing systems, vision systems, safety gates
Injection moulding production cell
Characteristics

- Machines from different vendors (heterogenous networks)
  - IMM from vendor A
  - Robot inserting parts from vendor B
  - Robot removing parts from vendor C
  - Tempering devices from vendor D

- Lot size is decreasing
  - More frequent reconfiguration of the production cell
  - Customers demand more flexible scheduling of jobs

- Production cells getting complexer
Production cell network
Current situation
Drawbacks

- **Use case 1: Interface between machine and robot**
  - Supporting many fieldbusses would be necessary, to make the interface between machine and robot interoperable
  - Euromap 67 was defined, but this is just a digital interface
    - Lack of functionality: position of mould and ejector is missing
    - Many proprietary extensions (customers asks for extra signal for movement)

- **Use case 2: Machine network**
Standardized interfaces
advantages

- Internal (at machine builder)
  - Reduced development costs
  - Reduce maintenance costs (at the moment >25 different interfaces available)
  - Higher overall test coverage
  - Reduced setup of production cell

- External (at customers site)
  - Reduced integration costs of peripheral devices
  - More flexibility in setting up a production cell
  - Higher investment safety
Interoperability
Look on OSI model

<table>
<thead>
<tr>
<th>Layer</th>
<th>What we are aiming for</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
<td>Standardized OPC UA information models, standardized OPC UA services</td>
</tr>
<tr>
<td>Presentation Session</td>
<td>(read, write, call)</td>
</tr>
<tr>
<td>Transport</td>
<td>TCP, UDP</td>
</tr>
<tr>
<td>Network</td>
<td>IP</td>
</tr>
<tr>
<td>Data link</td>
<td>Ethernet</td>
</tr>
<tr>
<td>Physical layer</td>
<td>100BaseTX, 1000Base Tx</td>
</tr>
</tbody>
</table>

To achieve interoperability we have to consider all layers of the OSI model!

Deterministic Ethernet (TSN) as normed in IEEE802.1, 802.3 and further for industrial Automation in IEC/IEE60802 profile is the way to go for us in layer 1+2
Use case robot integration

- Work in progress in EUROMAP79
- Interface between injection moulding machine and robot
- OPC UA Client/Server on machine and robot side (non-deterministic)
  - For remote actions (e.g. moving an axis)
  - For transferring datasets
- **OPC UA Publish/Subscribe on machine and robot side (determinism required) -> Pub/Sub over TSN**
  - Machine is publishing positions
  - Robot is locking/releasing machine movements (via variables or methods)
Euromap 79
Communication patterns – multiple robot scenario
## Use case robot integration

### Traffic characteristics

<table>
<thead>
<tr>
<th>Traffic</th>
<th>class</th>
<th>Cycle time (ms)</th>
<th>Payload (byte)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyclic data from injection moulding machine to robot (positions signals)</td>
<td>Cyclic with fixed priority</td>
<td>1-10</td>
<td>100-500</td>
</tr>
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</tr>
<tr>
<td>Acyclic Traffic for configuration</td>
<td>Best effort</td>
<td>/</td>
<td>Not bounded</td>
</tr>
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</table>
Production cell network
Topology and configuration

- Configuration of the production cell network is done at our customers site
- Customers doesn't have any know-how in
  - Setting up a TSN network
- Integration of a robot must be seamless for them
  - No need for calculating a schedule
- Production cell is in manual / standstill when reconfiguration is happening
- Network topology production cell:
  - in most cases a **star topology**
Use case machine network
Traffic characteristics

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<td>&lt;100 per Endpoint</td>
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Machine network
Topology and configuration

- Network configuration is known at design time
- Integration of a robot must be seamless for them
  - No need for calculating a schedule
- Machine in manual / standstill when reconfiguration is happening
- Network topology production cell:
  - Mostly line topology (so called „daisy-chaining“)
  - About 10-20 endpoints
Conclusio

Next steps
Thank you

- Get in contact:
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