Machine-To-Supervisory Communication Framework based on OPC Unified Architecture

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Technical Track

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Outline

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Introduction

- **Industrial manufacturing** is an important factor for global economy
- **Automated production machines**
  - Enable constant product quality
  - Ensure wealth of industrial nations
  - Ensure high flexibility
- **Flexible manufacturing systems** are required due to:
  - Decreasing product life cycle times
  - Variety of product configurations
- **Holistic Machine Optimization**
  - Ensures business turnover
  - Enables productivity awareness
  - Needs high engineering efforts due to variety of communication protocols
- **Universal framework for machine-to-supervisory (M-to-S) communication enabling interoperability**
Today’s Communication Architecture

Control feedback loops are implemented between supervisory and machine level (ERP to technical process)

High efforts exist for vertical integration due to variety of device suppliers and communication protocols

Hardware gateways are mandatory

ISA-95 Manufacturing Levels according to [1] from [2]
Controller to Field Device Requirements

- **Industrial Ethernet** based fieldbus protocols have gained acceptance during the last years
- **Ethernet** was already known from the office world
- Main *industrial* requirements:
  - **Determinism** (defined time slots) including Integration of **Synchronization** mechanisms
  - Integration of **COTS** hardware
  - **Availability** of products and components
M-to-S Communication Requirements

- **Open Standards**
  - Reduces vendor dependencies / minimize risks

- **Semantic Interoperability**
  - Same “language understanding” for information exchange between different suppliers

- **Security Mechanisms**
  - Prevent communication mechanisms from being misused (user authentication and authorization, data encryption)

- **Defined Interfaces**
  - Abstraction of application and communication by defining a way to describe (service) interfaces
Information Modeling

Goals:

► **Achieve Semantic Interoperability by**
  ► ... defining a common information interpretation
  ► ... creating entities and relationships
  ► ... using defined mechanisms / a framework

► **Maximize Use Case Coverage by**
  ► ... using an application layer of established protocols CIP and sercos

► **Main Goal:**
  Use information models in a standardized architecture enabling secure communication mechanisms
CIP Data Model Overview

- Objects include attributes and services
- Classes group objects
- Addressing data values by: Device.Class.Instance.Attribute
- 8Bit, 16Bit and 32Bit addressing supported
sercos Data Profiles:

- **SCP – sercos Comm. Profile**
  - configuration of comm.
- **GDP - Generic Device Profile**
  - Independent from device class
  - e.g. diagnosis, archiving
- **FSP - Function Specific Profile**
  - Dedicated device class functionality
  - E.g. drive control parameters

Each **device includes several profiles** covering different functional areas

Leads to **modularity** within a device
sercos Parameter Model:

- **sercos III IDN**
  - 4 byte identification number

- **Data Block Number**
  - Data content

- **Parameter Set**
  - Multiple parameter sets

- **S/P Parameter Bit**
  - Standard or Product Specific Parameter

- **Structure Element**
  - Index of Element to be addressed

- **Structure Instance**
  - Instance of structure to be addressed

### Table: sercos Data Model Elements

<table>
<thead>
<tr>
<th>element No.</th>
<th>Description</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IDN</td>
<td>mandatory</td>
</tr>
<tr>
<td>2</td>
<td>Name</td>
<td>optional</td>
</tr>
<tr>
<td>3</td>
<td>Attribute</td>
<td>mandatory</td>
</tr>
<tr>
<td>4</td>
<td>Unit</td>
<td>optional</td>
</tr>
<tr>
<td>5</td>
<td>Minimum input value</td>
<td>optional</td>
</tr>
<tr>
<td>6</td>
<td>Maximum input value</td>
<td>optional</td>
</tr>
<tr>
<td>7</td>
<td>Operation data</td>
<td>mandatory</td>
</tr>
</tbody>
</table>

NOTE: Elements 5 and 6 are mandatory for cycle time parameters (S-0-1050.x.10, S-0-1002).
OPC Unified Architecture

- Middleware-technology
- Extends the **OLE for process control (OPC)** standard
- Established technology for data exchange within factory automation and other applications

**OPC UA Technology**

- Integrates a semantic capable **information model**
- Is based on **SOA**
- Has **platform independency** (no Microsoft DCOM)
- Has **TCP/IP** based communication protocol

- OPC UA is an **industrial de facto standard** for higher level interoperability
OPC UA Data Modeling

- **Nodes** are “atomic entities”
- Nodes are organized within the server address space
- **Objects** can
  - Include **Variables**
  - Include **Methods**
  - Send out **Event Notifications**
- **References**
  - Define *relations* between objects
  - Are *typed to express* the relationship

Each **OPC UA Server** consists of an integrated address space containing information
OPC UA Services

- OPC UA server provides standardized services

- Discovery Service Set
  - Server and endpoint discovery services
  - Servers can register themselves to one discovery server
  - Servers provide own discovery services
  - Useful with complex factory networks

- Secure Channel Service Set
  - Security mechanisms
  - Secure channel establishing between Client and Server
  - Security mechanisms are stack integrated

- Methods Service Set
  - Method invocation services
  - Includes interface definition (input and output arguments)
  - browse and query services for method discovery
Framework concept

- OPC UA based communication between supervisory systems and machine level

- **Machine Controller Information Model** has standardized and non standardized Information Objects

- Server can be placed
  - On Controller Level
  - On Field Device Level

- Standard models are defined via companion specifications for **interoperability**

- Non-Standard models include application data and enable **flexibility**

- Field Device Data is provided within the Server
Conclusions and Outlook

- Machine-to-supervisory communication is essential for holistic optimization of machinery
- Standardized information models facilitate the implementation efforts for machine data integration
- Introduced **CIP, sercos and OPC UA data modeling** concepts
- **Communication framework** to solve the problems of integration

- Standardization of suitable information models has to be advanced
  - E.g. Energy Management, Condition Monitoring

- Work in **O.M.I. task force** is still in progress
Thank you for your attention!