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

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Technical Track

Outline

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- **Requirement Analysis**
  - Communication Architecture
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  - Machine-To-Supervisory Communication
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- **OPC Unified Architecture**
- **Framework Concept**
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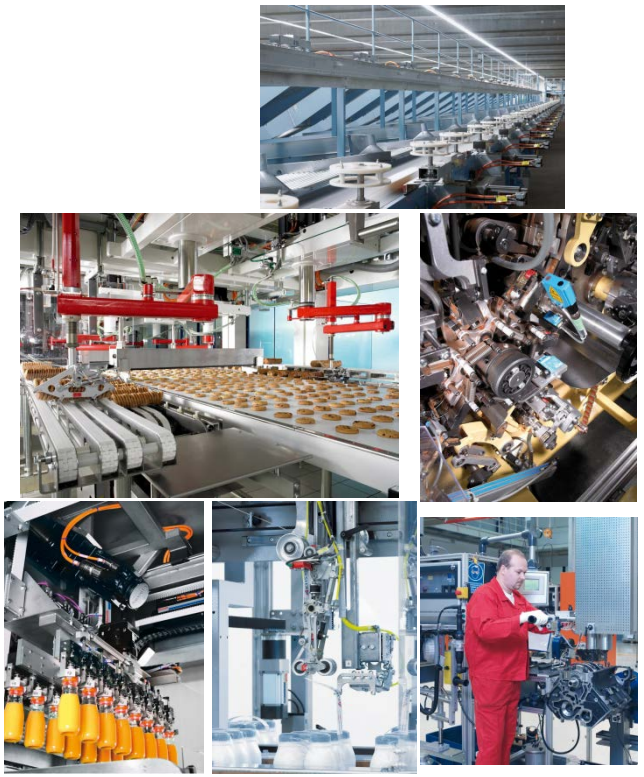
Introduction

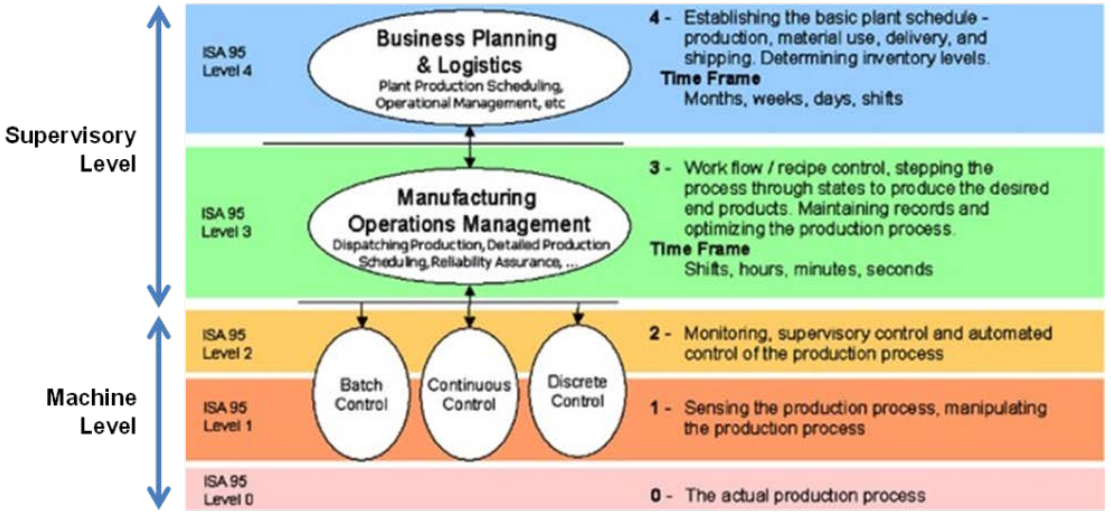
- **Industrial manufacturing** is an important factor for global economy
- **Automated production machines**
  - Enable constant product quality
  - Ensure wealth of industrial nations
  - Ensure high flexibility
- **Flexible manufacturing systems** are required due to:
  - Decreasing product life cycle times
  - Variety of product configurations
- **Holistic Machine Optimization**
  - Ensures business turnover
  - Enables productivity awareness
  - Needs high engineering efforts due to variety of communication protocols



Sample Applications © Bosch Rexroth AG

- **Universal framework for machine-to-supervisory (M-to-S) communication enabling interoperability**

Today's Communication Architecture

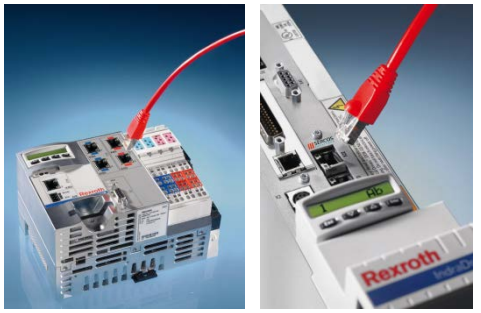


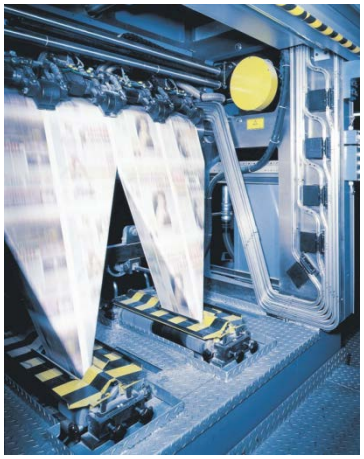
ISA-95 Manufacturing Levels according to [1] from [2]

- **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

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

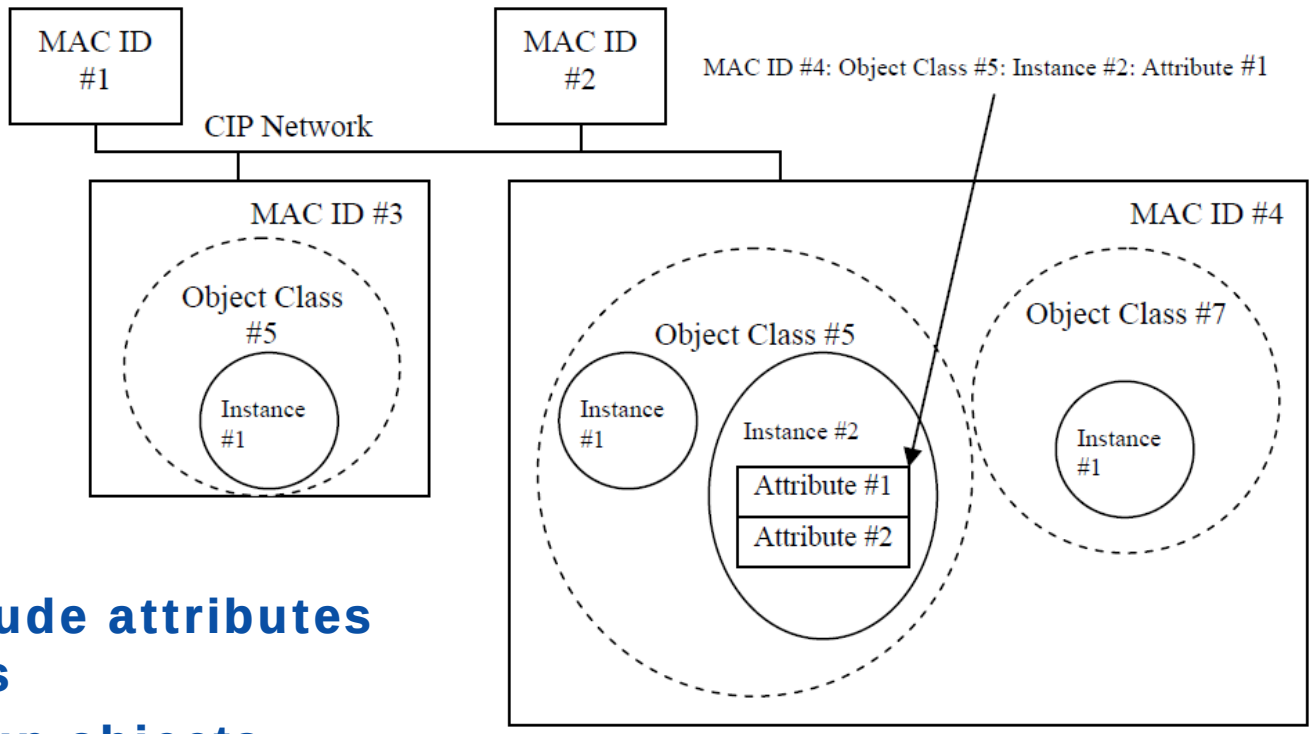
Goals:

- **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

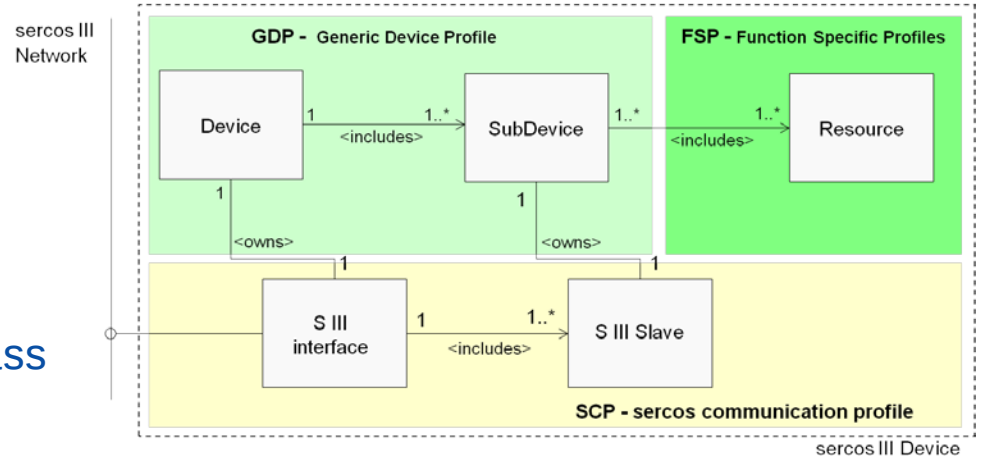
- **Main Goal:**
  Use information models in a standardized architecture enabling secure communication mechanisms

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 Model Overview 1 / 2



sercos Data Profiles:

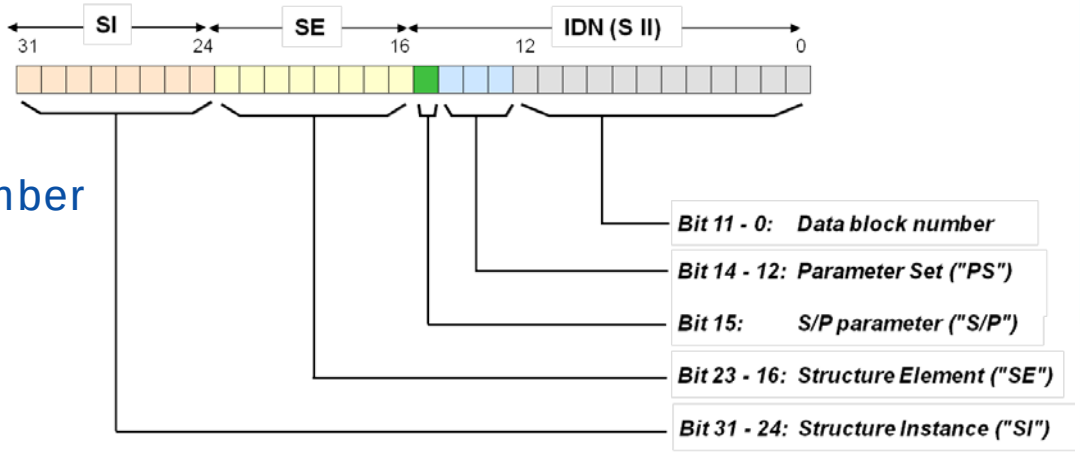
- **SCP – sercos Comm. Profile**
  - configuration of comm.
- **GDP - Generic Device Profile**
  - Independent from device class
  - e.g. diagnosis, archiving
- **FSP - Function Specific Profile**
  - Dedicated device class functionality
  - E.g. drive control parameters

- Each **device includes several profiles** covering different functional areas
- Leads to **modularity** within a device

sercos Data Model Overview 2 / 2

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



< IDN>.<SI>.<SE> e.g. S-0-1530.2.5

element No.	Description	Requirement
1	IDN	mandatory
2	Name	optional
3	Attribute	mandatory
4	Unit	optional
5	Minimum input value	optional
6	Maximum input value	optional
7	Operation data	mandatory
NOTE Elements 5 and 6 are mandatory for cycle time parameters (S-0-1050.x.10, S-0-1002).		

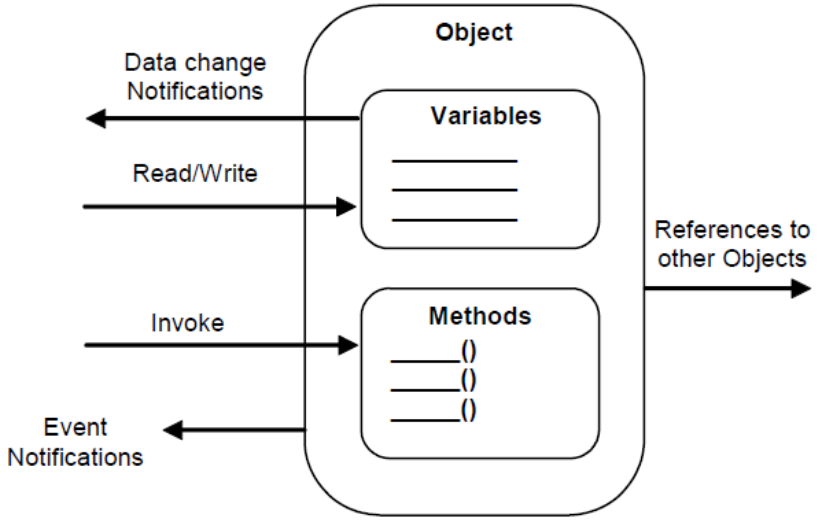
OPC Unified Architecture

- **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

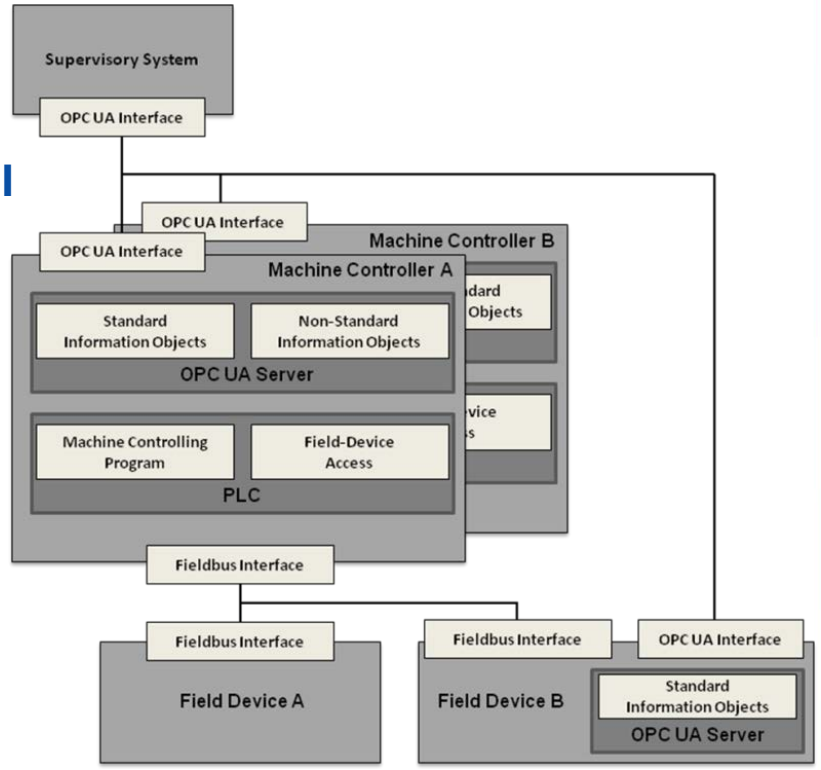
OPC UA Services

- 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 !