SOA PLC
With standardized interfaces for cloud-enabled services

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Product Manager TwinCAT
1. About Beckhoff

2. IoT vs Industry 4.0: What is different – what is similar?

3. Communication requirements for intelligent devices

4. SoA-PLC: Definition and Realization

5. Success Story: Experiences from customers
About Beckhoff Automation

Headquarters:
Production:
Headquarters premises in Verl:
Employees worldwide:
Number of engineers:
International representation:
Sales worldwide 2015
Sales worldwide 2016

Verl, Germany
Verl, Germany
> 452.000 sg ft
3,350
1,100
> 70 Countries
620 million € (+22 %)
679 million € (+9.5 %)

as of: 04/2017
Solutions for Industrial Automation:
- IPC, Motherboards, Display Panels, I/O
- Various fieldbus solutions EtherCAT Technology www.ethercat.org
- Scalable real-time extension for Windows
  DOS / NT / Win2K / XP / Win7 / Win8 / Win10 /
  Windows Embedded
  IEC 61131-3 PLC / C++ /
  Motion Control / HMI

High level of expertise in Embedded Automation
**Member**
- 1998 May: Beckhoff becomes a Corporate Member of OPC Foundation

**Products**: Early adopter of technologies
- 1999 OPC-DA Server for IEC 61131-3-PLC
- 2006 OPC-DevCon: First OPC-UA Server embedded into PLC
- 2008 First UA product available: TwinCAT OPC-UA for Data Access
- 2011 Certified OPC-UA Server product
- 2012 First OPC UA Client embedded into PLC
- 2014 First OPC UA Server with SOA functionalities
Vision: Actively pushing OPC-UA

- 2008: Chair of working group “PLCopen & OPC-Foundation”
- 2010: President OPC-Europe
- 2015: Vice President OPC Foundation | Member of OPC board
Agenda

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Simplified message:

- IT companies provide agents for all OS platforms → Push data into their cloud systems
- IoT starts with data in the cloud
- New business with analytics in the cloud

Required:

- (Only) data transport
- Security?
- Interoperability?
Simplified message:

- Focus on factory & process automation
- Devices become more intelligent
- Communication “Service to Service”
- Cloud as one option (platform to host services)

Requirements are higher:

- Horizontal and vertical communication
- “Ad-hoc” discovery of services
- Modeling: Information Model
- Scalability: From sensor to the cloud
- Operating system and language independent
- Security: authentication, signing, encryption
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1. Direction, “How”:
   - **Today**: Top down information flow
     - upper level: always initiates communication (as client)
     - lower level: answers (as server)
   - **Next**: Network of intelligent systems
     - Intelligent I/O sensor connected to intelligent camera

2. Content, “What”:
   - **Today**: Multiple converters
     - “electrical signal” → via data
     - via functions → to service
       (mostly: data/property based)
   - **Next**: Service to Service
## Summary: OPC Unified Architecture stands for…

### Data Modeling
- Generic object-oriented modeling
- Objects with variables, methods and events
- Extensible type system
- History for data and events
- State machines, programs, alarms & condition
- Complex data

### Communication
- Integrated security mechanisms
- High speed UA TCP protocol
- Web services for Internet
- Platform independent
- Built-in robustness and fault tolerance
- Redundancy

### Collaboration
- UA is IEC standard 62541
- UA is base for other information models
- EDDL and FDT
- PLCopen, BACnet, MES, MDIS, ISA95

### New Applications and Use Cases
- Profiles for different use cases
- Scalability
- Integration into embedded systems
- MES and ERP systems
- Specialized versions for different industries
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Service Oriented Architecture (SOA) PLC:

- Controller provides **Services**
- **Discovery** of Services
- **Standardized** Access
- Support of
  - **Interoperability**
  - **Security**: Rolls of access per user
  - **Information-Modeling**
    Type and Data consistency
Standardized models

- Standardized Models
- Beckhoff Model
- Customer Models
Standardized Models – definition of semantic simplify engineering

- PLCopen
- MES / AutoID /
- FDI / Oil&Gas (MDIS) / ..
- CNC-HMI
- BACnet
- ...

Hi, I am a IEC61131-3 controller – but I also support MES profile

Hi, I am an RFID device

Hi, I am a Smart Meter
SOA-PLC: Standardized Model IEC61131-3

- Connection: to the controller
- Integrated: PLC and OPC-UA Server in embedded device
- Mapping: Supports official mapping of IEC 61131-3 to OPC-UA
- Benefit: Secured, semantic interoperability
All information about IEC61131-3 project:

- FBs
- POUs
- Structures
- Tasks/Resources

Beckhoff „PLC1“

Bosch-Rexroth „Logic“

... but semantically identical objects!
SOA-PLC: Standardized Model IEC61131-3

- Connection: from the controller
- Integrated: PLC and OPC-UA Client in embedded device
- Benefit: Secured, semantic interoperability

- Vertical & Horizontal communication
- Fieldbus independent
- It’s fast – but not a fieldbus
Status: PLC function blocks for data communication and method invocation

- UA_Connect/Disconnect
- UA_NamespaceGetIndex
- UA_NodeGetHandle/GetHandleList
- UA_NodeReleaseHandle/ReleaseHandleList
- UA_Read/ReadList
- UA_Write/WriteList
- UA_MethodGetHandle/ReleaseHandle
- UA_MethodCall
SOA-PLC: Overview Architecture

Standardized models
- Standardized Models
- Beckhoff Model
- Customer Models
Monitoring Industrial-PC / Embedded-PC:

- IPC-Device Manager:
  - Both: Monitoring (read) and Configuration (write)
  - Independent from OS and device
  - HW: CPU temperature & usage, Fan speed, RAID status…
  - SW: OS version, available RAM, IP, display, resolution, …
File management of controller

- Scenario 1: Deploy new logic
  - "Stop" all devices in field
  - Download new files e.g. binary PLC project
  - "Start" all devices
- Scenario 2: Deploy OS update, receipes, ...
- Scenario 3: Upload measurement data, log files, ...

Administration
- Deploy binaries
- "Start": Start execution
- "Stop": Stop execution
- "Reset"
- Device management e.g. file transfer
SOA-PLC: Overview Architecture

Standardized models
- Standardized Models
- Beckhoff Model
- Customer Models
Customer to design own “my-SoA” services

- **Requirement:** Easy, quick, reliable, secure, international standardized
- **Define service:** IEC 61131-3 for easy implementation of services FUNCTIONBLOCK can be invoked from outside from any OPC-UA client
- **Invoke service:** Remote-procedure-call (RPC) based on international standards: IEC61131-3 + OPC-UA
SOA-PLC: Customer Models: Design own services  

- One-click engineering to enable service as SOA-service to IT world
- Design of SoA services available in

---

**Define service**

```plaintext
POU.Math.CallSumMul  -> MAIN
1   {attribute 'TcRpcEnable' := ""}
2   METHOD CallSumMul
3   VAR_INPUT
4     a: UDINT;
5     b: UDINT;
6   END_VAR
7     sum: UDINT;
8     pro: UDINT;
9   END_VAR
10   RESULT Module::CallSumMul(ULONG a, ULONG b, ULONG & sum, ULONG & pro)
11     {RESULT hr = S_OK;
12       sum = a+b;
13       pro = a*b;
14       return hr;
15     }
```

**Expose service**

```
MAIN
- prg_math
  - CallSumMul
  - numberOfCalls
```

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**Invoke service** (any OPC-UA-Client)
SOA-PLC: Increased efficiency

- **Service calls vs. data/property exchange**

Common practice:
- MES: “I like to send recipe data”
- PLC: “OK”
- MES: “Here are recipe data 1”
  “Here are recipe data 2…”
- MES: “Finished, please start production”
- PLC: “OK”

Time consuming handshake mechanism

New: service calls
- MES: “Here is new recipe”
- PLC: “OK”

ONE data communication to handle
- secure transport of inputs
- code execution and wait on result
- transport of outputs to caller

Increase efficiency
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   - Joint Water and Wastewater Authority
   - Elster, Regio-IT and Grundfos
Who?
Joint Water and Wastewater Authority
Vogtland, Germany
Silvio Merz, Divisional Manager, s.merz@zwav.de

What?
- Supply water to about 240,000 people and treating their wastewater as well
- Operate almost 600 Water and Wastewater treatment plants
  - Waterworks
  - Water pumps
  - Water reservoirs
- Distributed over about 1400 Km²

“The solution provided us with a saving on the initial licensing costs of more than 90% per device.”
- Autonom M2M between devices – additional monitoring and control via SCADA
**Who?**

Elster

- 7,000 employees in 38 major locations
- 200 million installations in the last 10 years

**What?**

- From shop floor (Beckhoff) controller to top floor (SAP)
- OPC-UA: Direct connection from SAP into controller

**Benefit**

- Quick: Connect machine within 30min
- Easy to use for PLC and MES team
- Standardized interface layer
- Fast connection, include security out of the box
Who?
- Regio IT, Germany

What?
- Smart metering project in Germany
- Decentral measurement of energy data
- Optional local buffering of data
- Pushing data into central databases for analytics
Smart metering: From sensor to cloud – Case 1
Who?
- Grundfos Holding A/S
- 18,000 employees in more than 55 countries
- One of the world’s leading pump manufacturers
- Annual production of 16 million pump units

What?
- Smart metering project in Denmark
- Measurement of energy data in a student dormitory
- Pushing energy data into Microsoft Azure cloud
- Goal: Scalable architecture with standardized communication
Smart metering: From sensor to cloud – Case 2

160 Beckhoff embedded controllers
3000 data points

Microsoft Azure

Azure IoT Suite
- Service Fabric
- Stream Analytics
- Machine Learning
- Alarm System
- SQL Azure

PowerBI

Gateway IPC
- TwinCAT IoT Data Agent
  Provides OPC-UA Client + Server

University and Grundfos Research

Students and Facility Management
Smart metering: From sensor to cloud - Case 2

- Microsoft Azure
- Amazon
- IBM Watson

New machine
Existing machine
Third-party

MQTT
AMQP
OPC UA
TwinCAT IoT Data Agent

OPC UA
TwinCAT IoT Data Agent

MQTT
AMQP
OPC UA