Joining forces to promote the service-oriented architecture PLC (SOA-PLC) - an Internet of Things enabler!

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- Chairman PLCopen & OPCF working group  
President OPC-Europe
Agenda

1. About Beckhoff

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

3. OPC-Unified Architecture: Basics and Modeling
   Collaboration PLCopen and OPCF

4. Success Stories

5. Service Oriented Architecture: SOA-PLC

6. More Information
Beckhoff: About us

- HQ located in Verl, Germany www.beckhoff.com
  HQ US located in Minneapolis area (Savage, MN)

- 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 / Windows Embedded
    IEC 61131-3 PLC / Motion Control / HMI

- High level of expertise in Embedded Automation

- BECKHOFF Pack Expo booth:
  North Hall, Booth 4740
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 Product available: TwinCAT OPC-UA for Data Access
- 2011 Certified OPC-UA Server product
- 2012 First OPC UA Client embedded into PLC

Vision: Actively pushing OPC-UA
- 2008: Chair of working group “PLCopen & OPC-Foundation”
- 2010: President OPC-Europe
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What is the Internet of Things?

“Connected world solutions combine sensors and technologies to enable objects and infrastructure to interact with monitoring, analytics and control systems over Internet-style networks.”

Source: Forrester
Microsoft delivers on the Internet of Things

Devices and assets
- Connect new and existing devices using open-source agents or gateway technologies

Cloud and infrastructure
- Store machine-generated data with data from other sources in the cloud

Analytics Ready
- View data, administer devices, and configure rules, alerts, and other actions using out-of-box or custom portals

Drive Insights
- Mine insights from your data to find gaps and opportunities to make better decisions and realize new business value
IoT: Simplified message:

- We provide an agent for all platforms
- IoT starts with data in the cloud
- New business with analytics in the cloud

Required:

- (Just) data transport
- Security
Industry 4.0: Simplified message:

- Devices become more intelligent
- Communication “Service to Service”
- Cloud is an option as one service

Requirements are higher

- Horizontal and vertical
- “Ad-hoc” discovery of services
- Modeling: Information Model
- Scalable: From sensor to the cloud
- Operating system and language independent
- Safe: authentication, signing, encryption
- International: IEC Standard
Today: Top down information flow

Direction, “How”:
- Today: Top down information flow:
  - upper level: always initiates communication (as client)
  - lower level: answers (as server)
- Next: OPC-UA client & server integrated into smallest devices
  - Network of intelligent systems

Content, “What”:
- Today: Multiple converters:
  From “electrical signal”
  -> via data -> via functions
  -> to service”
- Next: Service to service
New: OPC-UA integrated into devices allow “From service to service”

Source: Prof. Zühlke, DFKI
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**OPC-UA: Basics**

- **Communication infrastructure**
  - Secure, interoperable, reliable, performant, scalable
  - Platform-independent (OS, language, vendor)
  - Technology:
    - Service-oriented
    - Provide technology independent from services
  - Small set of easy-to-use services
    - 37 operations
    - “Grown up” in Automation market - (e.g. time stamp, status) but neutral for other vertical markets

- **Information modeling**
  - Rich, object-oriented and extensible typmodel
  - Typmodel in address space
  - Full mashed network
  - Scalable:
    - Supports simple and complex models
  - Standardized information models based on OPC-UA
    - PLCopen, BACnet, MTConnect…
## OPC-UA: Basics

### 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
UA on a PLC - Experience

- System configuration
  - UA Server directly on PLC
    - No configuration necessary
    - Address space is always consistent with PLC program
  - Server: C++ UA code
    - Easy to compile (VS2005)
    - C++ to support various platforms X86/ARM
    - C++ to support various OS: small CE-based PLC or highend multi-media XPE
  - It works...

>>> Expectation:
- Option for chaining server if multiple clients access the same device/data
- Massive implementations on PLCs
- End customers saving money for extra "OPC"-PC
- PLCopen:
  - History: Defined Funktionsblocks for e.g. Motion Control
  - Future: Define "PLCopen UA" FBs for communication!
#1: OPC-UA model for IEC 61131-3: How?

![Diagram showing the process of OPC-UA model development for IEC 61131-3](image-url)
Entry points into Address Space

Object types based on Function Blocks

Full object hierarchy below DeviceSet

Entry point for DA Clients like HMI
Beckhoff

“PLC1”

Bosch-Rexroth

“Logic”

Different entry point

All information about IEC61131-3 project:
- FBs
- POUUs
- Structures
- Tasks / Resources..

... but semantically identical objects!
PLCopen: Content “WHAT”

OPC-UA-Server: Communication “HOW”

UA-Clients: SCADA/MES/ERP Presentation

#1: OPC-UA model for IEC 61131-3: Results

All information about IEC 61131-3 project:
- FBs
- POUs
- Structures
- Tasks / Resources..

FUNCTION_BLOCK FB_InputParameter
VAR_OUTPUT
  rFillLevel : REAL;
  rSteamDemand : REAL;
END_VAR

Advantages:
- Standardized UA access
- Identical namespace
- Complete information model

Advantages:
- Reuseable HMI Faceplates
- Rapid engineering
- Transparent PLC controller
#1: OPC-UA model for IEC 61131-3: Results

- Connection **to the controller**
- Integrated: PLC and OPC-UA in embedded device
- Mapping: Support official mapping of IEC 61131-3 to OPC-UA
- Benefit: Secured, semantic interoperability
#2: OPC-UA Client FBs for IEC 61131-3: Vision

Connection >from the controller < Controller initiating communication

- Vertical & Horizontal
- Fieldbus independent
- It’s fast – but not a fieldbus
22 FBs for data communication and to invoke method

- UA_Connect/Disconnect
- UA_NamespaceGetIndex
- UA_TranslatePath
- UA_NodeGetHandle/GetHandleList
- UA_NodeReleaseHandle/ReleaseHandleList
- UA_NodeGetInfo
- UA_SubscriptionCreate/Delete/Operate
- UA_MonitoredItemAdd/Remove/Operate
- UA_Read/ReadList
- UA_Write/WriteList
- UA_MethodGetHandle/ReleaseHandle
- UA_MethodCall

1 FB for Diagnosis
- UA_ConnectionGetStatus

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   - M2M & IoT in decentral water treatment
   - Smart metering: From sensor to cloud
   - From shop floor to SAP top floor
5. Service Oriented Architecture: SOA-PLC
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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
M2M & IoT in decentralized, intelligent equipment

Closed User Group

Requests for process values and state changes

Due to problems at group 1 supplier of freshwater has changed to group 2

Waterworks 1

Pumping Plant 1

Please take over filling of elevated reservoir

Quality problems in freshwater!

Requests for process values and state changes

Elevated Reservoir

Level reached!

Stopped pumping

Waterworks 2

Pumping Plant 2
TwinCAT OPC-UA Client (PLCopen-based) and TwinCAT OPC-UA Server are integrated into one of the smallest Beckhoff controllers, a CX9020 Embedded PC.
Cost saving effects

- Transmission of complex data structures -> there’s no configuration of every single datapoint required
- Replacement of a proprietary solution with a combined OPC-UA client/server. Standardization of data communication reduces interfaces, just the OPC-UA client and server.
- A physical interruption of the connection does not lead to a loss of information -> automatically buffered in the OPC-UA server for a time and can be retrieved as soon as the connection has been restored
- Using security mechanisms like authentication, signing and encryption integrated in OPC-UA in addition to a closed mobile radio group to ensure the integrity of the confidential data
- “The solution provided us with a saving on the initial licensing costs of more than 90 % per device.”
Who:
- Regio IT, Germany

What:
- Smart metering project in Germany
- Decentral measurement (optional local buffering of data), pushing into central databases for analytics and deploying results
From shop floor to SAP top floor

Who: Company Elster
- 7,000 employees, 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 (OPC-UA is IEC 62541)
- Fast connection, include security out of the box
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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
SOA-PLC: Runtime and Transport

**OS**
- Microsoft Windows-based

**TwinCAT 3**
- Scalable devices
- Microsoft Windows-based
- Resource management
- Hard Realtime, scalable down to 50µs
- Visual Studio-based Programming Environment
- Implement modules in IEC 61131-3, C++ and Matlab/Simulink
- Distribute modules to all available CPU cores

**Transport**
- Service Invocation:
  - Request / Response
  - Publisher / Subscriber
- One-to-One or One-to-Many
- Security (encryption/signing based on X.509), optionally

OPC Unified Architecture (IEC 62541)
SOA-PLC: Services Overview

**Data- Services**
- Live-View of Variables (Data Access)
- Archiv: Historical Data
- Alarm & Event
- Recipes
- Method / Program / State Machine

**Administration**
- Deploy binaries
- “Start” : Start execution
- Stop: Stop execution
- Reset

**Engineering**
- Get TC3 PLC/C++ code from database
- Download source code to TC3 runtime
- Scan hardware I/Os
- Assign TC3 module code to hardware I/Os
- Create, configure and assign Tasks to CPU cores
- Assign TC3 logic modules to Tasks
- Compile code
- Activate

**Monitoring**
- Device: Hardware Diagnostics
- Customer-defined: Production / OEE

**Application-/Domain-specific**
Organization-defined services
Customer-defined services
Standardized Models
- PLCopen
- FDI
- MES
- CNC-HMI
- BACnet
- ...

Beckhoff Models
Providing access to information about
- Hardware: CPU temperature, fan status, RAID status
- Software: OS version, available RAM, IP address

Customer Models
- Self-defined models
  How to model?  Easy to handle?
SOA-PLC: Customer defined services in IEC 61131-3
OPC-UA provides RPC calls between IT and Automation BECKHOFF

- “SoA PLC”: Service oriented architecture is the key for industrial communication
  - IEC 61131-3: Easy implementation of services
    FUNCTIONBLOCK can be invoked from outside from any OPC-UA client
  - SOA-PLC: Remote-procedure-call (RPC)
    based on international standards: IEC61131-3 + OPC-UA
SOA-PLC: IEC 61131-3 and OPC-UA
Increase efficiency and data consistency

- SOA-controller as enabler for IoT and M2M optimized communication

Service oriented architecture: service calls instead of data (property) exchange

Common practice:
1. MES: “I like to send recipe data”
2. PLC: “OK”
3. MES: “Here are recipe data 1”
   “Here are recipe data 2…”
4. MES: “Finished, please start production”
5. 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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More Information

- Brochure: “OPC UA – Pioneer of the 4th industrial (r)evolution”
  Available in English and German

- Addresses the IT audience

- Quotes from
  - Academia / Industry / Organizations

- Technology

- Scenarios
  - Scalability: UA in sensor level
  - Identification: UA in RFID
  - Controller: Semantic Interoperability
  - Vertical: From controller to SAP
  - Horizontal: UA as enabler for M2M and IoT
  - User&Machine: UA in browser
More Information

- OPC Foundation www.opcfoundation.org
- PLCopen www.plcopen.org

- BECKHOFF Automation www.beckhoff.com
  - Free downloads of trial versions
  - TwinCAT 3: Automation - integrated into Microsoft Visual Studio
  - BECKHOFF Pack Expo booth: North Hall, Booth 4740