How does OPC Foundation software support the Industry 4.0 revolution?

What are the international trends to utilize production data?

Stefan Hoppe
President OPC Europe
Stefan.hoppe@opcfoundation.org

Chair of joined working group PLCopen & OPCF
Industrie 4.0 – Definition

Industry 4.0

- everyone is talking about it: politicians, organisations…
- in all journals are innumerable articles

→ Do you know what Industry 4.0 means?
Industry 4.0 is

- a future oriented project in the hightec-strategy of the Federal Government which should expedite the informazation of the classical industries, e.g. the industrial engineering.

- the ambition is the intelligent factory (Smart Factory) which is marked by adaptility, efficiency of resources and ergonomic as well as the integration of customers and business partners in business- and creation processes.

- technological basis are cyber-physical systems and the internet of things (Internet der Dinge).

Quelle: www.wikipedia.de
Securing the future of German manufacturing industry

Recommendations for implementing the strategic initiative INDUSTRIE 4.0

Final report of the Industrie 4.0 Working Group

Source: Acatech, Final report of the Industrie 4.0 Working Group, April 2013
The main focus of the preliminary draft from 2.10.2012

1. The creation of new forms of the intelligent production technology to be capable of generating innovative products for the world market and making regional factories more flexible and efficiently in dealing with resources

2. The optimization of existing and the invention of new products of the automation technology to ensure Germany`s competitive advantage in its automation competency.

3. The ensurance of location- and occupation with intelligent organization of the production, the engineers and the production environment, mainly in face of the demographic change and the challenges involved for an age-based work structuring.

4. The creation of new collaborative forms of the process organization in the Smart Factory which is oriented in the qualitative enhancement, interesting work context, increasing individual responsibility and self-development.
Germany is building up production again.
Why Industry 4.0?

Support of the mechanical and plant engineering to strengthen their competitiveness.

What should be achieved?

- flexible order processing
- efficient resource management
- connected, reliable production
- 100% traceability and quality assurance
- self-optimizing manufacture and production
- consistent engineering

Quelle: Nobilia - Werke J. Stickling GmbH & Co. KG
Actual technology developments lead to a paradigm shift in applications?

Industry 4.0

Cloud Computing
Big Data
Internet of Things
Self-Optimization
Smart Logistic
Smart Grid
Machines and Controls
Industrial Production
Industry 4.0: Intelligent control

**Challenge**
The members of the BITKOM, VDMA and ZVEI called standardization as the greatest challenge to the implementation of industry

**Requirement**
Horizontal and vertical communication

- Discovering services
- vertical, horizontal
- Modeling: Information Model
- Scalable: From sensor to the cloud
- operating system and language independent
- Safe: authentication, signing, encryption
- International: IEC Standard

Source: Acatech, Final report of the Industrie 4.0 Working Group, April 2013
Quotes from Industry
Das Industrie 4.0 Paradigma erfordert Standards auf mehreren Ebenen, um modulare Produktionsanlagen gemäß Plug ´n Play aufbauen zu können. OPC-UA ist ein wichtiger Standard, der uns hilft, die Kommunikation zwischen Anlagenteilen herstellerunabhängig und sicher zu gestalten.

Durch den industriegetriebenen Standardisierungsprozess ist eine hohe Akzeptanz seitens industrieller Anwender für OPC-UA als plattform- und herstellerunabhängige Kommunikationstechnologie über alle Ebenen der Automatisierungspyramide erkennbar.

Die Informationsmodelle innerhalb des OPC UA Standards bieten darüber hinaus die Grundlage zur Realisierung einer semantischen Interoperabilität.

Prof. Dr. Dr. Detlef Zühlke
Direktor Innovative Fabriksysteme
DFKI Kaiserslautern
As a founding member of the OPC Foundation, Siemens strives to create added value for its customers through driving automation as well as the further development and interoperability of technologies between different system manufacturers.

In many of our innovations – such as the network management solution Sinema Server, the Human Machine Interface Simatic HMI, or the flexible, modular motor management system Simocode pro – OPC standards have been applied. OPC UA is an implementation we attach especially great relevance to. Thus, we have always been strongly involved in this field, and were among the first companies to have their products certified. «

Thomas Hahn, Siemens AG
»OPC UA is the future oriented communication standard for the industry. The emergence of the 4th industrial revolution will boost the need for OPC UA.«

Dr. Reinhold Achatz
Head of Corporate Center Technology, Information & Quality
ThyssenKrupp AG
Quotes from Industry

»OPC UA allows a platform independent, easy and secure connection between SAP business systems with distributed shop floor data even on smallest embedded devices.«

Veronika Schmid-Lutz
Product Owner Manufacturing
SAP AG

»OPC UA unlocks the potential for ERP to Factory Floor communications.«

Dr. Jürgen K. Weinhofer
Vice President Control Architecture & Technology
Rockwell Automation
OPC Foundation
Vision, Organization, Activities, Events
OPC Foundation

• Vision of OPC is secure, reliable, multi-vendor, multi-platform interoperability
• Collaboration is key to incorporating multiple “open” standards into an unified platform architecture
OPC Vision: Interoperability
OPC Foundation Domains

The key markets for OPC technology include:

- Industrial Automation
- Building Automation
- Embedded Devices
- Energy Management (Smart Grid)
- Manufacturing Enterprise Management
- M2M
- Cloud-based Computing
OPC Foundation Membership

- Europe: 216; 47%
- North America: 142; 31%
- Japan: 28; 6%
- Rest of World: 43; 10%
- China: 29; 6%
OPC UA: The NEW Solution

- OPC Foundation defines high performance protocol (TCP Binary)
- One fixed set of services to access all information (DA, AE, HDA)
- Totally platform independent (Win, Linux, vxWorks, QNX, Solaris, …)
- Security (Authentication, Encryption, Signature)
- Object Oriented Information Model
OPC UA: What is specified?

- **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 modelling**
  - Rich, object oriented and extensible typmodel
  - Typmodel in address space
  - Full mashed network
  - Scalable: Support simple and complex models
  - Standardized Information models based on OPC UA
    - PLCopen, BACnet, MTConnect…
Unified Architecture

OPC-UA: New Generation OPC

- Definition 2003 – 2006
- Verification and Implementation 2006 – 2008
- Final OPC Foundation Release 2009

- **OPC UA = established OPC features**
  + Platform independence
  + Standard internet and IP based protocols
  + Built in security features
  + Generic object model
  + Extensible type system
  + Scalability through profiles
  + Migration path from Classic OPC
**OPC UA: Information modelling**

- **Objecttypes** define the semantic and structure of objects.
- **Variable types** define the semantic and structure of Variables.
- **Datatypes** define simple or complex datastructure.
- **Methodes** define the signature of an executable method.
- **Referencetypes** define the semantic of references.
- **"Views"** provides parts from address space.

**Objects**

- Objects
  - Devices
    - Device1
      - Configuration
      - FactorySettings
      - Status
      - OutOfSpecification
        - TrueState
        - FalseState
      - FunctionCheck
        - TrueState
        - FalseState
      - MethodSet
        - GetConfiguration
        - SetConfiguration
      - <ChannelIdentifier>
        - <ChannelIdentifier>
      - SpectrometerDeviceType
      - <ChannelIdentifier>
      - AnalyserStateMachine
  - Device2
    - Configuration
    - FactorySettings
    - Status
    - OutOfSpecification
      - TrueState
      - FalseState
    - FunctionCheck
      - TrueState
      - FalseState
    - MethodSet
      - GetConfiguration
      - SetConfiguration
    - <ChannelIdentifier>
      - <ChannelIdentifier>
    - AnalyserStateMachine

**AnalyserDeviceType**

- Configuration
  - FactorySettings
  - Status
  - OutOfSpecification
    - TrueState
    - FalseState
  - FunctionCheck
    - TrueState
    - FalseState
  - MethodSet
    - GetConfiguration
    - SetConfiguration
  - <ChannelIdentifier>
  - AnalyserStateMachine

**TwoStateDiscreteType (DataType: Boolean)**

- TrueState
- FalseState

**Variables contain data**

**Objects structure the address space**
OPC-UA: Complex?

- Internally it‘s not easy (super complex!) …but it‘s easy to use!

**Connection:**

```java
Session opcUaSession = new Session(uaChannel, uaConfiguration,
                                 uaEndpoint, clientCertificate);
opcUaSession.Open("SessionName", null);
```

**Polling read:**

```java
NodeId node = new NodeId("MAIN.bBool", 4);
DataValue read = opcUaSession.ReadValue(node);
```
Expensive? Getting started

„Build“ versus „Buy“

- **Build**: For members of OPC Foundation:
  
  OPC UA Server or Client on the basis of OPC stacks as provided by OPC Foundation

- **Buy**: For everybody – memers or non-members
  
  Build OPC UA Server or Client with help of an OPC UA Toolkit bought from a Toolkit vendor

  ~ 1.000,-€ once for .NET C# binaries for UA client
  ~ 15.000€ once for ANSI C/C++ client and server source

  Buy once – resell your product multiple times without runtime fees for OPC-UA stack or toolkit vendor
Collaboration

OPC UA

Information model
## OPC Collaboration / Evangelism

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**DAU Congress**

**Date:** 13.03.2014

**Page:** 29
MDIS

MCS-DCS Interface Standardization ("MDIS")
- All Major Oil companies (operators)
- All major DCS Vendors (Yokogawa, ABB, Siemens, Rockwell, Honeywell, GE…)
- Sub Sea Vendors
Collaboration: MDIS

MDIS Selects OPC UA as the MCS-DCS Protocol Standard
April 8, 2013;

The OPC Foundation, dedicated to ensuring interoperability in automation by creating and maintaining open Control System (MCS) and Distributed Control System (DCS) protocol standard. The selection of OPC UA was production.

MDIS is an international joint industry network group whose main mission is to optimize the MCS and DCS interface and establishes a standard for the interface, in order to simplify implementation of data communication linking protocol, the network considered a number of potential candidates for validation testing. The MDIS commends OPC UA for its flexibility and performance over a broad number of criteria such as scalability, reliability, object oriented design,” states the MDIS steering committee.

“The OPC Foundation is excited to collaborate with MDIS in providing the MCS-DCS interface standard,” said "OPC UA will allow secure and reliable information exchange for the topside systems within offshore production.

MDIS selected OPC UA based on several requirements. Here is a sample of the requirements:
- MDIS Vendor Support
- Communication Integrity
- Robust Test Tool
- Communication Integrity
- Reliable Implementation
- Redundancy and Robustness
- Independent Organization Support

About MDIS
To streamline the Master Control System (MCS) and Distributed Control System (DCS) communications on including a standard communication protocol. The MCS-DCS Interface Standardization (MDIS) network has controls area, topsides specialists and oil companies. Standardization of the interface simplifies implementation...
In September 2012 the OPC Foundation and BACnet Interest Group founded a new WG.

The main task is to create a mapping model for OPC UA and BACnet.
Group specified the mapping from **BACnet to OPC UA**.

End 2013 final working group draft for review

By April 2014 the final version is coming

In 2014: starting second step with mapping **OPC UA components into BACnet**

**Public Reviews will be available and feedback / support is welcome!**
Collaboration: BACnet / BIG-EU

»BACnet and OPC UA are already cooperating in the exploration of new opportunities for integration between industrial and building automation:

Energy data are semantically defined through BACnet and can conveniently and interoperably be made available to enterprise systems via OPC UA:

An ideal standardization from sensor right up to IT billing systems.«

Frank Schubert
Member of the Advisory Board of the BACnet Interest Group Europe
OPC & AutomationML
AutomationML (Automation Markup Language)
- **neutral data format** based on **XML** for the storage and exchange of plant engineering information
- provided as **free and open standard**
- to interconnect the heterogeneous tool landscape of modern engineering tools in their different disciplines

AutomationML incorporates different **standards**:
- **Topology** implemented with **CAEX** (IEC 62424)
  Properties and relations of objects in their hierarchical structure
- **Geometry** implemented with **COLLADA** of the Khronos Group
  Graphical attributes and 3D information
- **Kinematics** implemented with **COLLADA**
  Connections and dependencies among objects to support motion planning
- **Logic** implemented with **PLCopen XML**
  Sequences of actions, internal behavior of objects and I/O connections
Exchange of OPC system describing data between engineering tools based on AutomationML within the engineering of production systems

- How can these data be modeled using AutomationML structures and attributes?
- Responsible: Communication working group
Collaboration: PLCopen Overview

- PLCopen: www.plcopen.org
- IEC6-1131-3
- Global standard for Industrial Control Programming
- Languages: ST, IL, LD, FBD
2008 October: Kick off meeting common group

Chairman Stefan Hoppe (Beckhoff)
OPC Editor Matthias Damm (ascolab)
PLCopen Editor Prof. Rene Simon (ifak)

2009/2010
• Goal V1: Common Namespace for IEC 61131-3 Information model

2011/2014
• Goal V2: PLCopen-OPC-UA client function blocks for
  • Data Access
  • Method calls from PLC to external UA Server

2014
• Goal V3: PLCopen-OPC-UA client function blocks for
  • Alarm & Condition und Historizing
  • Kommandos
  • Zertifizierungslogo „PLCopen – OPC-UA“ compliance
PLCopen & OPC Group: How?

- **Source Code**
- **Engineering Environment**
- **Compiler**
- **Logic Motion Safety Program**
  - **Run time environment**
  - **Shared Information**
    - **Controller Implementation**
    - **OPC UA Server**
      - **Communication to OPC UA Client**

Standard

Proprietary
PLCopen & OPC Group: Results

PLCopen:
Content „WHAT“

Beckhoff
„PLC1“

All information about
IEC61131-3 project:
• FB’s
• POU’s
• Structures
• Tasks / Resources...

Bosch-Rexroth
„Logic“

Different entry point

... but semantic identical objects!
PLCopen: Content „WHAT“

All information about IEC61131-3 project:
- FB’s
- POU’s
- Structures
- Tasks / Resources...

OPC-UA-Server: Communication „HOW“

UA-Clients: SCADA/MES/ERP Presentation

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

- Re-useable HMI Faceplates
- Rapidly engineering
- Transparent PLC controller
Semantic connection into the controller

- Controller provides objects to external access
- Controller provides semantic identical access
- Security and access control
PLCopen & OPC: Current status

**FB’s for Data Communication**

- UaConnect
- UaNodeGetHandle
- UaNodeReleaseHandle
- UaNodeGetInfo
- UaMonitoredItemCreate
- UaMonitoredItemDelete
- UaRead / UaReadList
- UaWrite / UaWriteList
- UaMethodGetHandle
- UaMethodReleaseHandle
- UaMethodGetInfo
- UaMethodCall

**Prototype implementation of all FB’s done!**

- Call for Review Dec-2013
- Release März 2014

**Diagnosis**

- UaConnectionGetStatus
Connection out of controller

MES System
- OPC UA Server

Plant Engineering
- OPC UA Server

Virtual machine

Data base

- Controller initiating actions
  - Funktionblocks
- Read / Write / Subscribe / Call Method
Adoption

IEC 61131-3とOPCUAの連携デモ

Sysmac NJ (Omron)

OPC_UA server

OPC_UA Client

CX1020 (Beckhoff)

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Scenarios for data communication:

- Vertical communication
- Horizontal communication
- Fieldbus independent

It’s fast – but not a fieldbus!
UMCM – One MES Interface for all

MES-Connectivity
- Jan 23rd 2013: OPC UA workshop with focus MES
- 28 MES-DACH companies joined OPC UA workshop
UMCM – One MES Interface for all

Interface diversity will increase Project cost

Every machine builder has his own interface. Company specific standards – especially for big companies – will increase the diversity too. This leads into additional project cost, because:

- Any type of machine must be re-tuned to the MES
- Additional production downtime during customizing
- Increases the susceptibility of the machines by the individual adjustments
- Every company needs to build specialized expertise for MES interfaces.
UMCM – the direction to Industry 4.0

The objective of UMCM is to provide to any-sized companies a unified interface, a sustainable "Plug & Work" standard to offer an

- Industry-independent
- Automated and secure data provision
- Avoid misinterpretation of the data
- Support of Industry 4.0.

solution.
UMCM “Highway” for communication

MES

JSON, XML, ASCII-Dateien

OPC

OPC-UA
Collaboration: MES DACH Overview

OPC-UA @ first

»The fusion of automation technologies and information technologies requires 2 key elements. First – an intelligent network based system which is able to create rule based decisions and which could store data – that is a Manufacturing Execution System (MES) – and perhaps more important, secondly – a communication layer that is fast, platform independent, scalable, secure and could be integrated horizontally and vertically from the device level to ERP level – OPC UA. So we have – regardless of the location of the data storage – an industry 4.0 or a so called cyber-physical system (CPS).«
Collaboration: MES DACH Overview

MES-Connectivity

23. Jan 2013: OPC UA Workshop with focus MES
28 MES-DACH companies joined workshop

Goal
Optimal link between factory floor to top floor

Semantic
“What” will be communicated

Transport
“How” to transport (incl security)
MES: Data consistence and performance

Today:
- HMI or MES initiate communication (act as client)
- Controller answer (act as server)

Tomorrow:
- HMI or MES additionally act as server
- Controller additionally act as client
Vertical: From controller to cloud

Runtime: PLCopen Function Blocks for OPC-UA method call

```plaintext
fb_OpcUaOpen()
  bExecute := TRUE,
  sUrl := 'opc.tcp://ew2013.cloudapp.net:4840',
  tTimeout := T#15s,
  hSession => hSessionHandle);
...
fb_OpcUaMethodCall(
  bExecute := TRUE,
  sParam := 'INSERT INTO table VALUES(ID, Time, Val)',
  tTimeout := T#15s,
  hSession := hSessionHandle,
  hMethod := hMethodHandle);
```
Interoperability On The Next Level

- Enables OPC interfaces in embedded controller
- PLC information model in a standardized format
- Rapid engineering for HMI / MES / ERP
- Moving information from shop floor to enterprise
- Secure, remote “out-of-the-PLCopen-box” communication
- Base services for other organizations in domains like MES
OPC UA solutions

From Sensor to IT Enterprise & Cloud
OPC-UA at Chip Level: Hardware

- Company: MatrikonOPC
- OPC UA on a chip

The minimal memory requirements start at 240kB flash and 35kB RAM

»The integration of OPC UA into our measuring instruments provides our customers a comprehensive, secured communication«

Alexandre Felt
Project Manager at AREVA GmbH
OPC-UA at Chip Level: Software

OPC-UA at Chip Level enables Internet of Things

- One of the smallest OPC-UA server that makes software integration easy for the simplest devices in the Internet of things.
- Ported into very resource limited devices such as a sensor integrated with a communication interface, and communicate directly for vertical integration.
- Platform specification:
  - TPS-1 Chip, ARM9@100MHz
  - Available memory < 64 Kb
  - Operating system: EmbOS
  - Connectivity: Ethernet (two port switch and non real-time TCP/IP channel parallel with a real-time channel)
OPC-UA at Chip Level enables Internet of Things

- **OPC UA Services**
  - Nano Embedded Device Server Profile
  - Read, Browse

- **OPC UA Information Model**
  - Simple sensor data
  - Basic device information

- **Footprint (15 Kbyte)**
  - OPC UA Stack: 10 Kbyte
  - Micro TCP/IP stack: 5 Kbyte
Gateway level

Company SSV
HW: IGW/865 Gateway serial/TCP
CPU ARM9™ Atmel AT91SAM9263
OS Linux
OPC OPC-UA Server
Company Siemens
HW: SIMOCODE pro V PN
SIRIUS Motor Management System
CPU ERTEC200 with ARM946
OPC UA-Server
UA solutions: Controller level

Company Beckhoff

HW: CX8090 PLC controller
CPU: ARM9™ Freescale i.MX25
OS: Windows Embedded CE6
OPC: OPC-UA Server (DA/HA/AC) and also OPC-UA client
Footprint UA Server 3MB
UA solutions: Operator / HMI level

Company Siemens
HW: KTP400 Comfort HMI Panel
   WinCC V11 (TIA Portal)
CPU ARM11
OS Windows Embedded CE6
OPC OPC-UA Client

Company Garz&Fricke (HW) / Inosoft (SW)
HW: Panel PC Cupid
CPU ARM11™ Freescale i.MX35
OS Windows CE6.0R3
SW VisiWin HMI software
OPC OPC-UA Client
Company Unified Automation (SW)
HW: Samsung
CPU ARM
OS Android
OPC OPC-UA Client C++

Company ProSys (SW)
HW: Samsung
CPU ARM
OS Android
OPC OPC-UA Client Java
OPC-UA in RFID Reader

ERP

MES

OPC UA

RFID Reader

RFID Transponder on field level

PLC
From Controller to IT Level

Today

Transition process

“From signal -> via data -> via functions -> to services”
Status today

• Connectivity layers in our modern world
  
  • Vertical: SCADA / MES / ERP with PLC
    – OPC-UA for identical access to data profiles in shop floor devices
  
  • Horizontal: PLC with PLC
    • OPC-UA for identical protocol access for data exchange
  
  • I/O: PLC with Fieldbus
    – Identical access to data profiles in shop floor devices
  
  • Cloud: PLC with Cloud
    – OPC-UA for identical access to the Cloud for Data Logging
From Controller to IT Level

Tomorrow

Transition process

“From services -> to services”
Englisch: Technologie

OPC-UA: Pioneer of Industry 4.0

Deutsch:
OPC-UA als Wegbereiter für Industrie 4.0

English:
OPC-UA: Pioneer of Industry 4.0
http://www.opcfoundation-events.com/

See also download area
OPC DAY EUROPE 2014

FESTO

Block the Date | May 14/15, 2014

- Organized by OPC-Europe
- Hosted by Festo, Esslingen
- Details on web soon

www.opcfoundation.org
How does OPC Foundation software support the Industry 4.0 revolution?

Stefan Hoppe
President OPC Europe

Stefan.hoppe@opcfoundation.org