The Lean Connected Architecture:

Smart factories need smarter automation to reach Industry 4.0.

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1. Today’s engineering challenges

2. The Smart Factory and Automation
   - Internet of Things
   - Industry 4.0
   - IoT vs Industry 4.0: What is different – what is similar?

3. The Industry 4.0 Standard – OPC UA

4. Automation and IT Convergence

5. Further Information
The Lean Connected Architecture for Smart Factories

Engineering Challenges – Be More Flexible

- Shorter Product Runs
- Faster Delivery
- Higher Product Mix
- Flexible Material Changes
- More Complex Products
- Forecasting Changes
- Supply Chain Management
- Product Traceability
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Engineering Challenges II – Increase Productivity

- Improve Machine Uptime
- Decrease Labor Cost
- Utilize Factory Floor Space
- Improve Throughput
- Use Less Capital
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Engineering Challenges III – Reduce Waste

- Reduce Scrap
- Reduce Waste
- Reduce Energy

“Stop Wasting Money”
I - Be More Flexible
II - Improve Efficiency
III - Reduce Costs?

How to Manage I, II, and III at the Same Time?

- Globally!
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The Overall Challenge: Factory must meet consumer demand

Global Manufacturing Is Challenging:
Adapt Profitably, Quickly, and Consistently to Demand

- Can’t see production status
- Can’t measure performance
- Can’t improve execution

Disconnects

SAP

OPC Technology Summit 2012
The Lean Connected Architecture for Smart Factories

Agenda

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The Smart Factory - Definition

- Flexible Manufacturing Lines
- Faster Machines
- More Accurate Machines
- Smarter Machines
- Efficient Machines with:
- Connectivity to IT World of ERP and MES
So How Do You Get There?
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:
- 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:
- (Just) data transport
- Security?
IoT: ThyssenKrupp connected their elevators to Microsoft Azure

- Collect data from their sensors and systems to improve operations
- Goal: predictive and preemptive maintenance

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Industry 4.0: 4 stages of the Industrial Revolution

1st: Power generation
   1782 Steam engine
   GB
   Quality of life
   Engineering Sciences
   Drivers

2nd: Mechanical automation
   1913 Industrialization
   US
   conveyor belt
   Mobility

3rd: Computer, NC, PLC
   1954 Electronic Automation
   US/EU
   µelectronics

4th: Cyber Physical Systems
   2015 Smart Automation
   EU
   ICT

Source: Acatech, Final report of the Industrie 4.0 Working Group, April 2013
Industry 4.0 is:

- The fourth Industrial Revolution
- A future-oriented project which is part of the high tech strategy of the German Federal Government promotes the computerization of traditional industries such as manufacturing.
- The ambition is the intelligent factory (Smart Factory) which is marked by adaptility, resource efficiency and ergonomics as well as much more highly integrated and connected business processes.
- A technological concept that includes elements such as cyber-physical systems and the Internet of Things.
Industrie 4.0: 5 central research themes

- Horizontal integration through value networks
- End-to-end engineering across the entire value chain
- Vertical integration and networked manufacturing systems
- New social infrastructures in the workplace
- Cyber-Physical Systems technology
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Industry 4.0: Optimization by Cyber-Physical Systems

Vision for Industrie 4.0

- The **product** to be manufactured contains all necessary information on its production requirements
- **Self-organization of integrated production installations** considering the entire value chain (object-oriented)
- **Flexible decision on production process** on the basis of the current situation
- **Human beings remain essential as creative planners, controllers and decision-makers**

Source: Siemens at OPC@Microsoft: Industrial Revolution 2014
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Industry 4.0: Production based on Cyber-Physical Systems

- **“Smart” products**
  - The product to be manufactured has all the necessary information for every step of its production

- **Modular production units**
  - Optimized organization of networked production facilities taking into account the entire value chain
  - Production steps are configured flexibly in response to changing situations

Reduction of complexity due to “smarter” structures

Source: OPC@Microsoft: Industrial Revolution 2014
Challenge
The members of BITKOM, VDMA and ZVEI named standardization as the greatest challenge to the implementation of Industry 4.0.

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

What are the greatest challenges connected with implementing Industrie 4.0?
(you may select more than one answer)

- Standardisation
- Process/work organisation
- Product availability
- New business models
- Security know-how protection
- Lack of specialist staff
- Research
- Training and CPD
- Regulatory framework

Source: Acatech, Final report of the Industry 4.0 Working Group, April 2013
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Overview

- **OPC UA**: Vendor **Independent** Protocol
- **Standardized** protocol for data communication (IEC 62541)
- Enables communication between **different vendors** and devices
- Features a detailed **information model** and **integrated security**
- Widely spread across multiple industrial domains / industries
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Architecture Overview

- **Standardized** Access
- Controller provides **Services**
  Discovery of Services
- Service Oriented Architecture (SOA)
- PLC:
- Support of:
  - **Interoperability**
  - **Security**: User and Role based Access
  - **Information-Modeling**
    Type and Data consistency
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SOA-PLC: Transport

Transport

- Independent of transport method
  - Fast: TCP based binary
  - Web: HTTP/HTTPS with XML coded messages
  - Open: Support any new transport layer in the future

- OPC UA stacks guarantee
  - consistent transport of data and procedure arguments & events on tokens
  - Heartbeat, Unique sequence numbers
  - Automatic buffering in case of disconnection
  - Loss of physical connection does not mean loss of data

- OPC UA Service Invocation
  - Request / Response (1:1)
  - Pub / Sub (1:n)
SOA-PLC: Security

Security

- User management
  Configurable access rights for services and data on node level for different groups and users

- Security by design
  - Authentication (X509 certificates, user/password, kerberos)
  - Signing and encryption (SSL)
  - Rights on data point level with audit functionality

→ Already implemented in OPC UA stack - optional use
Who: Federal Office for Information Security (German Government, BSI)
What: Security Evaluation of OPC-UA

Holger Junker
Head of Unit 'Cyber-Security in critical IT-Systems, Application and Architectures' within the German Federal Office for Information Security

“The only communication technology for industrial environments that I currently know of which provides integrated security functionalities and also offers performance potential to tackle the challenges of Industry 4.0 is OPC UA.”

(11.18.2014)
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SOA-PLC: Standardized Models IEC61131-3: UA Client

Connection >from the controller < Controller initiating communication

Plant Engineering
- OPC UA Server

MES System
- OPC UA Server

- Vertical & Horizontal
- Fieldbus independent
- It’s fast – but not a fieldbus

Data base
Virtual machine

Windows Azure

PLCopen

PROFI

INDUSTRIAL
ETHERNET

EtherCAT

ODVA
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SOA-PLC: Standardized Models IEC61131-3

PLCopen:
Content “WHAT”

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

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

... but semantically identical objects!
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**TwinCAT OPC-UA**

**OPC-UA Server: MethodCall**

- Typical use case: Make handshake communication more efficient

**Common practice until now:**

1. **MES:**
   "I want to send recipe data"

2. **PLC:**
   "OK"

3. **MES:**
   "Here is recipe data 1"
   "Here is recipe data 2…"

4. **MES:**
   "Finished, please start production"

5. **PLC:**
   "OK"

**New: method calls**

- Time consuming handshake mechanism

**Increase efficiency**

- ONE data communication to handle
- secure transport of inputs
- code execution and wait on result
- transport of outputs to caller
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5. Further Information
<table>
<thead>
<tr>
<th>Year</th>
<th>Automation Technology (AT)</th>
<th>Information Technology (IT)</th>
<th>PC based Control</th>
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</thead>
<tbody>
<tr>
<td>1986</td>
<td>Special RTOS</td>
<td>Windows Embedded</td>
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<tr>
<td>1996</td>
<td>Stand Alone Automation Technologies</td>
<td>EtherCAT®</td>
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<tr>
<td>2003</td>
<td>Special Automation Comm Protocols</td>
<td>Internet, Cloud, Big Data, Analytics</td>
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<td>2010</td>
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<td>2015</td>
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Convergence of AT and IT Technologies

BECKHOFF
- PC-based Control: engineering environment and runtime on one PC
- TwinCAT: has been used in thousands of applications in different industries over more than 16 years
- TwinCAT 3 - the integration platform: I/O, PLC, C++, Matlab/Simulink, motion, safety configuration in one dynamic set of tools
- TwinCAT 3 Runtime: ONE runtime with highly deterministic real-time for the execution of PLC, C++, Matlab/Simulink modules, motion and safety
- Modern Software Engineering: integration into Microsoft Visual Studio serves as the basis for integrated engineering over the entire product lifecycle
- The Automation System for Industry 4.0
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Scan Into Live Demo with Your Smart Phone

http://ba-tradeshows-web.cloudapp.net/
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Industry 4.0: Intelligent control

- Standardized communication > from the control <

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- OPC UA
- EtherCAT

Virtual machine

Data base

Windows Azure

Amazon web services

PLCopen

ERP, MES, HMI

IEC 61131-3

C, T, R, L

OPC UA
Industry 4.0 is already happening today.
Go see it in the Beckhoff booth at #639!
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Questions? Contact us!

- BECKHOFF Automation
  - www.beckhoffautomation.com
  - TwinCAT 3: Automation - Integrated into Microsoft Visual Studio
  - No engineering cost for PLC and C++ development
  - Free downloads of trial versions

Visit us at Booth 639!

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