Connecting industrial PLC devices to AWS
Beckhoff Automation: facts and figures

Headquarters:
Verl, Germany
Employees worldwide:
3,900
Number of engineers:
1,400
Sales/technical offices in Germany:
22
Beckhoff companies worldwide:
37 countries
Subsidiaries and distributors:
75 countries
Sales worldwide 2016
679 million € (+9.5 %)
Sales worldwide 2017
810 million € (+19 %)

as of: 04/2018
Components for industrial automation

The IPC Company

The Automation Company

The I/O Company

The Motion Company
Products and system solutions

- Industrial PC
- EtherCAT Box
- TwinCAT

- Embedded PC
- Bus Terminals
- Drive Technology

- Panels
- EtherCAT
- XTS
Applications and solutions

Packaging  Window Production  Robotic
Tire  Plastic  Machine Tools
Woodworking  Forming  Printing
Applications and solutions

- Water Treatment
- Photovoltaic
- Automotive
- Building Automation
- Process Industries
- Test Facilities
- Shipbuilding
- Stage Technology
- Wind Turbines
1. Beckhoff Automation
2. **TwinCAT 3**
3. TwinCAT IoT
4. TwinCAT HMI
5. Scenarios
6. TwinCAT Speech
7. Summary
TwinCAT Architecture

PC System
- Windows 32/64 bit

TwinCAT 3 Engineering Environment based on Visual Studio®
- System Manager
  - Configuration
- Programming
  - IEC 61131-3
  - object-oriented extensions
  - C/C++

TwinCAT Transport Layer - ADS

TwinCAT 3 Runtime
- Real-time Kernel

TcCOM
- PLC
- Safety
- NC
- C Module
- CNC
- Simulink® Module
- C++ Module
- PLC

TwinCAT Automation Device Driver - ADD

Fieldbus

eXtended Automation Engineering (XAE)

eXtended Automation Runtime (XAR)
TwinCAT 3 Engineering based on Visual Studio

- Integration of PLC, Motion and HMI in **one** software on **one** CPU
- Programming in IEC 61131-3
- C/C++ for realtime programming
- Integration of MATLAB / Simulink
- Use of source control systems
Modular Runtime

- Environment for execution and administration of TwinCAT 3 modules
- Standardized modules with defined interfaces (e.g. TwinCAT Component Object Model – TcCOM)
- Distribution of modules to individual cores
- Scalable base time for each core
- Scalable CPU usage for each core
1. Beckhoff Automation
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TwinCAT IoT

- **TwinCAT IoT product family**
  - Includes products and technologies for MQTT connectivity
  - Supports bi-directional communication with AWS IoT and AWS Greengrass on the edge
  - Scalable down to small Beckhoff embedded controllers
TF6701 IoT Communication
- Function blocks for MQTT communication from within PLC
- PLC library "Tc3_JsonXml" to support JSON parsing
TF6710 IoT Functions

- Connectivity with native cloud services as AWS
- **TF6720 IoT Data Agent**
  - Gateway application for cloud connectivity
  - Easy-to-use graphical configuration tool
  - Connect third-party devices via OPC UA
TF6730 IoT Communicator + App
- Smartphone app with push functionalities
- Android and iOS
- PLC library for sending values and push messages
1. Beckhoff Automation
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Client-Server Architecture

TwinCAT HMI Client
- TwinCAT HMI Project
- TwinCAT HMI Framework

TwinCAT HMI Server
- TwinCAT HMI Server Extension

TwinCAT Runtimes
- 3rd Party Runtimes

WS(S)

Protocols

TwinCAT Runtimes
- 3rd Party Runtimes
Application Scenario

Panel

DVI/USB

TwinCAT HMI Client
TwinCAT HMI Server
TwinCAT Runtime
PC
Application Scenario

Mobile Device
TwinCAT HMI Client 2

Panel PC
TwinCAT HMI Client 1

Mobile Device
TwinCAT HMI Client 3

WS

PC
TwinCAT HMI Server

TwinCAT Runtime 2
PC

TwinCAT Runtime 1
PC

3rd Party Runtime
PC

ADS / OPC UA / MQTT
1. Beckhoff Automation
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3. TwinCAT IoT
4. TwinCAT HMI
5. **Scenarios**
6. TwinCAT Speech
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Beckhoff IoT scenarios overview

MQTT

Beckhoff IoT Gateway

Vendor-specific communication via ADS

New Beckhoff Controller with TC3

Old Beckhoff Controller with TC2

3rd party control

Machine Level

Field Level

Beckhoff IoT Gateway

Standardized communication via OPC UA

AWS Greengrass
EK9160 IoT Coupler

- Easily and securely push I/O data to AWS IoT
- Easy configuration via integrated website
- Automatic I/O detection
EK9160 IoT Coupler

- Connection credentials for AWS IoT and AWS Greengrass
  - URL, data format, topic, security settings (TLS)
Perfect industrial-proven gateway hardware

- fanless entry-level PC in the currently most compact form factor: 82 x 82 x 40 mm
- for industrial use: high temperature range (0…55 °C), EtherCAT compatibility, high resistance to vibration and shocks
- combined die-cast zinc and aluminium housing

Perfect IoT Edge device hardware: C6015 | Ultra compact control cabinet Industrial PC
Internet connection speeds (as of Q1/2017)

- Global avg. connection speed increased by 15% compared to Q1/2016

- Problem when transferring huge amounts of data: Available bandwith
Internet connection speeds

- Required bandwidth example
  - Dynamics of wind turbines
  - Condition Monitoring of a machine

- Compression or pre-processing mechanisms required
**AWS booth on the Hannover Fair 2018**

**AWS Greengrass on C6015:**
- AWS Lambda function retrieves process data from machine
- Every 10 seconds: AWS Lambda function publishes aggregated production data

```json
{
  "ProductionLast10s": {
    "Black": 3,
    "Blue": 0,
    "Green": 2,
    "Null": 0,
    "Red": 1,
    "Yellow": 0
  },
  "ProductionTotal": {
    "Black": 6,
    "Blue": 1,
    "Green": 6,
    "Null": 0,
    "Red": 5,
    "Yellow": 1
  },
  "TotalProductionCount": 19
}
```
TwinCAT Cloud Control

TwinCAT Cloud Control - Virtual Machine image

- TwinCAT Engineering
- TwinCAT Runtime
- TwinCAT Analytics
- TwinCAT IoT
- TwinCAT I/O
- TwinCAT HMI
- TwinCAT Scope
- TwinCAT Database

Message Broker

MQTT, secured via TLS

TwinCAT Controller
EK9160 IoT Coupler
TwinCAT Controller
EK9160 IoT Coupler
Use Case description: "Engineering/Diagnostics in the Cloud"

- Central engineering tools installed in the Cloud
- One common platform for every service technician
- Tool-chain easier to handle and update
Use Case description: "HMI Server in the Cloud"
- Central HMI Server installed in the Cloud
- Easily accessible from everywhere
- No ports have to be opened in the controllers’ firewalls
- Use Case description: "Runtime in the Cloud"
  - TwinCAT runtime in a virtual machine to control field devices
  - Ideal combination with EK9160 IoT Coupler hardware
  - MQTT allows easy and secure connection to devices
1. Beckhoff Automation
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The result of Evolutionary Genetic Engineering: A centralized CPU with modular function blocks

- **Human central CPU**
- **Mostly centralized point-to-point data connection**
- **De-centralized sensor input**
- **De-centralized actuator output**

**Senses and control mechanisms**
- Intelligence
- Personality
- Sight
- Touch
- Movement

Senses: Senses and control mechanisms

Intelligence, Personality, Sight, Touch, Movement
The result of Evolutionary Genetic Engineering: A centralized CPU with modular function blocks

Beckhoff Industrial-PCs

Beckhoff connectivity

Beckhoff I/O + Drives

TwinCAT 3 automation software suite
- Runtime
- Motion
- Vision

Hearing

Speaking
Automatic speech recognition (ASR) and text to speech (TTS)
No internet connection required
Based on Windows built-in features
ASR features:
  – Support for 26 different languages
  – Build your own grammar
  – Enables dialog and workflow creation
TTS features:
  – Support for 26 different languages
  – Direct audio output or caching
  – Intonations via SSML
Support for Amazon Polly
TwinCAT Speech - TTS with TcEventlogger integration

- TcEventlogger: Primary source of all events in TwinCAT
- TTS feature of TwinCAT Speech can be coupled with TcEventlogger
- Audio output informs machine user of an event
### Amazon Polly supported languages/voices:

<table>
<thead>
<tr>
<th>Language</th>
<th>Language code</th>
<th>Voices (female/male)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Danish</td>
<td>da-DK</td>
<td>Naja (f), Mads (m)</td>
</tr>
<tr>
<td>Dutch</td>
<td>nl-NL</td>
<td>Lotte (f), Ruben (m)</td>
</tr>
<tr>
<td>English (Australian, British, Indian, US, Welsh)</td>
<td>en-AU, en-GB, en-IN, en-US</td>
<td>Nicole (f), Russell (m), Amy (f), Emma (f), Brian (m), Aditi (f), Raveena (f), Ivy (f), Sallie (f), Joanna (f), Kendra (f), Kimberly (f), Joey (m), Justin (m), Matthew (m), Geraint (m)</td>
</tr>
<tr>
<td>French (French, Canadian)</td>
<td>fr-FR, fr-CA</td>
<td>Celine (f), Mathieu (m), Chantal (f)</td>
</tr>
<tr>
<td>German</td>
<td>de-DE</td>
<td>Marlene (f), Vicki (f), Hans (m)</td>
</tr>
<tr>
<td>Icelandic</td>
<td>is-IS</td>
<td>Dora (f), Karl (m)</td>
</tr>
<tr>
<td>Italian</td>
<td>it-IT</td>
<td>Carla (f), Giorgio (m)</td>
</tr>
<tr>
<td>Japanese</td>
<td>ja-JP</td>
<td>Mizuki (f), Takumi (m)</td>
</tr>
<tr>
<td>Korean</td>
<td>ko-KR</td>
<td>Seoyeon (f)</td>
</tr>
<tr>
<td>Norwegian</td>
<td>nb-NO</td>
<td>Liv (f)</td>
</tr>
<tr>
<td>Polish</td>
<td>pl-PL</td>
<td>Ewa (f), Maja (f), Jacek (m), Jan (m)</td>
</tr>
<tr>
<td>Portuguese (Brazilian, European)</td>
<td>pt-BR, pt-PT</td>
<td>Vitoria (f), Ricardo (m), Ines (f), Cristiano (m)</td>
</tr>
<tr>
<td>Romanian</td>
<td>ro-RO</td>
<td>Carmen (f)</td>
</tr>
<tr>
<td>Russian</td>
<td>ru-RU</td>
<td>Tatyana (f), Maxim (m)</td>
</tr>
<tr>
<td>Spanish (Spanish, Latin American)</td>
<td>es-ES, es-US</td>
<td>Conchita (f), Enrique (m), Penelope (f), Miguel (m)</td>
</tr>
<tr>
<td>Swedish</td>
<td>sv-SE</td>
<td>Astrid (f)</td>
</tr>
<tr>
<td>Turkish</td>
<td>tr-TR</td>
<td>Filiz (f)</td>
</tr>
<tr>
<td>Welsh</td>
<td>cy-GB</td>
<td>Gwyneth (f)</td>
</tr>
</tbody>
</table>
SSML:
- SSML = Speech Synthesis Markup Language
- Includes tags for phrasing, emphasis and intonation
- Helps to create lifelike speech

<table>
<thead>
<tr>
<th>Text</th>
<th>SSML</th>
</tr>
</thead>
<tbody>
<tr>
<td>This is how I speak normally</td>
<td>&lt;speak&gt;This is how I speak normally.&lt;/speak&gt;</td>
</tr>
<tr>
<td>I can speak in a higher pitched voice, or I can speak in a lower pitched voice</td>
<td>&lt;speak&gt;I can speak in a &lt;prosody pitch=&quot;high&quot;&gt;higher pitched voice&lt;/prosody&gt;, or I can speak &lt;prosody pitch=&quot;low&quot;&gt;in a lower pitched voice&lt;/prosody&gt;&lt;/speak&gt;</td>
</tr>
<tr>
<td>I can speak really slowly, or I can speak really fast</td>
<td>&lt;speak&gt;I can speak &lt;prosody rate=&quot;x-slow&quot;&gt;really slowly&lt;/prosody&gt;, or I can speak &lt;prosody rate=&quot;x-fast&quot;&gt;really fast&lt;/prosody&gt;&lt;/speak&gt;</td>
</tr>
<tr>
<td>I can also speak very loudly, or I can speak very quietly</td>
<td>&lt;speak&gt;I can also speak &lt;prosody volume=&quot;x-loud&quot;&gt;very loudly&lt;/prosody&gt;, or I can speak &lt;prosody volume=&quot;x-soft&quot;&gt;very quietly&lt;/prosody&gt;. &lt;/speak&gt;</td>
</tr>
<tr>
<td>I can whisper</td>
<td>&lt;speak&gt;I have a secret to tell you, I will whisper it to you.&lt;amazon:effect name=&quot;whispered&quot;&gt; &lt;prosody rate=&quot;x-slow&quot;&gt; &lt;prosody volume=&quot;loud&quot;&gt;I am not human.&lt;/prosody&gt;&lt;/prosody&gt;&lt;/amazon:effect&gt;Can you believe it?&lt;/speak&gt;</td>
</tr>
</tbody>
</table>
TwinCAT Speech - ASR interface to PLC

- TwinCAT Speech allows definition of voice commands
- Detected voice command is sent to PLC (function block)
- PLC developer can handle command

Voice command example:

```json
{
    "Action": "Open",
    "Parameters": {
        "Valve": true
    }
}
```
TwinCAT Speech - ASR interface to HMI

- TwinCAT Speech allows definition of voice commands
- Detected voice command is sent to TwinCAT HMI Server
- Possible use cases: HMI navigation and control

Voice command example:
1. "Open menu 'production'"
2. "Set field 'FillLevel' to '42'"
1. Beckhoff Automation
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Beckhoff Automation manufacturer of automation systems

AWS IoT and AWS Greengrass enable to connect machines and applications

TwinCAT IoT for connecting the PLC directly or via a gateway application

TwinCAT IoT Communicator App and TwinCAT HMI for visualization of applications

C6015 perfect gateway hardware for aggregation of data on the edge
  - Using TwinCAT
  - Using AWS Greengrass

TwinCAT in the cloud scenarios

TwinCAT Speech as a machine interface using Amazon Polly
Thank you!