Connecting industrial PLC devices to AWS

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1. **Beckhoff Automation**
2. TwinCAT 3
3. TwinCAT IoT
4. TwinCAT HMI
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7. Summary

Beckhoff Automation: facts and figures

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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 %)

aws partner network

Advanced Technology Partner

as of: 04/2018

Components for industrial automation

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The IPC Company

The Automation Company

The I/O Company

The Motion Company

Products and system solutions

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Industrial PC

EtherCAT Box

TwinCAT

Embedded PC

Bus Terminals

Drive Technology

Panels

EtherCAT

XTS

Applications and solutions

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Applications and solutions

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Water Treatment

Photovoltaic

Automotive

Building Automation

Process Industries

Test Facilities

Shipbuilding

Stage Technology

Wind Turbines

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TwinCAT Architecture

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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

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Modular Runtime

- Environment for execution and administration of TwinCAT 3 modules
- Standardized modules with defined interfaces (e.g. TwinCAT Component Object Model – TcCOM)

TwinCAT 3 Runtime

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- Distribution of modules to individual cores
- Scalable base time for each core
- Scalable CPU usage for each core

Settings | Online | Priorities | C++ Debugger

Router Memory (MByte): 2

Available CPUs (Windows/Other): 1 1

Read from Target | Set on target

CPU	RT-CPU	Base Time	CPU Limit	Latency Warning
0 (Windows)	✔ Default	1 ms	80 %	(none)
1 (Other)	✔	50 µs	100 %	(none)

Type	Object	RT-CPU	Base Time	Cycle Time	Cycle Ticks	Priority
TASK	NC-Task	CPU 1	50 µs	0.050 ms	1	1
TASK	PlcAuxTask	CPU 0	1 ms	(none)	0	50
TASK	PlcTask	CPU 0	1 ms	10 ms	10	20
TASK	Task4	CPU 1	50 µs	0.050 ms	1	2

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TwinCAT IoT

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- **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

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- **TF6710 IoT Functions**
  - Connectivity with native cloud services as AWS

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- **TF6720 IoT Data Agent**
  - Gateway application for cloud connectivity
  - Easy-to-use graphical configuration tool
  - Connect third-party devices via OPC UA

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- **TF6730 IoT Communicator + App**
  - Smartphone app with push functionalities
  - Android and iOS
  - PLC library for sending values and push messages

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TwinCAT HMI

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Client-Server Architecture

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Application Scenario

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Application Scenario

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Beckhoff IoT scenarios overview

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EK9160 IoT Coupler

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

aws IoT Hardware Program

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- **EK9160 IoT Coupler**
  - Connection credentials for AWS IoT and AWS Greengrass
    - URL, data format, topic, security settings (TLS)

aws IoT Hardware Program

Perfect IoT Edge device hardware:
C6015 | Ultra compact control cabinet Industrial PC

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- 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

Internet connection speeds

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- **Internet connection speeds** (as of Q1/2017)
  - Global avg. connection speed increased by 15% compared to Q1/2016

	Country/Region	Q1 2017 Avg. Mbps	QoQ Change	YoY Change
–	Global	7.2	2.3%	15%
1	South Korea	28.6	9.3%	-1.7%
2	Norway	23.5	-0.4%	10%
3	Sweden	22.5	-1.3%	9.2%
4	Hong Kong	21.9	-0.2%	10%
5	Switzerland	21.7	2.1%	16%
6	Finland	20.5	-0.7%	15%
7	Singapore	20.3	0.8%	23%
8	Japan	20.2	3.1%	11%
9	Denmark	20.1	-2.9%	17%
10	United States	18.7	8.8%	22%

Avg. Connection Speed by Country

25	Germany	15.3	4.9%	9.8%

	Country/Region	Q1 2017 Peak Mbps	QoQ Change	YoY Change
–	Global	44.6	n/a	28%
1	Singapore	184.5	n/a	26%
2	Macao	132.0	n/a	54%
3	Mongolia	131.1	n/a	63%
4	Hong Kong	129.5	n/a	17%
5	South Korea	121.0	n/a	17%
6	Jersey	108.4	n/a	40%
7	Qatar	107.9	n/a	21%
8	Thailand	106.6	n/a	53%
9	Israel	99.1	n/a	51%
10	Sweden	95.3	n/a	20%

Avg. Peak Connection Speed by Country

45	Germany	65.6	n/a	22%

  - Problem when transferring huge amounts of data: Available bandwith

Statistics based on Akamai Q1/2017 connectivity report

Internet connection speeds

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- Required bandwith example

Dynamics of wind turbines

Condition Monitoring of a machine

- Compression or pre-processing mechanisms required

AWS booth on the Hannover Fair 2018

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

to AWS IoT


```
{
  "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

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TwinCAT Cloud Control

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- 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

TwinCAT Cloud Control

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- Use Case description: "**HMI Server in the Cloud**"
  - Central HMI Server installed in the Cloud
  - Easily accessable from everywhere
  - No ports have to be opened in the controllers‘ firewalls

TwinCAT Cloud Control

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- 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

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The result of Evolutionary Genetic Engineering: A centralized CPU with modular function blocks

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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

The result of Evolutionary Genetic Engineering: A centralized CPU with modular function blocks

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TF4500 TwinCAT Speech

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- 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

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- 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

TwinCAT Speech - TTS languages in Amazon Polly

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- Amazon Polly supported languages/voices:

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

Amazon Polly

TwinCAT Speech - TTS with SSML support

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- SSML :
  - SSML = Speech Synthesis Markup Language
  - Includes tags for phrasing, emphasis and intonation
  - Helps to create lifelike speech

Text	SSML
This is how I speak normally	<speakThis is how I speak normally.</speak>
I can speak in a higher pitched voice, or I can speak in a lower pitched voice	<speak>I can speak in a <prosody pitch="high">higher pitched voice</prosody>, or I can speak <prosody pitch="low">in a lower pitched voice</prosody></speak>
I can speak really slowly, or I can speak really fast	<speak>I can speak <prosody rate="x-slow">really slowly</prosody>, or I can speak <prosody rate="x-fast">really fast</prosody></speak>
I can also speak very loudly, or I can speak very quietly	<speak>I can also speak <prosody volume="x-loud">very loudly</prosody>, or I can speak <prosody volume="x-soft">very quietly</prosody>. </speak>
I can whisper	<speak>I have a secret to tell you, I will whisper it to you.<amazon:effect name="whispered">'<prosody rate="x-slow"> <prosody volume="loud">I am not human.</prosody></prosody></amazon:effect>Can you believe it?</speak>

Example:

TwinCAT Speech - ASR interface to PLC

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

Voice command example:

```
{
    "Action": "Open",
    "Parameters":
    {
        "Valve": true
    }
}
```

TwinCAT Speech - ASR interface to HMI

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- TwinCAT Speech allows defintion 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' "*

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Summary

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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!

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