TwinCAT 3

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PC-based Control

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Motivation

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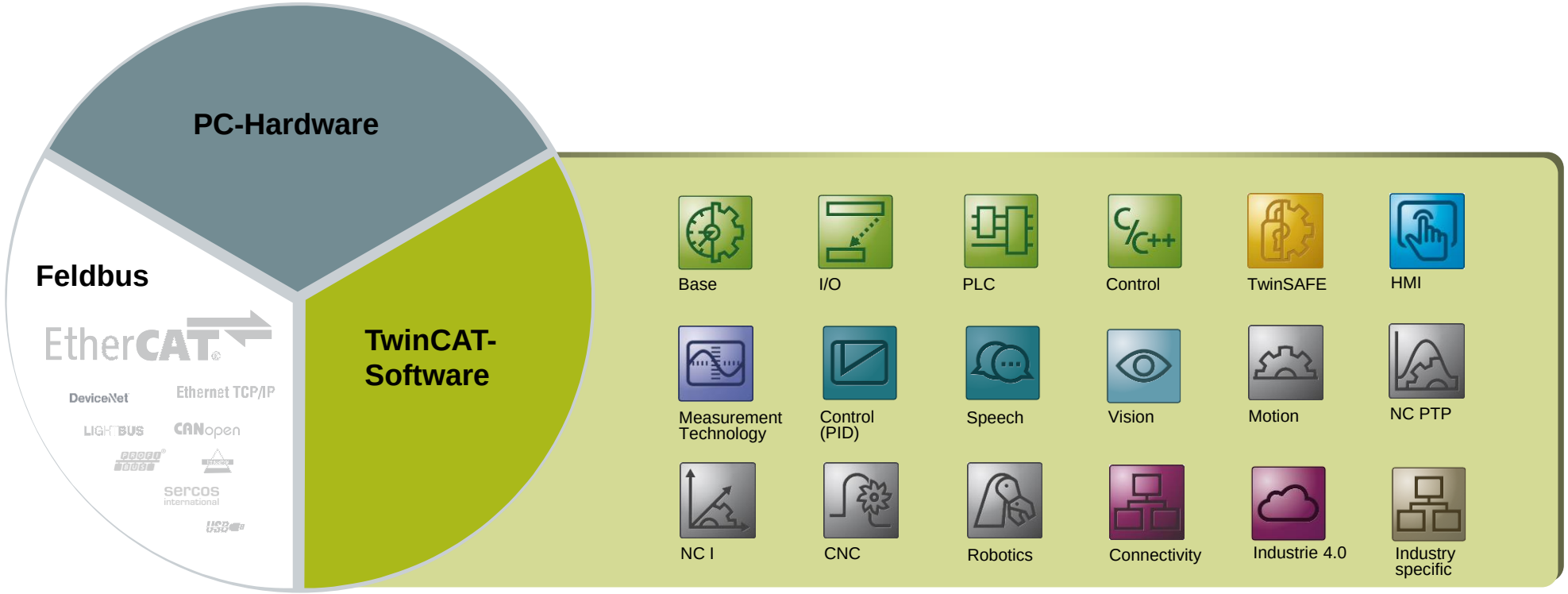
PC-based control technology from Beckhoff sets new standards in automation.



Motivation

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- integration of PLC, Motion and HMI in **one** software on **one** CPU:
  - minimised hardware expenditure
  - no hardware interfaces → faster cycle times
  - reduced interface complexity
  - improved diagnostics
- PC Control offers an “open” control system:
  - Abstraction is the principle.
  - functions in software, independent of the hardware
- scalability of performance and costs through the use of standard CPUs

Motivation

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- High-performance operating systems add IT functions to automation solutions.
- Automation and IT worlds share the same advantages of PC technology:
  - continuous increase in performance
  - continuous reduction in costs

PC-based control technology | Milestones

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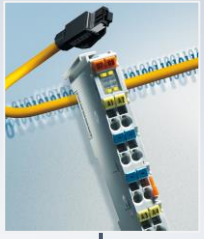

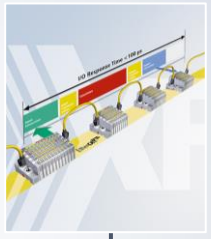

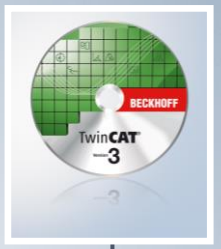

1986	1988	1989	1993	1995	1996	2003	2008	2010	2015	2017
PC-Control PC compatible machine control	**S1000** PLC/NC on PC	**Lightbus**	**S2000** PLC/NC/ CNC on PC	**Bus Terminal** Universal fieldbus module	**TwinCAT** IEC 61131 real-time PLC under Windows NT	**EtherCAT** Real-time Ethernet fieldbus	**XFC** eXtreme Fast Control technology	**TwinCAT 3**	**TwinCAT HMI, IoT, Analytics**	**TwinCAT Vision**

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eXtended Automation (XA)

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- Architecture (XAA)
- Engineering (XAE)
  - System Manager
  - PLC
  - Motion Control
  - C/C++ programming
  - MATLAB® integration
  - C#/.NET programming
- Runtime (XAR)

Architecture (XAA)

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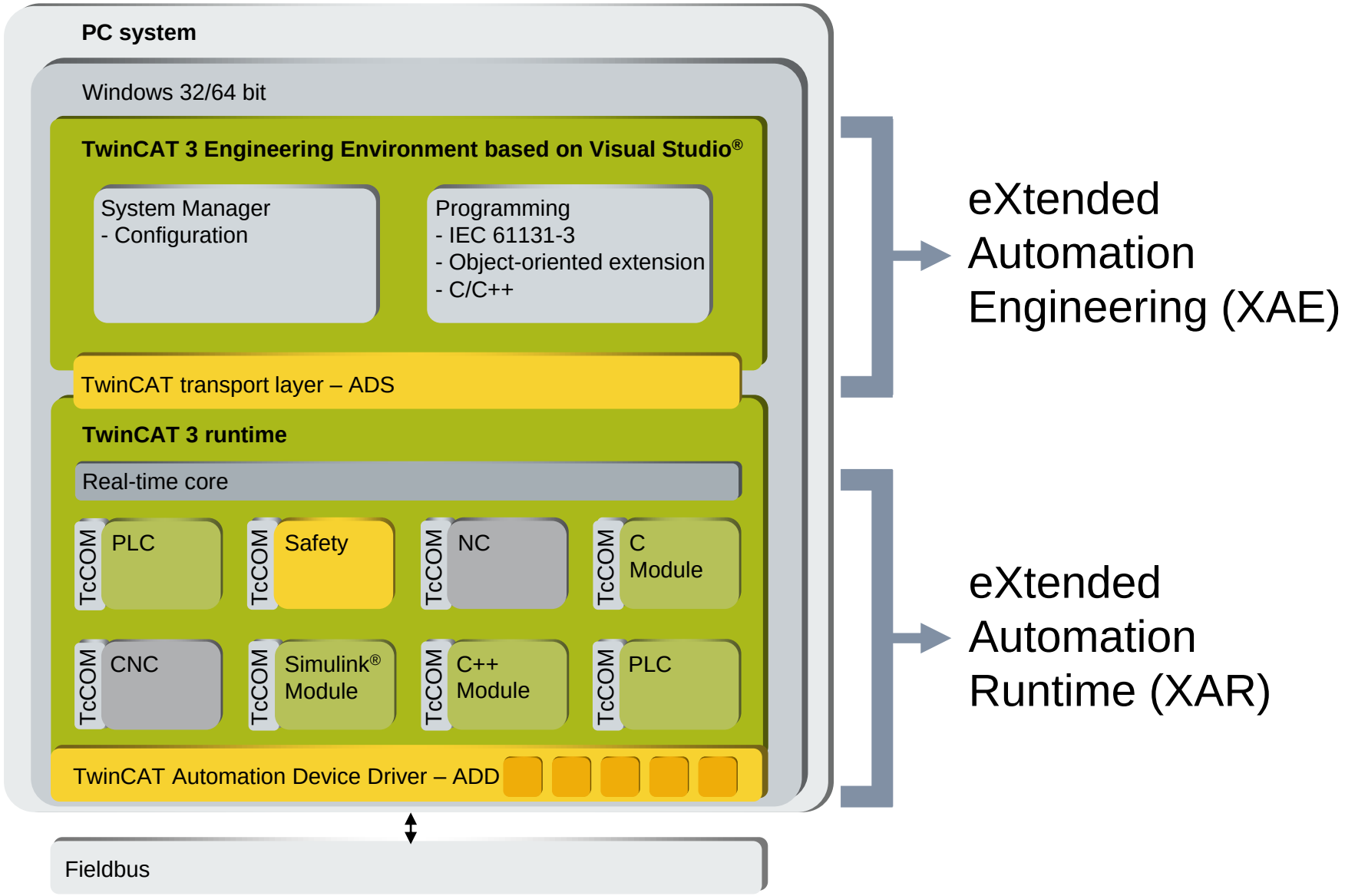

Engineering (XAE)

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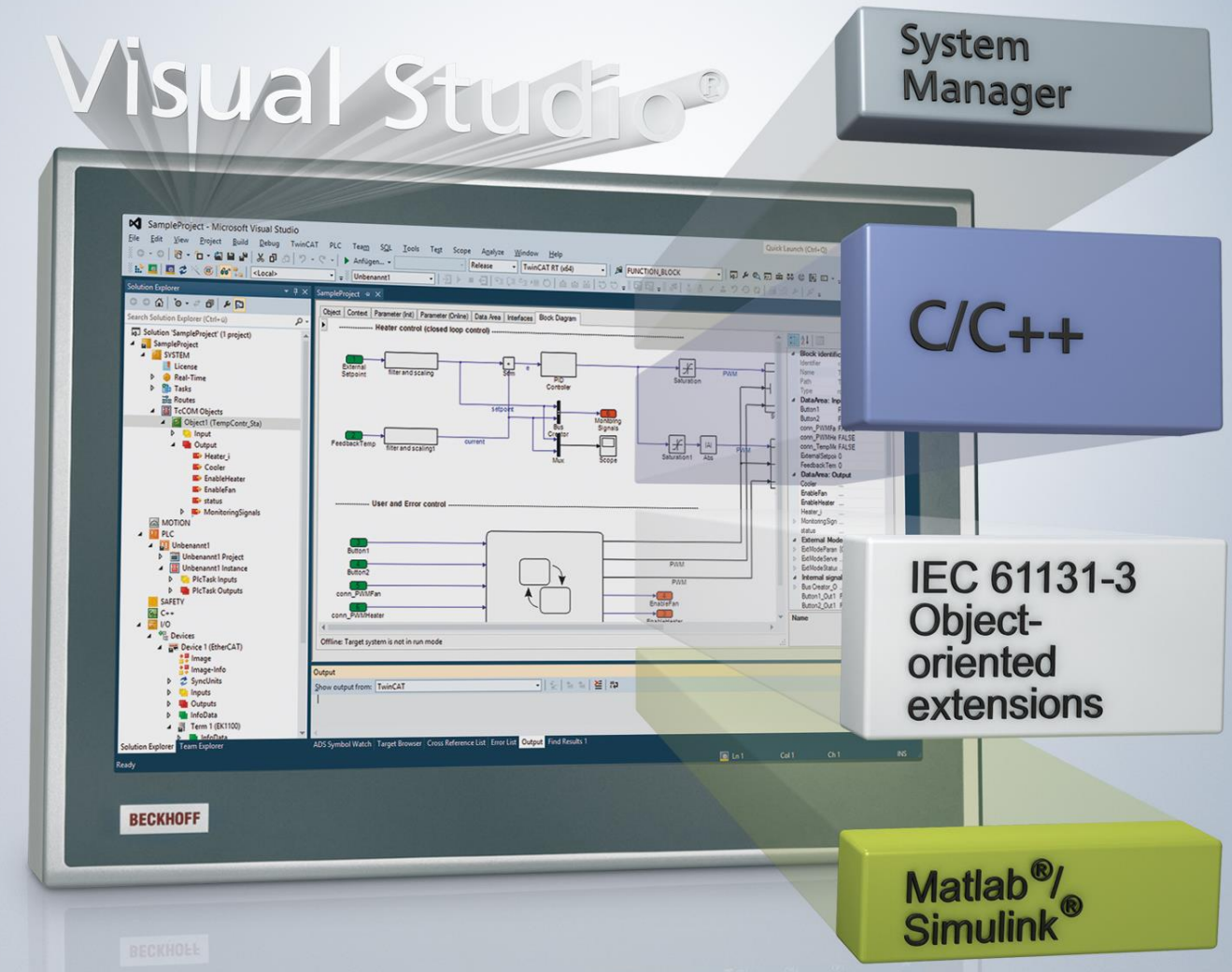

Features

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- TwinCAT 3 – extendable, modular engineering tool
- **one** programming environment, **one** project folder, **one** debugging environment
- **integrated** TwinCAT System Manager
- programming according to IEC 61131-3 3rd edition (including object-oriented extensions)
- use of C and C++ for real-time programming
- link to MATLAB®/Simulink®
- permits the migration of TwinCAT 2 projects
- integrated in Microsoft Visual Studio®

Scalable functionality

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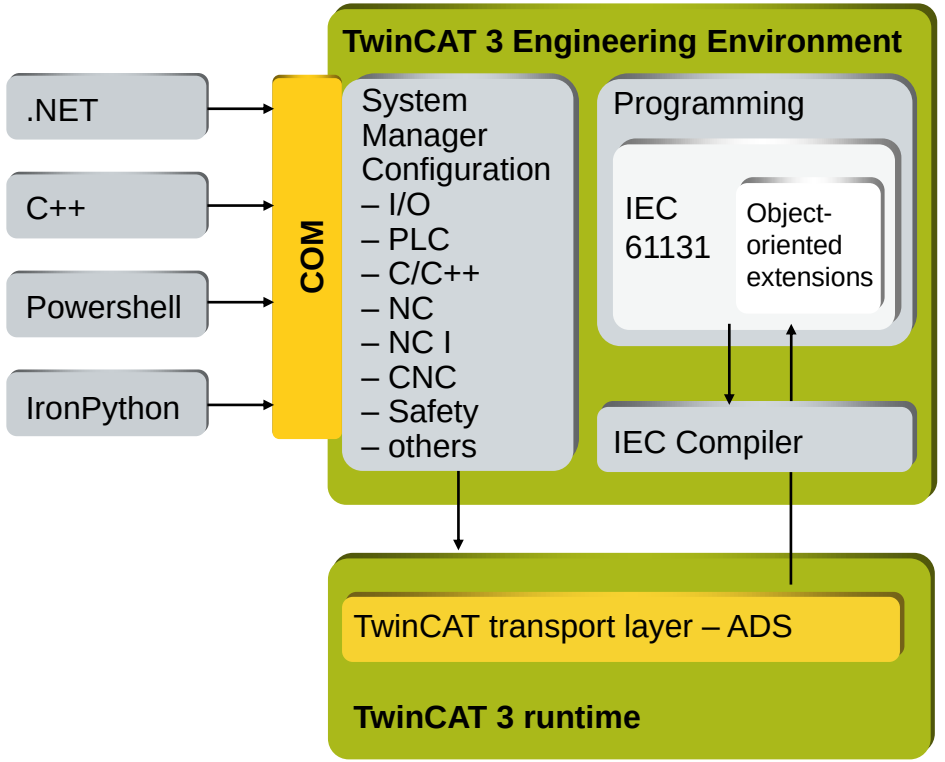
TwinCAT 3

- based on the Microsoft Visual Studio® Shell
- for PLC programmers and users of existing modules
- configuration, parameterisation and diagnostics of system/fieldbus/motion
- debugging of the PLC application



Scalable functionality

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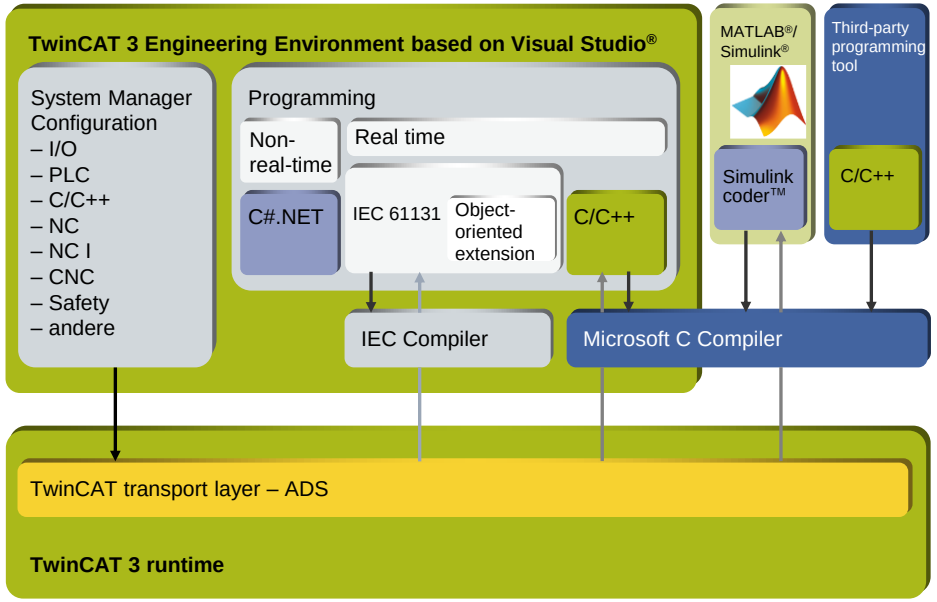
TwinCAT 3

- integration in Microsoft Visual Studio®
- for PLC, C/C++ and/or C# programmers
- configuration, parameterisation and diagnostics of system, fieldbus and motion
- module generation (C/C++ or MATLAB®/Simulink®)
- debugging PLC, C/C++, MATLAB®/Simulink®



Code generation

Debugging

Upload of TC modules

Workbench integration

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TwinCAT 3 framework = Microsoft Visual Studio®

- use of the world’s best-known programming environment
- maintenance by a single company
- extendable by plug-ins
- link to common source-code databases
- C and C++ for the programming of real-time applications
- use of.NET languages for non-real-time applications (e.g. HMI)

Freedom in the choice of programming language

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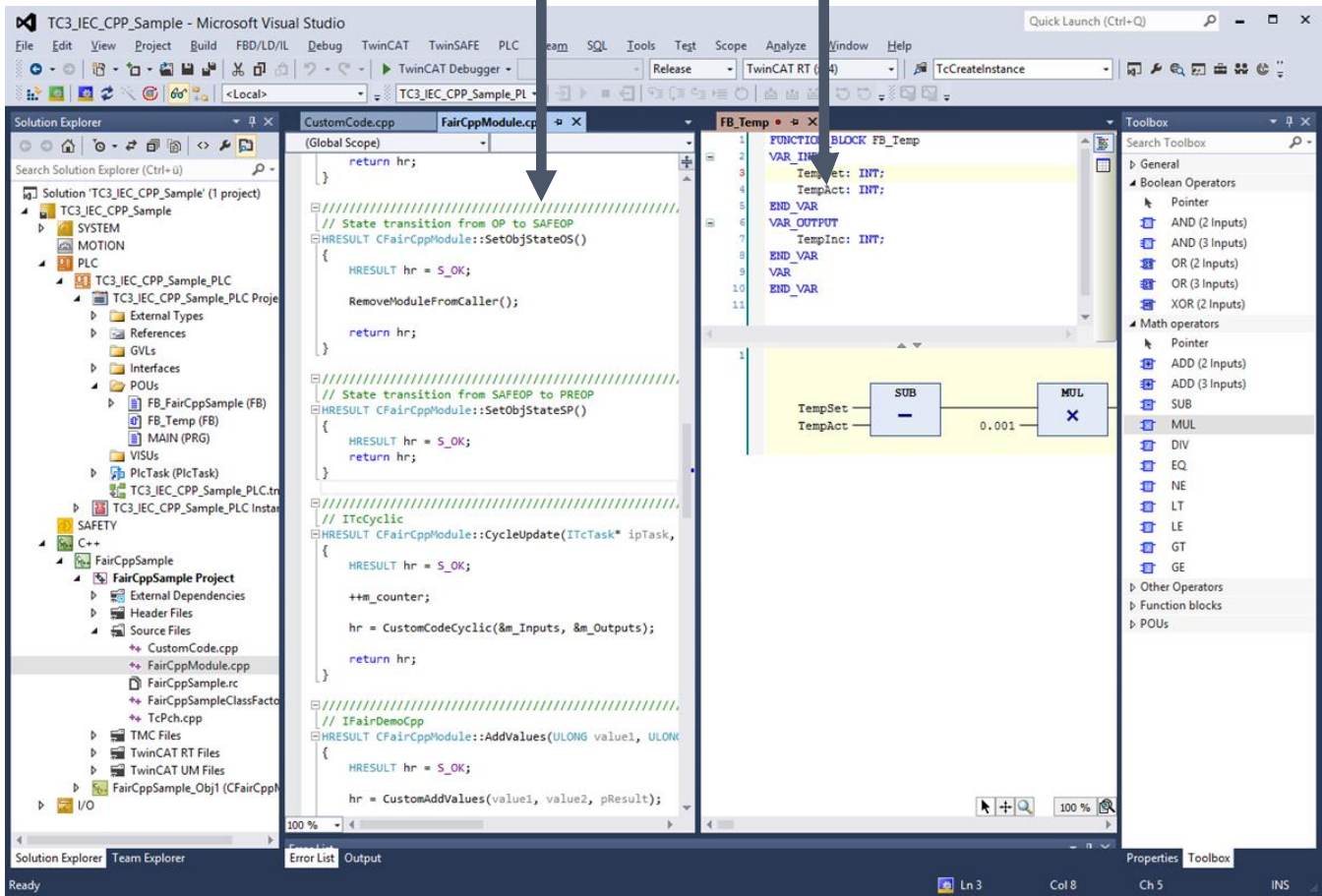
IEC 61131 and C++ programming
in one environment



TwinCAT I/O | Integrated System Manager

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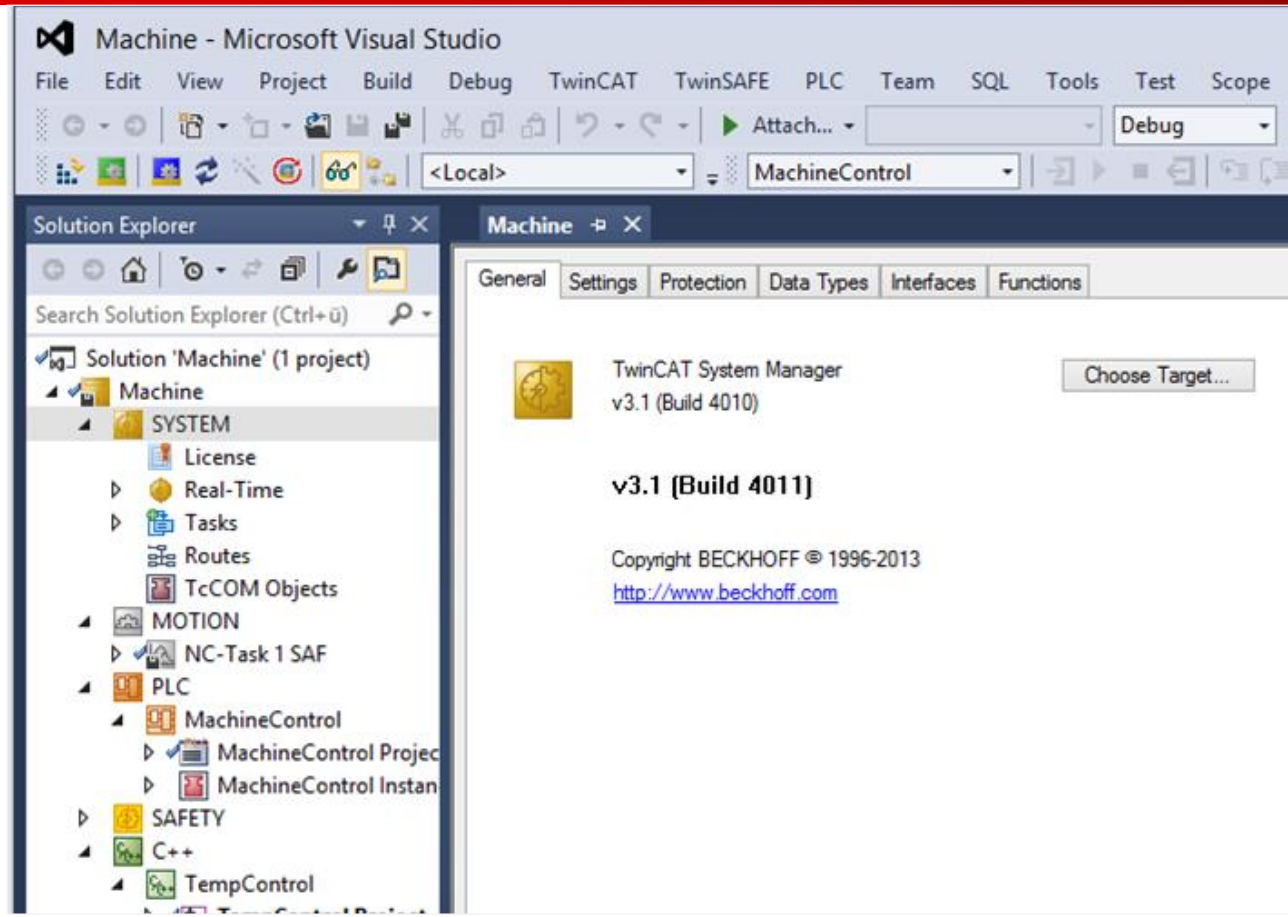
- programming, configuration and diagnostics in one tool
  - continuous development since 1996
- uniform task management
- parameterisation of TwinCAT modules
- creation and management of mappings between the process images
- simulation of I/Os and axes



TwinCAT I/O | Integrated System Manager

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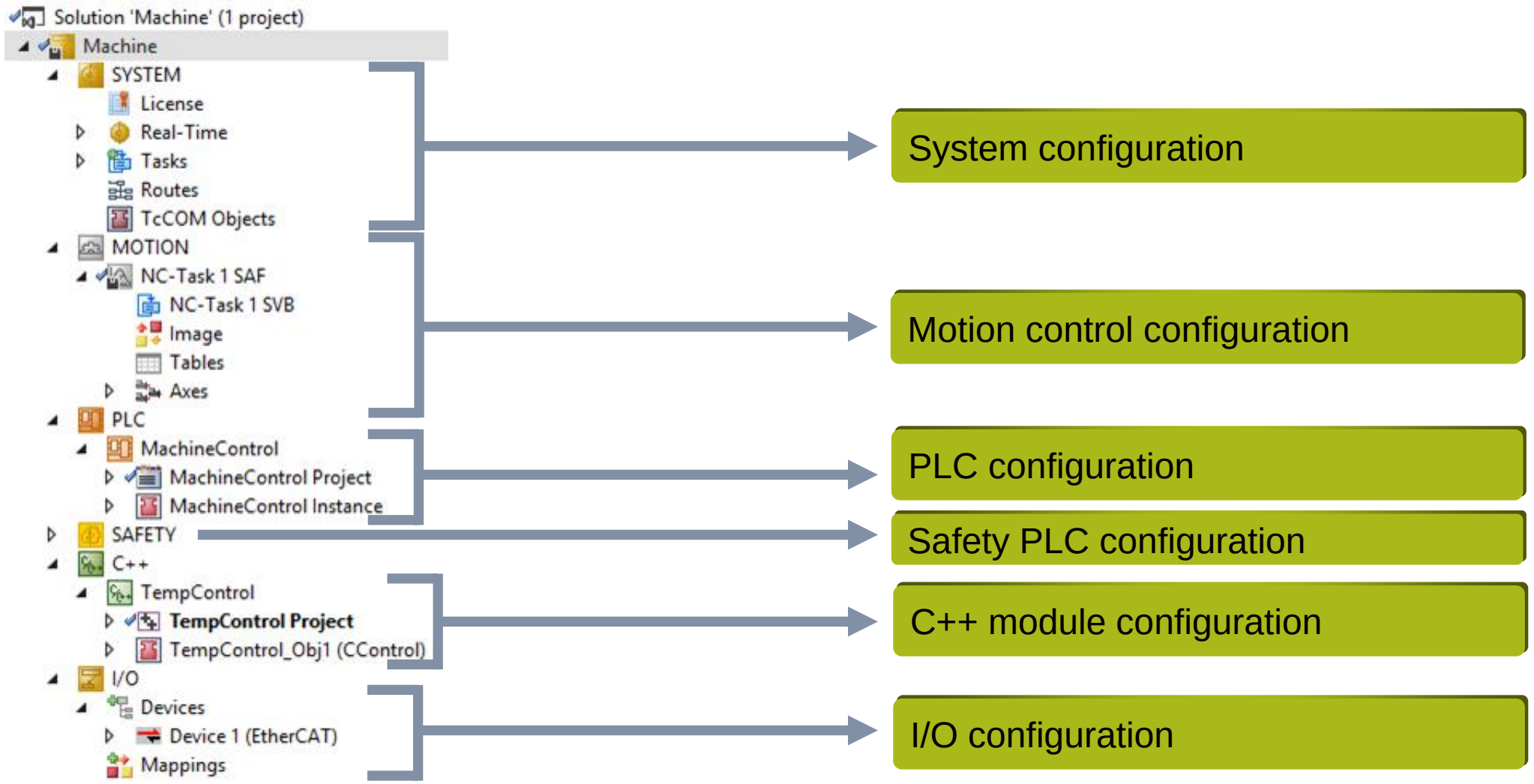

Mapping between process images

- open for all known fieldbuses
- simple commissioning and diagnostics
- separation into logical and physical process images

  → Change of the bus system does not require a change of the PLC code.

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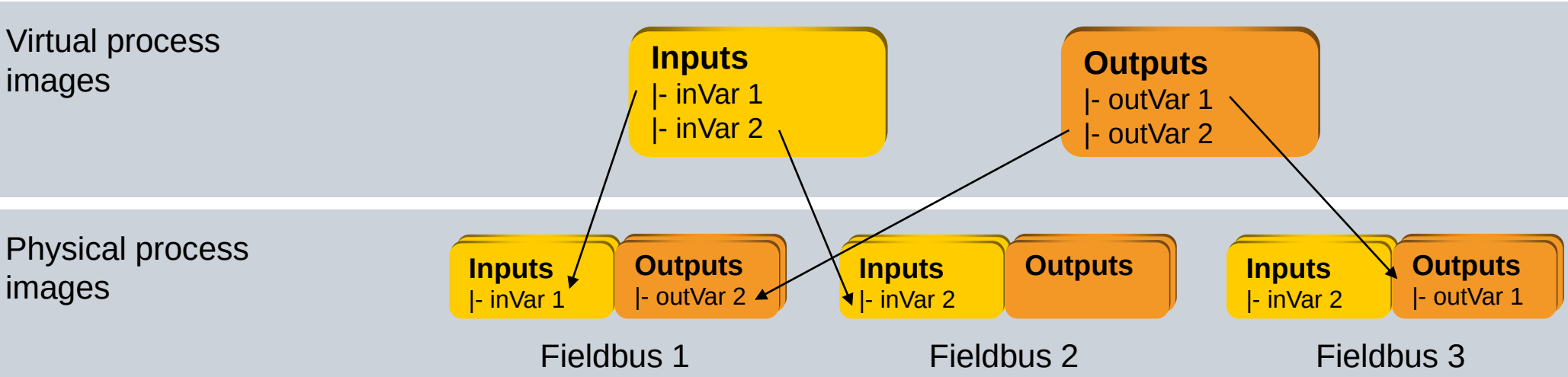
Symbolic mapping

- Mapping addresses are determined during start-up.
- The PLC boot project can be updated independently of the TwinCAT project.
- I/O configuration and mapping can be modified and updated independently of the PLC project.



Multiple PLC projects on one PC possible:

- number of PLC projects limited only by the available memory

Programming

- languages of IEC 61131-3 (IL, ST, FBD, LD, SFC) + CFC
- use of the object-oriented extension of the 3rd edition of IEC 61131
- calling of and/or data exchange with C/C++ and MATLAB®/Simulink® modules
- import and export interfaces
- no direct addressing necessary

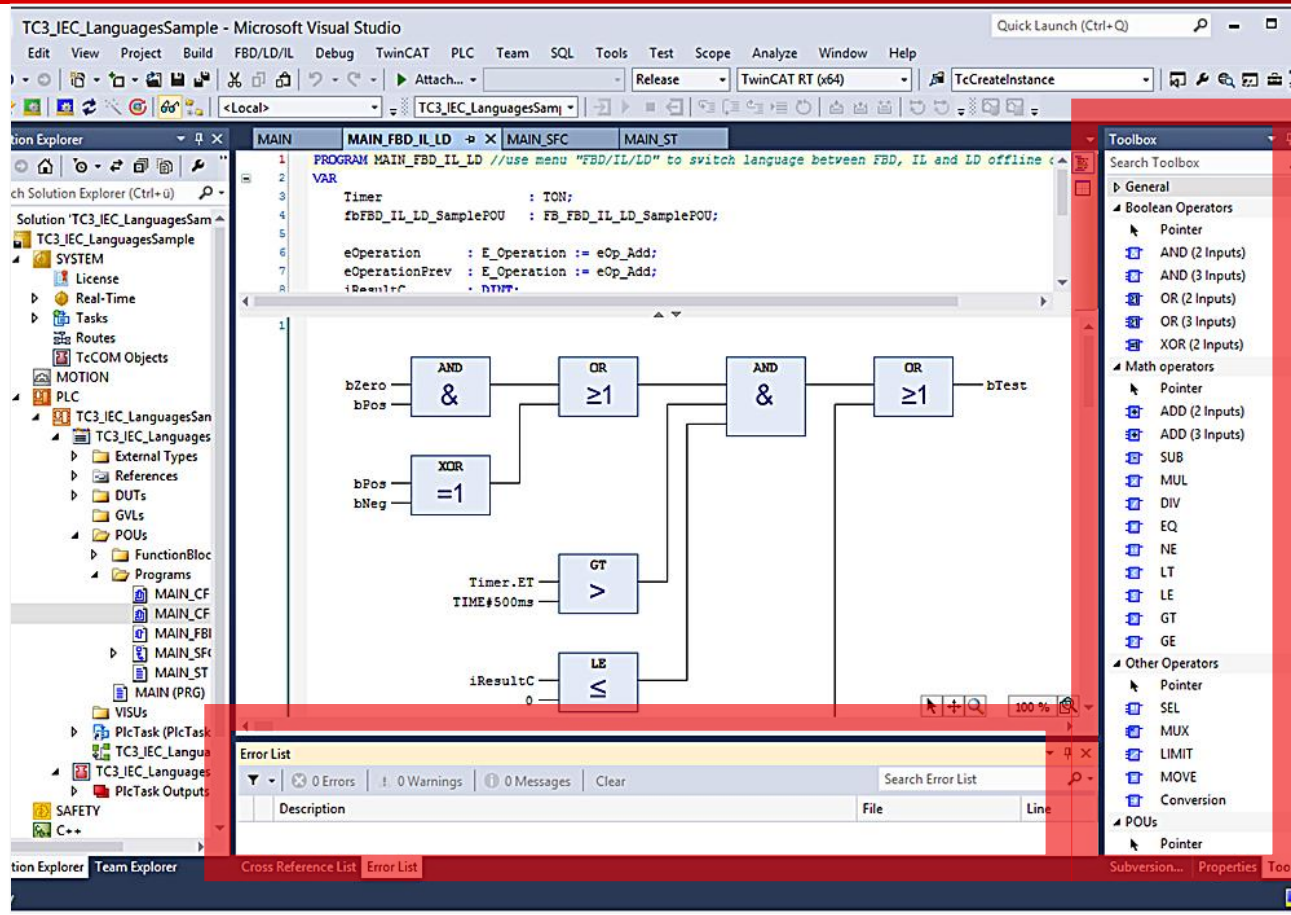
Commissioning/servicing:

- upload and download of source code
- change of code and data possible online
- complete debugging (breakpoints, monitoring, sequence control, etc.)

Single shared tree for software and hardware

- Shared toolbox for all languages

- Shared output window for all languages



Object orientation according to IEC 61131-3 3rd edition

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Language properties	2nd edition IEC 61131-3	3rd edition IEC 61131-3	C++	Java	C#
Multilingual capability	+	+	-	-	-
OOP/procedural mixed	-	+	+	-	-
Classes	~ (FB)	+	+	+	+
Methods	~ (Actions)	+	+	+	+
Interfaces	-	+	-	+	+
Partially abstract classes	-	-	+	+	+
Polymorphism	-	+	+/-	+	+
Reference semantics	-	+ (Interfaces)	-	+	+
Constructor/Destructor	-	+	+	+	+
Properties	-	+	-	-	+
Visibility	~ (Variables)	~ (Variables)	+	+	+
Dyn. memory (“new”)	-	- (in TwinCAT 3)	+	+	+

TwinCAT 3 Motion Control – Continuity

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- scalable solution (stepper… servo drive)
- various abstraction layers
  - SPS/SCADA/HMI always access identical structures.
- from mechanical to electronic systems (electronic cam, electronic gear, electronic clutch, electronic camshaft, “flying saw”)

Advantages:

- greater flexibility in the technology used (stepper, servo drive, etc.)
- greater flexibility when changing products
- shorter delivery and development times
- shorter commissioning times, due to fewer mechanical components
- reducing costs

TwinCAT 3 Motion Control
Abstraction Layer

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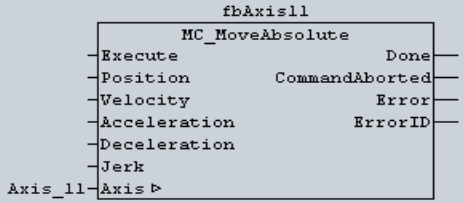
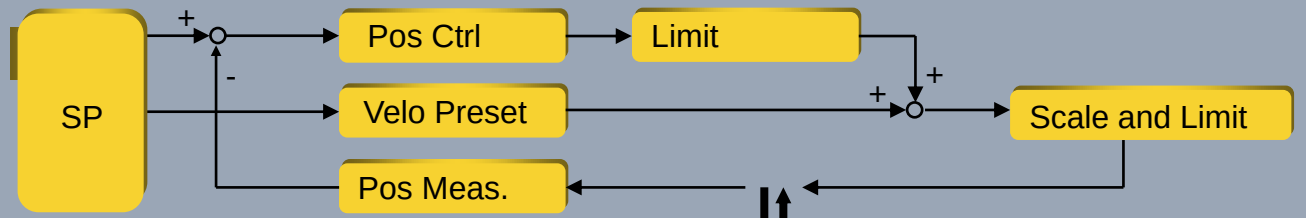
Soft SPS Layer



Soft Motion Layer



Fieldbus Layer

LIGHTBUS CANopen EtherCAT PROFIBUS sercos the automation bus

Drives Layer

TwinCAT 3 Motion Control
From PTP to Robot Control

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Functionality


NC PTP


NC I


CNC


Robotics

Point-to-point motion

- gear box
- cam plates
- superposition
- flying saw

Interpolated motion with 3 axes and 5 auxiliary axes

- programming according to DIN 66025
- technological features
- straightforward utilisation through function blocks from the PLC

Complete CNC functionality

- interpolated motion for up to 32 axes per channel
- various transformations

Interpolated motion for robot control

- support for a wide range of kinematic systems
- optional torque pilot control

C/C++ programming languages

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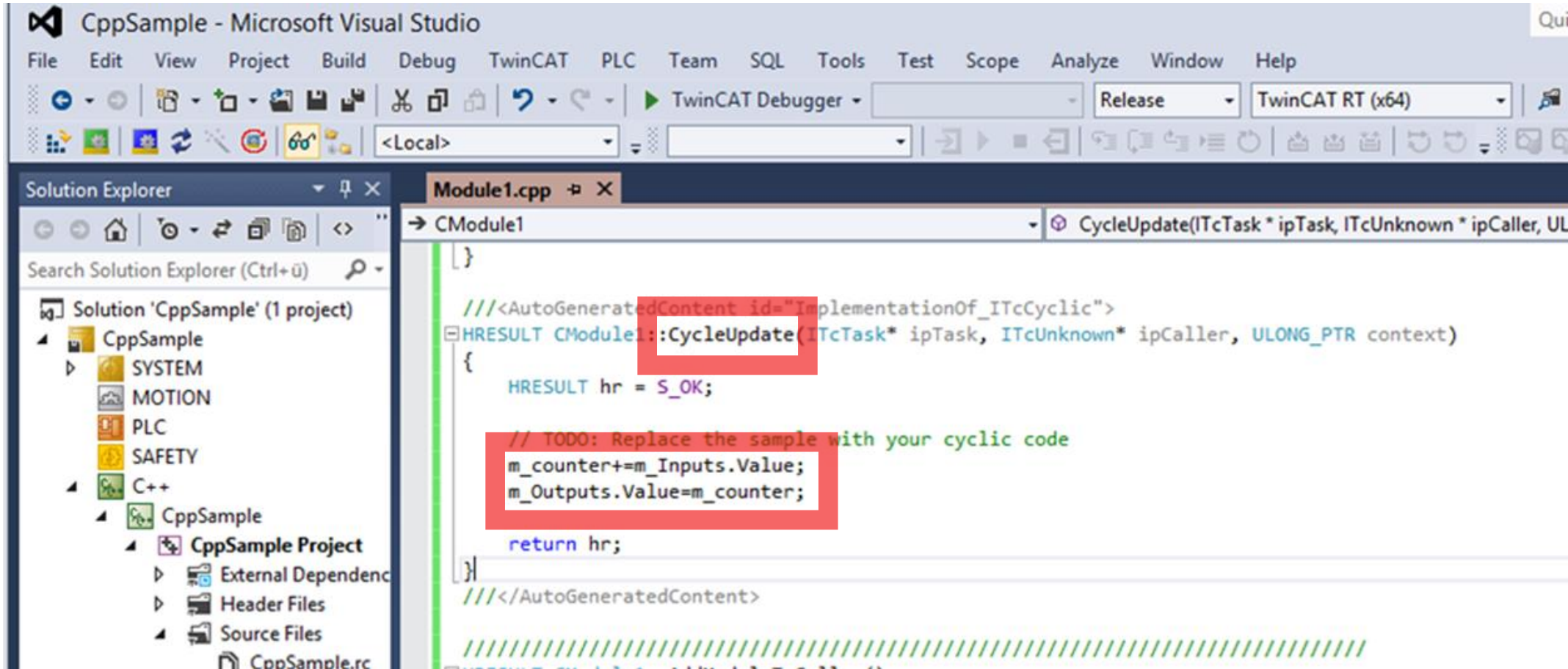
- reusability of already existing C/C++ code
- cooperation of C/C++ and PLC code
- opens up new application areas
- well-known programming languages
- standardised (C: ISO/IEC 9899 TC3, C++: IEC 14882)
- Beckhoff SDK provides the functional scope (similar to PLC libraries) for
  - ADS, File I/O (motion currently being prepared)

Application areas

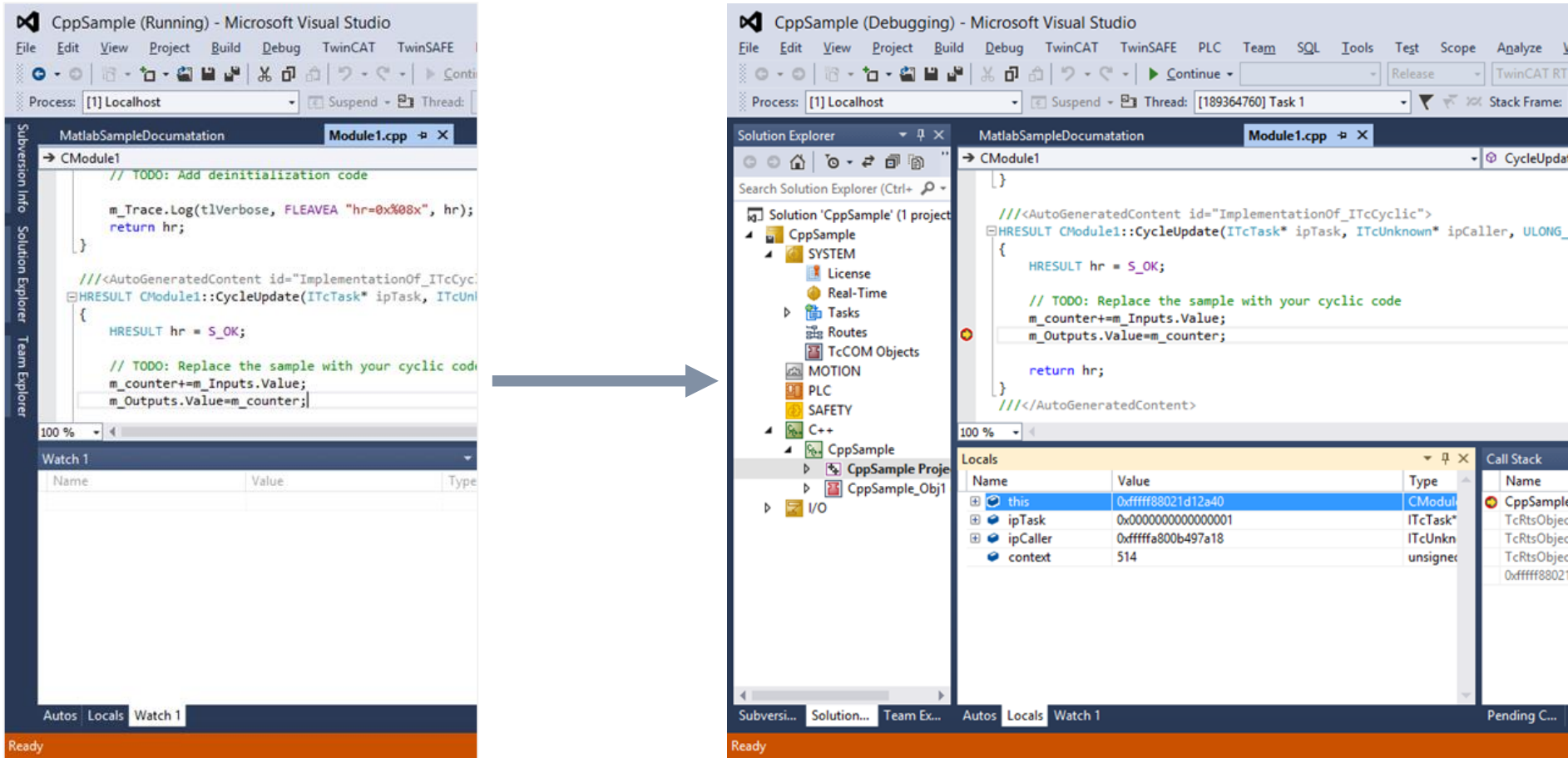
- image processing
- robotics
- measurement technology

- CycleUpdate method – is called cyclically
- logic input/output image



Visual Studio standard debugger:

- monitoring/modification of variables only by breakpoint:
  means “stopping” the machine



C/C++ programming languages

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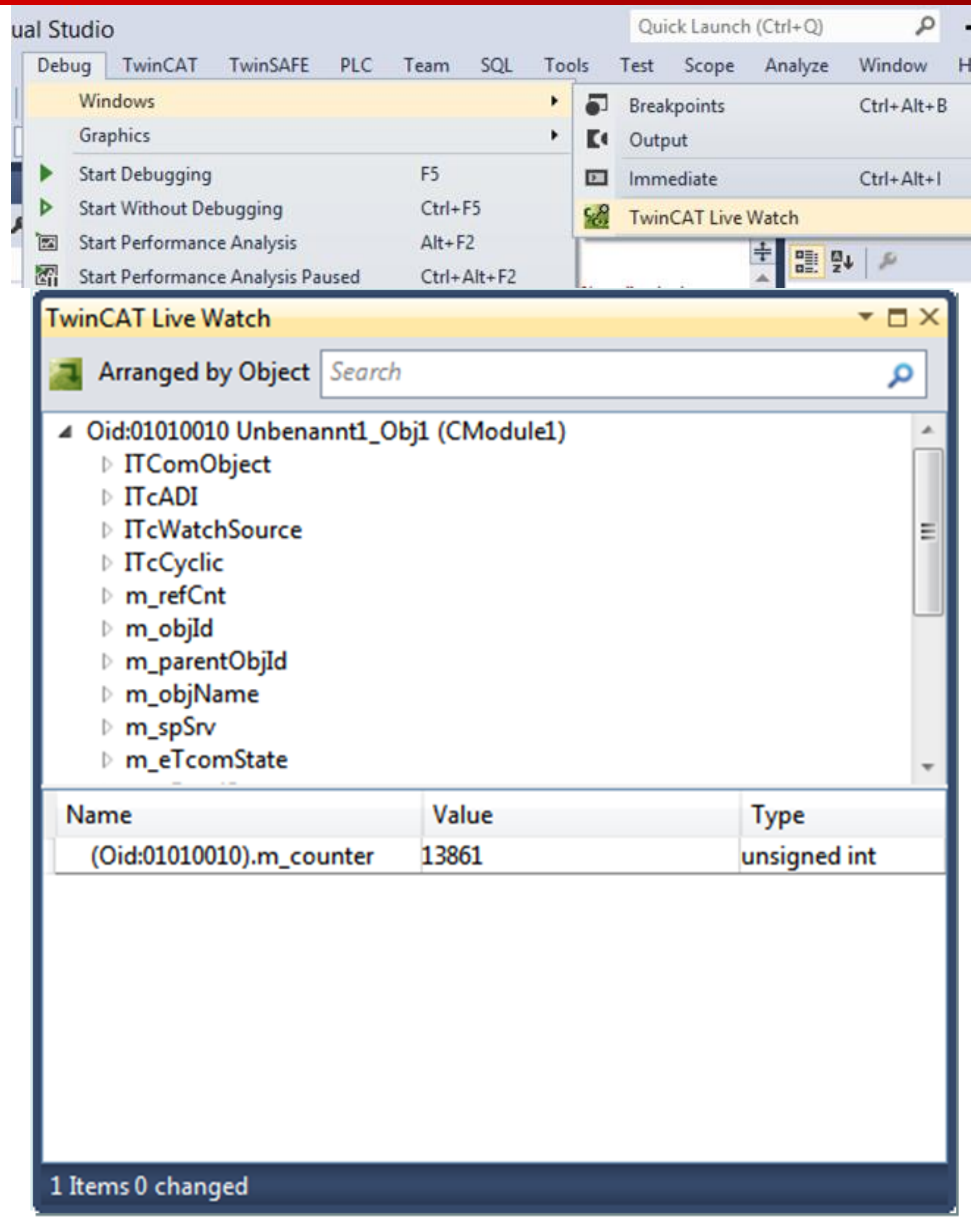
Beckhoff debugger:

- TwinCAT Live Watch
- extension of the Visual Studio® monitoring options
- monitoring/modification of variables without breakpoint (similar to PLC)



MATLAB®/Simulink® integration

- familiar from the scientific and measurement technology environment
- large number of toolboxes (e.g. fuzzy logic toolbox)
- creation, simulation and optimisation of control loops
- debugging interface between Simulink® and TwinCAT

Code generation

- design in Simulink®
- automatic generation of C++ code using the Simulink® coder
- compilation with Visual Studio® C Compiler
- parametrisation with TwinCAT System Manager

MathWorks Partner

MATLAB®/Simulink® integration

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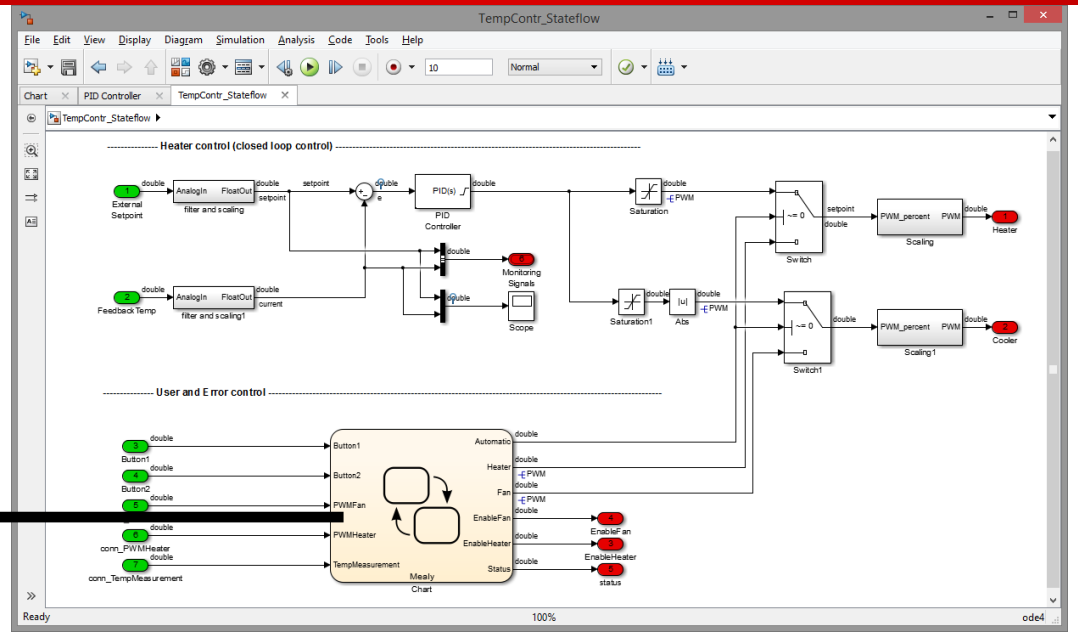
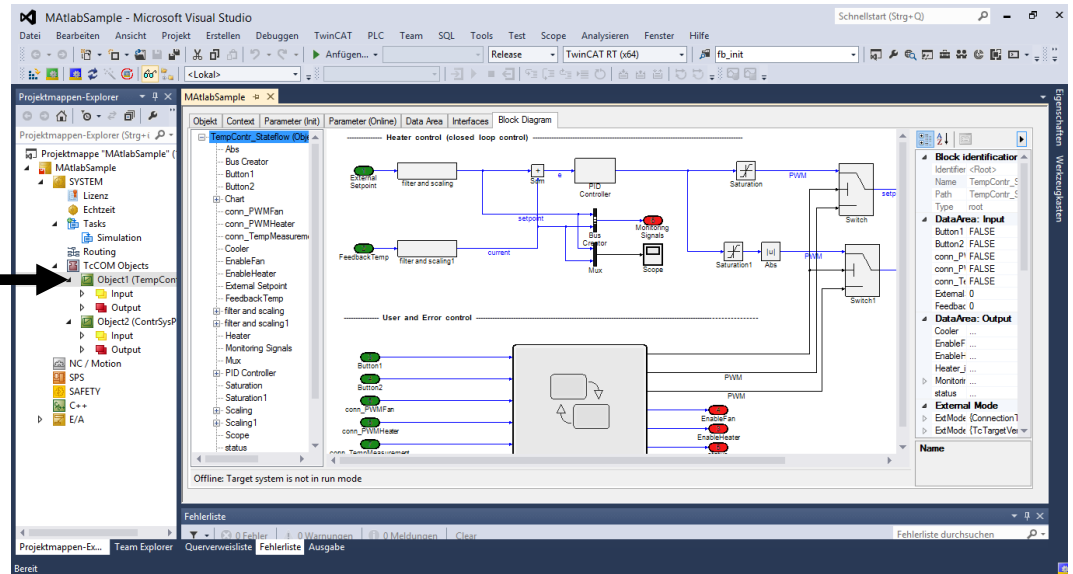
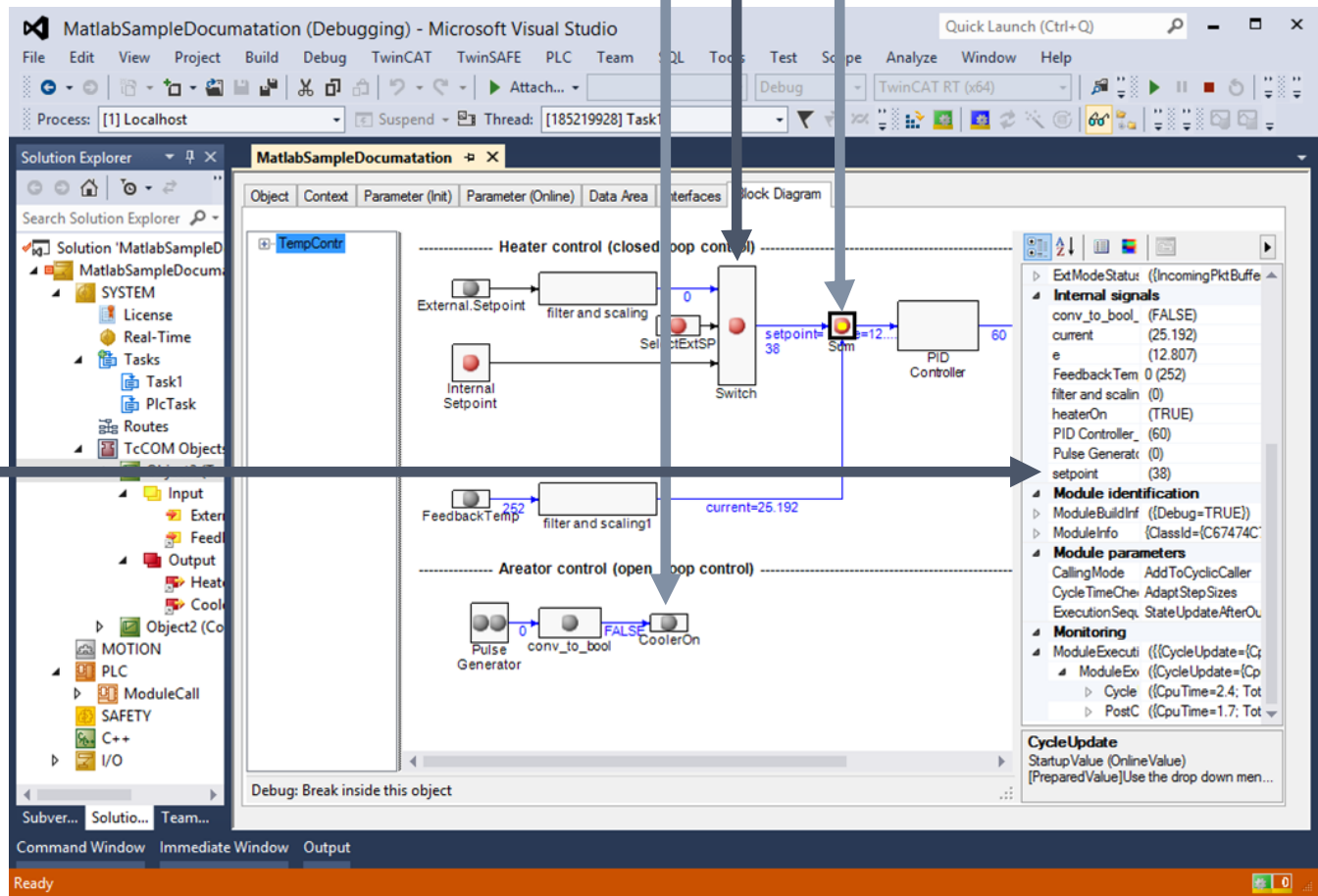




Debugging in TwinCAT 3

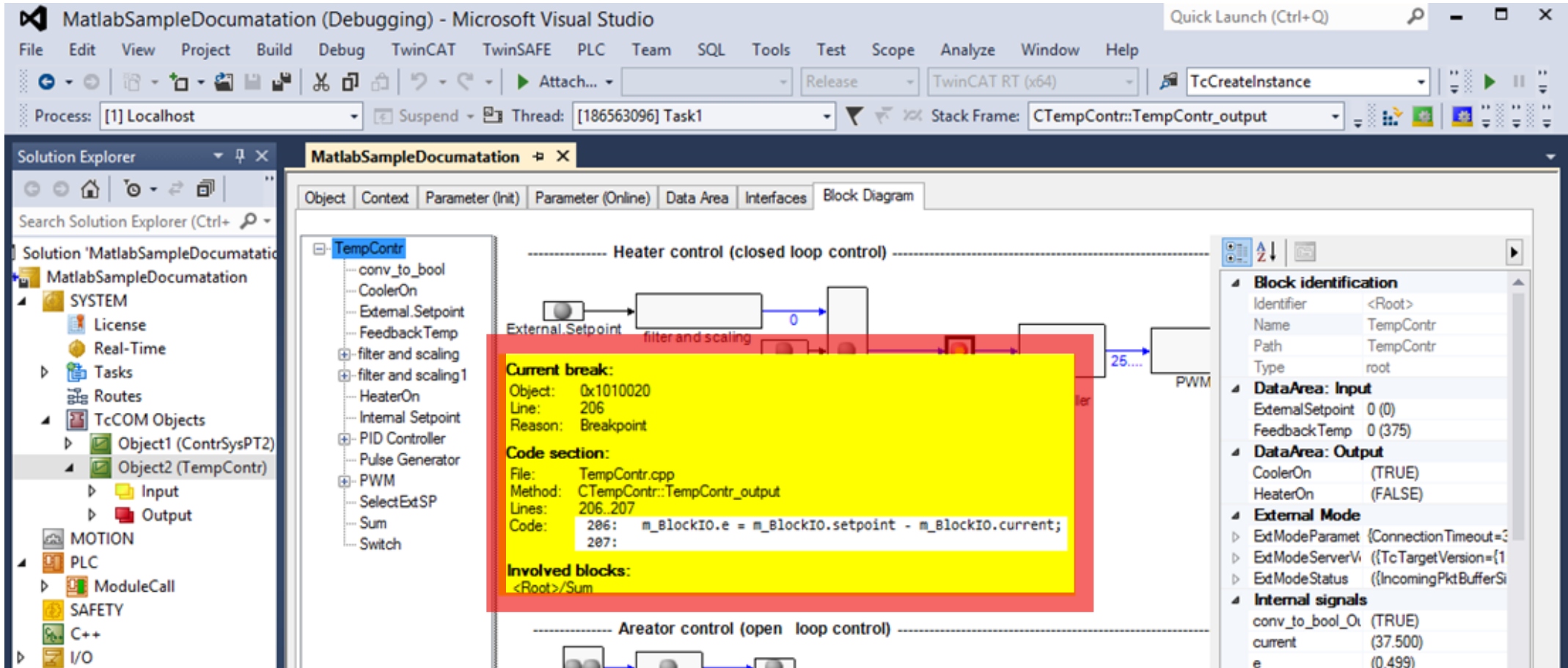
- online monitoring of signal values
- possibility to set breakpoints

- online monitoring of parameter values



Debugging in TwinCAT 3

- debug information after reaching a breakpoint



.NET programming languages (e.g. C#)

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- well-known programming languages
- standardised C# (ISO/IEC 23270)
- generates intermediate code (Common Intermediate Language – CIL)
- **Advantages**
  - efficient software engineering with higher abstraction level
  - widely accepted
  - “garbage collection” organised in the memory
  - can now be used as part of an integrated solution
- **Restriction**
  - not suitable for real-time applications

C#/.NET programming

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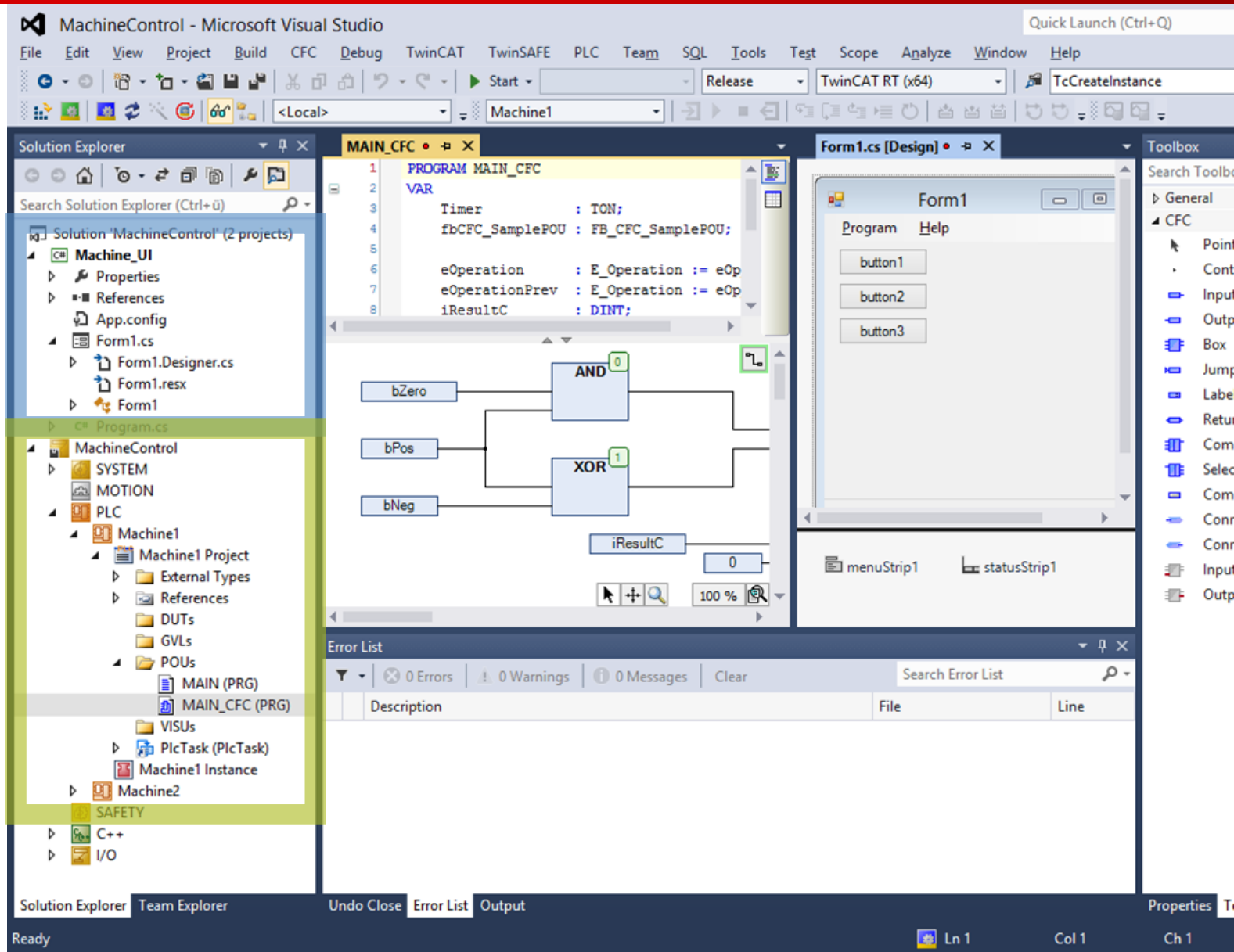
Non-real-time e.g. HMI
Windows processes

PLC module

C++ module

Real-time code



Integration of source control management

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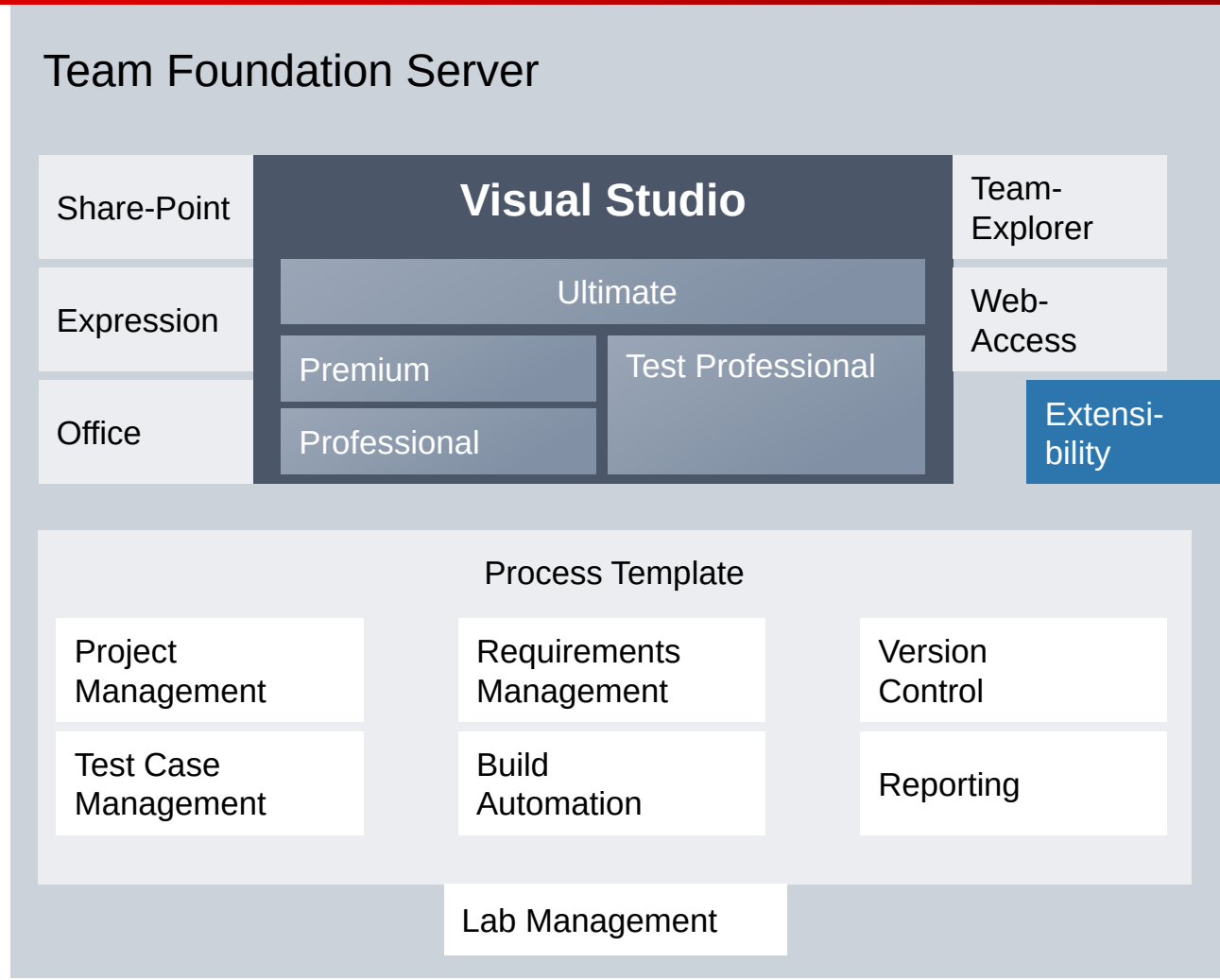
- well-known methods from IT
  - version management of source code, bug tracking, project management
  - mostly integrated in Microsoft Visual Studio
- essential capabilities for
  - large projects
  - collaboration of developer teams
  - lifecycle management



Free AIT Tools

Integration of source control management

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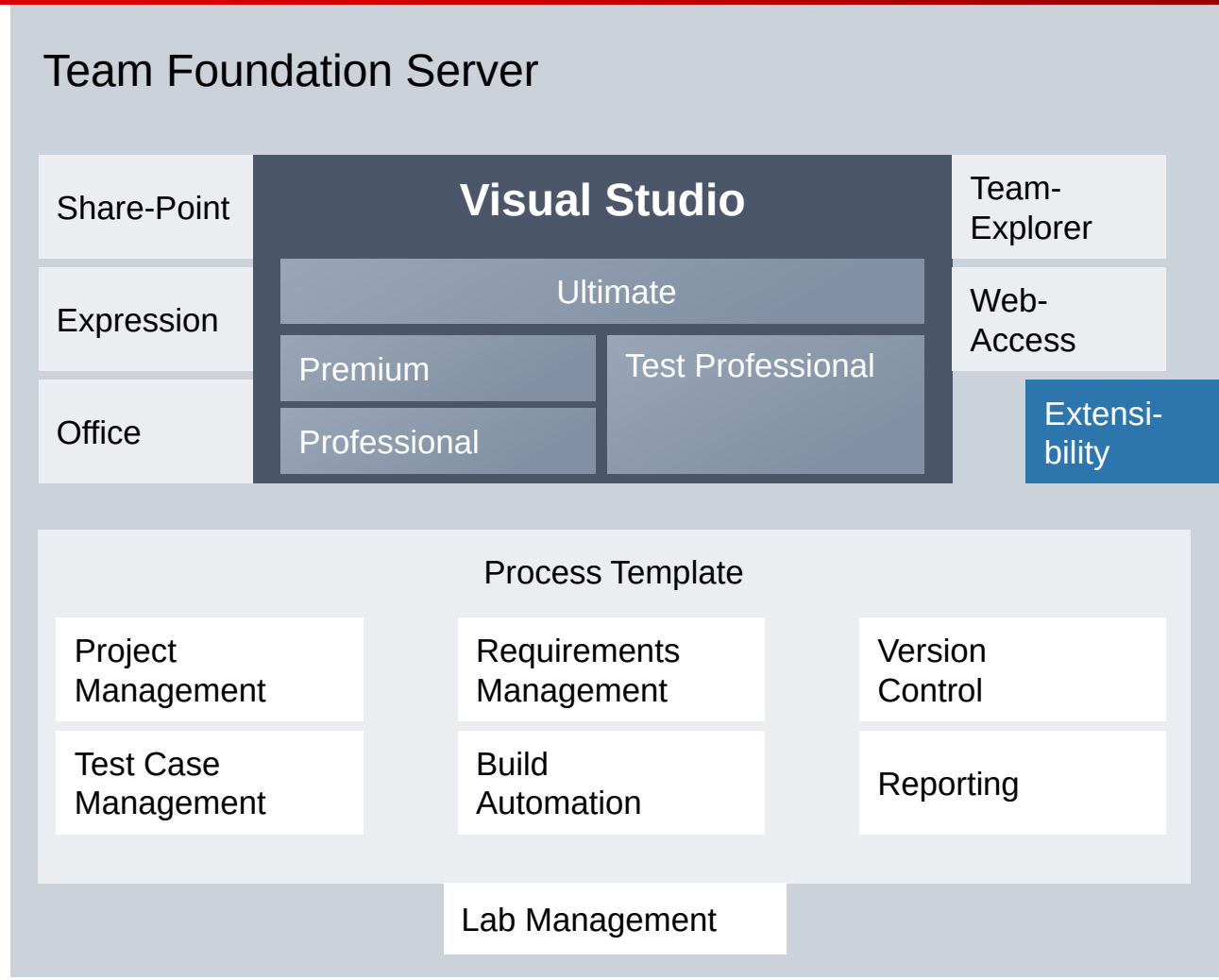
- Visual Studio supports various source code management tools:
  - Microsoft Team Foundation Server
  - GIT
  - Subversion
  - Plastics SCM and others

→ TwinCAT supports all these tools.

→ Database storage for configuration data and program code for IEC 61131-3/C++



Free AIT Tools

Integrated compare tool

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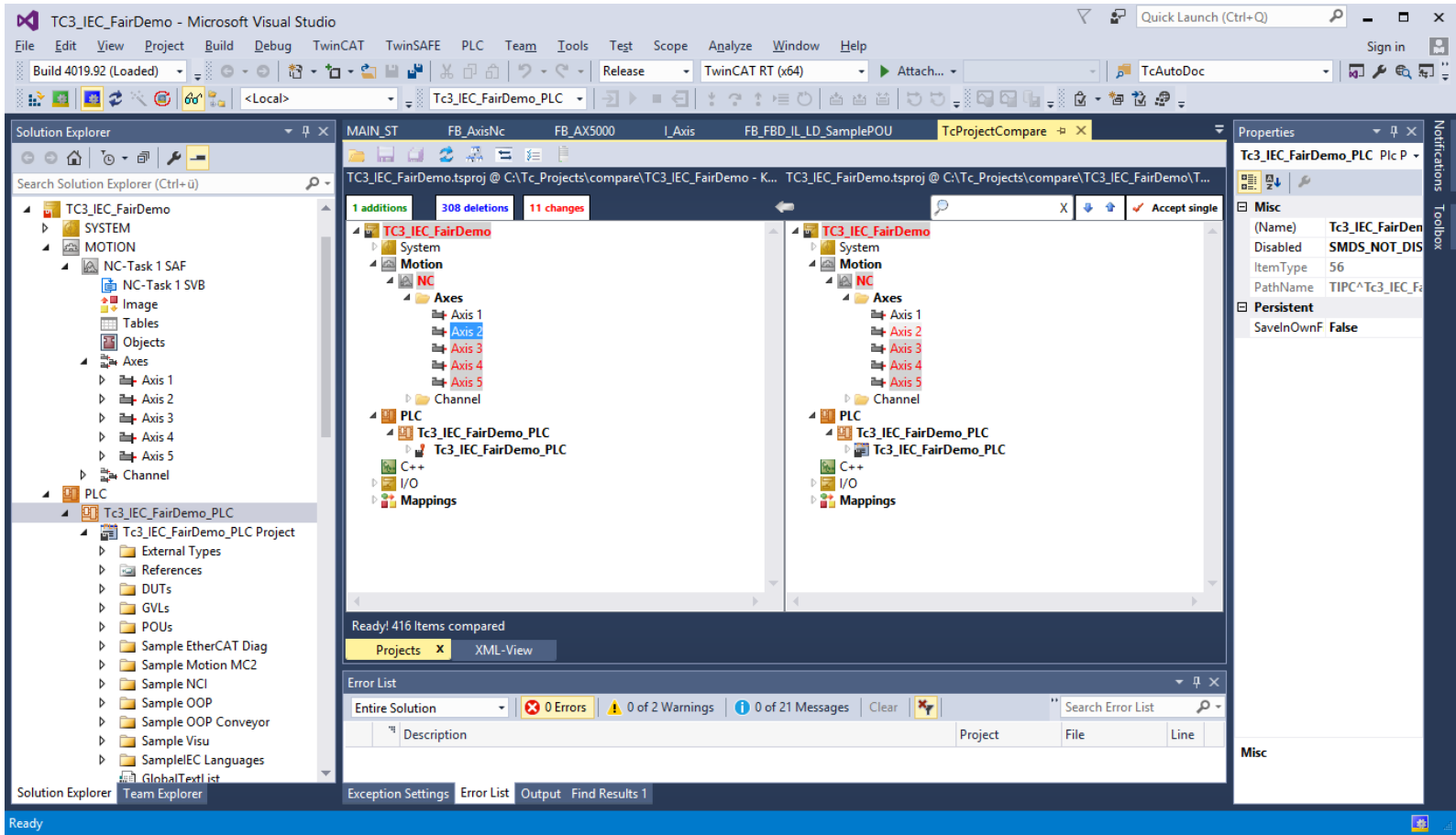
- Usage of encrypted sources is supported to enable data security management.
- also available as standalone version (but without encryption)



Runtime (XAR)

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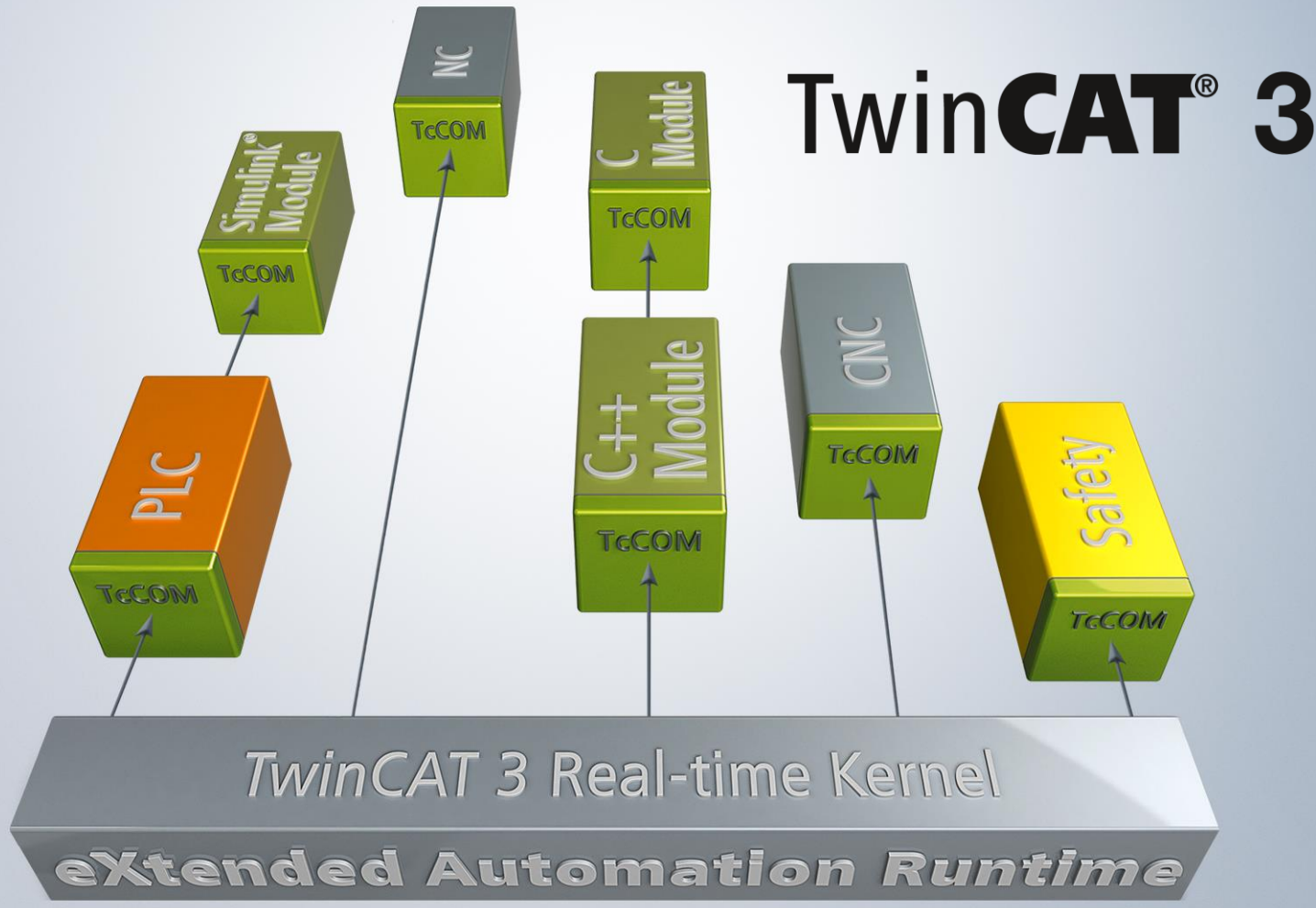

Modular runtime | Configurating instead of programming

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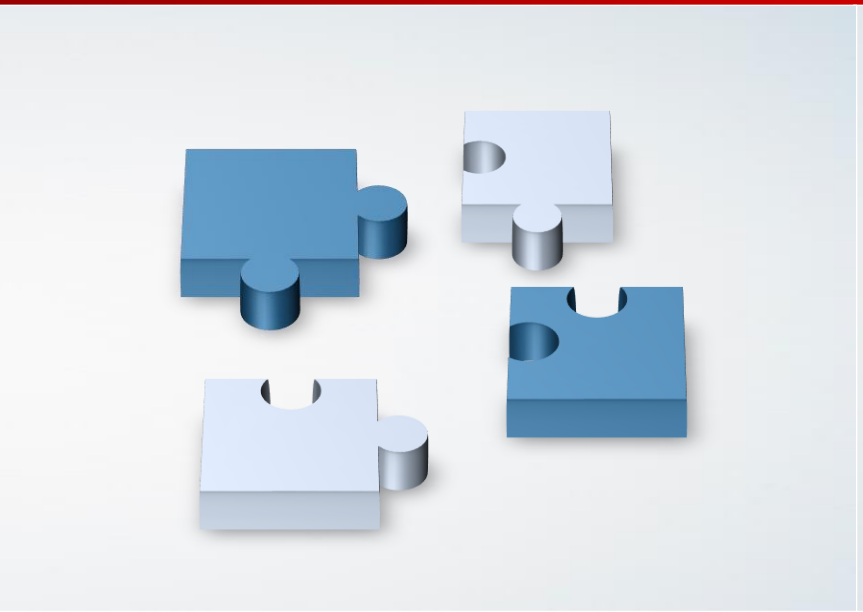

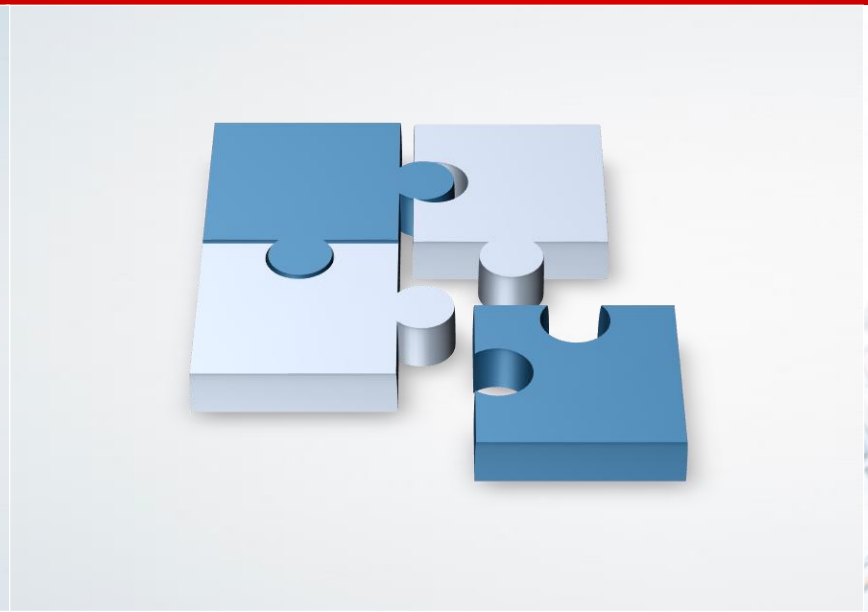

- Independant teams of developers
- can use different programming languages
- when they collaborate to build functionalities.

- Then the modules can be simply combined and configured …

- to generate the application.

Modular runtime

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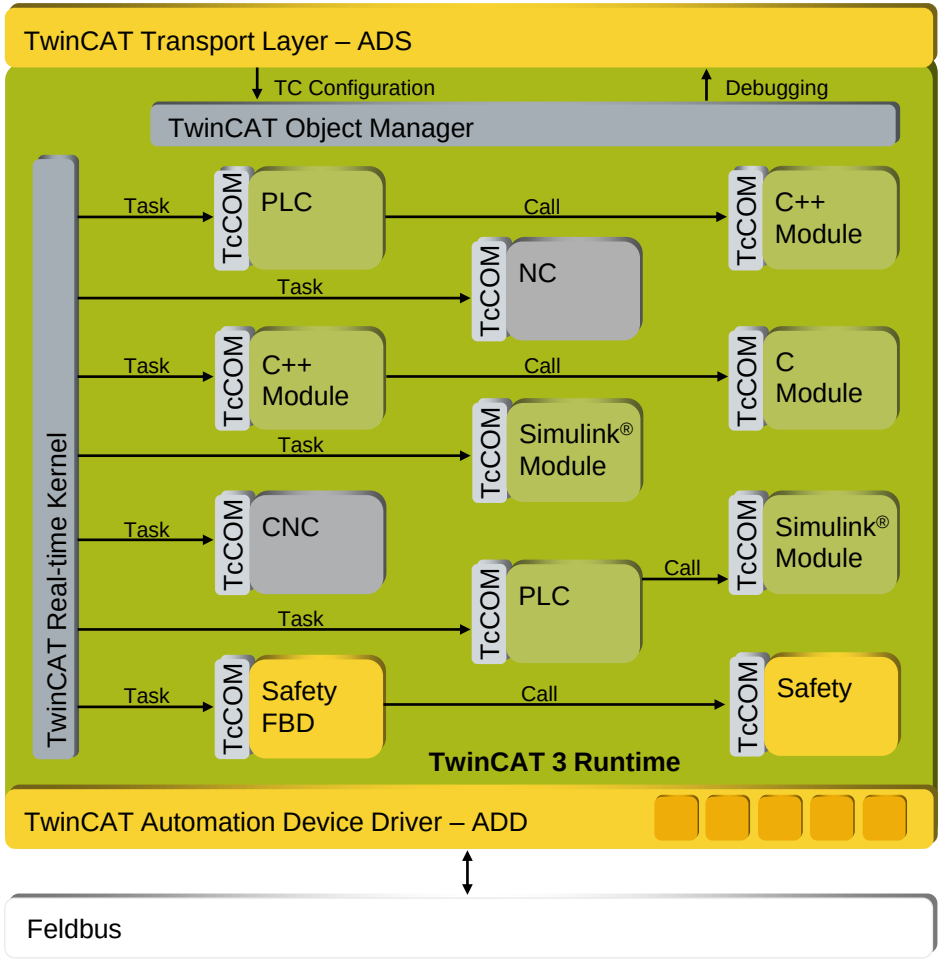
- **dynamic** environment for the execution and administration of TwinCAT 3 modules
- administration of runtime modules (TwinCAT object manager)
- defined interfaces – TwinCAT Component Object Model (TcCOM)



Modular interface at runtime

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- separation of encapsulated functionalities into modules
- extension of the basic system with one’s own drivers (Automation Device Drivers – ADD), e.g. fieldbus driver
- Scalability: modules can contain simple functions, complex algorithms and real-time applications or complete projects.
- reusability of modules
- cooperation of modules written in
  - IEC 61131-3
  - C/C++
  - modules generated with MATLAB®

Modular runtime interfaces for modules

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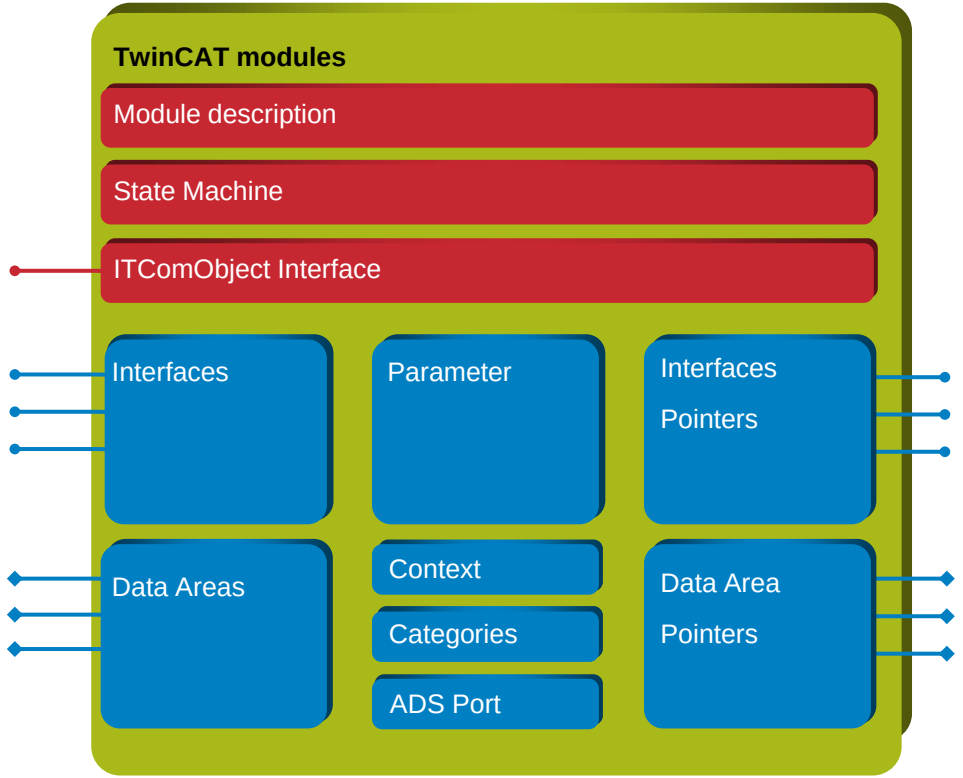
- standardised
- simple to handle
- with built in State Machine

options

4 different implementation options:

1. mapping of data range values
2. mapping of data range pointers
3. calling of interfaces
4. ADS messages
   - ADS server
   - ADS client



Multi-and many-core support

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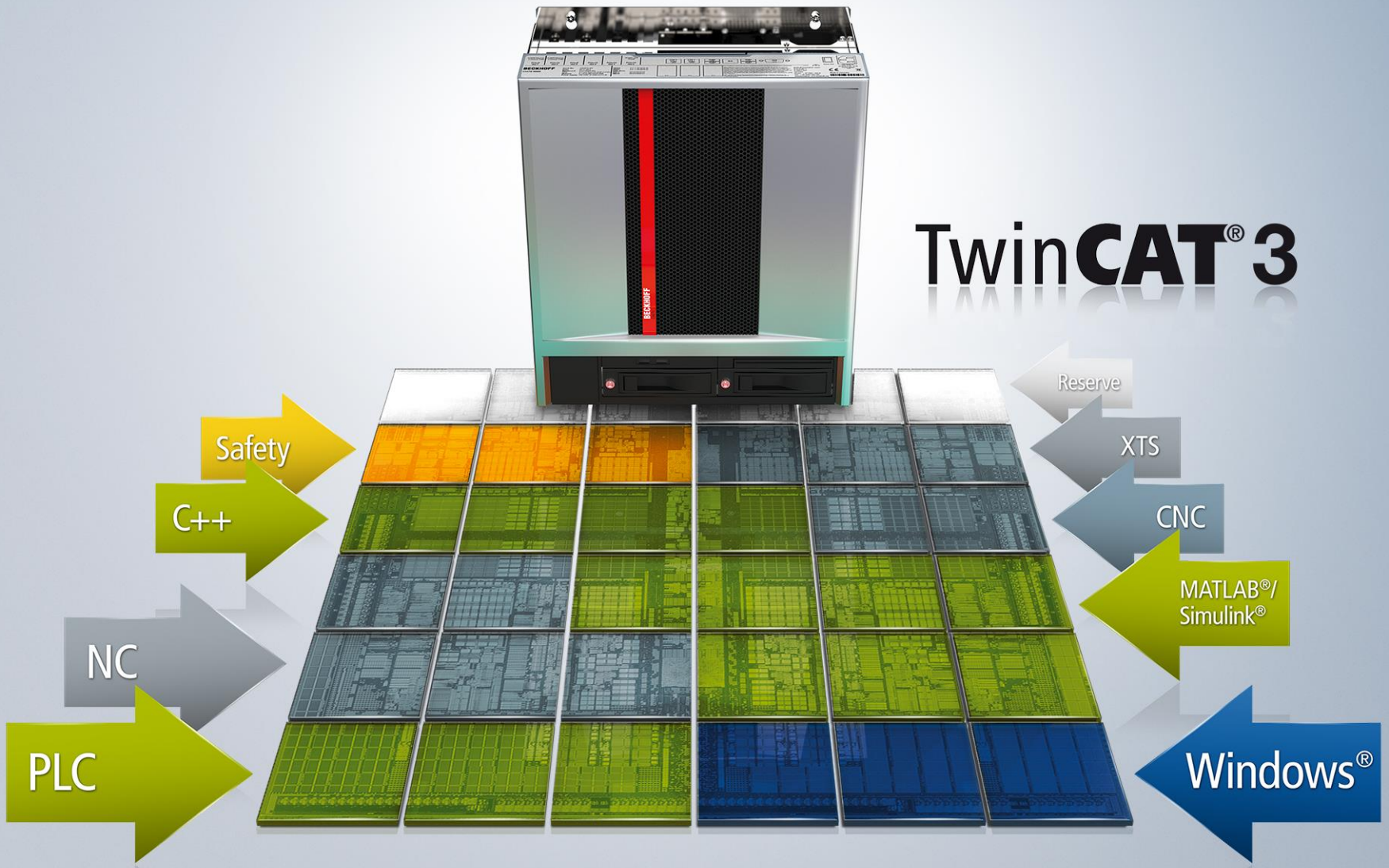

Support for multi-core systems

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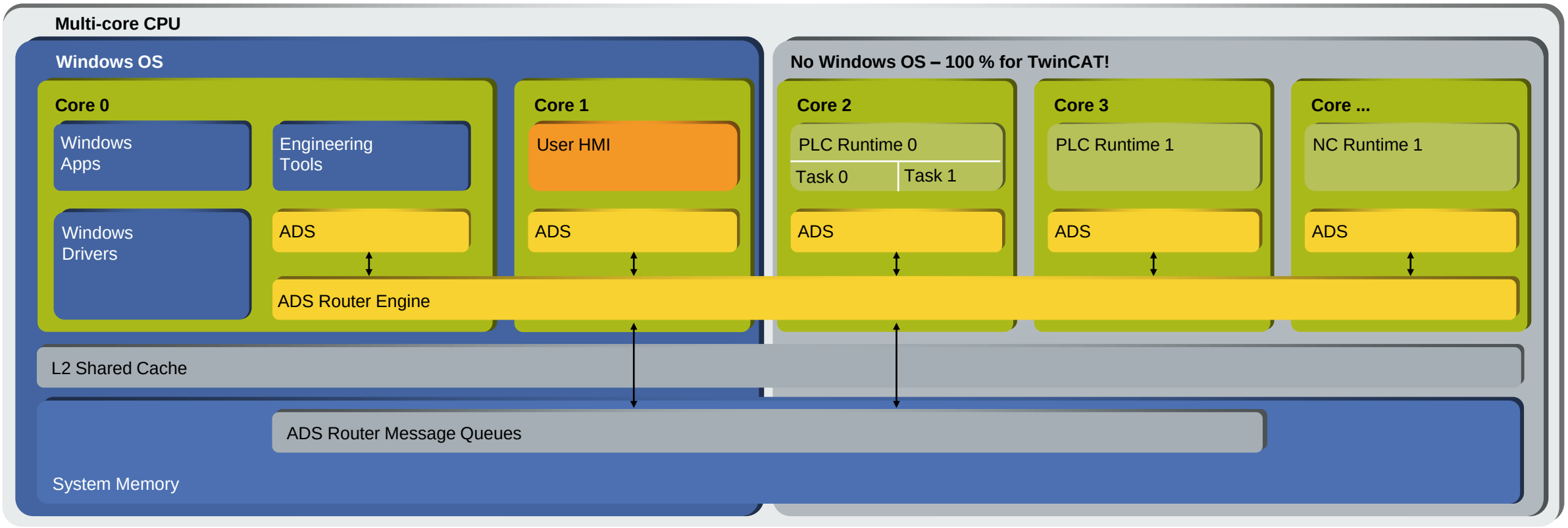
- distribution of modules to individual cores
  (e.g. PLC, Motion control and HMI run on different cores)
- scalable base time for each core
- scalable CPU usage for each core



Support for multi-core systems

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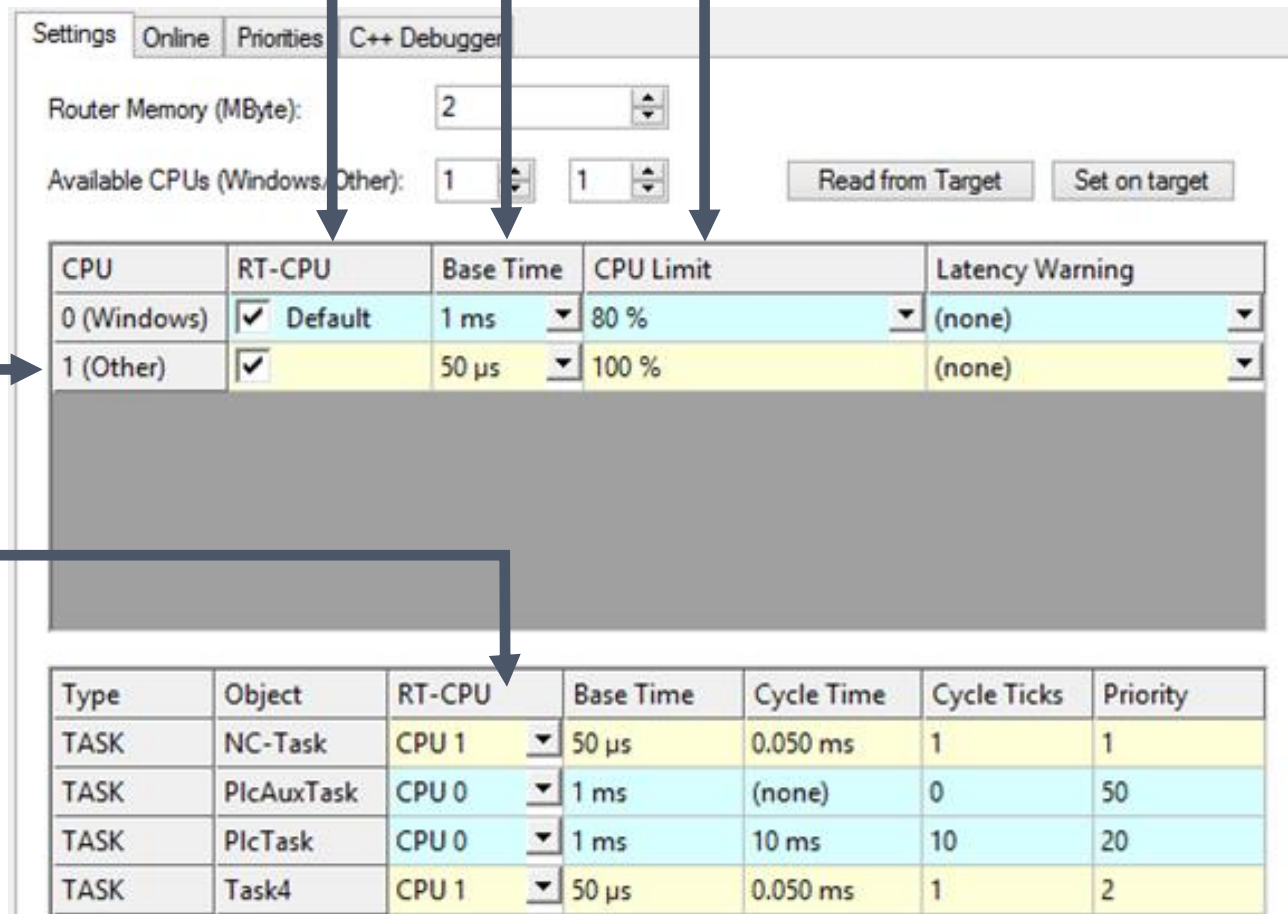
- assignment of a task to a CPU
- defines the base time for each core
- cores for real-time use
- isolated core
- definition of CPU limit per core



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Solutions for different areas

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Scientific Automation

Industry

SCADA, MES, ERP

FTP-Server, Database,
Webspace

TwinCAT Engineering

Remote Access

Cyber- Physical Systems

ADS (Automation Device Specification)

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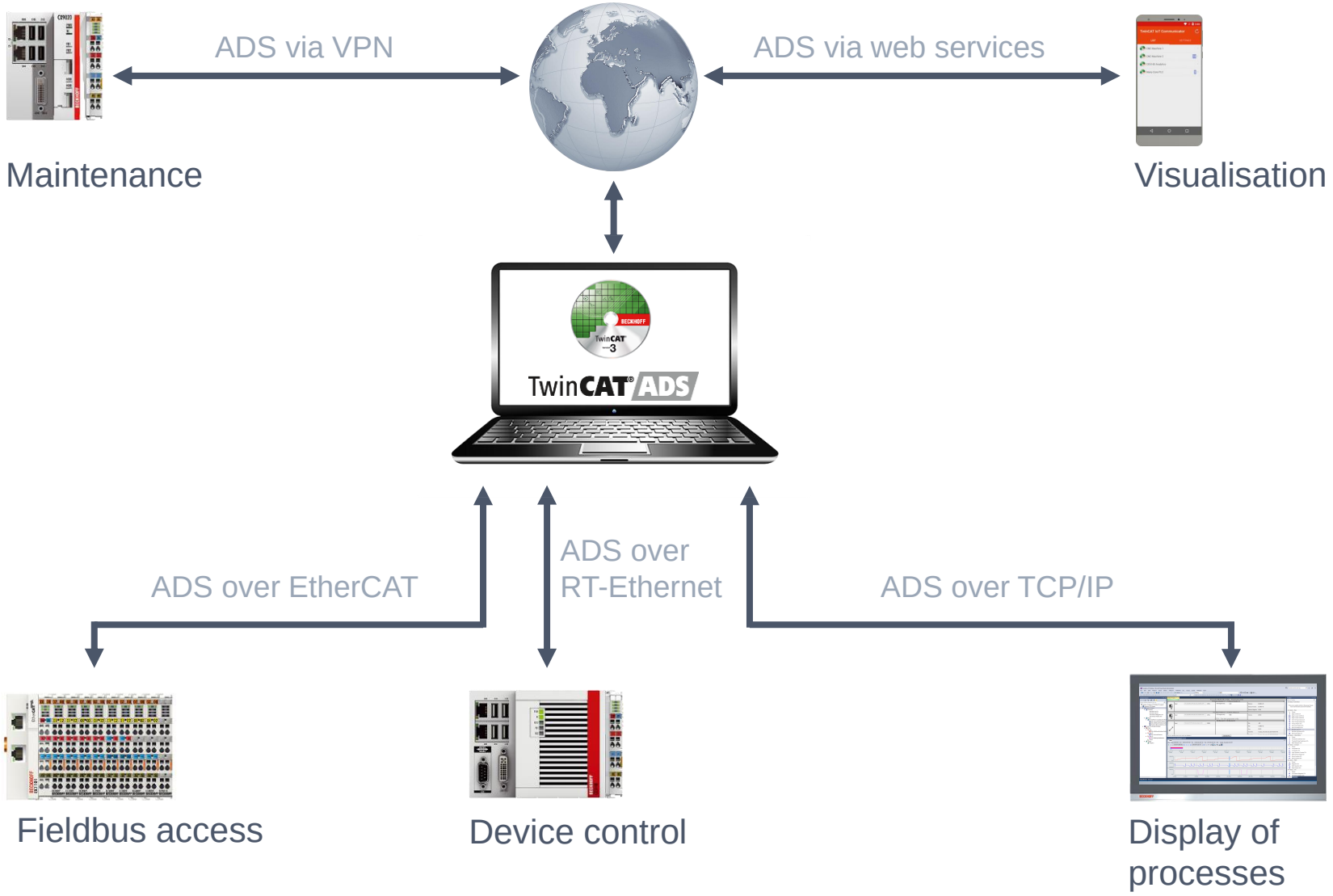

ADS (Automation Device Specification)

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- consistent, vertical, horizontal
- data exchange and/or commands
- open protocol with example code
- available for major Windows platforms
- access from PLC via function blocks
- routable via: local/network
- cyclical/event-driven
- components free of charge
  - OCX/DLL/.NET/Script/Webservice

Various solutions based on ADS

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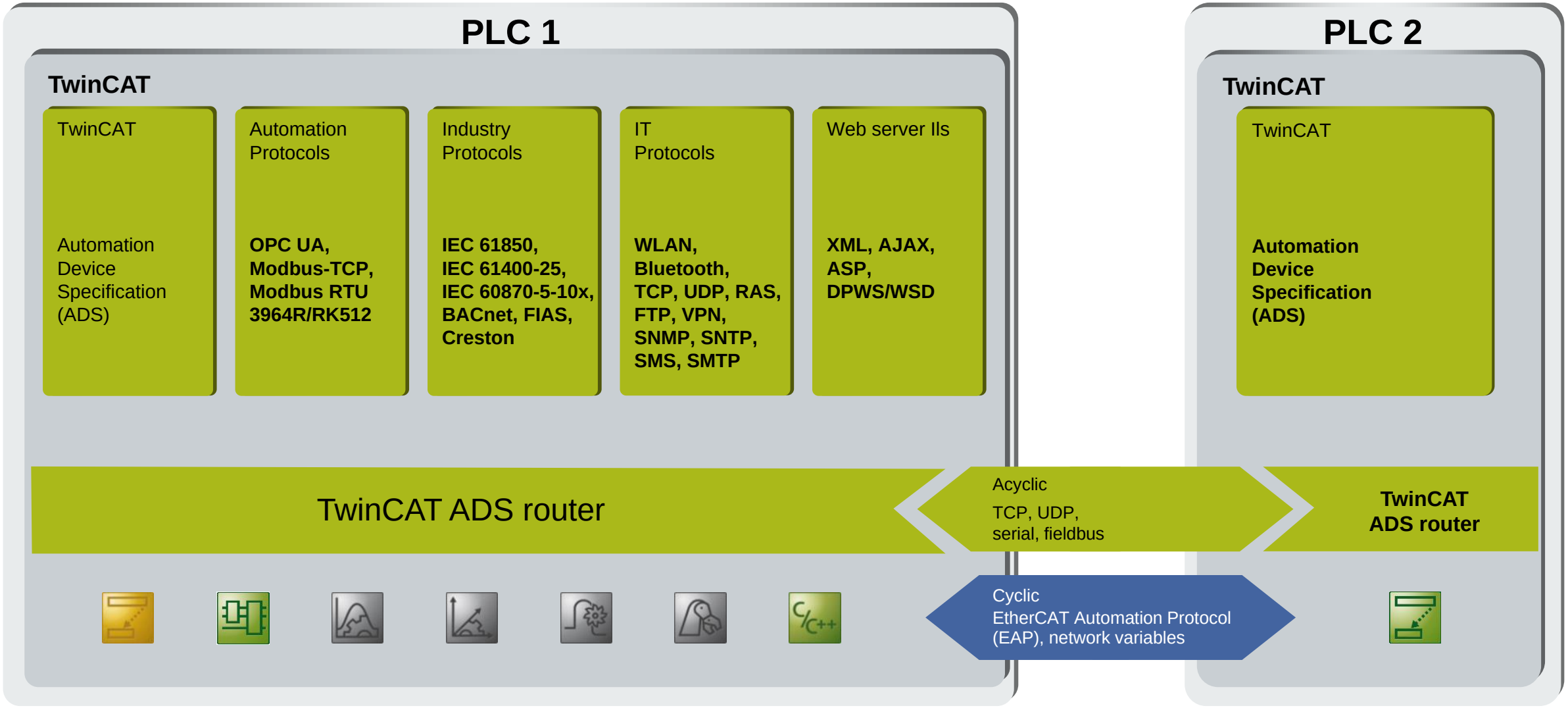

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Conversion of an existing TwinCAT 2 project to the TwinCAT 3 format:

- integrated convertor for TwinCAT 2 projects
  (System Manager & PLC control)
- extension of existing projects by new functionalities
- increased reusability of existing code parts in new projects
- use of the same tools for all projects/applications

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Continuity

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TwinCAT Functions offer a broad range of different add-ons that can also be used with TwinCAT 3:

- Communication
  - OPC UA, Modbus, telecontrol/remote control, serial
- Controller implementations
  - controller toolbox, temperature controller
- Engineering tools
  - ECAD import, Source code management
- Diagnostics/measurement technology
  - Scope 2

Highlights TwinCAT 3

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- only one software for programming and configuration
- Visual Studio® integration
- more freedom in the choice of programming language
- support for the object-oriented extension of IEC 61131-3
- use of C/C++ as programming language
- link to MATLAB®/Simulink®
- open interfaces for expandability and adaptation to existing tool landscape
- fast and flexible runtime environment
- configuration of binary PLC/C++/MATLAB® runtime modules
- active support for multi-core and 64-bit operating systems
- migration of TwinCAT 2 projects

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Products for Industrie 4.0 and IoT

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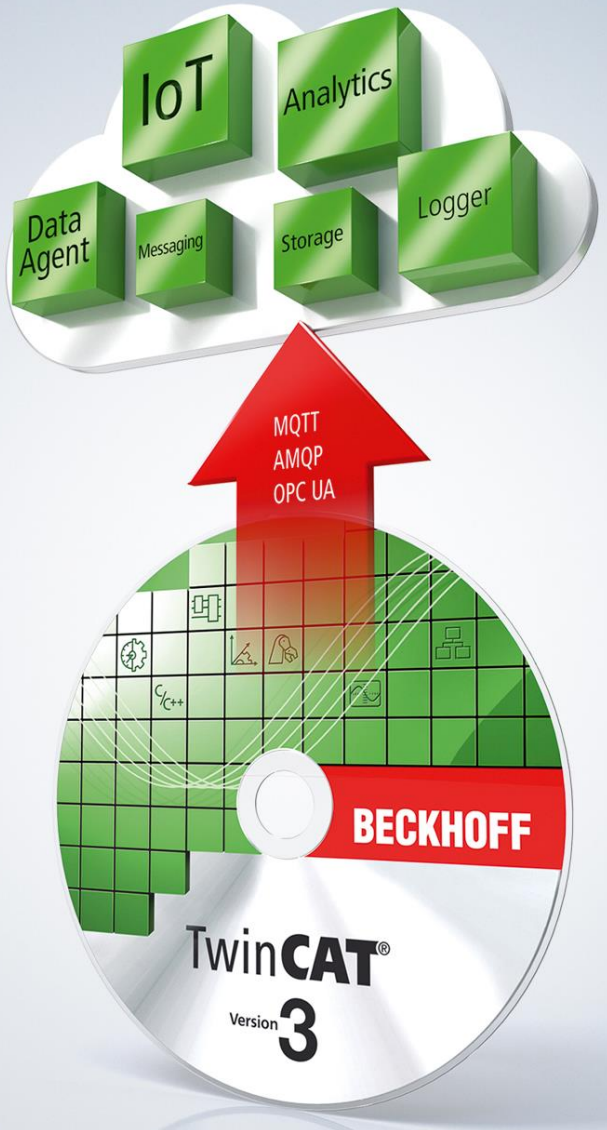

Cloud scenarios supported by Beckhoff TwinCAT IoT

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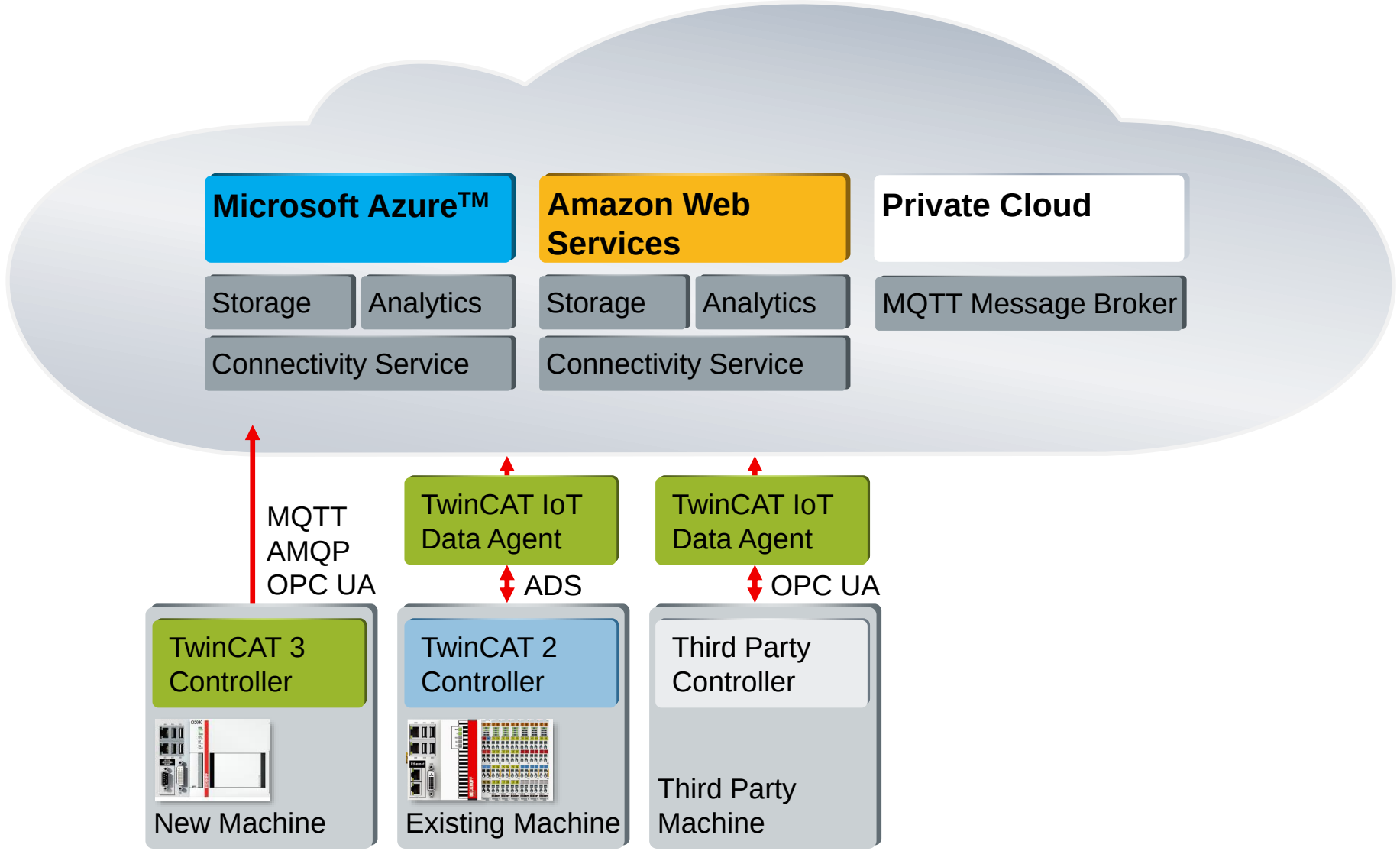

Cloud scenarios supported by Beckhoff TwinCAT IoT

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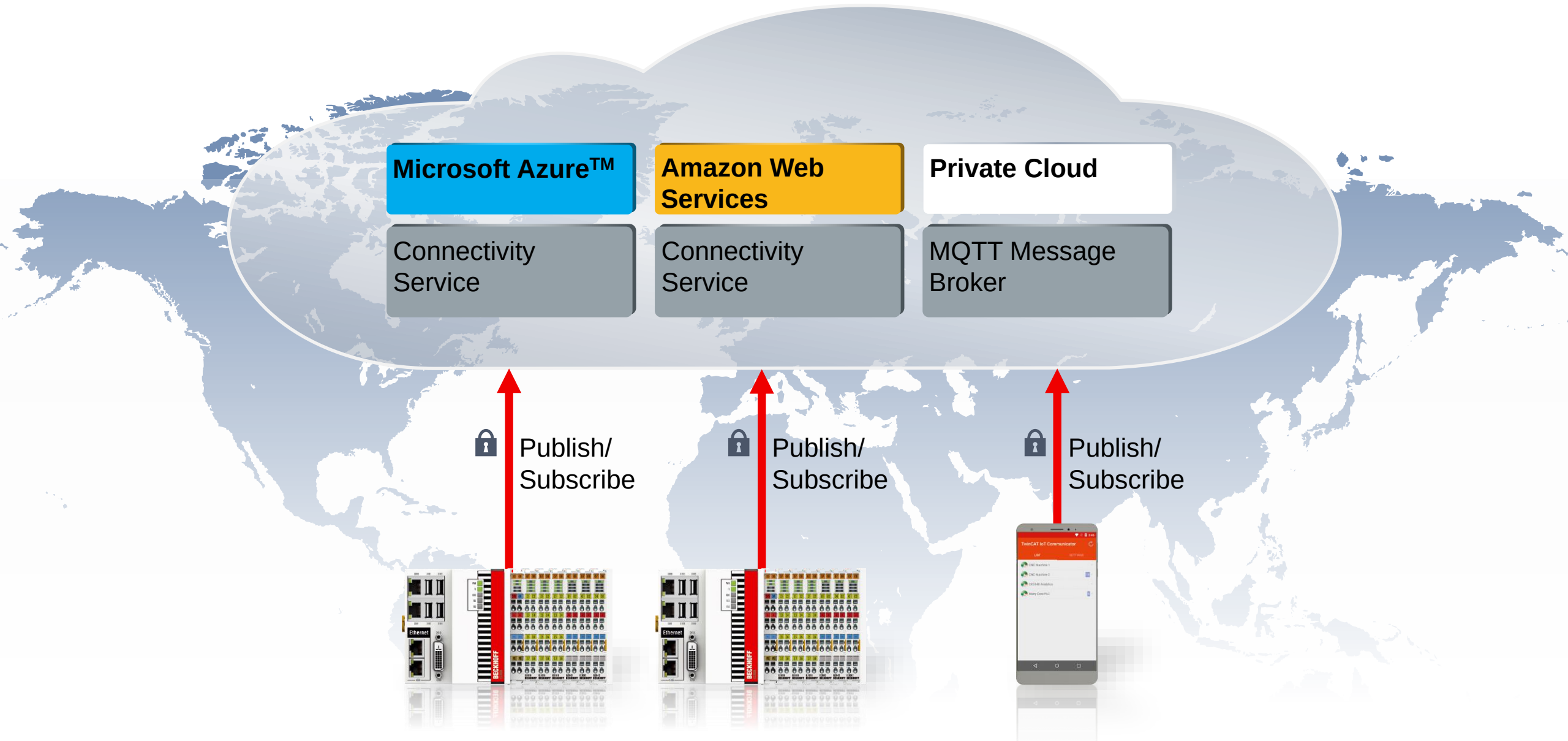

TF67xx: TwinCAT IoT

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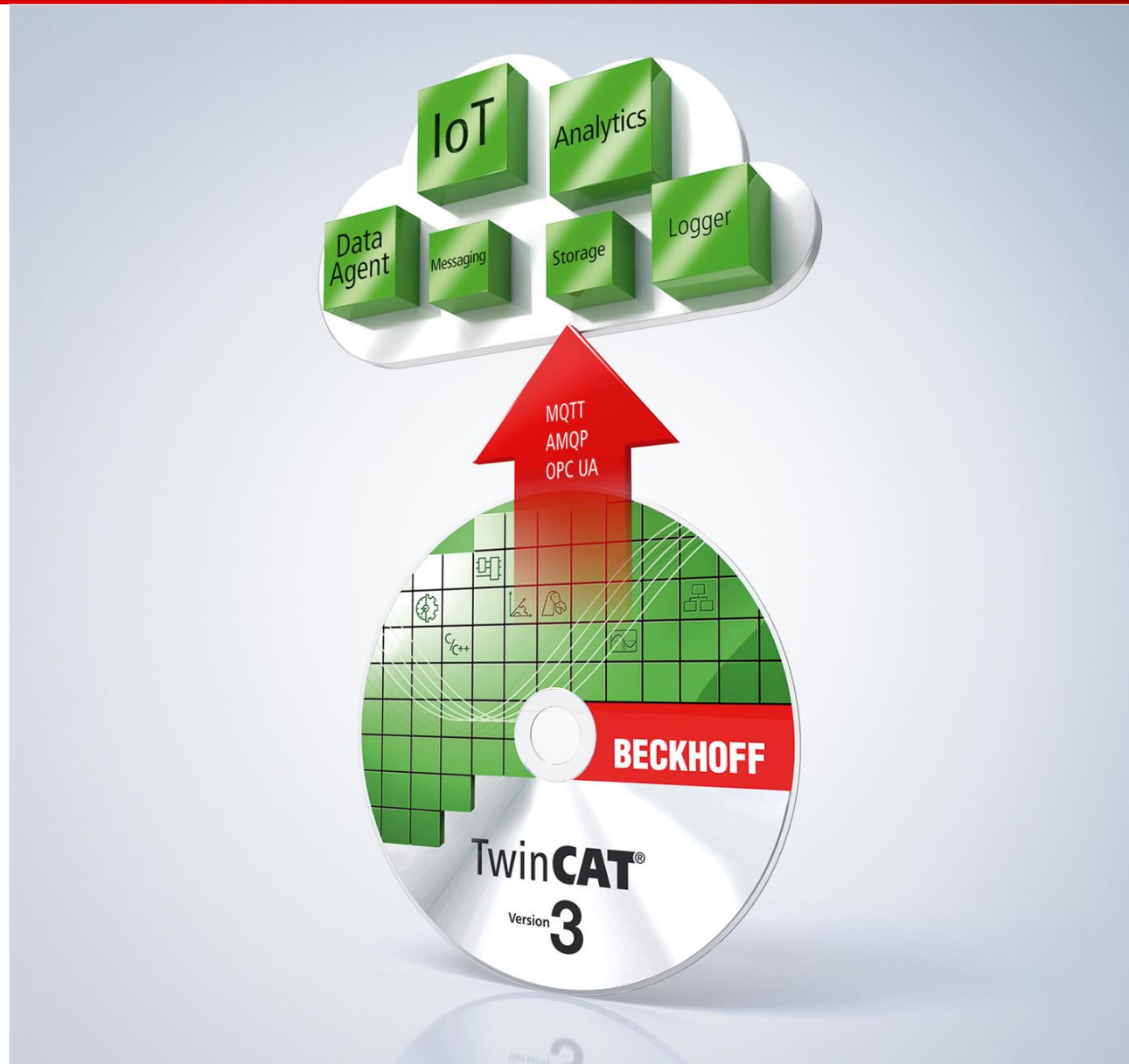
- TF670x IoT Communication
- TF671x IoT Functions
- TF6720 IoT Data Agent
- TF6730 IoT Communicator
- TF6735 IoT Communicator App



First TwinCAT IoT Success Story – Carheal+, Denmark

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Spray booth for the repair of scratches and minor damage to vehicle paintwork. An innovative air extraction system eliminates the risk of air contamination with emission and energy consumption being monitored via cloud-based data acquisition and evaluation

- The system provides information on key performance data such as e.g. filter operating hours, air quality and consumption of energy and paint resources.
- When VOC (Volatile Organic Compound) limit values are exceeded, the system raises an alarm.

Cloud scenarios supported by Beckhoff TwinCAT Analytics

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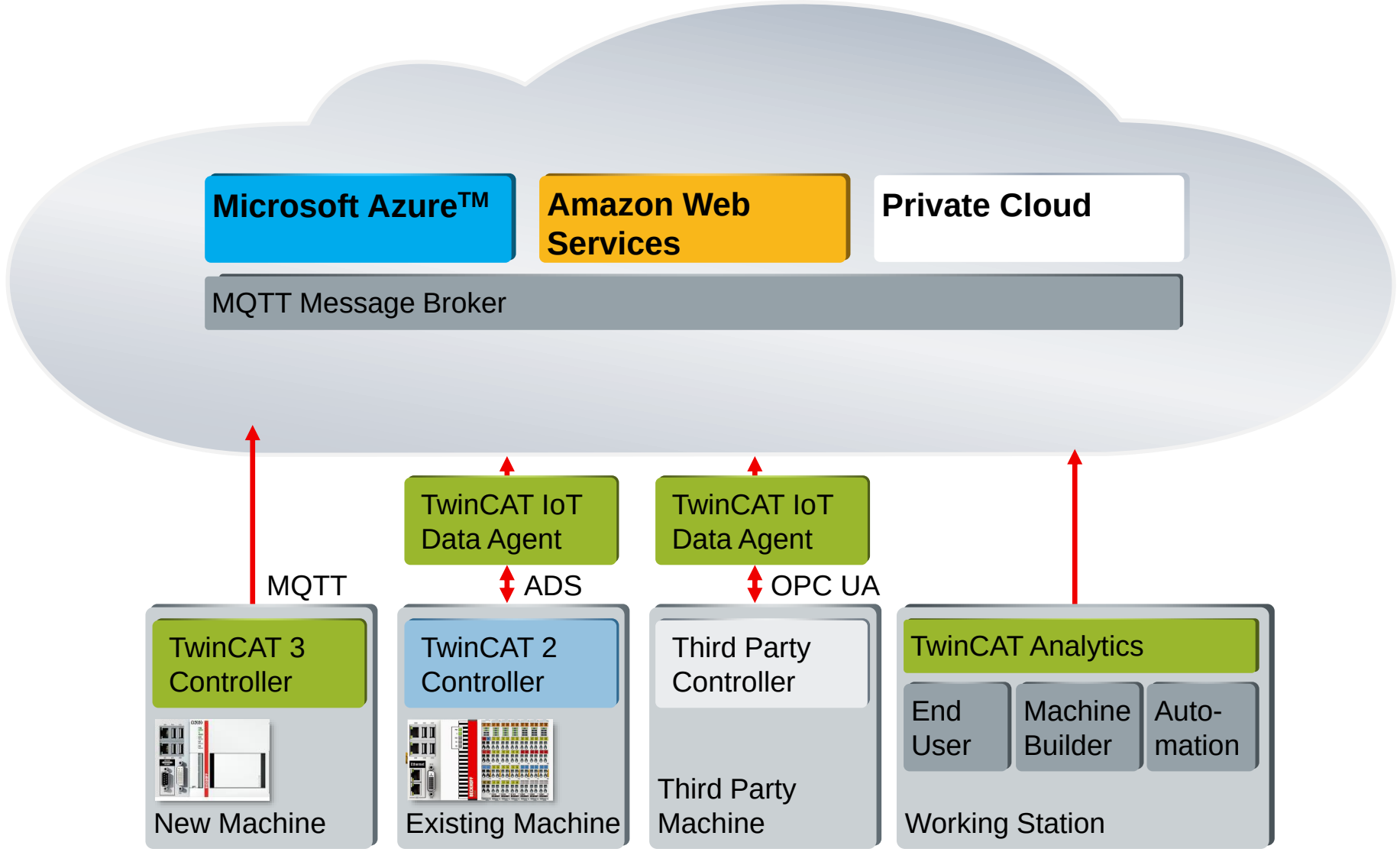

TwinCAT Analytics scenarios

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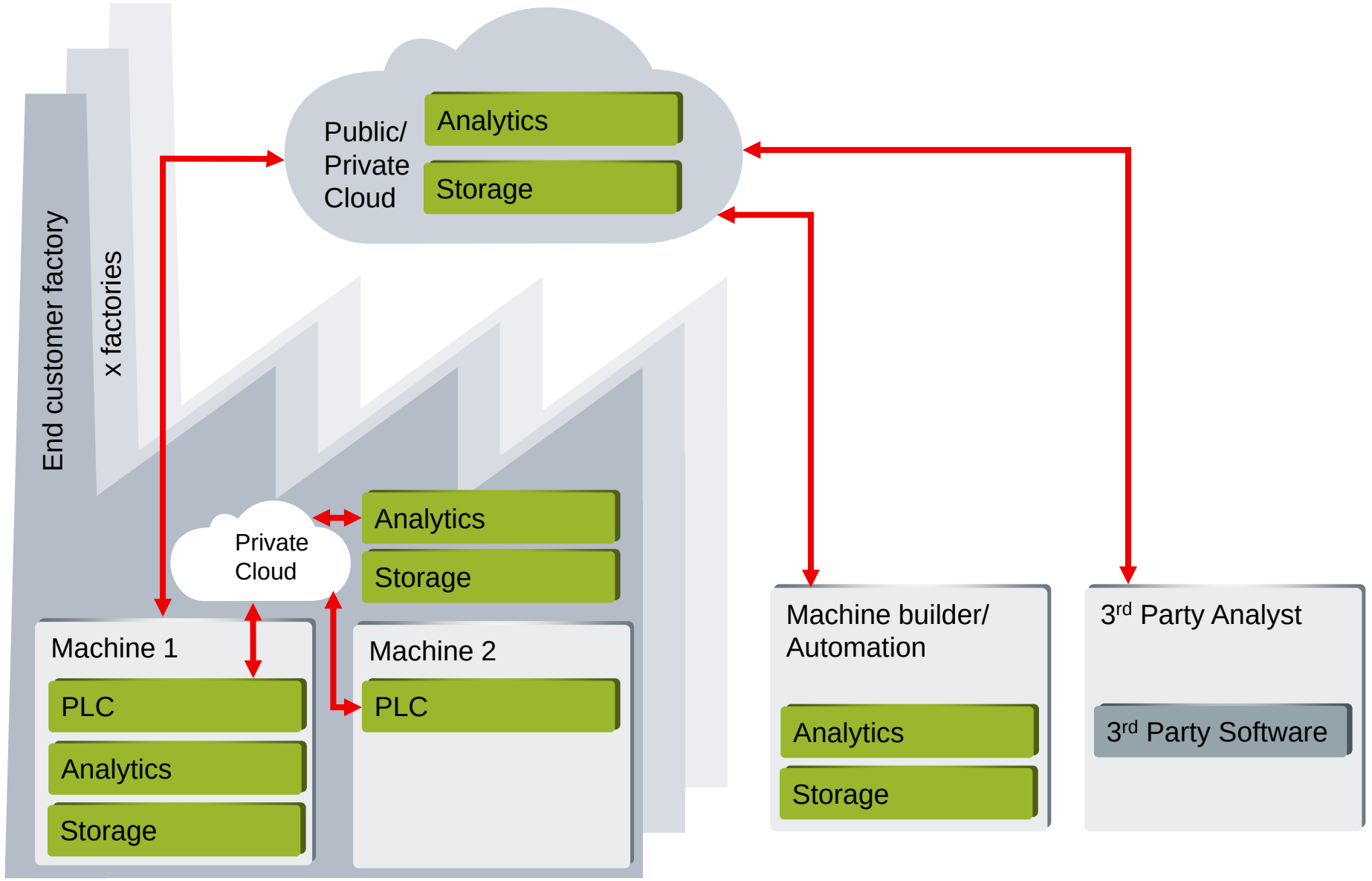

TwinCAT Analytics products

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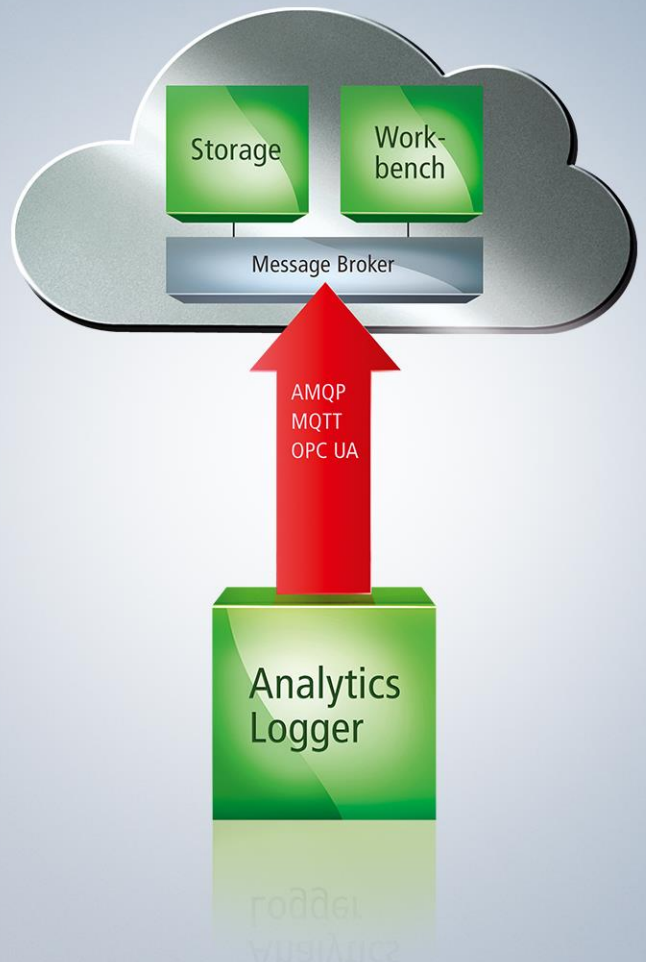
- TE3500 Analytics Workbench
- TE3520 Analytics Service Tool
- TF3500 Analytics Logger
- TF3510 Analytics Library
- TF3520 Analytics Storage Provider
- TF3550 Analytics Runtime
- TF356x Analytics Controller Packs



TwinCAT Analytics Logger

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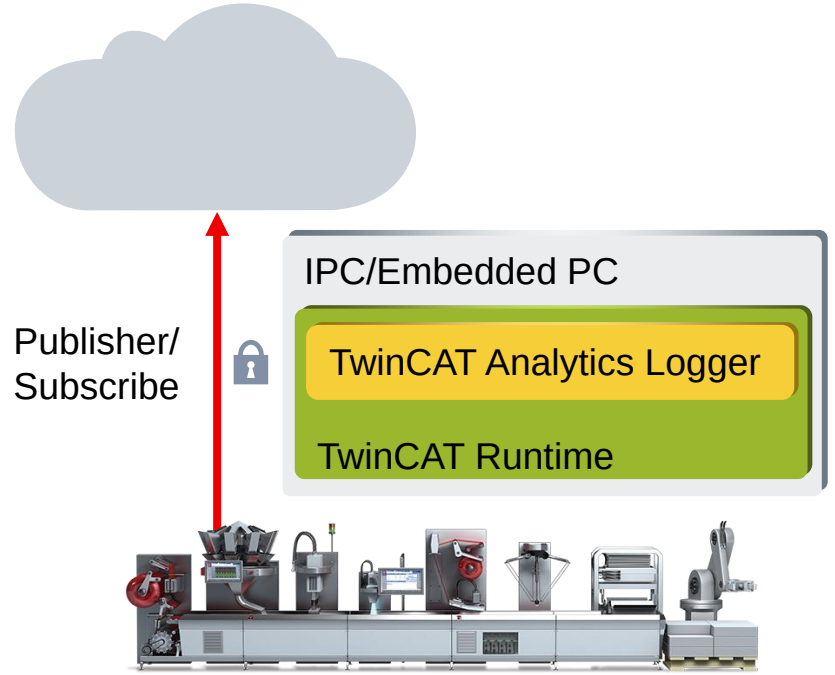
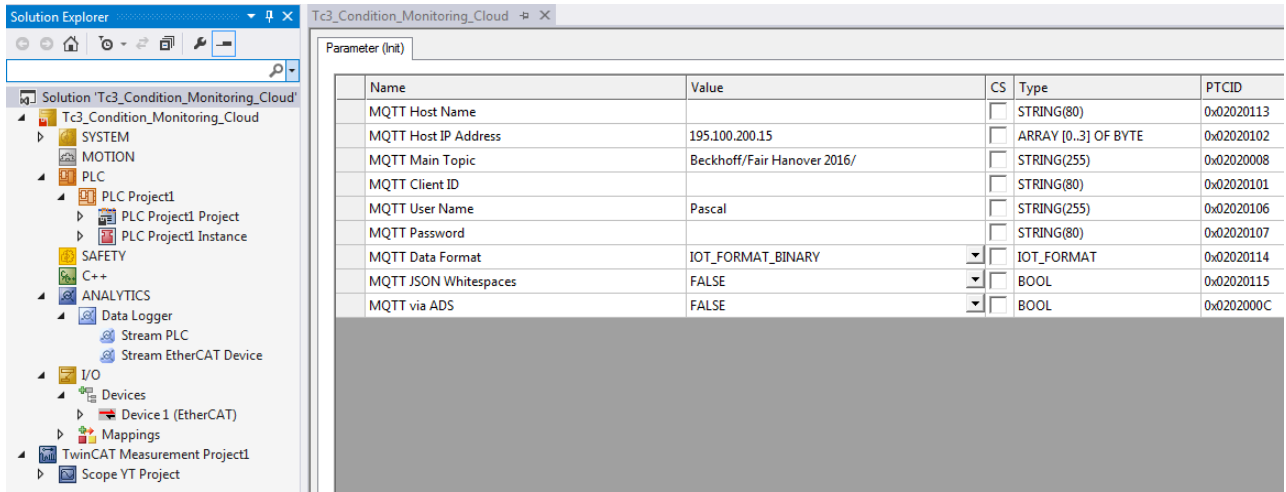
- cyclic data logging:
  - process image, PLC, NC, Diag
- easy configuration in Visual Studio®
- data logging
  - IoT with MQTT
  - file based





TwinCAT 3 Analytics product overview

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Dashboard

Analysis

Create data history

Communication/
Data acquisition

Analytics
Dashboard

Code generation

Ultra-compact IPC
C6030

TwinCAT Analytics Service Tool

TwinCAT Analytics Runtime

TwinCAT Analytics Workbench

MQTT

Storage

TwinCAT Analytics
Storage Provider

MQTT

Message Broker

MQTT

MQTT

MQTT

Beckhoff Edge Device

TwinCAT IoT Data Agent

Ultra-compact IPC C6015

ADS/OPC UA

OPC UA

Beckhoff control system

TwinCAT Analytics Logger

Embedded PC
CX2000
with TwinCAT 3

Existing Beckhoff control system

Embedded PC
CX5000
with TwinCAT 2

Existing 3rd-party controller

Beckhoff IoT Bus Coupler

IoT Device

IoT Bus Coupler
EK9160

TwinCAT 3 Analytics product overview

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Engineering products:

- **TE3520 Analytics Service Tool**
  - configurator including algorithms
  - Scope View and IoT connection
- **TE3500 Analytics Workbench**
  - See Service Tool
  - PLC code generation

TwinCAT 3 Analytics product overview

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Runtime products:

- **TF3500 Analytics Logger**
- **TF3550 Analytics Runtime**
  - PLC Runtime and Analytics library
  - IoT connection including 4 clients
  - HMI Server and HMI Client Pack 3
- **TF3520 Analytics Storage Provider**
- **TF3510 Analytics PLC library**

TwinCAT 3 Analytics – TE3520 Service Tool

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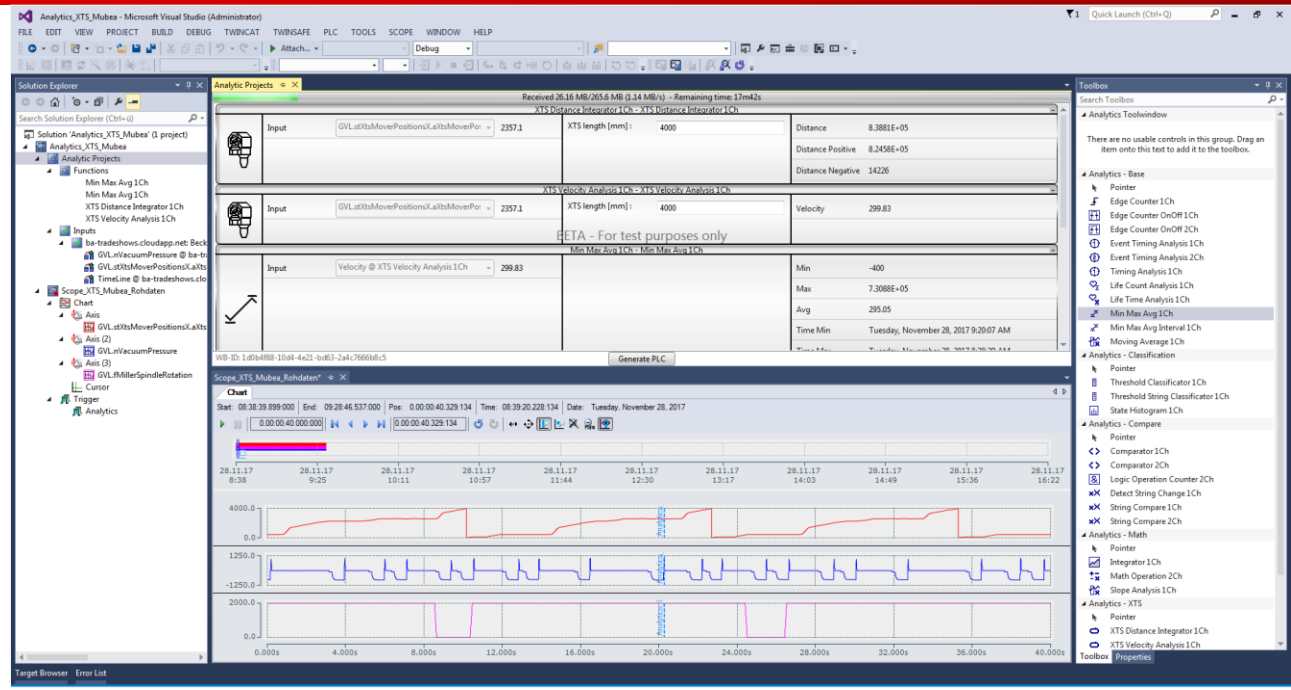
Expert tool from Beckhoff for machine commissioning and service measures

- fast configuration
- analysis of live and historical data
- toolbox with numerous algorithms for analysis purposes
- bracketing of algorithms possible, e.g.: XTS speed → Min/Max/Avg
- graphic charting tool for the visualisation of raw data
- interaction between results and charting tool → result finder



TwinCAT 3 Analytics – TE3500 Workbench

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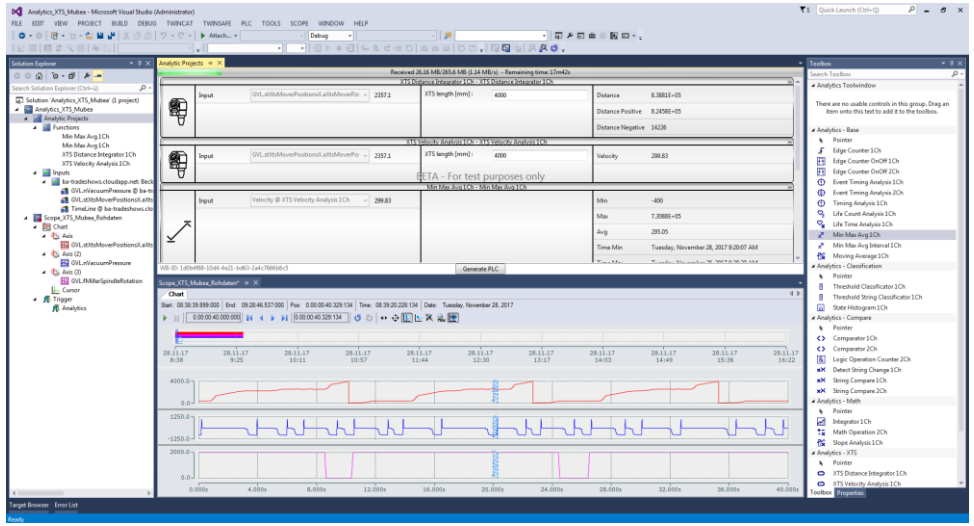
Beckhoff offers solution for machine manufacturers and end customers

- immediate automatic code generation for created configuration
- code supports 24/7 operation/“for the entire machine service life“
- user-specific, individual HTML5-based visualisation
  - platform-independent – Windows, iOS, Android etc.
  - responsive design supports diverse tablets and smartphones a.m.



Cloud scenarios supported by Beckhoff

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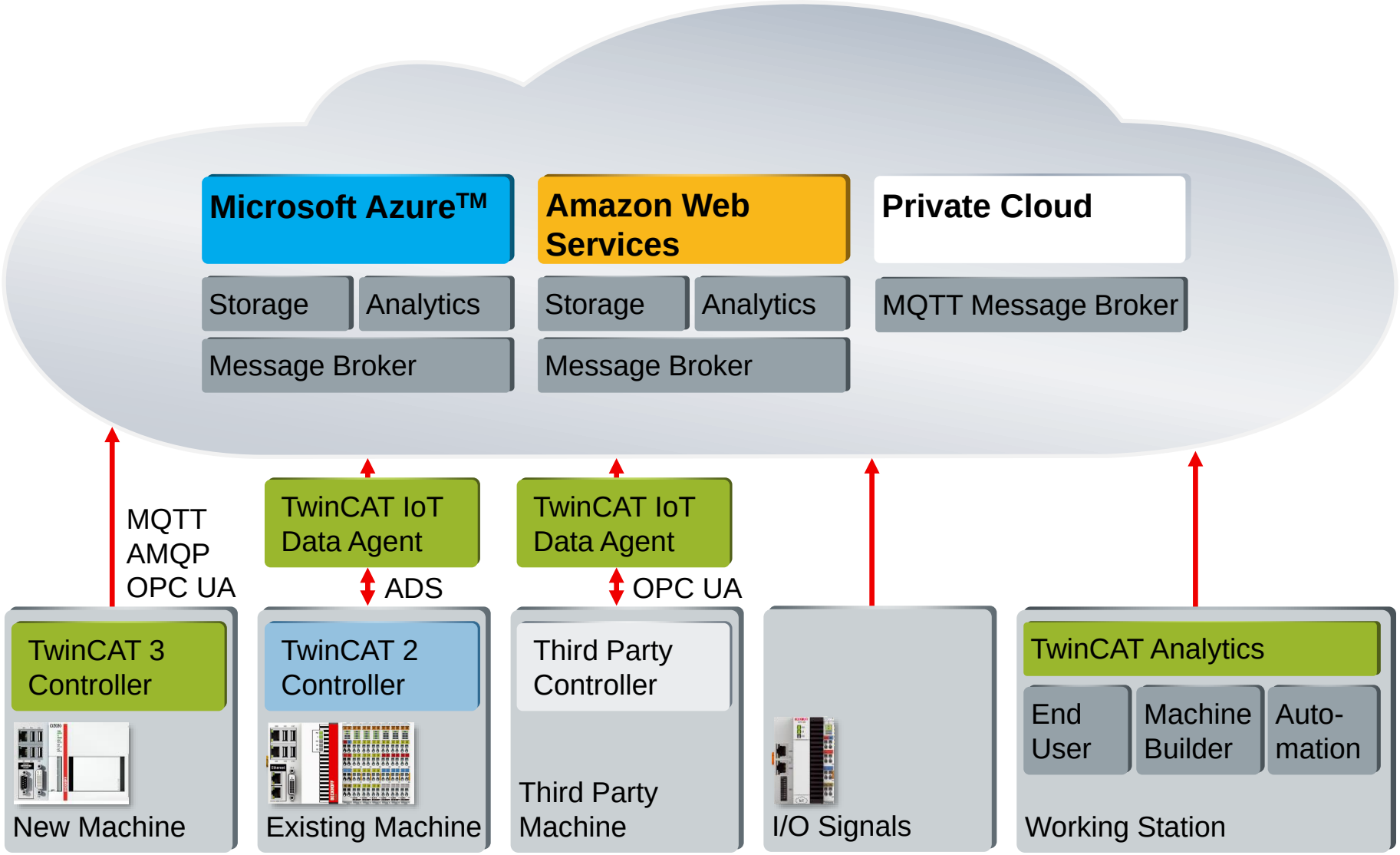

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Basic components

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TwinCAT 3 – eXtended Automation Engineering (XAE)

TwinCAT 3 – eXtended Automation Runtime (XAR)

Base

TC1270 | TC3 PLC/NC PTP 10/NC I/CNC
TC1260 | TC3 PLC/NC PTP 10/NC I
TC1250 | TC3 PLC/NC PTP 10
TC1200 | TC3 PLC
TC1100 | TC3 I/O
TC1000 | TC3 ADS

TC1220 | TC3 PLC/C++/MATLAB®/Simulink®
TC1210 | TC3 PLC/C++
TC1100 | TC3 I/O
TC1000 | TC3 ADS

TC1320 | TC3 C++/MATLAB®/Simulink®
TC1300 | TC3 C++
TC1100 | TC3 I/O
TC1000 | TC3 ADS

Functions

TF1xxx | System
TF2xxx | HMI
TF3xxx | Measurement
TF4xxx | Controller
TF5xxx | Motion
TF6xxx | Connectivity
TF7xxx | Vision
TF8xxx | Industry specific

Overview of functions

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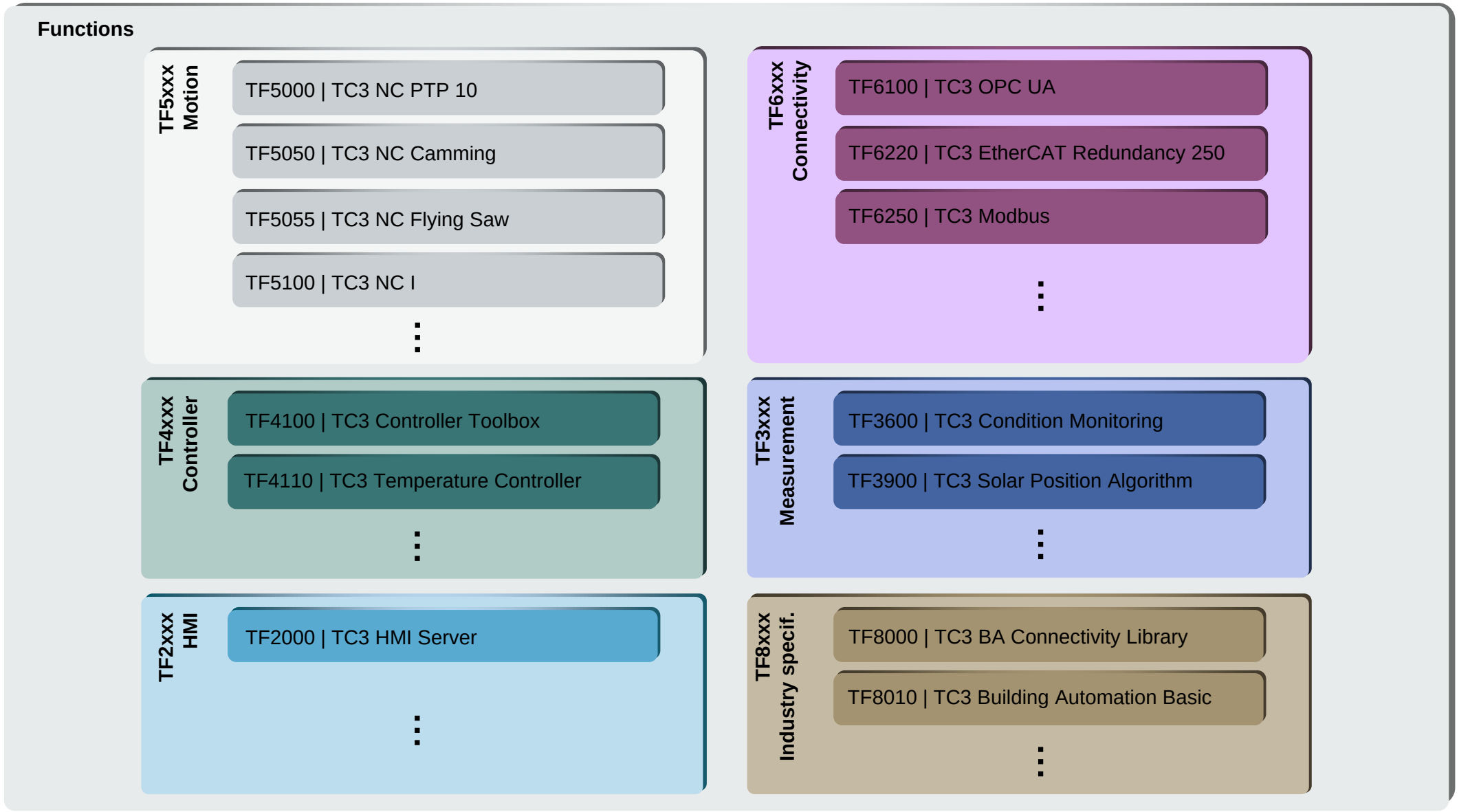

Contact

BECKHOFF

Beckhoff Automation GmbH & Co. KG
Headquarters
Huelshorstweg 20
33415 Verl
Germany

Phone: +49 5246 963-0
E-mail: info@beckhoff.com
Web: www.beckhoff.com