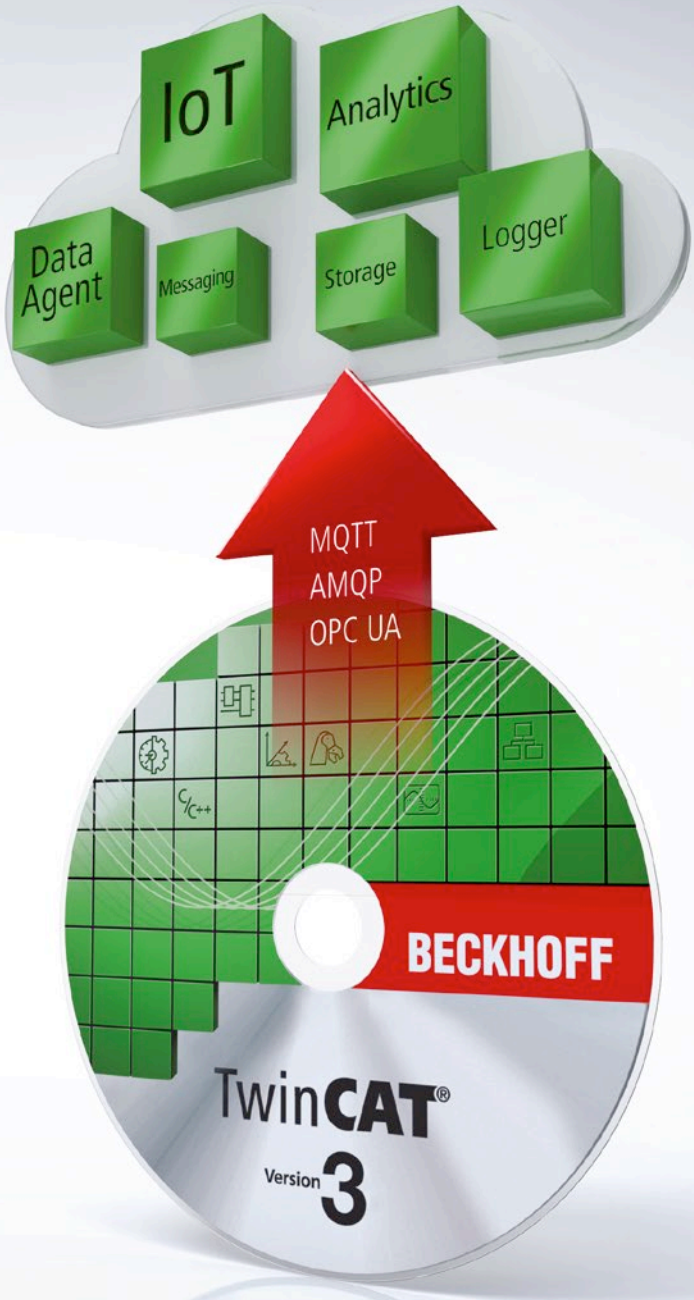
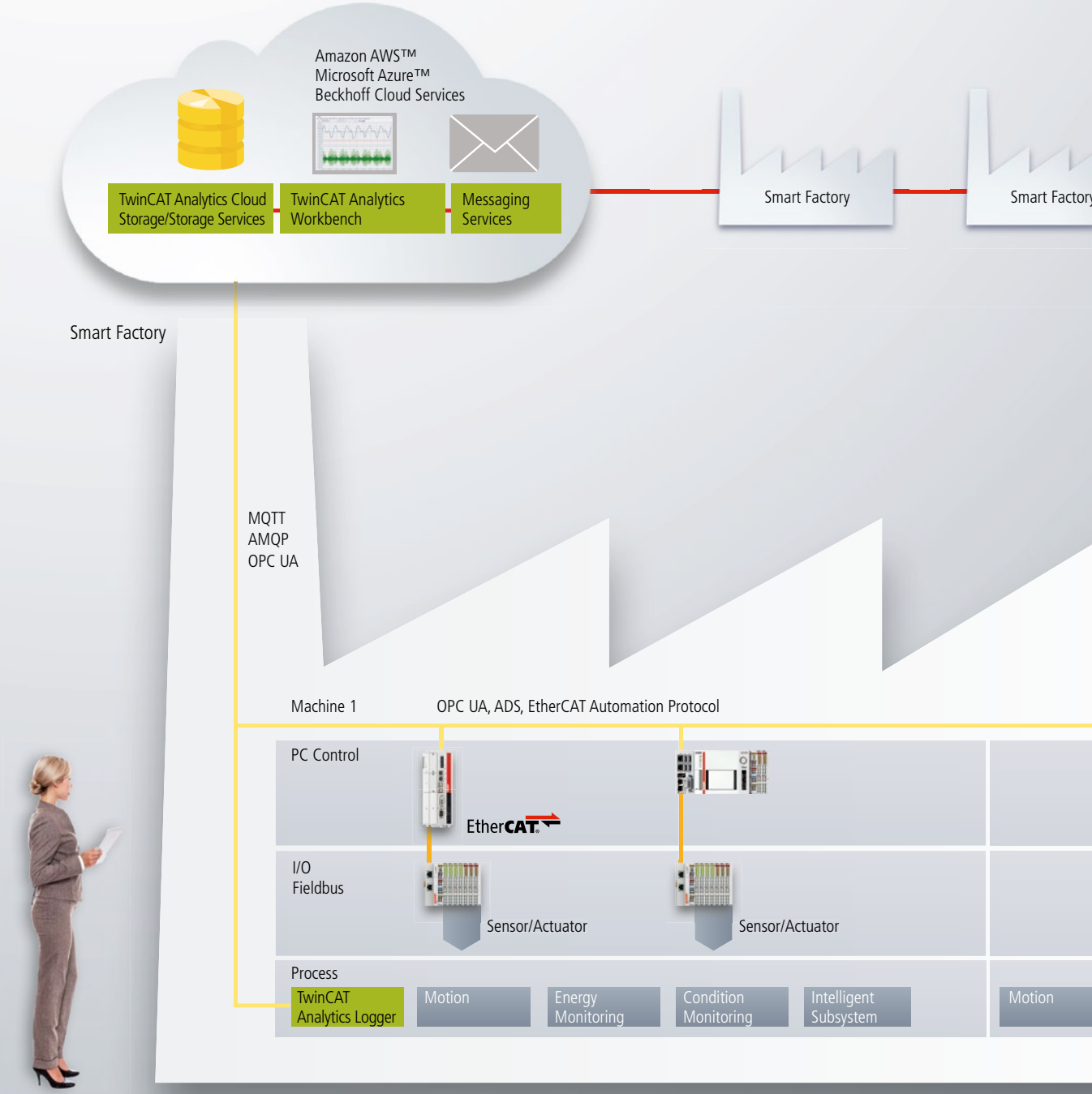
BECKHOFF New Automation Technology

IoT and Industry 4.0: Powered by TwinCAT



TwinCAT solutions for IoT and Industry 4.0



Beckhoff provides the foundational technologies and tools needed today to implement Industry 4.0 concepts and Internet of Things (IoT) connectivity, all via PC-based control. TwinCAT engineering and control software packages are available for the creation of applications such as Big Data, pattern recognition as well as condition or power monitoring, in addition to traditional control tasks – which can sustainably increase production and engineering efficiency as a result. New software libraries are now available for advanced analytics and communication between controllers and cloud-based services:

TwinCAT Analytics

For cyclically saving process images and analysing production data

- TF3500 | TC3 Analytics Logger
- TE35xx | TC3 Analytics Workbench
- TF3510 | TC3 Analytics Library
- TF3520 | TC3 Analytics Cloud Storage

TwinCAT IoT Communication

For communication with data and communication services in the cloud over standardised protocols

- TF6100 | TC3 OPC UA
- TF670x | TC3 IoT Communication
- TF671x | TC3 IoT Functions
- TF672x | TC3 IoT Data Agent
- TF6730 | TC3 IoT Communicator
- TF6735 | TC3 IoT Communicator App

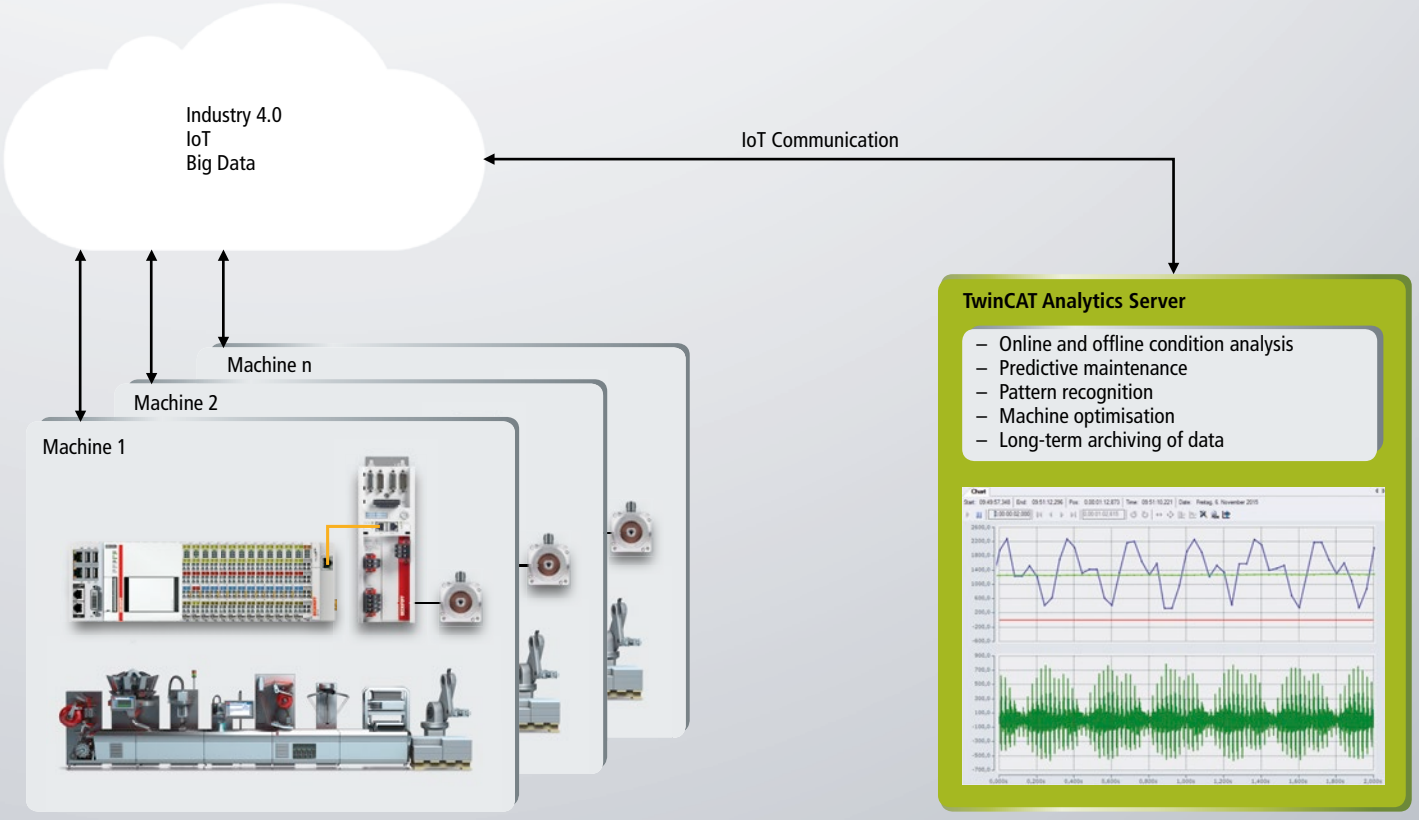
"TwinCAT Analytics" saves the process data locally, on the server or in the cloud in synchronisation with the machine cycle. All data are recorded and serve as the basis for extensive analyses; this enables new predictive maintenance technologies and minimises machine downtime. "TwinCAT IoT Communication" supports common protocols for cloud communication and push messages to smart devices. TwinCAT IoT is quick and easy to configure and, together with an Industrial PC or Embedded PC as the IoT controller, establishes a seamless connection between the Internet of Things and the Internet of Services.

TwinCAT for Industry 4.0/IoT

- Simplified, cycle-synchronous data analysis and preventive maintenance
- Simplified communication between controller and cloud
- Simplified monitoring and analysis of process data on mobile devices

TwinCAT Analytics for Industry 4.0

In the context of Industry 4.0, many different demands are placed on machines in terms of engineering, modularity, communication, data analysis and intelligent systems. The data analysis in particular can be multifaceted: online and offline condition analysis, predictive maintenance, pattern recognition, machine optimisation or long-term data archiving. The importance of this topic can be illustrated by taking condition analysis as an example. Of course, processing errors in machines are costly and undesirable in every case. However, it is even more serious if crucial data is no longer available for the analysis of the processing error, which could provide clues to the malfunction and the best possible solution. The consequence is often that the cause of a malfunction can no longer be discovered. The first measure most frequently taken is to integrate additional data logging mechanisms; however, these only provide clues if the processing error occurs again. There is therefore great uncertainty about whether a further loss of production could occur at any time. This is precisely what the new Industry 4.0 solution, TwinCAT Analytics, aims to prevent. It uses not only proven TwinCAT technologies such as PLC, Scope View, Condition Monitoring and MATLAB®/Simulink®, but also an entire range of new products created especially for TwinCAT Analytics.



Online and offline condition analysis

- Cyclically recorded process and production data can be analysed online or offline.
- Time-based analysis of machine cycles: minimum and maximum cycle time, average cycle time, total running time and time differences
- Cycle counter
- Offline trace analysis

Predictive maintenance

- Condition monitoring – frequency analysis, crest factor, kurtosis, RMS calculation and classification
- Limit value monitoring of process data

Pattern recognition

- Detection of regularities and repetitions in recorded data

Machine optimisation

- Process optimisation
- Energy optimisation
- Simplified drive design
- Optimisation of connected power

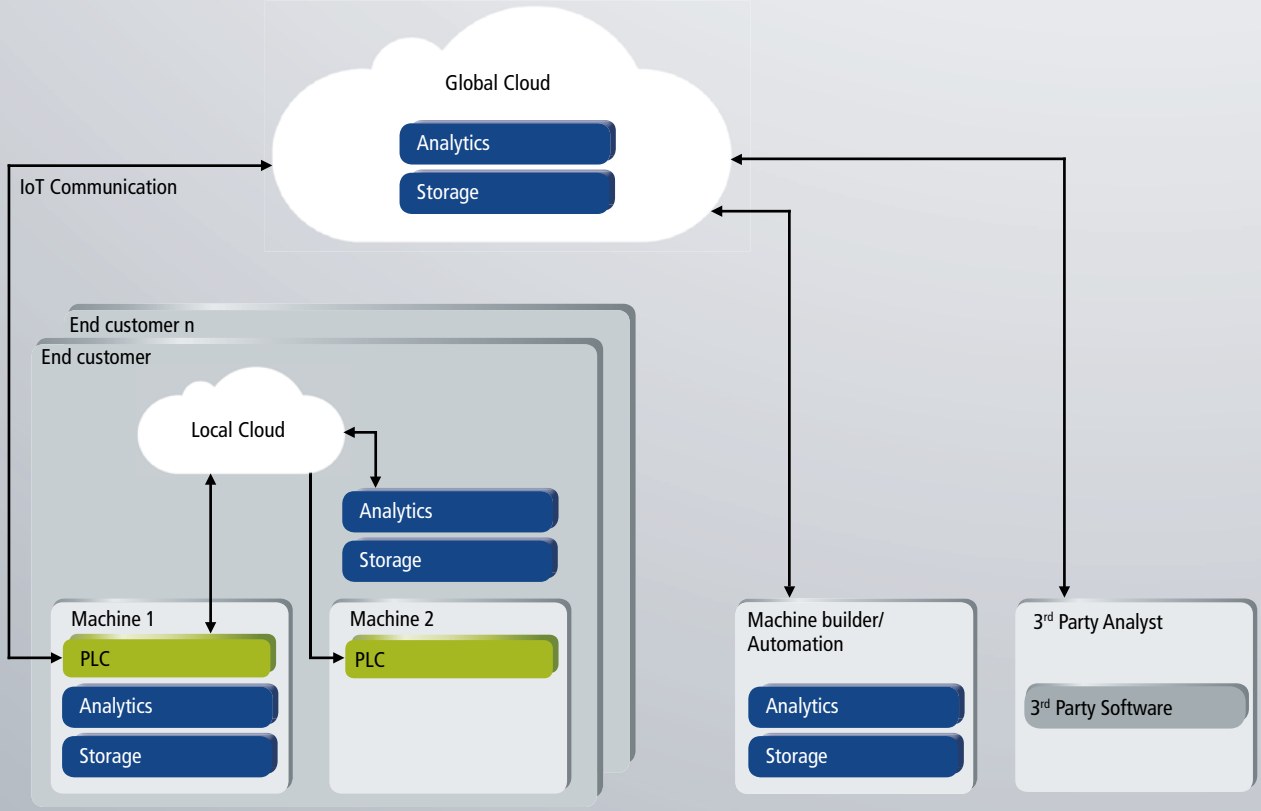
Long-term archiving

- Cloud connection via IoT communication or OPC UA
- Online or offline saving of data in relational databases
- Storage of data in NoSQL databases
- Support for many data formats

Analytics infrastructure

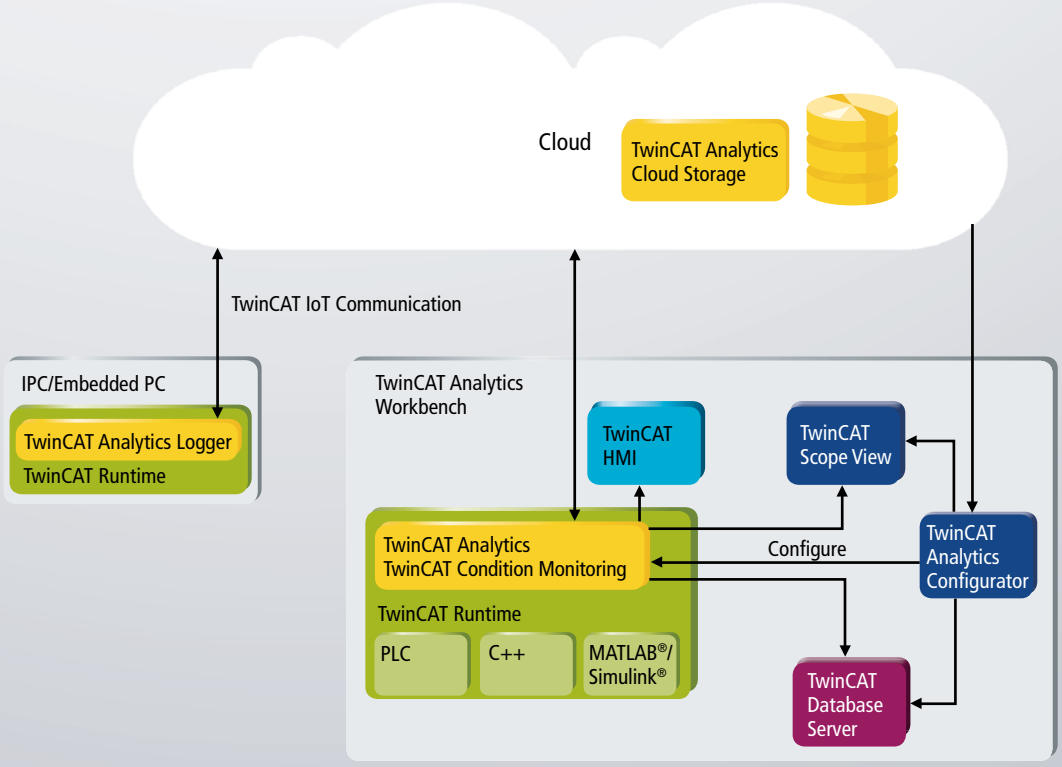
Through the IoT communication interface, machine manufacturers and end customers have ample room to manoeuvre when setting up TwinCAT Analytics. An important aspect here is that the IoT interface does not necessarily mean having to place one's data in the public cloud. The same technology can also be used in private networks, giving the user a high degree of flexibility and choice. This means that the recorded data can, of course, be analysed locally on any machine with the appropriate computing power. However, this is also possible via the IoT connection from a local cloud in the factory, enabling the machine manufacturer to analyse its machines in its own network environment on a powerful computer/server. In this case, the analytics server can analyse several machines in the factory at once. Alternately, TwinCAT Analytics can, of course, run on a virtual machine in the global cloud.

Processor power and memory, as well as the IT infrastructure can be rented and used from vendors such as Microsoft or Amazon. The global connection of machines to the analytics system becomes much simpler as a result. Due to the inherent expertise of machine manufacturers, they are in an excellent position to act as a service provider and analyst for the end user customer. In this case, TwinCAT Analytics can be hosted in the global cloud or in the machine manufacturer's IT infrastructure on virtual or physically existing devices. Authorised external analysts can get the data in various file formats or securely retrieve the data from TwinCAT Analytics Cloud Storage in the cloud.



TF3500 | TC3 Analytics Logger

In order to analyse data, it obviously needs to be recorded first. There are different ways to do this in TwinCAT, such as with TwinCAT Scope View or TwinCAT Database Server. These are now joined by a further mechanism offered in TwinCAT Analytics: the TwinCAT Analytics Logger enables the cyclic archiving of large amounts of data. The basic idea in the sense of Big Data is to cyclically save the entire process image. This is adjustable in the configuration interface, where an extract of the data can also be manually selected, of course. It is equally possible to add data to the recording from the application, e.g. from the PLC or the NC. The data storage is configurable in the Analytics Logger. The data can be stored on a file basis or sent with TwinCAT IoT Communication over the open and standardised communication protocol, MQTT. The latter variant in particular provides maximum flexibility in establishing one's own TwinCAT Analytics infrastructure.



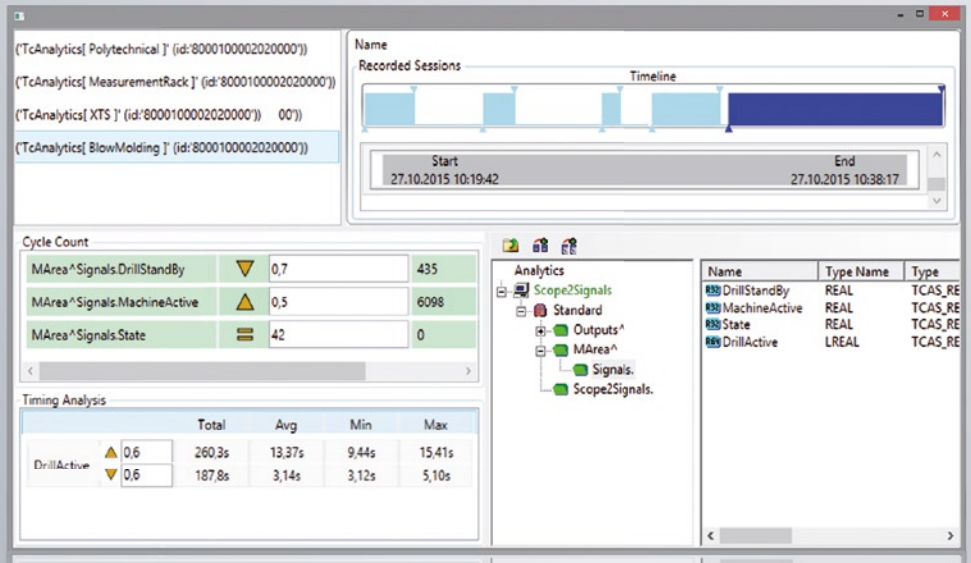
TE35xx | TC3 Analytics Workbench

The TwinCAT Analytics Workbench is defined as an engineering solution that consists of several useful components. Online and offline analyses can be carried out for one or more machines. The basic package, which offers the option to use modules from the TwinCAT Analytics library and extend them in the PLC code – if desired – with one's own algorithms, can be expanded with TwinCAT Condition Monitoring, C++ or MATLAB®/Simulink®. The basic package includes the TwinCAT PLC Runtime, the new TwinCAT Analytics Configurator and the associated Analytics PLC library as well as a Scope View Professional license and the IoT communication connection over MQTT. The license is scaled according to the number of machines to be analysed.

The great advantage of the TwinCAT runtime is its maximum flexibility. You have all degrees of freedom offered by the TwinCAT system to write your own online or offline analysis. The use of existing and tested algorithms is possible. Existing code can be used one-to-one. Individual mathematical analysis chains can be implemented for machine diagnostics through the condition monitoring library. It is similarly possible to integrate MATLAB®/Simulink® modules in the runtime. You can add your own algorithms in IEC 61131 or in C/C++. The TwinCAT Analytics Configurator enables the simple graphical configuration of the function blocks in the Analytics library.

With the TwinCAT Analytics Configurator you can comfortably sift through the data as they are cyclically acquired by the TwinCAT Analytics Logger. Many different variables can be selected from a large data package in order to graphically display them, for example, with a "post-scope configuration" in Scope View Professional. This means that previously recorded data can be subsequently displayed in the Scope View. The data can, of course, be written conveniently offline in a database via the TwinCAT Database Server. The configurator also provides some analysis algorithms with which you can examine the data offline for limit values or perform a runtime analysis of machine cycles.

The total running time of a machine cycle – the shortest, the longest and the average running time – can be determined with ease. The determination and monitoring of energy requirements can be used as further analysis criteria. Using state analysis it is very easy, for example, to determine whether a rotary milling head is frequently at a standstill, whether it is driving at speed A, B or C, or whether it is often in an error state. The results can be displayed exceptionally well in a histogram.

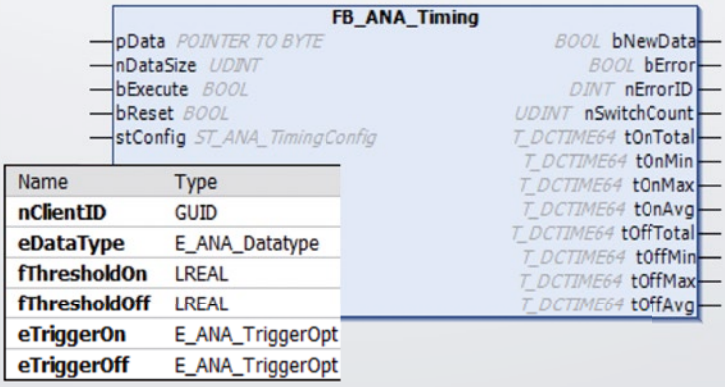


TwinCAT Analytics Configurator

TF3510 | TwinCAT Analytics Library

The TwinCAT Analytics library is a PLC library used for online or offline analysis in the PLC runtime of the TwinCAT Analytics Workbench. The library contains function blocks for cycle analysis and energy requirements or RMS calculations. The experienced PLC programmer can use the function blocks from the library directly in their own PLC application, for example, together with analysis chains from the condition monitoring library.

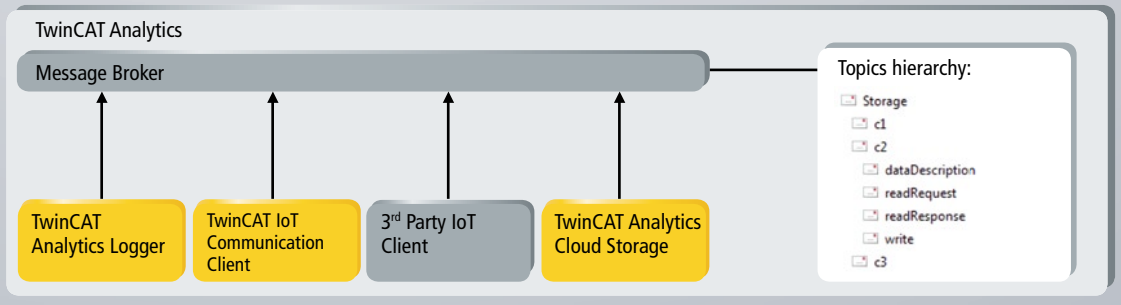
Another option is to have the function blocks configured by the configurator so that not a single line of PLC code needs to be written. The analysis function blocks can also be easily configured by personnel who have not been trained in PLC programming. A Scope View or the TwinCAT HMI can be used to display the analysis results.



Name	Type
nClientID	GUID
eDataType	E_ANA_Datatype
fThresholdOn	LREAL
fThresholdOff	LREAL
eTriggerOn	E_ANA_TriggerOpt
eTriggerOff	E_ANA_TriggerOpt

TF3520 | TwinCAT Analytics Cloud Storage

TwinCAT Analytics Cloud Storage offers the possibility to save data in public or private networks. The data can be provided for storage using a so-called message broker. The broker acts as a kind of intermediary between the clients that connect to it. The broker provides various topics for communication, so that any IoT client can "subscribe" to a TwinCAT Analytics Cloud Storage topic and can also "publish" values in a topic. Any IoT clients can access the storage, because the topics structure is disclosed, as is the description of the data in the storage.



TwinCAT IoT

With the convergence of information technology and automation technology (IT + AT), it is possible to implement more efficient and flexible automation projects. Because the complexity and diversity of the associated data is dramatically increasing, this is accompanied by a continuous increase in the demands placed by modern and distributed industrial projects on the exchange of process data with IT systems. The traditional use case of storing process data in a central location is transforming more and more into a basic functionality that is expected of any modern controller. Genuine added value is only achieved through the filtering, further processing and interpretation of collected data, as well as the simple establishment of the necessary infrastructures. It is becoming more and more necessary to collect process data from different locations and to evaluate it centrally. IT managers are concerned more and more with the provision of a suitable distributed IT infrastructure, including the relevant security measures.

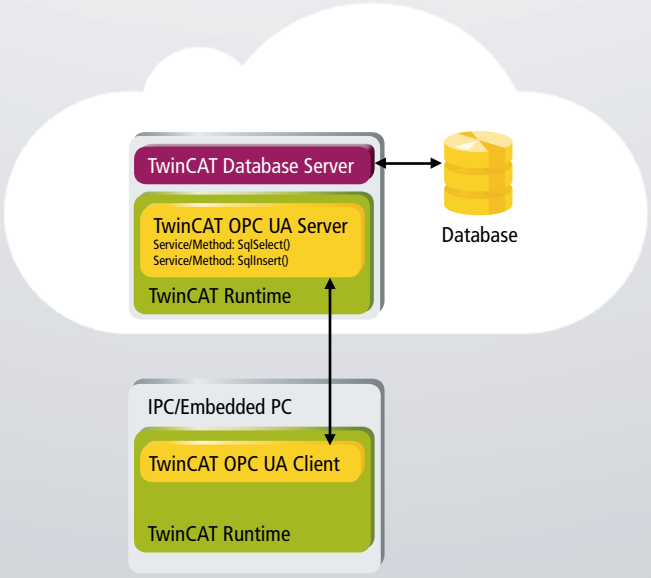
Such infrastructures and their maintenance are now relocated to cloud systems. These systems provide production managers with central and secure access to both process data and other analysis functions, as a result of which the collected data can be processed quickly and easily.

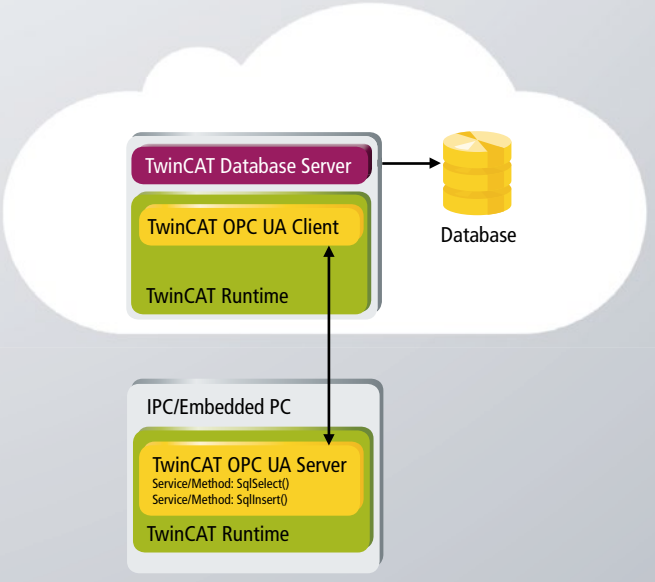
The TwinCAT 3 IoT products within the TwinCAT Connectivity product family provide the user with various functions for exchanging process data over standardised communication protocols and for directly accessing the data and communication services of cloud service providers. An important aspect here is that these services do not necessarily have to be hosted in a public cloud. The same technology can also be used in private networks. One of the big advantages here arises from the interplay of TwinCAT IoT with TwinCAT Analytics. The establishment of a TwinCAT Analytics Workbench for the central data analysis of multiple machines enables a high degree of flexibility through the use of the TwinCAT 3 IoT products.

TF6100 | TC3 OPC UA

OPC Unified Architecture (UA) is the next generation of the classic OPC standard and describes a globally standardised communication protocol that allows the vendor- and platform-independent transmission of process data. OPC UA addresses the requirements of Industry 4.0 and IoT, which is why it was chosen by various Industry 4.0 initiatives as the official communication protocol. One of the main features of OPC UA is the standard integration of security mechanisms directly in the communication stack.

TwinCAT OPC UA allows access to the TwinCAT runtime environment or communication with other UA devices directly from the runtime and consists of both client and server components to increase the flexibility in the design of connected machine projects. Through PC-based control technology, TwinCAT automation software supports infrastructure-as-a-service scenarios in which both a TwinCAT OPC UA server and a TwinCAT OPC UA client can be executed in the cloud. Based on a service-oriented PLC architecture, it is possible to retrieve process data and process them further in the cloud, e.g. to save data in a database. This so-called "SOA PLC" is based on user-definable methods from the TwinCAT runtime, which are available for secure remote method calls via OPC UA.

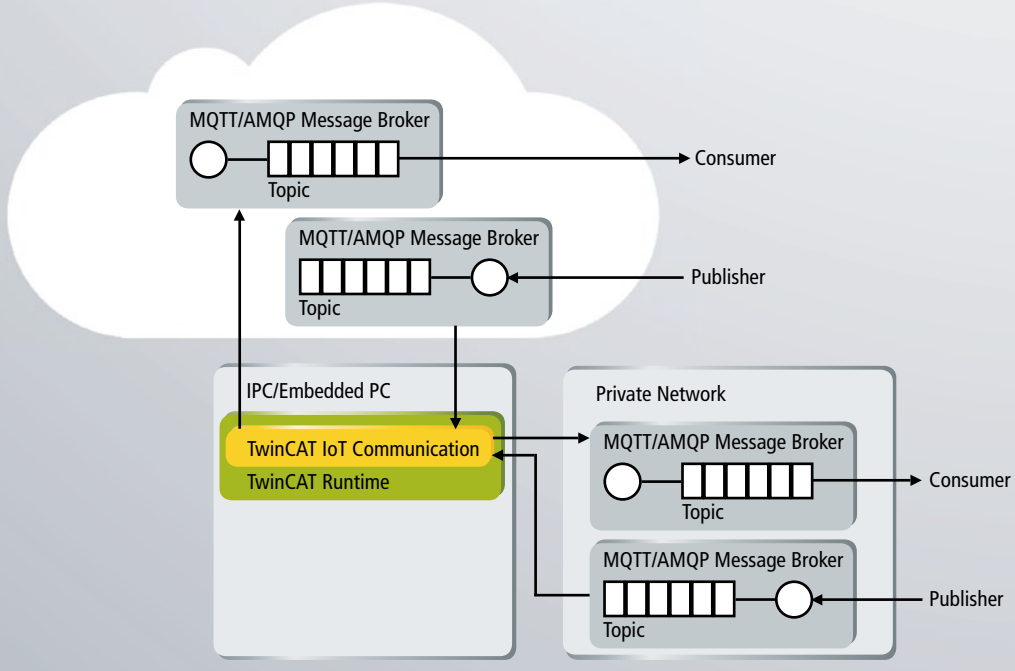




TF670x TC3 IoT Communication

TF670x IoT Communication provides basic functions for transmitting and receiving data over the MQ Telemetry Transport Protocol (MQTT) and the Advanced Message Queuing Protocol (AMQP) directly from the controller.

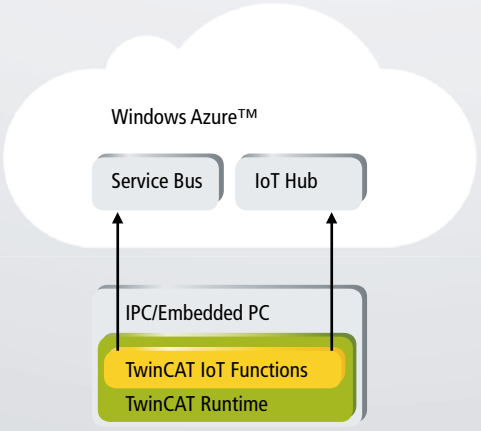
MQTT and AMQP are open and standardised communication protocols that are gaining importance in the fast and efficient transmission of data due to low overhead. Communication takes place here on the basis of the publisher/subscriber communication model with a so-called "message broker". Through this decoupling of the classic client/server architecture, communication with a message broker is based exclusively on outgoing communication connections, which represents a considerable advantage in the configuration of network infrastructure such as firewalls. The connection can optionally be secured via security mechanisms, as offered in the respective protocol. When using the TF670x, any MQTT/AMQP message brokers can be used; these are located either in the machine operating company's local network or in the public cloud, providing a variety of application scenarios.

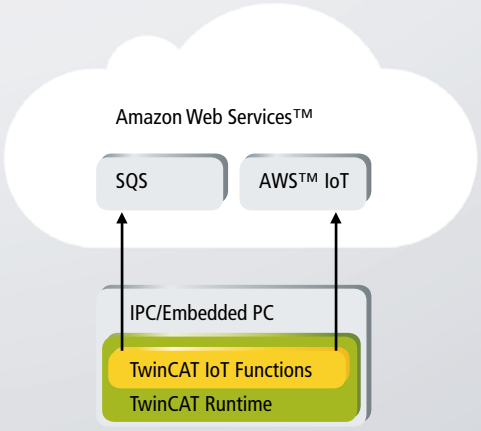


TF671x | TC3 IoT Functions

Cloud service providers offer users various services for receiving, processing and storing process data. These so-called "platform-as-a-service" services offer the advantage of an abstracted perspective of the lower-level IT infrastructure, which means customers no longer have to worry about creating a suitable infrastructure, but can concentrate fully on the machine application. In the case of an extension to the project, for example, when process data are to be collected from additional machines, such services offer the advantage of automatic scaling or adaptation to the new data load without the machine end user company itself having to take care of adaptations to its IT infrastructure.

TF671x IoT Functions are based on the basic protocols of the TF670x package and extend them with a PLC library, which enables simple and direct communication with the cloud services of providers such as Microsoft Azure™ and Amazon AWS™.





Microsoft Azure™
Microsoft offers various communication and data services in the Windows Azure™ cloud, which can be directly addressed via TF671x. The messaging services of the Azure™ Service Bus provide various functions here to enable reliable, secure and flexible exchange of data between various distributed devices and applications.

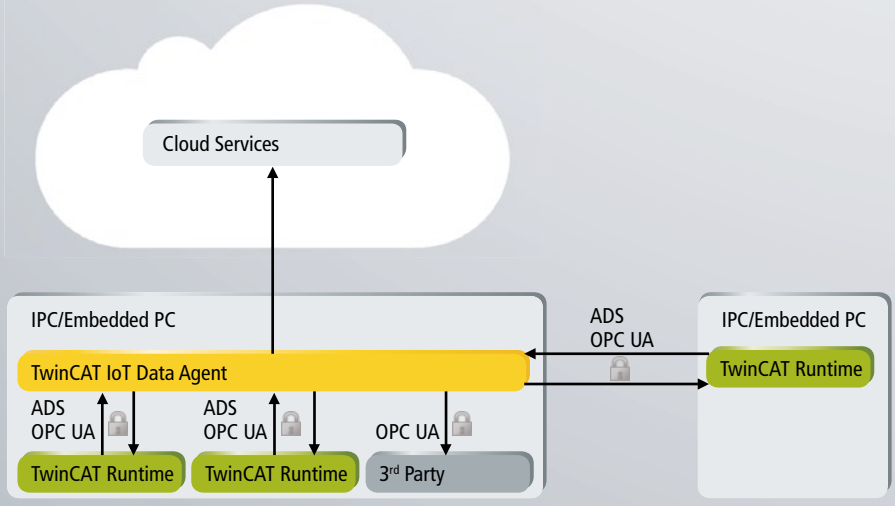
Amazon AWS™
The Amazon AWS™ cloud is regarded as one of the world's first "public cloud systems" and provides various messaging and data services. TF671x supports, above all, the so-called Simple Queue Service (SQS) and AWS™ IoT.

TF672x | TC3 IoT Data Agent

The TwinCAT 3 TF672x IoT Data Agent extends the functionalities of the TF670x and TF671x package with a gateway application that can be configured and operated independently of the TwinCAT project. The Data Agent independently collects the process data configured for this purpose and transmits it to a particular communication or data service in the Microsoft Azure™ or Amazon AWS™ cloud, or sends it to an MQTT or AMQP message broker. The entire parameterisation of the Data Agent takes place on an XML-based configuration file, making it easier to reuse. A graphical configuration tool is also available that reduces setup time and offers support during commissioning.

Both TwinCAT ADS and the IEC standard OPC UA, including the security mechanisms contained within it, are available for communication with the TwinCAT runtime environment. This enables the additional protection of data and communication with the controller. Several TwinCAT systems can optionally be aggregated via the Data Agent and their process data acquired. In order to provide a uniform data format for the transmitted process data, JavaScript Object Notation (JSON) can also be used as the data exchange format as an alternative for transmitting a pure byte stream, allowing the recipient to easily interpret the received data.

The data agent supports advanced sampling mechanisms such as OnDataChange transmissions and publisher/subscriber for the reduction of data traffic and associated costs. Buffering algorithms are available that prevent the loss of data in case of a disconnection.

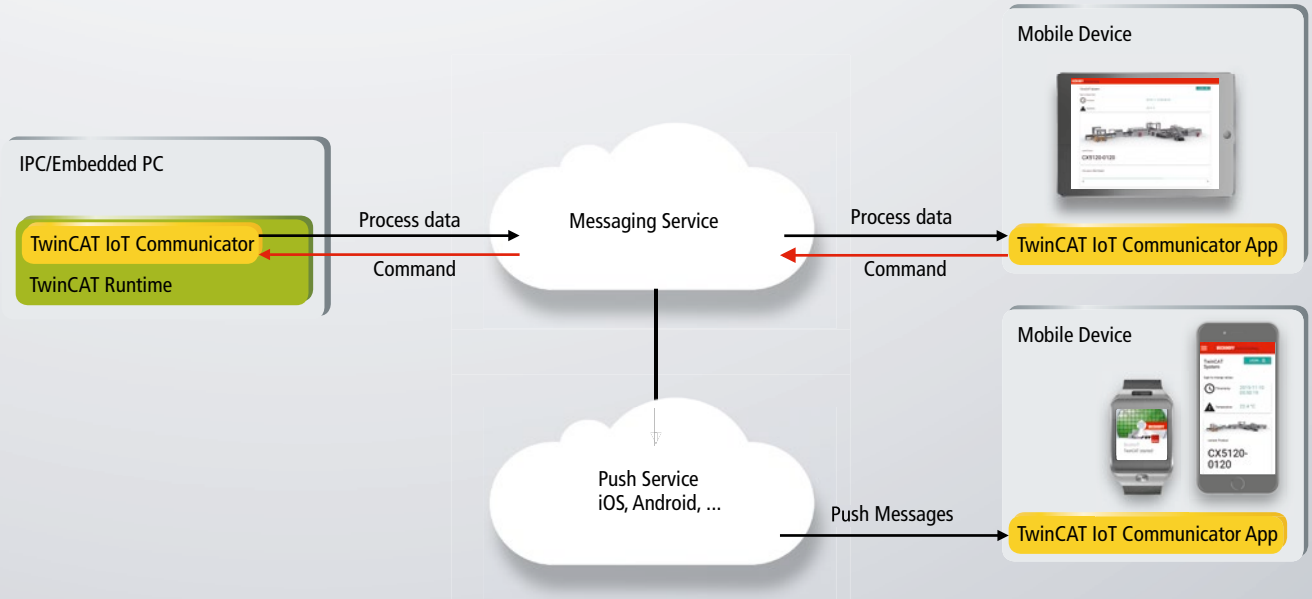


TF6730 | TC3 IoT Communicator

Using the TwinCAT extension, "IoT Communicator", process data can be transmitted in a simple manner to any end device, state changes can be monitored and information can be communicated back to the machine. This extension connects the TwinCAT controller to a messaging service and enables simple setup within the TwinCAT development environment for the transmission and reception of push messages between the PLC and mobile operating systems. TwinCAT registers each end device with a unique identifier. As a result, messages can be transmitted specifically to certain people and/or controllers. An indicator within the message defines whether messages and status values are cached and available on-demand in the messaging service.

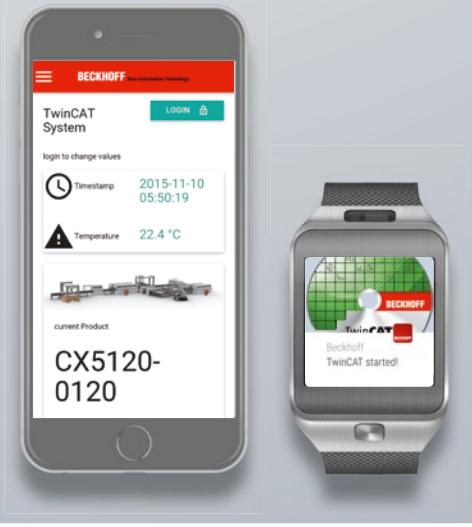
The TC3 IoT Communicator is based on outgoing connections ("publish-subscribe pattern") and therefore needs no special firewall settings. It can be simply integrated into existing IT networks.

Apps for receiving, transmitting and displaying these messages are available in the app stores of major mobile OS providers for free download.



TF6735 | TC3 IoT Communicator App

The TwinCAT IoT Communicator app offers a simple solution for the monitoring and analysis of TwinCAT process data on mobile end devices. Apps for receiving, transmitting and displaying selected TwinCAT messages are available in app stores for free download. An Internet connection of the mobile end device, the TwinCAT runtime environment and the TF6730 IoT Communicator are required. The Communicator App communicates with the TwinCAT control via a predefined messaging service in the cloud. Alternately, you can establish a connection to your own service.



Glossary

Term	Definition
AMQP	The Advanced Message Queuing Protocol (AMQP) is an open, standardised and message-based communication protocol that has been optimised for sending binary data with user-defined attributes.
Cloud Computing	Cloud Computing describes the on-demand access to a pool of configurable computing resources that can be made available quickly and securely with minimal management effort. [Source: NIST, 2011]
Cloud Storage	This is a logical memory service for data from different origins. The physical memory location can be distributed over several servers in private and public networks.
Condition Monitoring	This describes monitoring of the condition of machines and plants through the permanent evaluation of physical variables such as vibration and temperature.
Infrastructure-as-a-Service (IaaS)	The concept Infrastructure-as-a-Service describes an abstract perception of the cloud system and its services, which are mostly provided to the user as one or more virtual machines.
JSON	The JavaScript Object Notation (JSON) is a simple, easy to interpret data format that can be used in a textually noted form for the exchange of information between various applications.
MQTT	The Message Queue Telemetry Transport protocol (MQTT) is an open, standardised and message-based communication protocol that enables simple and fast transmission between different devices on account of its low overhead.
OPC UA	OPC Unified Architecture (UA) is an IEC-standardised, client/server-based communication protocol that has been optimised for an extensive information model and can be used over various transport channels.
Platform-as-a-Service (PaaS)	The Platform-as-a-Service concept describes an abstract perception of the cloud system and its services, which are provided to users in the form of runtime environments for their own applications.
SOA PLC	The Service Oriented Architecture (SOA) defines services that provide functions from real-time contexts and can be called from the outside as methods.
Software-as-a-Service (SaaS)	The Software-as-a-Service concept describes an abstract perception of the cloud system and its services, which are provided to the user in the form of ready-made applications that fulfil a certain task (e.g. Webmail).
Topic	In a publisher/subscriber communication scenario, a topic describes a data context that is used for the transmission and reception of messages.

DK3372-1115

Product announcement

TwinCAT IoT: estimated market release 2nd quarter 2016

TwinCAT Analytics: estimated market release 3rd quarter 2016

TwinCAT solutions for IoT and Industry 4.0.
See all information at
▸ **www.beckhoff.com/TwinCAT-Industry40**

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