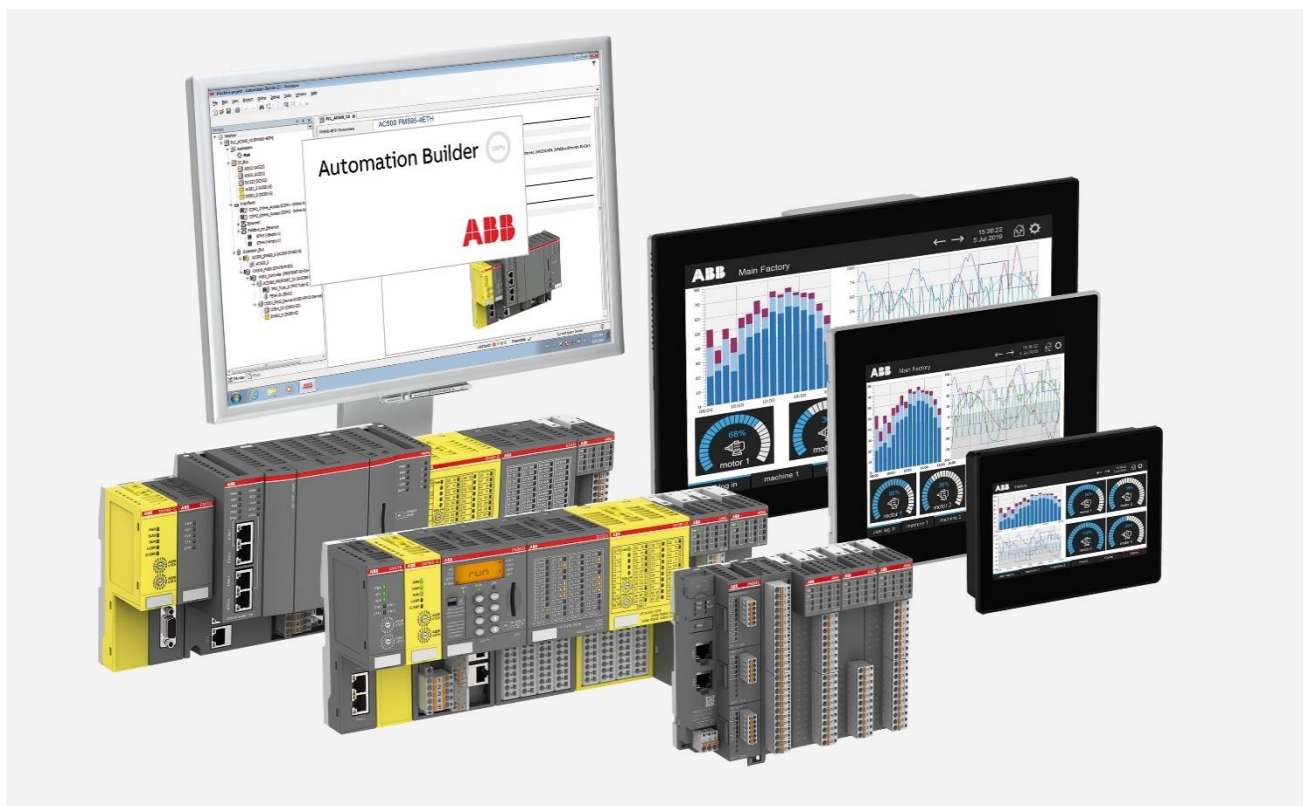


APPLICATION NOTE

AC500 MQTT FAQS



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1 Introduction

1.1 Scope of the document

The most raised questions, regarding Mqtt are listed here.

Please check also our [Whitepaper](#) for further information regarding Cyber Security. The most raised questions, regarding AC500 Cyber Security are listed here: [FAQs](#)

Some additional information can be found in the Automation Builder documentation.

1.2 Compatibility

The application note explained in this document has been used with the below engineering system versions. They should also work with other versions, nevertheless some small adaptations may be necessary, for future versions.

- AC500 V2 PLC
- AC500 V3 PLC
- Automation Builder

1.3 Application Examples

You can find two application examples here:

- [AC500 MQTT & MS Azure - First steps and configuration](#)
- [AC500 MQTT & Mosquitto - First steps and configuration](#)
- [AC500 MQTT – Monitor Connection](#)

2 FAQs

Here is a list of most asked questions.

2.1 General Information's

2.1.1 What PLC types are supporting Mqtt?

AC500 V2

- PM556 and above supporting Mqtt applications

AC500 V3

- PM5032 and above supporting Mqtt applications

2.1.2 How can I resolve my domain name into an IP address?

For both AC500 V2 and AC500 V3 PLCs, we have a DNS Resolve function block.

For V3 PLC, this function block is available AB V2.2.2 and above.

2.1.3 What is the required hardware infrastructure to send data to the Mqtt Broker?

You need of course:

- AC500 V2 or AC500 V3 PLC
- Router or any device that establish a connection to the internet

2.1.4 Is Online Change supported?

AC500 V2

- Online Change is not supported if Mqtt is used together with AC500 V2 PLC

AC500 V3

- AC500 V3 PLC is supporting Online Change

2.1.5 Do we have a Mqtt Broker on the PLC available?

Mqtt broker is not available for any AC500 PLC.

It is also not planned to support this.

2.1.6 Do I need a battery for Mqtt?

Mqtt itself do not requires a battery.

Mqtt is supporting TLS to encrypt the communication. Therefore, we need certificates. This certificate has a validation time. The PLC time is required to check if the certificate is valid.

After reboot of the PLC, the date and time in the PLC is set to 1970 if no battery is plugged or SNTP client configured. As a result, a connection to the broker cannot be established.

2.1.7 Do I need to set the date and time in the PLC?

It's recommended to always set the time and date in the PLC.

For Mqtt and the Certificates, it is required to have a valid date and time set in the PLC.

2.1.8 Can I use CM577-ETH or CM597-ETH to establish a connection to a Mqtt broker?

CM577-ETH and CM597-ETH are not supported. Only the onboard interface is supporting Mqtt.

2.2 Mqtt Library

2.2.1 Is QoS (Quality of Service) 0, 1 and 2 supported by the Mqtt library?

The QoS 0, QoS1 and QoS2 are supported by the Mqtt library.

Please also check other FAQs, there are some limitations for Azure, AWS etc.

If a value is published with a QoS level and the Done output is set, then the telegram was sent correctly. If there is a timeout or any other Err triggered, then the function block must be called again, until the Done is true and no error appears.

2.2.2 When I try to connect, I got this error message *MQTT_ERR_CONN_SERVER_CERT_NOT_VALID*

This will be solved when the date and time inside the PLC is set.

Please use a battery to restore the date and time in the PLC after a reboot.

2.2.3 What to do if I receive error: *MQTT_ERR_CONN_SERVER_CERT_NOT_PEM*

Invalid format of the server certificate. Please check the point 2.3.2

2.2.4 Is there a limitation in the length of cert file name at the input?

AC500 V2:

- The max length is 255 chars including path "sdcard/" and name of the cert file itself. Please be sure, that V2 PLC has the 8.3 file format. This means max. 8 chars for the filename

AC500 V3:

- The max length is 255 chars including path "sdcard/" and name of the cert file itself. V3 PLC can have more than 8 chars for the filename.

2.2.5 How to send a topic to Azure?

To use the MqttPublish function block, you need to use this topic:

"devices/<YourDeviceId>/messages/events/"

2.2.6 How to subscribe to a topic from Azure?

To use the MqttSubscribe function block, you need to subscribe to this topic:

"devices/<YourDeviceId>/messages/devicebound/#"

2.2.7 Why do I need to use MqttGetReceivedPacket function block?

Once, you have subscribed to a topic, you need to trigger the MqttGetReceivedPacket function block to get the data from the internal buffer. The MqttGetReceivedPacket function block will show the received topic and the received length of the data.

With the SysMemCpy() function for example, you can copy the data from the byte array to a string. The string you will receive is a Json format.

To parse the string, you can use the Json library. This is a free library.

An application example can be found here:

AC500 V2:

- [Link](#)

AC500 V3

- [Link](#)

2.2.8 What should I do, if I receive error ID MQTT_ERR_INPUT_06_0?

Please check the format of your SD card. The format of the SD card must be FAT for V2 PLCs.

Please check if the path to the SD card is correct or the correct Thumbprint is used, if the certificate is installed to the Trusted Certificates in the AC500 V3 PLC.

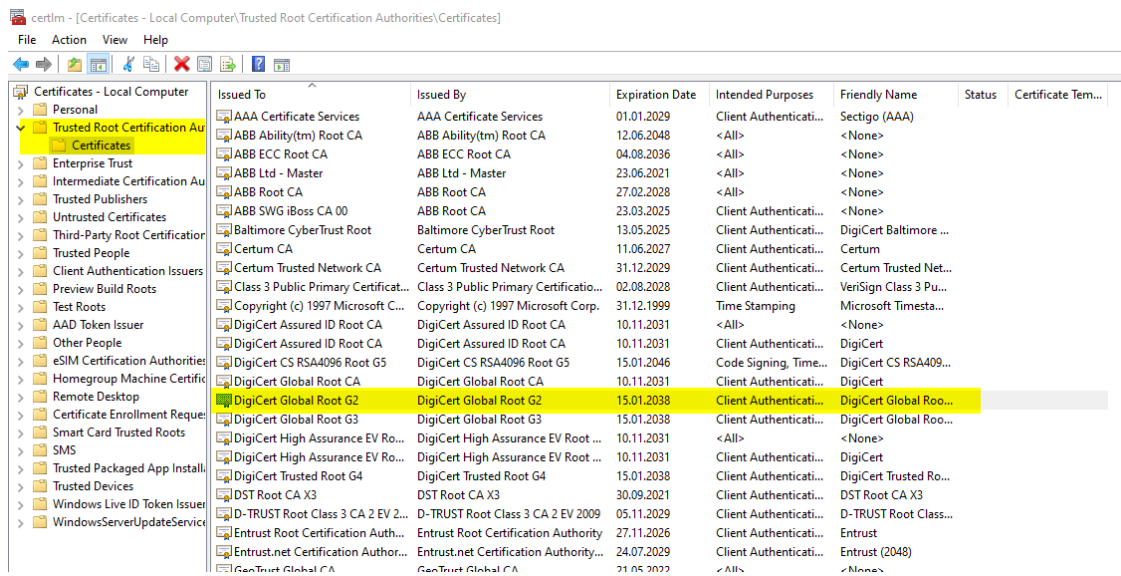
2.3 Certificates

2.3.1 What formats for certificates are available?

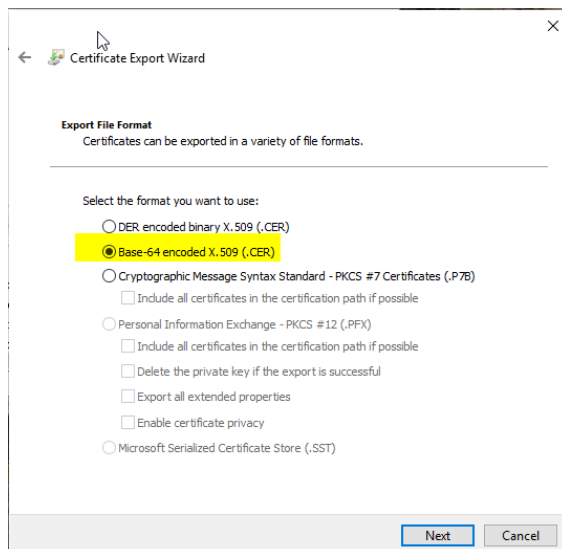
- PEM Format → ascii (readable)
- DER format → binary (not readable)

2.3.2 Where can I get the server cert for Azure?

Azure is using the “**DigiCert Global Root G2**” root certificate for signing. This can be extracted from Windows CertMgr (Run “certmgr.msc”) for example



Please be sure, that you extract the file as “Base-64” encoded:



2.3.3 How to change the server cert from Baltimore to DigiCert for Azure?

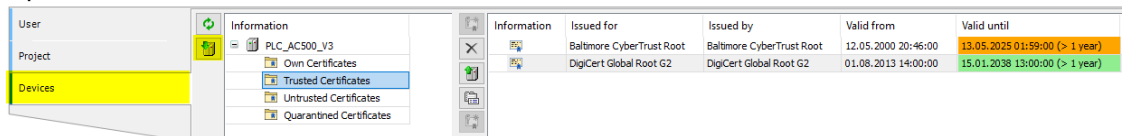
“Starting in February 2023, all IoT hubs in the global Azure cloud will migrate to a new TLS certificate issued by the DigiCert Global Root G2.” <https://learn.microsoft.com/en-us/azure/iot-hub/migrate-tls-certificate?tabs=portal>

To change the root certificate steps in the AC500 and the Azure portal are necessary.

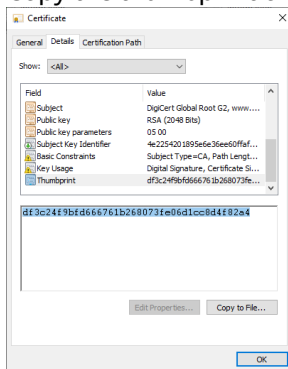
Here the certificate exchange via the Cert Store is described. In case the Cert file or Cert buffer is used the steps below are a bit different. All changes can be done via online change.

Attention not only the root certificate but also the IP address is changing. A DNS resolve inside the program is required. If missing please add before doing the connect.

1. Export the **DigiCert Global Root G2** as described in chapter 2.3.2
2. Connect to the PLC and open the Security Screen
3. Open Devices, select Trusted Certificates and install the new certificate



4. Copy the thumbprint of the certificate



5. In the code, where the connect fb is called, change the ServerCert

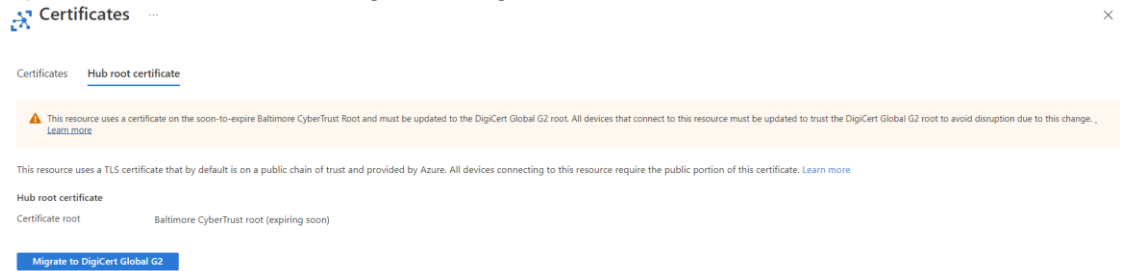
```
10: //Connect
    Connect(Execute := TRUE,
           Conn := ADR(MQTT.Connection),
           IPAddress := DnsResolve.IPAdrString,
           Port := 8883,
           Secure := TRUE,
           ServerCert := 'df3c24f9bfd666761b268073fe06d1cc8d4f82a4',
```

6. Login to the PLC via onlinechange

The existing MQTT connection will remain only new connections will be done via the new certificate

7. Login to azure portal

8. Open the IoT hub and click “Migrate to DigiCert Global G2”



Certificates Certificates Hub root certificate

Warning: This resource uses a certificate on the soon-to-expire Baltimore CyberTrust Root and must be updated to the DigiCert Global G2 root. All devices that connect to this resource must be updated to trust the DigiCert Global G2 root to avoid disruption due to this change. [Learn more](#)

This resource uses a TLS certificate that by default is on a public chain of trust and provided by Azure. All devices connecting to this resource require the public portion of this certificate. [Learn more](#)

Hub root certificate
Certificate root Baltimore CyberTrust root (expiring soon)

[Migrate to DigiCert Global G2](#)

9. Check all boxes and click Update



Update resource certificate

Connected Devices

1
0.8
0.6
0.4
0.2
0

12 PM 6 PM Jan 12 6 AM UTC

Learn more about IoT Hub migration

- I have updated my devices to trust the DigiCert Global G2 root.
- I understand that any devices not updated will not be able to connect.
- I understand that my IoT hub's IP address may change as part of this migration, and that it can take up to an hour for devices to reconnect.
- I understand that my devices will be disconnected and will reconnect using the DigiCert Global G2 root.

[Cancel](#) [Update](#)

Please be patient. The update might take some time

10. After the update check if the PLC is still connected. Trigger a new connect to check if the connection with the new certificate is working properly.

2.4 Connectivity

2.4.1 Do I need to configure a Gateway in my PLC to connect to the Internet?

Yes, you need to set the gateway in the PLC to connect to the internet. Please use the IP-Configuration tool to set the IP address and gateway.

2.4.2 What should be minimum specification for internet connection e.g. internet speed?

We have tested here with our bandwidths. It is around 6 Mbit/s.
Slower bandwidths are maybe possible, this must be tested for each site.

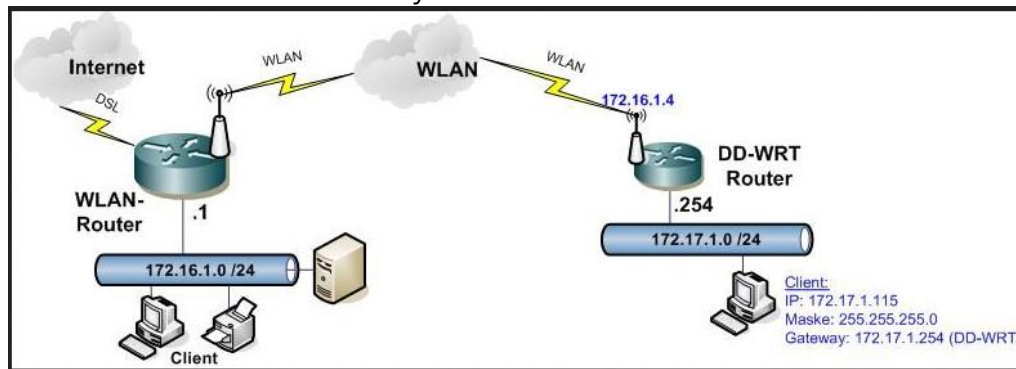
2.4.3 Do I need any special coupler to connect to the Internet?

No additional couplers are required. You need only an internet connection. You can plug your internet connection to the PLC, set the **gateway** in the PLC and use the Mqtt library.

2.4.4 AC500 support only Ethernet based internet. If customer has only a Wi-Fi connection available, then is there any possibility to run Mqtt?

Yes, you can use a Router. The router receives the Wi-Fi signal and you can connect the network cable to the same Router to get internet access.

In addition, there are also Wi-Fi Repeater on the market available they provide the possibility to connect a network cable directly to it.



2.4.5 Does Mqtt affect other protocols like Modbus TCP or reduce the communication speed?

You can use different protocols like Modbus TCP, Mqtt, CoDeSys ETH, UDP etc. on the same ethernet slot. Mostly Scada systems creating a high load on the line, this can affect other protocols.

For example, the Panel took longer to update the tags. Or you receive some timeouts. Separating of networks could improve the speed. At the end it's depends on the application and the number of tags und update rates.

2.4.6 What is the limit of data which we can transferred by using Mqtt in one cycle?

The limitations of TCP are based. Mqtt is TCP based so, you have 1460-byte data for a single telegram. If there are more data transferred, the TCP stack will separate the telegrams.

2.4.7 How can we define the publish rate?

The communication speed is dependent of your cycle time in the PLC and how fast you trigger the MqttPublish() function block.

2.4.8 Are any limitation of Tags in Mqtt?

Mqtt has no limitations of how many tags you can send to the broker.

2.4.9 In single message, how many parameters can we send?

There is not a limitation in number of parameters. There is limitation in number of bytes you want to send. In a single telegram, the TCP default is 1460 byte. If more bytes shall be send the IP Stack split the data in separate telegrams.

2.4.10 Can we communicate with multiple IOT Hubs?

With one instance of MqttConnectWithCertXXX() you can connect to one IoT Hub. You can use multiple instances of MqttConnectWithCertXXX () to connect to different brokers.

2.4.11 In case of Internet disconnection, is there any option in PLC to locally buffer the data and restore buffered data with the timestamp once the internet connectivity resumes?

The data will not be stored automatically if no Internet connection is available. This must be programmed manually or using Data Logger for V2 PLCs. Using the Data Logger, needs additional afford to use. This interface is not available and must be programmed.

For V3 this must be done in an own application.

The Mqtt library provides a MqttPing() function block. There you can check if you can ping your Broker. Or use ICMP Ping function block to check if you can ping a server in the internet.

If the internet connection is not available, but you toggle the execute of the MqttPublish() function block.

The Done can show true and no error, this means the data will be forwarded to the Send() buffer of the operating system.

Once the connection is back on the connection was not closed from the Mqtt Broker, all telegrams will be send from the Send() buffer to the Mqtt Broker and the data will be stored in the database. If a database is used.

BUT: if the Keepalive time (input at MqttConnectWithCertXXX()) is over, the connection will be closed and all buffers are cleared.

This means if the Keepalive time is over and the connection is closed. If after the close of the connection, the internet connections returns, the data from the PLC will not send to the broker, because the connection was closed and the buffers (send buffer) will be cleared.

If the Keepalive time is set to a high time, it could happen, that the data will be send once, the connection to the internet returns.

The Send buffer of the V3 PLC is ~160KByte. This value contains not only raw data, it contains also header of Mqtt telegram and maybe other telegrams they are used in the project.

So, we cannot confirm how many data can be buffered in the send buffer.

Also, important: Timeouts from the different clients are important. Once a connection is closed, the buffer is cleared.

So, you can never be sure, that the connection will continue after a defined keepalive time.

2.4.12 If data is stored with timestamp (data during the disconnection). How the system will do the priority for data transfer for current data and old data (data from disconnection time).

This must be programmed by the customer.

There is no buffer or function that provides this feature.

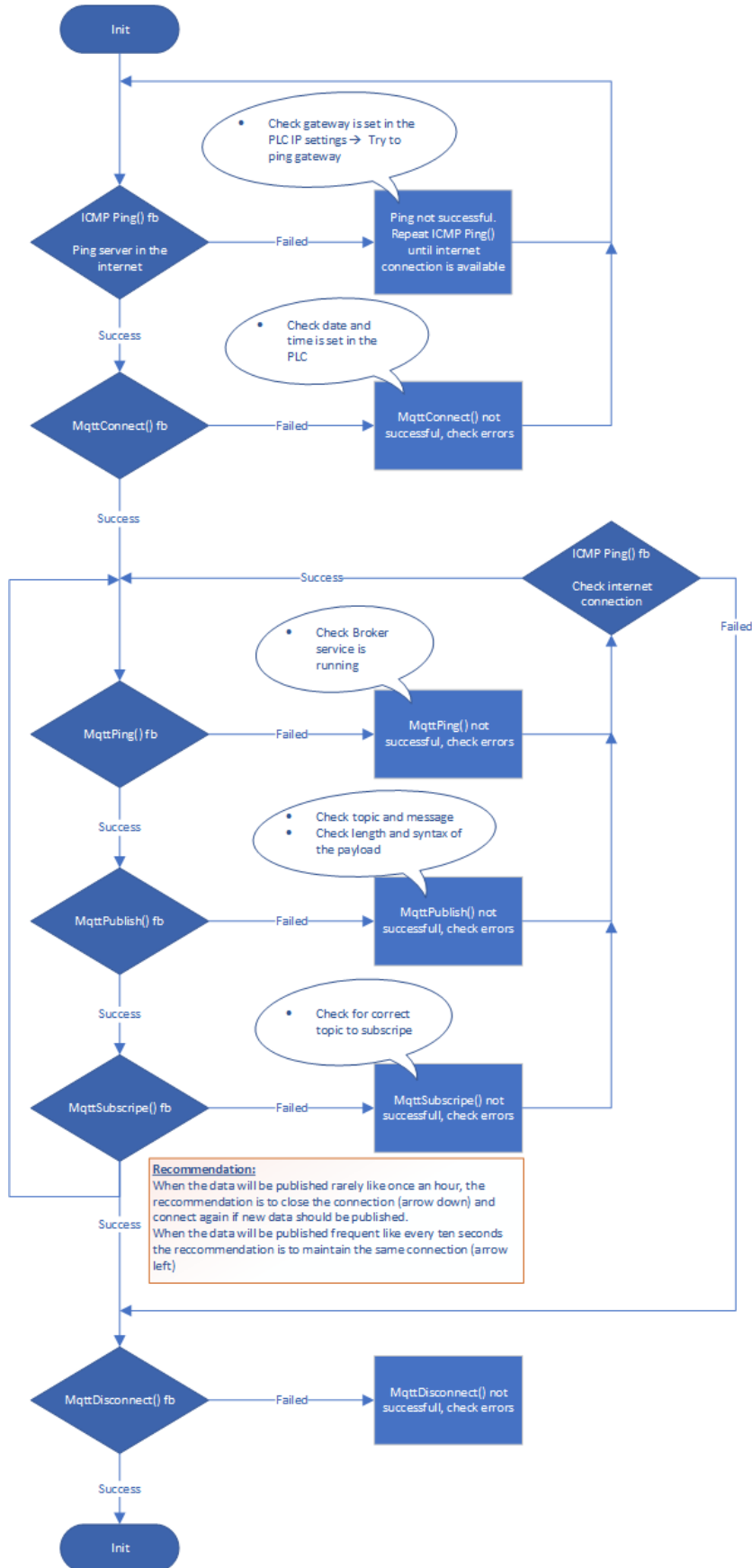
We are currently on a Datalogger library for AC500 V3 PLC. For AC500 V2 this library is already available.

2.4.13 How fast data can be send/published to a broker?

It depends on the application, the cycle time, the PLC load, performance of the PLC type and the requirement. When an application publishes temperature values it's mostly enough to publish this data each minute. Temperature changes are not so fast.

Some other applications, where fast calculations are required, the data can be published much faster, down to less milliseconds depending on the cycle time, PLC load and the performance of the PLC type.

2.4.14 Recommended connect and Re-connect behavior



2.5 Services in the Cloud

2.5.1 What settings / knowledge is needed for customer to store / view data on the cloud?

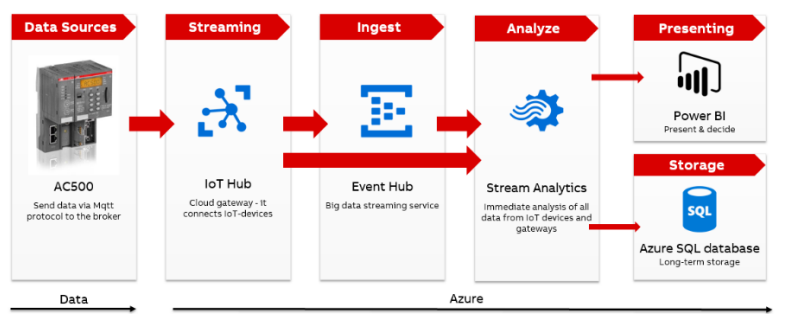
When using Microsoft Azure services, you need an IoT Hub, this is a generic broker/buffer. With another service, called Streaming Analytics, you can read the data from the broker/buffer and forward them e.g., to:

- Power BI (for visualization)
- MS SQL database (for storage)

There are also other services where you can show the data on a dashboard.

Example overall data flow and Architecture

AC500 to Cloud



2.5.2 What is the hardware infrastructure like type/capacity of servers etc. required for building an on-premise cloud infrastructure?

This cannot be answered by us. We will provide only the Mqtt functionality and the hardware. The cloud hardware and software are not covered by us.

2.5.3 What are the licenses /subscriptions required of the Azure software's?

Please check with Azure support what licenses and subscriptions are required. For playing around, Azure is providing a free account.

2.5.4 What Edge services are required?

There is no Edge device required.

You can connect with the AC500 PLC and the Mqtt library directly to the Mqtt broker.

2.5.5 Does Azure support QoS?

Please have a look at this link:

<https://docs.microsoft.com/de-de/azure/iot-hub/iot-hub-mqtt-support>

Azure IoT Hub does **not** support QoS 2 messages.

When a device app publishes a message with QoS 2, IoT Hub closes the network connection.

2.5.6 Does Azure support multiple connections with the same device?

Please have a look at this link:

<https://docs.microsoft.com/de-de/azure/iot-hub/iot-hub-mqtt-support>

Azure IoT Hub only supports one active Mqtt connection per device. Each new Mqtt connection for the same device ID causes the IoT Hub to delete the existing connection.

2.5.7 Does Azure support Retain flag?

Please have a look at this link:

<https://docs.microsoft.com/de-de/azure/iot-hub/iot-hub-mqtt-support>

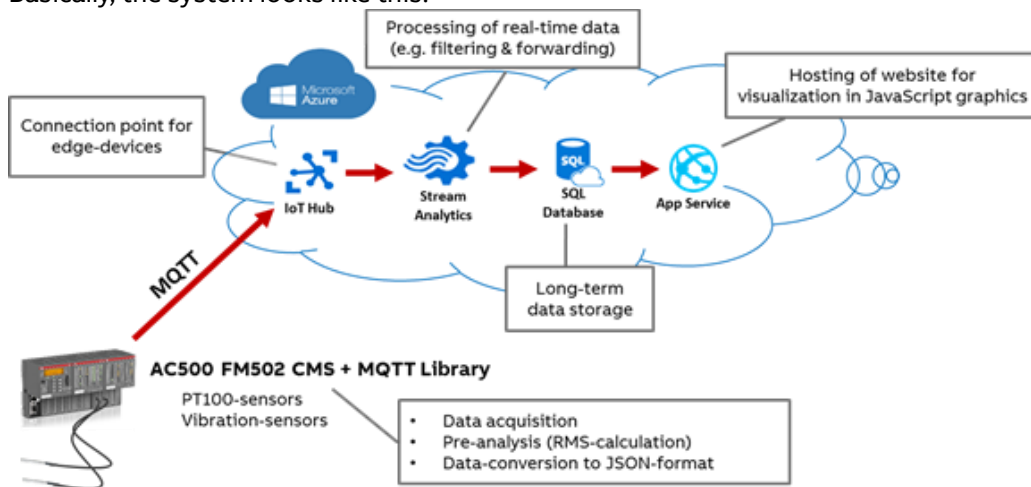
IoT Hub does not persist retention messages. When a device sends a message with the RETAIN flag set to 1, IoT Hub adds the application property x-opt-retain to the message. In this case, IoT Hub does not persist the retention message, but passes it on to the back-end app.

2.5.8 How to configure the services in the cloud?

Generally, there are multiple ways how to configure your cloud. It totally depends on the use case and underlying requirements.

We have created an application example and some additional information's. The link to the examples can be found in chapter: **Error! Reference source not found.**

Basically, the system looks like this:



With the IoT Hub you can connect edge devices to MS Azure. It is possible to connect devices from different locations to one IoT Hub.

Typically, all data received in the hub are forwarded to a standardized endpoint in the IoT Hub. From that endpoint other services like Stream Analytics can access the arriving data. You could also implement rules for message routing based on message properties (e.g. device id) and create customized endpoints.

Stream Analytics processes the messages that are received by the selected IoT Hub endpoint. You can e.g. select specific values from your message and forward them to other services (e.g. a SQL-database table for storage or Power BI for direct visualization).

Here an example of a Stream Analytics query:

```

1  Need help with your query? Check out some of the most common Stream Analytics query patterns here.
2  -- Take the data from the IoT Hub and forward all this data to
3  -- the SQL database
4  -- We add two hours to the UTC time and save them as a new column named: EventProcessedCetTime and EventEnqueuedCetTime
5  SELECT
6  EventProcessedUtcTime, Dateadd(hour , 2 , EventProcessedUtcTime) AS EventProcessedCetTime,
7  PartitionId,
8  EventEnqueuedUtcTime, Dateadd(hour , 2 , EventEnqueuedUtcTime) AS EventEnqueuedCetTime,
9  IoTHub,
10 temp1,
11 temp2,
12 temp3,
13 spstime,
14 alarm1,
15 alarm2,
16 drehzah11,
17 drehzah12,
18 RfS1,
19 RfS2
20 INTO [toSQLDatabaseTableDatad]
21 FROM [fromMessageIoTHub]
22 -- ***** ENDE *****

```

Defines which parameters should be taken from the message

Defines to which output (e.g. database table) data should be forwarded

Defines where the data is coming from (e.g. a certain endpoint of IoT Hub)

2.5.9 What are the costs for sending and storing data on Azure?

It depends on the amount of data that will be send. Each data they will be send to Azure, will be received by a generic broker, called IoT Hub on Azure side. This data will be stored in the broker database until the Streaming Analytics job from Azure access the data and forward them, for example to a SQL database. This means, as more data they will be send to Azure, as more you have to pay.

A rough calculation can be done here: [Link](#)

2.6 Reference Solutions

2.6.1 References of AC500 Mqtt solutions?

We have a few customers who are already using our AC500 PLCs (V2 and V3) to sending data to the Azure Cloud.

We have also a dashboard running on a Azure server, where we send real measured data to the Cloud:

<https://dashboard.ac500.abb.com/>



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