Transforming Manufacturing with IIoT

Industrial Ethernet

26 maart 2024 | De Basiliek, Veenendaal

How to IIoT (verb) properly

1

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Begin with the End in Mind

- Steven R Covey

https://www.iot-now.com/2022/08/05/122841-why-iot-projects-fail/

74% of companies considered their IIoT projects to be unsuccessful in 2022.

State of Industrial IoT in July 2023

IOT ANALYTICS
MARKET INSIGHTS FOR THE INTERNET OF THINGS

Industrial IoT (IIoT) in 2023 is on the way to becoming mainstream:
https://iot-analytics.com/iot-solution-development/

66%

66% of industrial organizations reported they are executing an IoT strategy.

14%

IoT projects have a 14% higher success rate than five years ago.

50%

Common challenges have diminished by approximately 50%.

Build, buy, or buy and integrate?

1 Custom-build approach

Share of initiatives using this approach 47%

Advantages	Disadvantages
+ **Provides freedom to customize entire solution** + **Does not generate lock-in with any vendor** + Provides the opportunity to develop a unique solution that may provide a competitive advantage	- **Requires major in-house (IT) capabilities or a reliable partner** - **Typically leads to unpredictable costs** - Typically has the longest project timeline (from start to large-scale roll-out)

Bold = key considerations

ROI Time?

Share of initiatives exceeding expectations ★★★ 40%

2 Buy-and-integrate approach

Share of initiatives using this approach 38%

Advantages	Disadvantages
+ **Allows to combine proven technology with freedom to customize majority of the solution** + Is faster to set up (compared to custom- build) + Allows for shorter time-to-market (compared to custom-build) + Provides the ability to receive external support/maintenance for part of the solution	- **Requires management of multiple stakeholders (internal and external)** - Leads to increased solution complexity (compared to custom-build)

Share of initiatives exceeding expectations ★★★ 40%

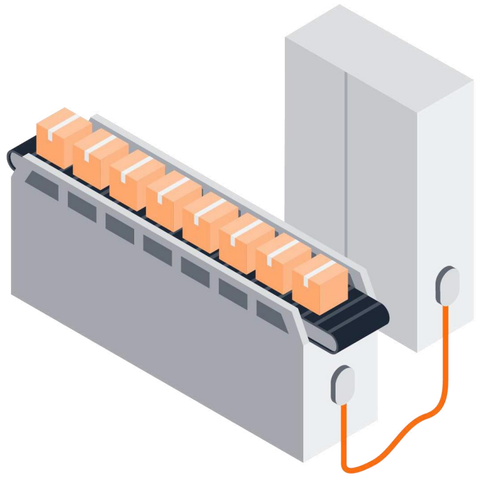
3 Buy approach*

Share of initiatives using this approach 14%

Advantages	Disadvantages
+ **Allows the usage of tested and proven technology** + **Provides the ability to receive external support/ maintenance for the entire solution** + Leads to predictable outcomes	- **Makes it difficult to integrate specific security requirements** - Has limited customization options - Does not provide ability to differentiate to gain a competitive advantage - Is difficult to integrate into own IT/OT architecture

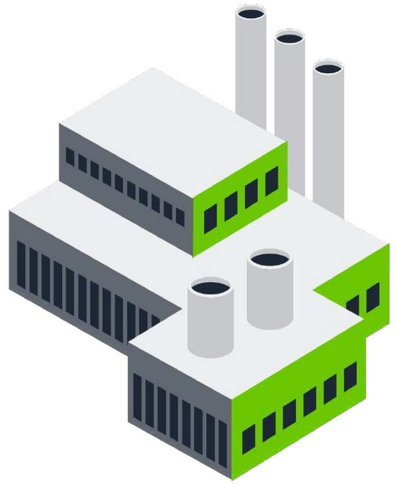
Share of initiatives exceeding expectations ★☆☆ 13%

Two Models for IIoT in Manufacturing



OEM: Create Value Added Services

- Predictive Maintenance as a Service
- Remote Machine Monitoring and Diagnostics
- Data Analytics and Machine Optimization Services
- Pay-per-Use Business Model



Manufacturer: Improve Efficiency

- Predictive Maintenance to reduce downtime
- Energy Optimization (WAGES)
- Quality Control and Real-time Analytics (Camera)

Predictive Maintenance Application

2

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Evolution of Maintenance Applications

Reactive

Wait until it breaks

Preventative

Maintain it on regular intervals

Predictive

Threshold Alarms

Statistical Analysis

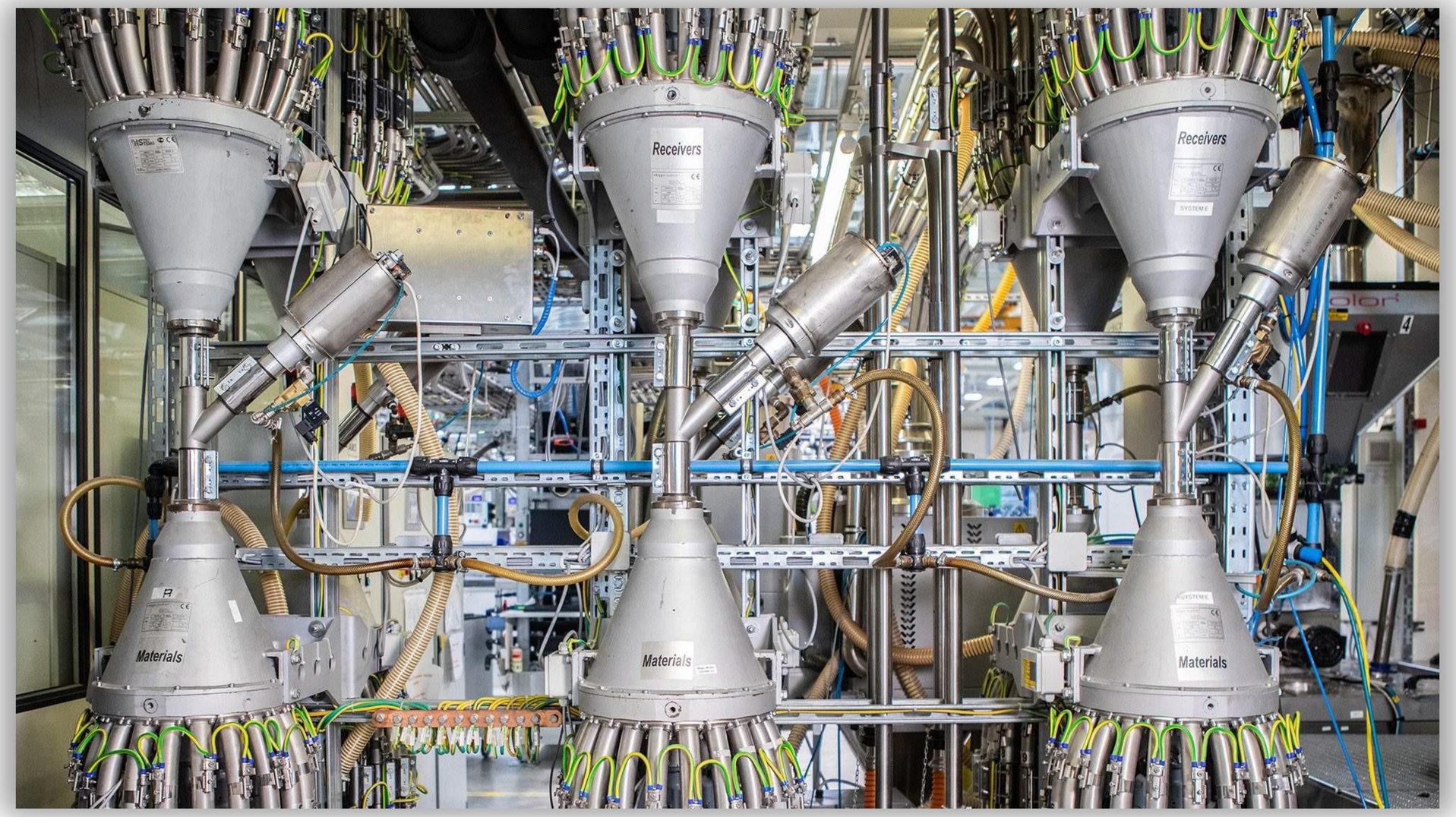
Machine Learning

Physics Based

Prescriptive

Automatically determine how to plan/prepare for failures

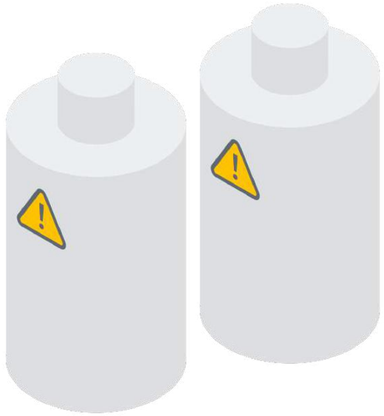
What is this?



Application: Predictive Filter Maintenance

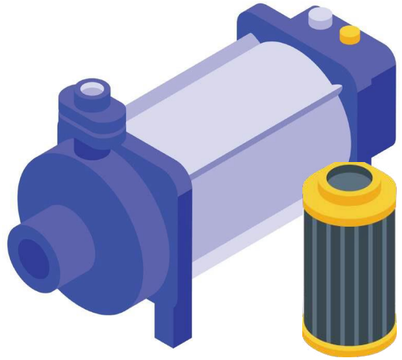
Plastic Transport System for Injection Molding:

1



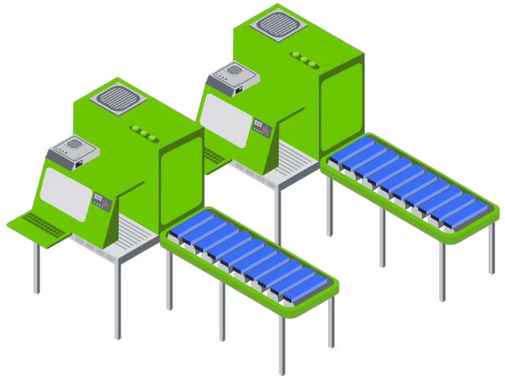
Plastic Bins

2



Vacuum Pump

3



Injection Molding Machines

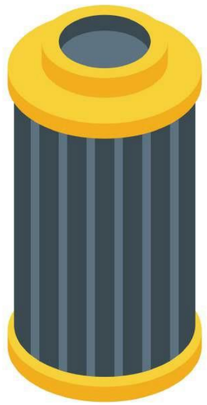
The Problem:

The vacuum pump filters must be cleaned regularly, but it is labor and time intensive.

If cleaned too soon, it is a waste of resources. If cleaned too late, production is affected.

Key Required Outcomes

1



Determine if and when pump filters should be cleaned to reduce cost and maximize uptime.

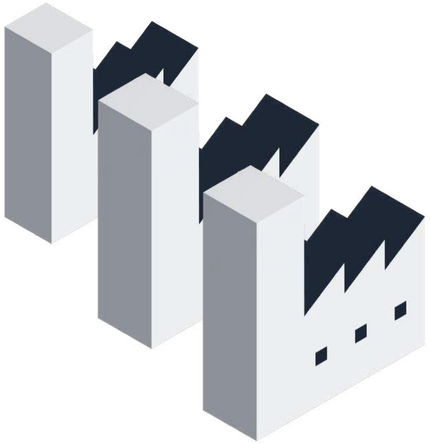
2

Provide visualization for local operators to see status.

3

Output an MQTT message from the system to trigger a work order in the ERP system.

4



The application must scale to multiple production sites.

Outcomes analytics project

Predicts filter performance, triggering a maintenance Work Order for optimum cleaning times, reducing costs, and increasing reliability.

=

Cost reductions and automation.

Detects faults in the material distribution system, reducing troubleshooting time by over 50%.

=

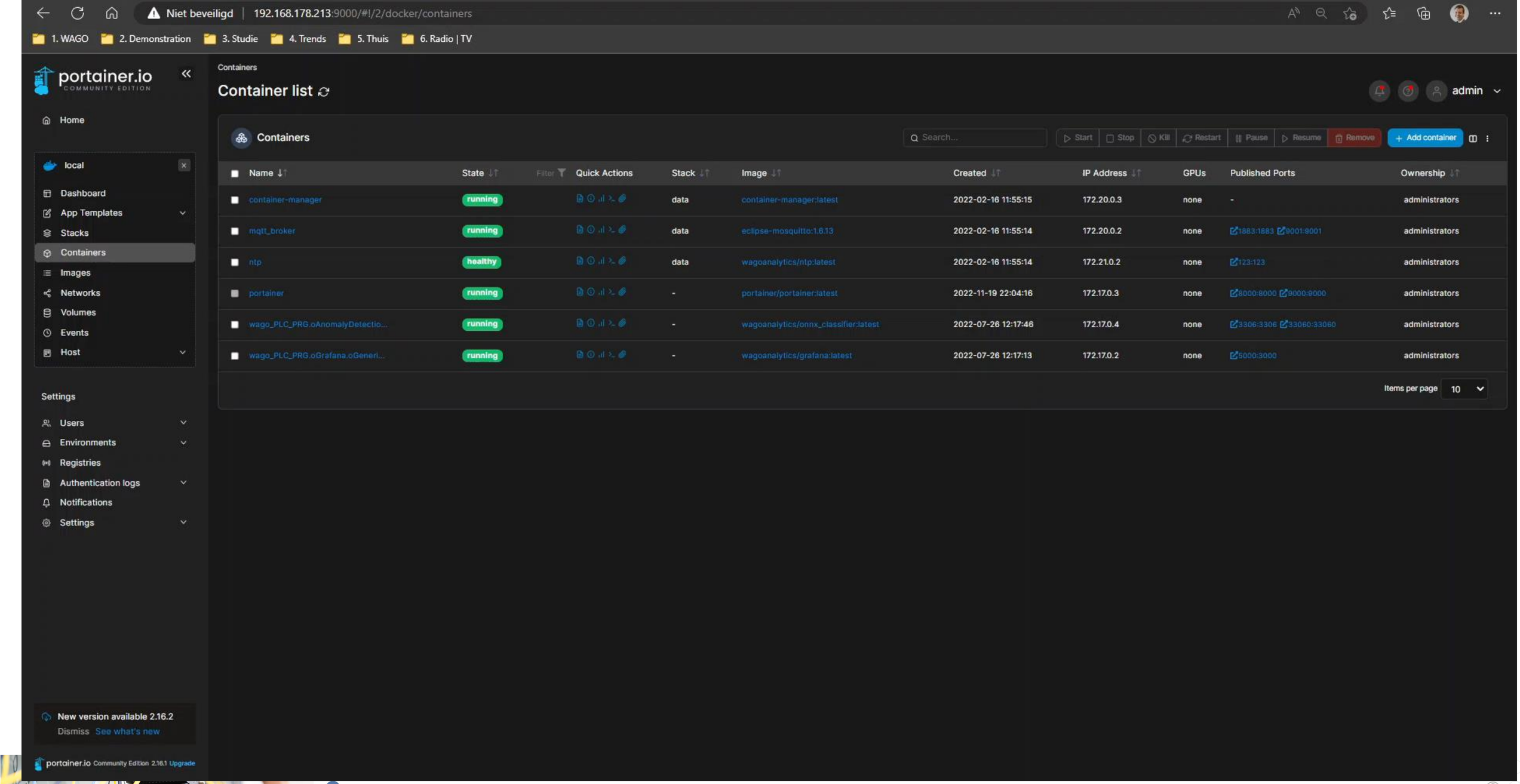
50%

Reduced troubleshooting time.

A dashboard displays the data and provides an instant overview of the process quality, system utilization, and capacity.

=

Increased visibility for production staff.


Niet beveiligd | 192.168.178.213:9000/#!/2/docker/containers
1. WAGO
2. Demonstration
3. Studie
4. Trends
5. Thuis
6. Radio | TV
portainer.io
COMMUNITY EDITION
Home
local
Dashboard
App Templates
Stacks
Containers
Images
Networks
Volumes
Events
Host
Settings
Users
Environments
Registries
Authentication logs
Notifications
Settings
New version available 2.16.2
Dismiss See what's new
portainer.io Community Edition 2.16.1 Upgrade
Containers
Container list
admin
Containers
Search...
Start
Stop
Kill
Restart
Pause
Resume
Remove
Add container
Name
State
Filter
Quick Actions
Stack
Image
Created
IP Address
GPUs
Published Ports
Ownership
container-manager running data container-manager:latest 2022-02-16 11:55:15 172.20.0.3 none - administrators
mqtt_broker running data eclipse-mosquitto:1.6.13 2022-02-16 11:55:14 172.20.0.2 none 1883:1883 9001:9001 administrators
ntp healthy data wagoanalytics/ntp:latest 2022-02-16 11:55:14 172.21.0.2 none 123:123 administrators
portainer running - portainer/portainer:latest 2022-11-19 22:04:16 172.17.0.3 none 8000:8000 9000:9000 administrators
wago_PLC_PRG.oAnomalyDetectio... running - wagoanalytics/onnx_classifier:latest 2022-07-26 12:17:46 172.17.0.4 none 3306:3306 33060:33060 administrators
wago_PLC_PRG.oGrafana.oGeneri... running - wagoanalytics/grafana:latest 2022-07-26 12:17:13 172.17.0.2 none 5000:3000 administrators
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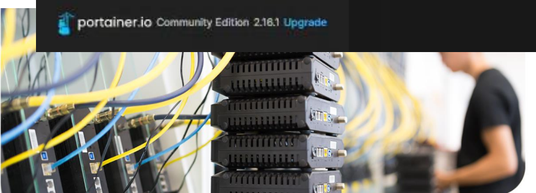

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IIOT Protocols

3

IIoT key technology and trends from multiple industries

Edge computing: Processing data closer to the source, rather than in a centralized cloud.

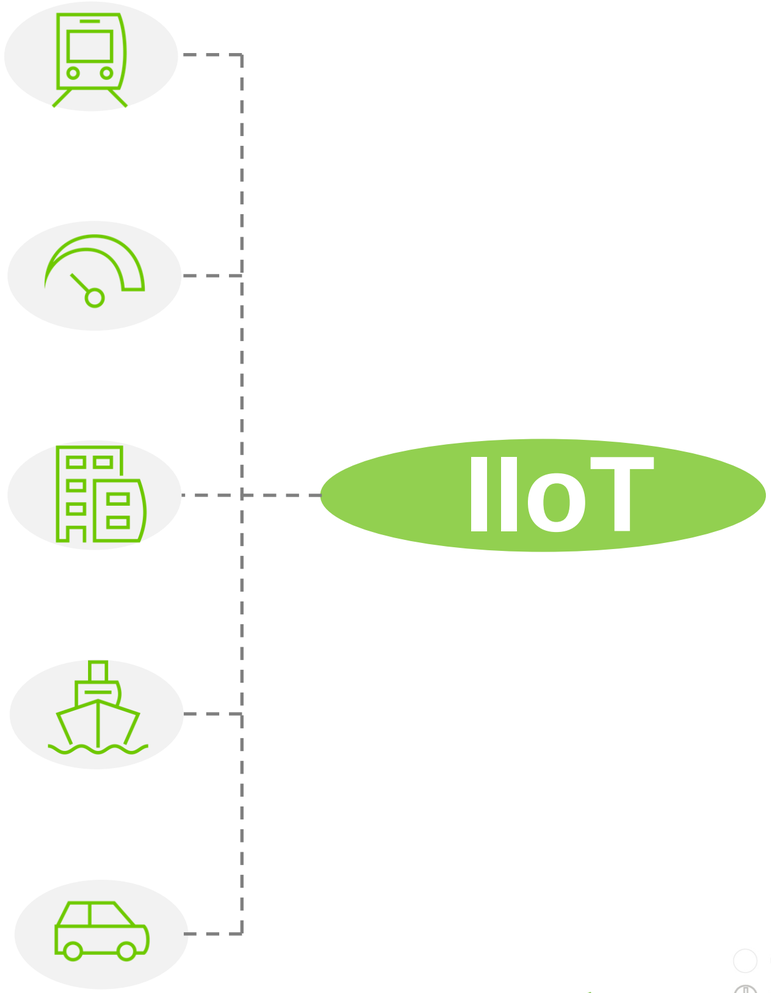
Artificial Intelligence (AI) and Machine Learning (ML): Improving data analysis and decision-making in IoT applications. Examples include AI-based Quality Control in production lines (machine vision) and predictive maintenance and diagnostics for various types of production facilities and process industries.

Security: Ensuring the security of IoT devices and data, as they increasingly become targets for cyber attacks.

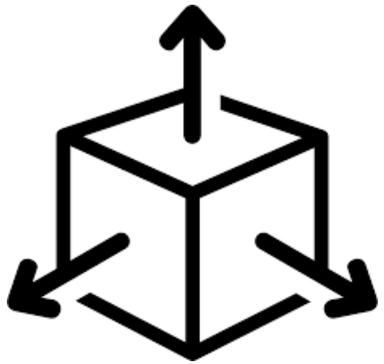
Interoperability: Allowing devices from different manufacturers to communicate with each other seamlessly.

Building Automation: Automating various tasks in homes and buildings for increased convenience and energy efficiency.

Low-Power Wireless Sensors: LoRaWAN (Long Range Wide Area Network), Bluetooth LE (Low Energy), and others for smart building and smart city applications.

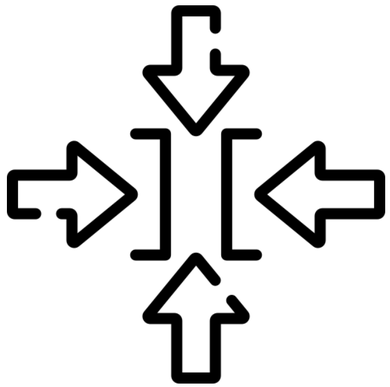


IIoT key elements



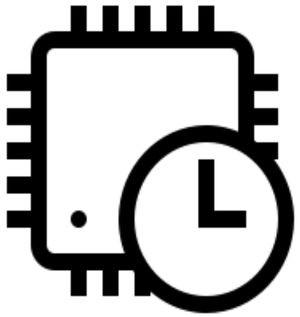
Scalability

Security

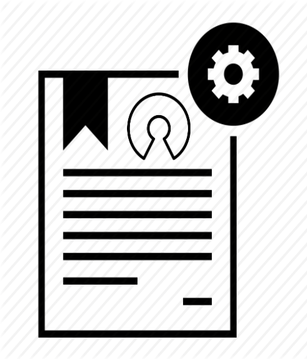


Constrained

Mobility



Real time /
deterministic



Standarized

IIoT key communication protocols

	MQTT	REST	OPC UA
Closed Firewalls	Yes	Yes	No
Encryption	Yes	Yes	Partial
Low bandwith & Low latency	Yes	No	Partial
Ability to scale	Yes	No	Partial
Standardized / Interoperable data format	No	No	Yes
Data compression	Yes	No	No
Real Time / TSN	No	No	Yes
QoS	Yes	No	Partial

MQTT

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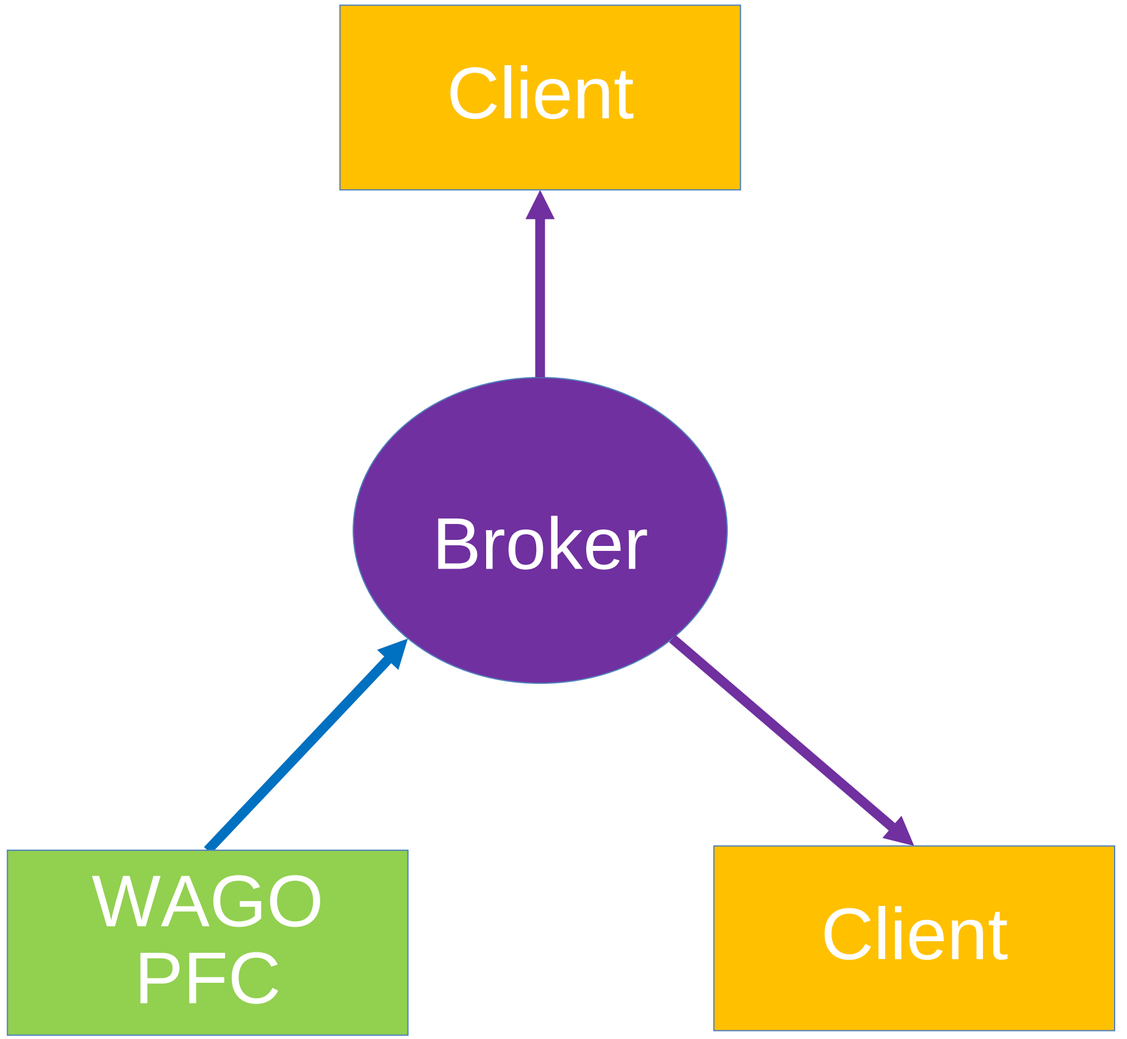
IoT key technology and trends from multiple industries

- **Topic**
- Payload
- State management
- Quality of Service (QoS)
- Security



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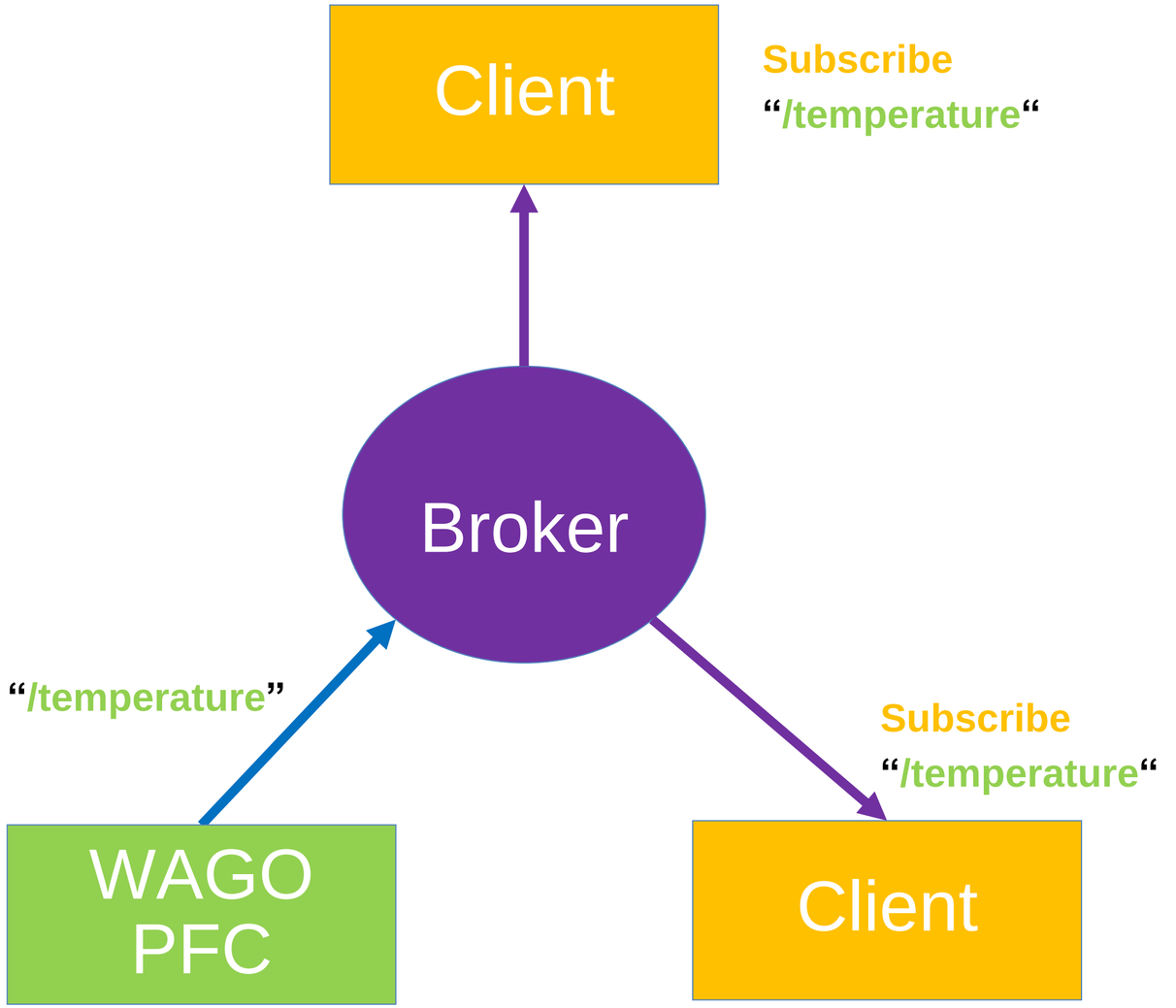

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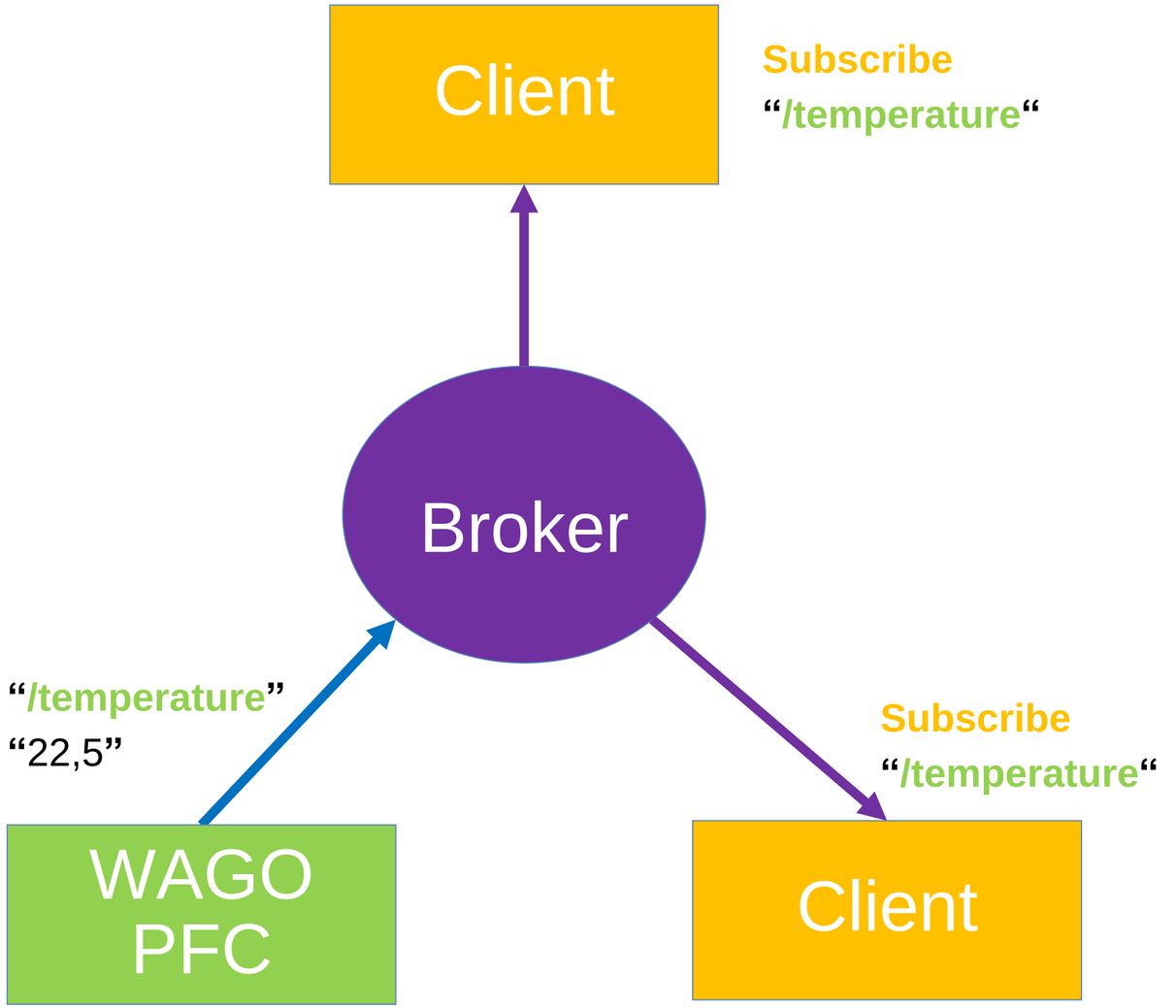

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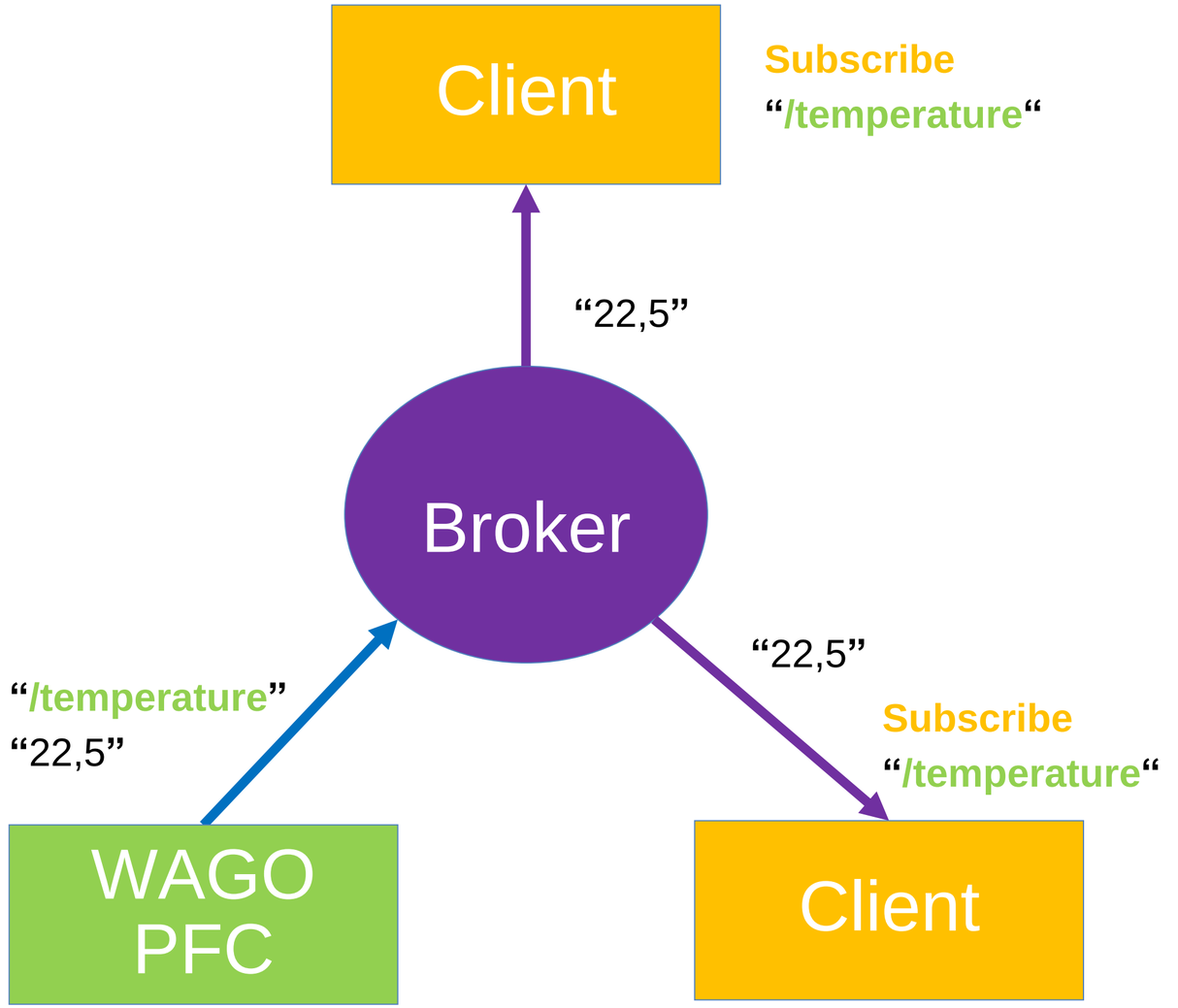


MQTT

- topic
- payload
- **State management**
- Quality of Service (QoS)
- Security

MQTT-Packet:

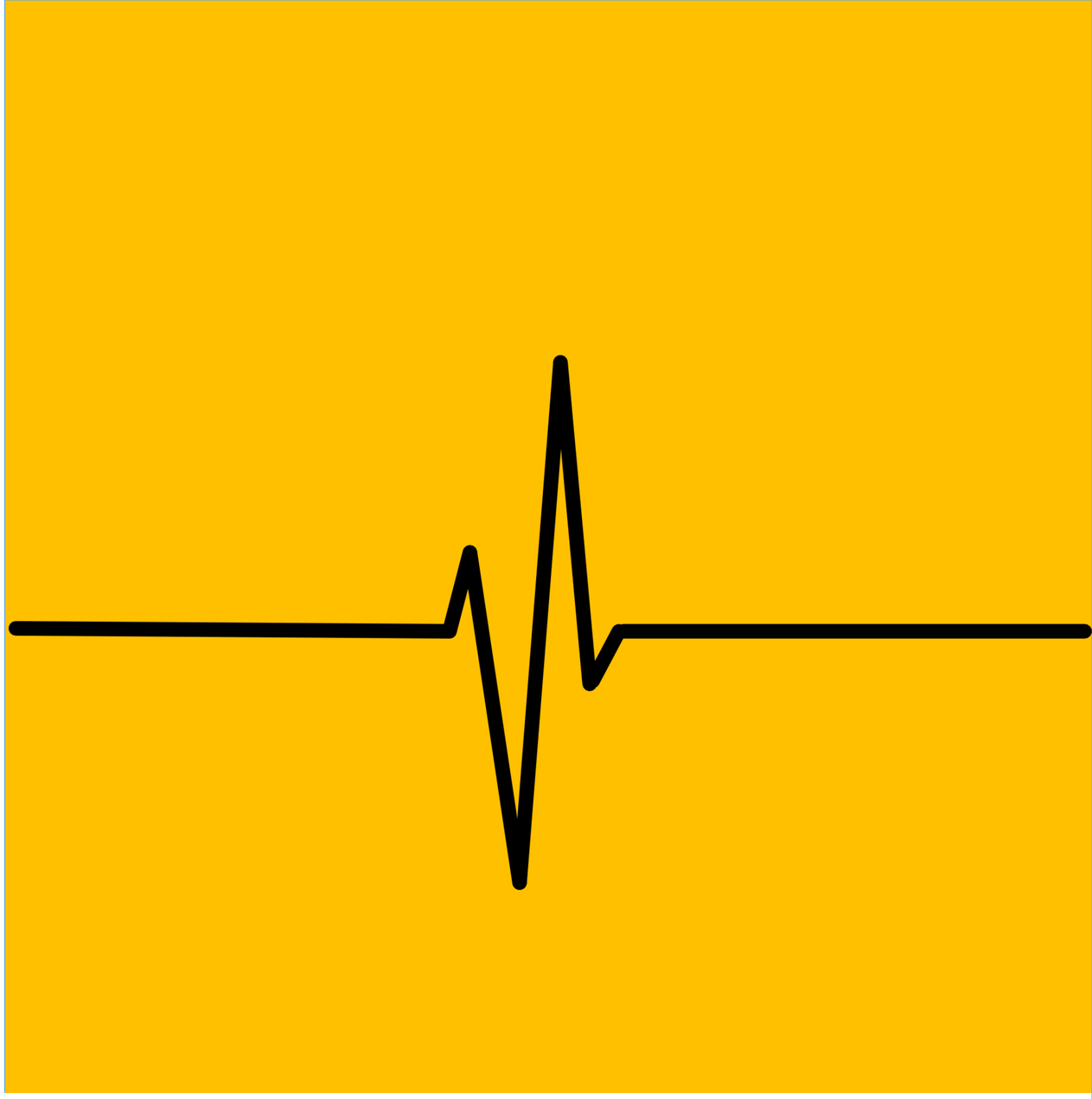
PUBLISH

contains:	Example
packetId (always 0 for qos 0)	4314
topicName	“topic/1”
qos	1
retainFlag	false
payload	“temperature:32.5”
dupFlag	false

MQTT

State management

- The **broker** has a mechanical that sends a heartbeat based on the **"keep alive time”.**



MQTT

State management

- The **broker** has a mechanical that sends a heartbeat based on the "**keep alive time**".

- "If not answered, the **broker** will send **a last will & testament (LWT)** message to all **subscribed** clients.

MQTT-Packet:

CONNECT

contains:	Example
clientId	"client-1"
cleanSession	true
username (optional)	"hans"
password (optional)	"letmein"
lastWillTopic (optional)	"/hans/will"
lastWillQos (optional)	2
lastWillMessage (optional)	"unexpected exit"
lastWillRetain (optional)	false
keepAlive	60

MQTT

- Topic
- Payload
- State management
- **Quality of Service (QoS)**
- Security

MQTT-Packet:

PUBLISH

contains:	Example
packetId (always 0 for qos 0)	4314
topicName	“topic/1“
qos	1
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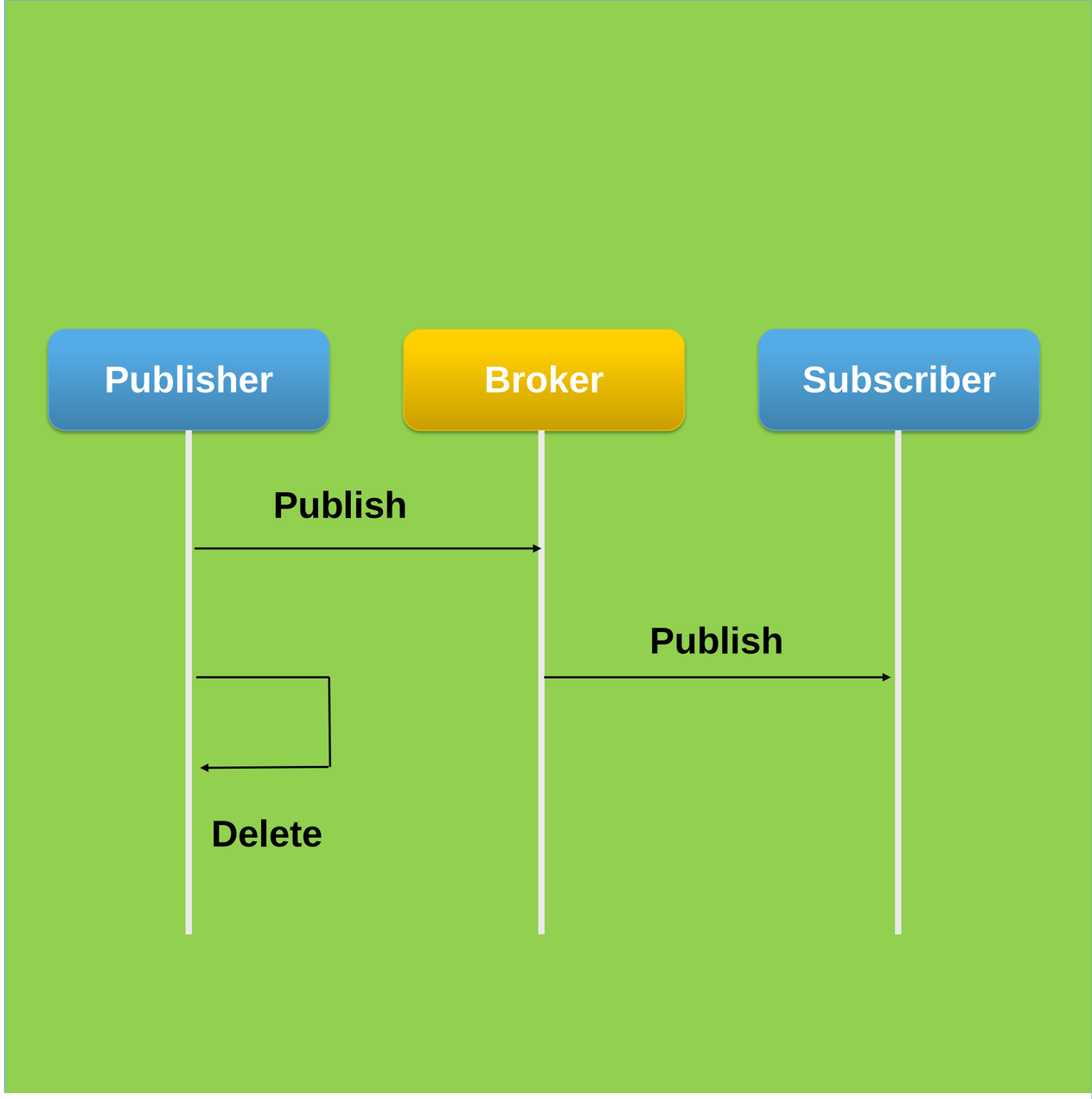
MQTT

QoS 0 (Quality of Service)

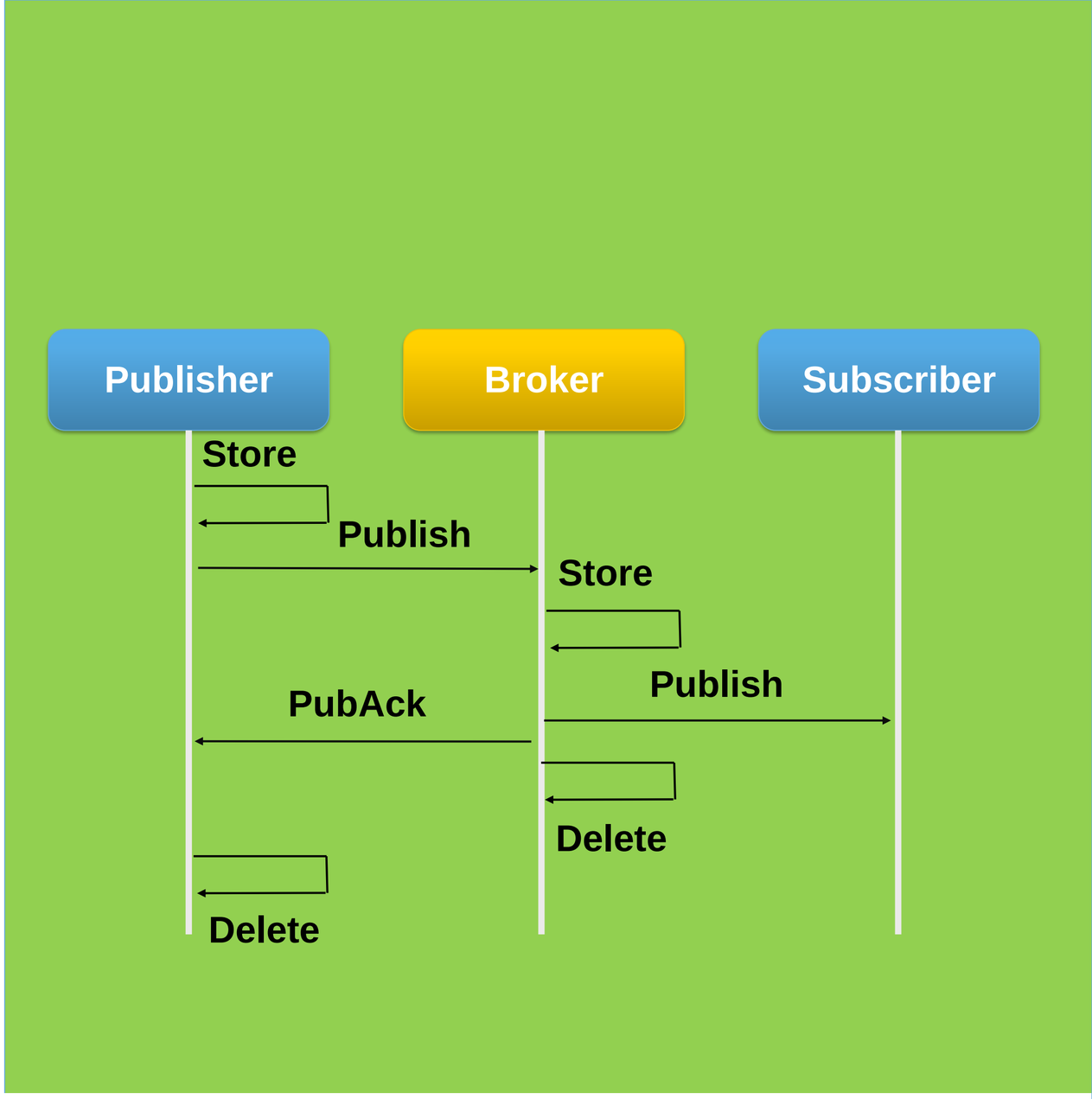
- At most once ► Fire and forget



MQTT

QoS 1 (Quality of Service)

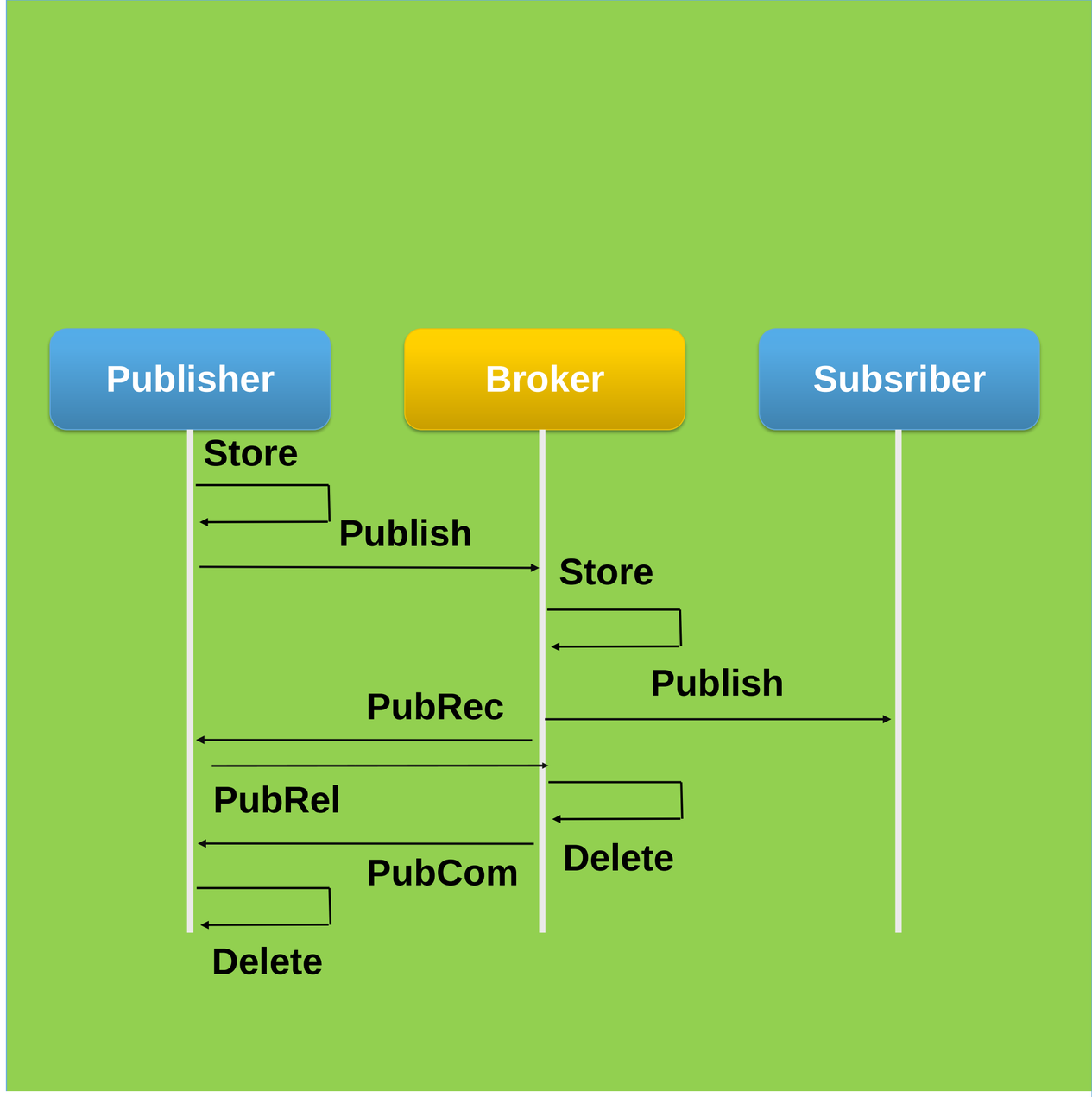
- At least once ► Store function & confirmation (PubAck).



MQTT

QoS 2 (Quality of Service)

- Exactly one ► every message will received onces by 4 handshakes



MQTT

- topic
- payload
- State management
- Quality of Service (QoS)
- **Security**

MQTT-Packet:

PUBLISH

contains:	Example
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MQTT

Security

- **Networklayer**
  - VPN
  - Firewalls

MQTT

Security

- Networklayer
- **Transportlayer**
  - TLS / SSL

MQTT

Security

- Networklayer
- **Transportlayer**
  - TLS / SSL

```
13 24.637425      192.168.2.152      192.168.2.216      MQTT
Frame 13: 157 bytes on wire (1256 bits), 157 bytes captured (1256 bits)
0000  00 30 de 43 c5 2d b8 27  eb 11 3e 7a 08 00 45 00   ·0·C·-·'  ··>z··E·
0010  00 8f 42 58 40 00 40 06  71 50 c0 a8 02 98 c0 a8   ··BX@·@·  qP······
0020  02 d8 07 5b bd 52 c6 73  41 53 28 80 f3 1e 80 18   ···[·R·s  AS(·····
0030  00 e3 87 42 00 00 01 01  08 0a 25 31 73 19 00 00   ···B····  ··%1s···
0040  41 d2 30 59 00 2e 77 61  67 6f 2f 70 66 63 2f 63   A·0Y··wa  go/pfc/c
0050  6c 6f 75 64 63 6f 6e 6e  65 63 74 69 76 69 74 79   loudconn  ectivity
0060  2f 65 78 61 6d 70 6c 65  2f 6d 71 74 74 70 75 62   /example  /mqttpub
0070  6c 69 73 68 7b 7d 7b 22  54 61 6e 6b 5f 31 22 3a   lish{}{"  Tank_1":
0080  38 30 7d 7b 22 54 61 6e  6b 5f 32 22 3a 31 30 7d   80}{"Tan  k_2":10}
0090  7b 22 54 61 6e 6b 5f 33  22 3a 31 30 7d            {"Tank_3  ":10}
Message (mqtt.msg), 41 byte(s)
```

MQTT message **without** encryption.

MQTT

Security

- Networklayer
- **Transportlayer**
  - TLS / SSL

No.	Time	Source	Destination	Protocol
1	0.000000	192.168.2.77	192.168.2.150	TLSv1.2

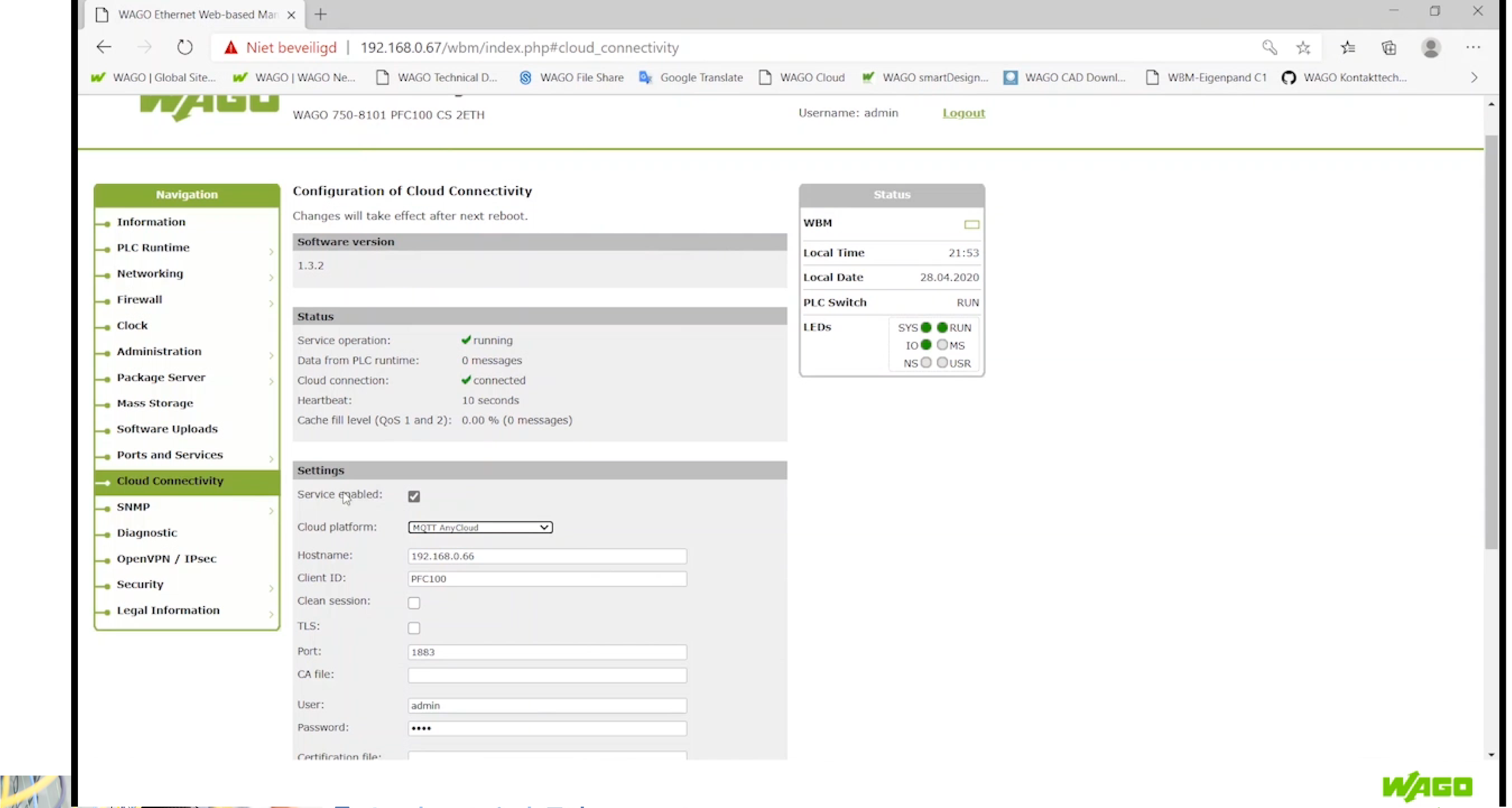
```
0000  b8 27 eb 9a 46 c4 00 30  de 43 06 08 08 00 45 00
0010  00 ae 17 62 40 00 40 06  9c b4 c0 a8 02 4d c0 a8
0020  02 96 9b ee 22 b3 ff bb  4c b6 cd 6c a6 42 80 18
0030  02 50 00 4b 00 00 01 01  08 0a 02 fc 16 bf 5a 7d
0040  fb 02 17 03 03 00 75 8c  32 5a 6b 5d fd b3 d2 a7
0050  ae 48 d0 42 b1 b8 11 b6  d1 56 94 89 79 ae 47 08
0060  8b 49 18 49 61 8a b8 de  46 63 7e 5b 36 8b 52 18
0070  03 19 7f 3f 29 e8 b3 a0  a1 b0 c2 10 5c 7d 48 38
0080  23 ec 85 83 b6 9d 27 d8  29 7f ed 19 02 5e b1 1c
0090  d7 ce c4 53 66 f4 94 43  e9 cf 2b ab dd 1c a5 99
00a0  7a 75 ff 5f d0 99 8e de  23 55 1e f2 aa 9e 70 a2
00b0  05 21 9b ee fc 7d a4 7f  d9 d9 51 40
```

MQTT message **with** encryption.

MQTT

Security

- Networklayer
- Transportlayer
- **Applicationlayer**
  - Username
  - Password


WAGO Ethernet Web-based Mar
Niet beveiligd | 192.168.0.67/wbm/index.php#cloud_connectivity
WAGO | Global Site...
WAGO | WAGO Ne...
WAGO Technical D...
WAGO File Share
Google Translate
WAGO Cloud
WAGO smartDesign...
WAGO CAD Downl...
WBM-Eigenpand C1
WAGO Kontakttech...
WAGO 750-8101 PFC100 CS 2ETH
Username: admin
Logout
Navigation
Information
PLC Runtime
Networking
Firewall
Clock
Administration
Package Server
Mass Storage
Software Uploads
Ports and Services
Cloud Connectivity
SNMP
Diagnostic
OpenVPN / IPsec
Security
Legal Information
Configuration of Cloud Connectivity
Changes will take effect after next reboot.
Software version
1.3.2
Status
Service operation: running
Data from PLC runtime: 0 messages
Cloud connection: connected
Heartbeat: 10 seconds
Cache fill level (QoS 1 and 2): 0.00 % (0 messages)
Settings
Service enabled:
Cloud platform: MQTT AnyCloud
Hostname: 192.168.0.66
Client ID: PFC100
Clean session:
TLS:
Port: 1883
CA file:
User: admin
Password: ••••
Certification file:
Status
WBM
Local Time 21:53
Local Date 28.04.2020
PLC Switch RUN
LEDs
SYS RUN
IO MS
NS USR

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