# Industrial Shared Wireless Communication System – Use Case of Autonomous Guided Vehicles

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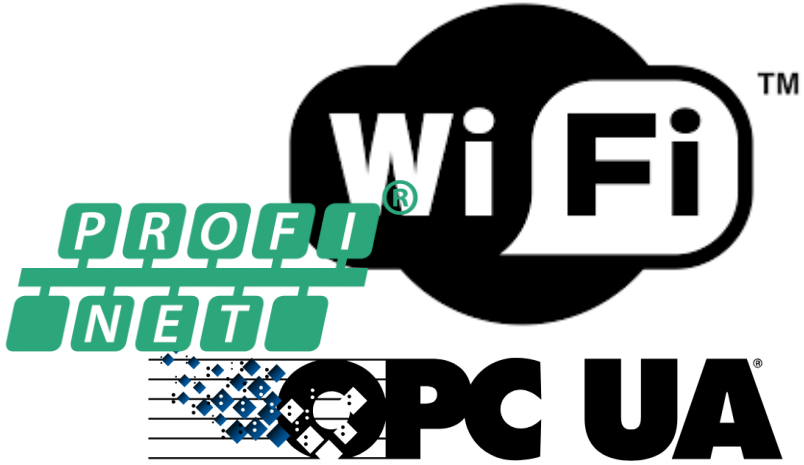
# Agenda

1. Infrastructure
2. Profinet IO
3. OPC UA
4. Experimental research
5. Connection quality
6. Future works

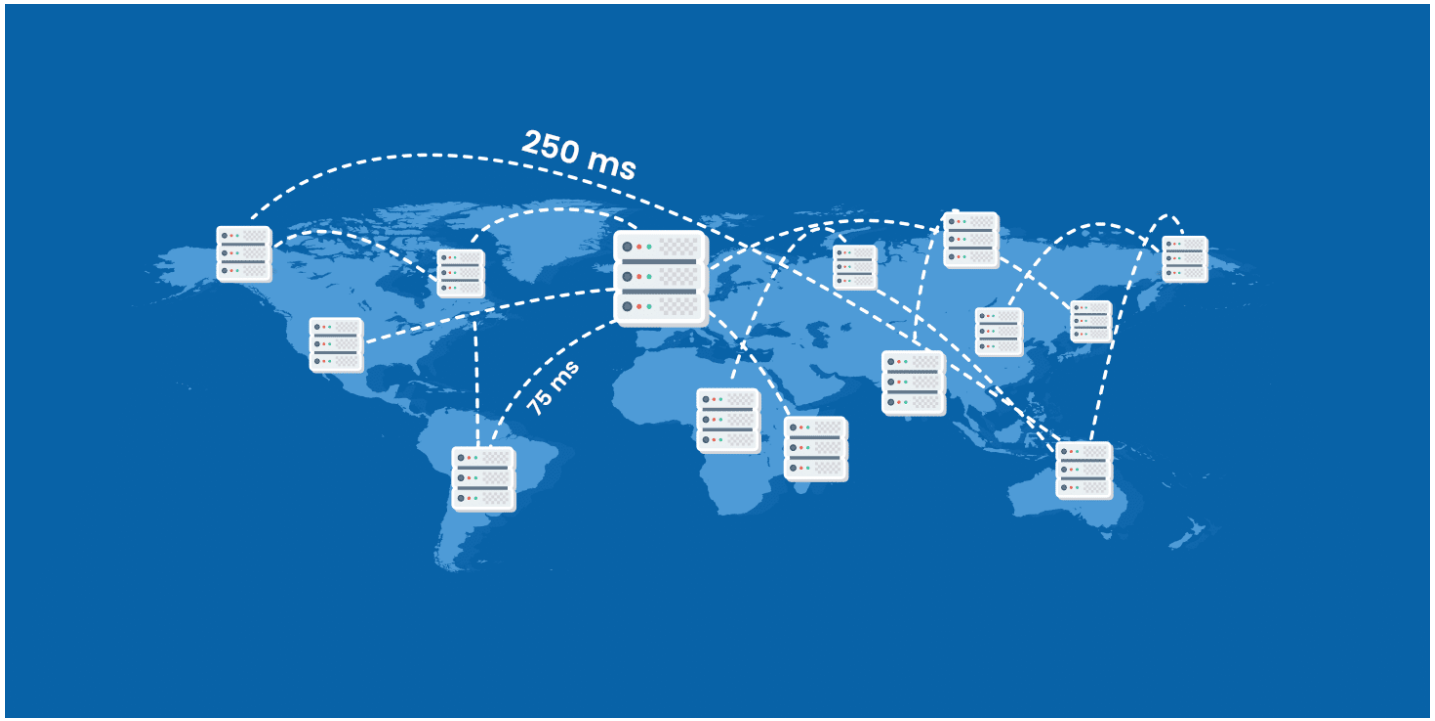


# Goal

Checking the influence of additional network traffic to the parameteres of the RealTime industrial network.

Profinet + OPC UA

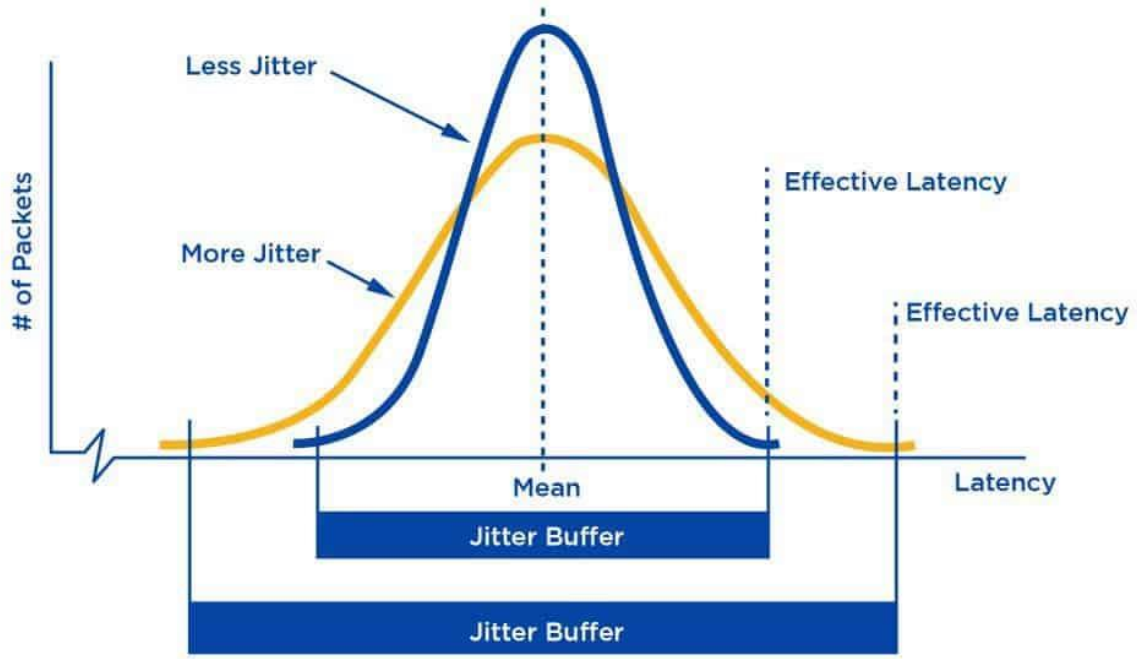
# Goals




Latency

https://networkencyclopedia.com/wp-content/uploads/2019/08/jitter-1024x576.jpg

# Goals




Jitter

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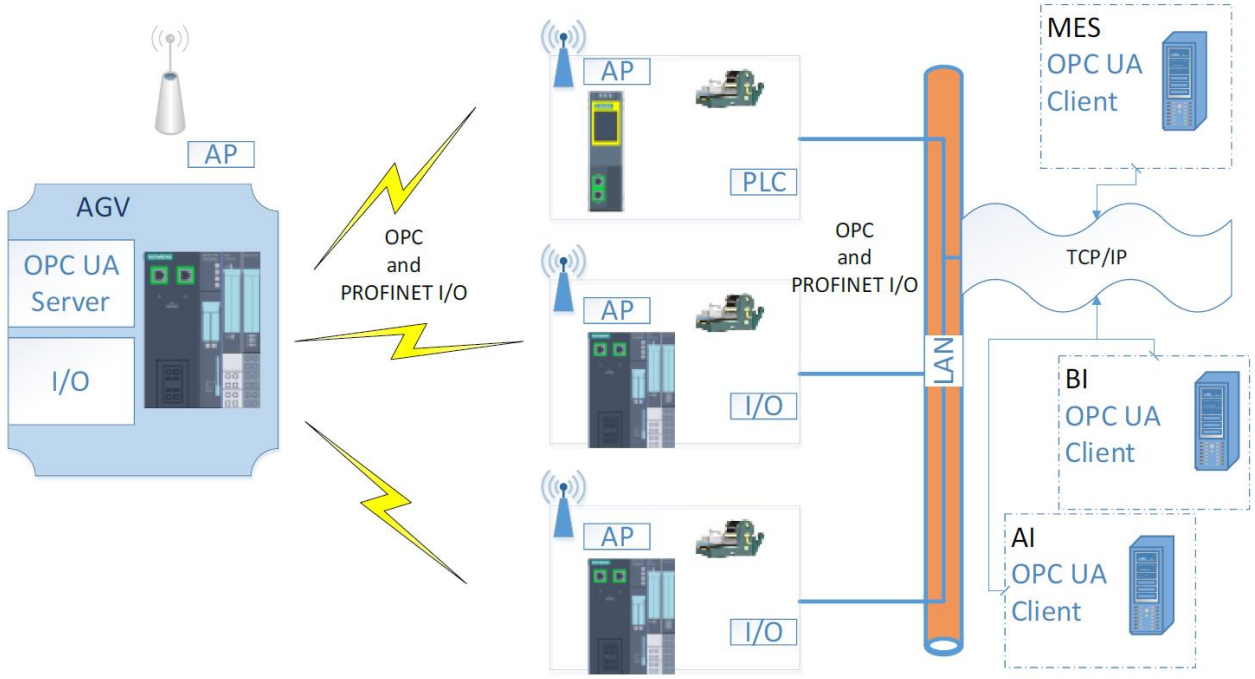
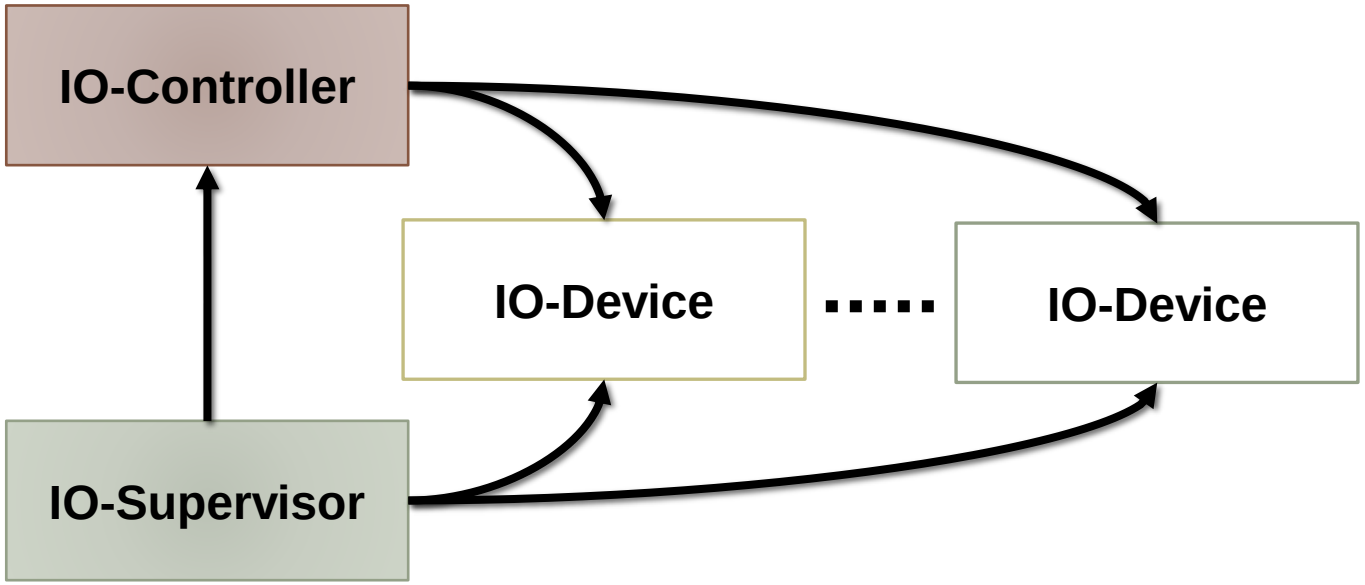
# Infrastructure



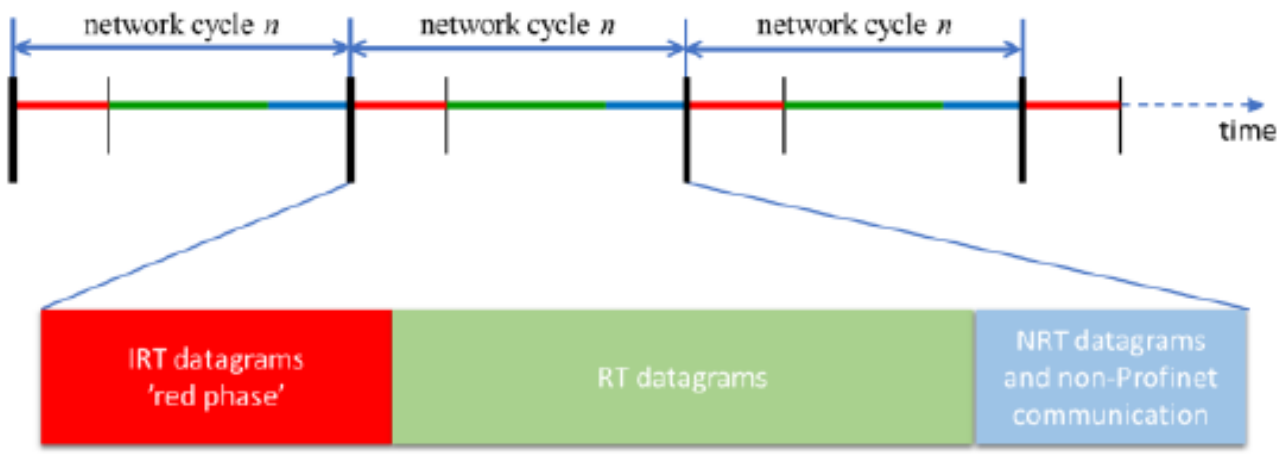
# Profinet



# Profinet

- ***NRT No Real Time*** – TCP/UDP channel, configuration, parameteres
- ***RT* Real Time** – Real Time channel,
- ***IRT* Isochronus Real Time –** IRT channel, isochronus communication with Real Time

Devices work in Full Duplex mode



# Profinet IRT

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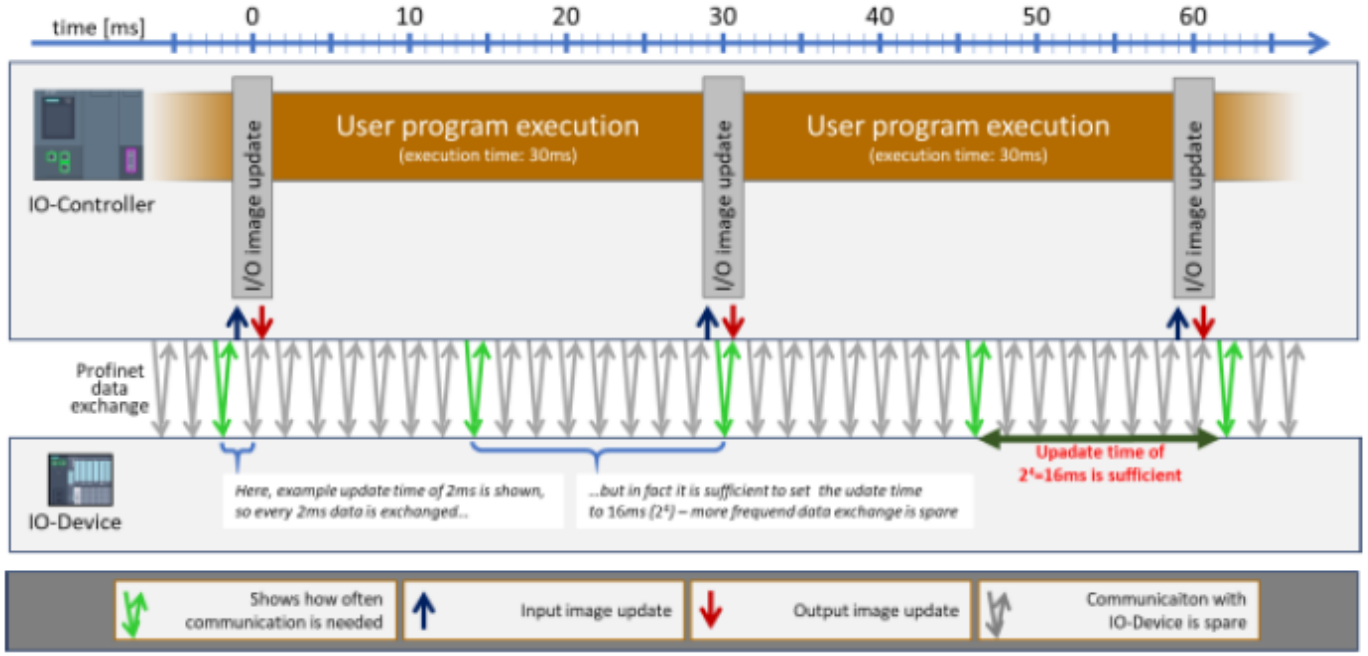
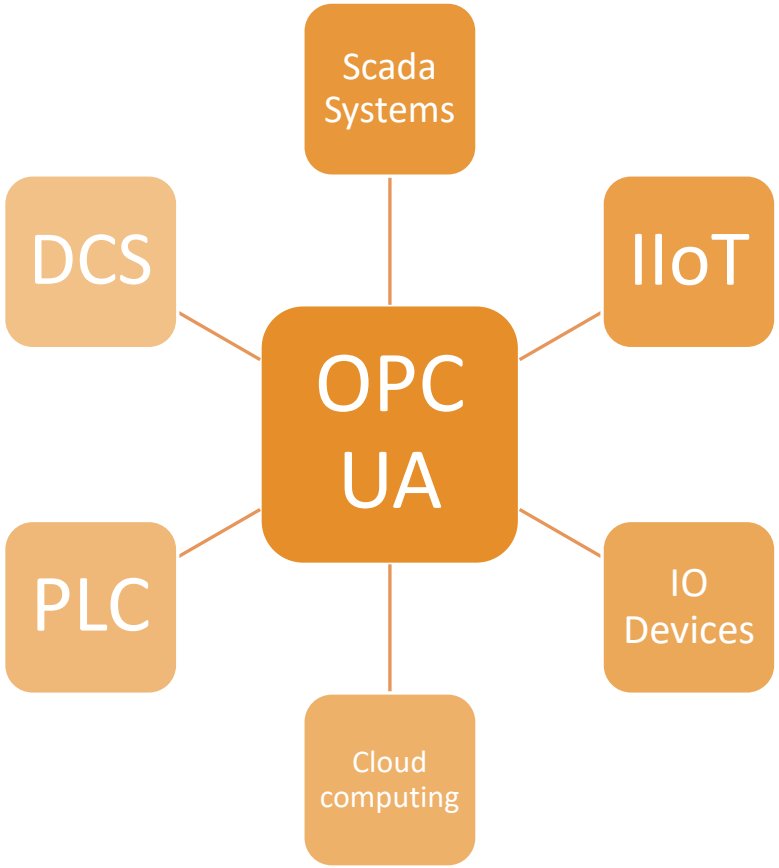



Why the update time of a Profinet IO-Device should be adjusted to the PLC cycle time ?

# OPC UA


Scada Systems
DCS
IIoT
OPC UA
PLC
IO Devices
Cloud computing

# OPC UA – publisher/subscriber

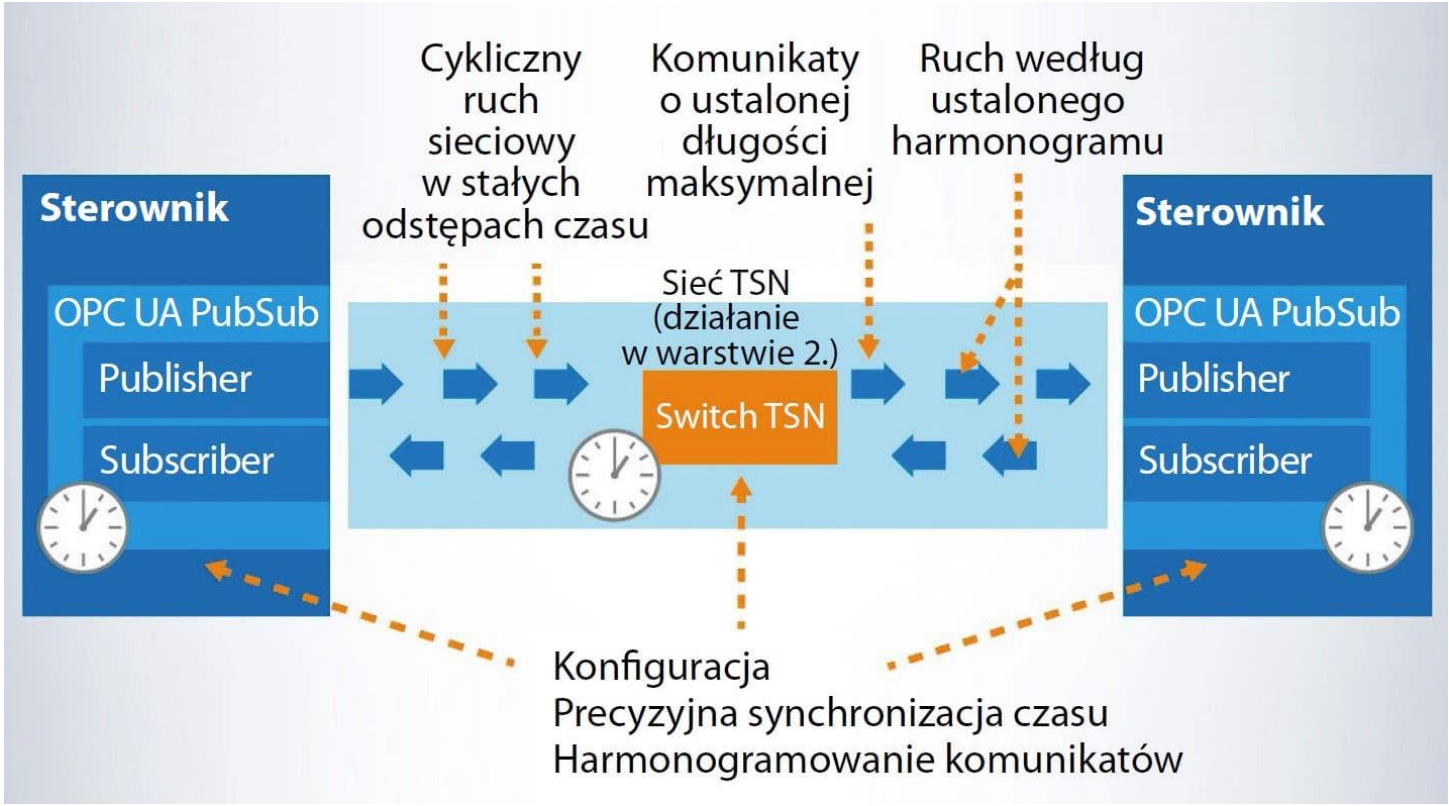
~~Client ←→ Server~~

Publisher ←→ Subscriber

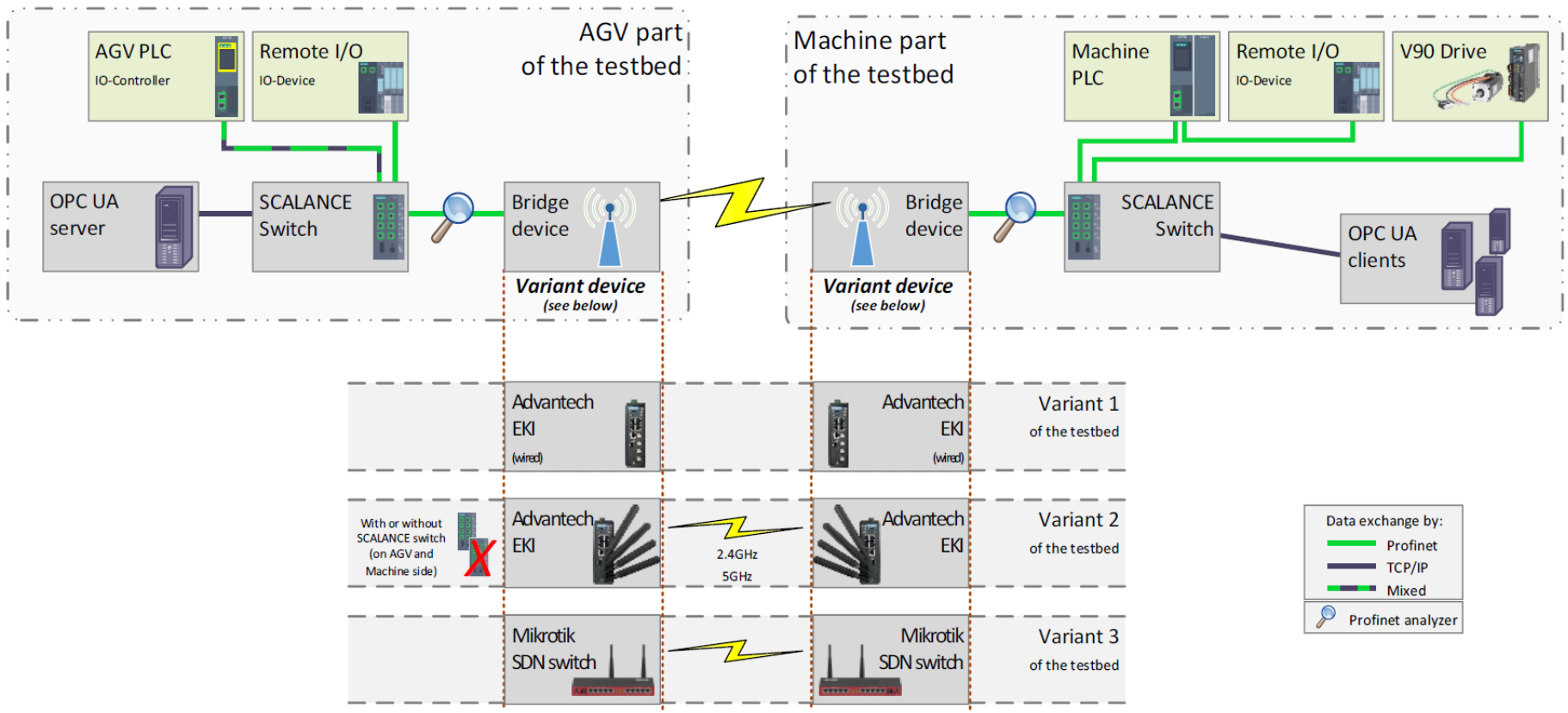
# OPC UA – publisher/subscriber

- No requirement for continuous connection to the server
- Reduction of the required hardware resources
- Easy access to data when data is collecting from several systems

# OPC UA Time Sensitive Network



# Experimental research



# Experimental research

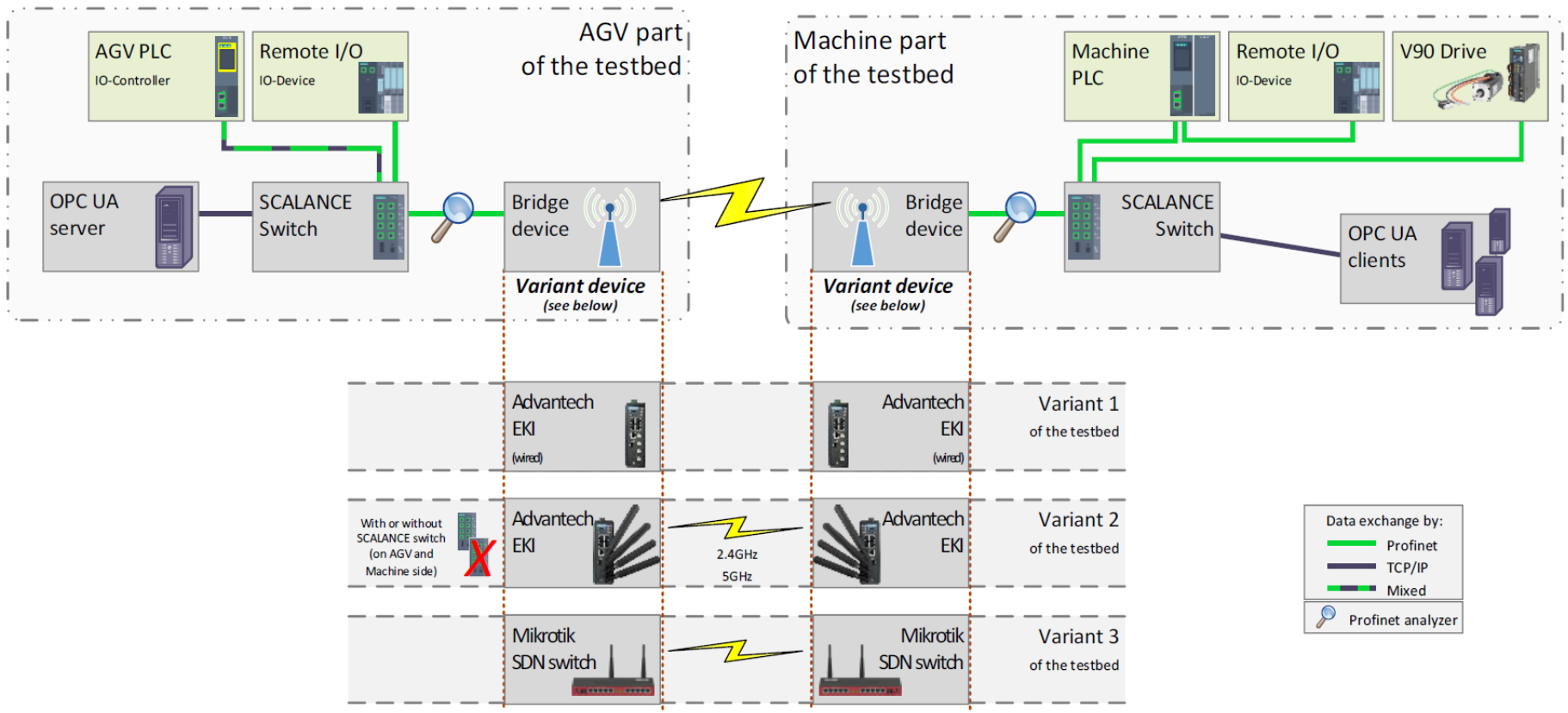
| Testbed configuration | | Update time | | | |
|---|---|---|---|---|---|
| | | 2ms | 4ms | 64ms | 128ms |
| Wired connection | Jitter | 10.7% | 4.78% | 0.1% | ~0.1% |
| | Jitter [ms] | 0.2 | 0.19 | 0.06 | ~0.06 |
| Wireless 2.4GHz | Jitter | --- | --- | --- | 14.1% |
| | Jitter [ms] | --- | --- | --- | 18.0 |
| Wireless 5GHz | Jitter | --- | --- | 18.8% | 7.6% |
| | Jitter [ms] | --- | --- | 12.0 | 9.72 |

# Experimental research

| Measurement setup | Wired | | 2.4Ghz | | 5Ghz | |
|---|---|---|---|---|---|---|
| | Jitter % | Jitter [ms] | Jitter % | Jitter [ms] | Jitter % | Jitter [ms] |
| No OPC UA server | 2.4% | 3.0 | 14.1% | 18.0 | 18.8% | 12.0 |
| OPC UA server active – only background communication with AGV | 3.2% | 4.1 | 20.4% | 26.1 | 17.6% | 11.3 |
| 1 client on 1 PC computer | 3.7% | 4.7 | 39.2% | 50.2 | 19.4% | 12.4 |
| 2 clients on 2 PC computers | 4.4% | 5.6 | 32.5% | 41.6 | 17.1% | 10.9 |
| 4 clients on 4 PC computers | 5.5% | 7.0 | 35.7% | 45.7 | 17.3% | 11.1 |
| 6 clients on 6 PC computers | 6.8% | 8.7 | 37.0% | 47.4 | 19.8% | 12.7 |
| 8 clients on 6 PC computers | *7.3%* | *9.3* | *38.9%* | 49.8 | 19.9% | 12.7 |
| 10 clients on 6 PC computers | *8.5%* | 10.9 | *40.2%* | 51.5 | 19.9% | 12.7 |
| 12 clients on 6 PC computers | *10.8%* | 13,8 | *41.8%* | 53.5 | 20.6% | 13.2 |

Results for wireless connection with an update time of 128ms

# Experimental research



# Experimental research

| Measurement setup | Wired | | 2.4Ghz | |
|---|---|---|---|---|
| | Jitter % | Jitter [ms] | Jitter % | Jitter [ms] |
| No OPC UA server | 2.4% | 3.0 | 14.1% | 18.0 |
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| 1 client on 1 PC computer | 3.7% | 4.7 | 39.2% | 50.2 |
| 2 clients on 2 PC computers | 4.4% | 5.6 | 32.5% | 41.6 |
| 4 clients on 4 PC computers | 5.5% | 7.0 | 35.7% | 45.7 |
| 6 clients on 6 PC computers | 6.8% | 8.7 | 37.0% | 47.4 |
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| 12 clients on 6 PC computers | *10.8%* | 13,8 | *41.8%* | 53.5 |

| Measurement setup | Jitter % | Jitter [ms] |
|---|---|---|
| No OPC UA server | 12,6% | 16.1 |
| UPC UA server active, no clients | 24.5% | 31.4 |
| 1 client on 1 PC computer | 23.4% | 29.9 |
| 2 clients on 2 PC computers | 37.6% | 48.1 |
| 3 clients on 2 PC computers | 65.9% | 84.4 |
| 4 clients on 2 PC computers | 110.5% | 141.4 |

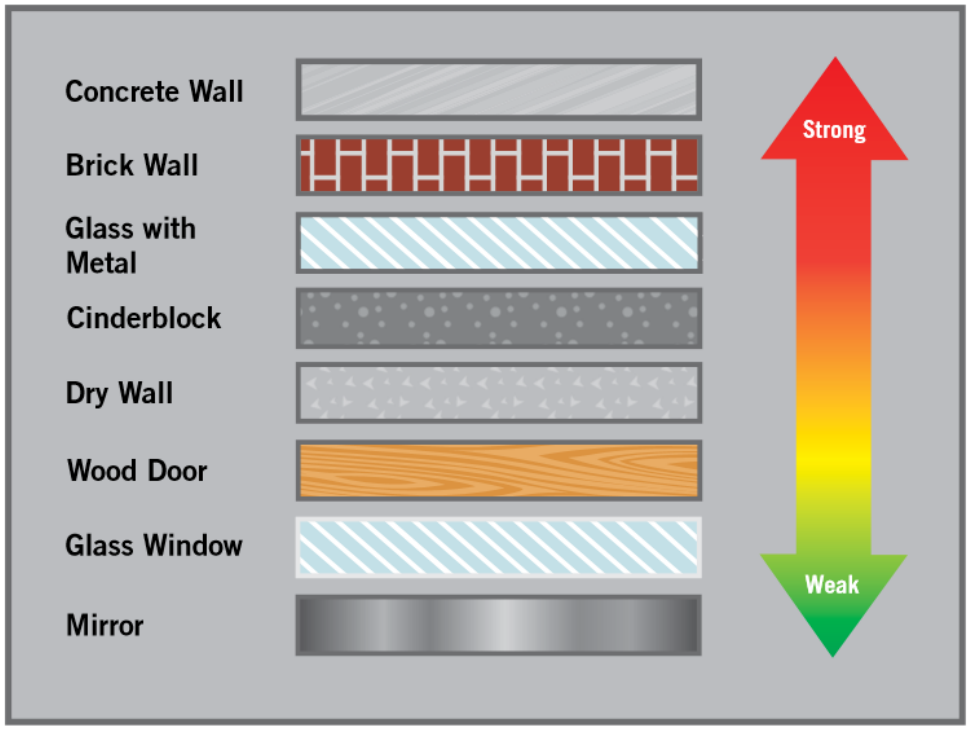
Results for wireless connection with an update time of 128ms without Scalance switch

# Connection quality

| IEEE Standard | Maximum Linkrate |
|---|---|
| WiFi 6 | 600 to 9608 Mbit/s |
| WiFi 5 | 433 to 6933 Mbit/s |
| WiFi 4 | 72 to 600 Mbit/s |
| 802.11g | 3 to 54 Mbit/s |
| 802.11b | 1.5 to 54 Mbit/s |
| 802.11a | 1 to 11 Mbit/s |

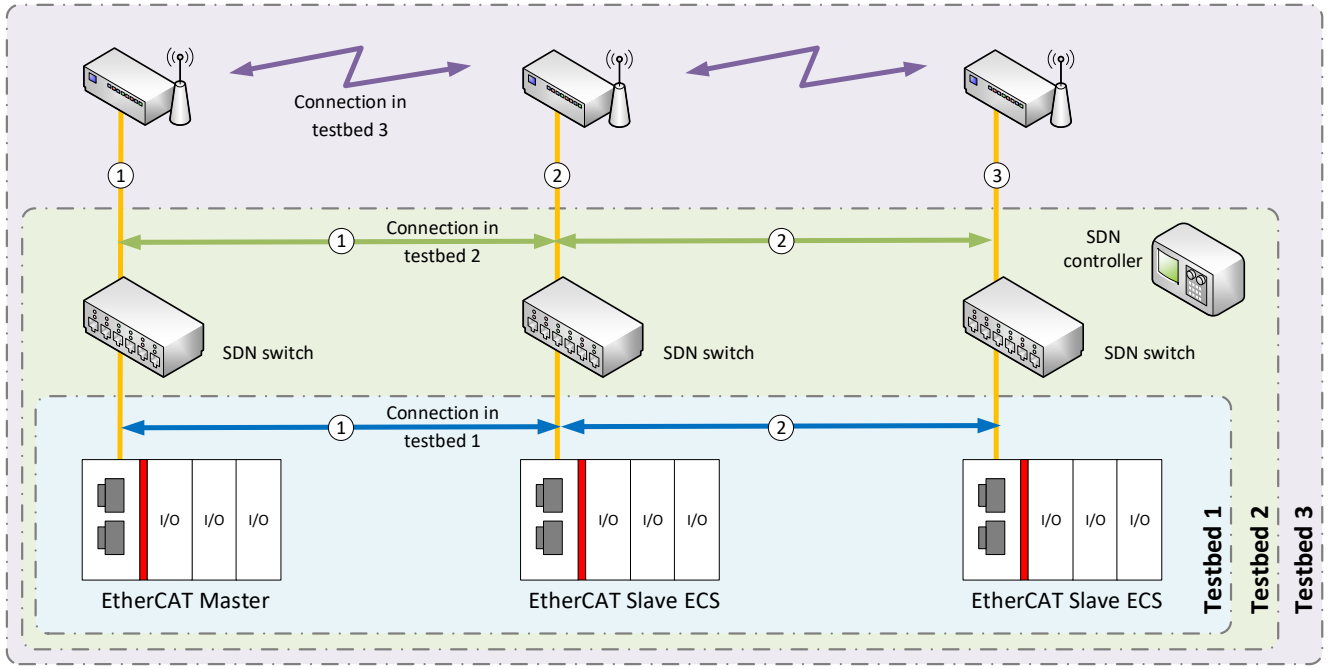
# Connection quality

| Material | Thickness [cm] | Attenuation [dB] |
|---|---|---|
| Brick | 30 | 9 |
| | 10 | 7 |
| Concrete | 30 | 11 |
| Wood | 4 | 2,5 |
| Glass | 2 | 4,5 |



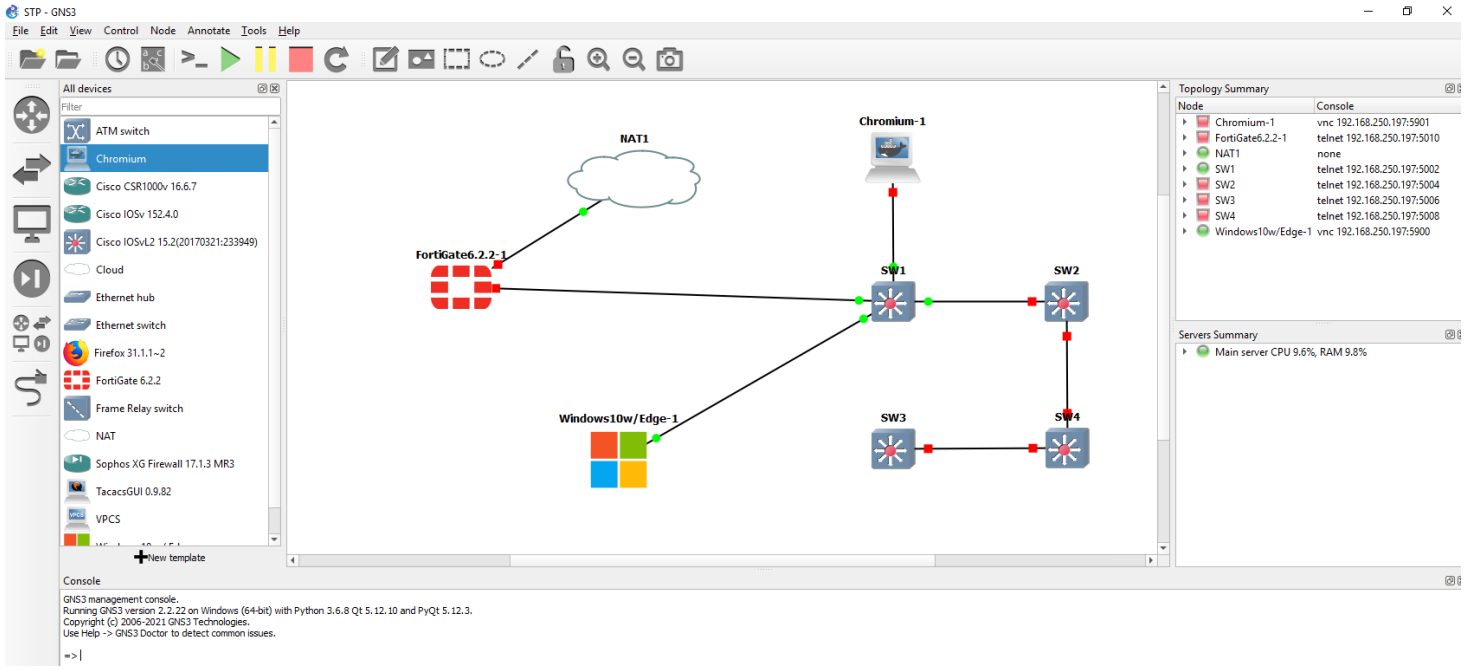
# Future works

- Change network protocol – EtherCAT



# Future works

- Simulation in GNS3 environment



# Thank you for your attention