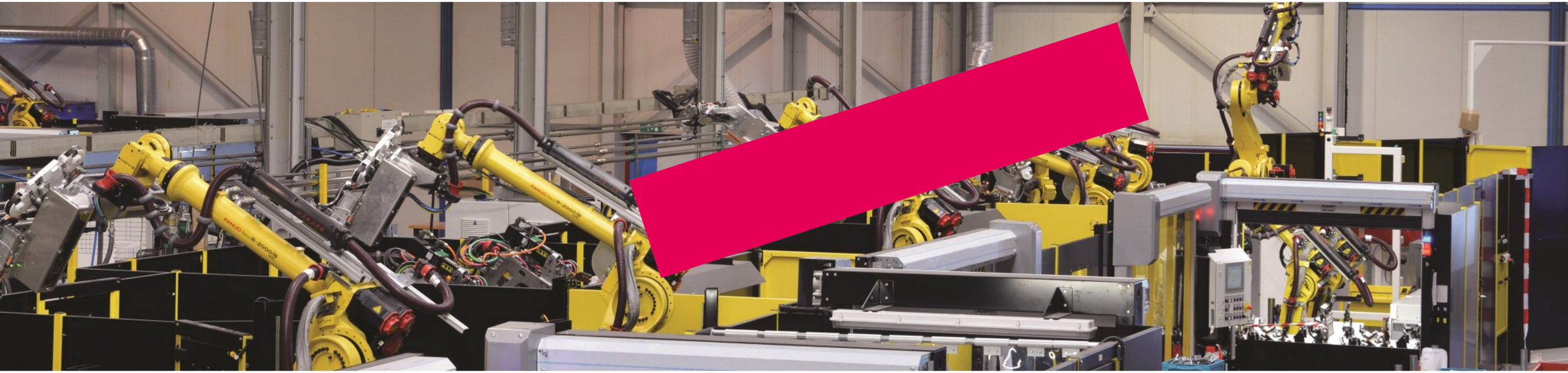
# Connected Factories lecture 3/6: Protocols




Associate Degree Smart Industry
Faculty of Engineering and Automotive

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HAN_UNIVERSITY
OF APPLIED SCIENCES

# Originele Leerdoelen (kneden en aanpassen)

De student heeft kennis en begrip van internationale standaarden op het gebied van gekoppelde IT systemen (Cyber Physical Systems). De student heeft kennis van *digitale identificatie* en uitwisseling van objecten als offertes, tekeningen, orders, transportinformatie en facturen conform open industrie standaarden.

De student heeft kennis en begrip van technologieën als blockchain, glasvezelverbindingen en 5G. De student heeft kennis en begrip van juridische contracten (zoals copyrights op sensor data, databankwet, privacy wetgeving, gebruiksrechten op software in equipment). De student kan zijn bedrijf adviseren welke mogelijkheden deze technologieën bieden op het gebied van integrale ketenoptimalisering.

# Schedule

| | Theme | |
|---|---|---|
| Lecture 1 | Introduction | |
| Lecture 2 | Network connections | |
| **Lecture 3** | **Today: Network protocols** | |
| Lecture 4 | Interconnections | |
| Lecture 5 | Security | |
| Lecture 6 | Safety | |
| Assessment | | |

# Recap: what did we learn the last two weeks…

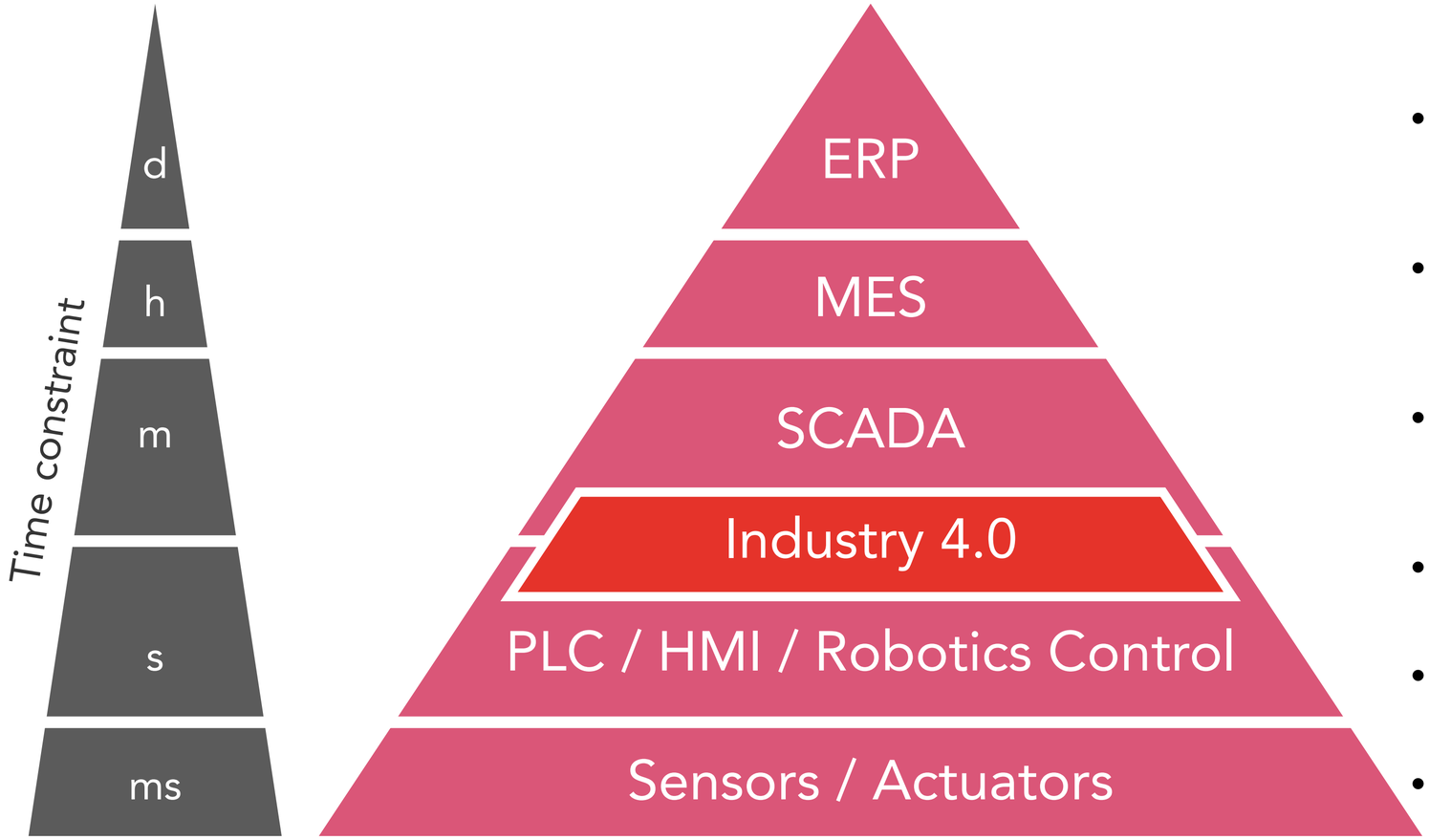
Industry 4.0 is all about connectivity

Same functionality can be achieved using different type of connections

# Protocols

Remember what you saw in the terminal in the Arduino lab of week 1?

# Industrial Connections: Automation Pyramid (IEC 62264 / IEC615112)




- Enterprise level (Enterprise Resource Planning)
- Operating level (Manufacturing Execution System)
- Process level (Supervisory Control and Data Acquisition)
- M2M communication
- Control level (Programmable Logic Controllers)
- Field level

Model was derived from: http://eecatalog.com/chipdesign/2018/02/22/new-class-of-embedded-design-emerges-to-support-virtualized-fog-servers/
See also: Niedermaier, M., Hanka, T., Plaga, S., von Bodisco, A., & Merli, D. (2019). Efficient Passive ICS Device Discovery and Identification by MAC Address Correlation. *arXiv preprint arXiv:1904.04271*.

https://link.springer.com/chapter/10.1007/978-3-319-56430-2_3

# Industrial Connections: basic software standards (protocols)

| (Lower level) Protocol | Type / Characteristic | Standard(s) / Organization |
|---|---|---|
| TCP/IP | Internet protocol suite<br>(also common for non-industrial usage) | RFC 1958 |
| UDP | User Datagram Protocol<br>(also common for non-industrial usage) | RFC 768 |
| | | |

# Industrial Connections: more specific standards

| High level Protocol | Type / Characteristic | Standard(s) / Organization |
|---|---|---|
| MQTT | Message Queuing Telemetry Transport for M2M communication | ISO/IEC PRF 20922 |
| CIP | Common Industrial Protocol | ODVA |
| CoAP | Constrained Applications Protocol | RFC 7252 |
| | | |

https://www.odva.org/Technology-Standards/Common-Industrial-Protocol-CIP/Overview

https://www.embedded.com/industry-adoption-of-iot-a-constrained-application-protocol-survey/

# Modbus: varieties using different protocols

Modbus RTU

Modbus ASCII

Modbus TCP(/IP)

Modbus over TCP/IP

Modbus over UDP

Modbus Plus (Modbus+, MB+ or MBP)

Pemex Modbus

Enron Modbus

See: http://www.modbus.org

# Modbus

Developed by Schneider Electric (Modicon, 1979)

- developed for industrial applications
- royalty-free and open standard
- easy deployment and maintenance
- moves raw bits or words without placing many restrictions on vendors.

Examples of usage:

- Connecting RTU (Remote Terminal Unit) in SCADA (Supervisory Control And Data Acquisition) systems

# PROFINET: consequences of different protocols

- TCP/IP (Standard) reaction time ± 100 ms
- RT (Real-Time) cycle times up to 10 ms
- IRT (Isochronous Real-Time) cycles times of less than 1 ms

PROFIsafe (PROFIBUS safety or PROFINET safety) (IEC 61508) **(Verder uitwerken)**

See: http://www.modbus.org; https://en.wikipedia.org/wiki/Isochronous_timing;

# Cisco modules

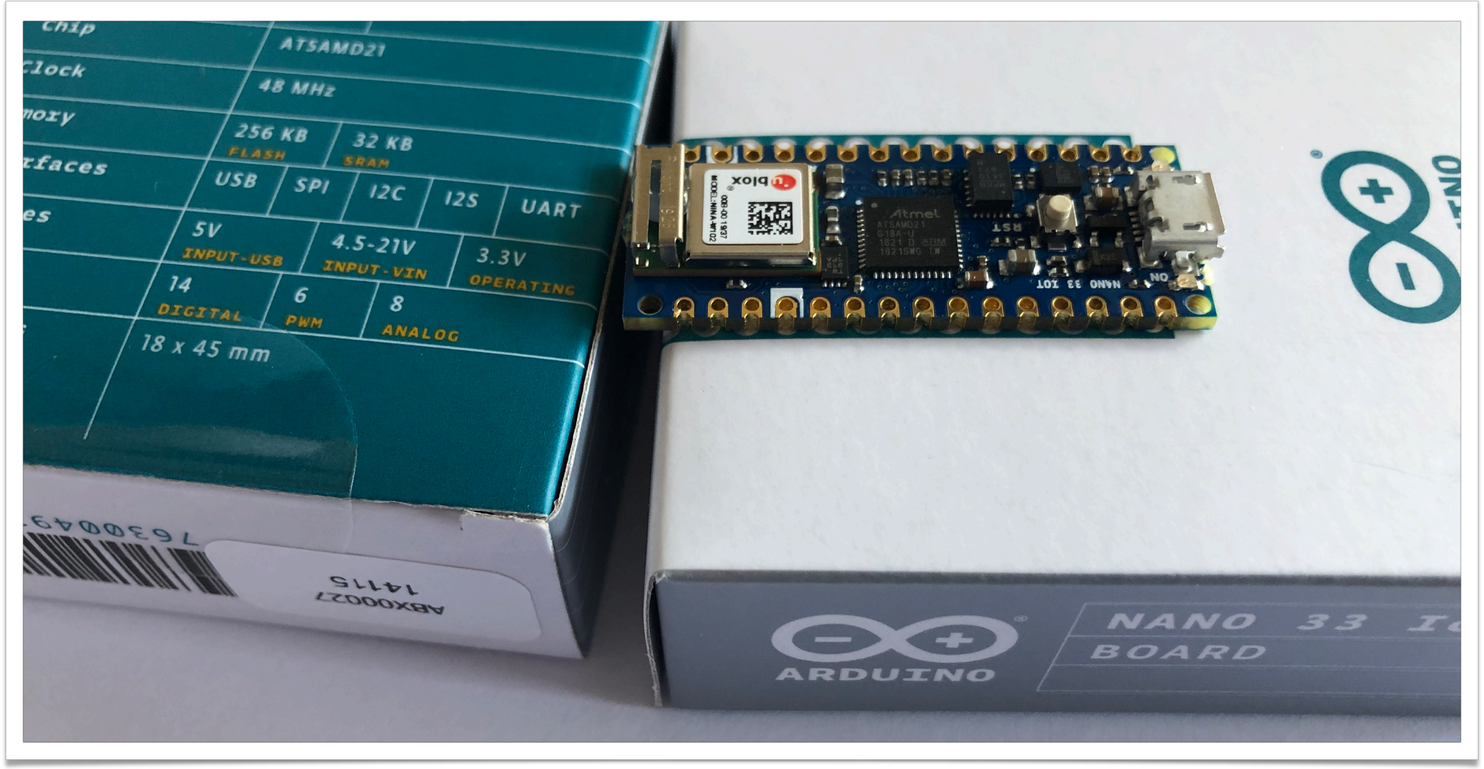
Remember, course URL: https://www.netacad.com/portal/learning

Homework for next session:
- Les 4. Slimme oplossingen  t/m 4.5,
- 4.6 Niet

- Les 5. Slimme apparaten 5.1, 5.3, 5.5 - 5.9
- 5.2, 5.4 Niet, Opdracht slimme stad niet.

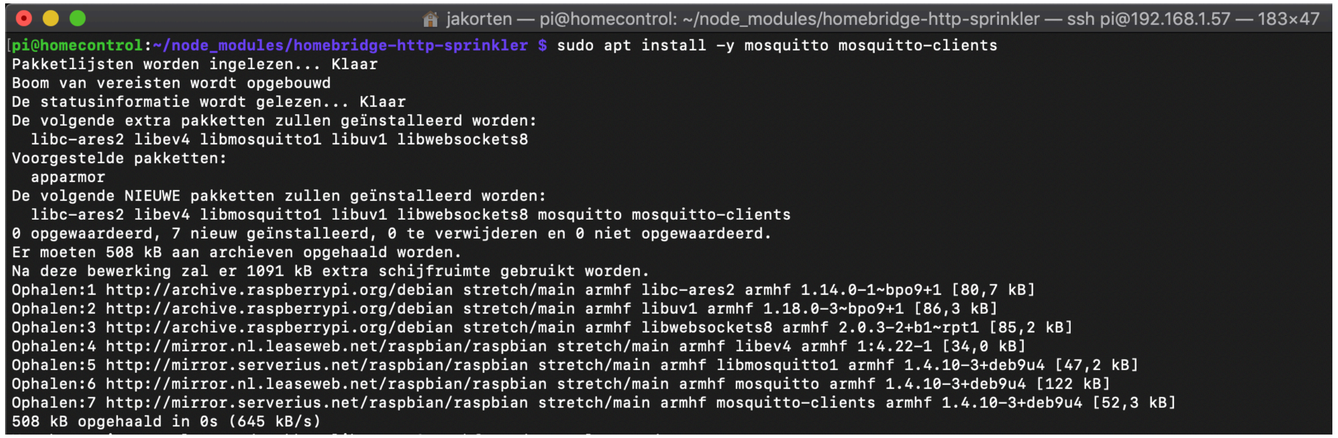
# Towards your own IoT / MQTT device.

Practical: connecting your Nano 33 IoT Board to your Phone network.



# Using your Pi as an MQTT broker

In case you haven't done that yet…




Update your packages:
*sudo apt update*

Install Mosquitto:
*sudo apt install -y mosquitto mosquitto-clients*

Auto start Mosquitto on boot up:
*sudo systemctl enable mosquitto.service*

*See also:* https://appcodelabs.com/introduction-to-iot-build-an-mqtt-server-using-raspberry-pi

# Test MQTT on your Pi

Open two terminals:


Terminal 1:

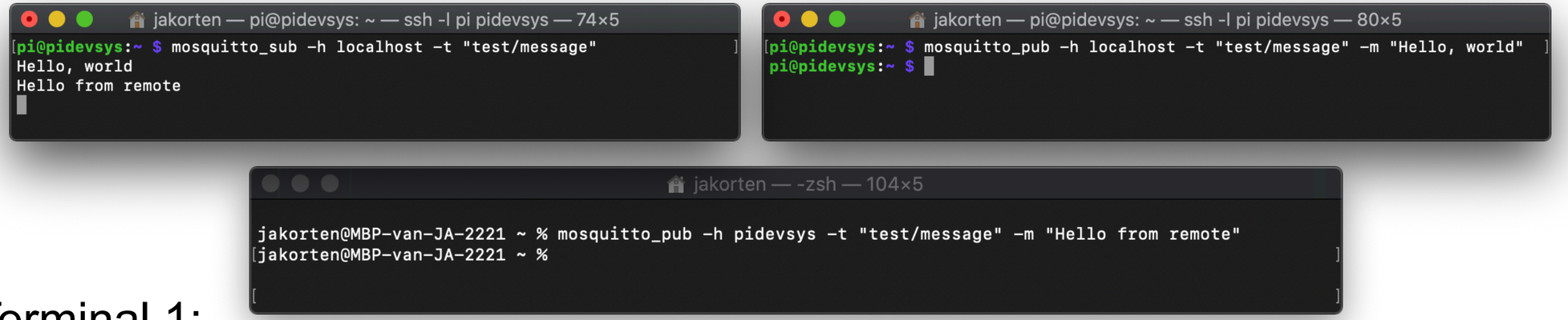
*mosquitto_sub -h localhost -t "test/message"*

Terminal 2:

*mosquitto_pub -h localhost -t "test/message" -m "Hello, world”*

# Test MQTT on your Pi

Open another (local) terminal:




Terminal 1:

*mosquitto_sub -h localhost -t "test/message"*

Terminal 2:

*mosquitto_pub -h localhost -t "test/message" -m "Hello, world”*

Local (Macbook) Terminal 3:

mosquitto_pub -h pidevsys -t "test/message" -m "Hello from remote”

# Installing Mosquitto on Windows:

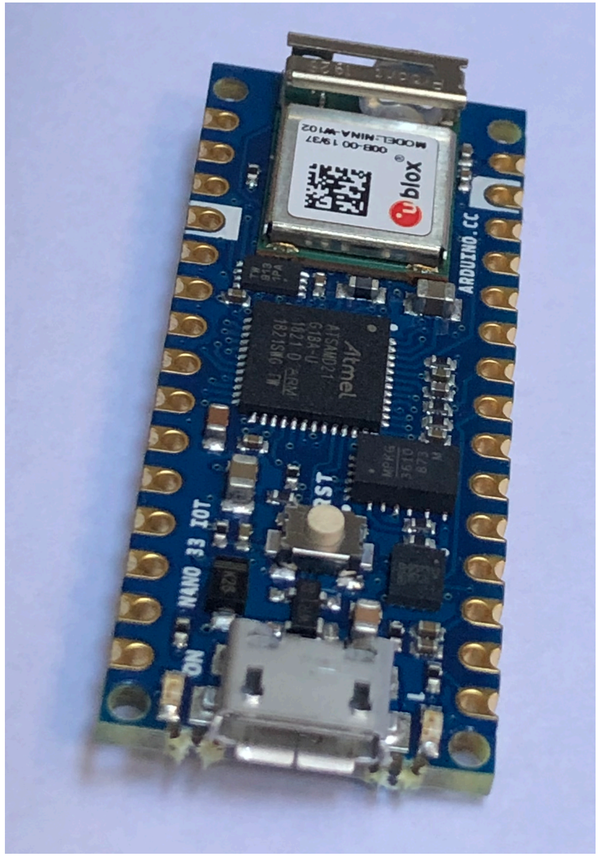
http://www.steves-internet-guide.com/install-mosquitto-broker/

# Towards your own IoT / MQTT device.

During online session we will do this live, but you can also do it for yourself.

- Turn the module into a MQTT IoT client.
- Try to switch an LED using MQTT.

Video: [Protocollen, MQTT - Raspberry Pi + Arduino Nano 33 IoT]



# Arduino Menu cheat sheet… (not entirely visible in videos)

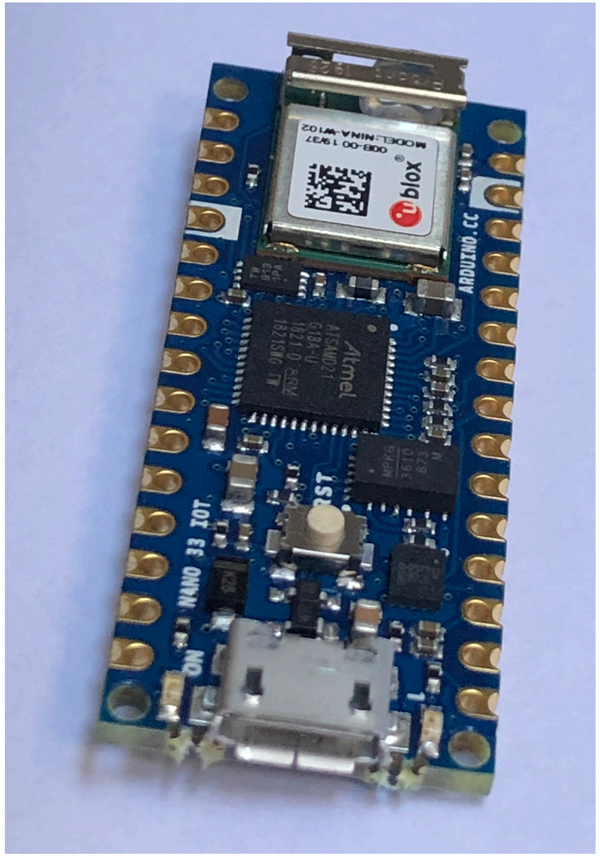
# Reflection Arduino Lab

- If you think back of lesson 1 about the Sensor and Actuator Reference Architecture (SARA), what architecture would fit in best with the MQTT solution (monolythic, silo or horizontal layers), and why?

If you look in the Arduino example you also see the following code:

*char pubTopic[] = "arduino/ledState";*

- What would that be useful for?
- How would one be able to use it?



# Links

https://www.cisco.com/c/en/us/td/docs/solutions/Verticals/PROFINET/2-0/DIG/PROFINET2-DIG/PROFINET2-DIG-Chapter.html