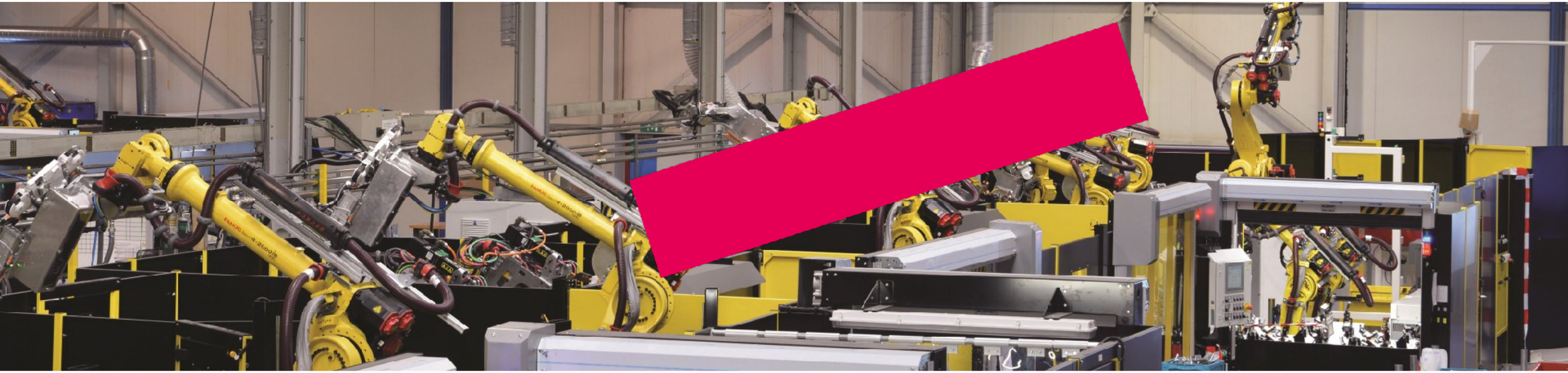
# Connected Factories lecture 2/6: Network connections




Associate Degree Smart Industry
Faculty of Engineering and Automotive

johan.korten@han.nl



V1.0 April 2, 2020


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** | **Today: Network connections** | |
| Lecture 3 | Network protocols | |
| Lecture 4 | Interconnection | |
| Lecture 5 | Integration | |
| Lecture 6 | Trusting the Network | |
| Assessment | | |

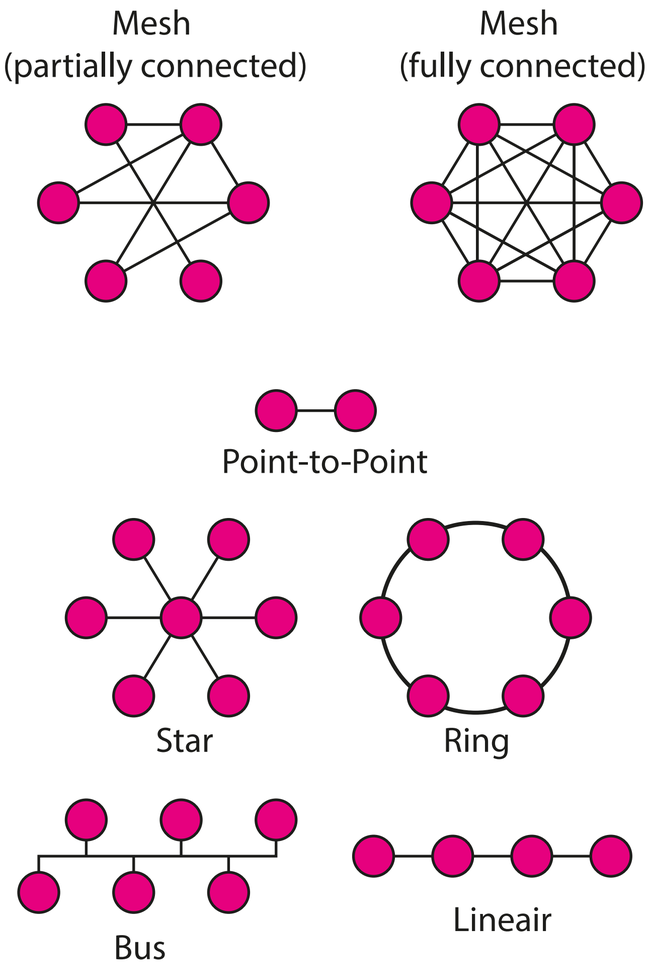
# Connections: ‘Physical’ layer

- Network cables
  - Coax (deprecated)
  - Twisted pair (Unshielded Twisted Pair, Shielded Twisted Pair, different categories)
  - Fibre optics
- Wireless
  - Radio (Telegraph (deprecated), WiFi, Bluetooth, GSM, 3G, 4G, 5G, propriety, NFC, etc.)
  - Satellite
  - Light: Infrared (e.g. ‘TV’-remote), laser, (future: Philips LiFi)

# Connections: Network cables, Wired Topologies

Look at different network structures (topologies):

What do you notice?



# Connections: Network cables, Wired Topologies

Topologies depend on their physical medium.

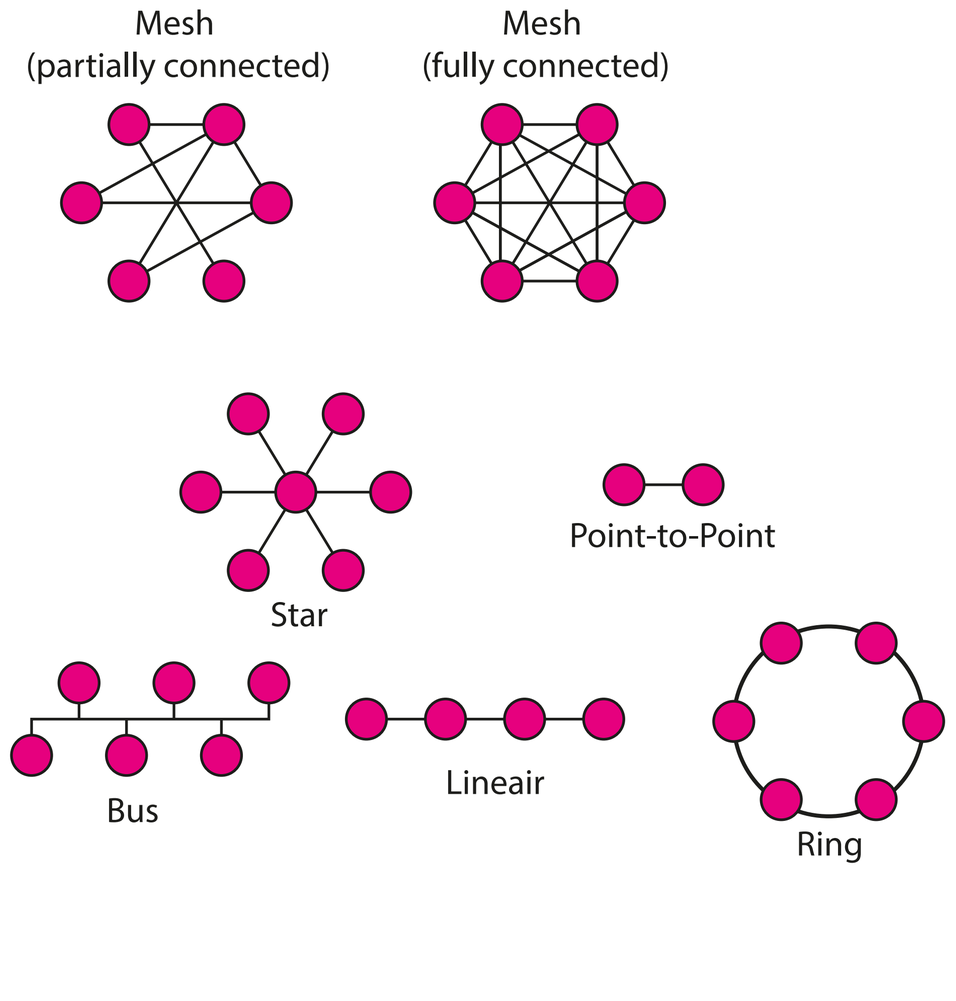
What topology fits:

- a mobile phone (4G)
- a laptop (WiFi)
- a printer (USB)
- Philips Hue (ZigBee)

Typically wireless

Either wired or wireless

Typically wired

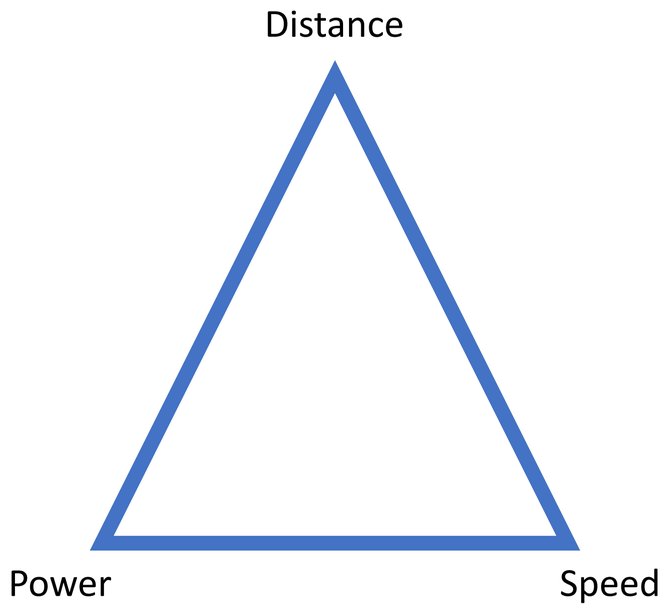


# Connections: Network cables

- Half-Duplex (comparable with walkie-talkie)
- Full-Duplex (comparable with normal phone)

- Parallel vs. Serial
- Asynchronous vs. Synchronous

# Connections: Wireless Trade-offs



# Industrial Connections: some hardware standards

| Connection | Type / Characteristic | Standard(s) |
|---|---|---|
| RS-485 | Serial communication | TIA-485(-A), EIA-485 |
| Modbus | PLC bus | ISO 15745-4:2003 |
| CAN (2.0) bus | Vehicle bus | ISO 11898-1/2/3 |
| PROFIBUS | Industrial Ethernet | IEC 61158 |
| PROFINET | Industrial Ethernet | IEC 61784-2 |
| SafetyNET/PROFISafe | Industrial Ethernet for safety | IEC 61784-3-3 |

This list is by no means complete but lists common standards. See also: https://en.wikipedia.org/wiki/Fieldbus; https://en.wikipedia.org/wiki/Industrial_Ethernet

# Industrial Connections: connectivity protocols

| Wired | | Wireless |
|---|---|---|
| **Fieldbus** | **Industrial Ethernet** | |
| Profibus<br>ModBus<br>DeviceNET<br>CANOpen<br>CC-Link<br>AS-I<br>Interbus<br>ControlNet | Profinet<br>Ethernet/IP<br>Ethernet/CAT<br>Modbus TCP | 802.15.4<br>6LoWPAN<br>Bluetooth/LE<br>Cellular<br>LoRa<br>Wi-Fi<br>WirelessHART<br>ZigBee |

Source: https://www.arrow.com/en/research-and-events/articles/industrial-connectivity-protocols

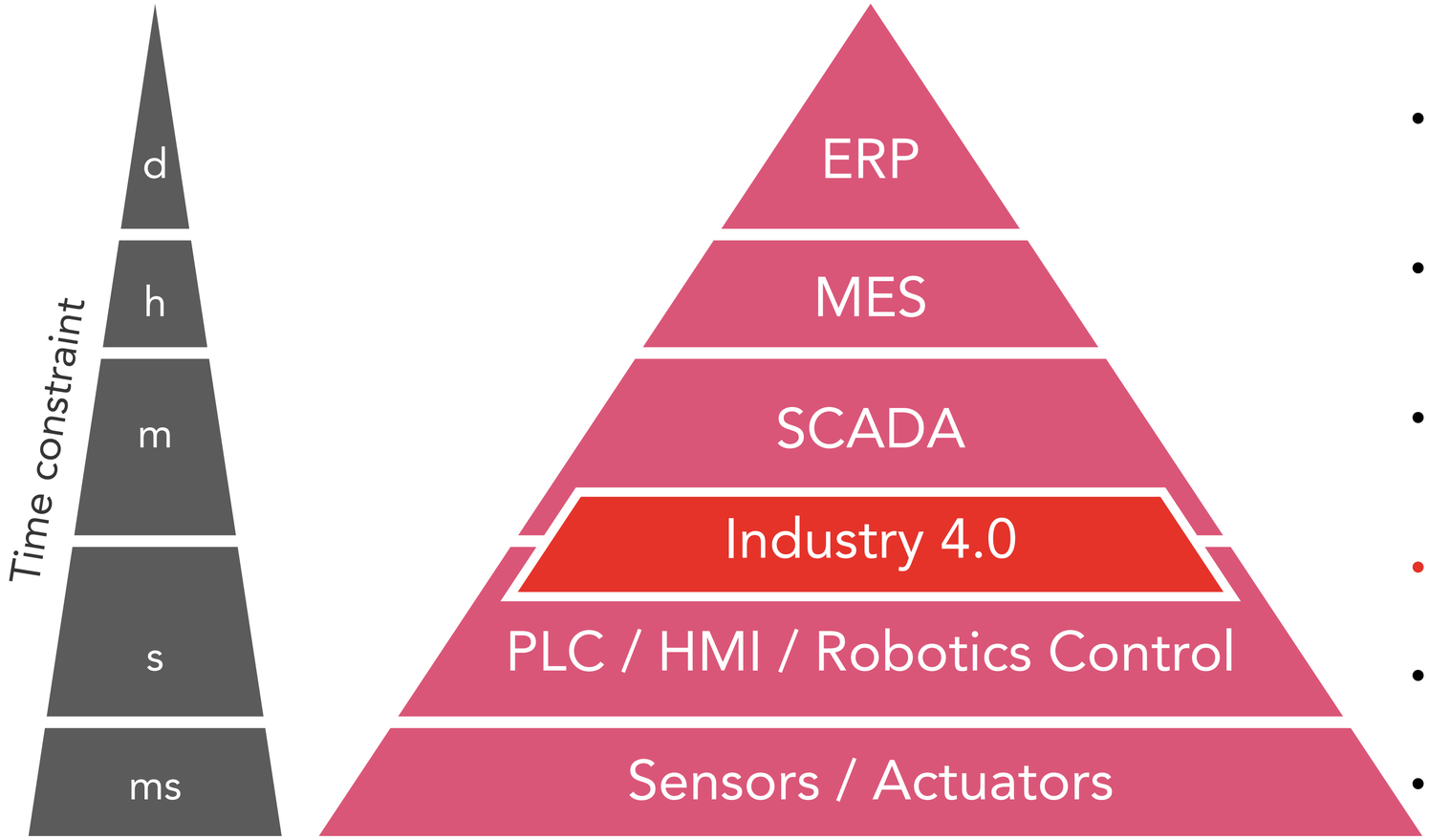
# Industrial Connections: basic software standards

| Connection | 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

| Connection | Type / Characteristic | Standard(s) / Organization |
|---|---|---|
| MQTT | Message Queuing Telemetry Transport for M2M communication | ISO/IEC PRF 20922 |
| CIP | Common Industrial Protocol | ODVA |
| | | |
| | | |

# 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

HAN_UNIVERSITY OF APPLIED SCIENCES

# 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

# Wired vs. Wireless

Would Wired Profinet be sufficient for all Industry 4.0 networking needs?

# Cisco modules

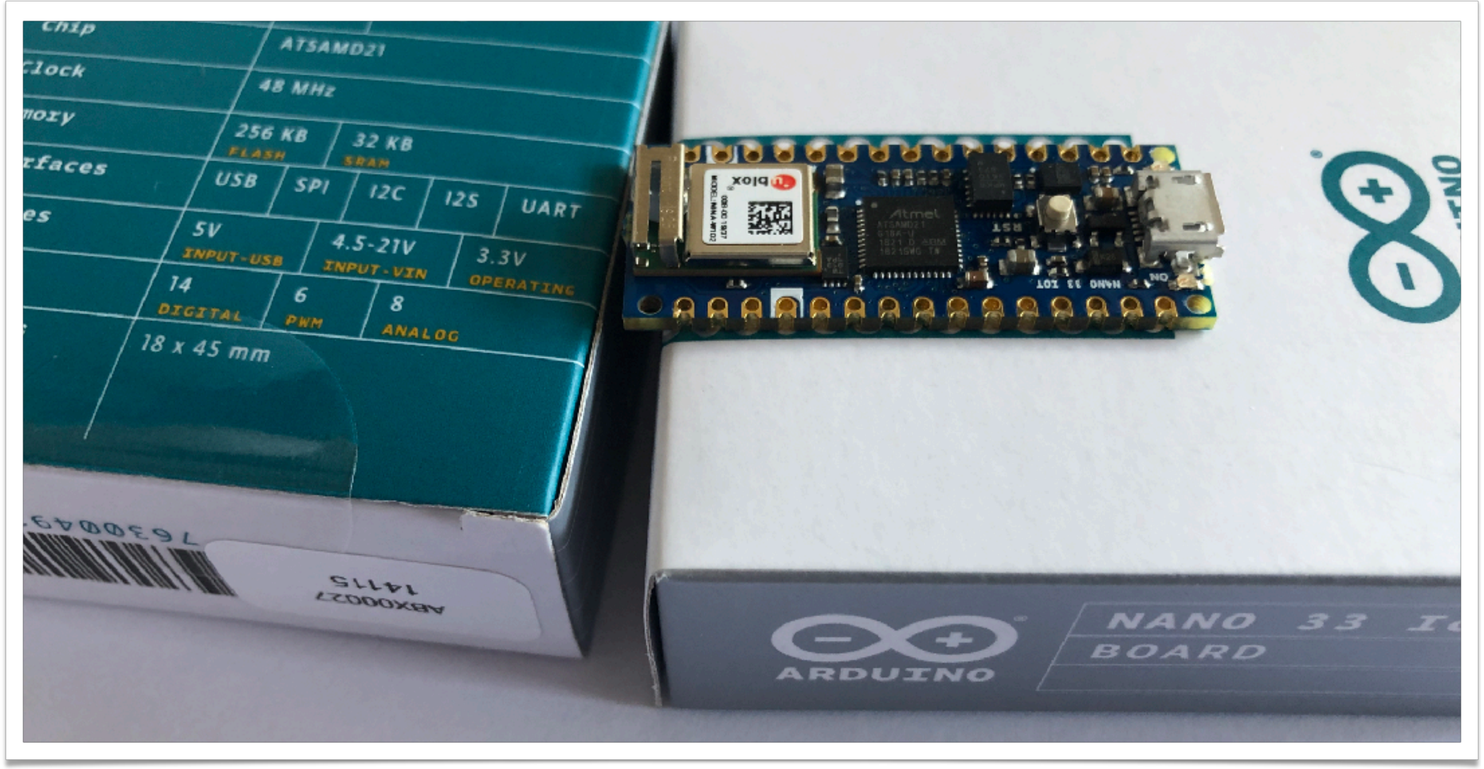
Remember, course URL: https://www.netacad.com/portal/learning

Homework for next session:
- Les 3. Dingen verbinden, thuis en industrieel
- 3.6 en Opdracht (laatst item van 3) overslaan.

- Les 6. Communicatieprotocollen (voorbereiding voor thema van volgende week).
- 6.6 - 6.7 is optioneel

# Towards your own IoT / MQTT device.

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

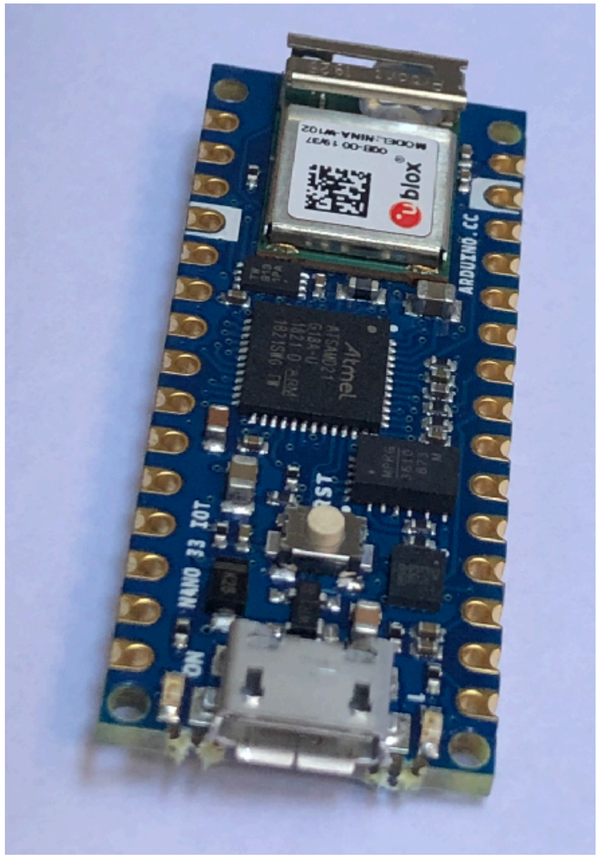


# Towards your own IoT / MQTT device.

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

- Turn the module into a Bluetooth Low Energy device
- Try to switch an LED using your phone and bluetooth.

Video: https://youtu.be/JZiPvO7VjoE




BLExplr
App Store iOS:
(Click image)

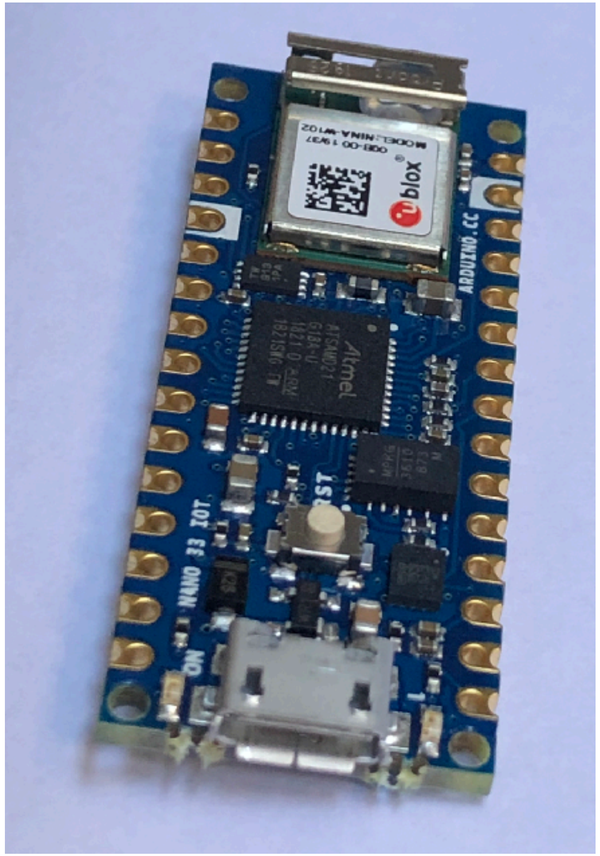
Google Playstore: LightBlue®
Bluetooth Low Energy
(click image)

HAN_UNIVERSITY
OF APPLIED SCIENCES

# Towards your own IoT / MQTT device.

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

- Arduino Installation etc (see menu cheat sheet on next slide)
- Your first IoT application
- Source code



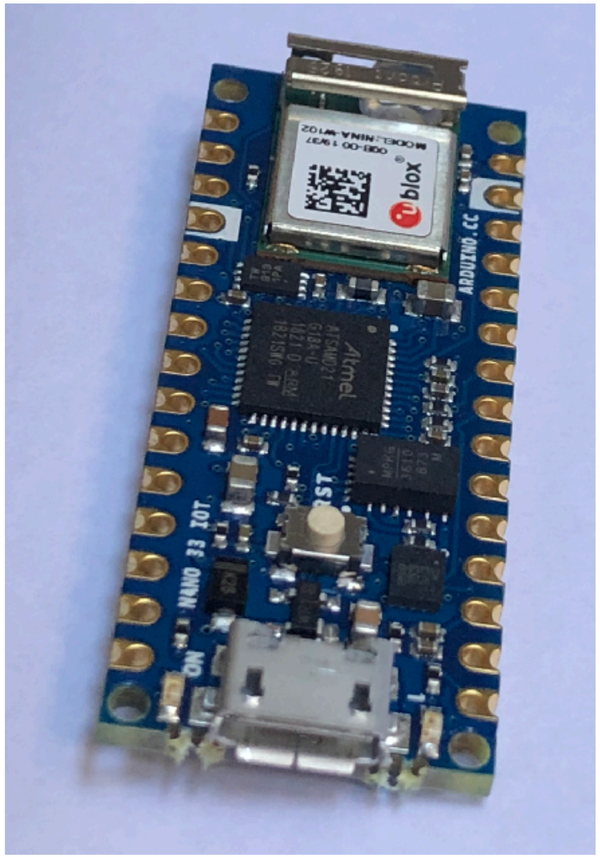
# Arduino Menu cheat sheet… (not entirely visible in videos)

# 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 Bluetooth Low Energy device
- Try to switch an LED using your phone and bluetooth.

Video: https://youtu.be/XH76ig948Fc




BLExplr
App Store iOS:
(Click image)

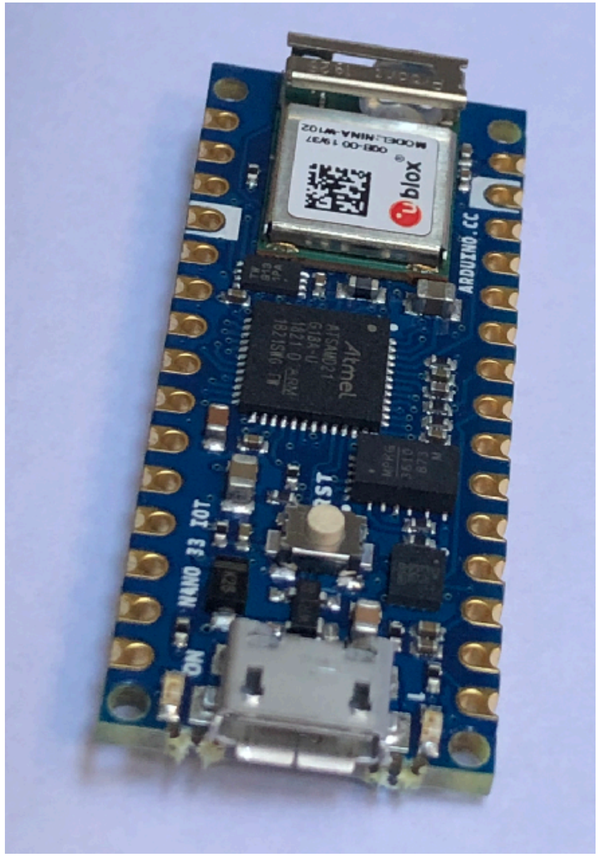
Google Playstore: LightBlue®
Bluetooth Low Energy
(click image)

HAN_UNIVERSITY
OF APPLIED SCIENCES

# Reflection Arduino Lab

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

- would (in theory) one be able to implement the same functionality with the Raspberry Pi?
- If so, what type of connections could be used?



# References

White-paper Sensor/Actuator networks:

https://www.technolution.eu/uploads/2019/07/architecturen-voor-sensor-actuator-netwerken.pdf (Dutch)

https://www.technolution.eu/uploads/2019/11/architectures-for-sensor-actuator-systems.pdf (English)

Arduino Nano 33 IoT:

https://www.arduino.cc/en/Guide/NANO33IoT

https://github.com/ostaquet/Arduino-Nano-33-IoT-Ultimate-Guide

https://www.arduino.cc/en/Reference/ArduinoBLE

https://rootsaid.com/arduino-ble-example/

# Questions?