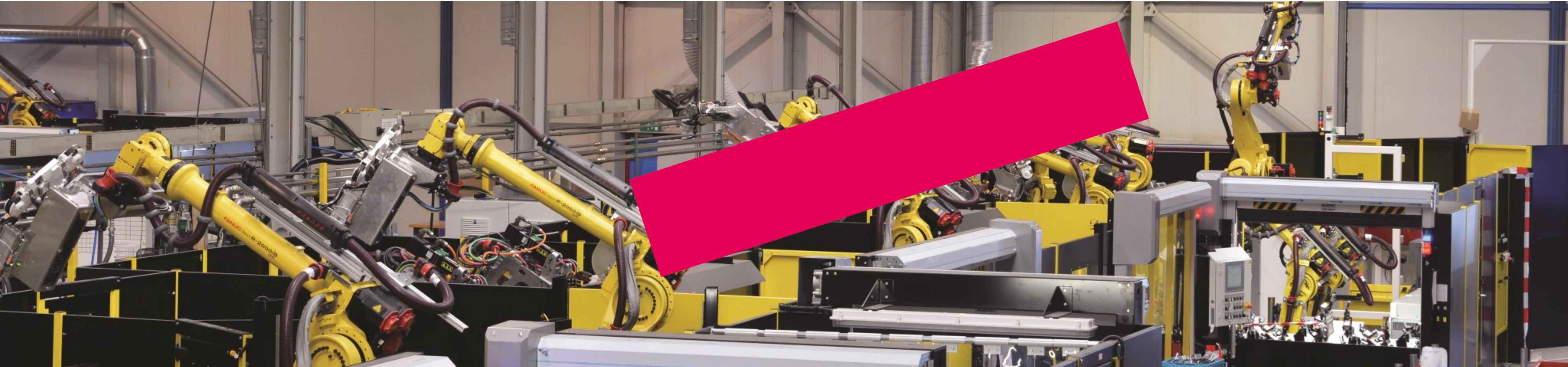


Connected Factories/IoT lecture 2/6: Connections



Associate Degree Smart Industry / Technische Bedrijfskunde
Faculty of Engineering and Automotive

johan.korten@han.nl

V1.2 May, 2022

Schedule

| | Theme | |
|------------|----------------------------|--|
| Lecture 1 | Introduction | |
| Lecture 2 | Network connections | |
| Lecture 3 | Network protocols | |
| Lecture 4 | Interconnections | |
| Lecture 5 | Safety | |
| Lecture 6 | Security | |
| 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)

Channels

- Half-Duplex (comparable with walkie-talkie)
- Full-Duplex (comparable with normal phone)
- Parallel vs. Serial
- Asynchronous vs. Synchronous

Connections: Network cables, Wired Topologies

Node (Device, e.g. computer, router, switch, phone, or ‘thing’): 

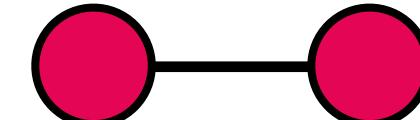
Connection: 

Connections: Network cables, Wired Topologies

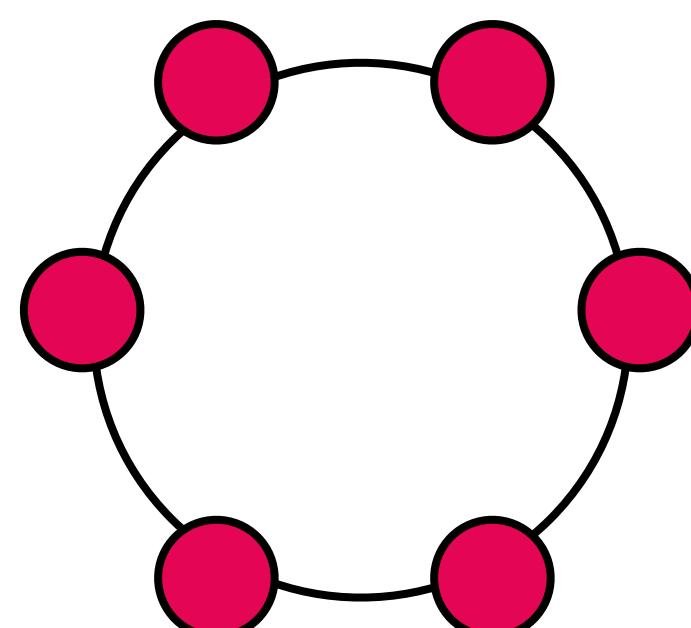
Look at different network structures (topologies):

What do you notice?

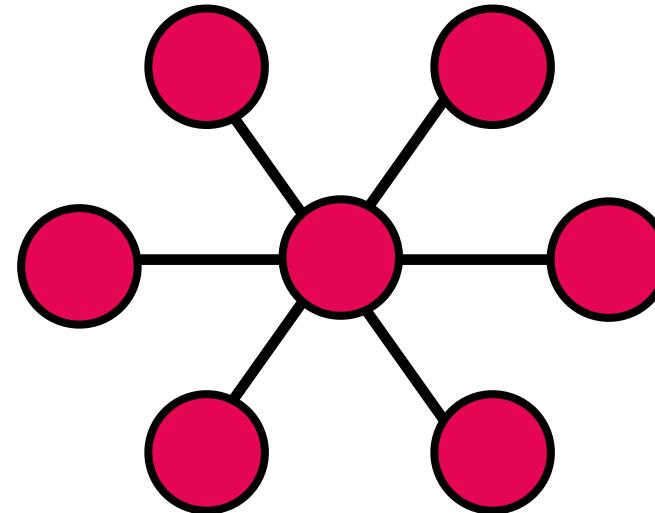
Point-to-Point



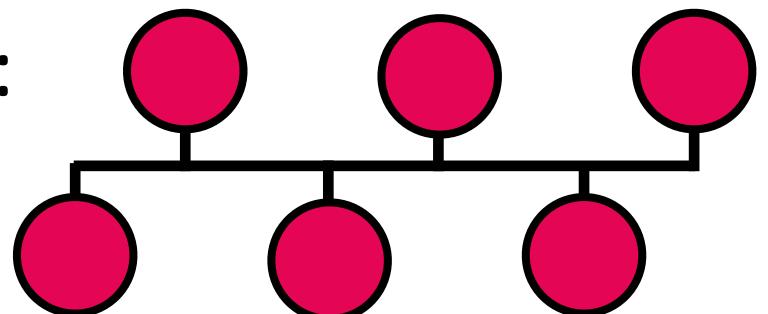
Ring:



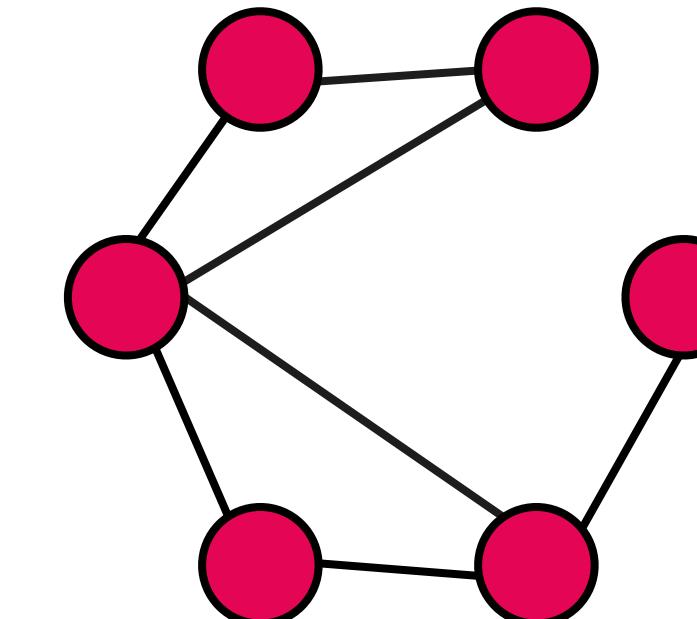
Star:



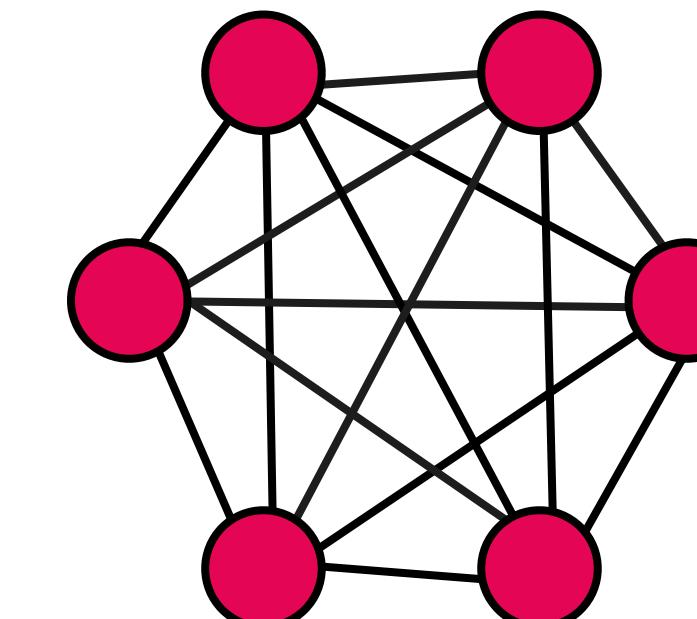
Bus:



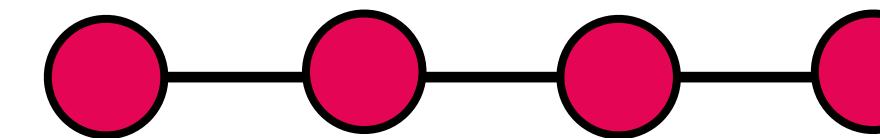
Mesh
(partially connected):



Mesh
(fully connected):



Lineair:



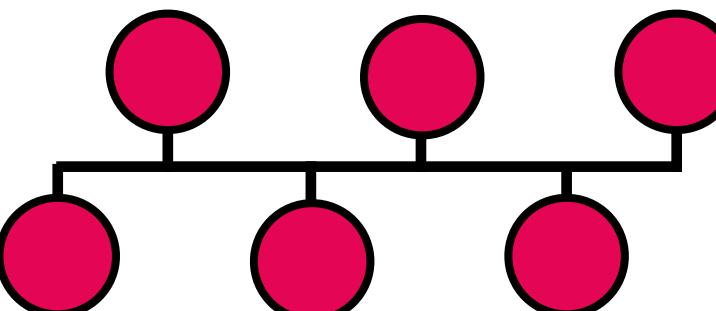
Connections: Network cables, Wired Topologies

Look at different network structures (topologies):

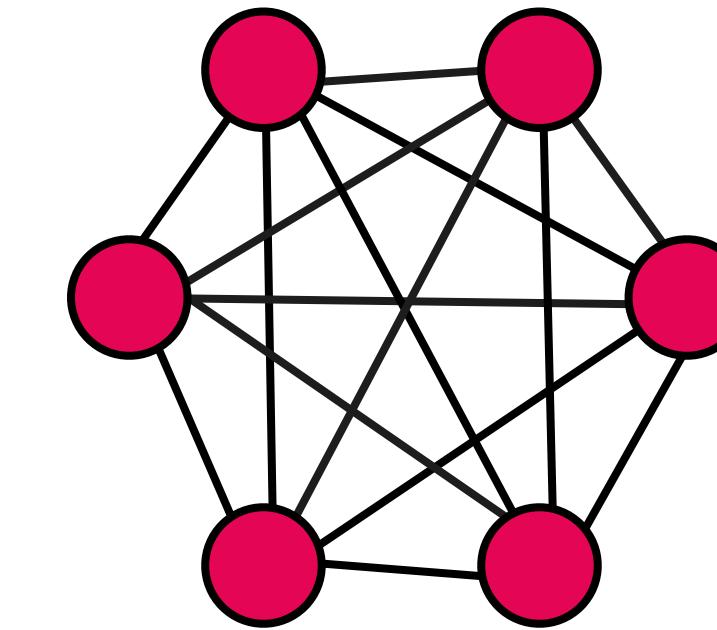
What topology fits:

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

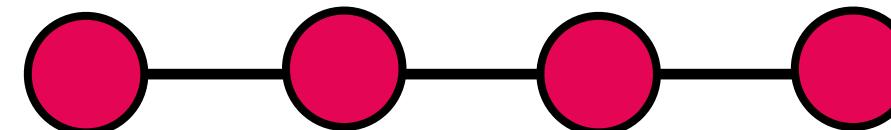
Bus:



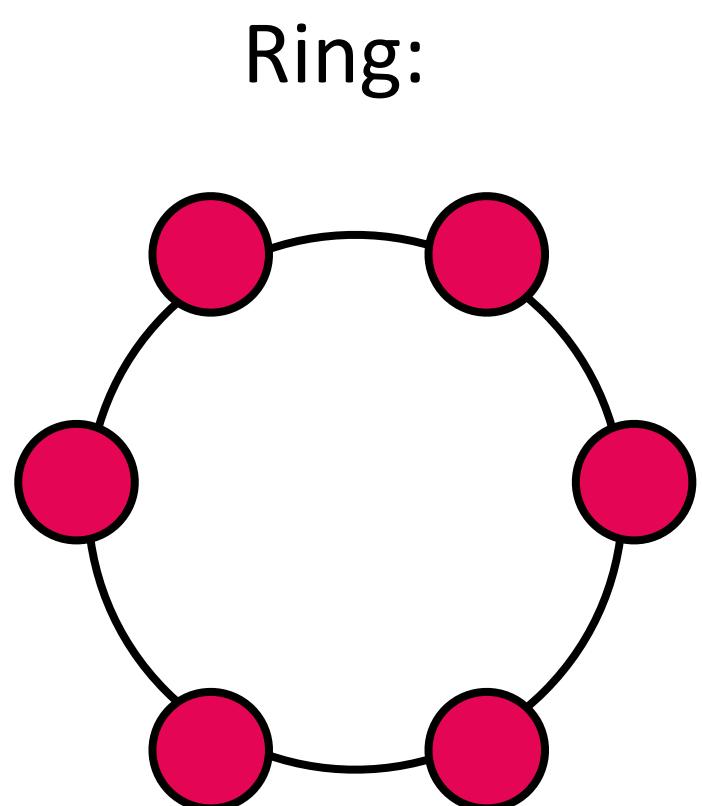
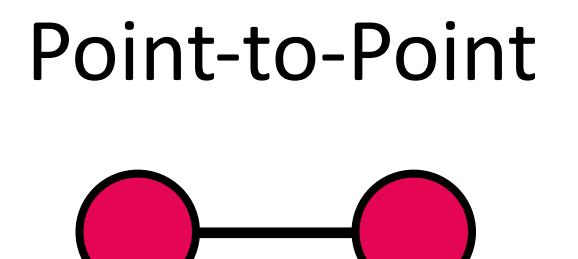
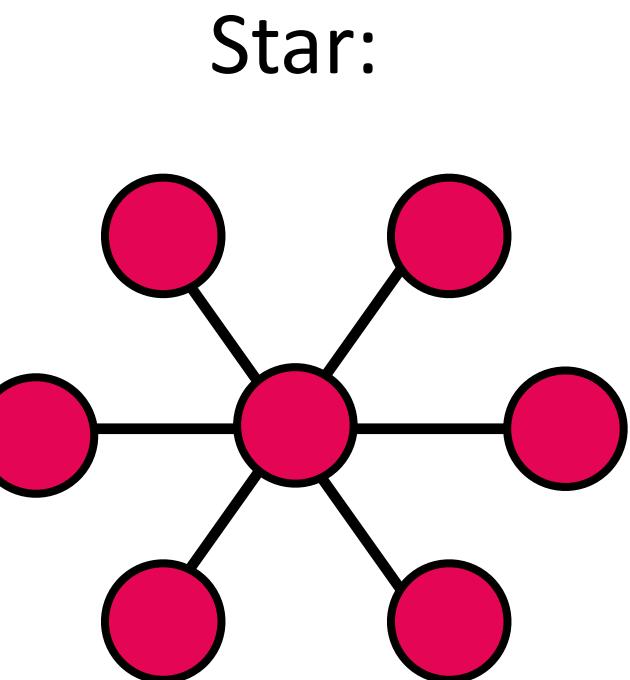
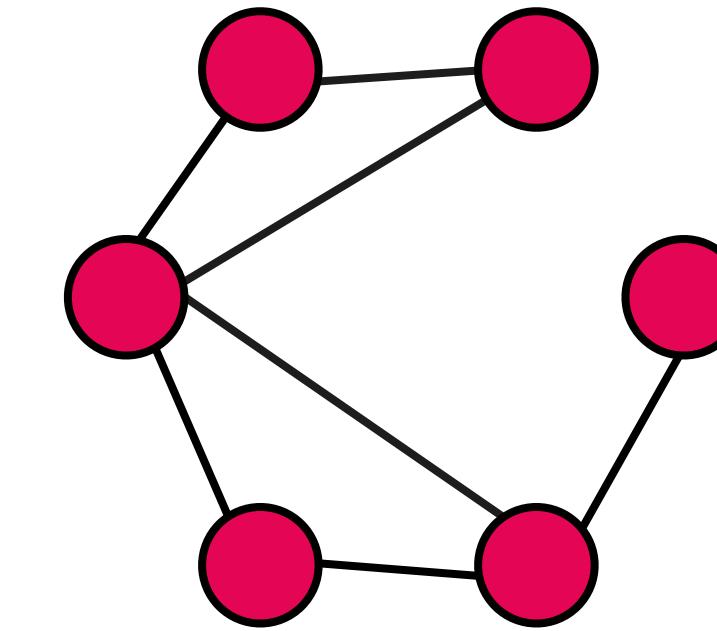
Mesh
(fully connected):



Lineair:



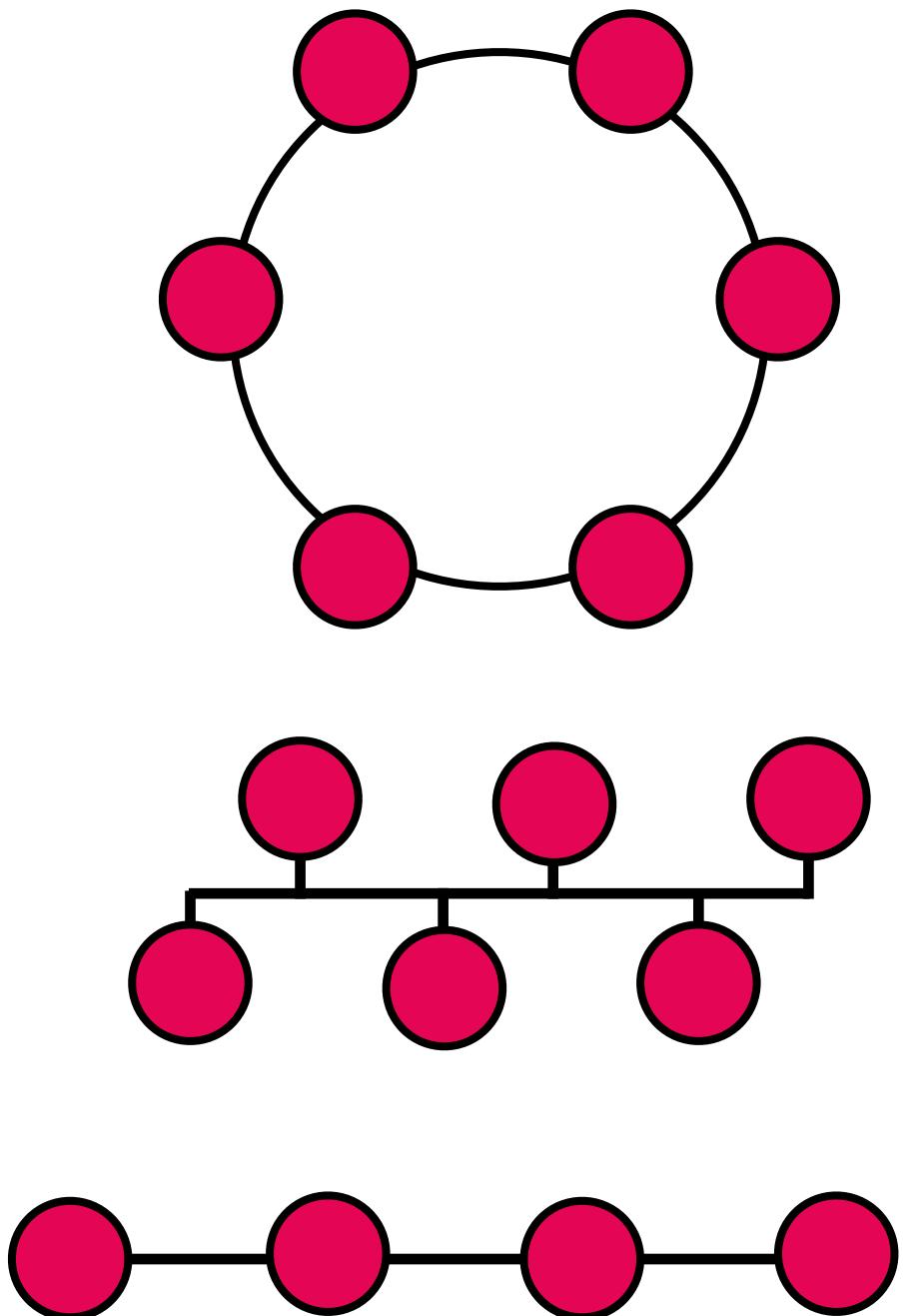
Mesh
(partially connected):



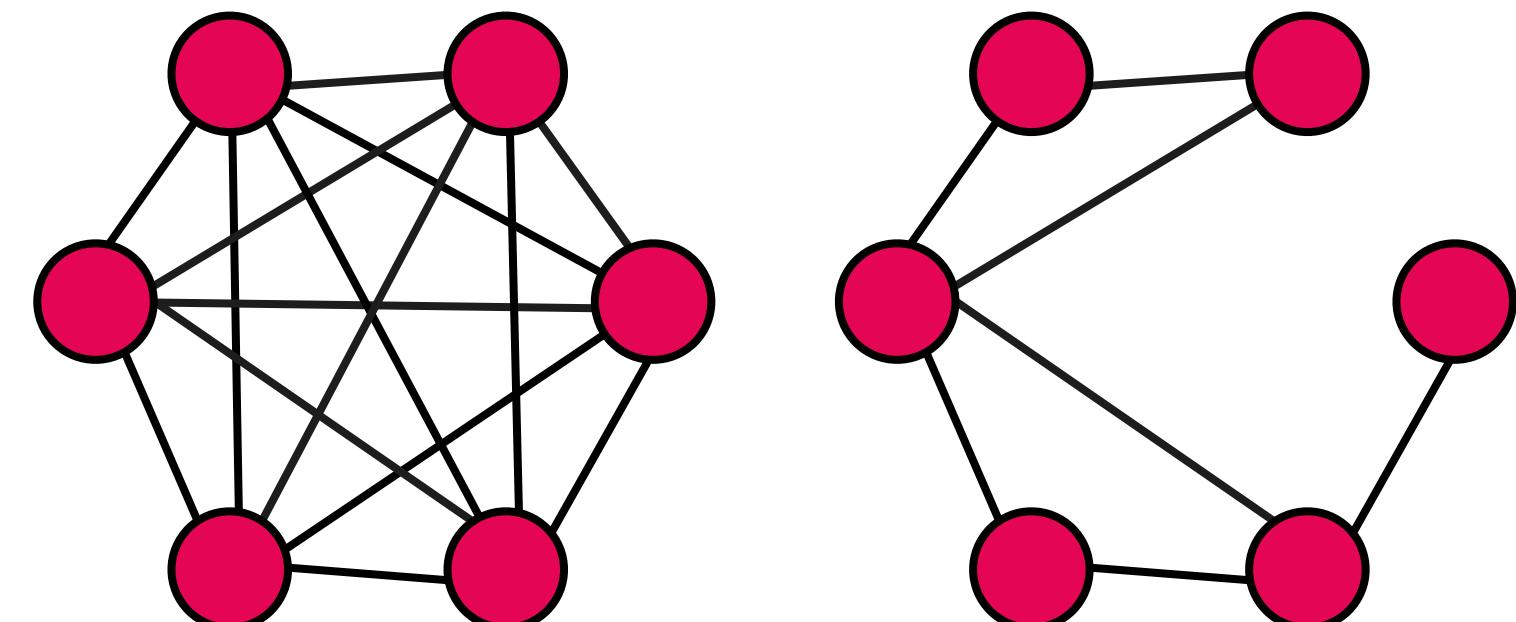
Connections: Network cables, Wired Topologies

Topologies depend on their physical medium.

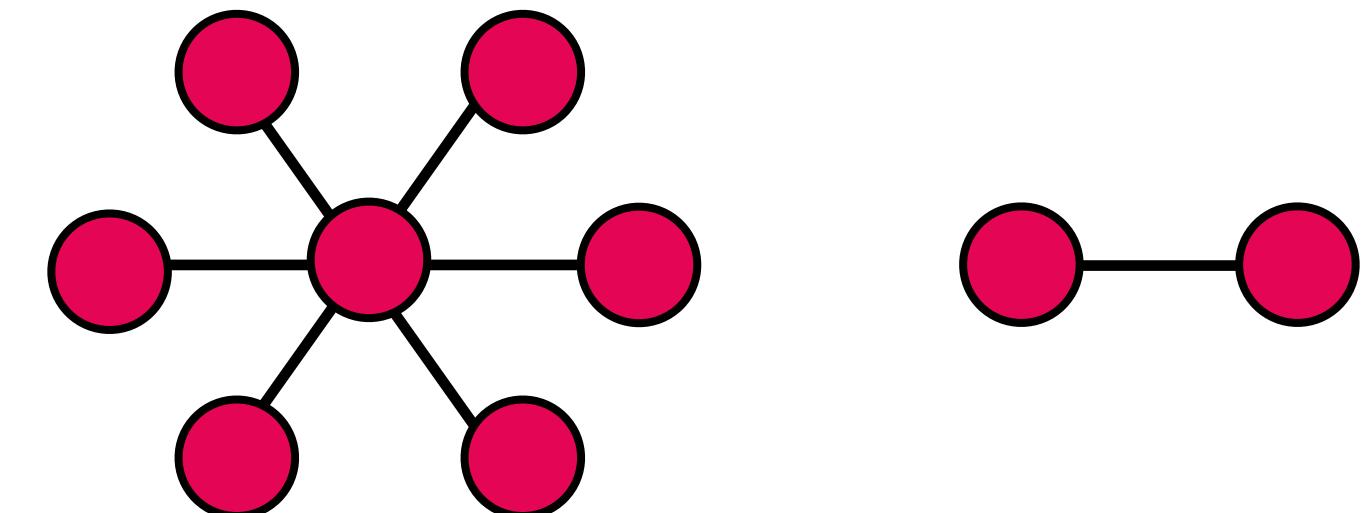
Typically Wired:



Typically Wireless:



Wired or Wireless:



Connections: Network cables, Wired Topologies

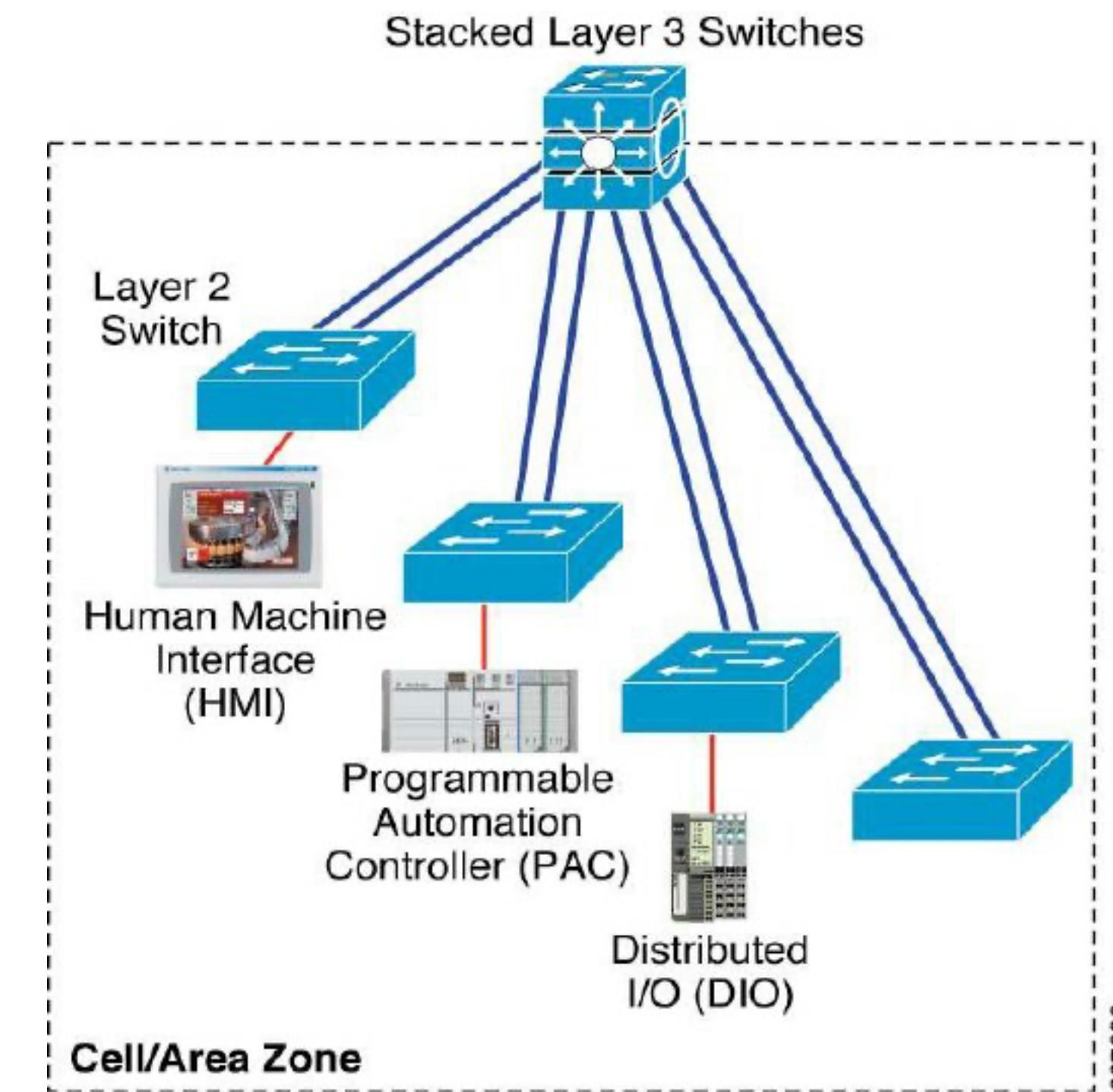
Topologies depend on their physical medium.

What topology fits:

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

Industrial Topologies: Redundant Star Topology

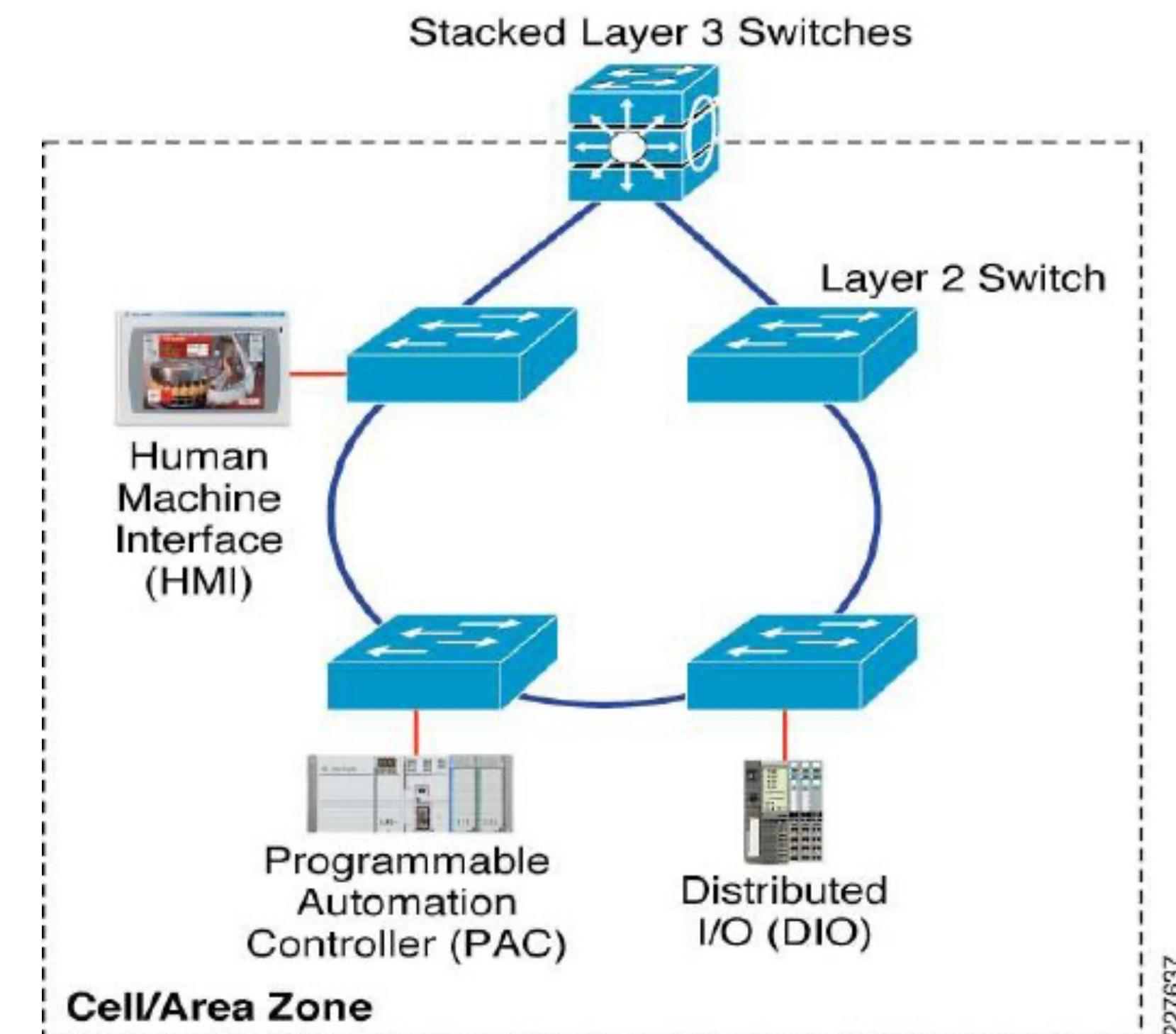
Redundant Star Topology



https://www.researchgate.net/publication/289139888_BEng_Seminar

Industrial Topologies: Redundant Star Topology

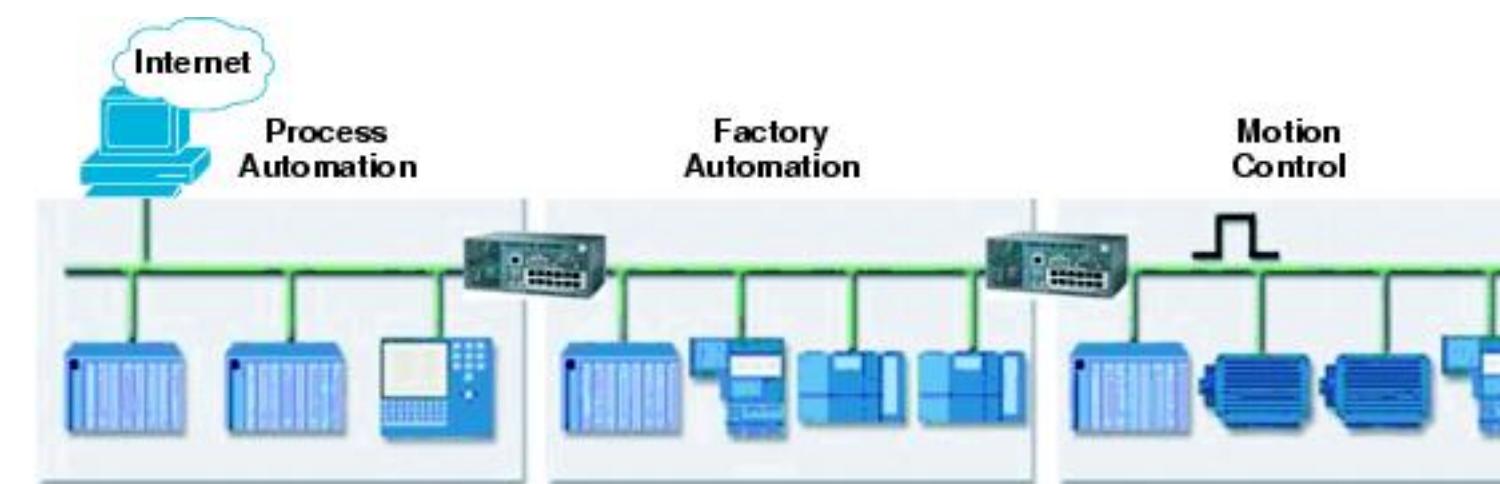
Ring Topology



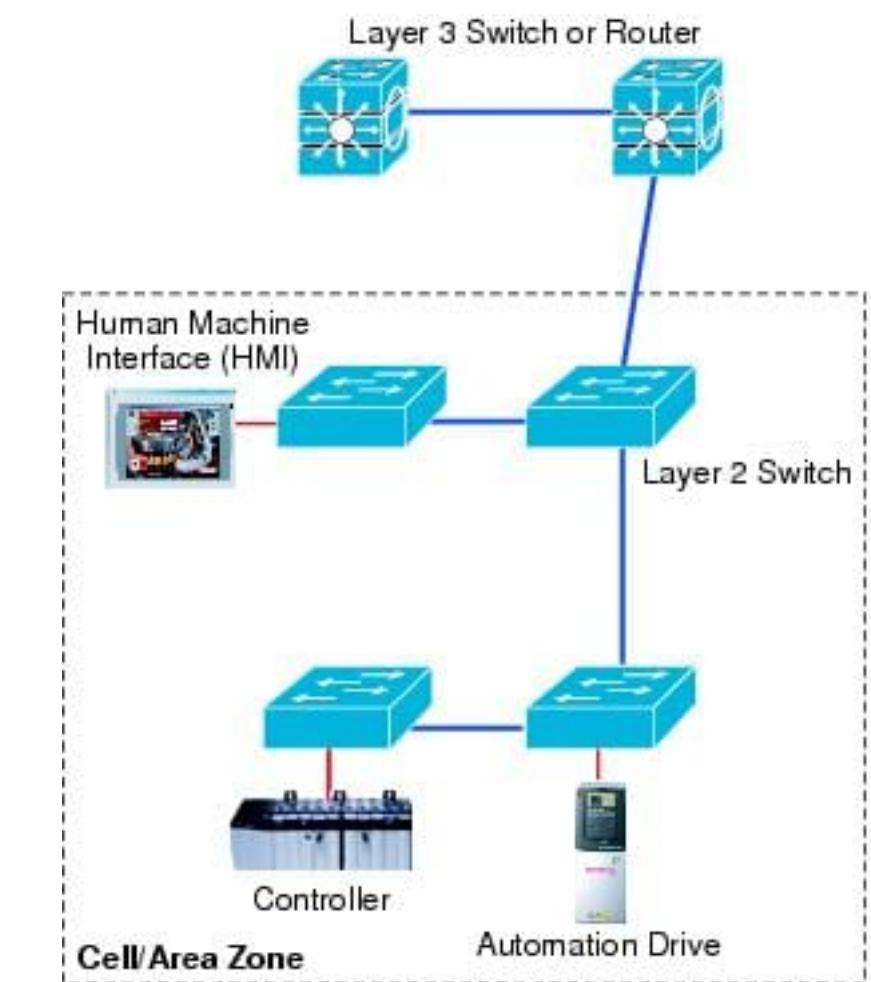
227637

Industrial Topologies: Redundant Star Topology

Bus Topology



| Function | Information Integration, Slower Process Automation | Factory Automation | Motion Control |
|------------------|---|---|--|
| Comms Technology | .Net, DCOM, TCP/IP | Standard Ethernet + RT Protocol | Hardware/software solution |
| Period | 1 second or longer | 10 ms to 100 ms | <1 ms |
| Industries | Oil and gas, chem, energy, water | Auto, food and bev, elect. assembly, semiconductor, metals, pharma | Subset of factory automation |
| Applications | Pumps, compressors, mixers Monitoring of temp, press, flow | Material handling, filling, labeling, palletizing, packaging Welding, stamping, cutting, metal forming, soldering, sorting | Synchronization of mult. axes: printing presses, wire drawing, web making, picking and placing |



https://www.cisco.com/c/en/us/td/docs/solutions/Verticals/EttF/EttFDIG/ch1_EttF.html

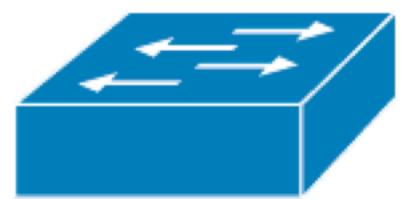
IACS Network Components

What do all those strange figures in the previous slides mean?

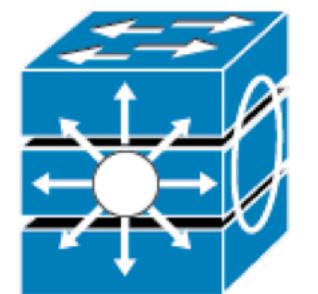
IACS:

Industrial Automation and Control Systems

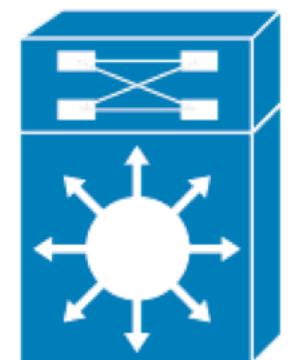
IACS Network Components (Converged Plantwide Ethernet (CPwE))



Layer 2 Industrial Ethernet access switch



Multilayer distribution switch



Router/Switch



Firewall

IACS Network Components (Converged Plantwide Ethernet (CPwE))



Programmable Automation Controller (PAC)



Variable Frequency Drive (VFD)



Human Machine Interface (HMI)



Distributed Input/Output (DIO)



Safety Distributed Input/Output (DIO)

https://literature.rockwellautomation.com/idc/groups/literature/documents/td/enet-td001_-en-p.pdf

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 | | 802.15.4 |
| ModBus | | 6LoWPAN |
| DeviceNET | Profinet | Bluetooth/LE |
| CANOpen | Ethernet/IP | Cellular |
| CC-Link | Ethernet/CAT | LoRa |
| AS-I | Modbus TCP | Wi-Fi |
| Interbus | | WirelessHART |
| ControlNet | | ZigBee |

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

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?

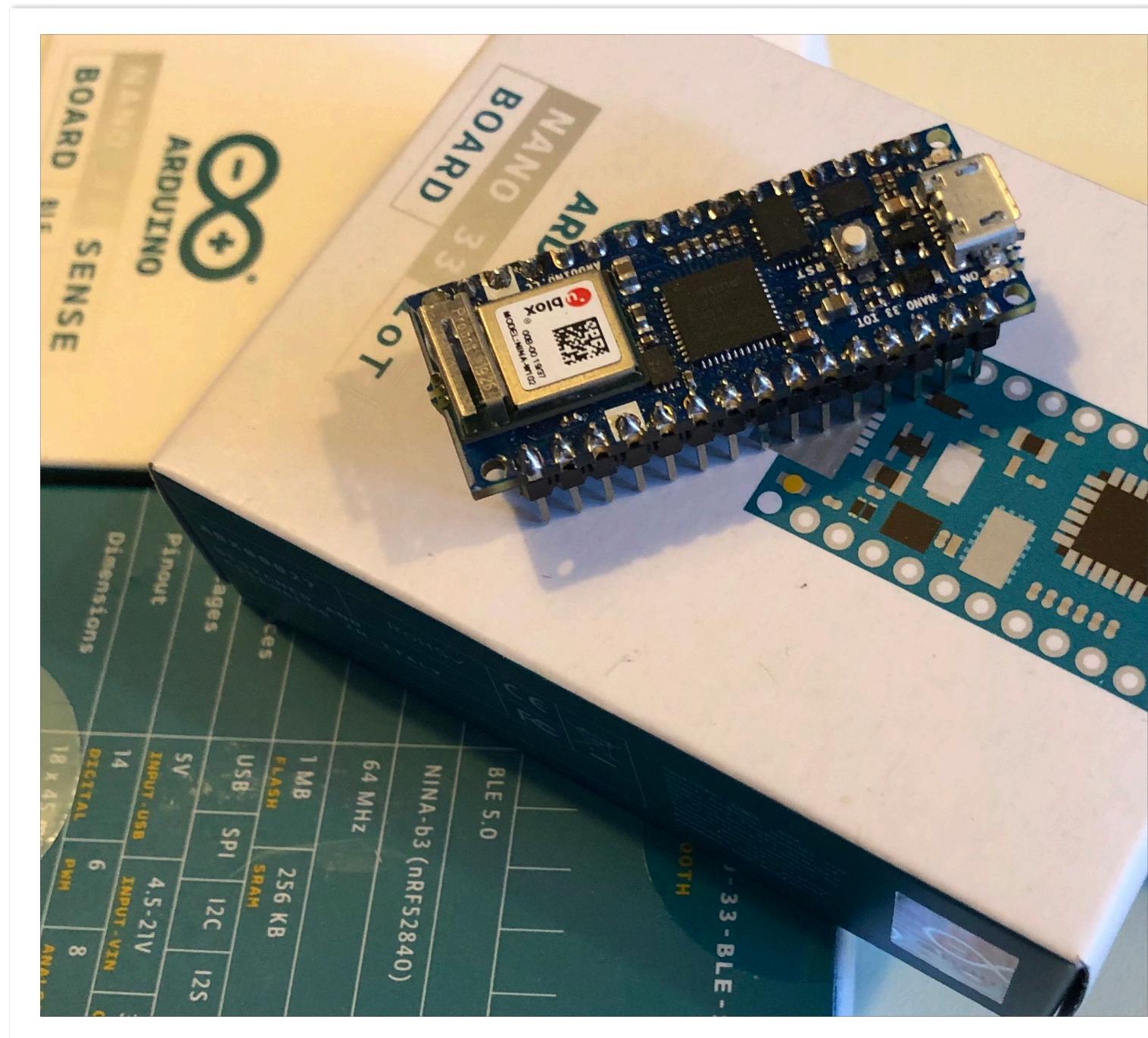
Cisco modules

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

Homework for next session: Les 3.

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: [Bluetooth Low Energy and IoT](#)



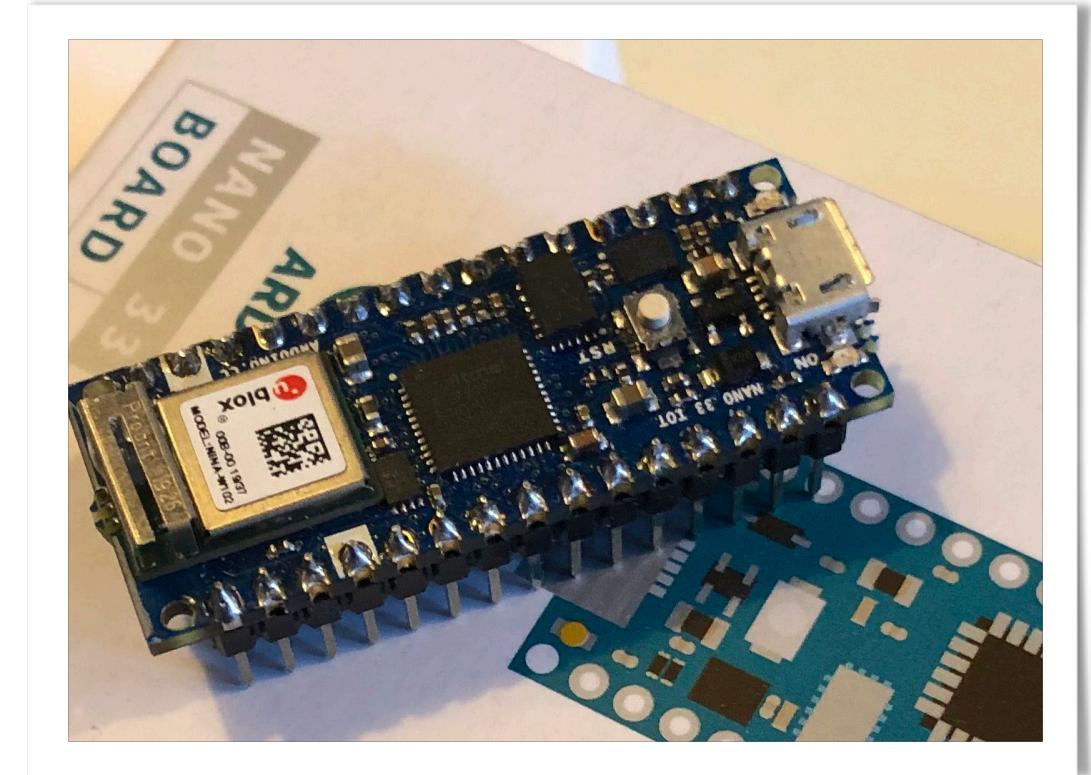
BLExpr (iOS)



LightBlue (iOS)



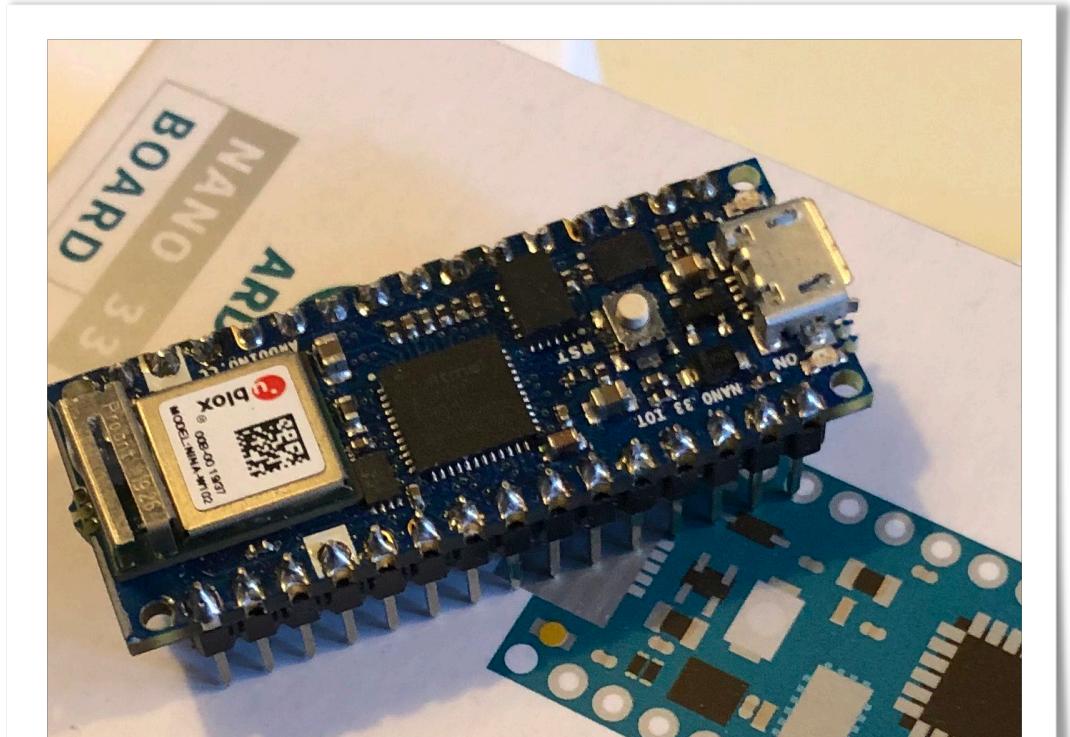
LightBlue (Android)



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](#)



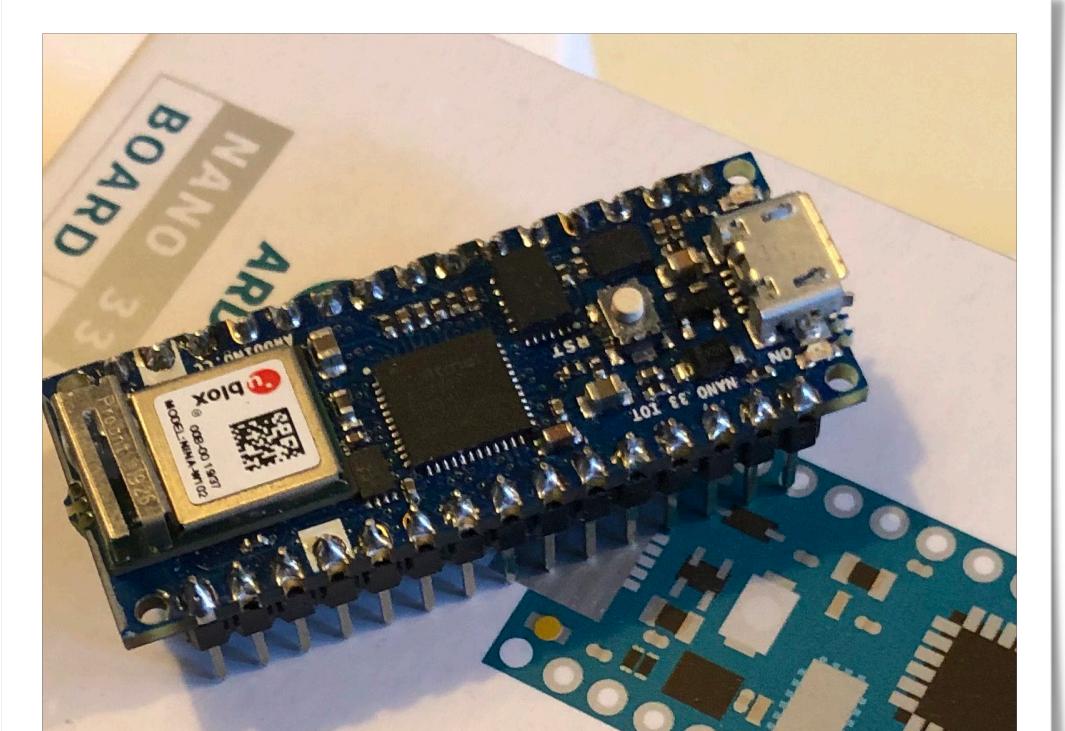
Arduino 1.x IDE Menu Cheat Sheet (not entirely visible in videos)

| Arduino | Bestand | Bewerken | Schets | Hulpmiddelen |
|--------------------|-----------------------|---------------------------------------|---|---|
| About Arduino | Nieuw ⌘ N | Ongedaan maken ⌘ Z | Verifieer/Compileer ⌘ R | Automatische opmaak ⌘ T |
| Preferences... ⌘ , | Open... ⌘ O | Opnieuw doen ⌘ ⌥ Z | Upload ⌘ U | Sla schets op |
| Services > | Open Recent > | Knippen ⌘ X | Uploaden met programmer ⌘ ⌥ U | Codering herstellen en opnieuw laden |
| Hide Arduino ⌘ H | Schetsboek > | Kopiëren ⌘ C | Exporteer gecompileerd Binair bestand ⌘ ⌥ S | Bibliotheken beheren... ⌘ I |
| Hide Others ⌘ H | Voorbeelden > | Kopiëren voor het Forum ⌘ ⌥ C | Schetsmap weergeven ⌘ K | Seriële monitor ⌘ M |
| Show All | Sluiten ⌘ W | Kopiëren als HTML ⌘ ⌥ C | Bibliotheek gebruiken > | Seriële Plotter ⌘ L |
| Quit Arduino ⌘ Q | Opslaan ⌘ S | Plakken ⌘ V | Voeg bestand toe... | WiFi101 / WiFiNINA Firmware Updater |
| | Opslaan als... ⌘ ⌥ S | Alles selecteren ⌘ A | | Board: "Arduino NANO 33 IoT" > |
| | Pagina-instelling ⌘ P | Ga naar lijn... ⌘ L | | Poort: "/dev/cu.usbmodem141201 (Arduino NANO 33 IoT)" > |
| | Afdrukken ⌘ P | Opmerking maken/opmerking wissen ⌘ / | | Haal Board Info |
| | | Insprong vergroten ⌘ → | | Programmer > |
| | | Insprong verkleinen ⌘ ← | | Bootloader branden |
| | | Increase Font Size ⌘ + | | |
| | | Decrease Font Size ⌘ - | | |
| | | Zoek... ⌘ F | | |
| | | Zoek volgende ⌘ G | | |
| | | Zoek vorige ⌘ ⌥ G | | |
| | | Selectie gebruiken voor zoekactie ⌘ E | | |

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

Industrial Topologies:

https://www.cisco.com/c/en/us/td/docs/solutions/Verticals/CPwE/CPwE_DIG/CPwE_chapter1.html

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?!

Thank you! That's all for now!