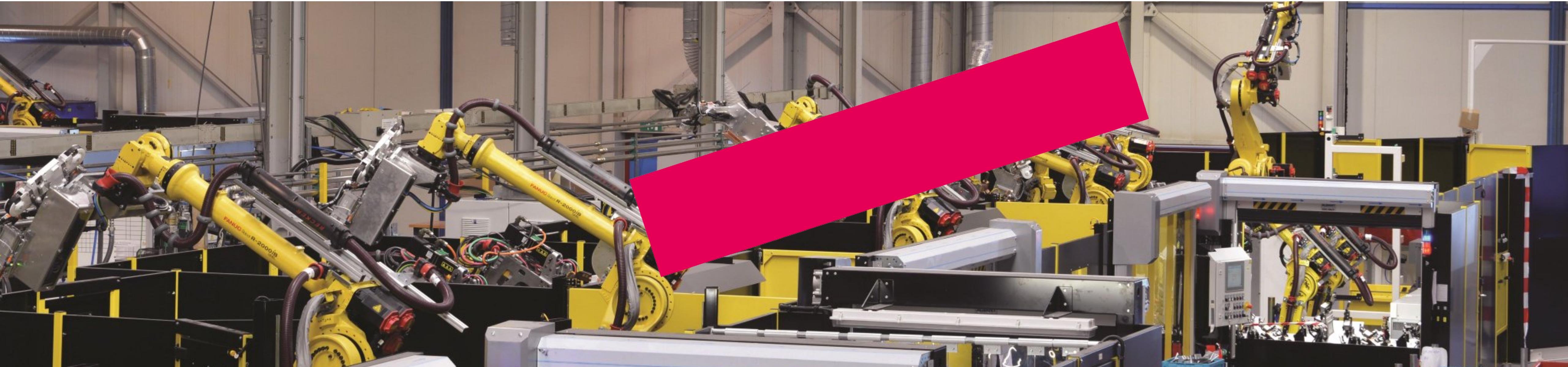


Connected Factories lecture 2/6: Network connections



Associate Degree Smart Industry
Faculty of Engineering and Automotive

johan.korten@han.nl

V1.0 April 2, 2020

Schedule

	Theme	
Lecture 1	Introduction	
Lecture 2	Today: Network connections	
Lecture 3	Network protocols	
Lecture 4	Interconnections	
Lecture 5	Security	
Lecture 6	Safety	
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, proprietary, 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)

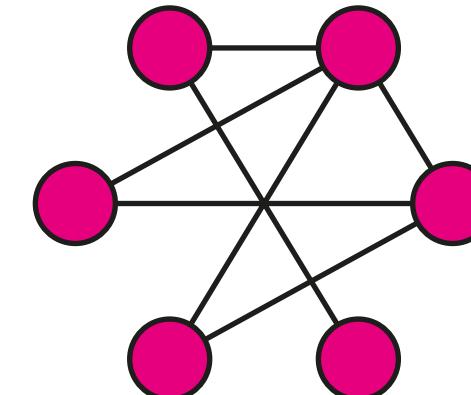
- Parallel vs. Serial
- Asynchronous vs. Synchronous

Connections: Network cables, Wired Topologies

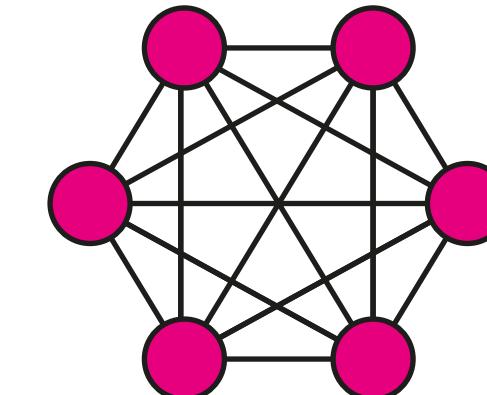
Look at different network structures (topologies):

What do you notice?

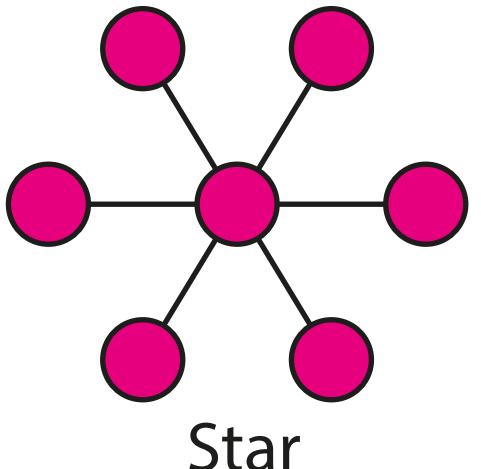
Mesh
(partially connected)



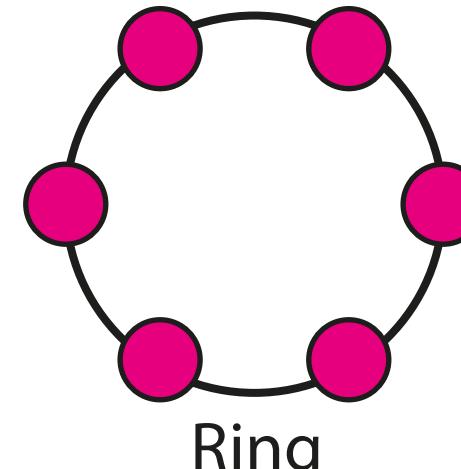
Mesh
(fully connected)



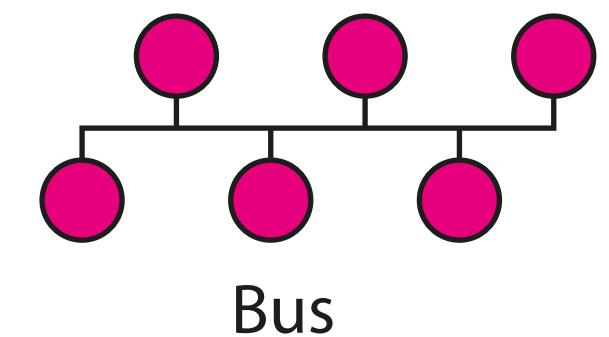
Point-to-Point



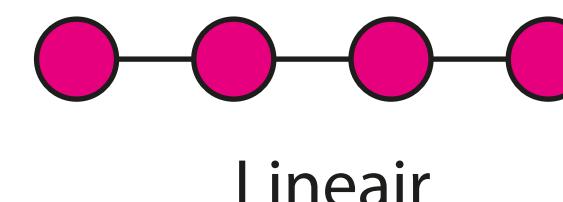
Star



Ring



Bus



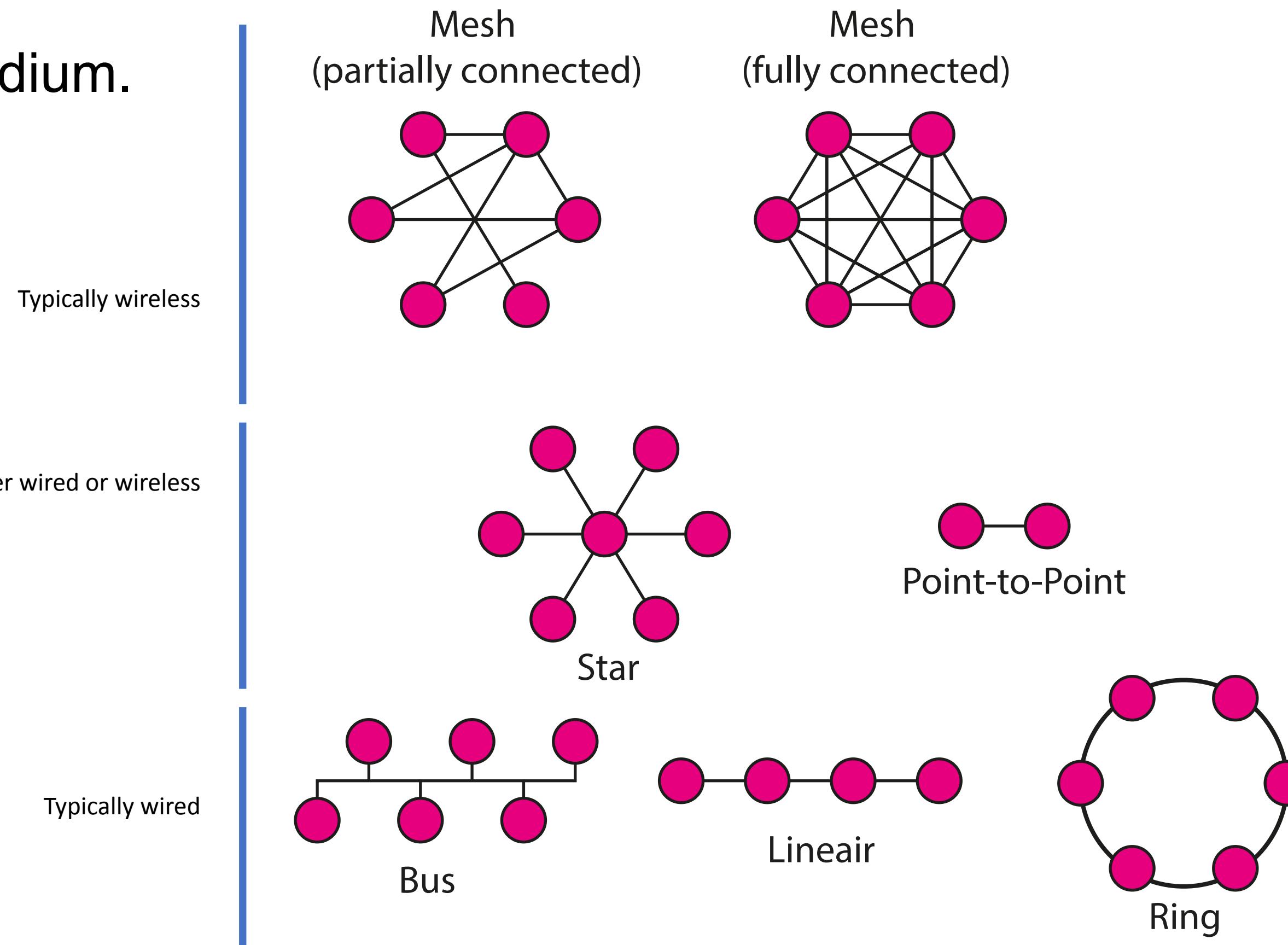
Lineair

Connections: Network cables, Wired Topologies

Topologies depend on their physical medium.

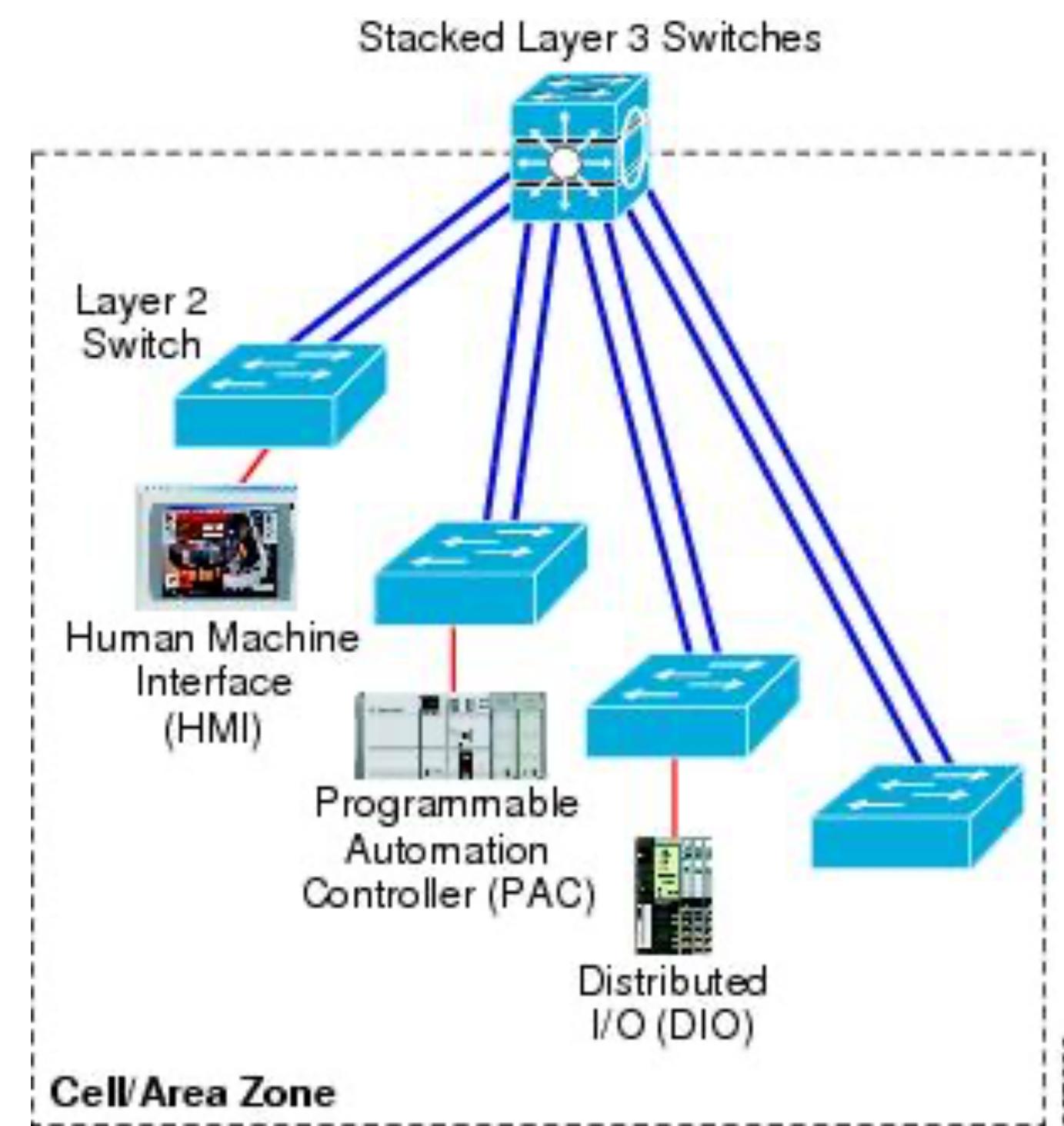
What topology fits:

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



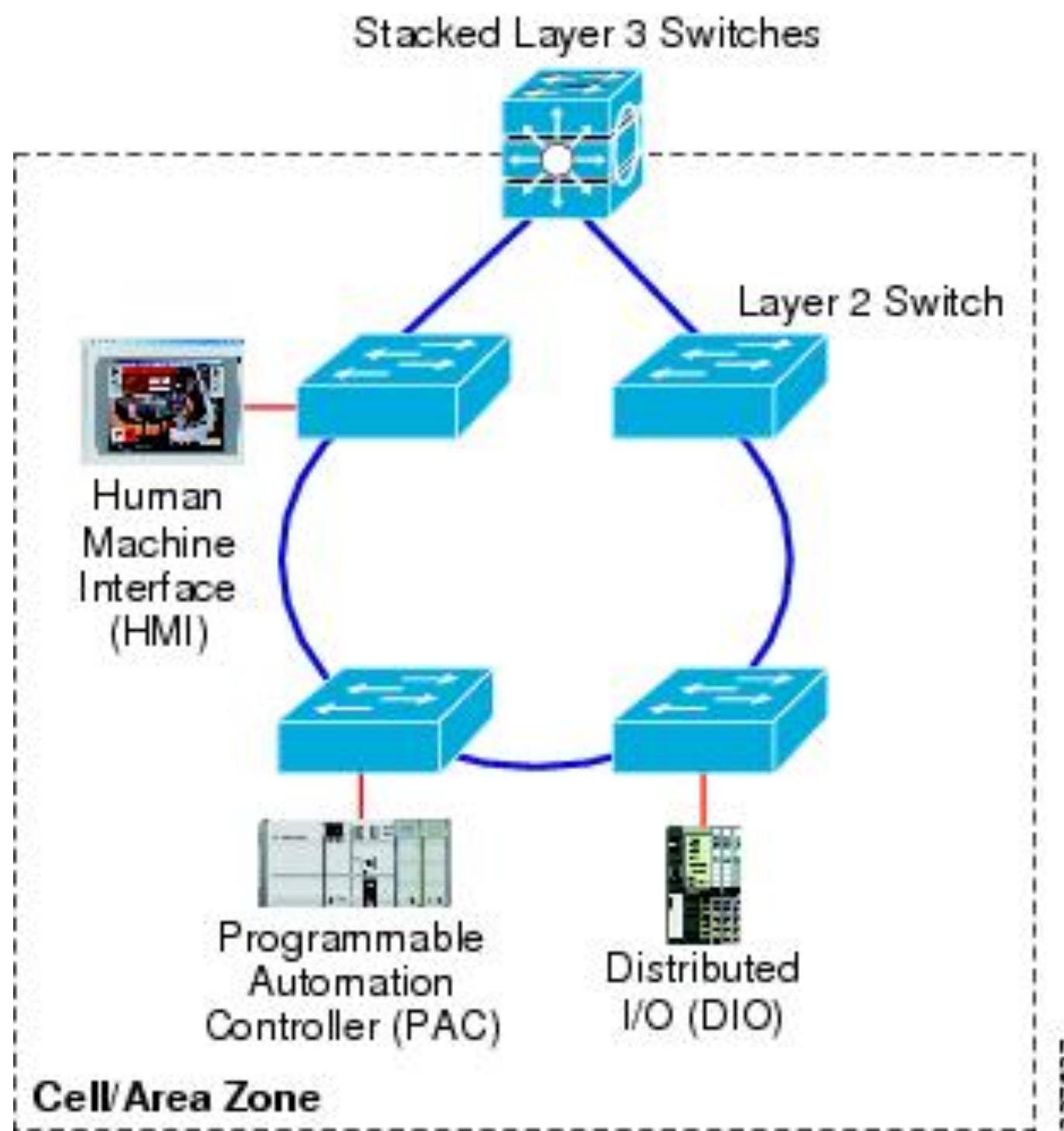
Industrial Topologies: Redundant Star Topology

Redundant Star Topology



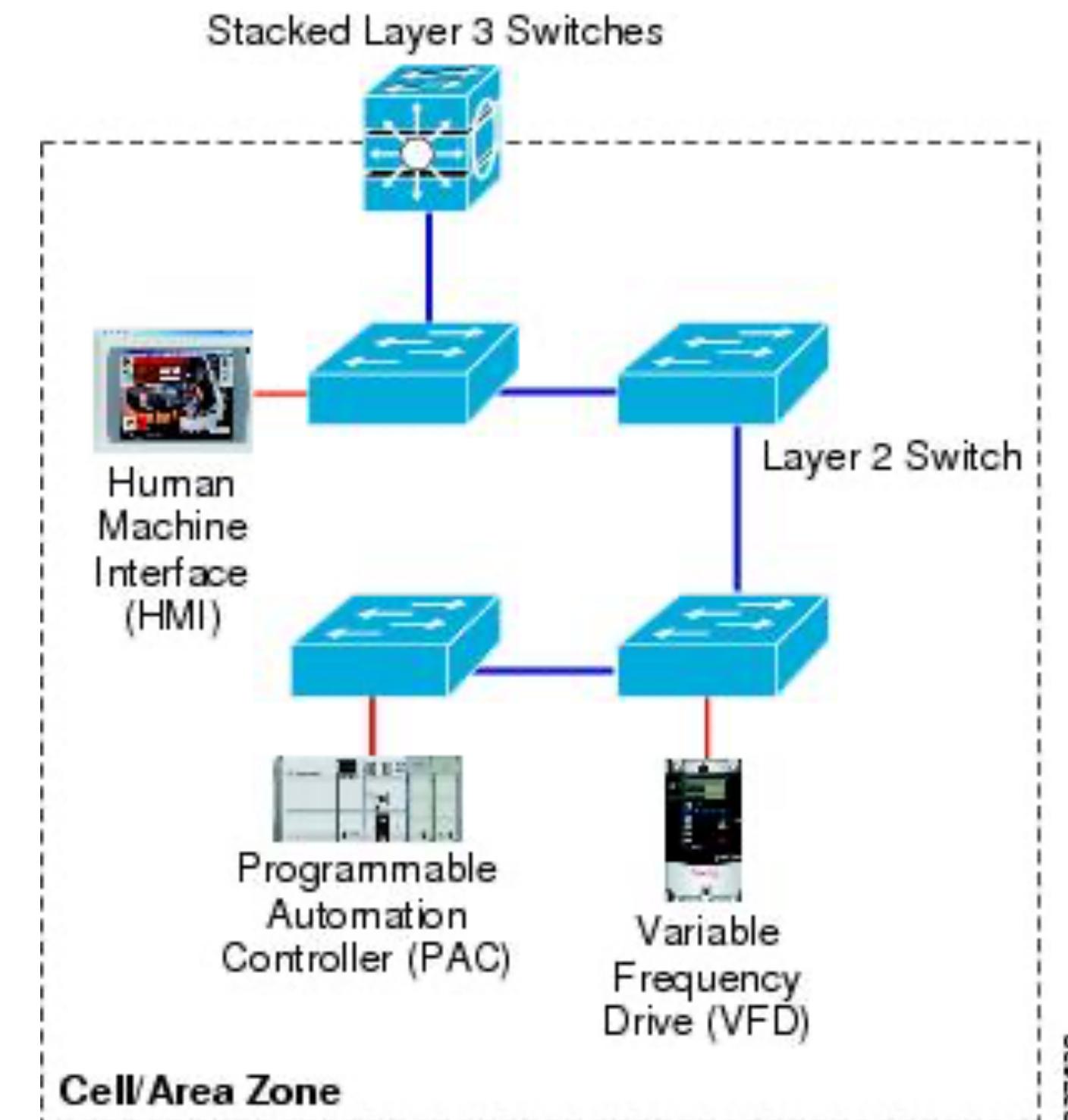
Industrial Topologies: Ring Topology

Ring Topology



Industrial Topologies: Bus Topology

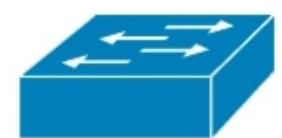
Bus Topology



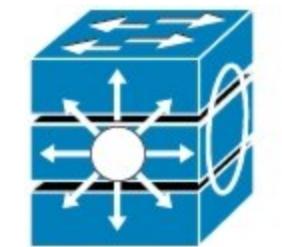
IACS Network Components

IACS: Industrial Automation and Control Systems

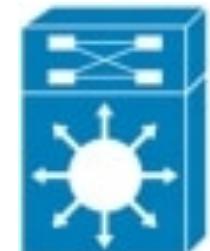
IACS Network Components



Layer 2 Industrial Ethernet access switch



Multilayer distribution switch



Router/Switch



Firewall

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

IACS Network Components



Programmable Automation Controller (PAC)



Safety Programmable Controller



Variable Frequency Drive (VFD)



Human Machine Interface (HMI)



Distributed Input/Output (DIO)



Safety Distributed Input/Output (DIO)

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

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

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

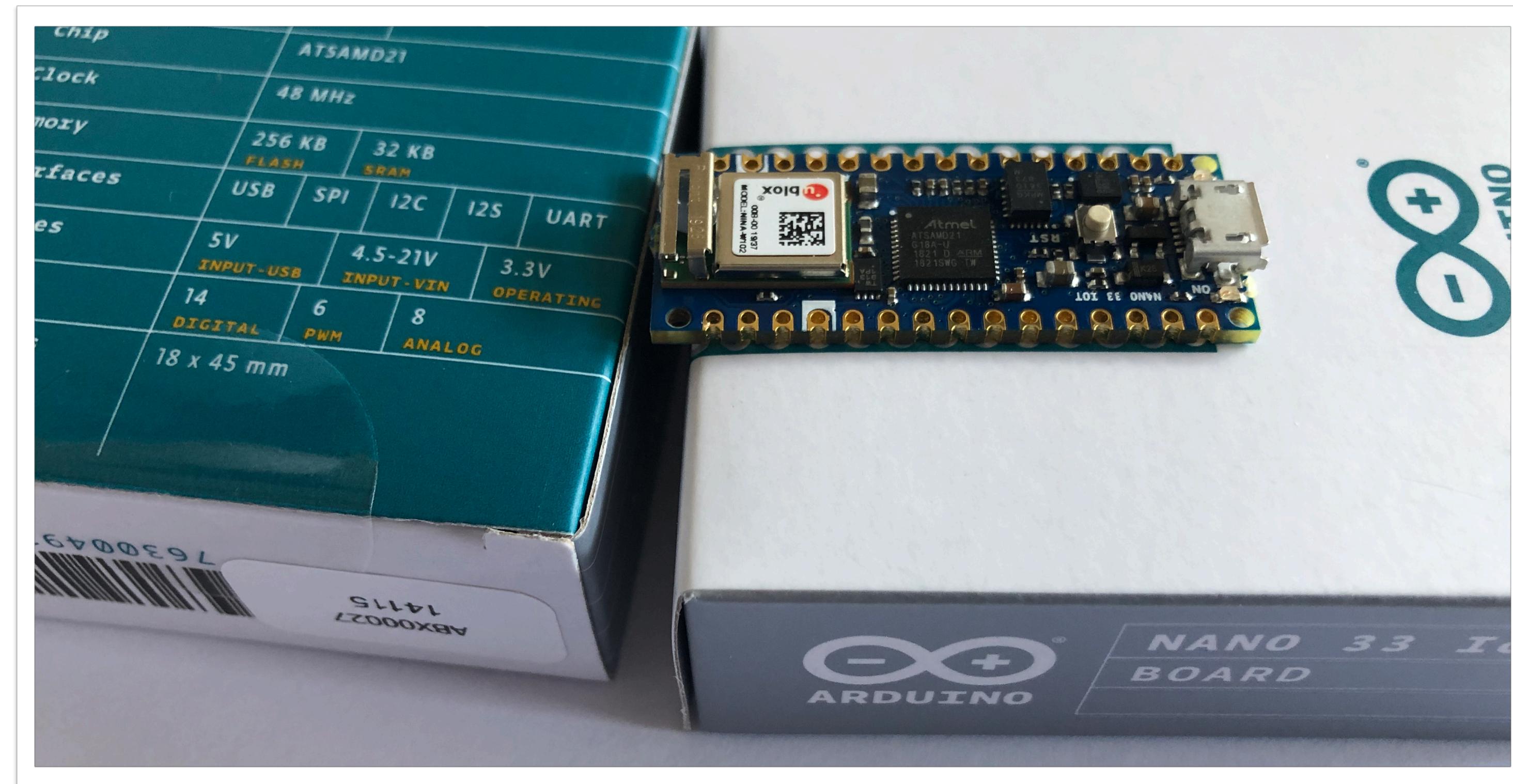
Remember, course URL: <https://www.netacad.com/portal/learning>

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.

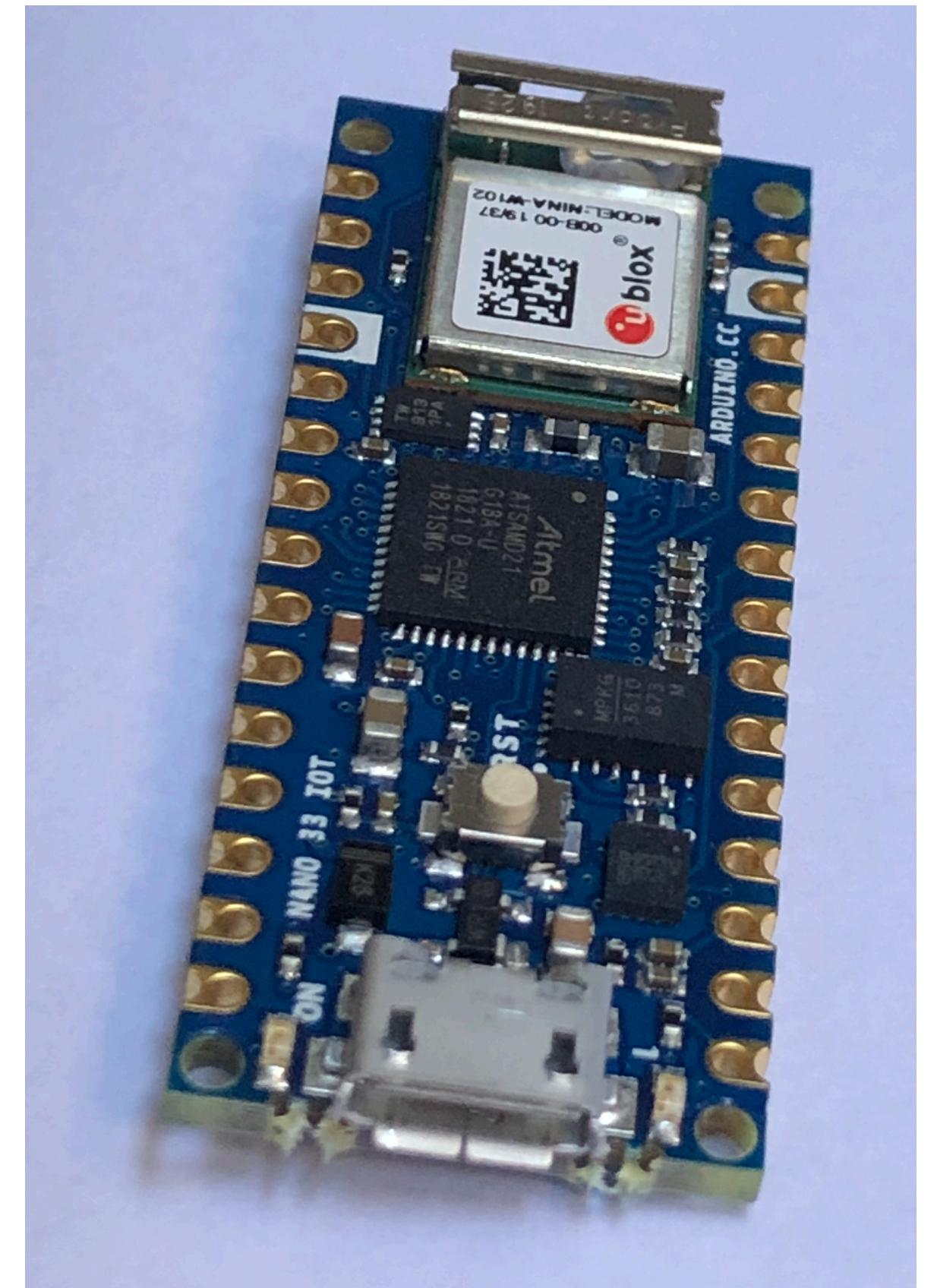
- Turn the module into a Bluetooth Low Energy device
- Try to switch an LED using your phone and bluetooth.

Video: [Bluetooth Low Energy and IoT](#)

BLExr
App Store iOS:
(Click image)



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



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>

BLExr
App Store iOS:
(Click image)



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



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)

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?