Wireless network for AGV

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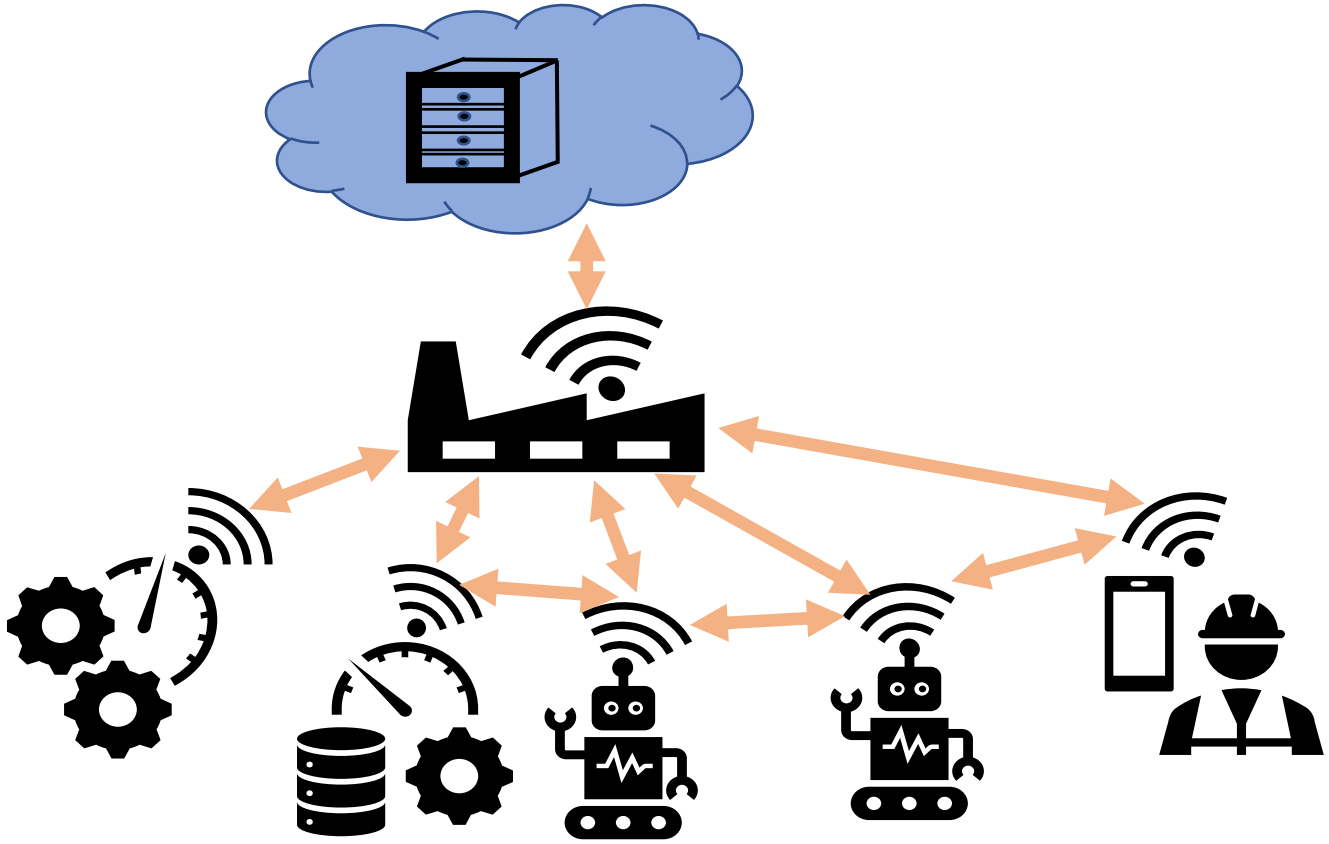
Outline of the presentation

- Why wireless
- Communication Requirements
- Presentation / discussion of protocols / solutions
- A kind of conclusion

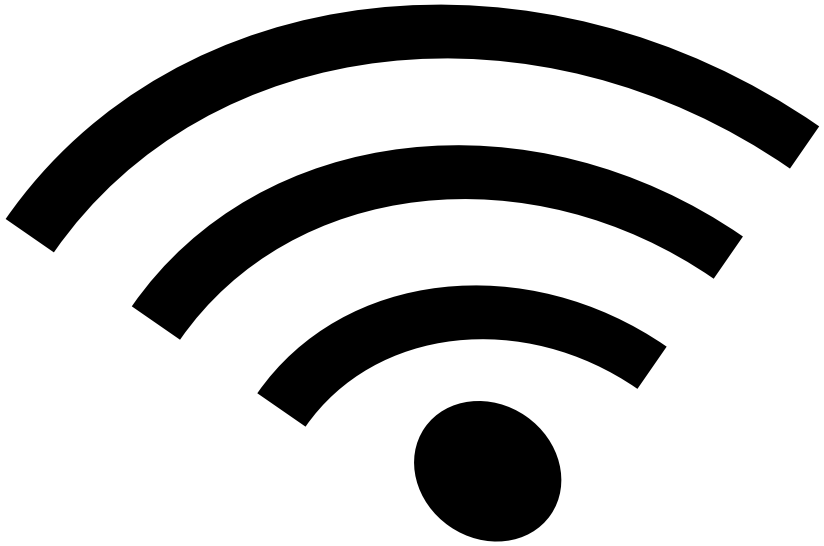
Why wireless

- AGV must be able to move freely across the factory floor
- Neat environments simplify maneuvering moving nodes
- Prevent cutting its own cables
- Prevent getting tangled into its own cable
- Equipping machinery with wireless instead of wired communication makes it easier to change factory layout if needed or desirable



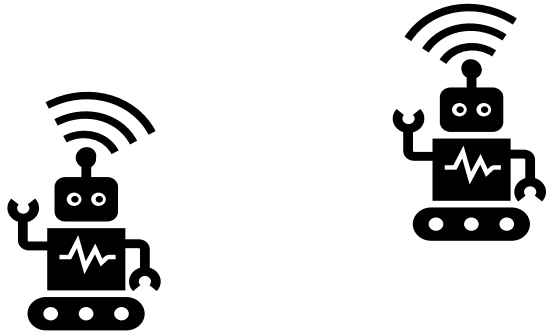
Various wireless protocols

- The wireless protocols have different characteristics in terms of:
  - Delay
  - Range
  - Throughput
  - Reliability



AGV communication requirements

- Reliable
- Delay lower than a given threshold
- Availability
- Energy-awareness
- Security
- Insusceptible of EMI (electromagnetic interference)
- Maintain connectivity while moving



Some potential wireless protocols

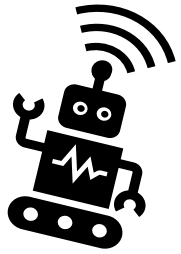
- Long Range Wireless Technologies- LoRaWAN
- Celluar: 5G
- IEEE802.15.4
- ZigBee
- WirelessHART
- ISA100.11A
- IEEE802.11

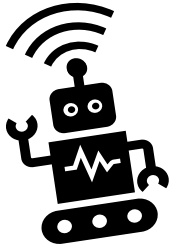
Long Range Wireless IoT Technologies

- Some advantages
  - Long range
  - Ultra low power on the end points
  - Low cost of operations
  - Low cost of ownership.
- Some disadvantages
  - Low data rate
  - Delay

Active / sleep - duty cycling of the end-devices is used to reduce energy consumption

- Different solutions used:
- Downlink only after uplink: End-devise stays awake a limited time after transmission
- Scheduled downlink: A node periodically wake up





LPWAN LoRa

- Sub-GHz ISM band
- Phy layer, proprietary
  - CSS (Chirp Spread Spectrum)
  - The data rate ranges from 300 bps to 50 kbps
  - Link budget 154 dB

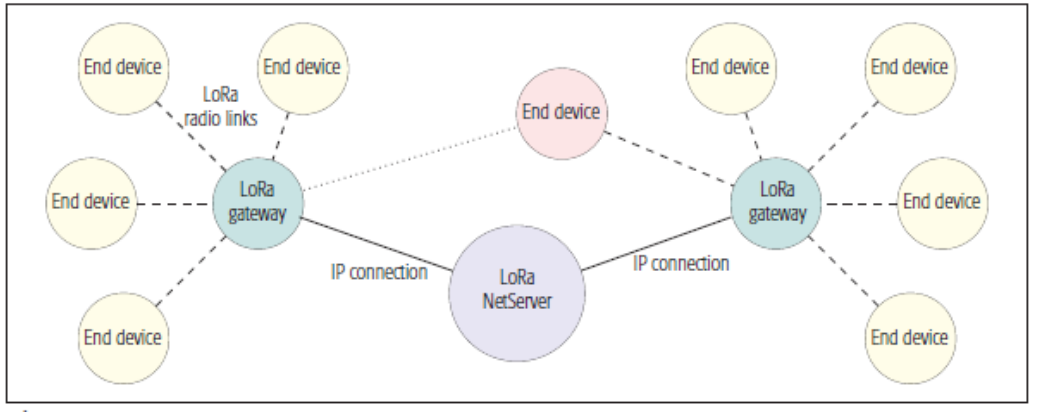


Figure from: M. Centenaro, L. Vangelista, A. Zanella, and M. Zorzi, "Long-range communications in unlicensed bands: The rising stars in the IoT and smart city scenarios," *IEEE Wireless Communications,* vol. 23, no. 5, pp. 60-67, 2016.

- **LoRaWAN,** layer above physical
  - Unslotted Aloha –based
  - Topology: star-of-star topology
    - End device does not associate with a certain gateway, only to the backhaul NetworkServer
  - Three different classes of end-devices
    - A: listen to download communication only shortly after uplink transmission
    - B: can additionally schedule downlink reception from base station at certain intervals
    - C: have capability to continuously listen

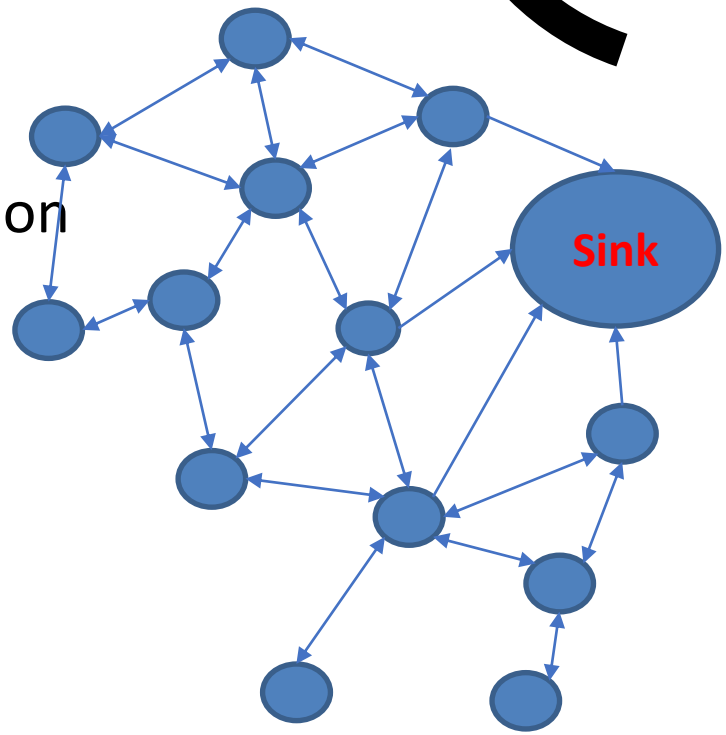
[1] Almuhaya, Mukarram AM, et al. "A Survey on LoRaWAN Technology: Recent Trends, Opportunities, Simulation Tools and Future Directions." *Electronics* 11.1 (2022): 164.

Long Range Wireless IoT Technologies; Network layer

- Long range transmission compared to multihop

- Advantage
  - Multihop have unequal and unpredictable energy consumption
    - Management traffic, forwarding
  - Multihop require dense and expensive deployment of infrastructure

- Disadvantage
  - Long range have lower data rate
  - More delay?



Cellular – 5G Wireless

- High-frequency 3~300 GHz
- Data rate 1 ~ 10 (20?) Gbps
- Low latency: 1ms (according to the 5G- providers)
- Support IoT (M2M)
- Virtual networks (5G slicing) tailored to each use case.
- Massive MIMO- serve multiple users/ combine with beamforming
- Beamforming
- Direct Device to Device (D2D)
- To support massive IoT connections:
  - Heterogeneous Networks (HetNets), small cells having low transmission power

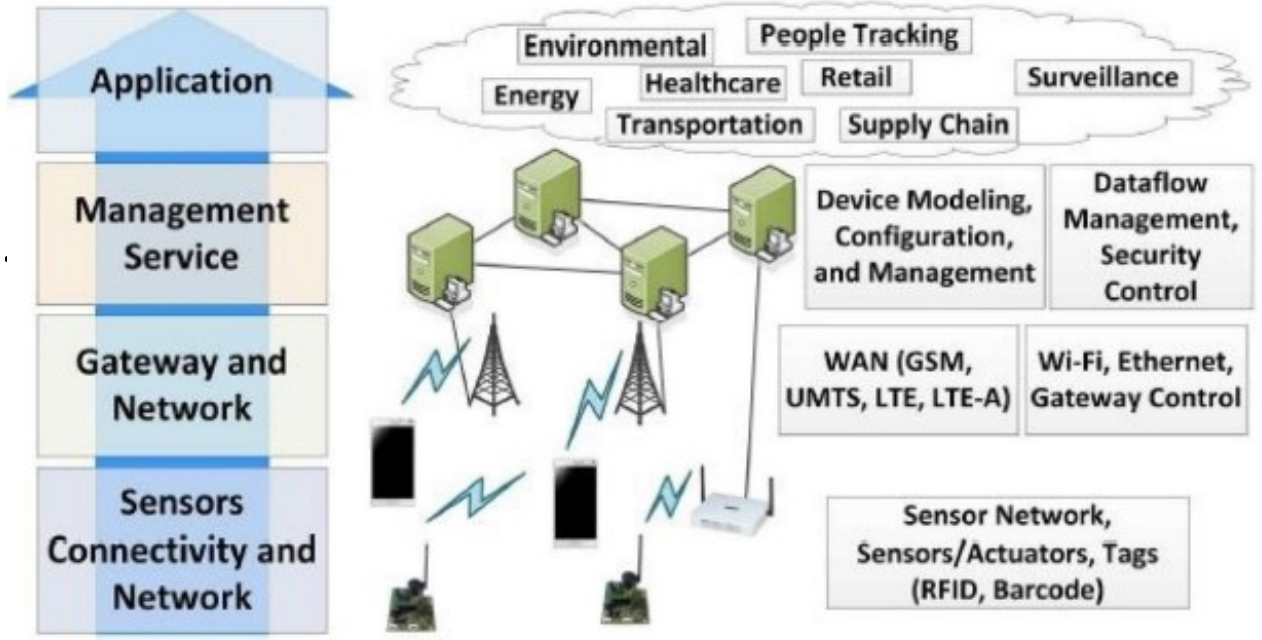


Figure from: Attaran, Mohsen. "The impact of 5G on the evolution of intelligent automation and industry digitization." Journal of Ambient Intelligence and Humanized Computing (2021): 1-17.

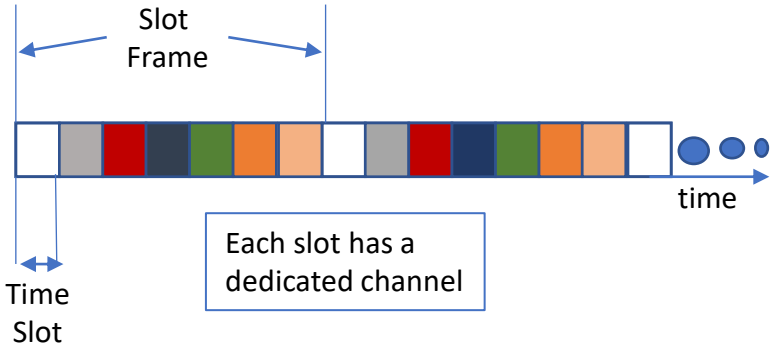
Cellular – 5G Wireless

- Some disadvantages

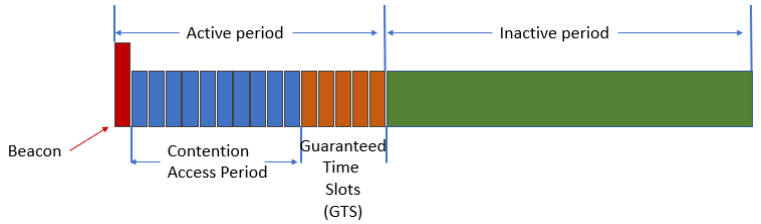
- Cost of spectrum
- Base station density
- Equipment cost / amount of equipment (MIMO), small cells
- Management of large number of small cells
- …..

Conclusions

- Wireless communication is needed to support moving nodes
  - Avoid cutting cables
  - Neat environments
- Communication in industrial environments are subject to both spatial and temporal changes.
- The moving AGV may require adaptable communication solutions



- Technology solutions
  - WirelessHART and ISA100.11a:
    - Timeslot communication to reduce the number of collisions
    - Channel hopping to reduce interference
  - ZigBee
    - Let nodes enter sleep state to reduced energy consumption
    - There is a general tradeoff between delay and energy consumptior
  - LPWAN (ex. LoRaWAN)
    - Long range low cost, low energy
  - Cellular network:
    - QoS guarantee is easier in the licensed spectrum



Thank you for listening !