

Emerging Technologies for the Circular Economy

Lecture 5a: Internet of Things Communications

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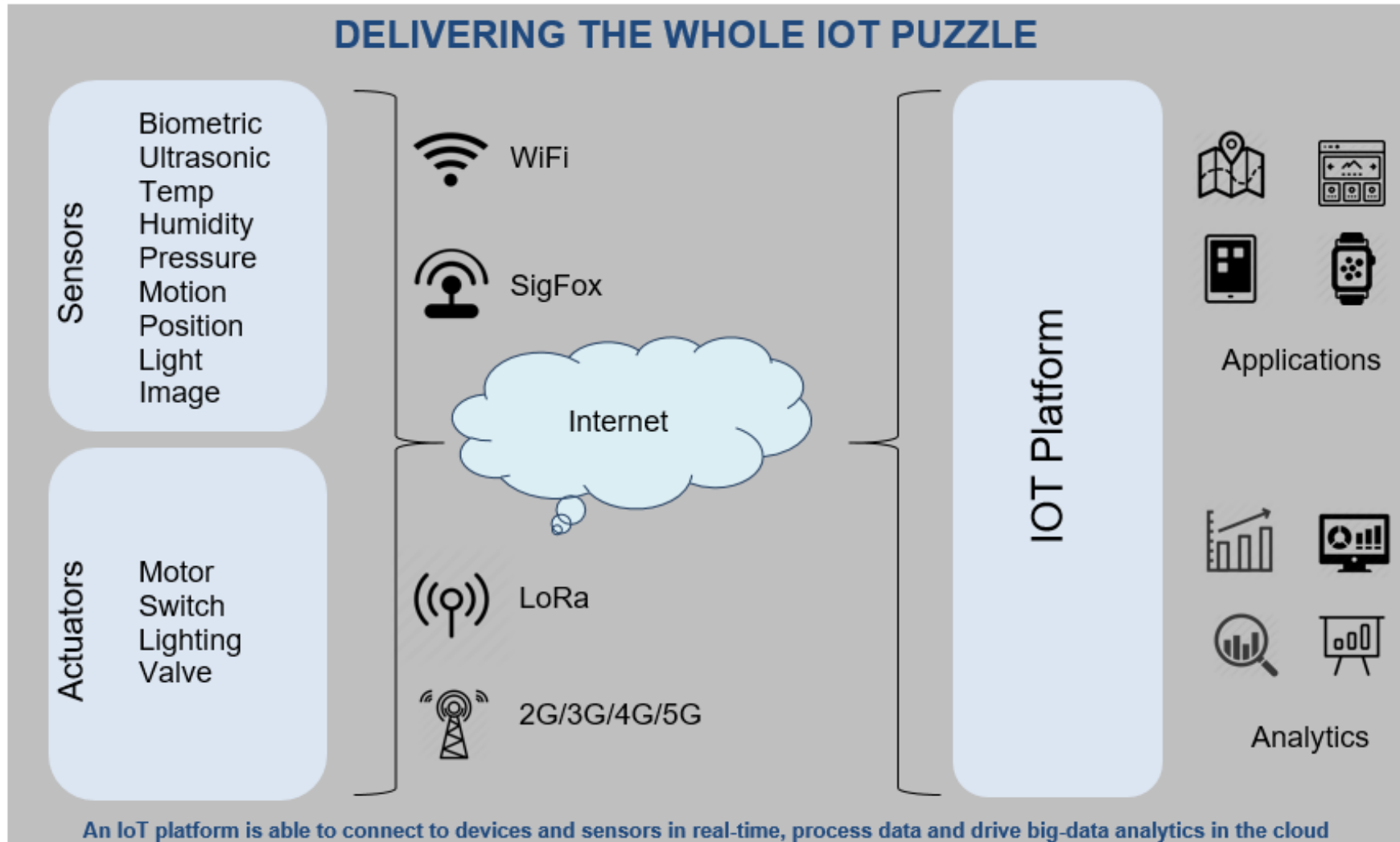
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- Updated versions of these slides will be available in our [Github repository](#).

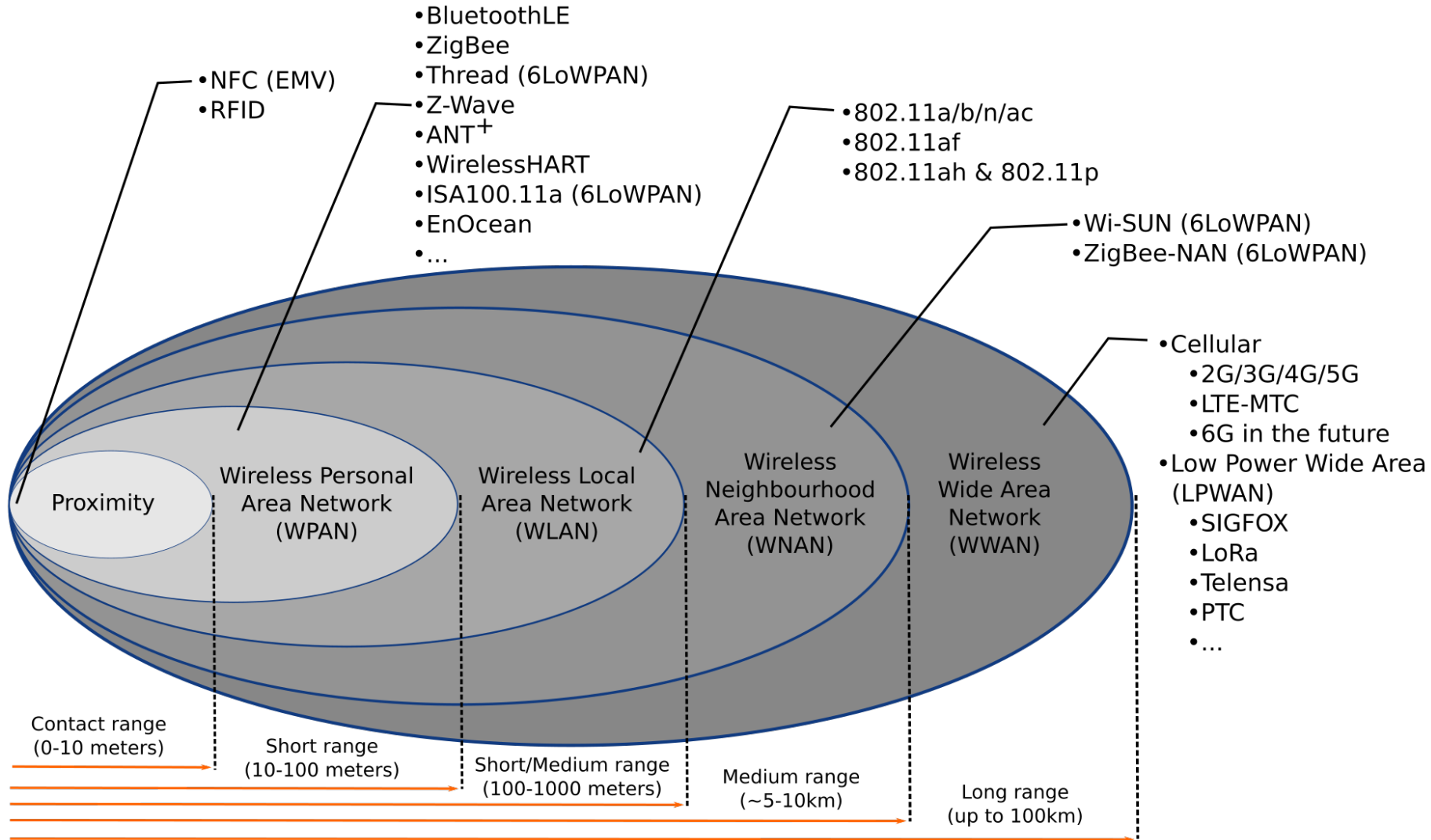


IOT COMMUNICATIONS

Overview



Different ranges, different standards



Source: M.S. Mahmoud, A. Mohamad, "A Study of Efficient Power Consumption Wireless Communication Techniques/ Modules for Internet of Things (IoT) Applications", January 2016, Advances in Internet of Things 06(02):19-29, DOI:10.4236/ait.2016.62002

WPAN

Wireless Personal Area Network

IP based

- 6LoWPAN (IPv6 over Low-Power Wireless Personal Area Networks)
- IEEE 802.11p (V2V)
- RuBee (IEEE standard 1902.1)

■ Not IP based

- Bluetooth
- ZigBee (IEEE 802.15.4-based)
- IrDA (Infrared Data Association)
- Z-Wave

And more.

Bluetooth

Pros

- Low power requirements
- Resilient against interference

Cons

- Low bandwidth
- Limited range
- Limited number of participants in network

Applications

- Beacons
- Fitness trackers, smart watches
- Medical applications
- Smart homes
- Smart cars
- Earbuds, headsets etc.

Classes for different applications with different ranges/power usages.

Zigbee

Pros

- Low power requirements
- Scales to large network sizes (~6500 nodes)

Cons

- Low range
- Low bandwidth
- Security issues (fixed, known fallback keys in at least one profile)

Applications

- Wireless sensor networks (WSN)
- Industrial automation
- Smart homes

6LoWPAN

Pros

- IPv6 based
- Built-in security
- Scalability
- Interoperability

Cons

- Higher minimum requirements due to IPv6 minimum complexity
- Not as popular as ZigBee

Applications

- Wireless sensor networks (WSN)
- Internet of Things
- Industrial Internet of Things

IEEE 802.11p

Vehicular network optimized

- Vehicle to vehicle (V2V)
- Vehicle to infrastructure (V2I) such as road side units (RSU)
- Built in time synchronization

Applications

- Vehicular networks

WAN

Wide Area Network

- Service/subscription model based
- Service provider runs infrastructure such as base stations and radio towers
- Examples:
 - Cellular networks (UMTS/LTE/5G)
 - LoRa (**L**ong **R**ange, physical layer), LoRaWAN (MAC layer)
 - Sigfox

Cellular network architecture

- Grid of cell towers
- Overlapping cells
- Requires handover for mobile stations between cells

- Network planning
- Space division multiple access
- Minimize interference
- Avoid allocating overlapping spectrum on nearby cells

5G

- New radio communication techniques and spectrum
- Support for device to device communications (D2D)
- Improved performance
 - Theoretical latency in single digit ms
 - Bandwidth in gbps range
 - Ability to provide connectivity in fast moving vehicles
 - Enables more dense connectivity and scalability (more devices)

LoRa/LoRaWAN

- Uses unlicensed spectrum
- Low number of base stations (Gateways) covers wide area
 - 7 are enough to cover Belgium
- Only produced by a single company (Semtech)
- High latency, no realtime applications
- Subscription based
- Misses some common features from LTE networks
 - Only physical and MAC layers are covered => Higher OSI layers have to be implemented on top

Sigfox

- Uses unlicensed spectrum
- Uplink
 - 100bps
 - 12B payloads
 - Maximum of 6 messages per device and hour (140 per day)
- Downlink
 - 600bps
 - 8B payloads
 - Maximum of 4 messages per day
- Open hardware
- Network subscription based



ROUTER AND GATEWAYS

Router and Gateways

Router

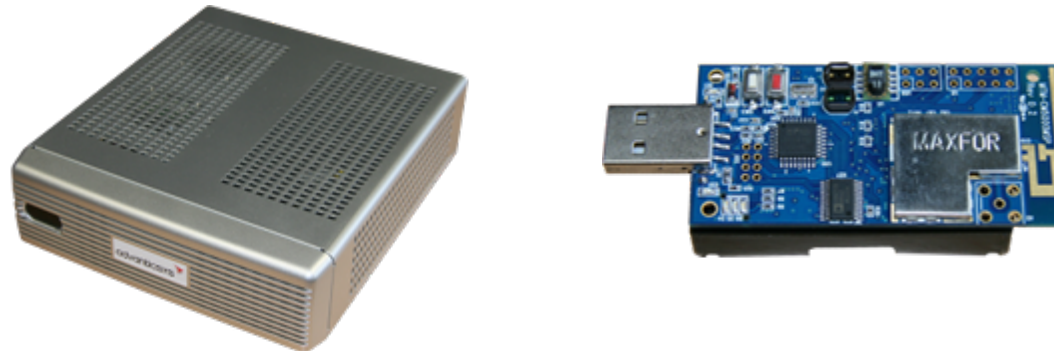
- Bridges two networks
- Can translate between protocols
- Routes data
- Port forwarding and network address translation (mainly end user or carrier grade)
- VNETs

Gateways (not in the routing sense)

- Bridges wireless network and internet
- Can translate between protocols
- Edge/Fog computing capabilities (see next lecture)
- Routers can be gateways

Gateway example

- Wireless sensor nodes running Contiki RPL with Ipv6
- Node attached to gateway over USB acts as gateway
- IPv6 connectivity between networks provided through SLIP (Serial Line Internet Protocol)



Updated Exercise Schedule

The schedule of the exercises, **IoT Data Processing & IoT Security**, will be switched. The new order is as follows:

- 15.04.2024 → Exercise 01 – Knowledge Test (MC)
- 22.04.2024 → Exercise 02 – Circular Economy (MC)
- 29.04.2024 → Exercise 03 – Lifecycle Assessment (LCA)
- 06.05.2024 → Exercise 04 – IoT Sensing and Gathering Data
- **13.05.2024 → Exercise 05 – IoT Data Processing**
- **27.05.2024 → Exercise 06 – IoT Security**
- 03.06.2024 → Exercise 07 – Industrial IoT
- 10.06.2024 → Exercise 08 – Blockchain (MC)
- 17.06.2024 → Exercise 09 – Blockchain Basics
- 24.06.2024 → Exercise 10 – Blockchain Consensus
- 01.07.2024 → Exercise 11 – Blockchain Tokens

Questions?