

# Emerging Technologies for the Circular Economy

## Lecture 5a: Internet of Things Communications

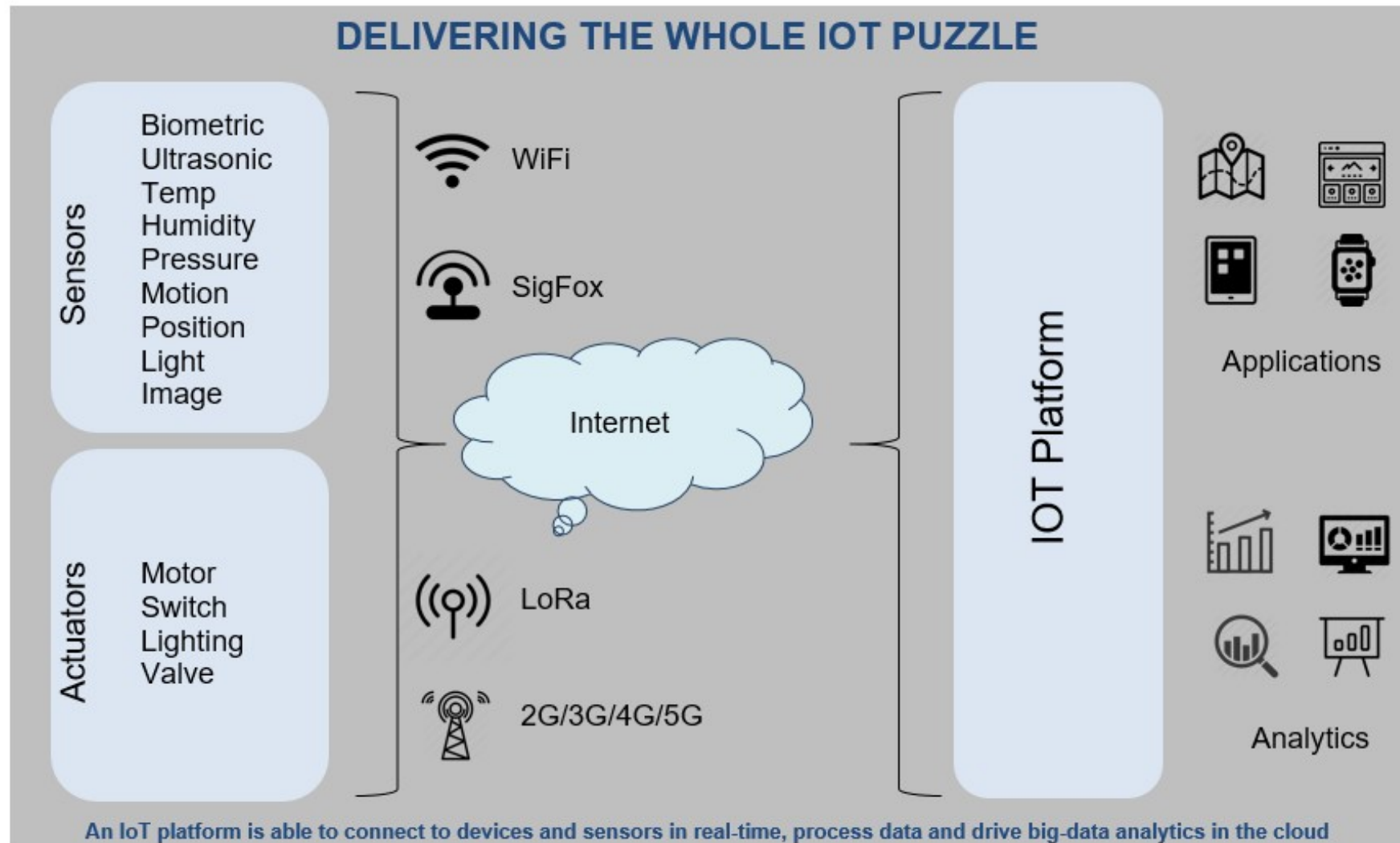
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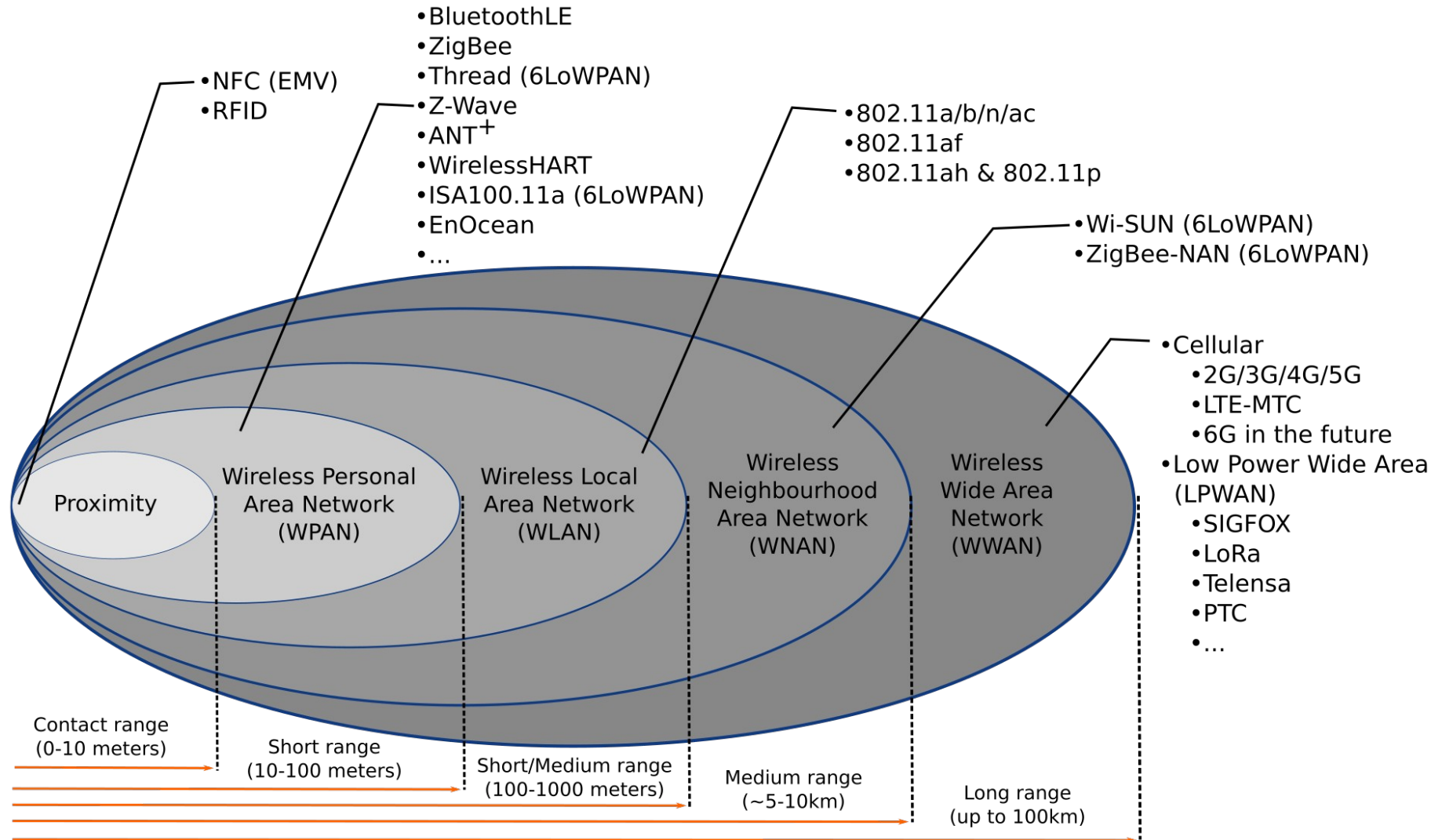
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- Updated versions of these slides will be available in our [Github repository](#).

# IOT COMMUNICATIONS

## Overview



# Different ranges, different standards



**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)



# Questions?