WIRELESS COMMUNICATION, LOCALIZATION (AND MORE) FOR ROBOTICS

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IDLAB
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INTERNET & DATA SCIENCE LAB

GHENT & ANTWERP

300

Internet experts and data scientists

IDLab focuses its research on *internet technologies* and *data science*. We develop technologies outperforming current solutions for communication subsystems, high speed and low power networking, distributed computing and multimedia processing, machine learning, artificial intelligence and web semantics.

+500

Collaborations with innovative industry

IDLab collaborates with many universities and research centres worldwide and jointly develops advanced technologies with industry (R&D centers from international companies, Flanders' top innovating large companies and SMEs, as well as numerous ambitious startups).

40+ Professors, 40+ Post Docs

Total income (projects): 15 M€/Y

- **Fundamental: 3 M€**
- **Strategic: 3,5 M€**
- **EU projects: 4 M€**
- **Local industry: 4,5 M€**

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IDLAB - RESEARCH FOCUS – 3 LAYERS

ACT

INTELLIGENT THINGS WITH LEARNING CAPABILITIES

AUTONOMY

OPTIMIZING

CONTROL

MONITORING

DELIVER

GUARANTEED NETWORK AND CLOUD SERVICES

APPLICATIONS ON SENSORS, GATEWAYS, CLOUDLET AND CLOUD

CONNECT

ENSURE WIRELESS PERFORMANCE

SENSORS, ACTUATORS, CYBER PHYSICAL SYSTEMS, GATEWAYS

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CONNECT : WIRELESS COMMUNICATION

& DELIVER : WIRELESS LOCALIZATION

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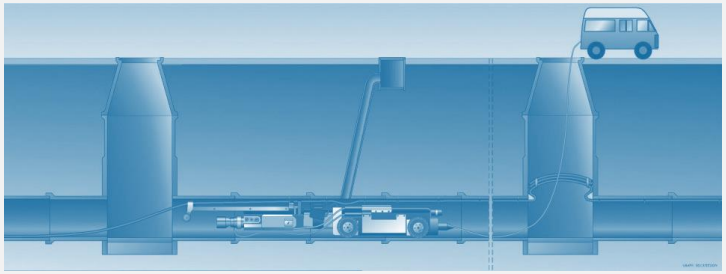
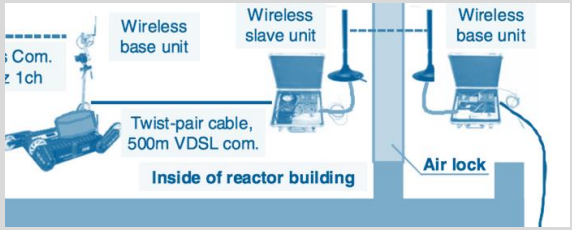
WHY WIRELESS FOR ROBOTICS?

WIRED





Avoid drilling holes

WIRELESS

Support systems that can freely move around (ground, air)

Localisation

Direct interactions with environment (workers, sensors, …)

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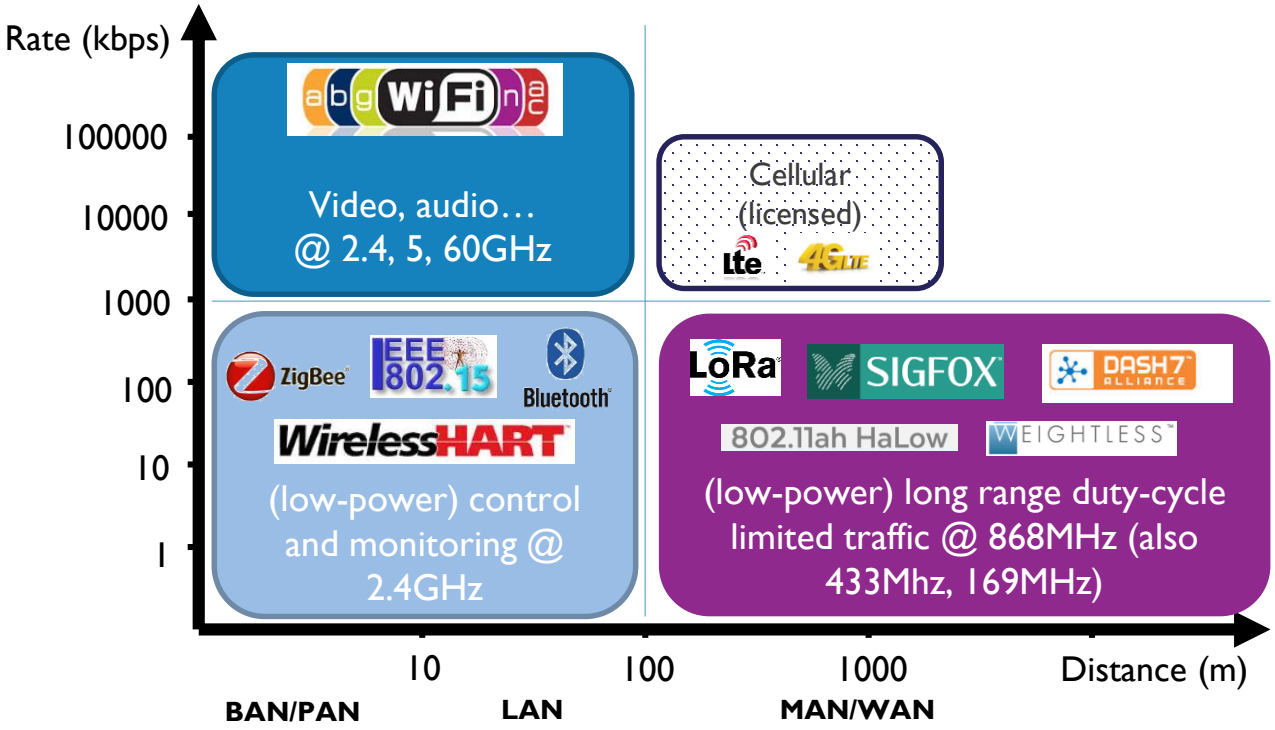
WHICH WIRELESS SOLUTION TO PICK?

CRITERION: THROUGHPUT AND RANGE (IN AIR)



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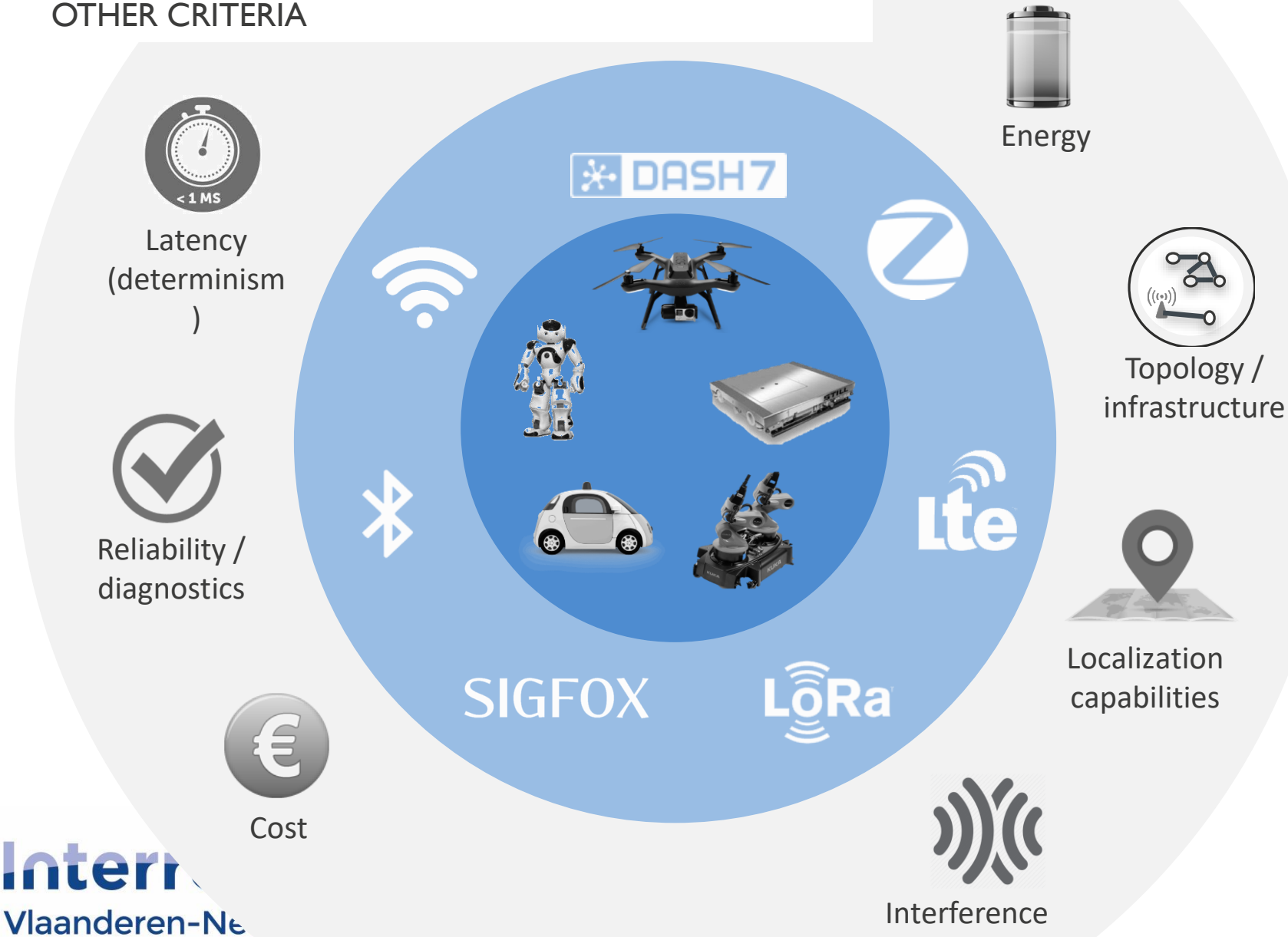
WHICH WIRELESS SOLUTION TO PICK?

OTHER CRITERIA



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EXAMPLE 1
RELIABLE & ROBUST DRONE COMMUNICATION

Reliability / diagnostics

Traffic types: control, monitoring, other

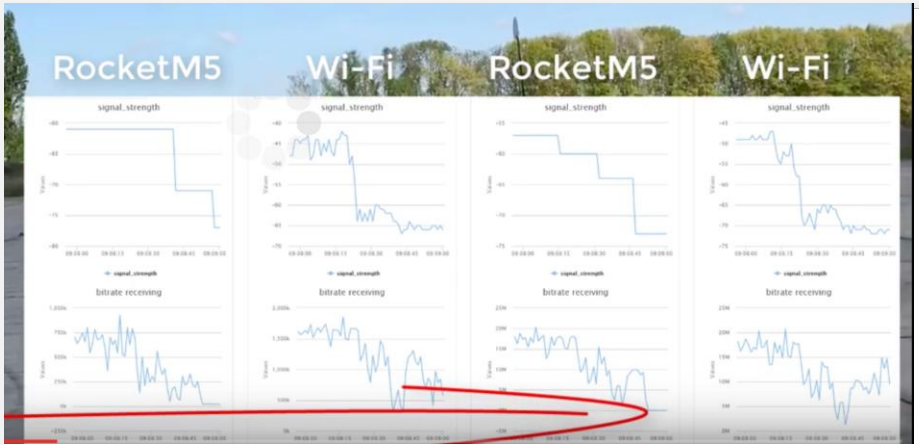
DJI Matrice 100
DJI Manifold
Wi-Fi (.11n, 2 monopole antennas)
RocketM5 (2 cloverleaf antennas)

Mini-PC gateway/router
batteries, switch, 4G uplink
Wi-Fi (.11n, 2 monopole antennas)
RocketM5 (2 cloverleaf antennas)

I. Real-time diagnostics of wireless communication links

II. Advanced communication strategies:

- Redundancy: combination of different complementary technologies
- New technologies: LTE unlicensed
- Traffic handling: classification, priorities…



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EXAMPLE 2
A FLEXIBLE AGV NETWORK ARCHITECTURE

Topology / infrastructure

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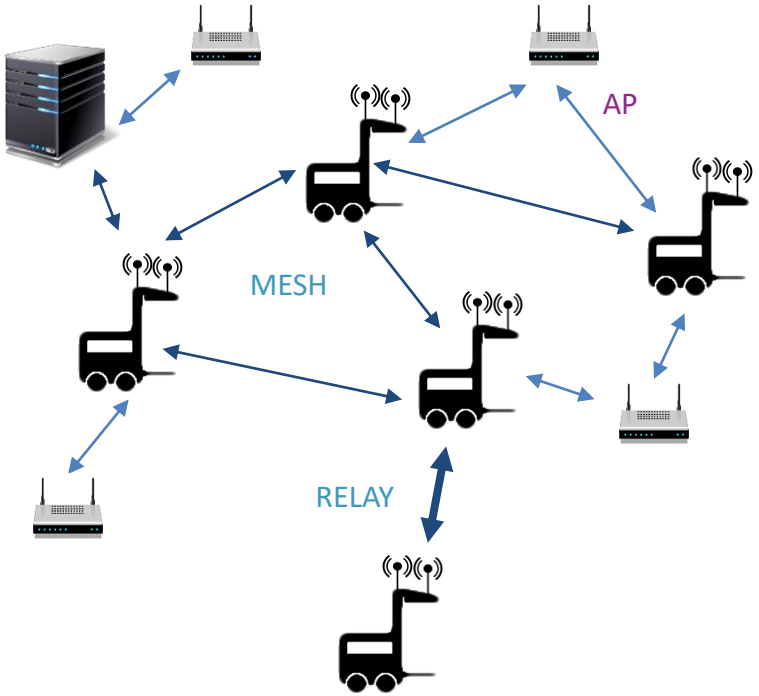
EXAMPLE 2
A FLEXIBLE AGV NETWORK ARCHITECTURE

Topology / infrastructure

REQUIREMENTS

- Timely deliver broadcast traffic (< 20ms)
- Deal with mobility
- Function in absence of infrastructure, exploit when present → AGV-to-AGV
- Handle coverage problems → relay via AGV



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EXAMPLE 2
A FLEXIBLE AGV NETWORK ARCHITECTURE

Topology / infrastructure

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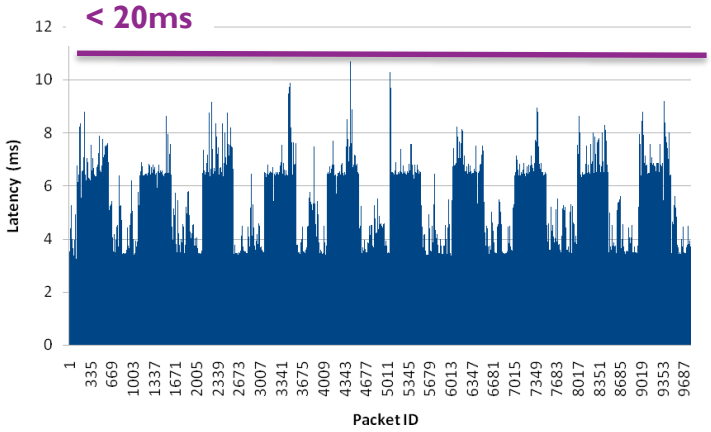
MIXED MESH/AP MULTI-INTERFACE SOLUTION

- Fully configurable
- Low-latency broadcast over mesh
- Handling coverage problems via meshing



Low-latency broadcast traffic

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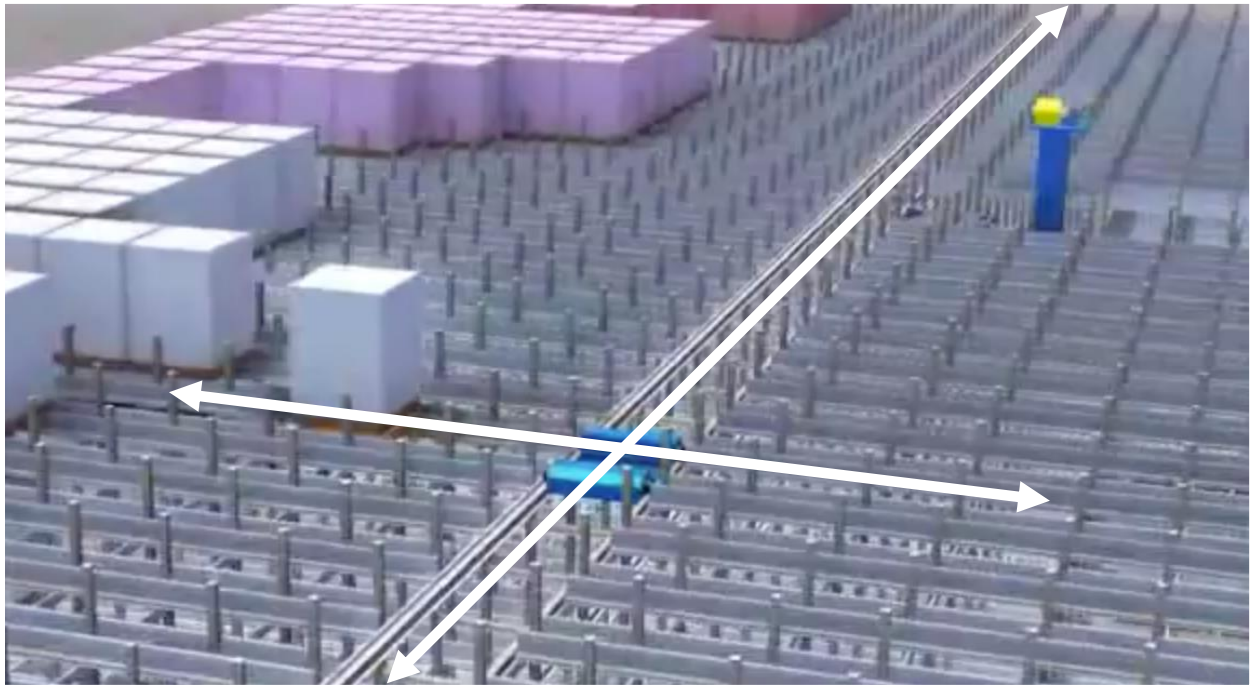
EXAMPLE 3
DETERMINISTIC SHUTTLE COMMUNICATION

Latency (determinism)



CONTINUOUS & RELIABLE WIRELESS COMMUNICATION

In a challenging wireless environment and in the presence of continuous mobility.

- Which technology?
- Network planning?
- Determinism?

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EXAMPLE 3
DETERMINISTIC SHUTTLE COMMUNICATION
MEASUREMENT CAMPAIGN TO ASSESS COVERAGE

< 1 MS
Latency
(determinism)

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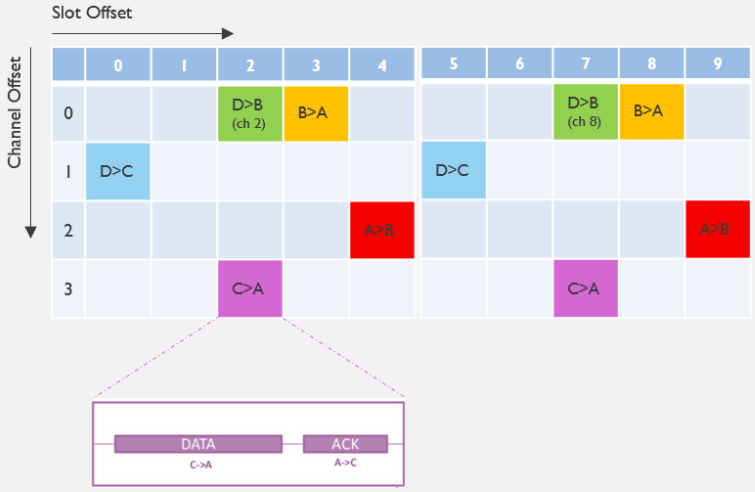
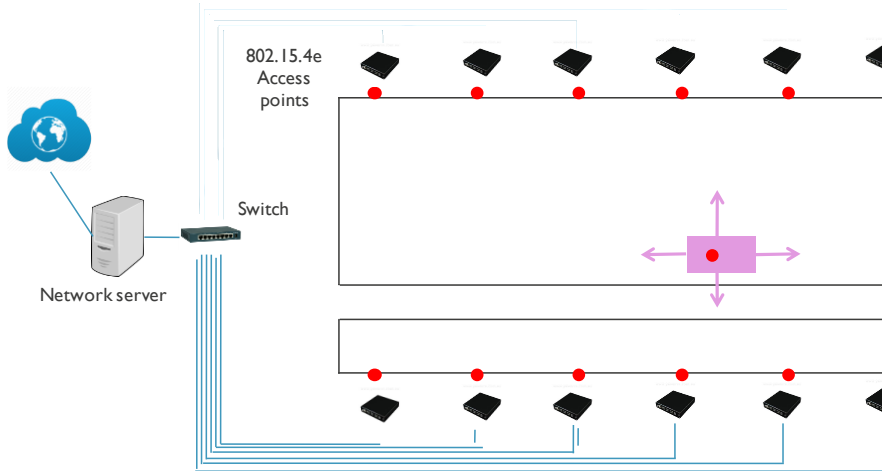
EXAMPLE 3
DETERMINISTIC SHUTTLE COMMUNICATION
DESIGN OF NOVEL 802.15.4E-BASED ARCHITECTURE

Latency (determinism)

IEEE 802.15.4e



but no mobility support



Seamless mobility support and determinism

- Fully synchronized
- Uplink slots shared with all APs
- Dedicated downlink slots known by all APs + central intelligence

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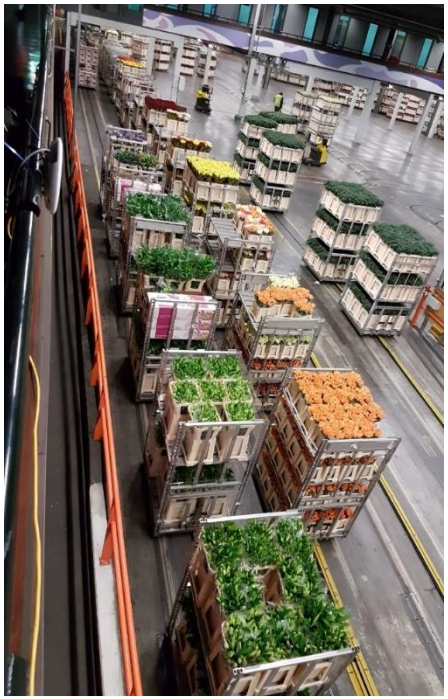
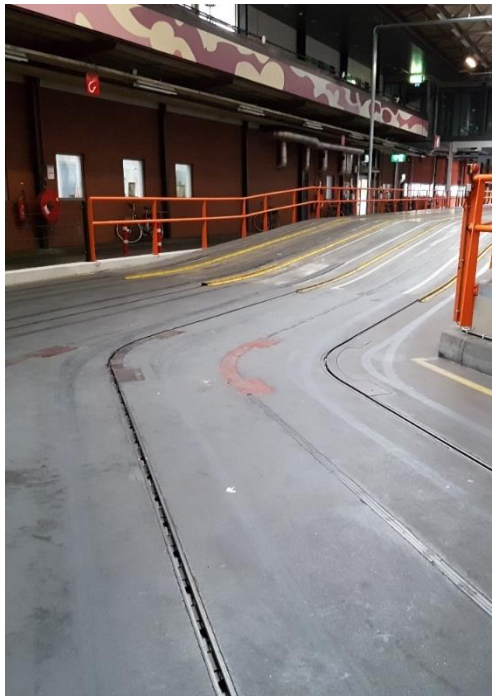
EXAMPLE 4
ACCURATE INDUSTRIAL LOCALIZATION

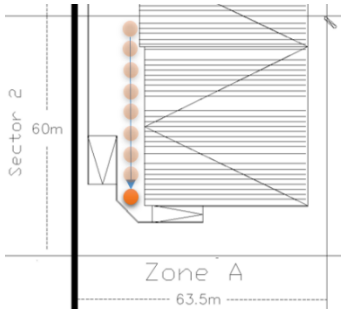
Localization capabilities





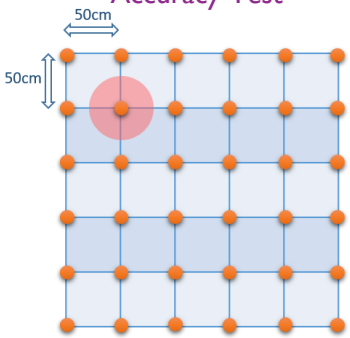
Variety of tests

Mobile Tags



On-Trolleys & Dynamic Env.

Accuracy Test



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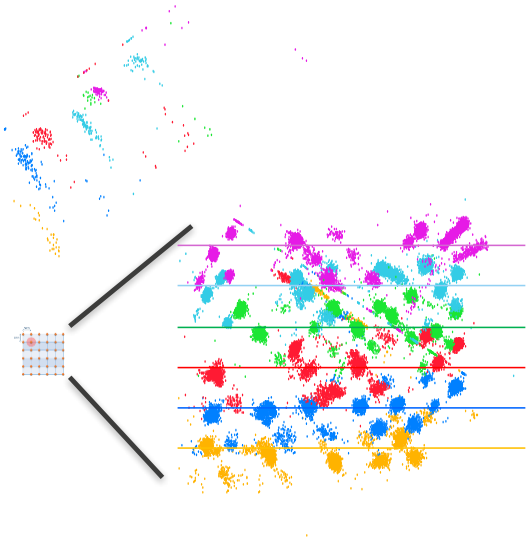
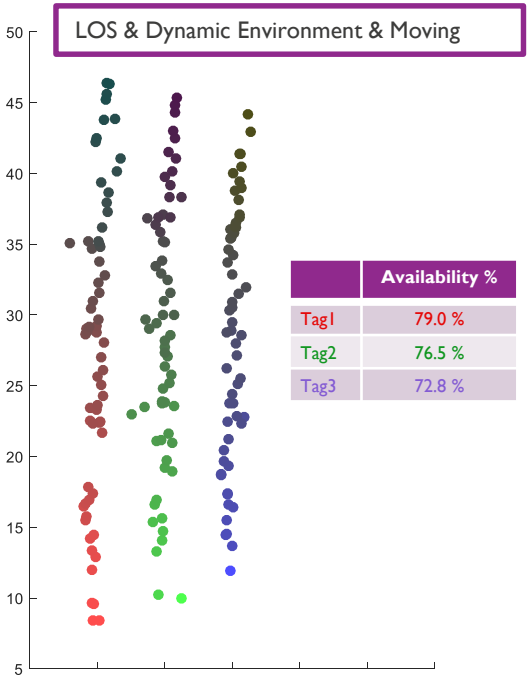
EXAMPLE 4
ACCURATE INDUSTRIAL LOCALIZATION

Localization capabilities

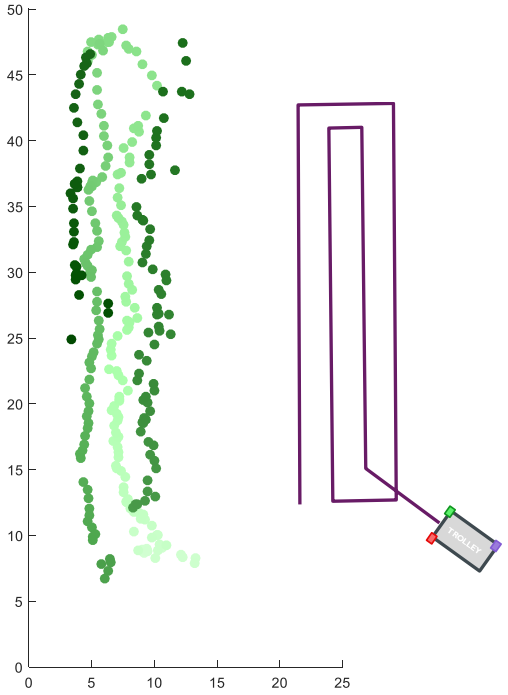
Accuracy Pozyx



Dynamicity/mobility Quuppa



On track - Quuppa



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DELIVER & ACT

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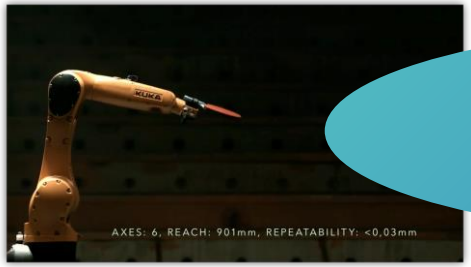
THE INTERNET OF ROBOTIC THINGS

WHAT MAKES ROBOTICS HARD?

Real-world

Controlled environment

Let the IoT environment command and assist the robot



Let a robot learn instead of executing a program

Single task

Multiple task

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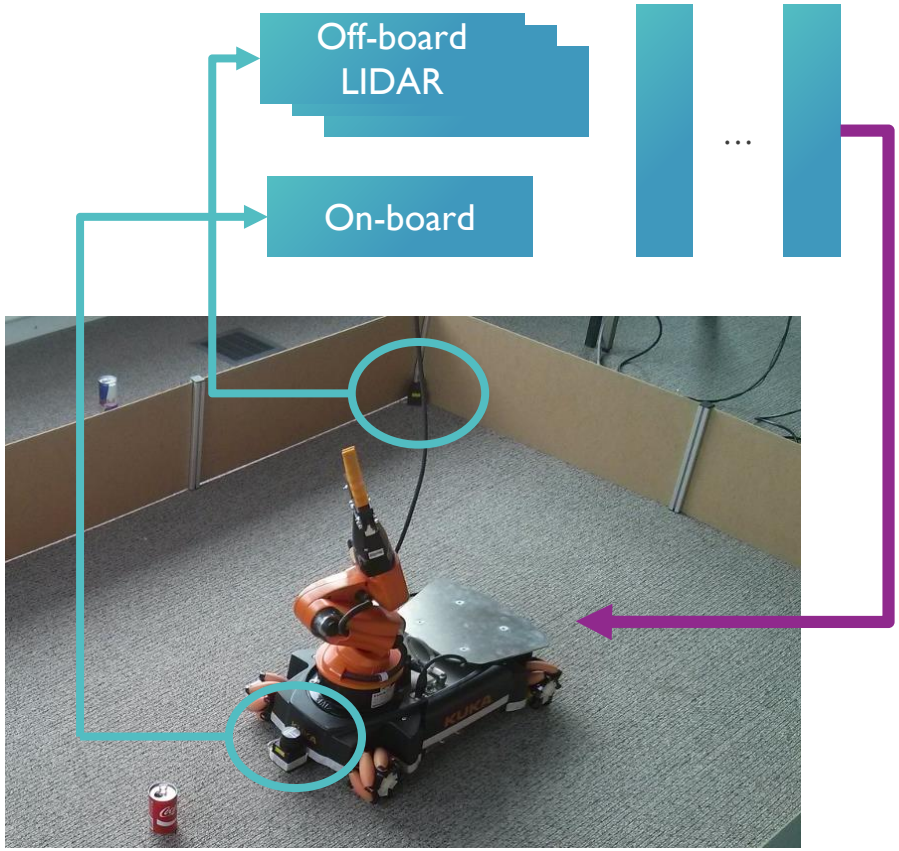
EXAMPLE: IOT SENSOR FUSION FOR ROBOT CONTROL

MODULAR DEEP REINFORCEMENT LEARNING



OSGI-based middleware for robots, sensors and the cloud

http://dianne.intec.ugent.be

Task execution

- Deep Q-learning
- Fusion of on-board and off-board sensors
- Modular approach

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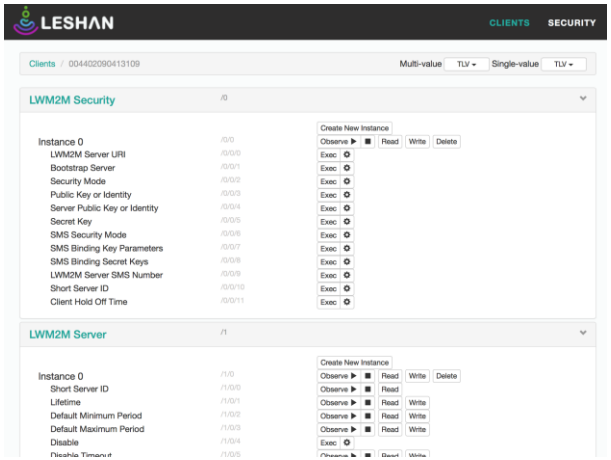
EXAMPLE: OPEN IOT STANDARDS



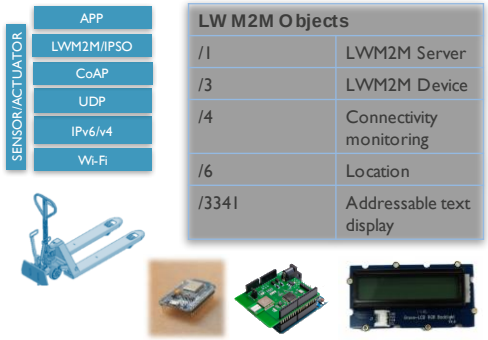
OPEN IoT STANDARD-BASED

- *Discovery*
- *Device and network management*
- *Data access and data exchange*

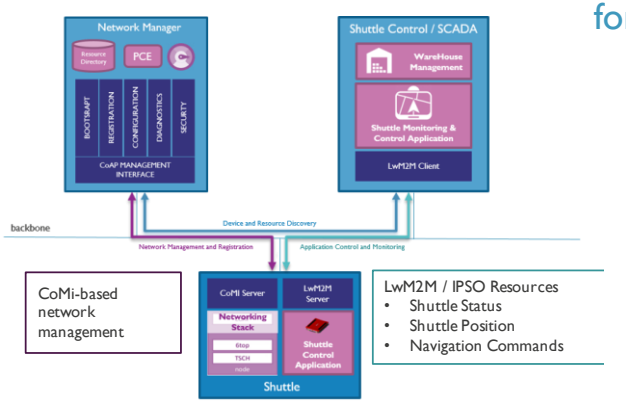
…

CONNECTED OPERATOR

CONVEYOR SYSTEM



2D-SHUTTLE



HYBRID TAG for localization

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DRONE RESEARCH

Reliable software
dependable execution in harsh/hostile environments

Drone assistance
drone assistance in finding and tracking assets of interest

Emergency support
improve situational awareness through automated decision making support

Drone networking
reliable and robust network communication

4 class 1 drone pilots in training
<150kg, <90m height

Drone lab: ~20 drones (3DR, dji, Parrot)

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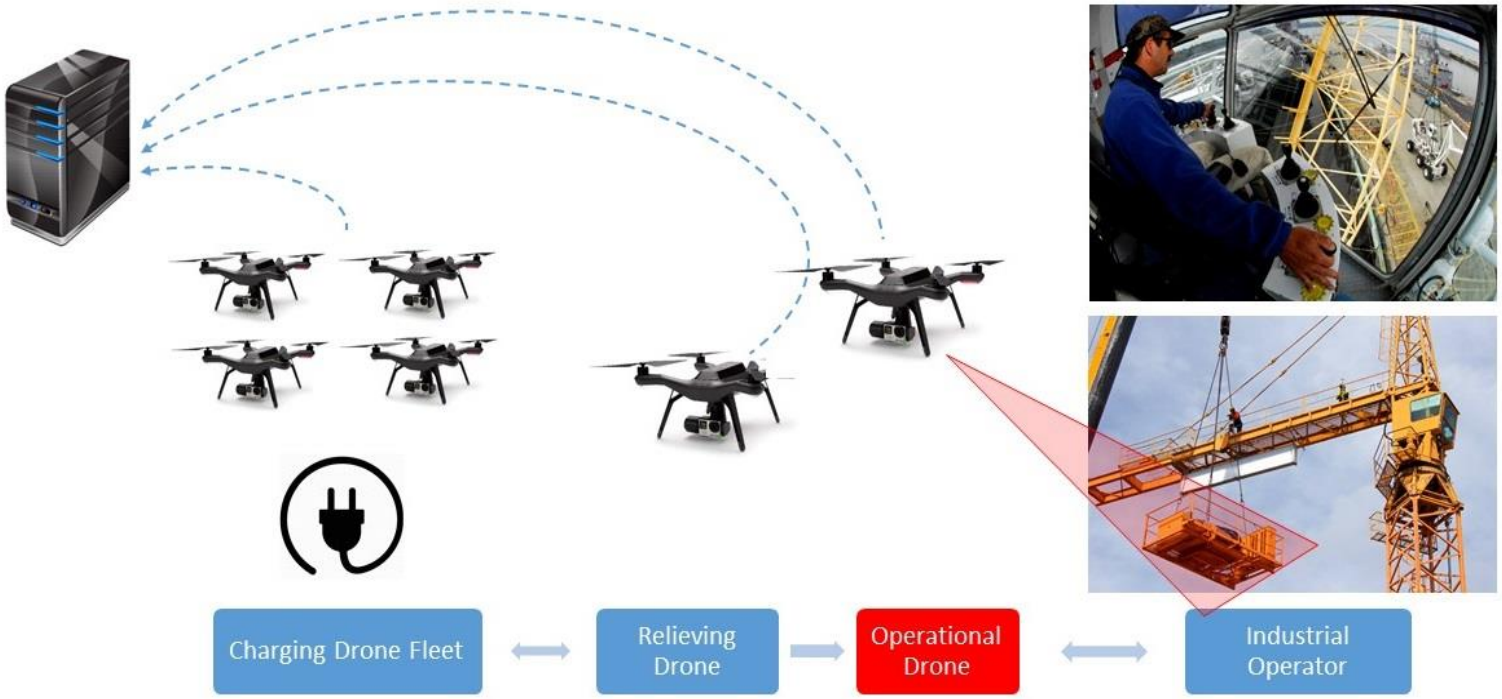
EXAMPLE: INDUSTRIAL OPERATOR ASSISTANCE

- Drone-fleet autonomously tracking labeled goods
- Planning of drone charging / relieving for uninterrupted view on tracked goods



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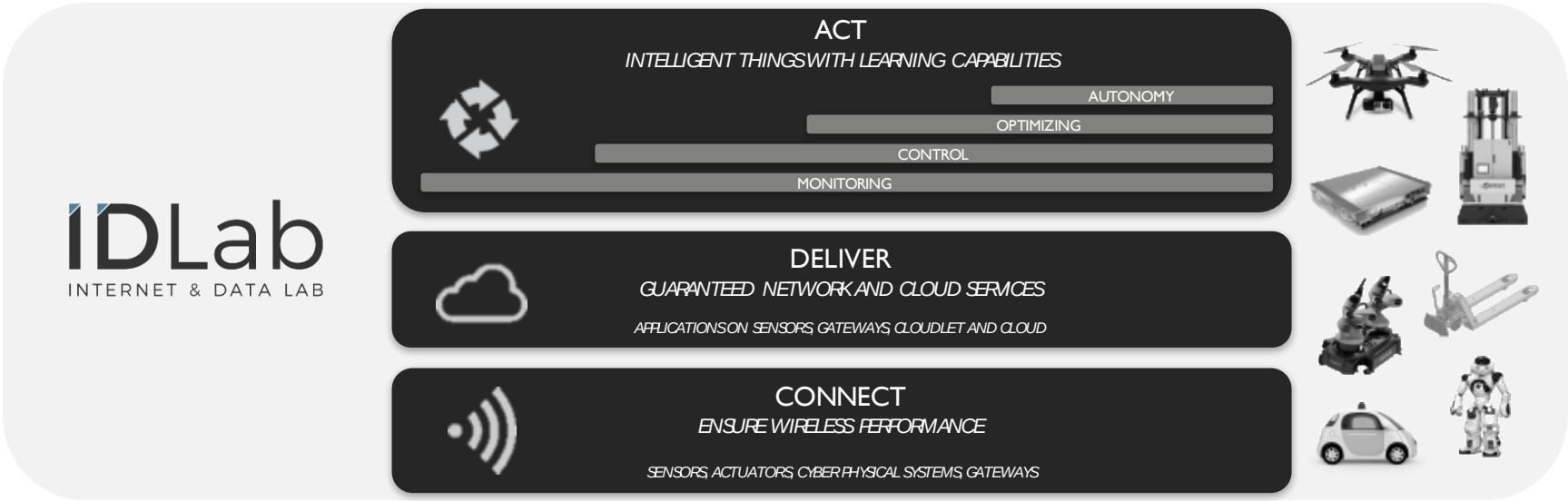
CONCLUSION

ROBOTICS IS A MULTI-DISCIPLINARY DOMAIN



Collaborations w.r.t. robotic hardware (sensors, actuators, mechanics, etc.), domain knowledge, user interfaces, etc.

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