Testing Protocols for the Internet of Things and Coexistence with Wi-Fi Networks

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Outline

1. EuWIn: Testing IoT Protocols
2. IoT Applications
3. Comparing Protocols for IoT
4. Coexistence Issues at 2.4 GHz

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1. **EuWIn: Testing IoT Protocols**
2. IoT Applications and Motivations
3. Comparing Protocols for IoT
4. Coexistence Issues at 2.4 GHz

NEWCOM#

Network of Excellence in
Wireless Communications

EuWIn

European Laboratory of
Wireless Communications for the Future Internet

www.euwin.org

EuWIn: partners

CNIT (Italy)
CNRS (France)
CTTC (Spain)
Aalborg Univ. (Denmark)
Bilkent Univ. (Turkey)
IASA (Greece)
INOV (Portugal)
Poznan Univ. of Technology (Poland)
Technical Univ. of Vienna (Austria)
Technion (Israel)
Univ. of Cambridge (UK)
Univ. Catholique de Louvain (Belgium)
Univ. of Dresden (Germany)
Univ. of Oulu (Finland)

EuWIn: sites

The Lab is composed of three main sites

It is open to all researchers, SMEs, institutions

Director: Prof. Roberto Verdone

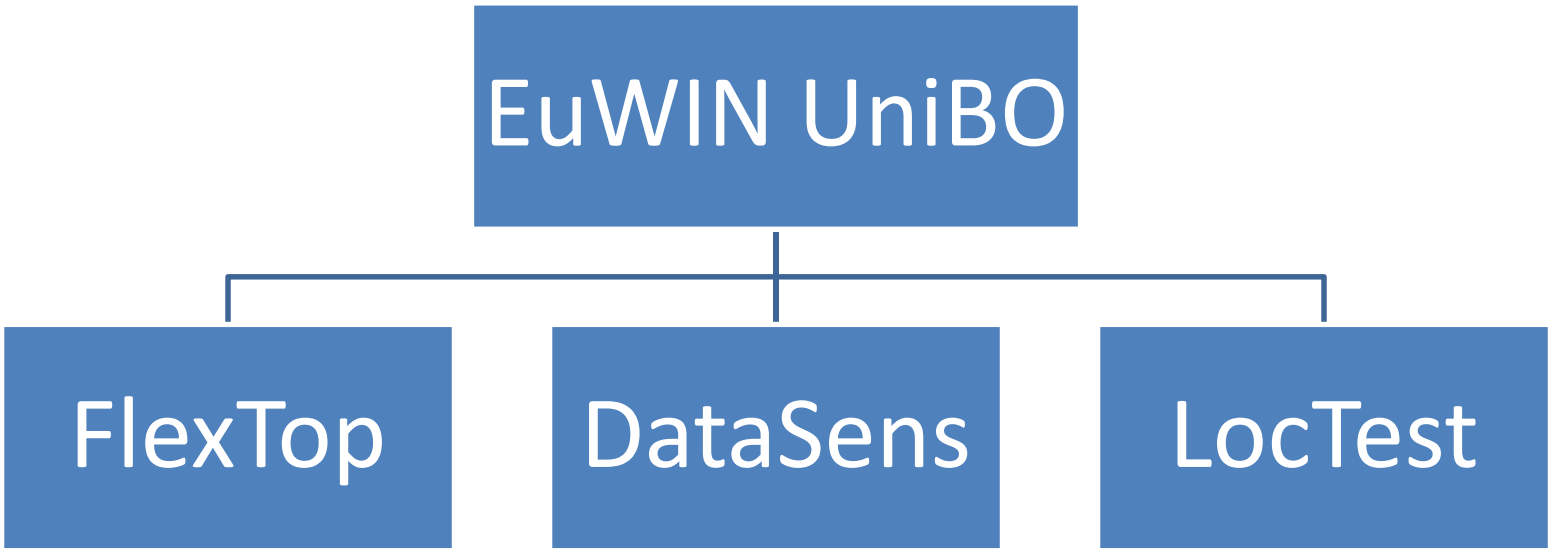
Radio Interfaces
(EuWIn@CTTC, Barcelona, ES)

Internet of Things
(EuWIn@UniBO, Bologna, IT)

Flexible Communication Terminals
(EuWIn@EURECOM, Sophia Antipolis, FR)

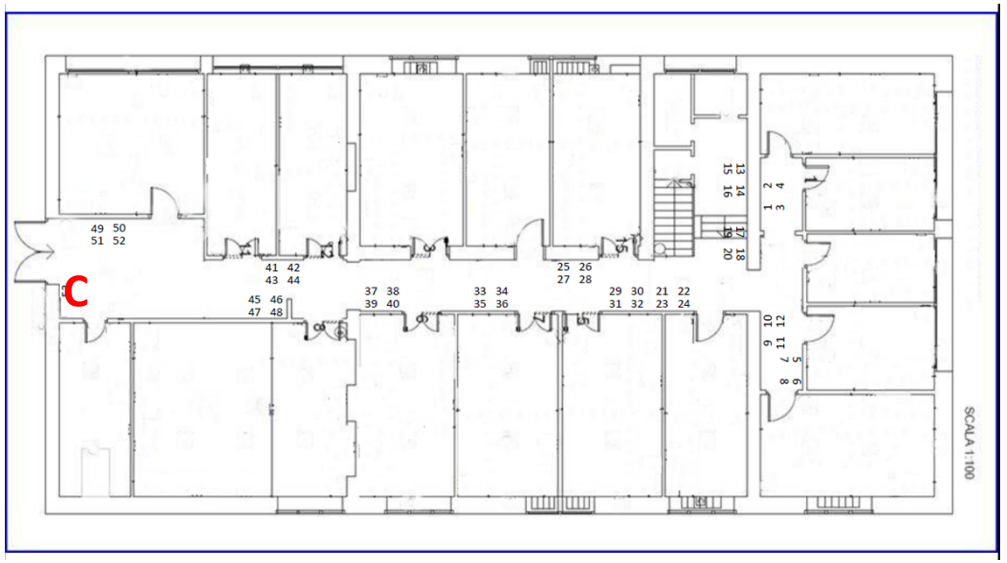
EuWIn@Unibo

The lab provides more than **200 wireless nodes** implementing different types of radio interfaces and distributed according to different **platforms**



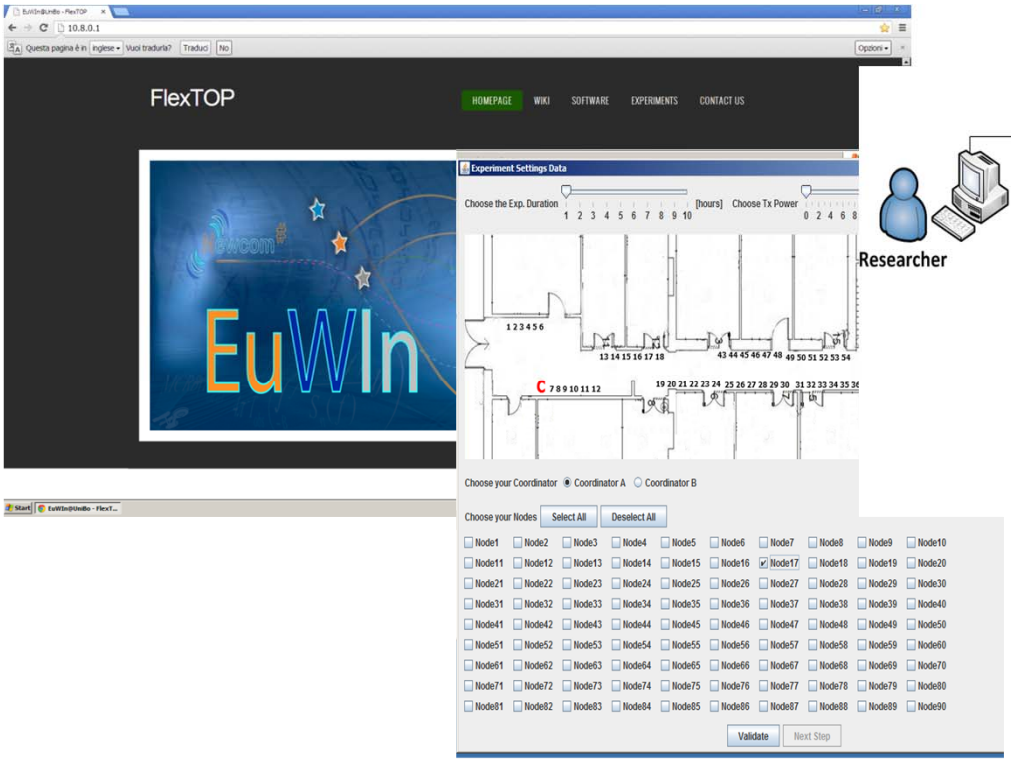
Flextop: deployment

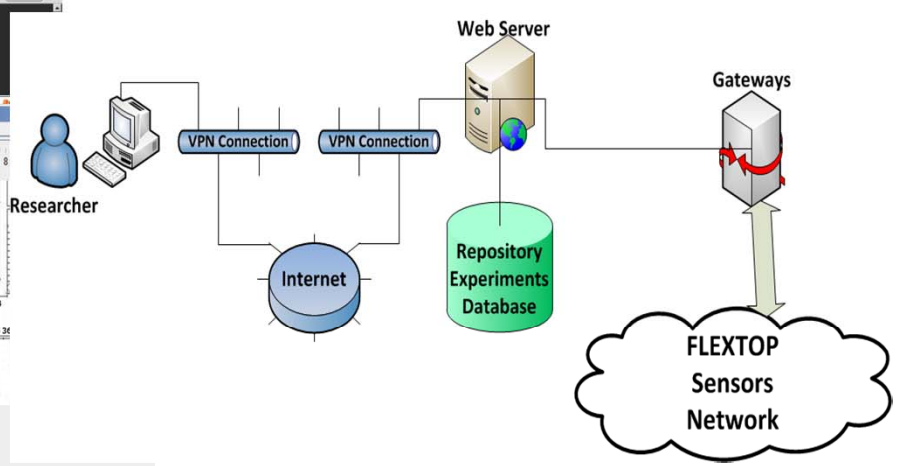
- 53 devices in fixed positions
- 1 Coordinator / Gateway
- 2 Sniffers
- TI CC2530 802.15.4-compliant devices



Flextop: the access

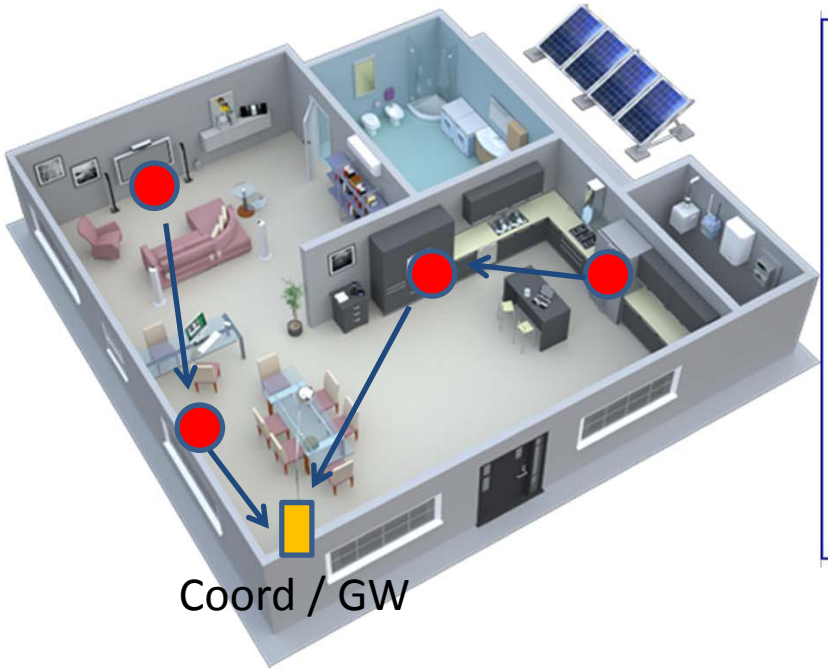
- **Remotely accessible**
- **Over-the-air programming**





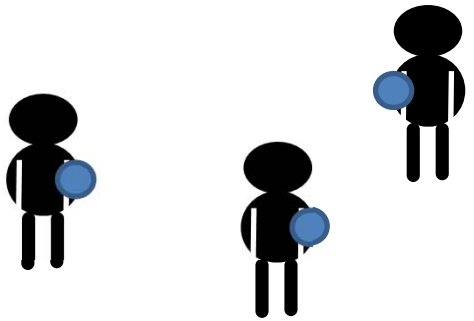
Flextop: strengths

- Controllable environment
- Possibility to emulate different topologies



DataSens: aims

- **Studying social behaviour of human environments**
- **Testing Delay Tolerant Networking approaches**

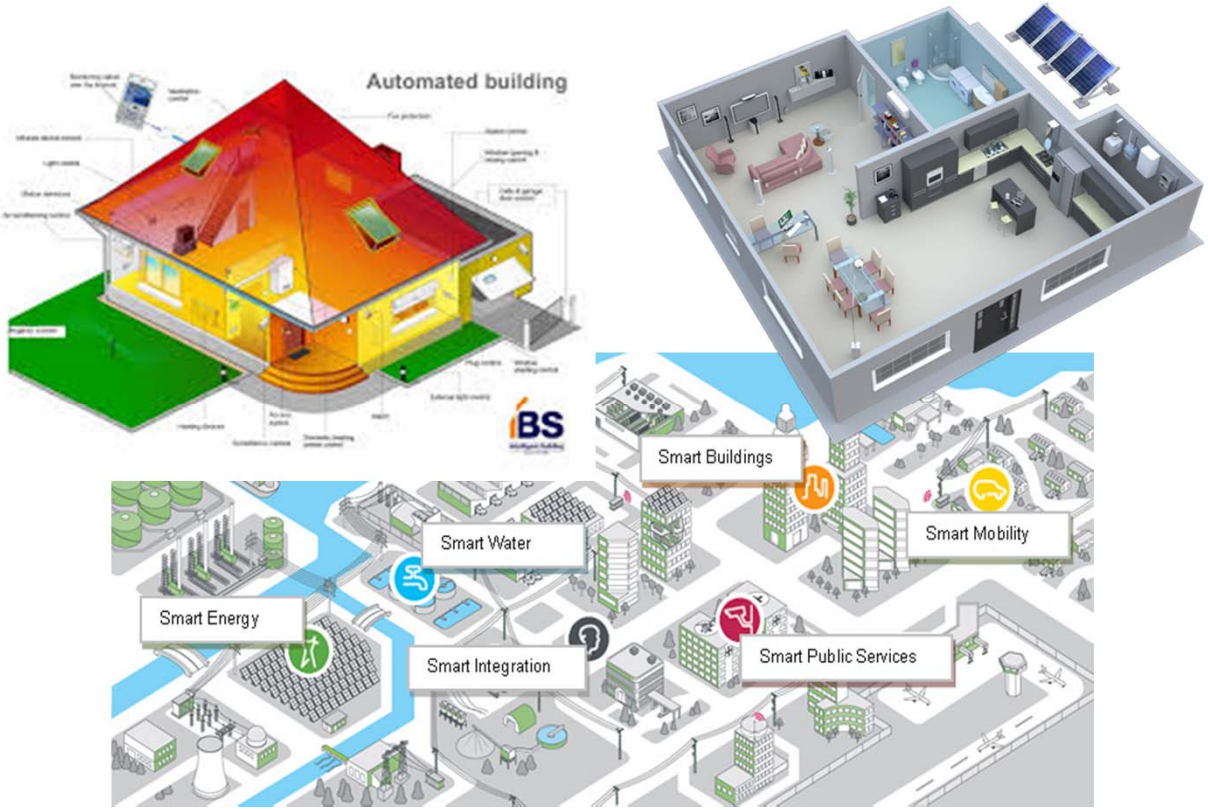


Outline

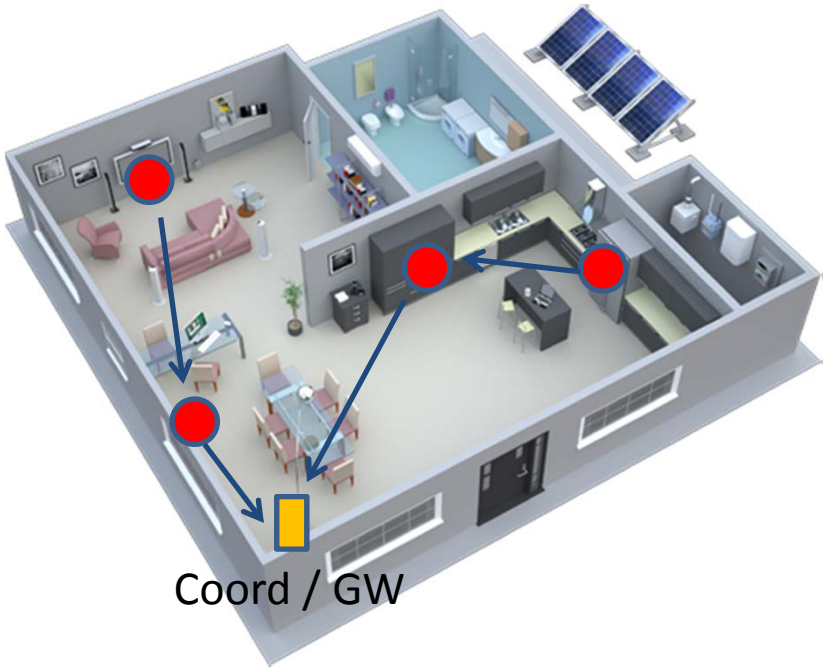
1. EuWIn: Testing IoT Protocols
2. **IoT Applications and Motivations**
3. Comparing Protocols for IoT
4. Coexistence Issues at 2.4 GHz

IoT: applications

- Smart Cities
- Smart Grid
- Smart Bodies
- Smart Homes
- Smart Buildings



IoT: smart home



- **GW/Coordinator periodically queries devices in order to monitor their status**

IoT: motivation

- Which is the best standard solution to be used?
- Which is the impact of interference?

- Studied Metrics:
  - Round Trip Time
  - Overhead

→ Directly connected to Energy Consumption

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3. **Comparing Protocols for IoT**
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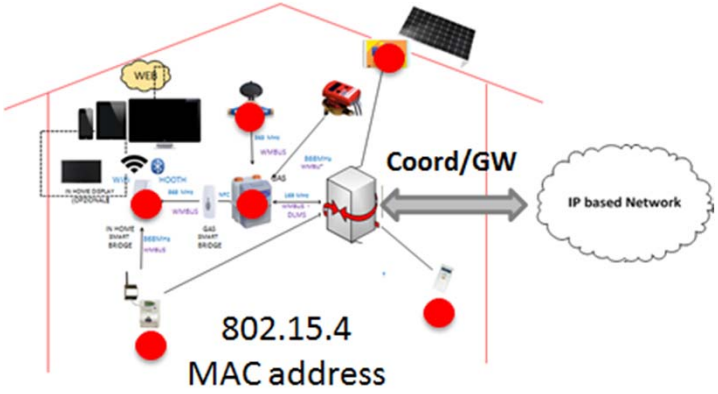
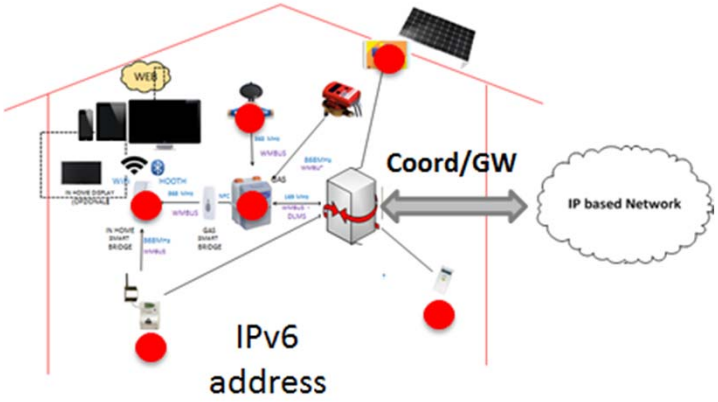
Protocols for IoT: considered solutions

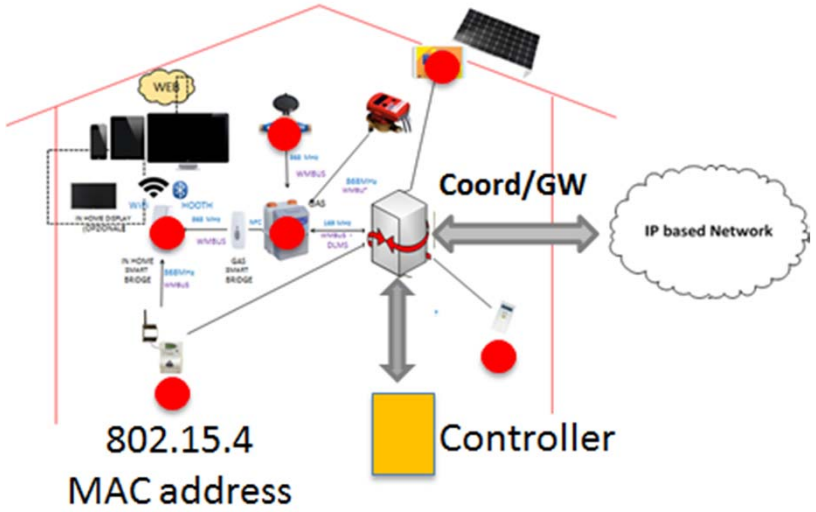
IEEE 802.15.4 / **Zigbee**



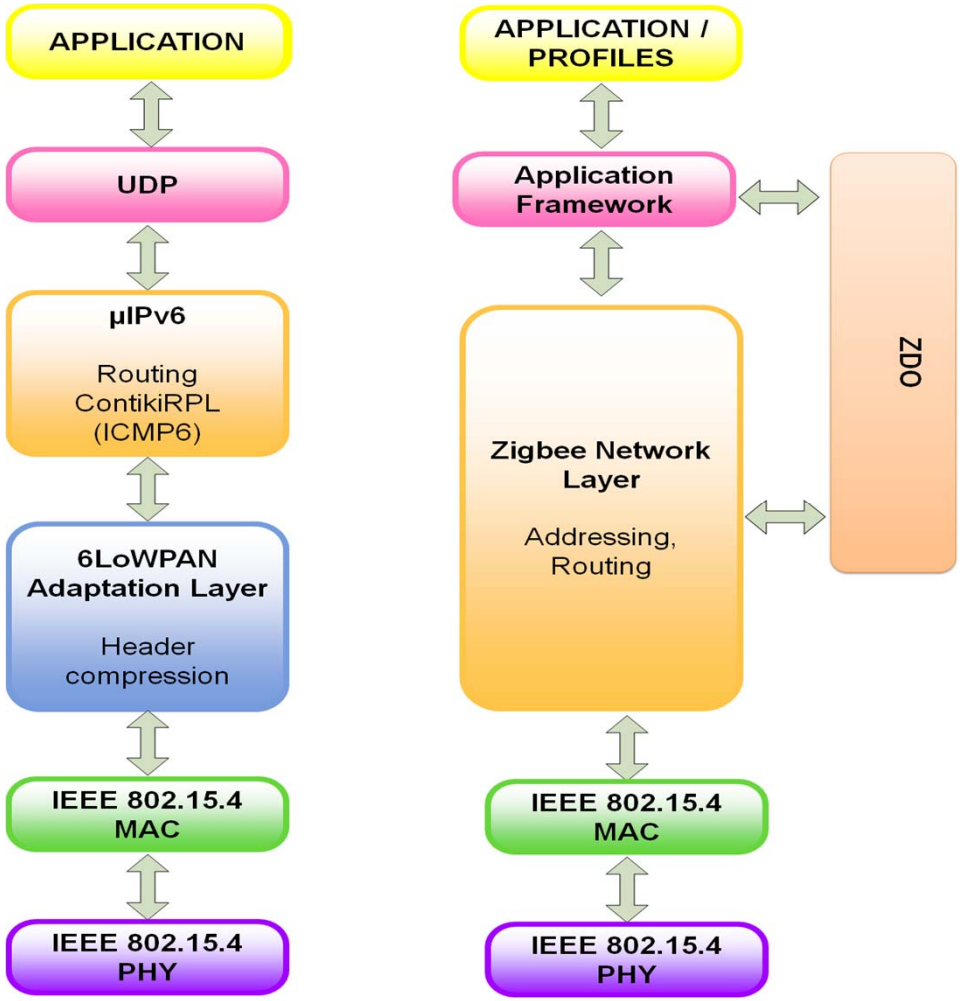
IEEE 802.15.4 / **6LowPAN**



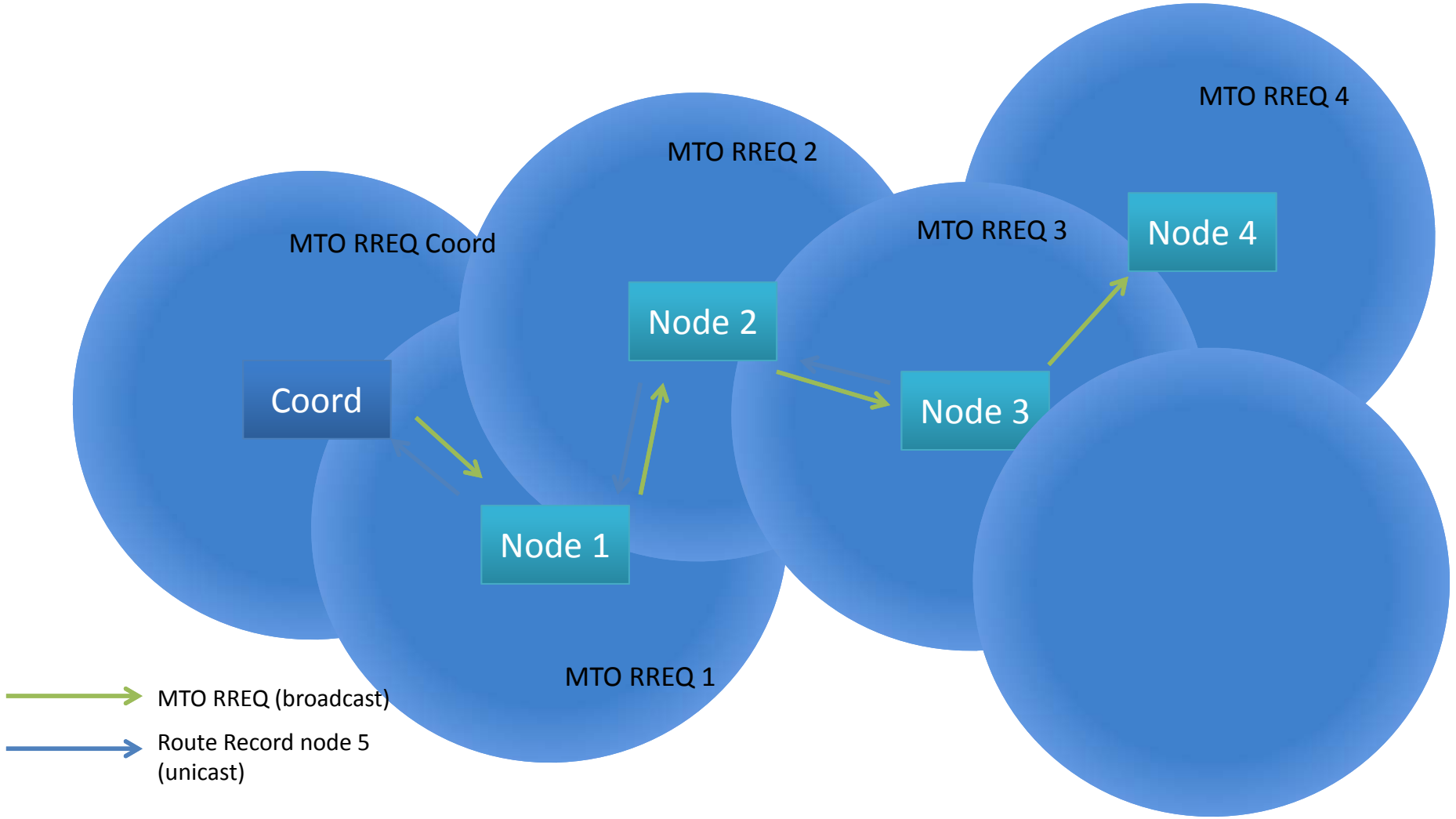
IEEE 802.15.4 / **SDWN**



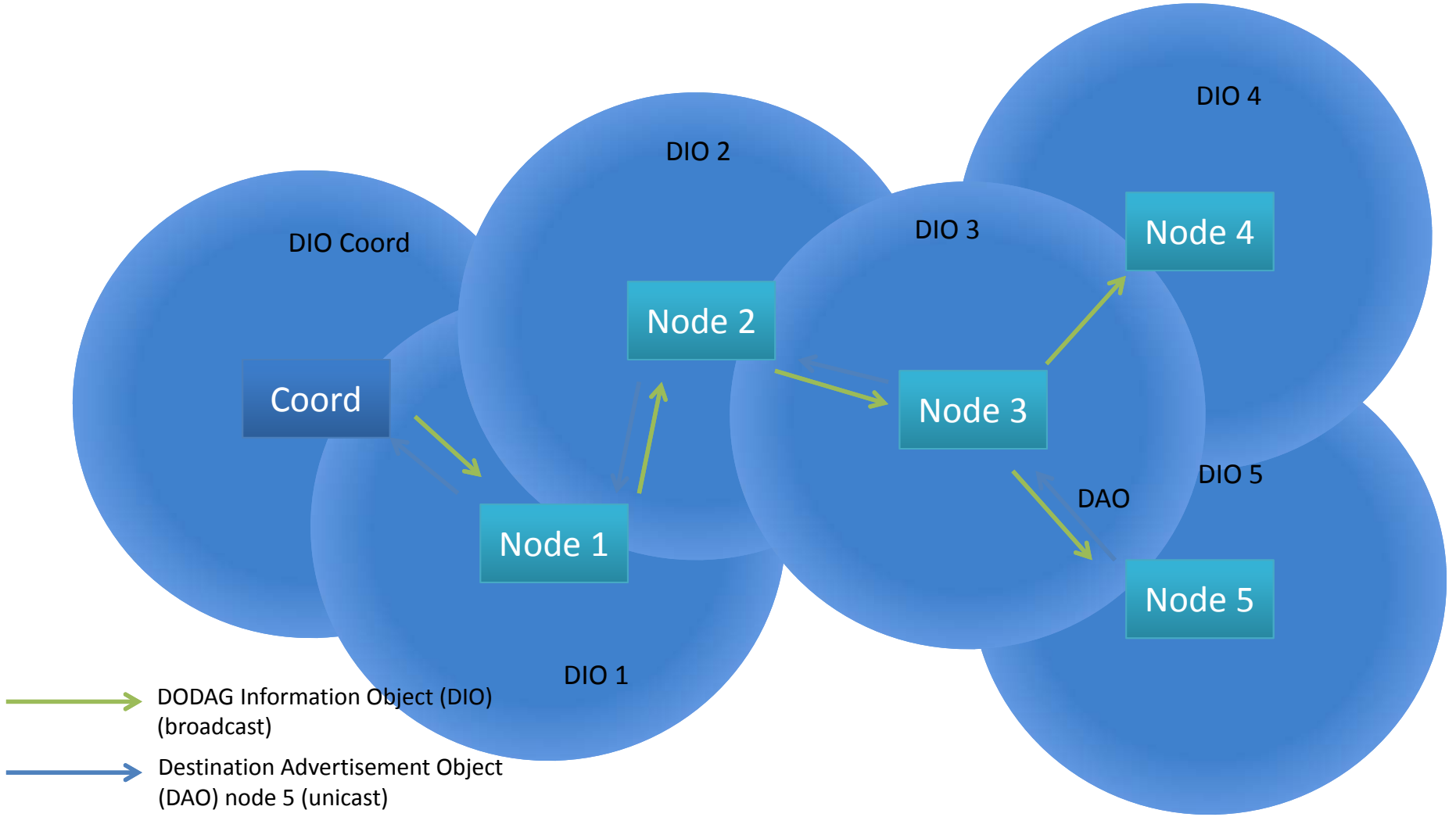
Protocols for IoT: stacks



Zigbee: Many-to-One routing

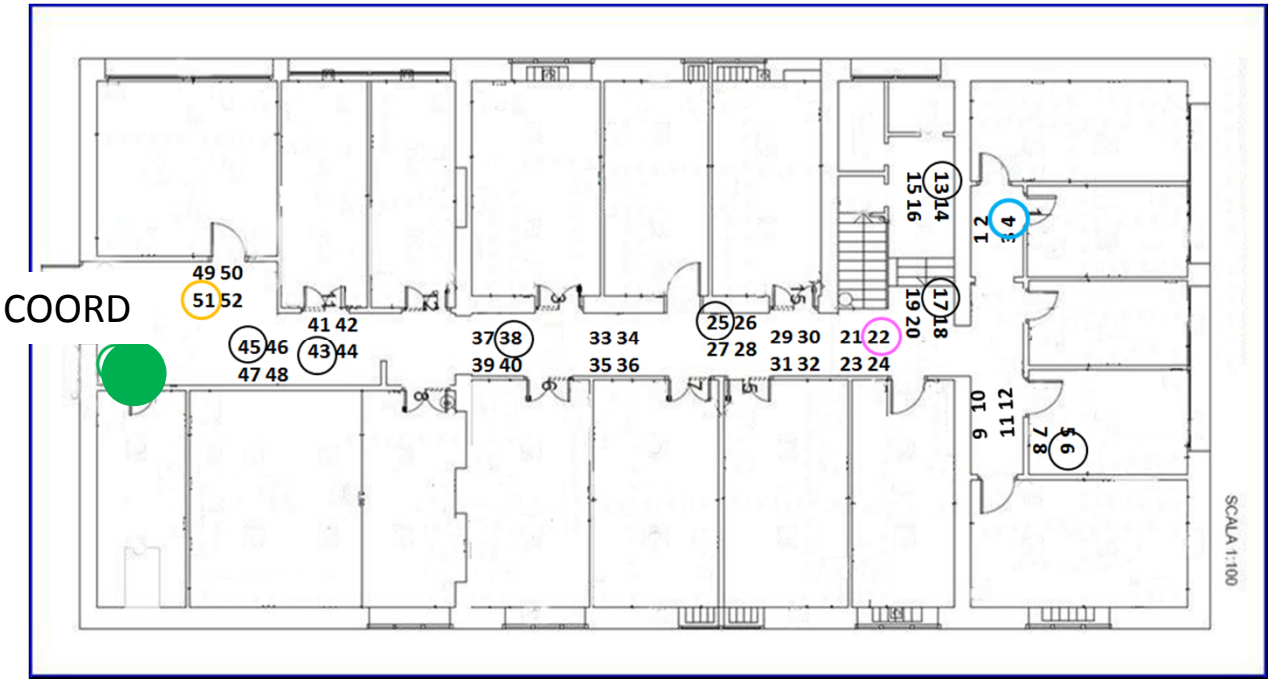


6LowPAN: RPL routing



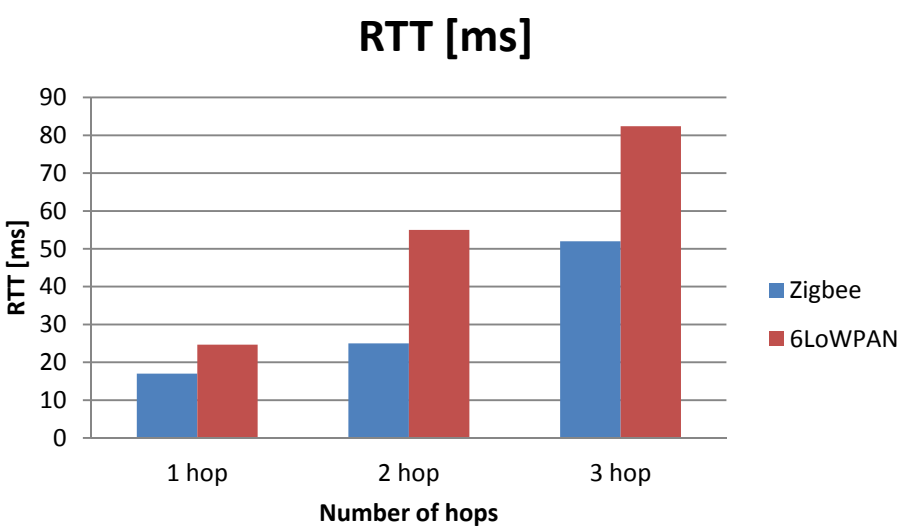
Numerical Results: scenario

- Coordinator and 10 Nodes switched ON
- Coordinator periodically queries one of the nodes

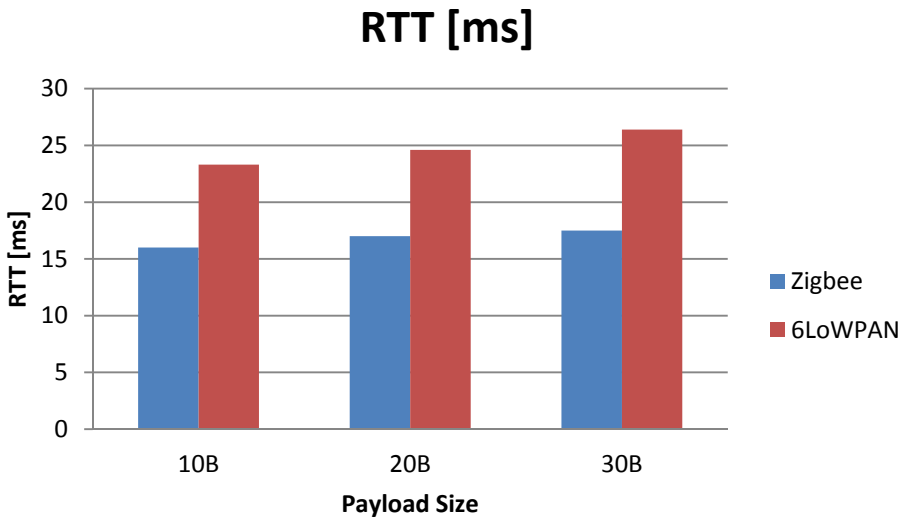


Coordinator
Node at 1 hop
Node at 2 hops
Node at 3 hops

Numerical Results: RTT comparison



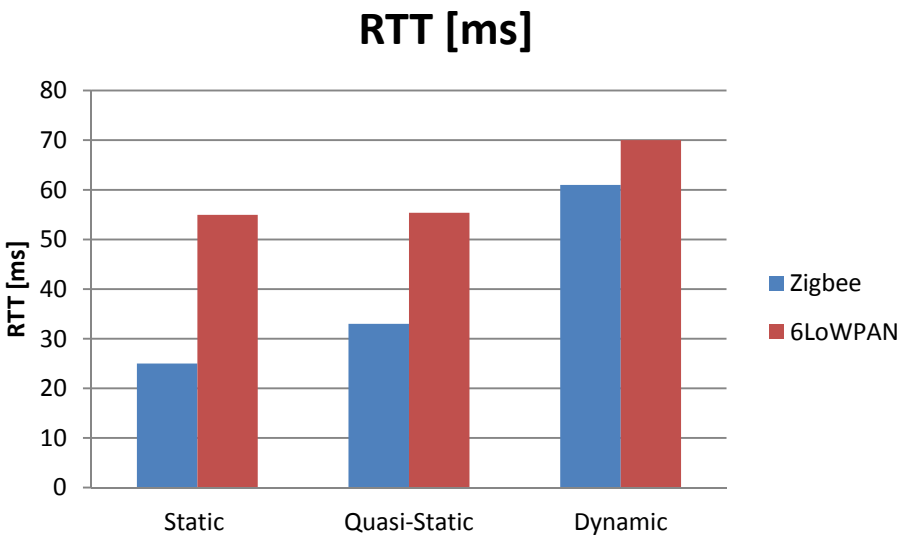
20 Bytes payload



1 hop scenario

Zigbee improvement from 10% to 30% !

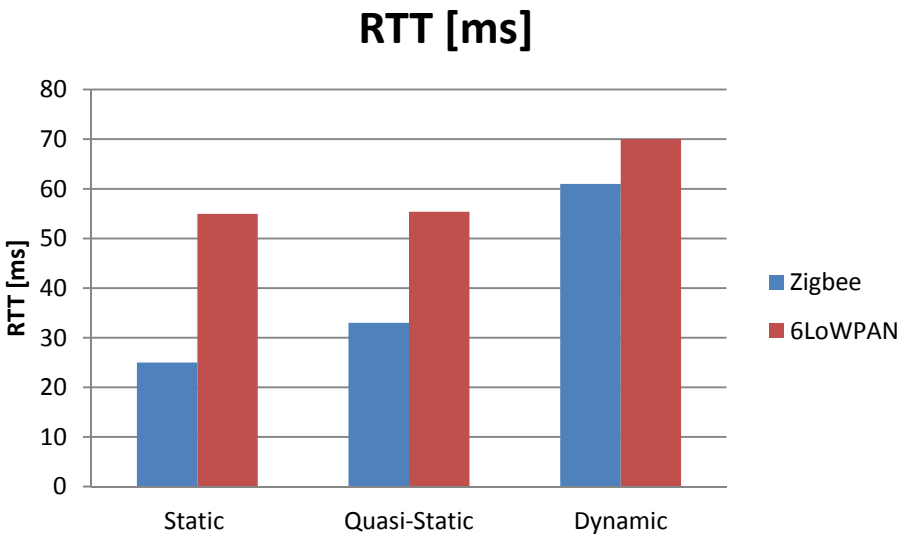
Numerical Results: impact of environment



Quasi-Static conditions

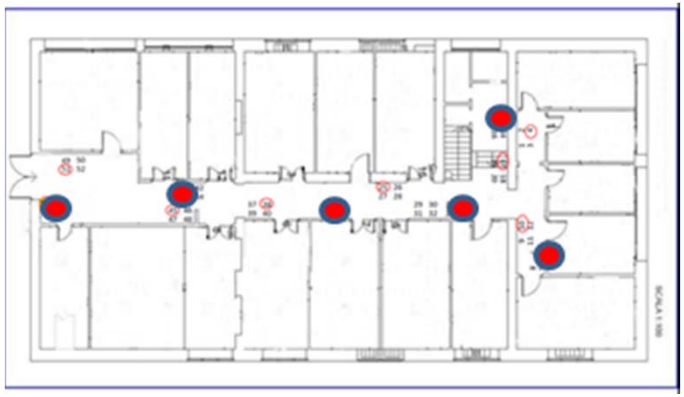
Dynamic conditions

Numerical Results: impact of environment



Quasi-Static conditions

Dynamic conditions

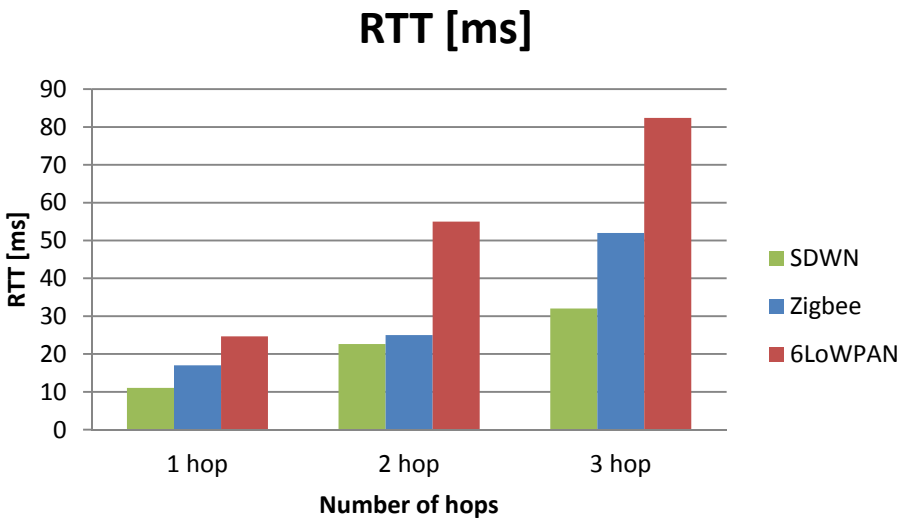


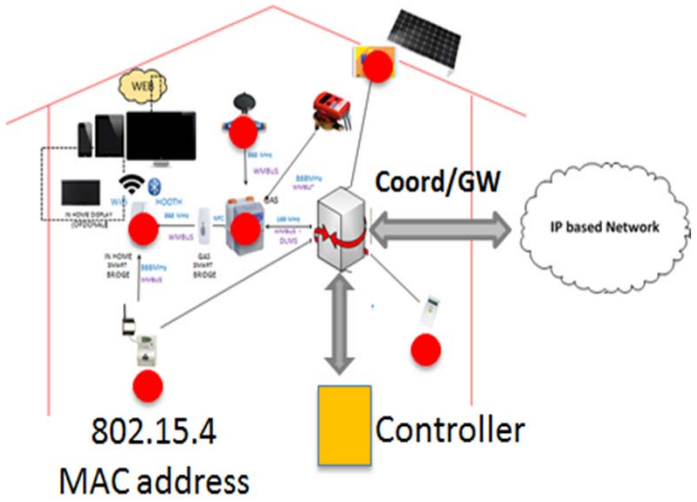
Numerical Results: overhead

	One Hop [#packets]	Two hops [#packets]	One Hop [#Bytes]	Two hops [#Bytes]
Zigbee	4.7	8.7	6.5	11.4
6LoWPAN	6.2	9.5	10.9	16.8

Numerical Results: Zigbee vs SDWN

- Centralised routing: Controller takes decisions
- Low delay at routers





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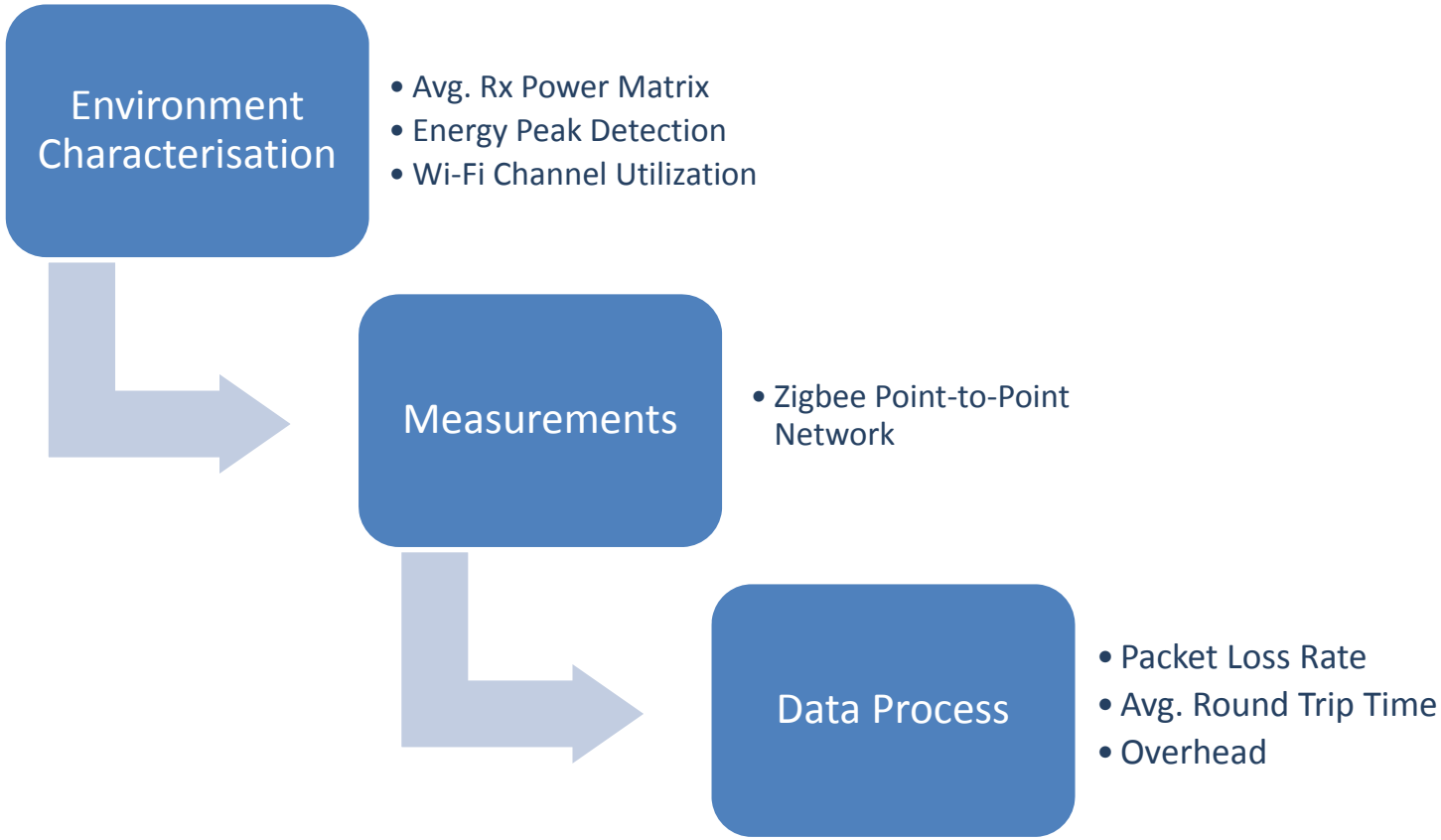
4. **Coexistence Issues at 2.4 GHz**

Motivation

- Smart Home: strong presence of Wi-Fi
- Check the impact of Wi-Fi on Zigbee
- Extremely bad conditions tested
  - Up to 3 APs setup
  - Close proximity of APs to Zigbee Coordinator
  - No frequency agility used

Methodology: why EuWIn?

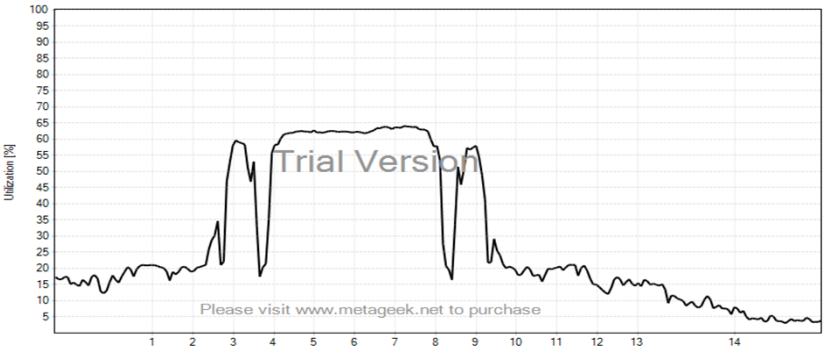


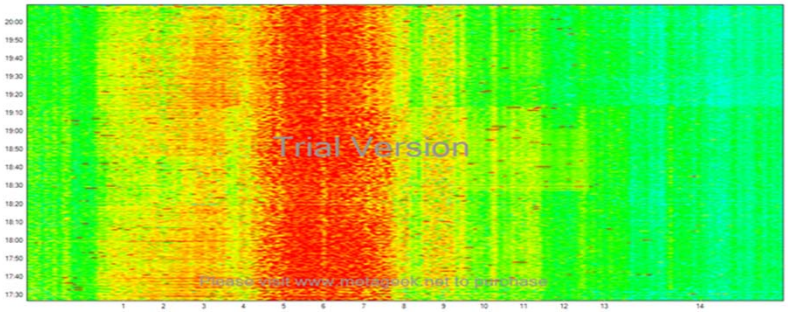
Experimental Characterisation: why EuWIn?

Avg. Rx Power Matrix [dBm]

	Coord	22	33	45
Coord	0	-48	-60	-84
22	-49	0	-78	-79
33	-65	-75	0	-68
45	-81	-77	-66	0

Wi-Fi Channel Utilization

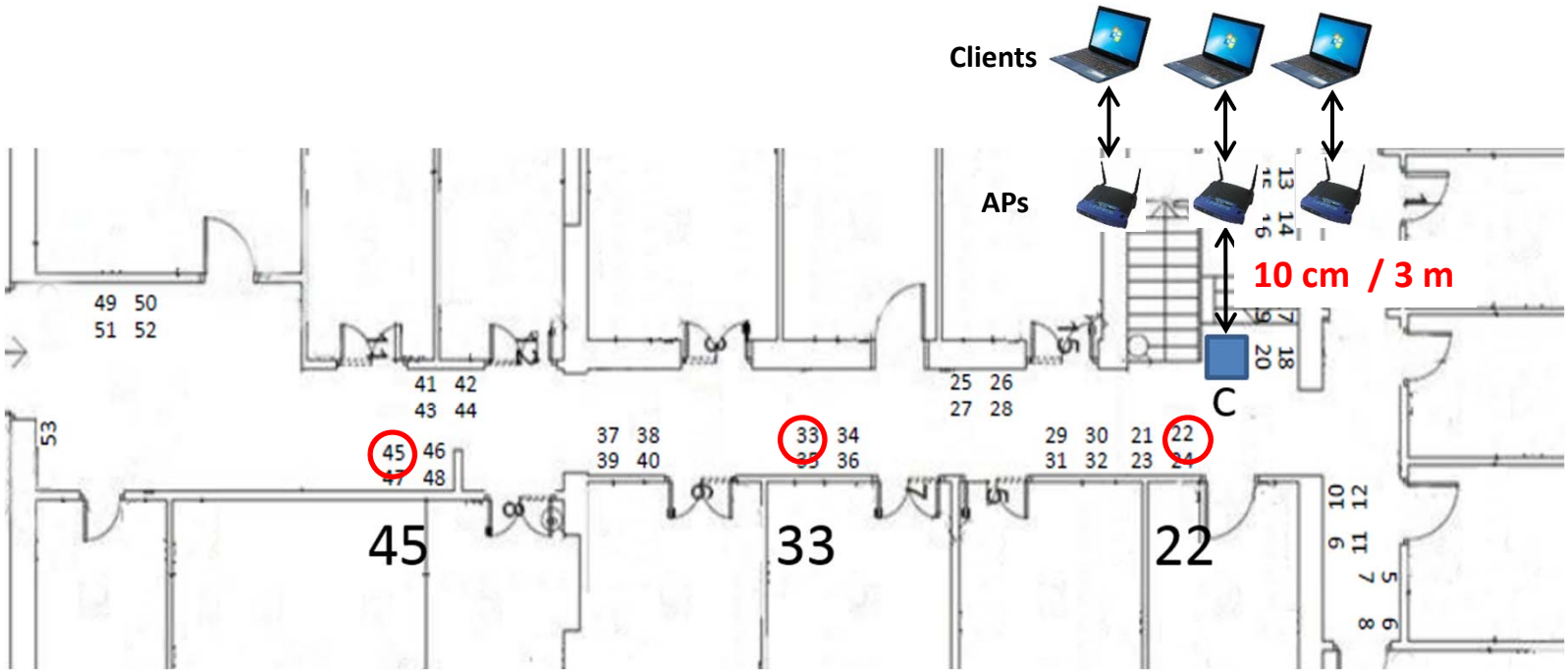


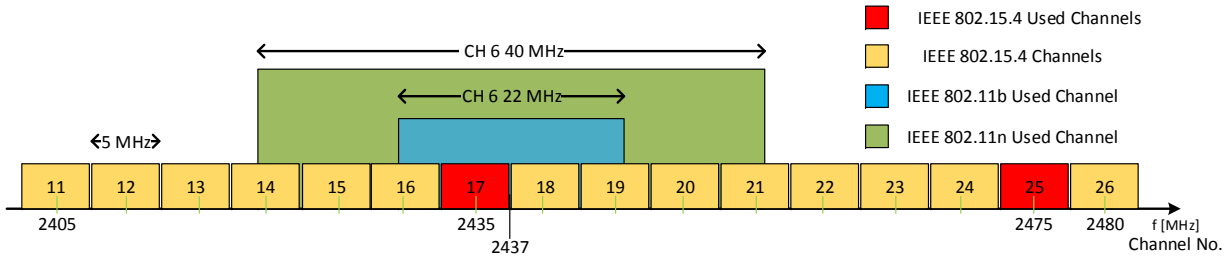


Energy Peak Detection [dBm]

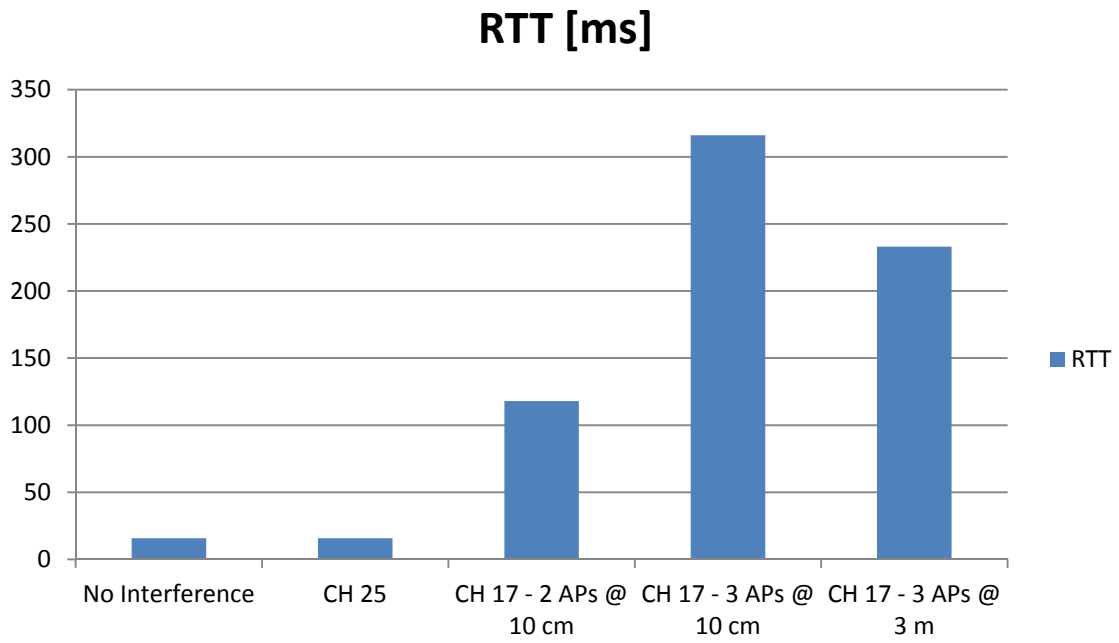
	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
C	-64.9	-51.4	-50.2	-46.2	-46.2	-25.1	-13.5	-13.5	-30.2	-43.0	-44.2	-50.2	-49.4	-54.5	-62.9	-66.9
22	-74.5	-74.5	-71.3	-76.5	-71.3	-48.2	-36.6	-37.8	-48.2	-83.6	-70.1	-69.3	-66.9	-66.9	-74.5	-92.0
33	-66.9	-64.9	-62.9	-61.7	-69.3	-64.1	-50.2	-52.6	-75.3	-92.0	-77.7	-70.1	-70.1	-73.3	-92.0	-92.0
45	-48.2	-41.8	-39.8	-49.4	-60.9	-71.3	-62.9	-60.9	-77.7	-92.0	-81.6	-83.6	-77.7	-90.0	-92.0	-92.0

Test: testbed setup





Numerical Results: an example



Conclusions

- **EuWIn: a remote programming platform for testing IoT protocols at disposal of SMEs**
- **Zigbee outperforms 6LoWPAN**
- **Coexistence Issues between Zigbee and Wi-Fi should be properly checked**

If you want to know something more…

Visit Our EuWIn DEMO !

c.buratti@unibo.it

References

D. Abrignani, C. Buratti, L. Frost, R. Verdone, “Testing The Impact of Wi-Fi Interference on Zigbee Networks”, EuroMed 2014, Napoli, Italy, 2014.

D. Abrignani, C. Buratti, L. Frost, R. Verdone, “Technical Report on Testing The Impact of Wi-Fi Interference on Zigbee Networks”, presented to Home Gateway Initiative.

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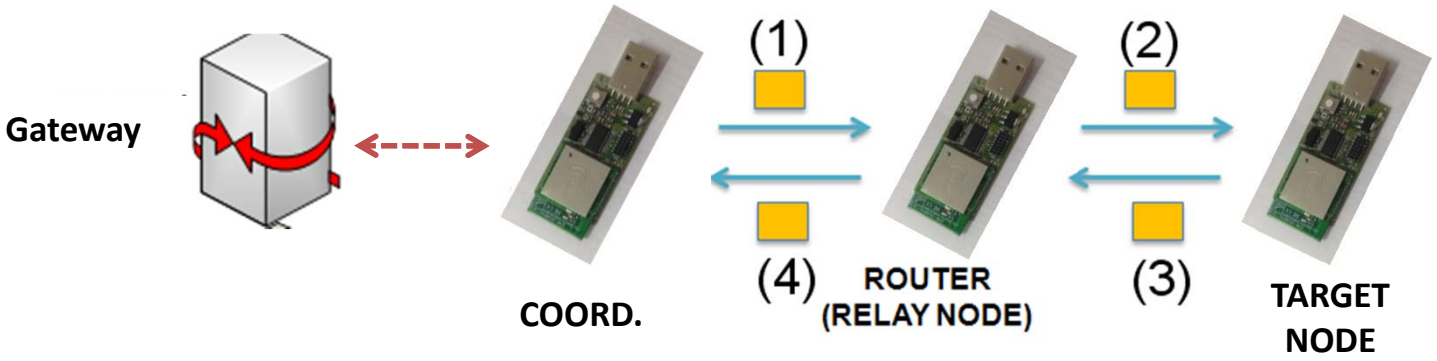
M. D. Abrignani, C. Buratti, D. Dardari, N. El Rachkidy, A. Guitton, F. Martelli, A. Stajkic, R. oberto Verdone, “The EuWIn Testbed for 802.15.4/Zigbee Networks: From the Simulation to the Real World”, Proc. of ISWCS 2013, August 27-30 2013, Ilmenau, Germany.

C. Buratti, G. Gardasevic, S. Milardo, M.D. Abrignani, S. Mijovic, A. Stajkic, G. Mirabito, R. Verdone, “Testing Protocols for The Internet of Things on The EuWIn Platform ”, submitted to IEEE IoT Journal.

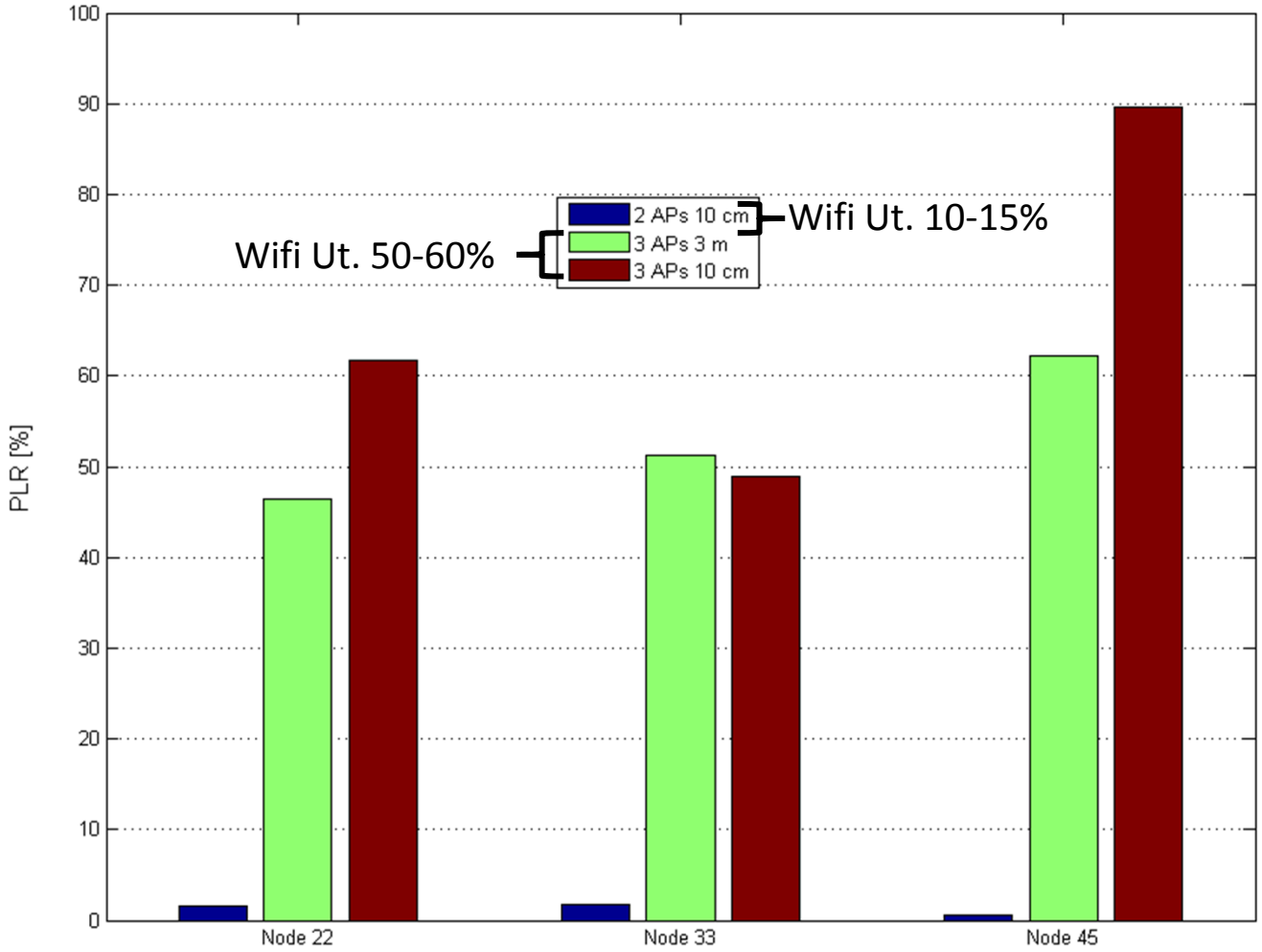
Numerical Results: traffic and metrics

- **Traffic:** Query-based APPs
  - Coordinator periodically triggers one of the nodes
  - Packets are generated every 300 ms

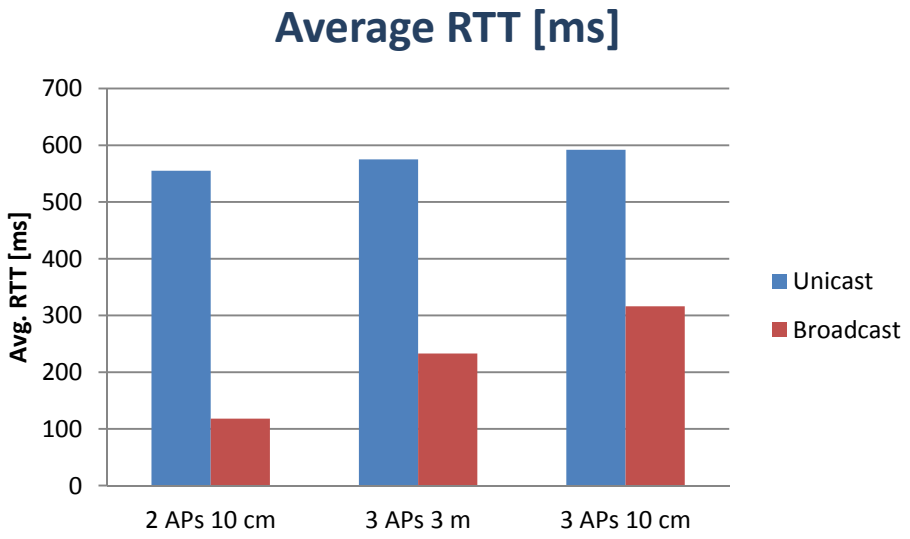
- **Metrics**: Average Round Trip Time, Overhead

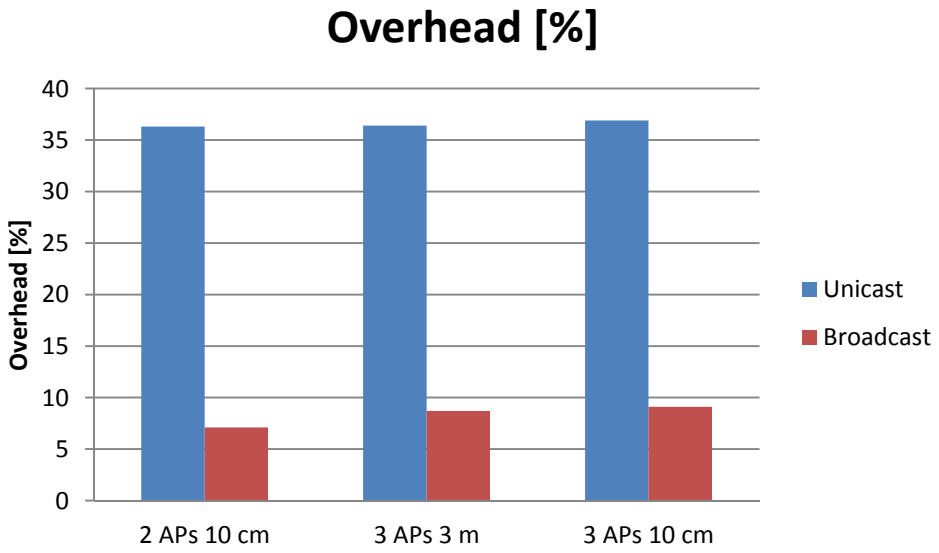


Measurements Result: PLR – CH 17 – Unicast



Measurements Result: RTT – CH 17 – Broadcast vs Unicast





Measurements Result: RTT – Unicast – CH 17 vs CH 25