TECHNISCHE HOCHSCHULE LÜBECK

IoTiSS: Internet of Things in Smart Streetlighting

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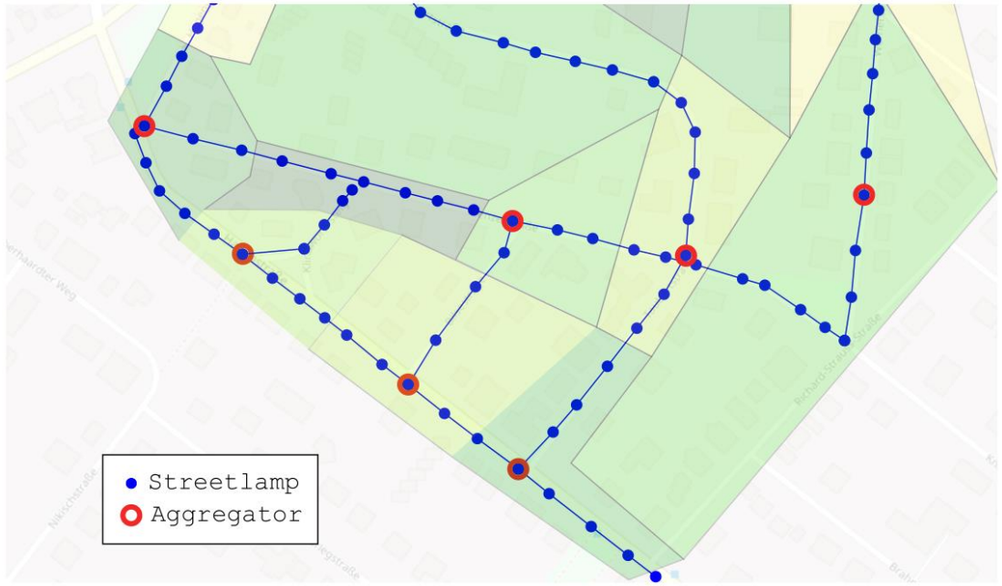
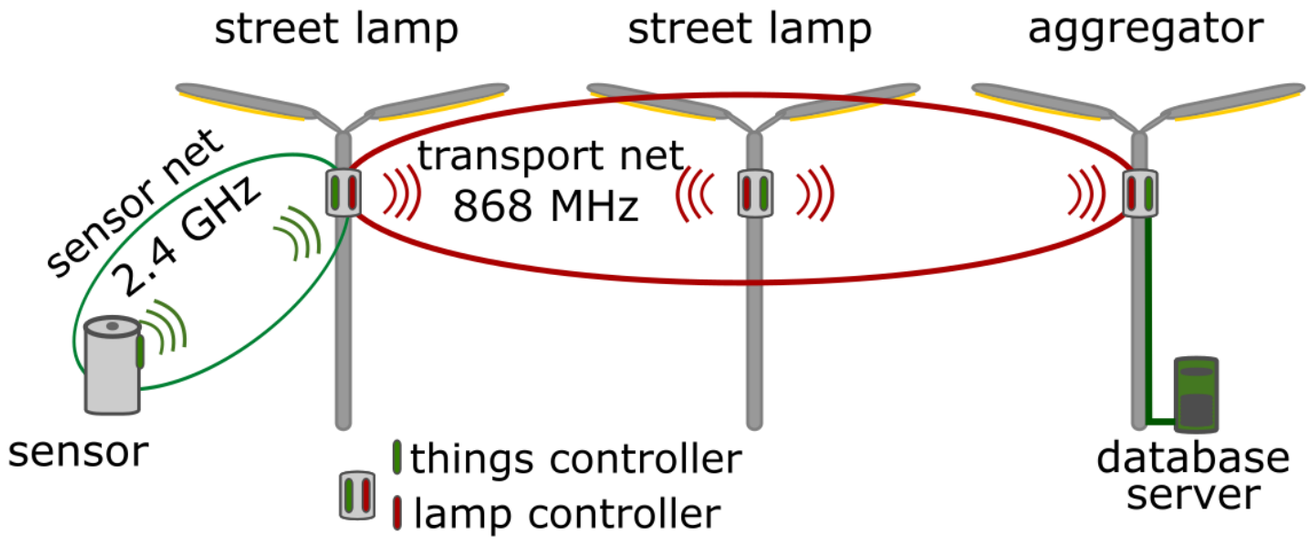
Introduction

- Street lamps spread over a wide area in proximity of points of interests
- Ideal gateways for wireless devices in the IoT
- Equipping of street lamps with radio frequency modules enable the controlling of street lamps
- Radio network serves as a backbone for the IoT



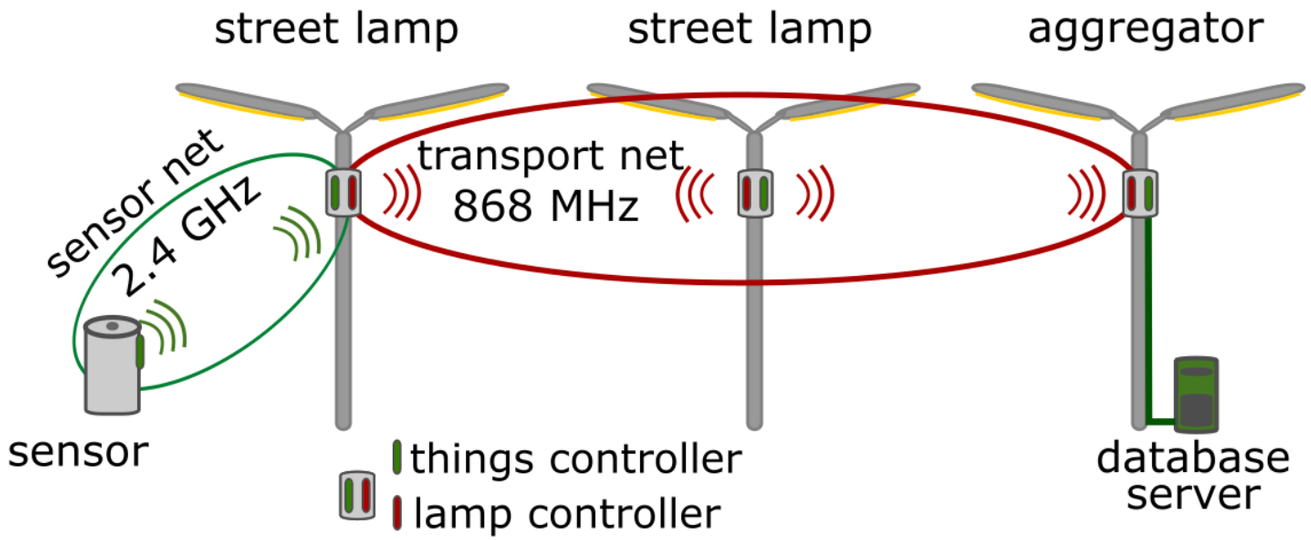
Components

- Sensor
  - Perform measurements
- Things controller
  - Receives measurements and forwards to transport network
- Lamp controller
  - Controls lamps and establishes the transport network
- Aggregator street lamp
  - Communication endpoint (database)



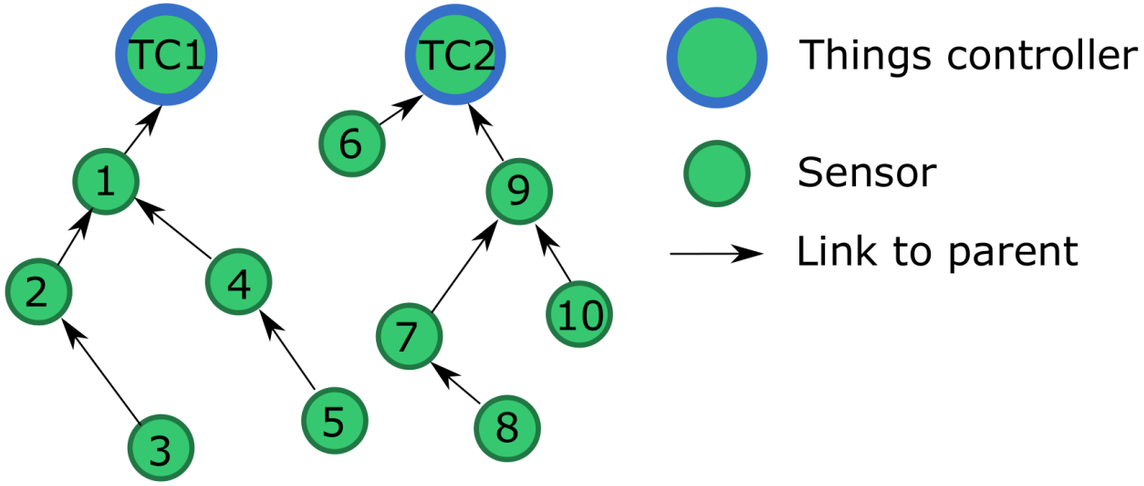
Concept

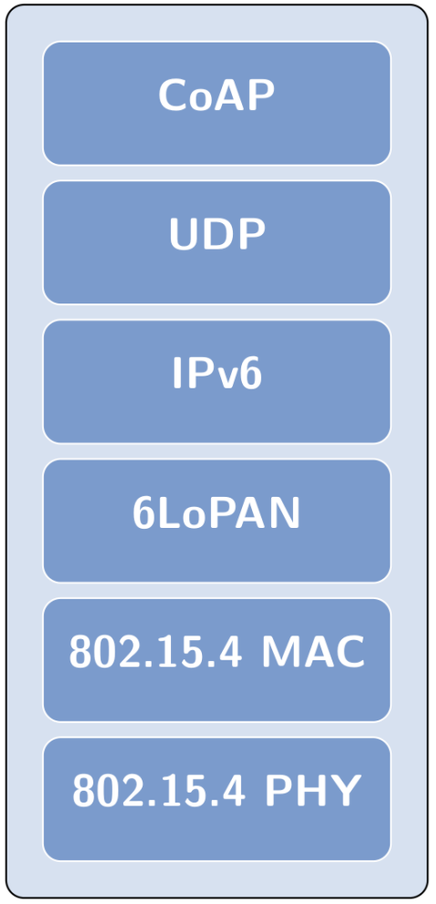
- Sensor Net
  - Communication from the Things towards the nearest street lamp
- Transport Net
  - Controlling and operation of the lamps
  - Forwards data from the Things towards the nearest aggregator
- Interface
  - Connects the sensor network with the transport network
  - I²C Interface between a things controller and a lamp controller



Sensor Net

- Sensor network consists of numerous sensor nodes
- Sensor network operates at 2.4 GHz ISM-band
- Contiki-NG as operating system
- Uses RPL as routing protocol





Transport Net

- Backbone of the system
- Transmit control messages to street lamps & read out diagnosis data
- Transmit sensor readings towards the aggregator
- For sensor nodes, the transport network is transparent

- Transport network is developed by our project partner

I²C Interface

- Read and write variables from the transport network
- Addresses of physical neighbors and aggregators are programmed during commissioning of the actual street lamps
- Transfer messages from sensor network to the transport network and vice versa

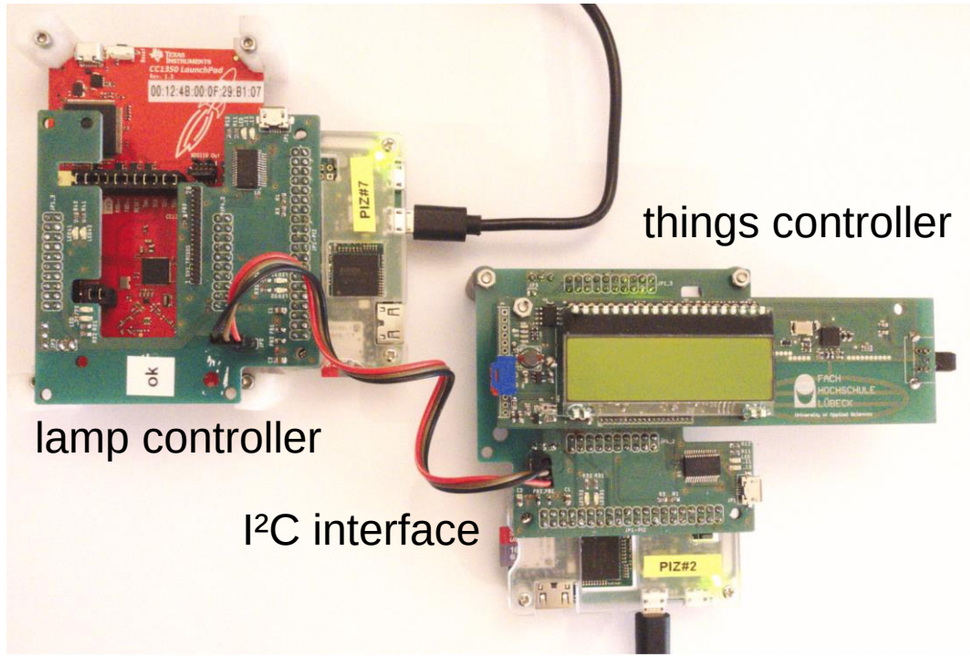
Hardware

TriSOS

- ATxmega128A1 microcontroller
- AT86RF233 radio chip

CC1350 Launchpad

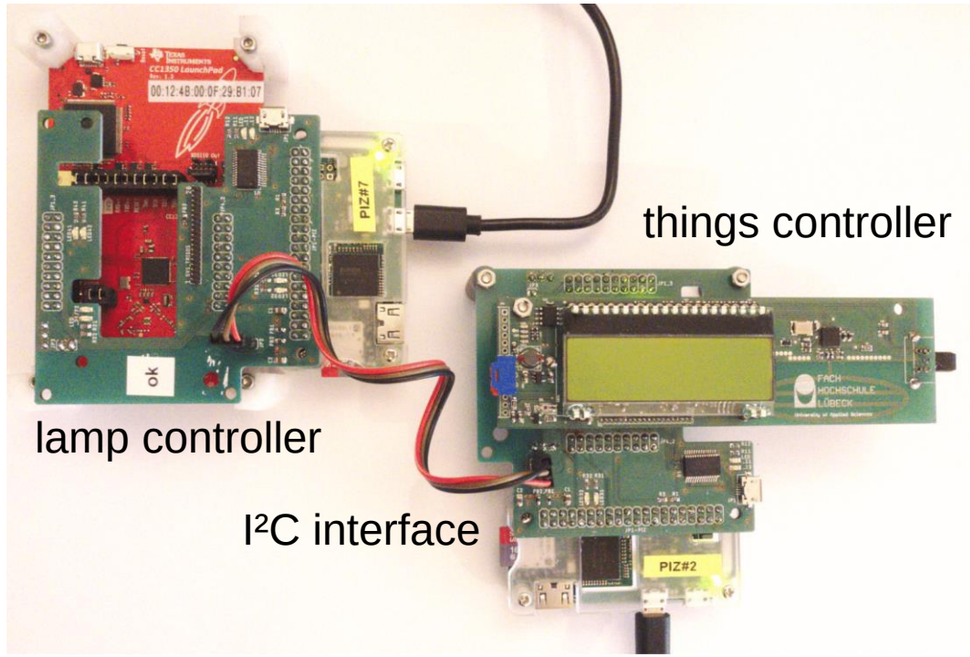
- Cortex-M3 microcontroller
- CC1350 radio chip
- 2.4 GHz and 868 MHz operation mode



Deployment Tool

MQTT-based Testbed

- Each node's I/O is connected to Raspberry Pi Zero
- Update of firmware via WiFi
- Reset and supervision of sensor nodes

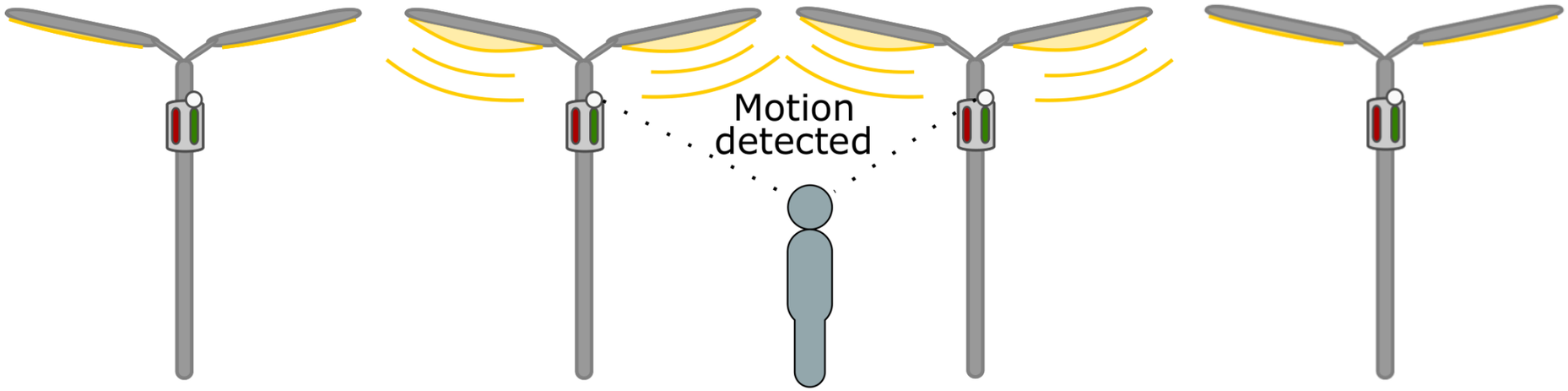


Connection-Board

- Connects I/O of sensor nodes with Raspberry Pi Zero
- Access to I²C interface

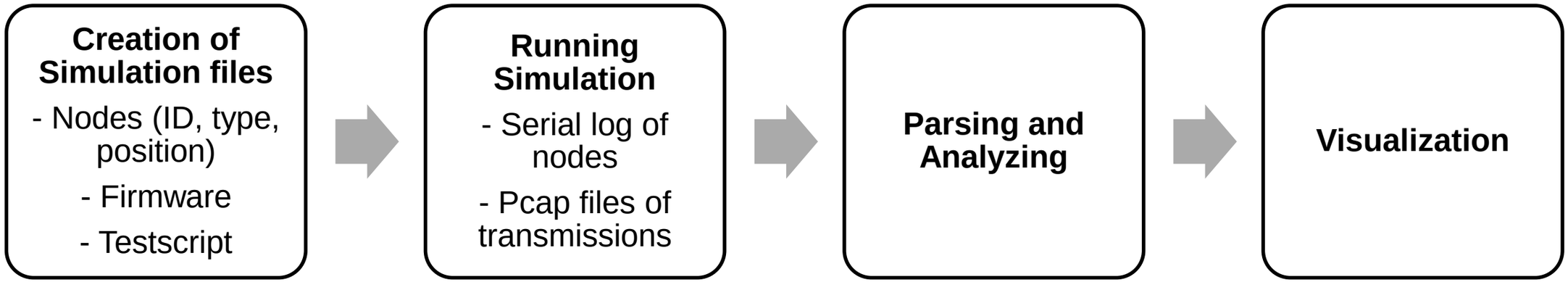
Applications

1. Transfer of sensor measurements, e.g. level of a garbage bin
2. Dimming of lamps on demand
   - Motion detection via passive infrared sensor



Simulation

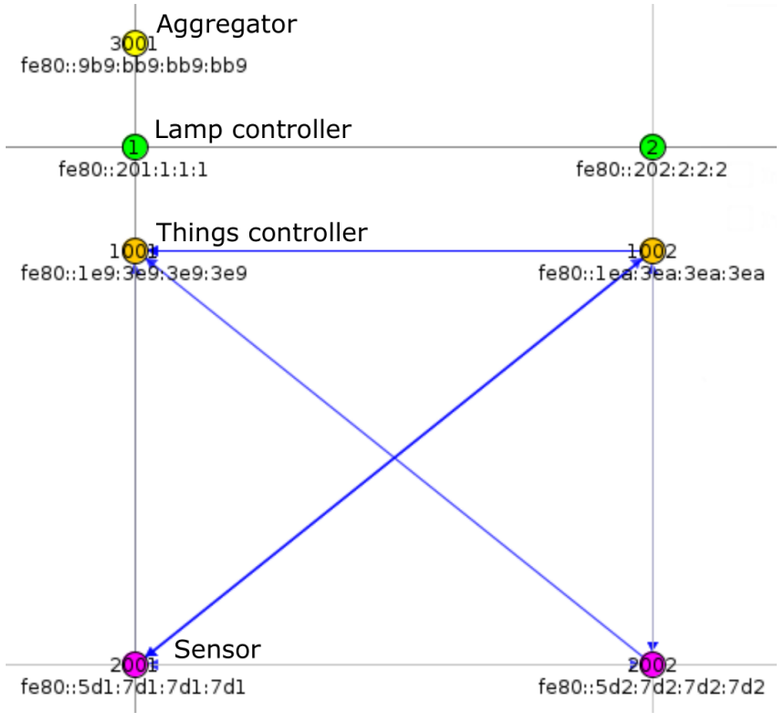
- Cooja network simulator (part of Contiki tool chain)
- Same source code as for real deployment



- Adoption of the MakeSense framework [1]
- All configured and executed within a Jupyter Notebook

[1] Leone, Rémy, et al. "MakeSense: Managing Reproducible WSNs Experiments." *Fifth Workshop on Real-World Wireless Sensor Networks, 2013*. 2013.

Simulation



10 Street lamps each with 1 sensor placed with 25 m distance from each other

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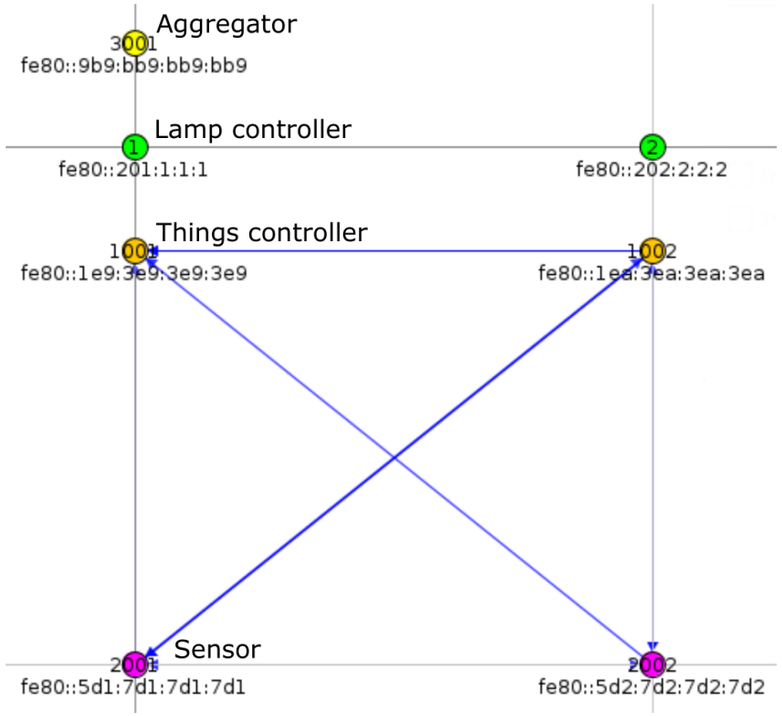
```
1809000 ID:7 [INFO: iotiss_i2c] checsums: 0xc862 vs 0xc862
1809000 ID:7 [INFO: iotiss_i2c] rx_pkt[4] 01 20
1809000 ID:7 [INFO: iotiss_i2c] i2c_tx_frame[25]: 18 3 20 12 fd 0 0 0 0 0 0 0 2 12 4b 0 f 29 d9 83 1b eb 3a 88 ff
1826000 ID:8 [INFO: app       ] Dim status: 0
1826000 ID:8 [INFO: iotiss_i2c] checsums: 0xe868 vs 0xe868
1826000 ID:8 [INFO: iotiss_i2c] rx_pkt[4] 01 11
1826000 ID:8 [INFO: iotiss_i2c] i2c_tx_frame[25]: 18 3 11 12 fd 0 0 0 0 0 0 0 9 b9 b b9 b b9 b b9 1b eb a2 97 ff
1826000 ID:8 [INFO: iotiss_i2c] checsums: 0xc862 vs 0xc862
1826000 ID:8 [INFO: iotiss_i2c] rx_pkt[4] 01 20
1826000 ID:8 [INFO: iotiss_i2c] i2c_tx_frame[25]: 18 3 20 12 fd 0 0 0 0 0 0 0 2 12 4b 0 f 29 d9 83 1b eb 3a 88 ff
```

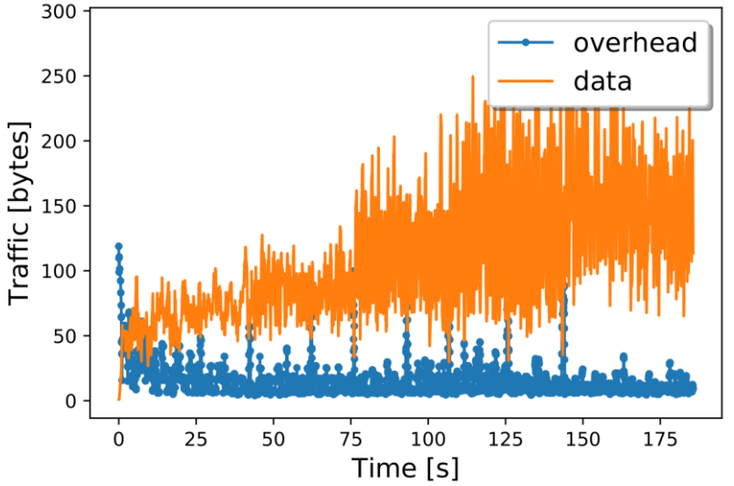
No.	Time	Source	Destination	Protocol	Length	Info
79	3.095568			IEEE 802.15.4	5	Ack
80	3.109000	fe80::5d4:7d4:7d4:7d4	fe80::1ec:3ec:3ec:3ec	CoAP	51	ACK, MID:50041, 2.05 Content, TKN:03 (text/pla
81	3.111568			IEEE 802.15.4	5	Ack
82	3.248000	fe80::1ee:3ee:3ee:3ee	fe80::5d6:7d6:7d6:7d6	CoAP	42	CON, MID:34440, GET, TKN:03, /prox
83	3.250280			IEEE 802.15.4	5	Ack
84	3.277000	fe80::5d6:7d6:7d6:7d6	fe80::1ee:3ee:3ee:3ee	CoAP	51	ACK, MID:34440, 2.05 Content, TKN:03 (text/pla
85	3.279568			IEEE 802.15.4	5	Ack
86	3.361000	fe80::5d9:7d9:7d9:7d9	fe80::1f0:3f0:3f0:3f0	ICMPv6	102	RPL Control (DODAG Information Object)
87	3.365200			IEEE 802.15.4	5	Ack
88	3.381000	fe80::5d7:7d7:7d7:7d7	fe80::1ee:3ee:3ee:3ee	ICMPv6	102	RPL Control (DODAG Information Object)
89	3.385200			IEEE 802.15.4	5	Ack
90	3.452000	fe80::5da:7da:7da:7da	fe80::1f2:3f2:3f2:3f2	ICMPv6	102	RPL Control (DODAG Information Object)
91	3.456200			IEEE 802.15.4	5	Ack
92	3.563000	fe80::202:2:2:2	fe80::9b9:bb9:bb9:bb9	ICMPv6	102	RPL Control (DODAG Information Object)
93	3.567200			IEEE 802.15.4	5	Ack
94	3.799000	fe80::1e9:3e9:3e9:3e9	fe80::5d2:7d2:7d2:7d2	CoAP	42	CON, MID:61316, GET, TKN:03, /prox
95	3.801280			IEEE 802.15.4	5	Ack
96	3.812000	fe80::1e9:3e9:3e9:3e9	fe80::5d1:7d1:7d1:7d1	CoAP	42	CON, MID:61315, GET, TKN:03, /prox
97	3.814280			IEEE 802.15.4	5	Ack

Simulation



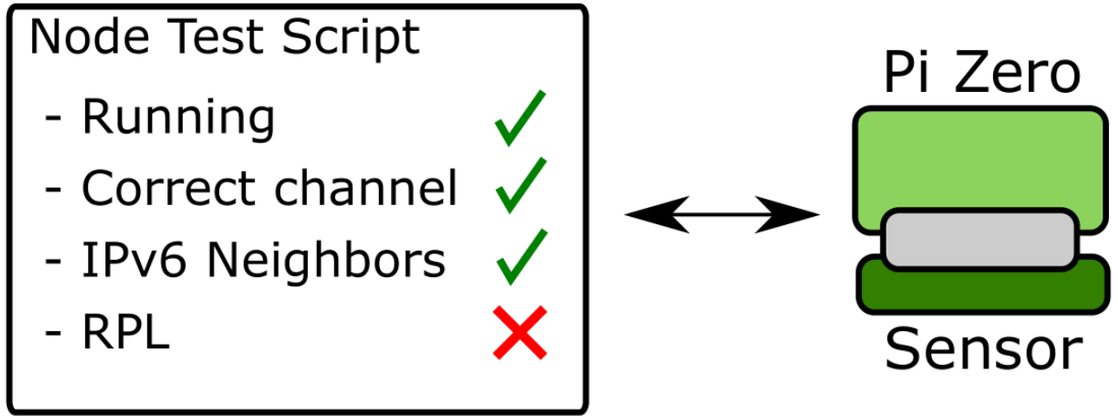
10 Street lamps each with 1 sensor placed with 25 m distance from each other

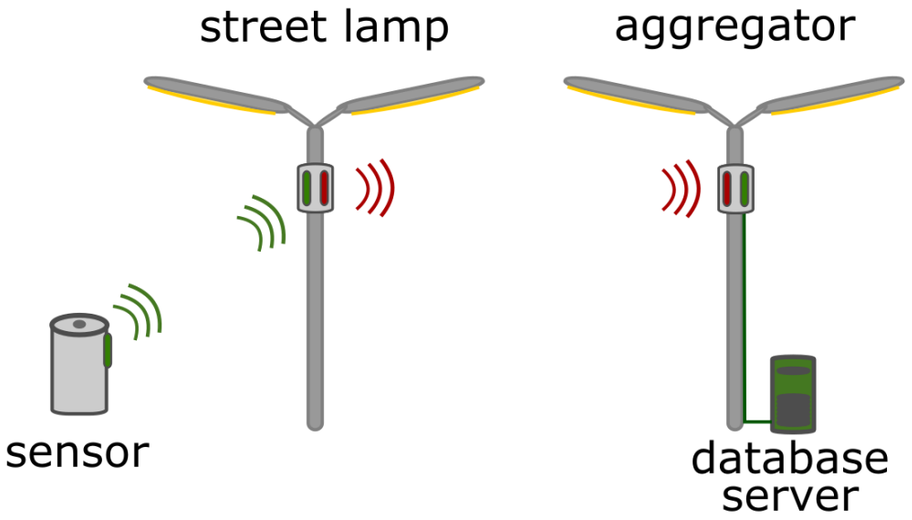
Overhead (RPL messages & ACKs)



Test Scripts

- Test scripts for testing the functioning of the different nodes
- All nodes are reset, functioning of the nodes are checked after a delay





Start delay [s]	0	10	20	30
# tests failed	294	4	3	3
# tests passed	0	290	291	291

Conclusion

- Present open platform that support multiple radio frequency stacks for smart street lamps
- Transport network for controlling of the lamps
- Sensor network for the IoT
- Concept is developed and implemented

Future Work

- Add security and authentication mechanisms for the networks
- Expanding and thoroughly evaluate the testbed

Thank you for your attention
Questions or Remarks?
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