

Routing under heterogeneity and mobility for the Internet of Things: a centralized control approach



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IoT /WSN Routing problem

Routing is challenging network function in IoT:

power storage memory

Processing and signal limitations

Also, in view of characteristics such as:

large-scale deployment Dynamicity

Heterogeneity Mobility

One of dominant protocols is RPL (Routing Protocol for Low-power and Lossy Networks)

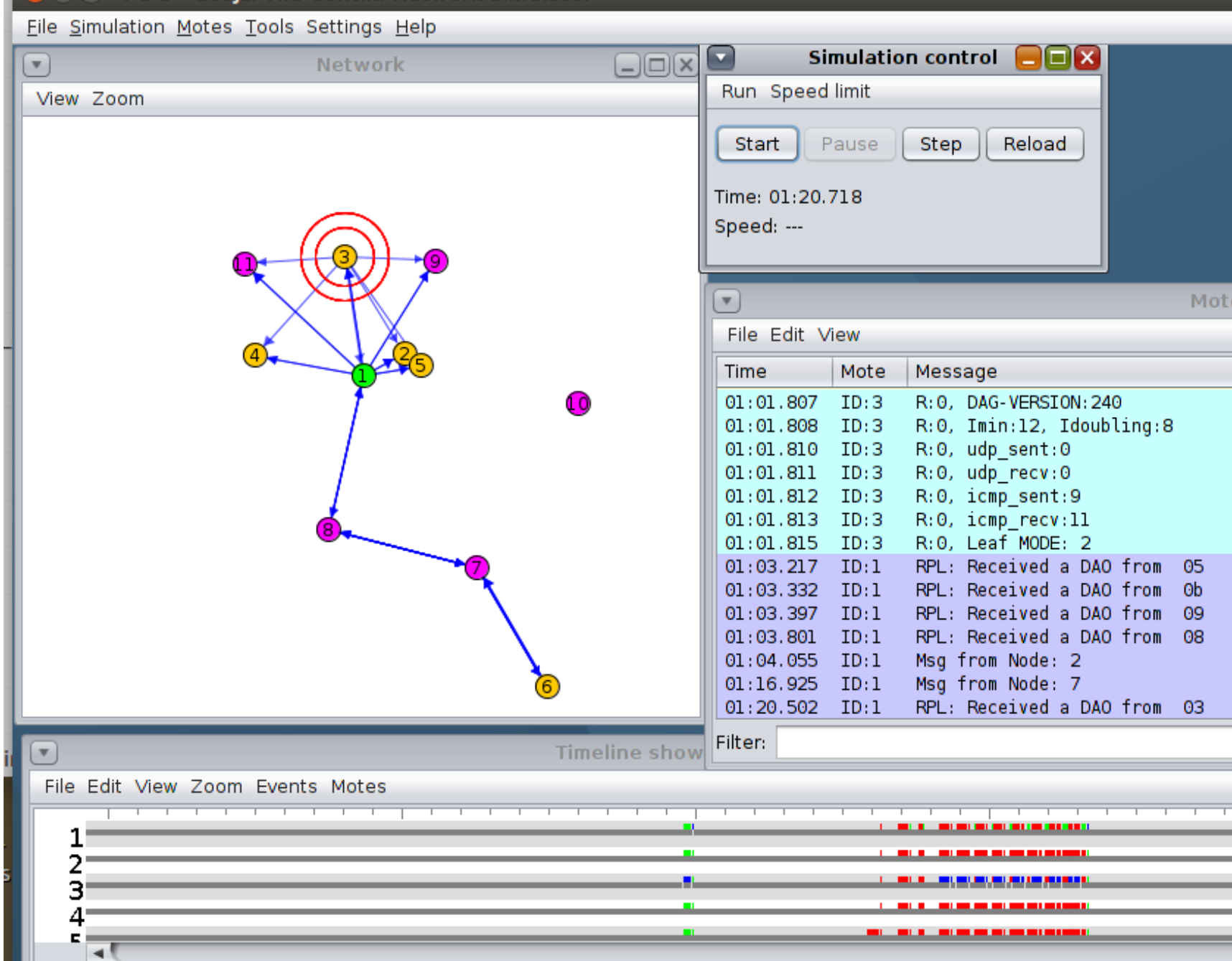
DODAG is the network depiction in RPL

RPL organizes network nodes as a Destination-Oriented Directed Acyclic Graph (DODAG) rooted at a single destination (root or sink node), the only node that can launch the DODAG's construction,

Based upon the exchange of routing control messages

- DODAG Information Object (DIO)
- Destination Advertisement Object (DAO)
- DODAG Information Solicitation (DIS)

COOJA Contiki OS Simulator



The screenshot displays the COOJA Contiki OS Simulator interface. The main window shows a network topology with 10 nodes (1-10) connected by blue arrows. Node 3 is highlighted with a red circle. The 'Simulation control' panel on the right includes buttons for 'Start', 'Pause', 'Step', and 'Reload', along with 'Run' and 'Speed limit' options. The 'Time' is 01:20.718 and 'Speed' is ---. Below this, a 'Mot' panel shows a log of messages. The 'Timeline show' panel at the bottom displays a timeline of events for nodes 1, 2, 3, 4, and 5.

Simulation control

Run Speed limit

Start Pause Step Reload

Time: 01:20.718
Speed: ---

Mot

File Edit View

Time	Mote	Message
01:01.807	ID:3	R:0, DAG-VERSION:240
01:01.808	ID:3	R:0, Imin:12, Idoubling:8
01:01.810	ID:3	R:0, udp_sent:0
01:01.811	ID:3	R:0, udp_rcv:0
01:01.812	ID:3	R:0, icmp_sent:9
01:01.813	ID:3	R:0, icmp_rcv:11
01:01.815	ID:3	R:0, Leaf MODE: 2
01:03.217	ID:1	RPL: Received a DAO from 05
01:03.332	ID:1	RPL: Received a DAO from 0b
01:03.397	ID:1	RPL: Received a DAO from 09
01:03.801	ID:1	RPL: Received a DAO from 08
01:04.055	ID:1	Msg from Node: 2
01:16.925	ID:1	Msg from Node: 7
01:20.502	ID:1	RPL: Received a DAO from 03

Filter:

Timeline show

File Edit View Zoom Events Motes

1
2
3
4
5

RPL Parameters

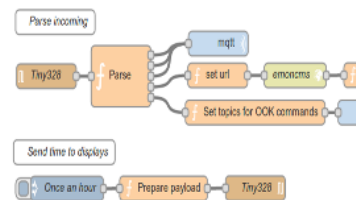
Tackling the parameters that RPL sends/receives DIO, DIS (i.e. I_{min} , I_{double}), but also routing algorithms (i.e., Objective Function), can significantly improve the protocol's communications.

Combined with SDN inspired **centralized management**, we can adapt the protocol ad-hoc and in real-time

CORAL Platform: Can easily be expanded, adapted, adjusted

CORAL Dashboard

Node-RED Designer



Network Visualizer (Measurements & Topology Visualization)



Experiment Configuration Dashboard

Experimentation
manager

Protocol Deployer

Test-bed Deployer

Management
plane

CORAL Network Management

Intelligent Orchestrator

JSON Engine

CORAL API

Control plane

WiSHFUL Platform

Unified Network Control

Unified Radio Control

WiSHFUL UPIs

Data Communication
plane

IoT – Scenarios with Heterogeneity and Mobility

WSN emulator (Cooja)

Multiple Scenarios

Mobility Models

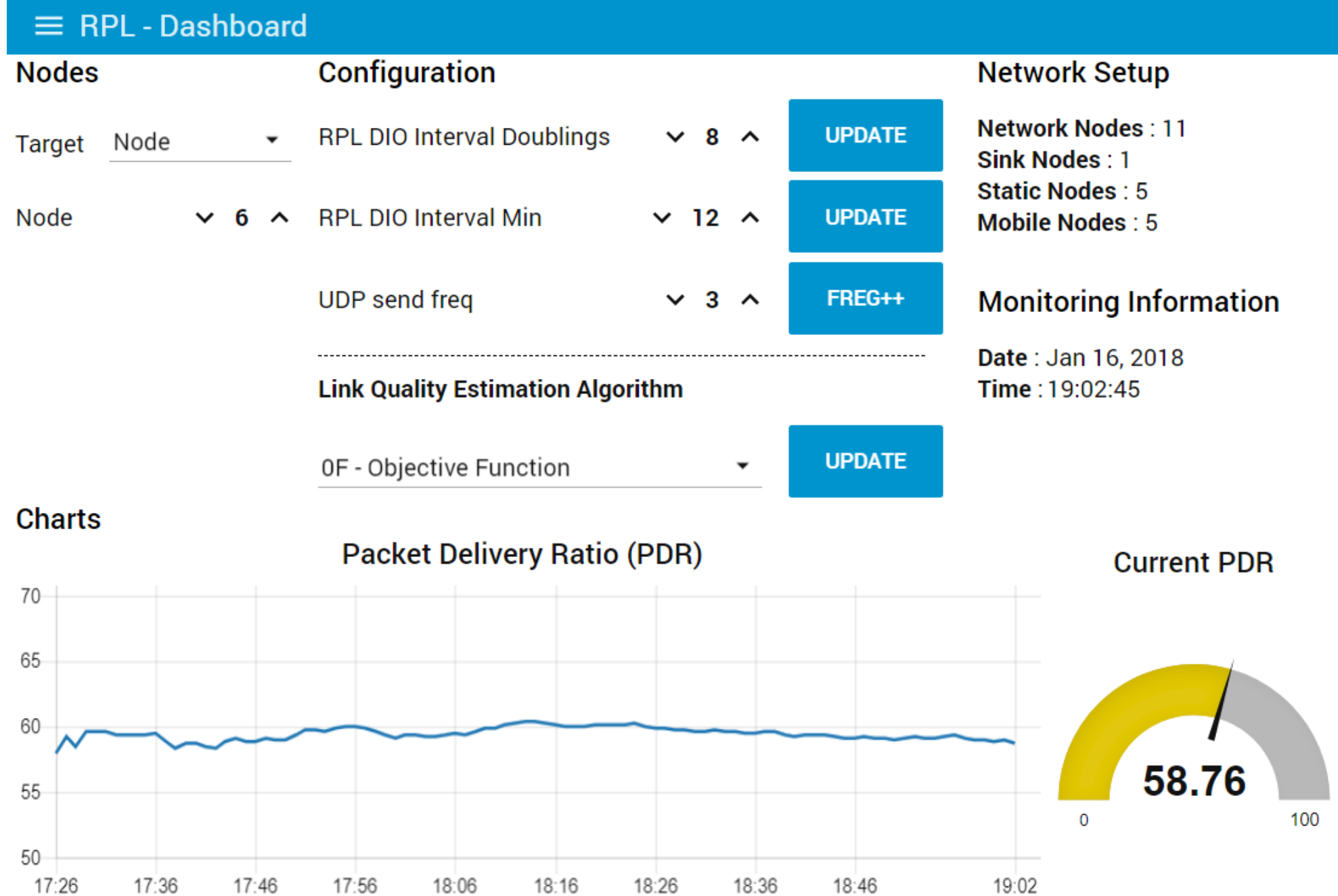
Protocols

RPL

Adaptable
RPL

Other CORAL
Protocols

CORAL Cross- Layer Control of Data Flows

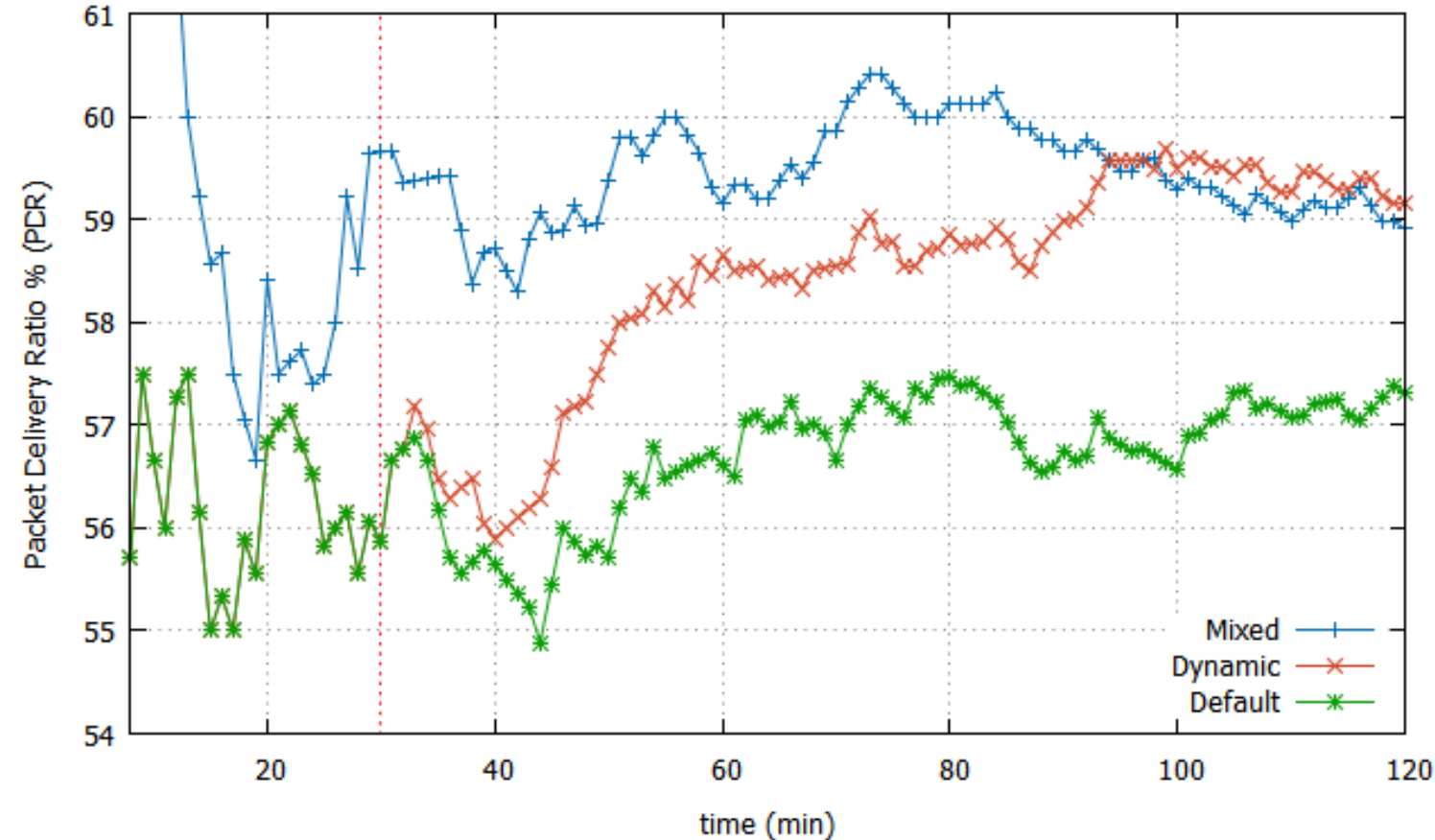


Network Initialization (DODAG setup time)

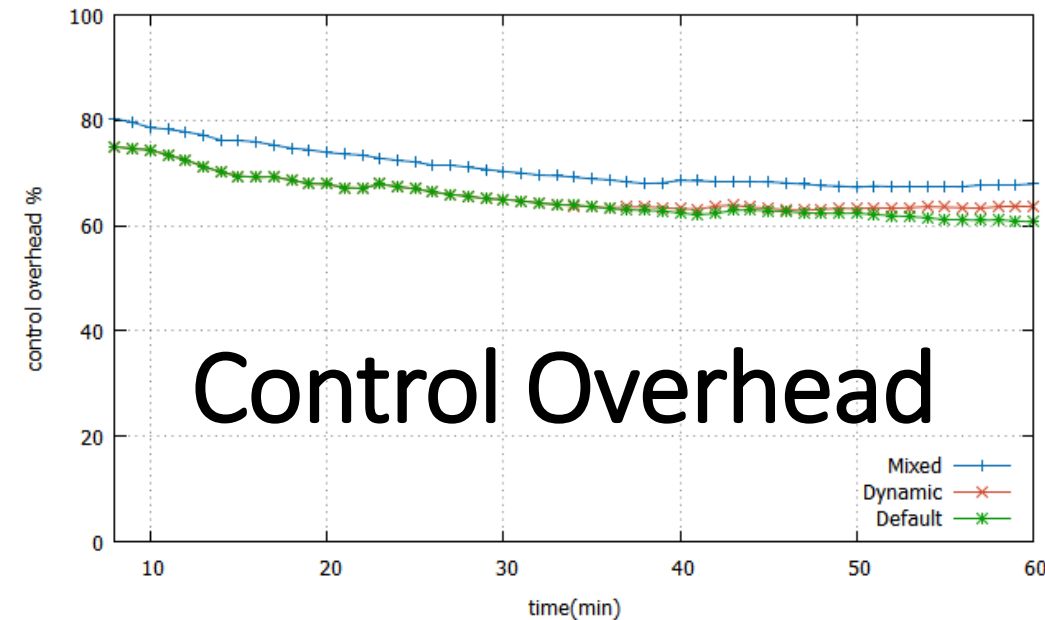
#	No. of nodes	Heterog.	Topology	I_{min}	Setup time (sec)
1	11	Y	Fig 1a	8	13.8
				12	45.0
2	15	N	chain	8	6.2
				12	50.9
3	15	N	lambda (Λ) - sink on top	8	4.8
				12	26.8
4	30	N	as in [3]	8	5.1
				12	23.0
5	30	N	chain	8	11.3
				12	107.4
6	50	N	random	8	10.2
				12	27.3
7	100	N	random	8	32.4
				12	68.1

2 hrs simulation in Cooja

1 sink – 5 fixed - 5 mobile nodes



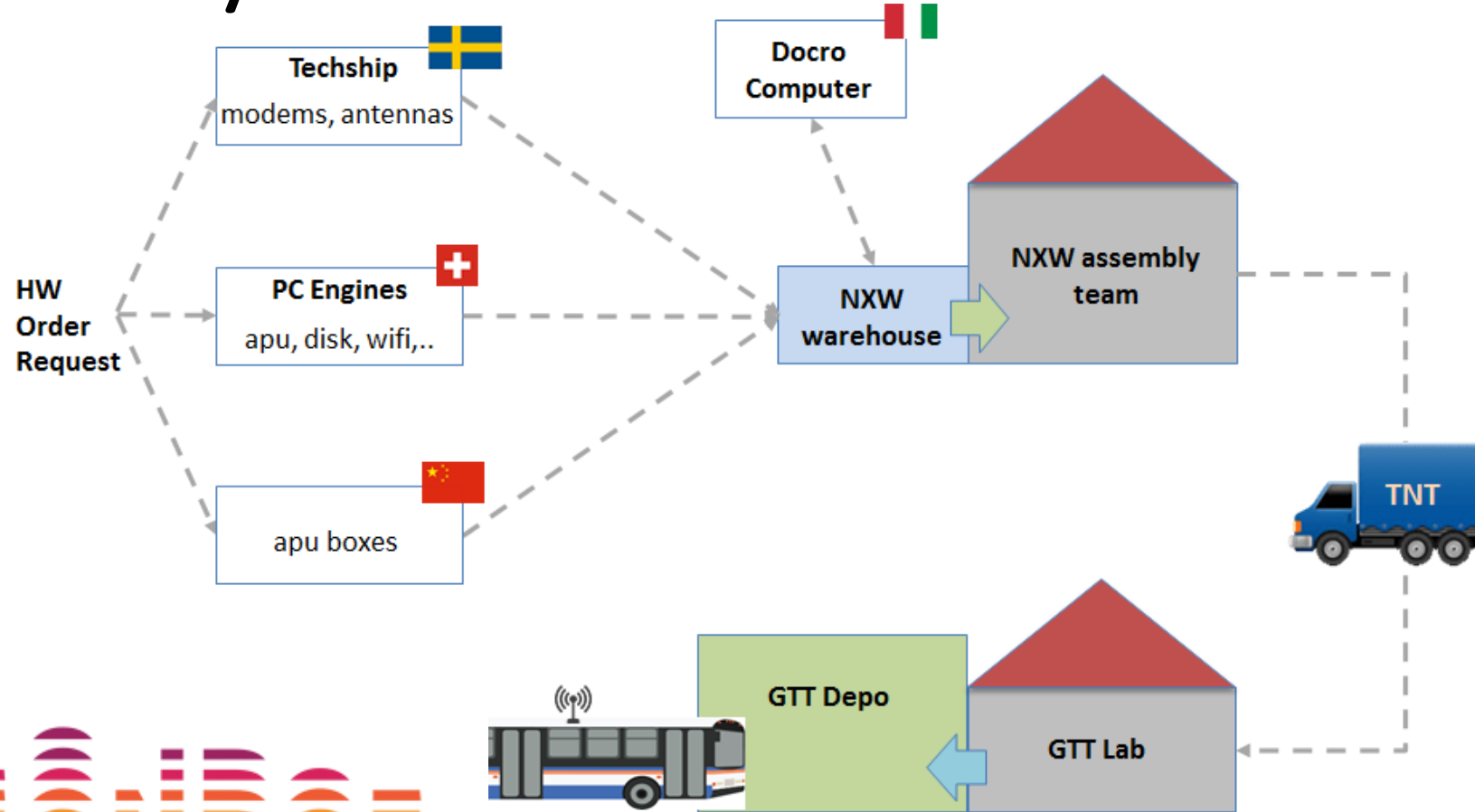
Avg Packet Delivery Ratio



Control Overhead

Real Mobility Traces

Stockholm,
Sweden
buses traces
used



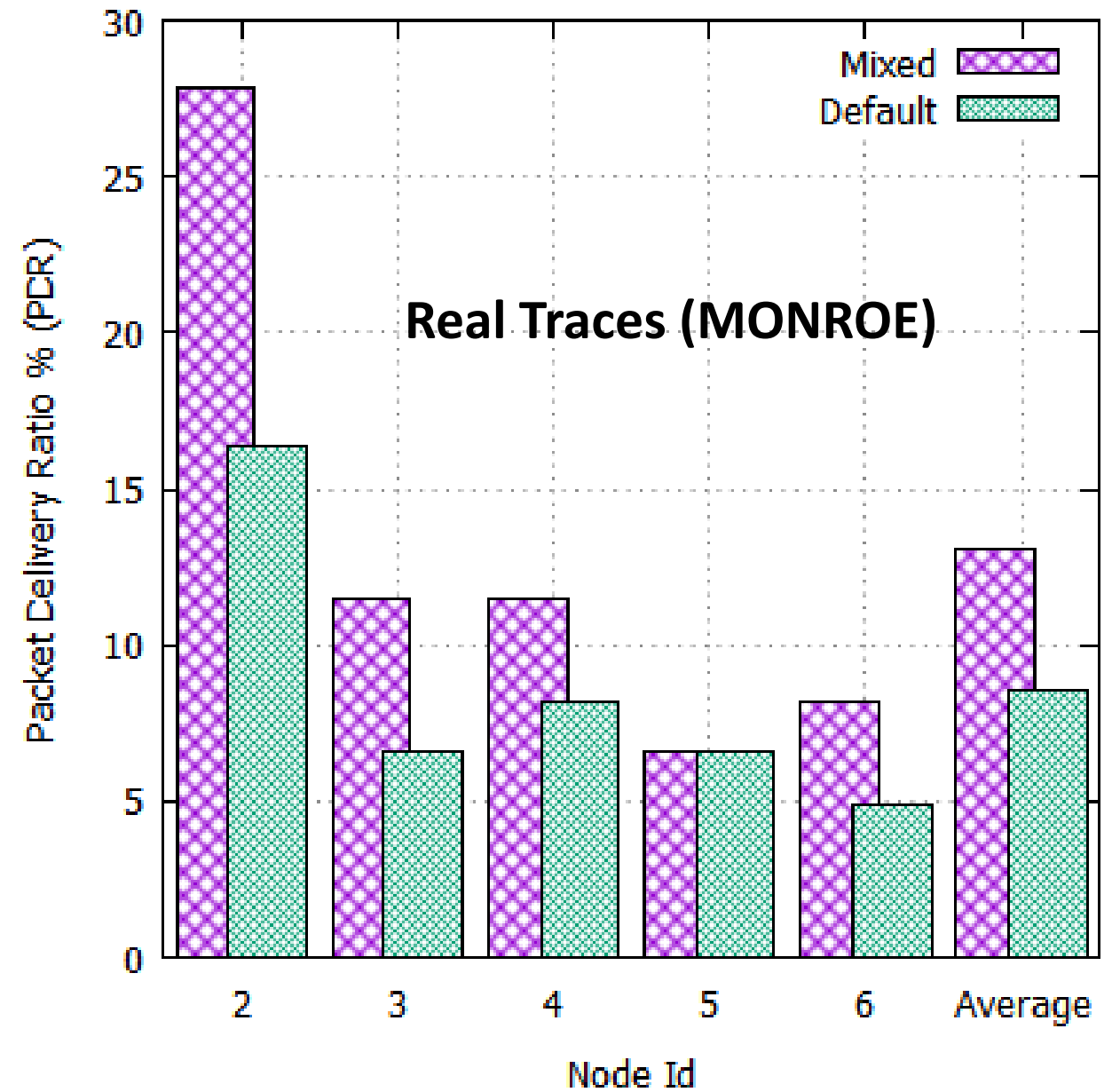
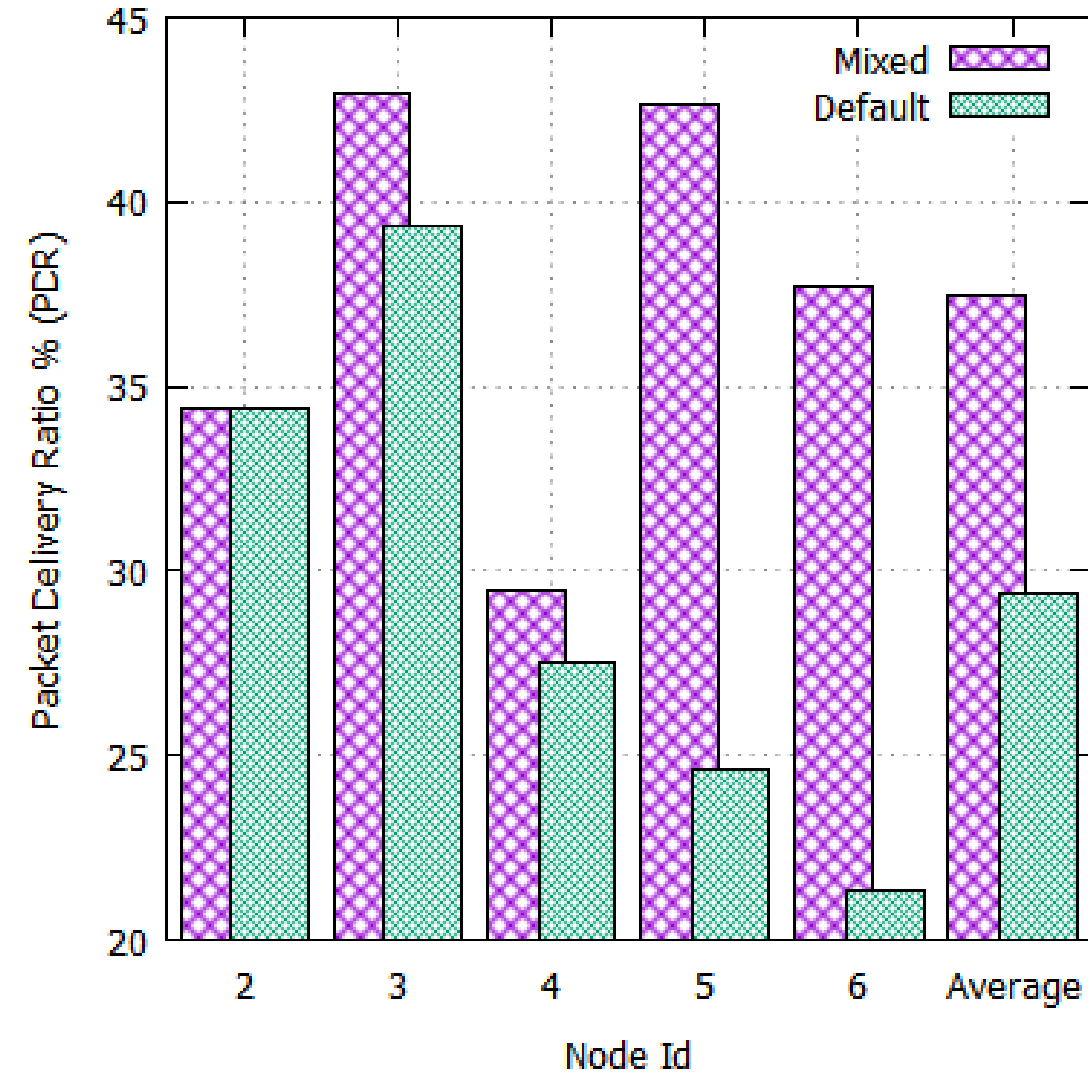
Measuring Mobile
Broadband
Networks in Europe



European Union Horizon 2020 Project



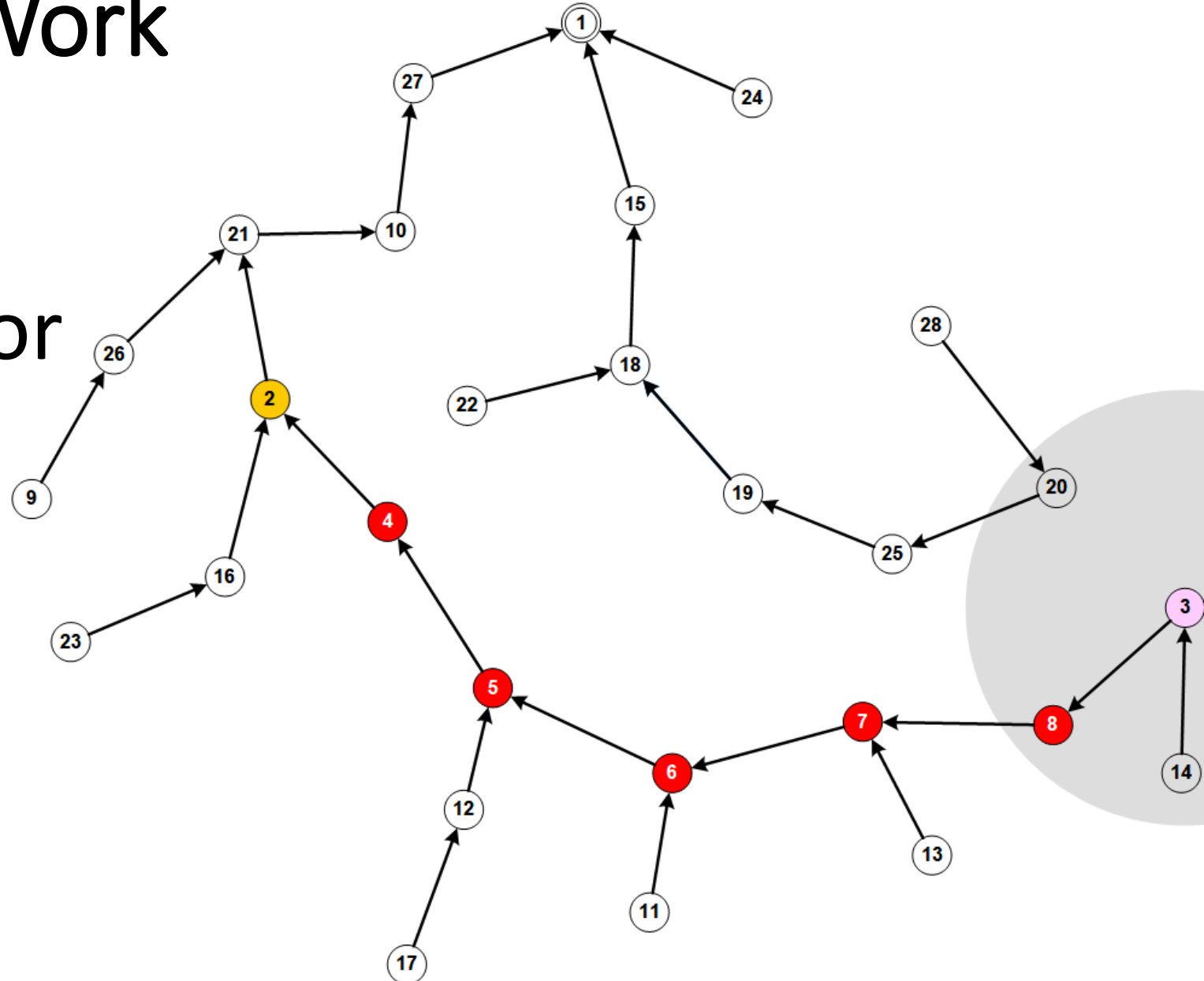
Mobile Nodes Only



Future Work

Created new algorithms (new Objective Function) for peer-to-peer routing for

- Low latency
- High reliability



Conclusion

- RPL has issues with mobility
- Centralized Administration (SDN logic) can improve it /adapt it
- Ad-hoc, real time solutions are needed for IoT/WSN complex networks



QUESTIONS?

Paper title:

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Speaker: George

Thank you