Softwarized & Wireless Networks Research Group

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Software-Defined Wireless Sensor Networks

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University of Macedonia

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Discussion: WSNs fit naturally the SDN paradigm (1)

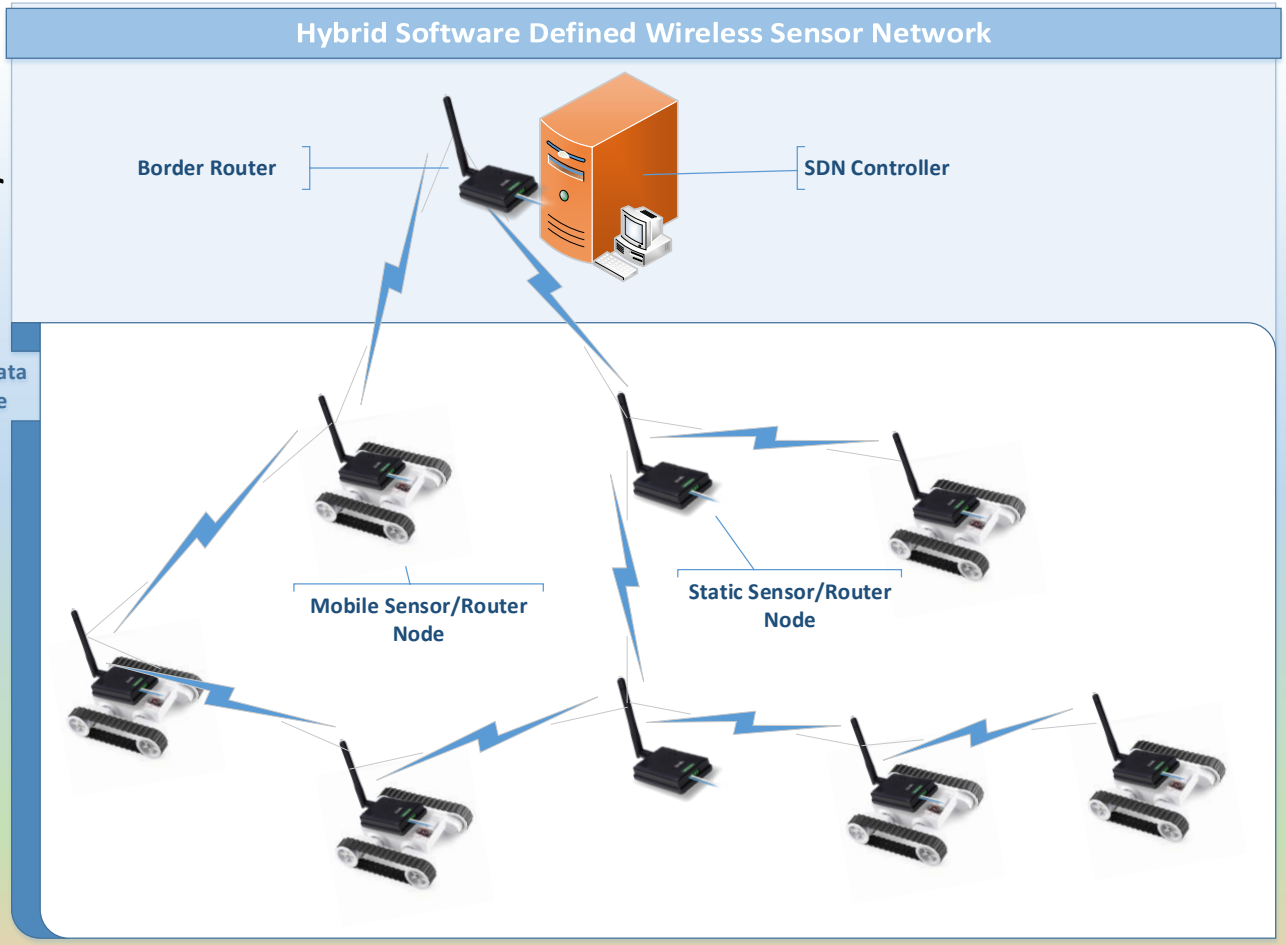
- WSNs architecture relies on one or more centralized base station/sink to task the sensor network and to gather the data
- It naturally maps to the SDN model:
  - the sink could become the centralized controller
  - the motes / sensors could become data plane elements forwarding and processing data along the way

Discussion: WSNs fit naturally the SDN paradigm (2)

- Motes offload network control tasks to the controller:
  - routing, topology management
  - simplifying their architecture and improving their energy efficiency
- The controller armed with a global network view can offer **efficient resource** allocation and **optimized management** through:
  - centrally controlled topology control, scheduling, routing, network coverage and connectivity planning.

Software Defined Wireless Sensor Network

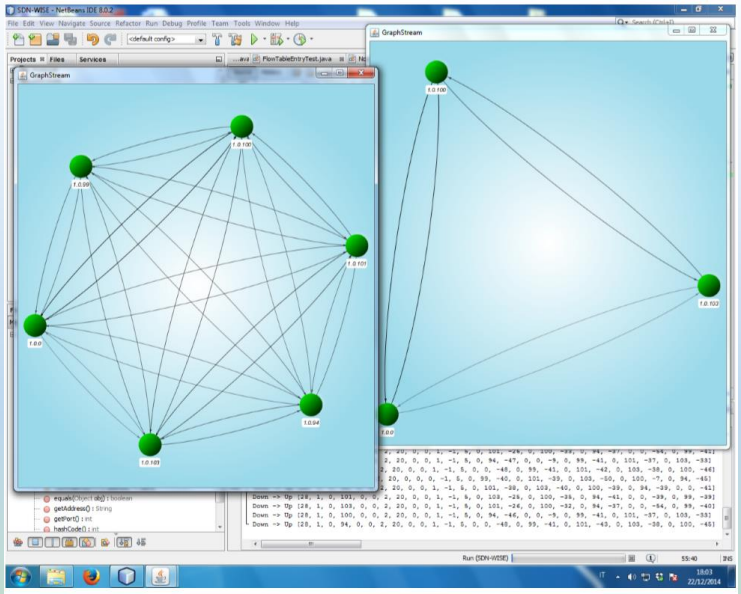
- SDN Controller:
  - Border Router (Sink)
- Data plane:
  - Motes (fixed or mobile)



WSN Software-Defined Architectures

- SDN-WISE
- CORAL-SDN
- SDWN
- Smart
- Spooled
- Flow Sensor
- Sensor OpenFlow
- Multi-task SDSN
- Software Sensor

SDN-WISE



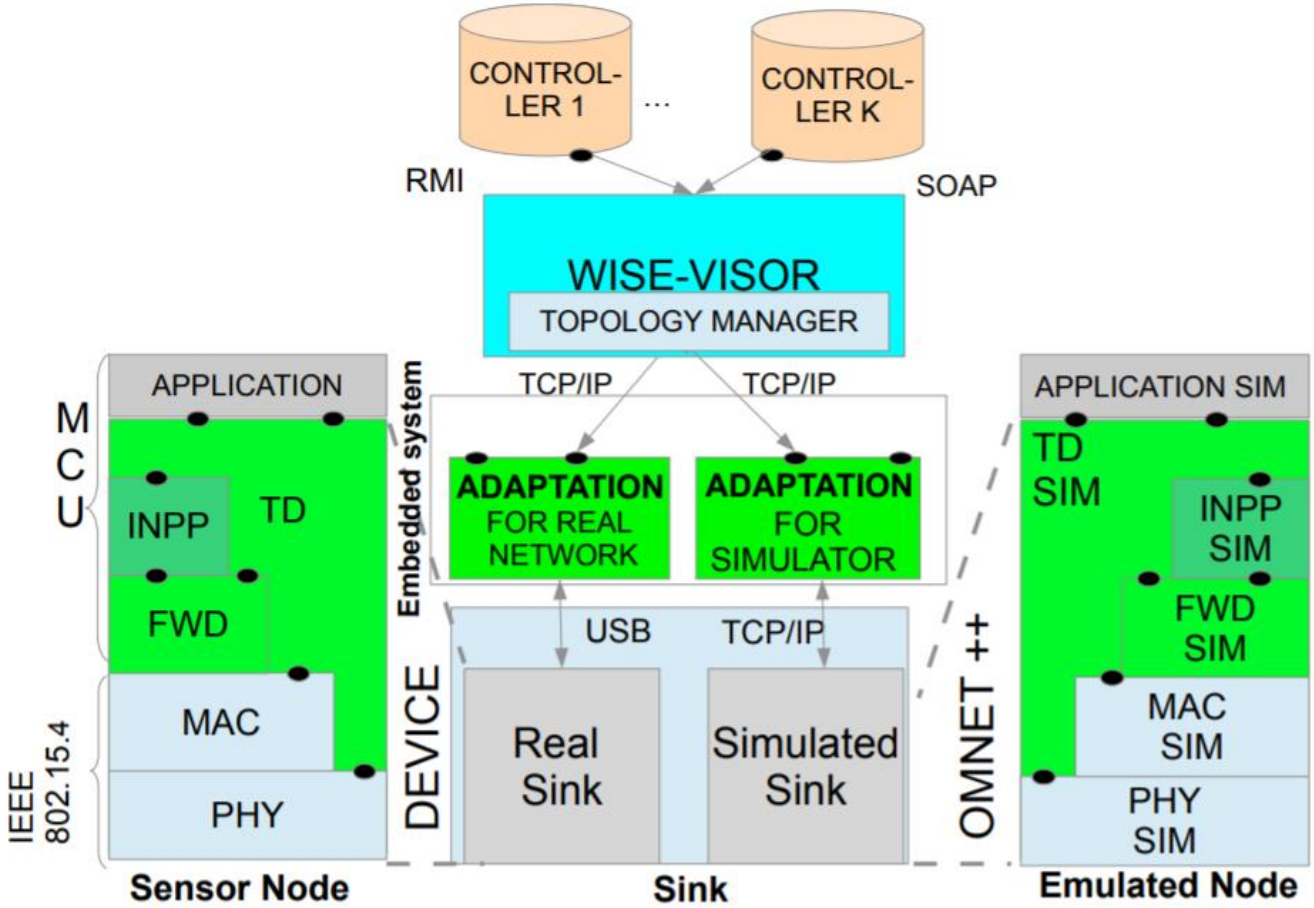
- **SDN-WISE**

is **S**oftware **D**efined **N**etworking solution for **WI**reless **SE**nsor Networks.

The aim of SDNWISE is to simplify the management of the network, the development of novel applications, and the experimentation of new networking solutions in WSNs.

http://sdn-wise.dieei.unict.it/

SDN-WISE Architecture



http://sdn-wise.dieei.unict.it

SDN-WISE Special Characteristics

- **Statefulness**
- OpenFlow is stateless but SDN-WISE is stateful: a buffer of memory is reserved for state information
- Rules can state info to classify packets in flows
- Actions can modify state info

Why **Statefulness**?

To reduce the number of interactions with the Controller using local policies

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CORAL

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Cross-Layer Control of Data Flows

Experimentation of SDN-inspired capabilities aiming at improved QoE of users and QoS of applications over Internet of Things (IoT) devices

WiSHFUL enabling technologies for CORAL:

- radio- and network-control abstractions
- novel experimentation facilities
- heterogeneous wireless environments

CORAL novel features:

- bespoke protocol configurations per node
- efficient SDN-inspired communication strategies
- novel heterogeneity handling

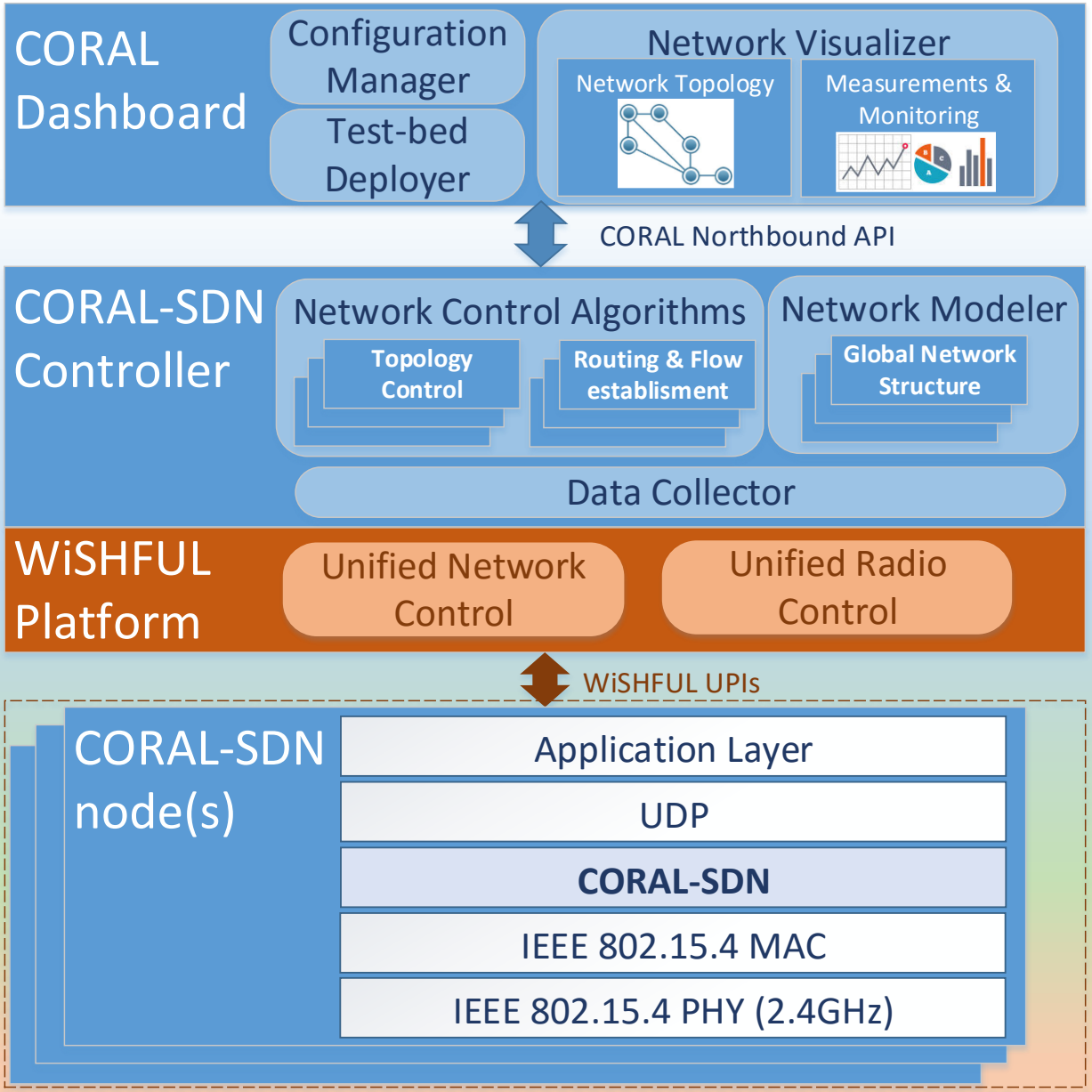
WiSHFUL

European Commission | Horizon 2020 European Union funding for Research & Innovation

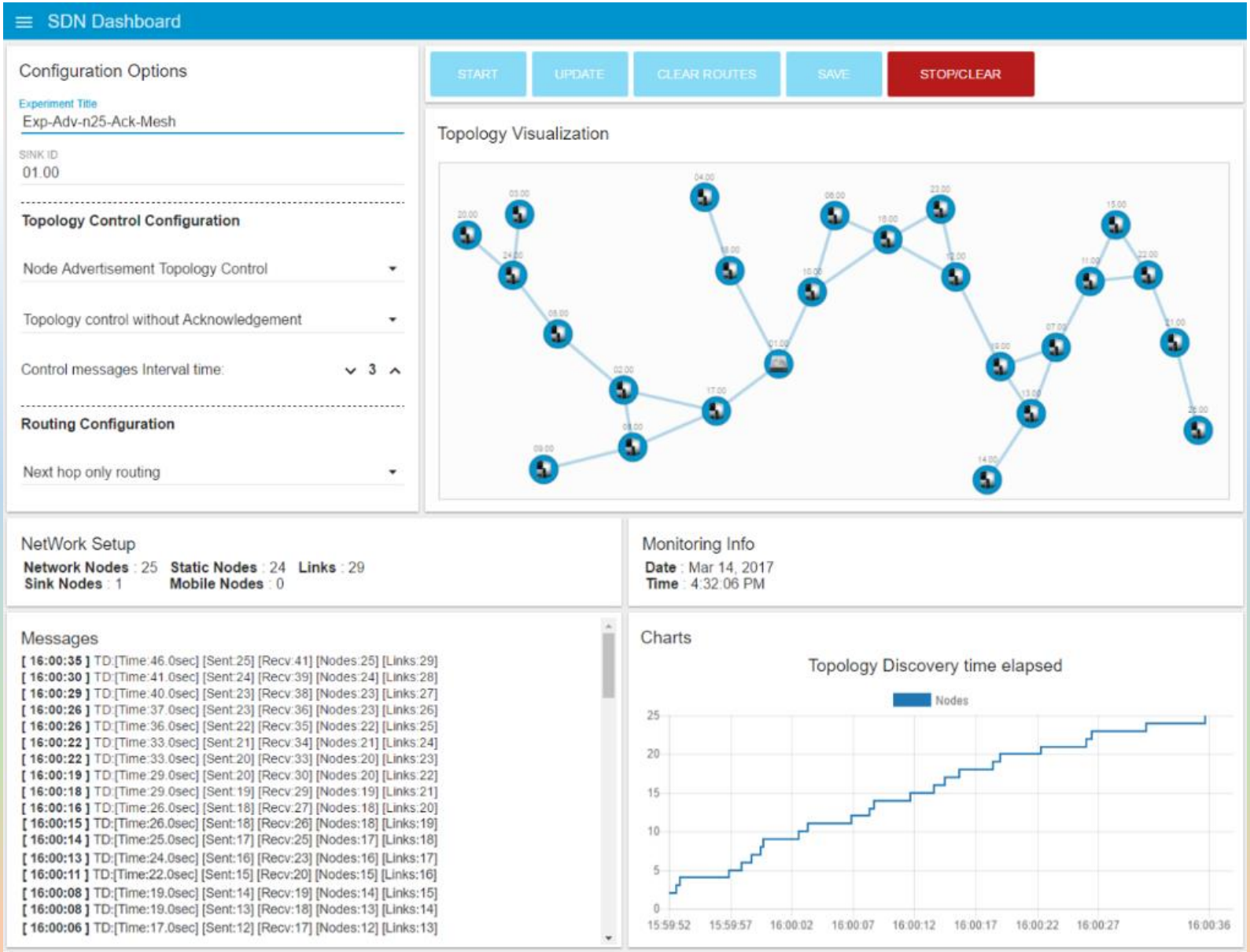
Publications:

- **"Intelligent Network Control for the Internet of Things INTER-IOT", eWINE Grand Challenge 1st runner up award 2017**
- **T. Theodorou, L. Mamatas, "Software Defined Topology Control Strategies for the Internet of Things", IEEE Conference on Network Function Virtualization and Software Defined Networks - NFVSDN 2017, Berlin Germany, November 2017.**
- **T. Theodorou, L. Mamatas, "CORAL-SDN: A Software-Defined Networking Solution for the Internet of Things", IEEE Conference on Network Function Virtualization and Software Defined Networks - NFVSDN 2017, Berlin Germany, November 2017.**

CORAL-SDN Architecture



CORAL-SDN Framework Interface



CORAL-SDN Characteristics

CORAL-SDN:

- uses intelligent centralized control mechanisms to adjust dynamically the protocol functionalities
- supports elasticity to the challenging requirements of the WSNs
- maintains a scalable architecture
- exhibits improved network management and operation in terms of performance and resource utilization

CORAL-SDN Aims

- improves WSN management, control, and operation in terms of performance and resource utilization
- enhances network control intelligence through centralized control and dynamic protocol adjustments
- enables elastic network operation utilizing cross-layer information
- supports scalable evolution through a modular extensible architecture

CORAL-SDN
Hands-on 1-3 Demonstration

The demo can operate in two IoT WSN real test-beds:

a) the IMEC w-iLab.2 (http://wilab2.ilabt.iminds.be) test-bed based in Ghent, Brussels, equipped with forty (40) RM090 motes

b) the SWN (https://www.emulab.swn.uom.gr/) test-bed based in the University of Macedonia, Thessaloniki, Greece, equipped with fifteen (15) Zolertia RE-Mote sensor motes

For demonstrating very large scale scenarios (>50 nodes) the system collaborates with the Cooja WSN emulator

SDWN

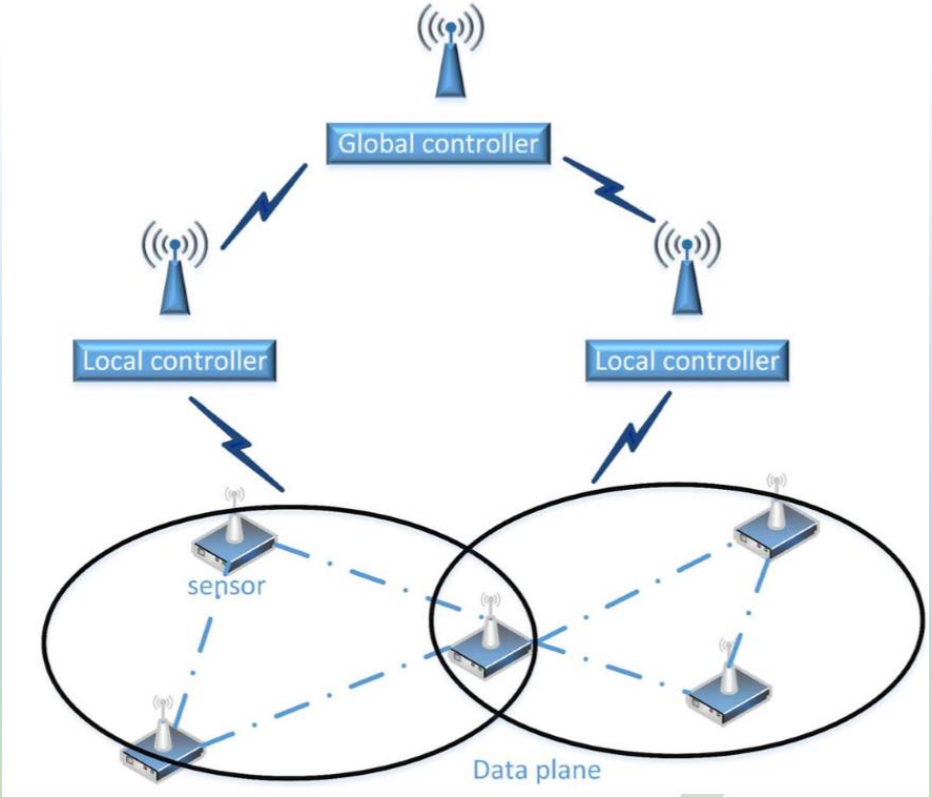
- Targets efficient duty cycling (turning off the radio not in service)
- Data-aggregation
- Flexible routing rules for cross layer optimization through a decoupled architecture.
- The controller operates at the sink
- In motes, a forwarding layer on top of the physical and MAC layers, which consists of the flow tables
- The sink is similar to a regular sensor with an embedded system that serves as the controller.
- The layers include an:
  - adaptation layer (for message formatting),
  - a virtualization layer (slices the network in terms of the topology, which is also formed by the same layer),
  - a controller (creates flow table rules based on the current topological knowledge),
  - an application layer.

Smart

- Proposes a controller architecture for better WSN management
- The controller resides on the sink and comprises a five layer stack
- The lower three layers are the physical, MAC, and NOS layers
- The next layer up is called the middleware where the controller sits.
- Centralized architecture, improves routing, QoS, mobility management, and localization leading an energy efficient.

Spooled

- Uses hierarchical controllers to reduce the communication overhead relative to a centralized controller architecture
- Local controllers manage a part of the network and inform the global controller about the topological and other state changes



Flow Sensor

- Hierarchical controller organization to cluster the sensors according to their gathered data type or context
- Sensors from the same context form a cluster even if they are physically distant
- Each such cluster has its own controller or cluster head that performs the local processing for the cluster
- Local controllers form a logical controller for the entire network

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Softwarized RPL adaptation

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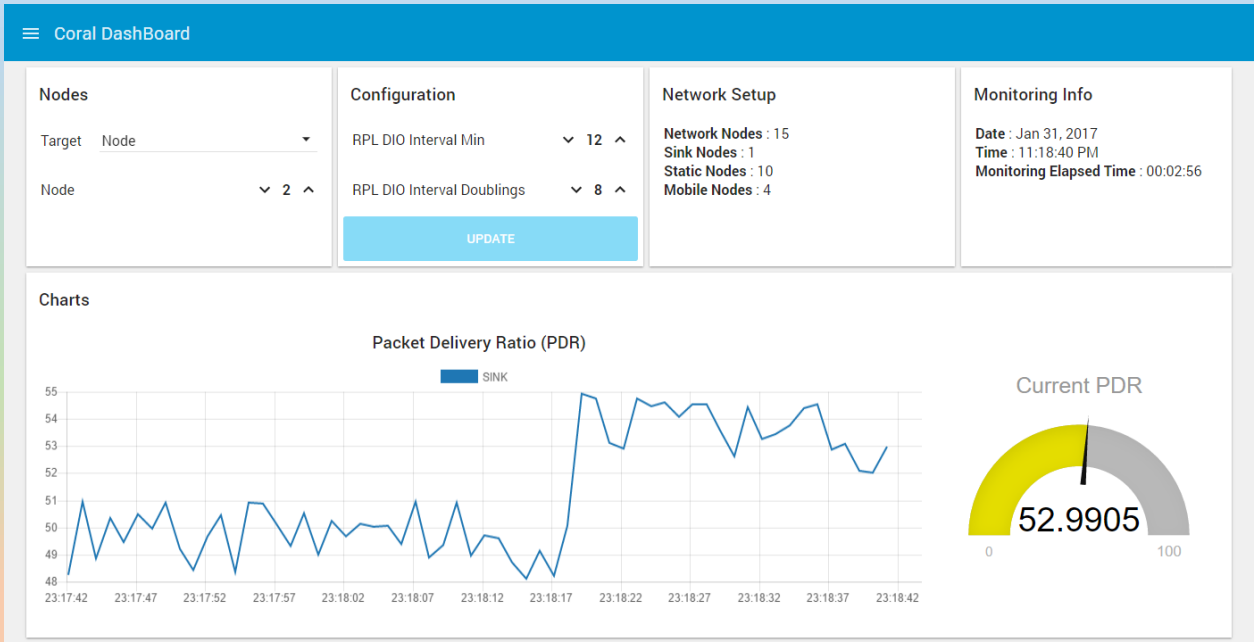
Softwarized Enhancements for existing algorithms like RPL:

- RPL network map regeneration and neighbor discovery are not functioning well for mobile IoT
- Those parameters (Imin, Idouble) adaptations can significantly improve the network performance

InfoCom 2017

G.Violettas, T.Theodorou, S. Petridou, A. Tsioukas, L. Mamatas, "An Experimentation Facility Enabling Flexible Network Control for the Internet of Things," in *2017 IEEE Conference on Computer Communications (INFOCOM)*, Atlanta, 2017



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Softwarised RPL Performance

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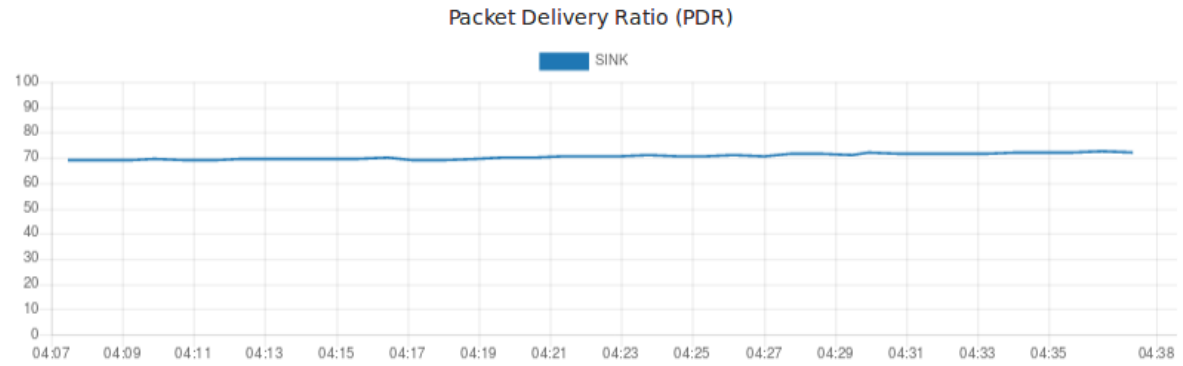
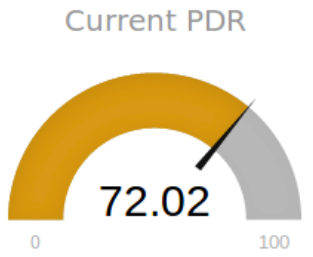
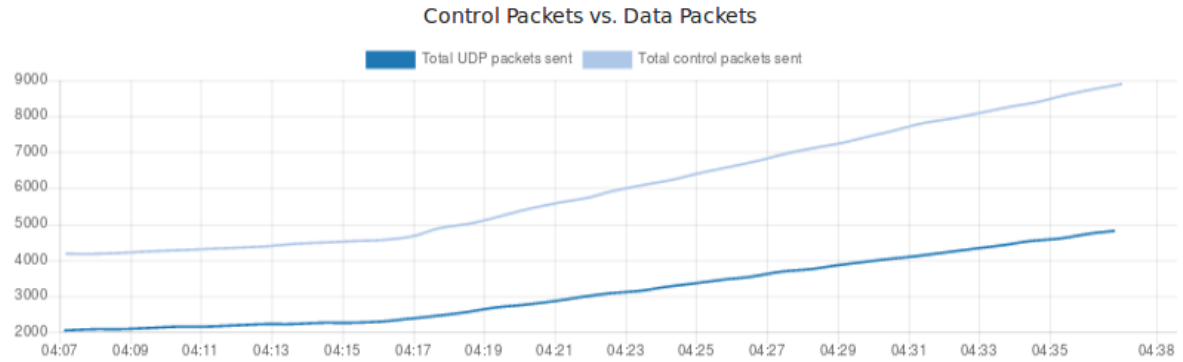
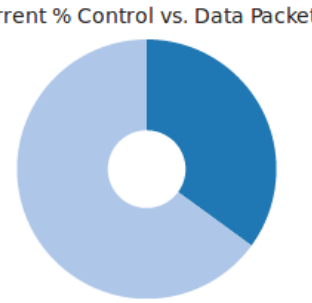
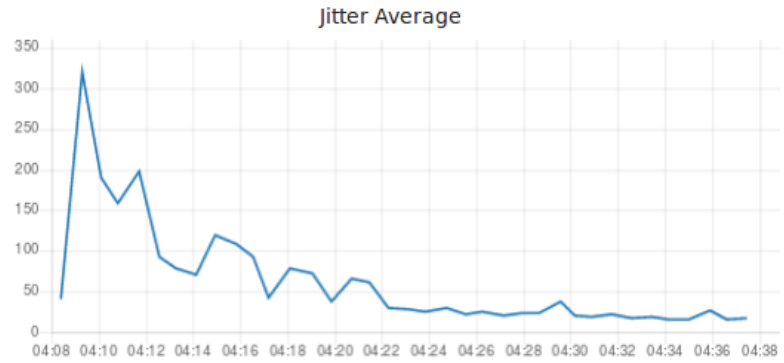
Charts

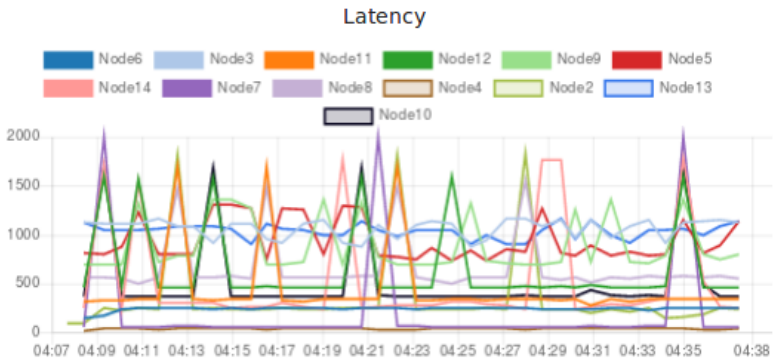






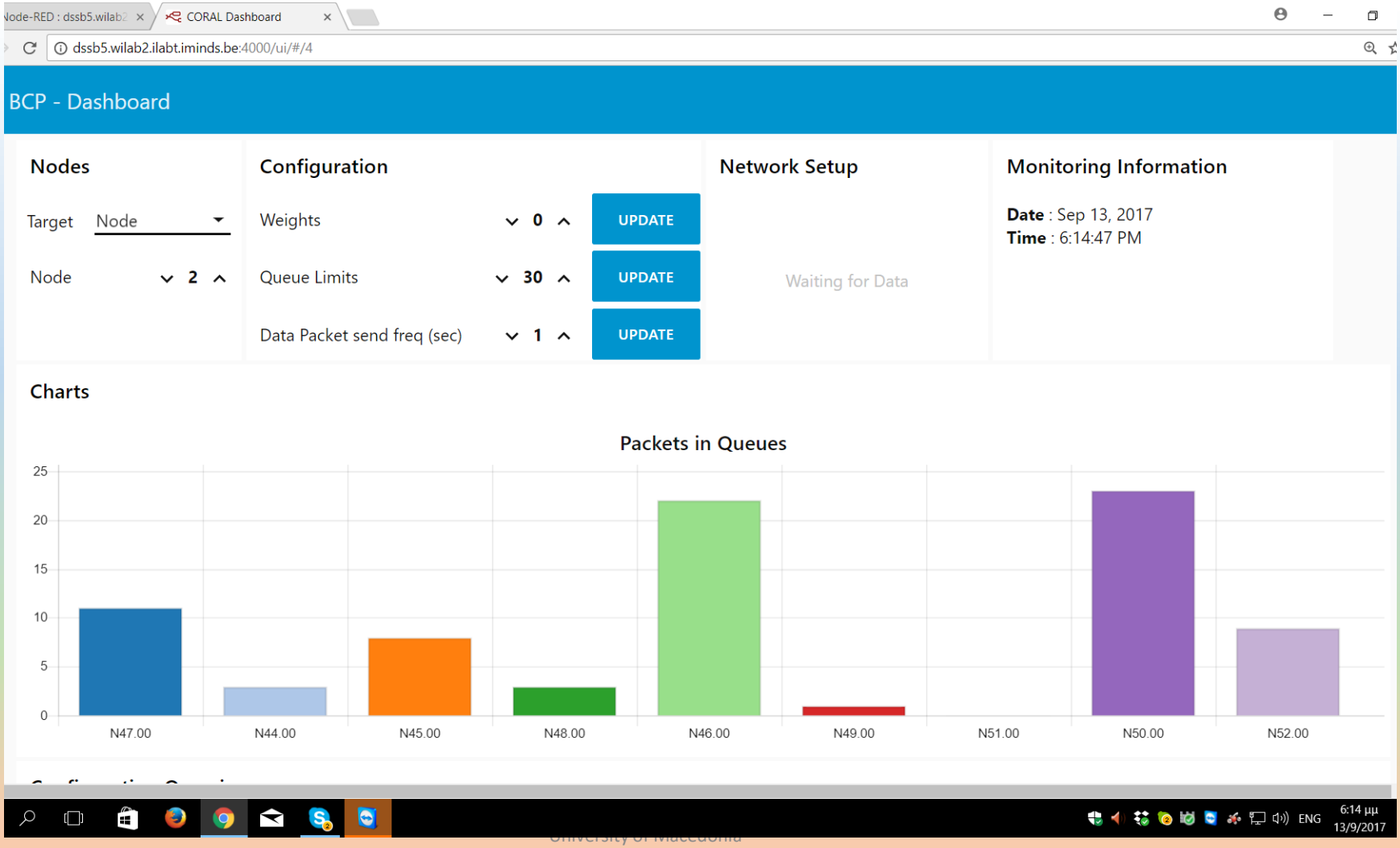






Softwarized Adaptable BPR Protocol

- Balancing traffic load with the Adaptable Back-Pressure Routing Protocol



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