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Towards Wireless Sensor Network Softwarization

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Outline

- Background
- Literature Review
- WSN System Architecture and related Softwarization
- Remote Server Organization
- Software Control Flexibilities
- System Implementation (Physical & Virtual Sensor Clouds)
- Physical Sensor Cloud Data Representation
- Result & Discussion
- Conclusion

Background

- **IoT-based sensor networks**
  - Gather real-life data from sensor nodes embedded in the physical space
  - Large scale WSN governed by remote server or the cloud through the IoT
  - Advantage: Organization offers avenue for a flexible system capable of reacting to dynamic changes of monitored process conditions

- **WSN Softwarization & SDN**
  - Offer features that are favorable for centralization of network control to make the network
    - directly programmable, flexible and
    - easily manageable (**Qadir et. al, 2014)**

- **Incorporation of Softwarization for IoT-based sensor networks**
  - Promotes flexibility
  - Proposed organization offers potential for benefitting from SDN implementation with significant cloud support through further softwarization.

LITERATURE/ PAST RESEARCH REVIEW

SDN proposals

Open Flow protocol (McKeown et. al., 2008):

- Std. interface between the control and data plane (switches) Via a secure channel, SDN Controller updates the flow tables
- **Han** propose WSN optimization via Openflow,Global SDN controller decides data routing for each Clusterhead.

Sensor OpenFlow (SOF) (Luo et. al., 2012) adds new classes of forwarding rules to OpenFlow ; includes support for

- Routing and QoS network control
- energy optimization through efficient duty-cycle control
- multi-application operation data aggregation
- Facilitating user-defined transport protocols & flow tables using IP alternatives **"The contiki os," 2013. [Online], "Blip : Berkeley IP," 2011. [Online]**

SDN-WISE (Galluccio et. al., 2015) :

- Extension of Sensor OpenFlow is an flexible, stateful OpenFlow based solution with Multiple controllers
- PSC execute local tasks without interacting with Global SDN Controller
- Thus a packet may follow different flow rules for different controllers as per the application requirements.

Current trend….

A number of works implement SDSN relying on a logically centralized controller node **(Qin et. al., 2014)** with

- Flow tables, Mapping function **(Gante et. al., 2015)**
- Localization and tracking algorithms and
- FPGA-based sensors **(Miyazaki et. al., 2014)**

SDN Controller present at the application layer (Combination of CoAP and SDN):
For improvement QoS and flexibility **(Constanzo et. al., 2012, Hu, 2015)**.

SaaS model in cloud **(Zheng et. al., 2013)**:

Integration of WSN and cloud resources (mashup-services).
SDN functional capabilities implemented in sensor controller node

NFV: **(Mouradian et. al. 2015)** propose NFV architecture for virtualizing WSN Gateway:

- Protocol conversion and information model processing
- centralized store of VNFs (Virtualized Network Functions) as software modules
- Network Functions executed by VNFs

Limited discussion on:

- **Softwarization/SDN within cloud.**
- **Cloud level or WSN node level is best suited for softwarization?**

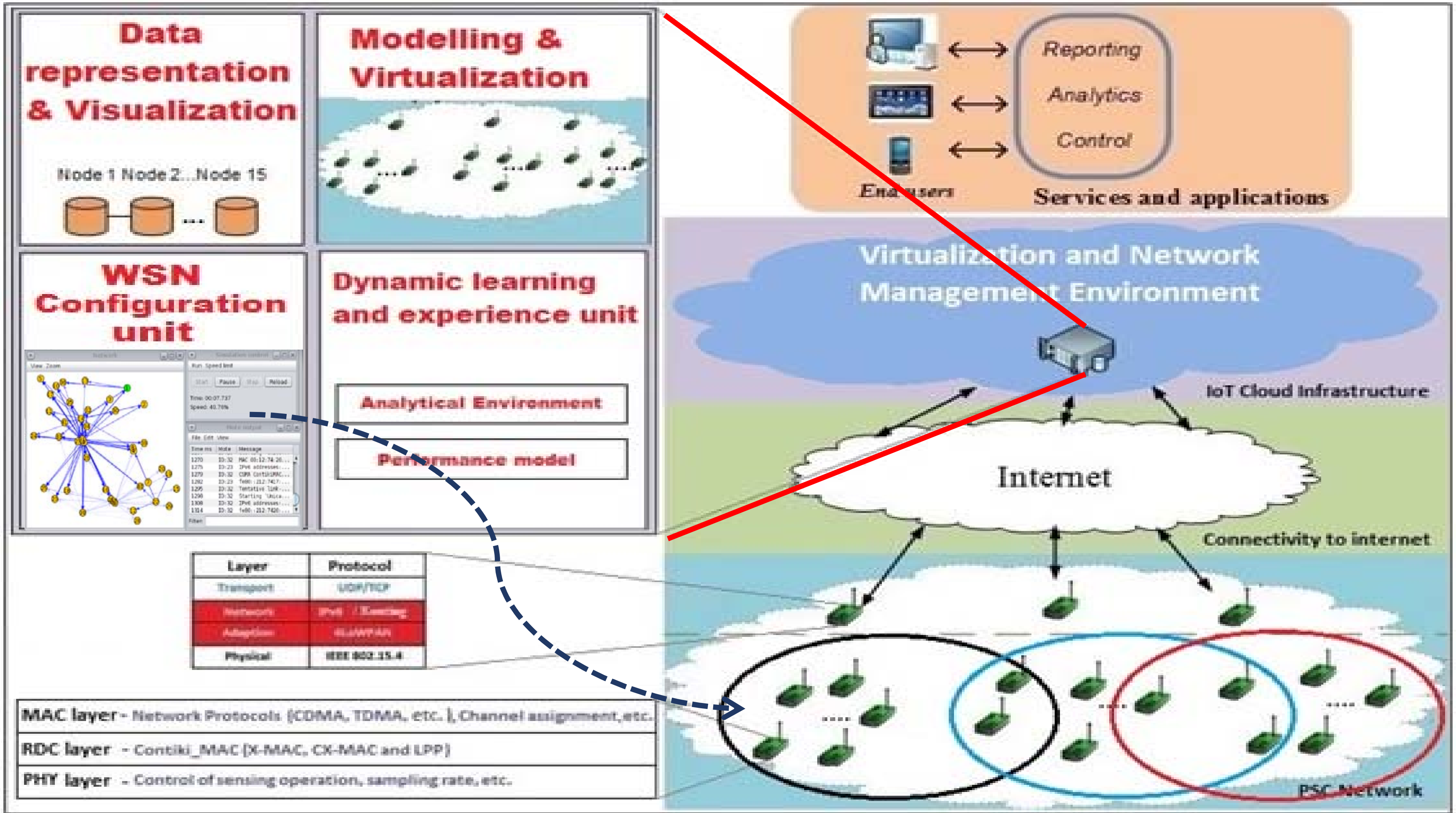
Proposed ideas/Main intentions:

- Concept of SDR/SDN could be extended to utilize of the degree of freedom available at WSN Comm. layers **(Haque et. al., 2016).**
- Further enhancement: Multi-SDN Controllers can utilize data from VSC to impose dynamic changes on PSC

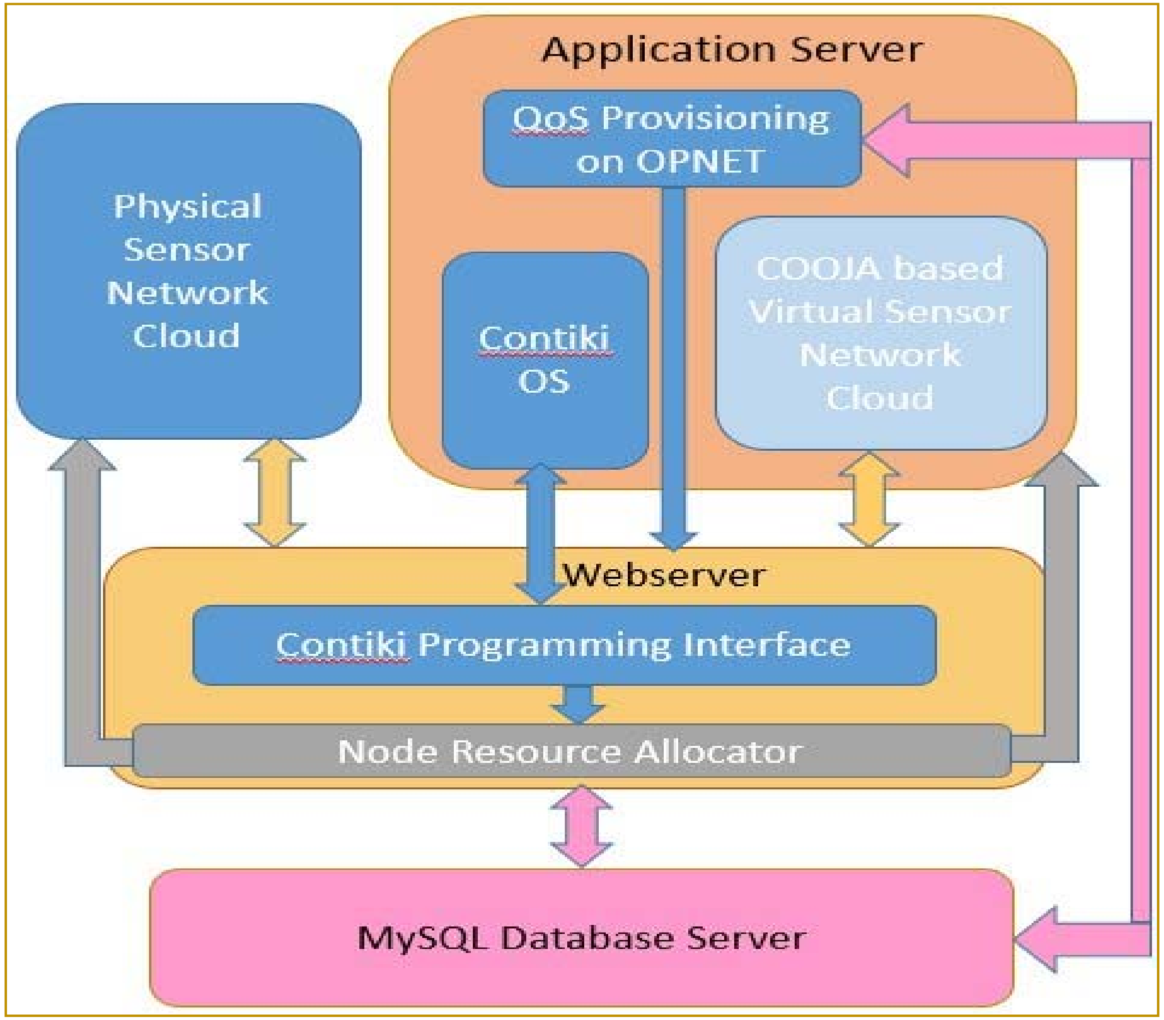
SOFTWARE CONTROL FLEXIBILITIES AVAILABLE
(WITHIN CONTIKI COMMUNICATION LAYERS)

NETWORK STACK	SOFTWARE CONTROL AVAILABLE FOR FLEXIBILITY
APPLICATION	Implementation of HTTP or CoAP
TRANSPORT	Packet sequencing
NETWORK	Packet routing, Implementation of IPv6, ICMP or RPL protocols Implementation of unicast, multicast or broadcast addressing
ADAPTION	Header compression, Fragmentation and reassembly, etc.
MAC	Implementation of Network protocol (TDMA, CSMA, Polling), addressing and retransmission of lost packets, etc.
RADIO DUTY CYCLING	Sleep awake period of nodes, Packet transmission time, RDC layers : ContikiMAC, X-MAC, CX-MAC, LPP, and NullRDC, etc.
PHYSICAL/RADIO (PHY)	Setting the sampling rate, RF Channel allocation, node address, etc.

WSN Softwarization System Architecture



Remote Server Organization (Syarifah et. al. 2015)



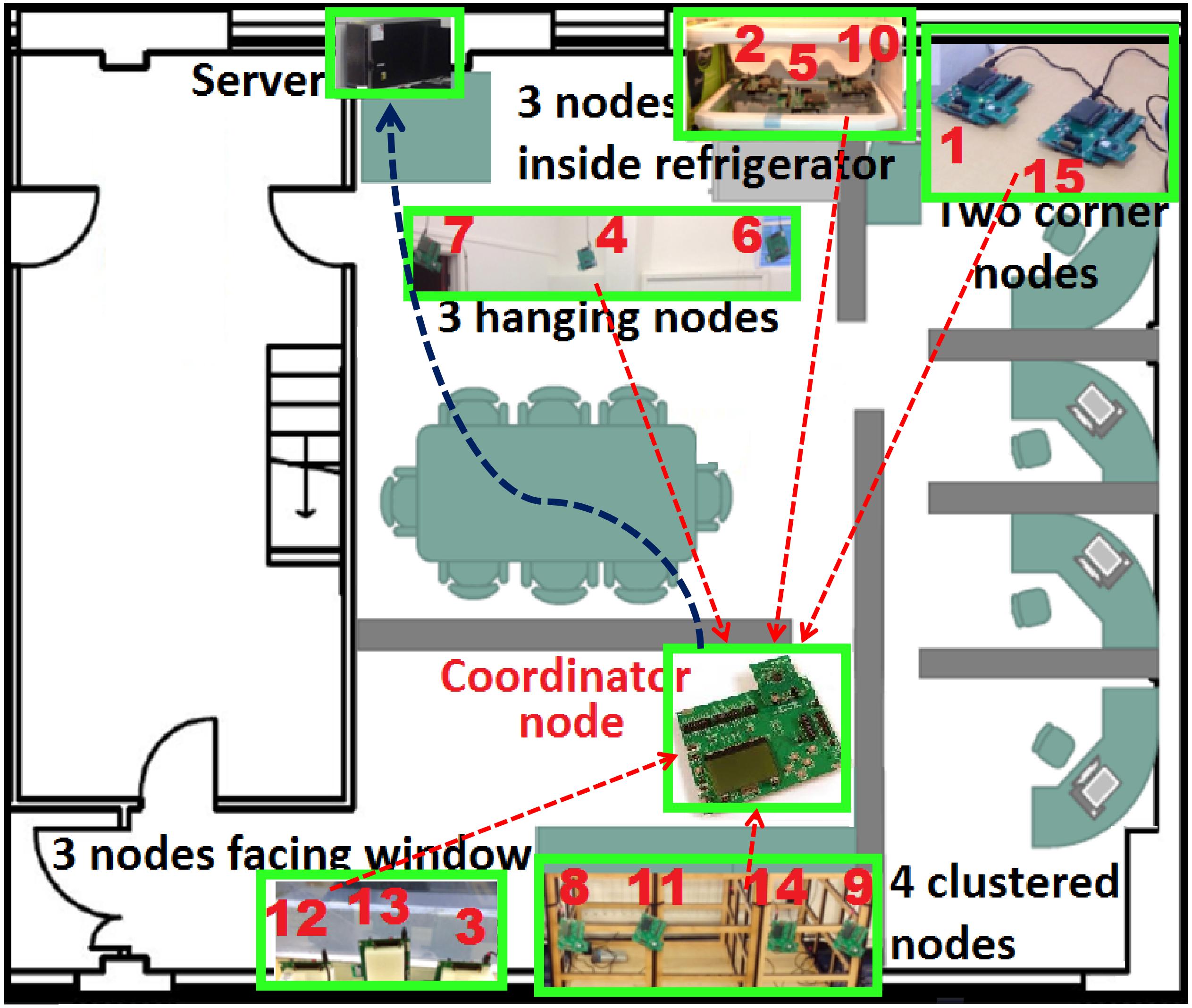
Application server – hosts Contiki OS, network simulators & analytical software

Web server – uses REST APIs to establish comm. with users

Database server – implements MySQL as the RDBMS

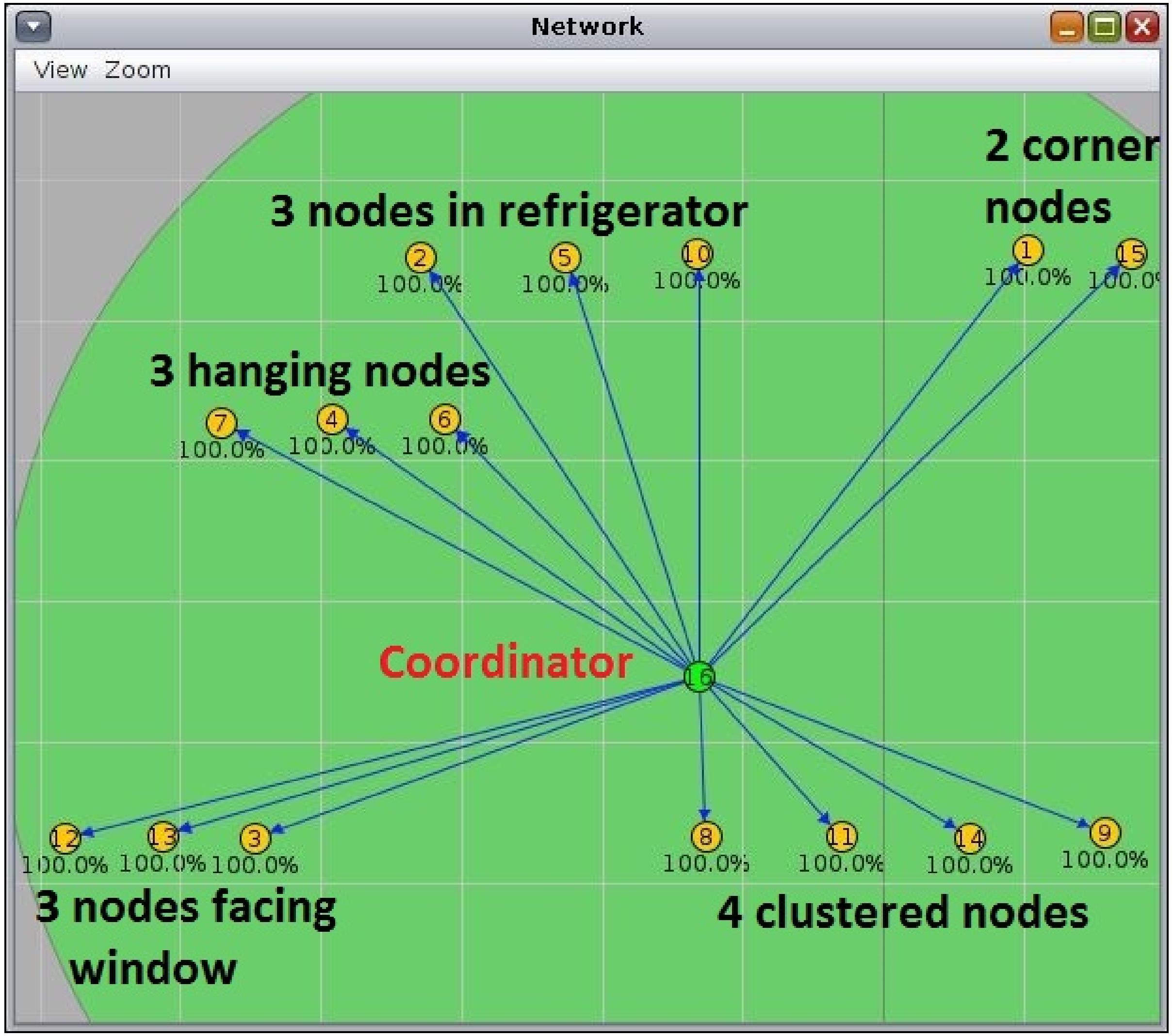
PSC Implementation

- **Physical Sensor Setup**
  - 15 end devices and 1 coordinator deployed in SeNSe lab
  - Each node reads 3 types of sensor data:
    Light, temperature, RSSI
  - Time Division Multiple Access (TDMA) Protocol is implemented.



VSC Implementation

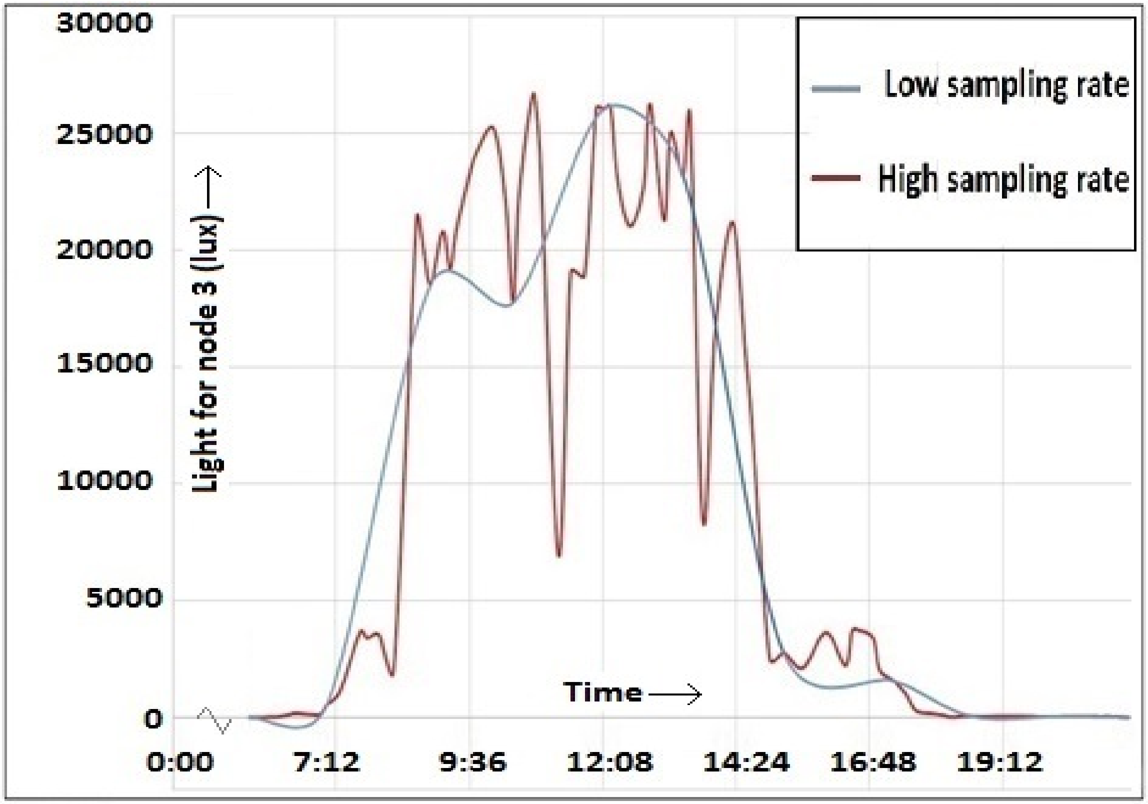
- **Virtual Setup employing Cooja motes**
  - Mimic dataflow of PSC deployed in SeNSe lab
  - VSC nodes run exact same code and operating system as that for physical hardware
  - Time Division Multiple Access (TDMA) is implemented.
  - Clustered in a similar manner to PSC

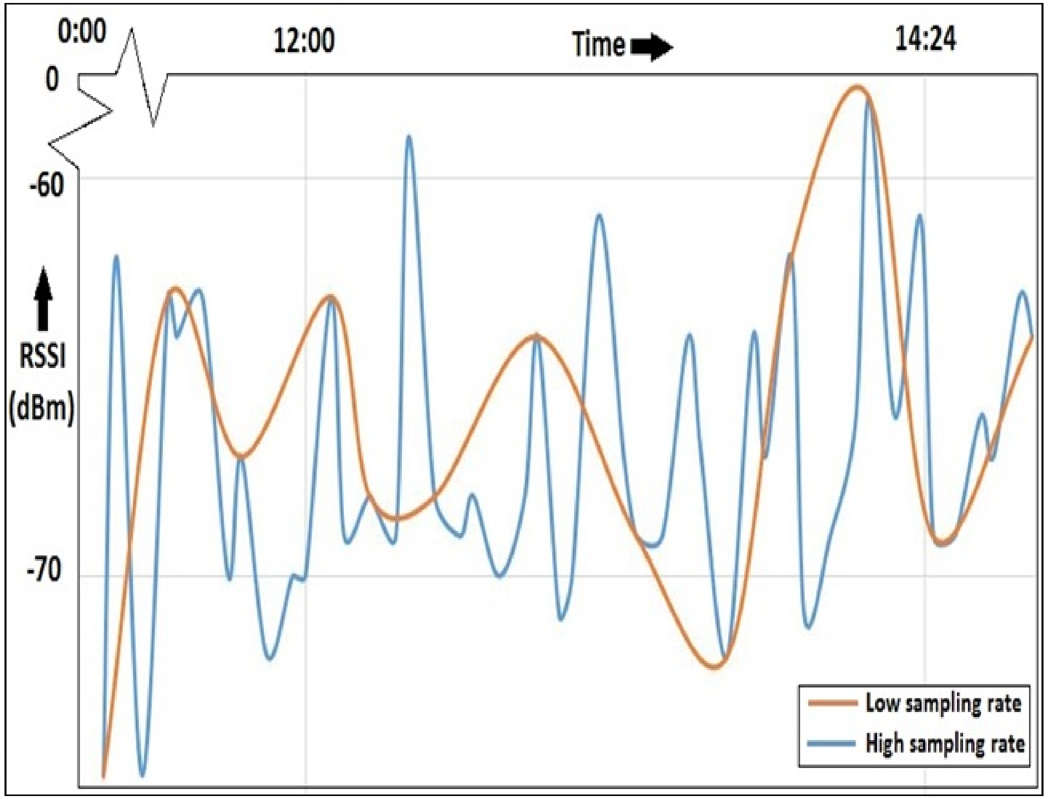


PSC Stored Data Presentation

Result and Discussion – Test cases-I&II (Light & RSSI)

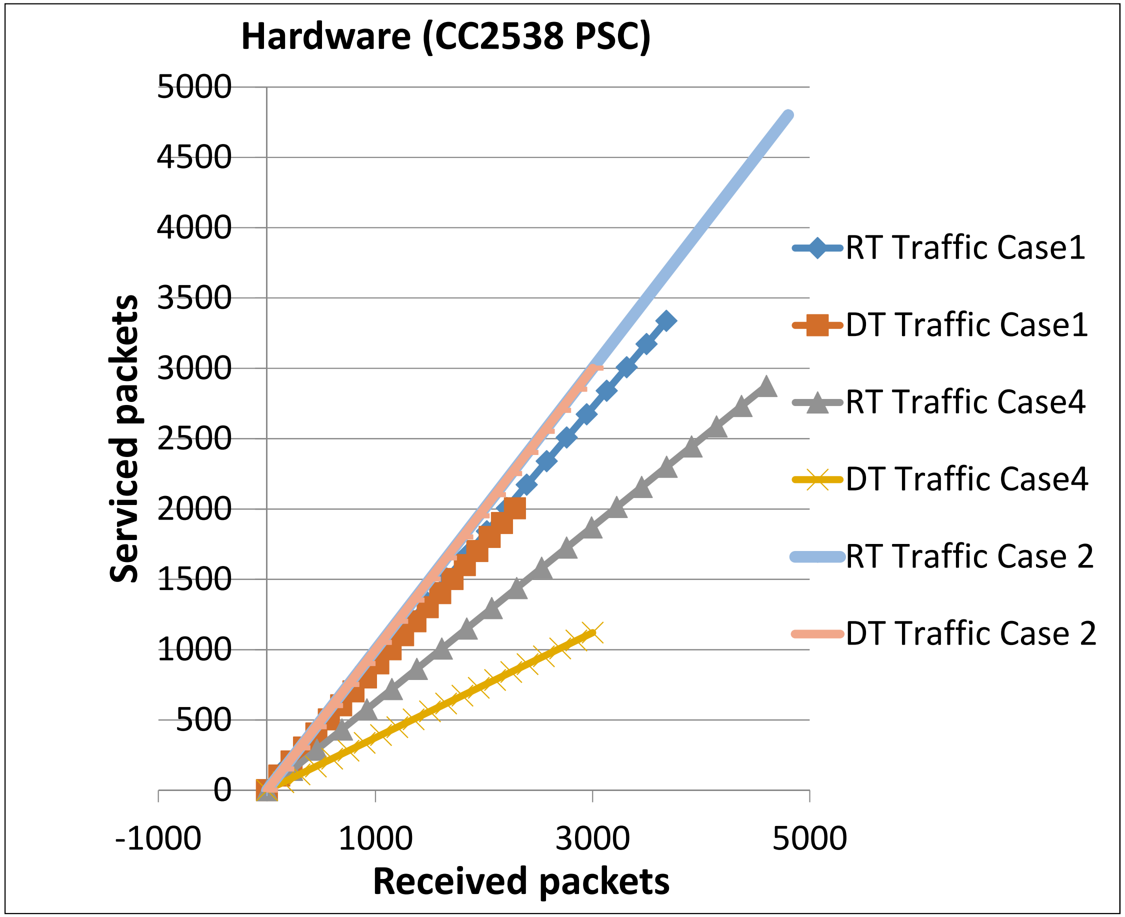
- Graph showing impact of varying sampling rate on accuracy post PSC reconfiguration.
- Increasing the sampling rate via reconfiguration, more accurate waveforms are obtained.

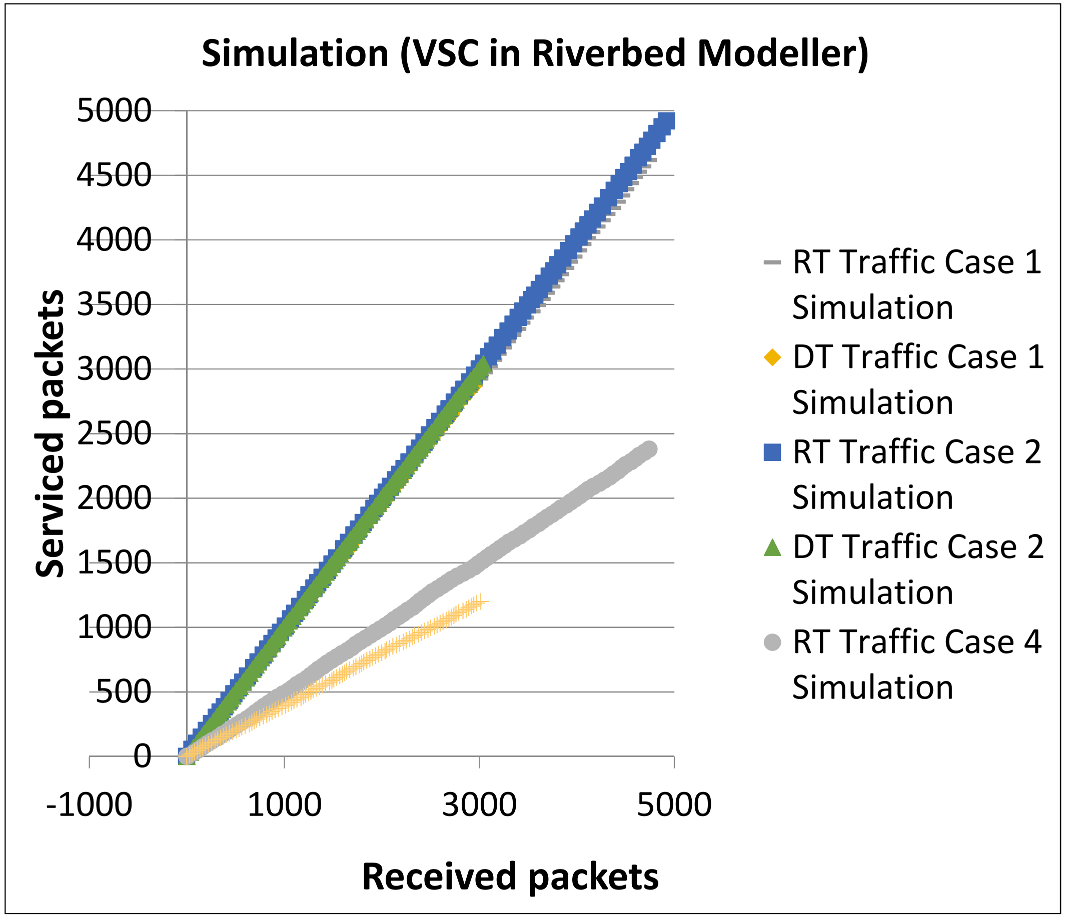




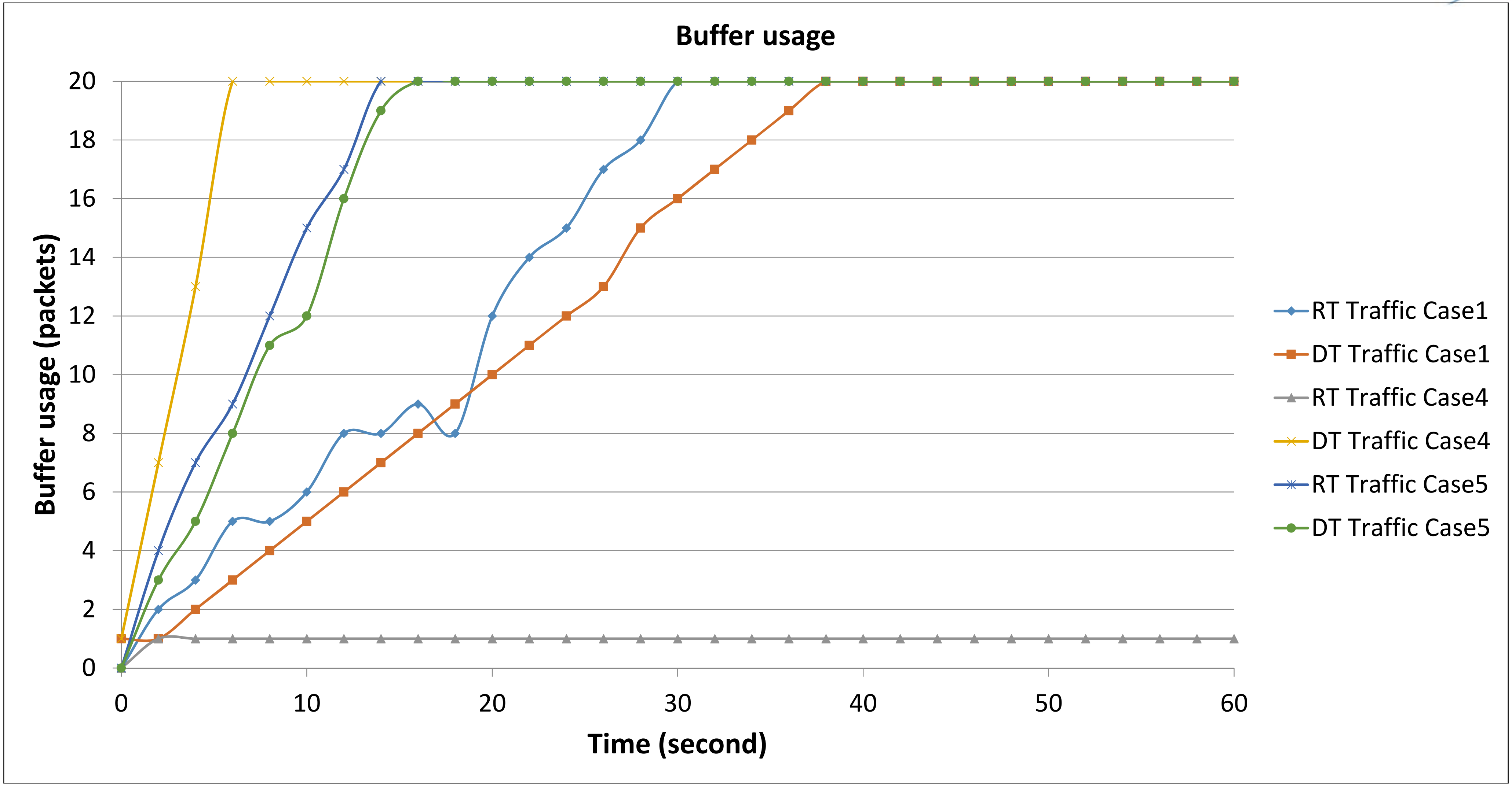
Comparison between Simulation & Hardware:

Adaptive QoS testing (Serviced packets Vs Arrived packets)





Adaptive QoS testing (Buffer usage Vs Time)



Conclusion

- Paper concluded an organization for closing the loop between the PSC and cloud resources represented by the VSC.
- PSC management through available degree of freedom: Flexibility to interact with dynamics of physical phenomenon.
- Concept incrementally tested.
- Organization offers potential for benefitting from SDN implementation with significant cloud support through further softwarization.
- Initial work done on Network Function Virtualization. Further work will involve virtualization of more involved network functions (with respect to sampling rate, buffer saturation, packet loss aspects, etc.) as implemented on WSN/PSC.
- Potential research directions –
  - Further validation of the ideas will be done through more robust integrated testing.
  - Furthermore, field data on particular case studies in various domains are planned.

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Thank You.

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