Controlling Wireless Sensor Networks through a Software Defined approach

Sebastiano Milardo

Dipartimento di Energia, Ingegneria dell'Informazione e Modelli Matematici, University of Palermo, Italy

Abstract

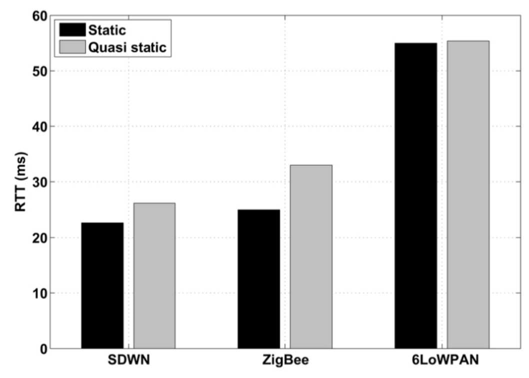
Exploring the benefits and drawbacks of a Software Defined Networking (SDN) approach to Wireless Sensor Networks (WSN).

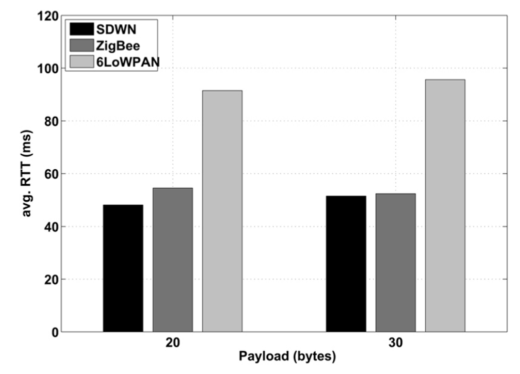
SDN

In SDN the Control Plane, which is responsible for managing network policies, is decoupled from the Data Plane, which is in charge of implementing them using the so called flow-rules.

Comparison with existing solutions

A SDN solution for WSNs, called SDWN, has been compared to 6LowPAN and ZigBee in the EuWIN testbed [1]. Experimental results show that the SDN solution achieves better results in static or quasi static environments, while the performance degrades in highly dynamic conditions because of the messaging with the Control plane.





TWENTY NODES NETWORK: COMPARING RTT AND PLR

Protocol	RTT (ms): static	RTT (ms): quasi-static
SDWN	44	49
ZigBee	51	76
Protocol	PLR (%): static	PLR (%): quasi-static
SDWN	1.5	2
ZigBee	13	21.5

DYNAMIC CONDITIONS: COMPARING SDWN AND ZIGBEE

Protocol	RTT (ms)	PLR (%)
SDWN	40	96
ZigBee	61	33.5

Figure: RTT Unicast 2 hops (left), Avg. RTT Multicast 2 hops (center).

SDN-WISE

To reduce the dependency from the Control plane, a stateful approach, called SDN-WISE [2, 3], has been developed in order to turn SDN sensor nodes into rule-based remotely programmable linear bounded automatons. An example of a rule that takes into account a state variable is the following:

```
if (STATE_ARRAY[0] == RED && PACKET[PRIORITY_LEVEL] == C1) {
  DROP (10%, Node2)
}
```

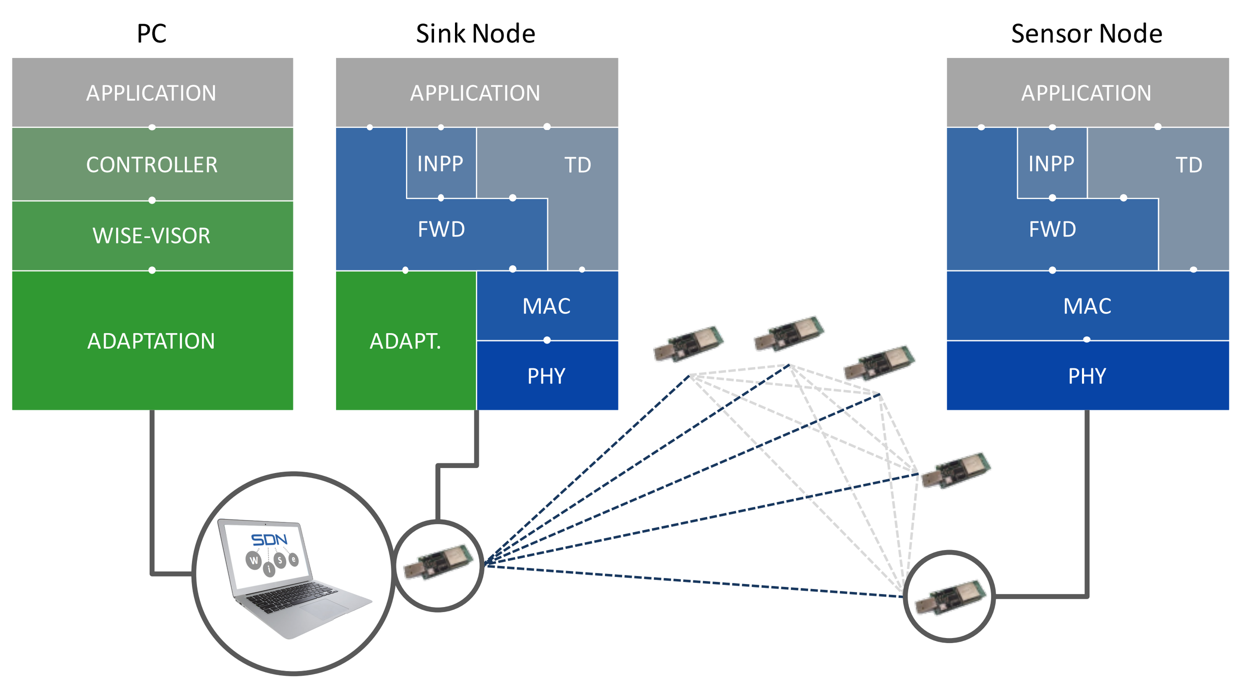
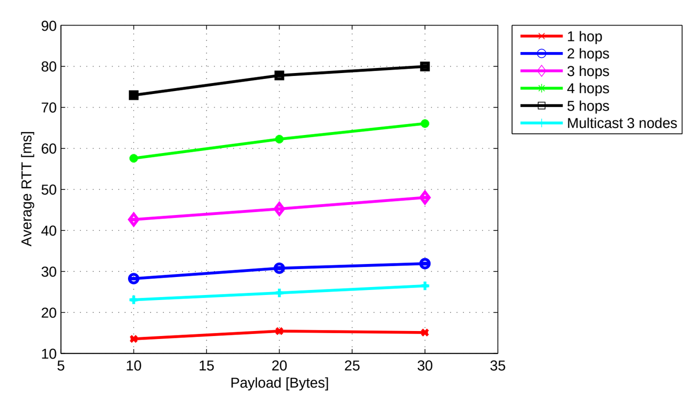
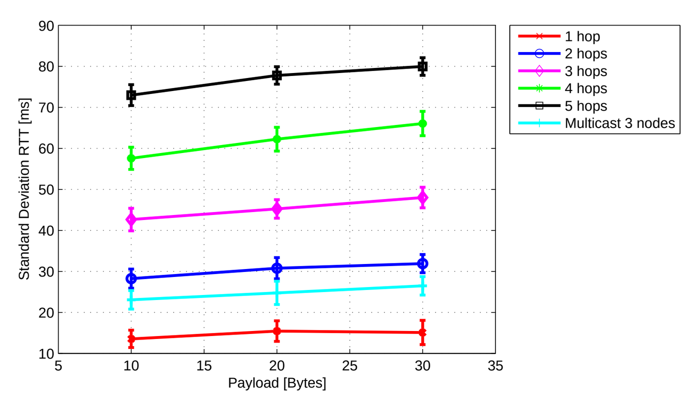


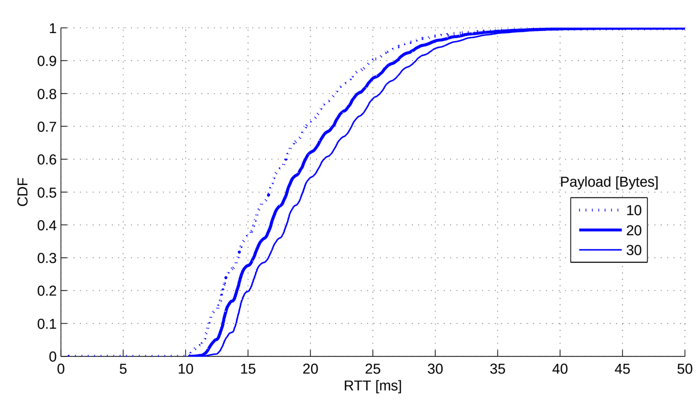
Figure: SDN-WISE Architecture and UNICT Testbed.



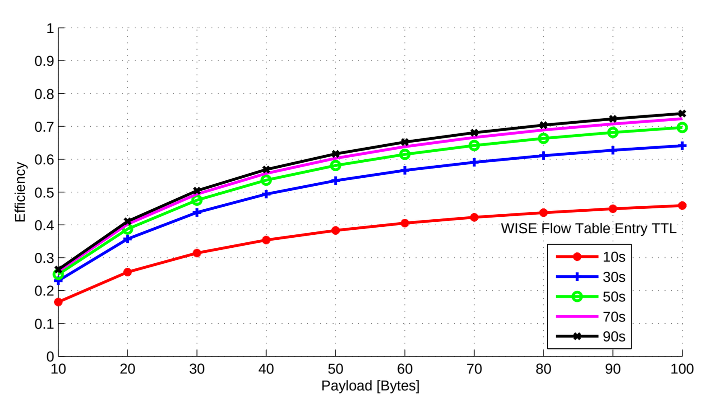
(a) Average RTT vs. the payload size, for different values of the number of hops.



(b) Standard deviation of the RTT values vs. the payload size, for different values of the number of hops.



(c) CDF of the RTT in the multicast case for different payload sizes.



(d) Efficiency for different values of maximum WISE Flow Table entry TTL.

QoS in SDN-WISE

Rules can be sent to the nodes to set different drop probabilities for different flows depending on the level of congestion [4].

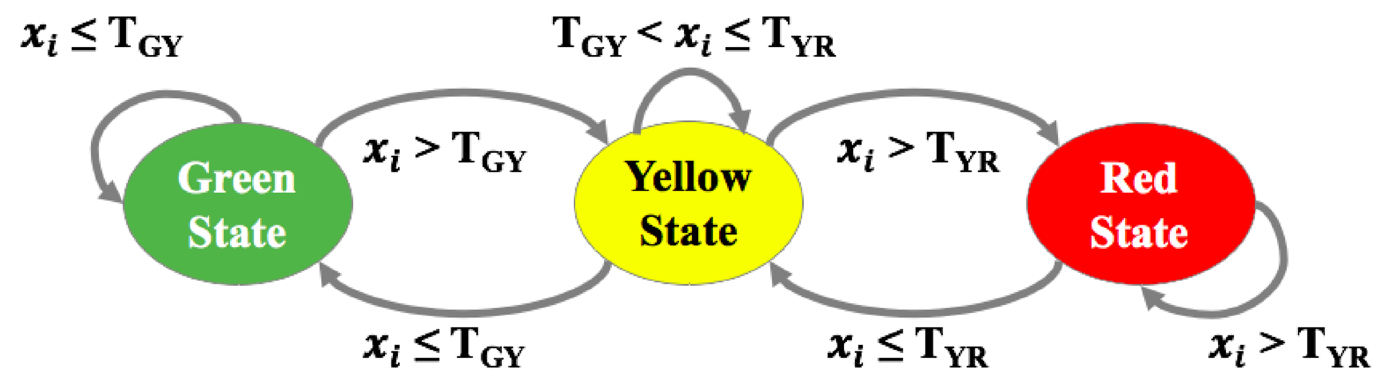
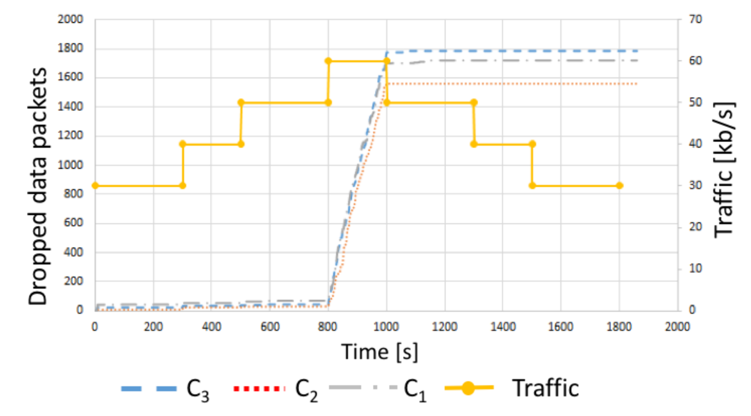
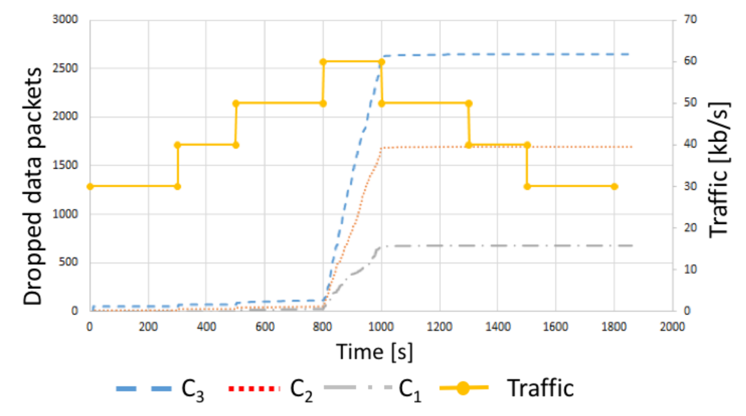


Figure: A Finite State Machine for a QoS policy.



(a) Dropped data packets without QoS support.



(b) Dropped data packet $T_{GY} = 85$, $T_{YR} = 105$.

NOS

SDN-WISE as been integrated into the Open Networking Operating System (ONOS) and Contiki-OS. An application on top of the NOS can interact uniformly with standard OpenFlow switches and Contiki-OS motes [5].

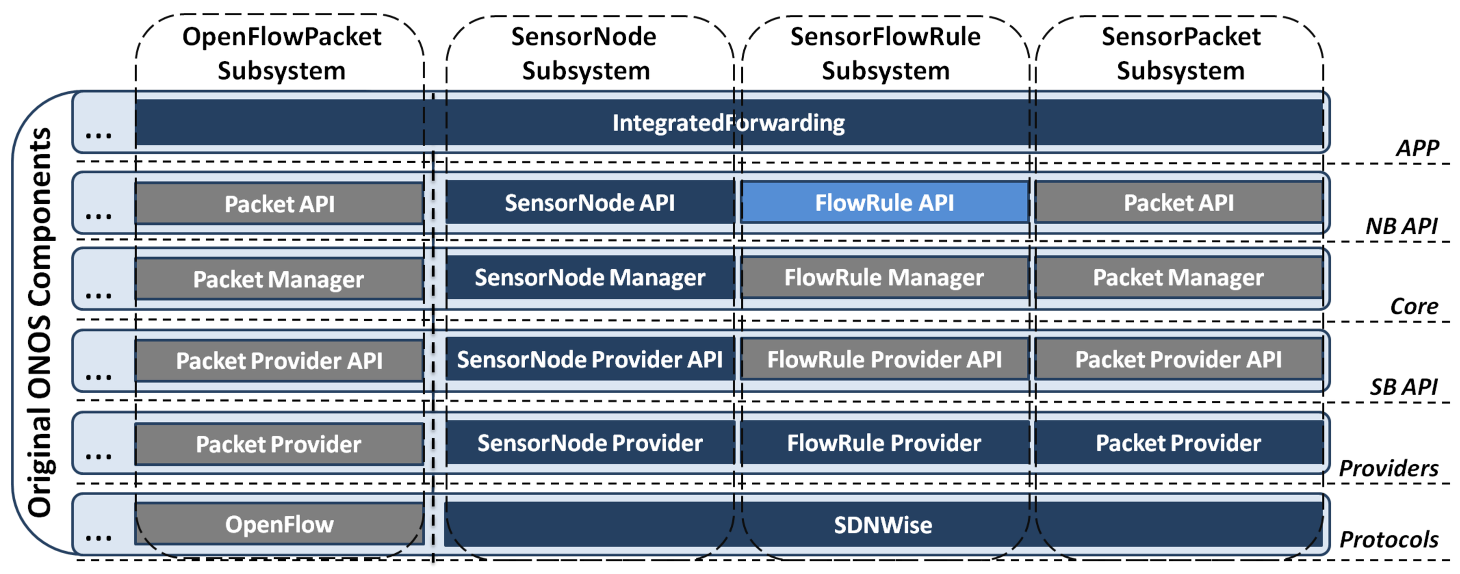
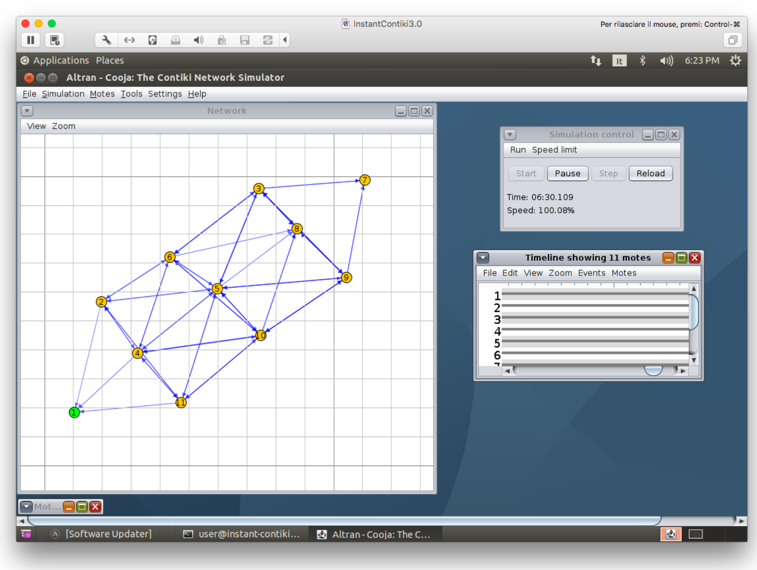
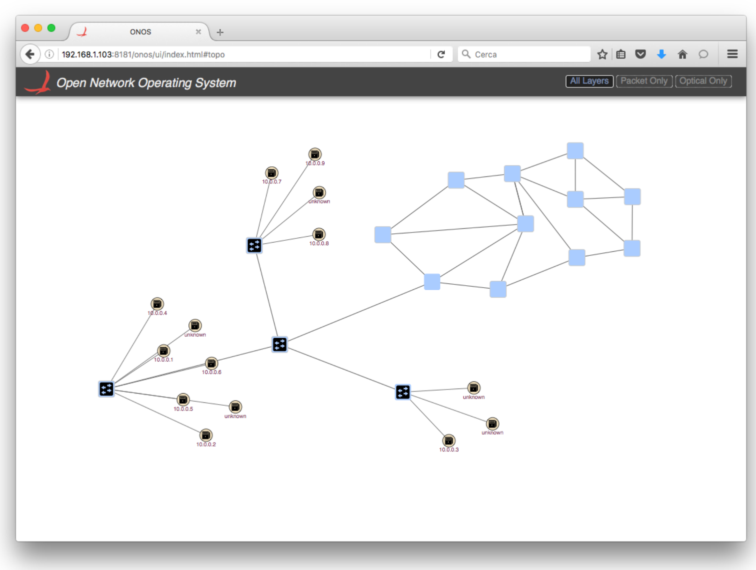


Figure: ONOS extended architecture.



(a) A simulated network of Contiki-OS motes in Cooja



(b) An heterogeneous network of Mininet OF switches (dark blue) and Cooja motes (light blue) controlled by ONOS.

Conclusion

The SDN approach increases the flexibility of a WSN at the cost of a strong dependency from the Control plane. A stateful solution has been developed to reduce such bond and a future work will involve the use of a distributed geographic forwarding algorithm orchestrated by the Control plane.

References

[1] C. Buratti, A. Stajkic, G. Gardasevic, S. Milardo, M. D. Abrignani, S. Mijovic, G. Morabito, and R. Verdone, "Testing Protocols for the Internet of Things on the EuWIn Platform," **IEEE Internet of Things Journal**, vol. 3, pp. 124–133, Feb 2016.

[2] L. Galluccio, S. Milardo, G. Morabito, and S. Palazzo, "SDN-WISE: Design, prototyping and experimentation of a stateful SDN solution for WIreless SEnsor networks," in *Computer Communications (***INFOCOM***), 2015 IEEE Conference on*, pp. 513–521, April 2015.

[3] L. Galluccio, S. Milardo, G. Morabito, and S. Palazzo, "Reprogramming Wireless Sensor Networks by using SDN-WISE: A hands-on demo," in *Computer Communications Workshops (***INFOCOM WKSHPS***), 2015 IEEE Conference on*, pp. 19–20, April 2015.

[4] P. Di Dio, S. Faraci, L. Galluccio, S. Milardo, G. Morabito, S. Palazzo, and P. Livreri, "Exploiting State Information to Support QoS in Software-Defined WSNs," in *2016 15th Annual Mediterranean Ad Hoc Networking Workshop (***MED-HOC-NET***)*, June 2016.

[5] A. C. Anadiotis, L. Galluccio, S. Milardo, G. Morabito, and S. Palazzo, "Towards a Software-Defined Network Operating System for the IoT," in *2015 IEEE World Forum on Internet of Things (***WF-IoT***)*, Dec. 2015.

UNIVERSITÀ DEGLI STUDI DI PALERMO
UNIVERSITÀ degli STUDI di CATANIA
cnit
ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA