O-MAC: An Organized Energy-Aware MAC Protocol for Wireless Sensor Networks

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Outline

- Introduction
- Related work
- S-MAC protocol design
- O-MAC protocol design
- Simulation
- Conclusion and future work

Introduction

- The lifetime of the sensor network is based on the average power consumption of the sensor nodes
- Our goal is to design a new MAC protocol for WSN to extend the lifetime of the network by avoiding collisions, overhearing and idle listening
- The power consumed:

  send>recieve>idle>>sleep

S-MAC

- Three major parts of this scheme
  - Periodic Listen and Sleep
  - Collision and Overhearing Avoidance
  - Message passing

Periodic Listen and Sleep

- Each node goes to sleep for some time, and then wakes up and listen to see if any other node wants to talk to it.

Fig. 1. Periodic listen and sleep.

Periodic Listen and Sleep

- It requires periodic synchronization among neighboring nodes to remedy clock drift
- All nodes are free to choose their own listen/sleep schedules.
- However, to reduce control overhead, we prefer neighboring nodes to synchronize together

Collision Avoidance

- It follows similar 802.11, including both virtual and physical carrier sense and RTS/CTS exchange

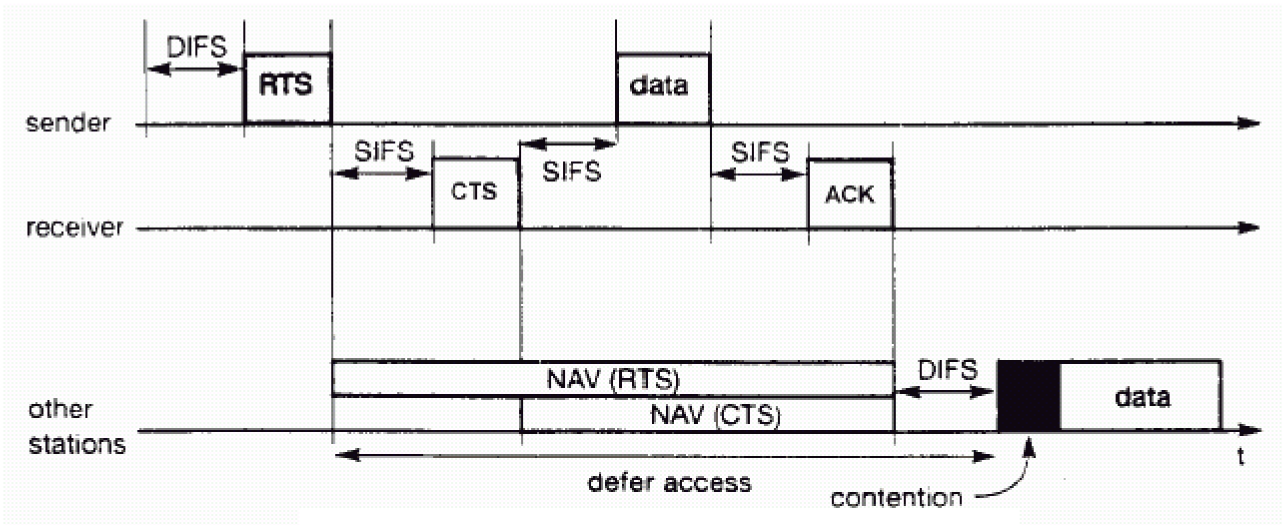
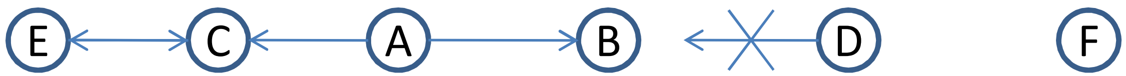


Figura 15. Modo RTS/CTS

Overhearing Avoidance

- Suppose A is currently transmitting a packet to B. which of the remaining nodes should go to sleep now



The drawback of S-MAC

- A major drawback is that it permits third party nodes receiving RTS or CTS frames to sleep immediately.
- However, when such RTS or CTS are unsuccessful because of collisions, all third party nodes receiving them will go to sleep for the duration of hypothetic transmision

O-MAC

- This protocol is inspired by S-MAC
- Introduce two new control frames OTS and NTS to help nodes confirm the channel reservation to all the nodes who may go to the sleep due to RTS or CTS collisions
- Allow isolated nodes in the vicinity of one transmission to turn off their radio transceiver

Scheduled Access Method over CSMA

- Initially, each node obtains the id of its neighbors and sort them according to increasing id.

- Any nodes in the vicinity of the sender and receiver must follow a scheduled algorithm based on the node id

Scheduled Access Method over CSMA

- Any node n_i having a list of neighbors $N(n_i)$ will access the channel exactly after all the nodes n_j , where n_j is in $N(n_i)$ and $j<i$

- To access the channel, as in IEEE 802.11 and S-MAC, the sender and receiver must exchange successfully RTS/CTS.

OTS

- OTS: Order To Sleep
- This frame contains the list of neighbors and the duration of the ensuing data
- After a successful transmission/reception of RTS/CTS, the sender will send the OTS to its neighbors

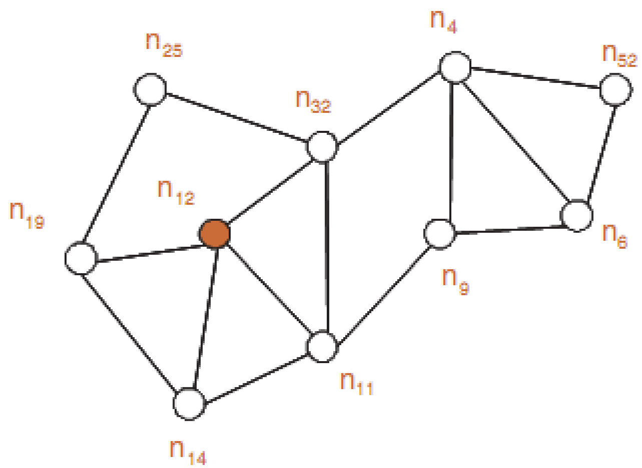
NTS

- NTS: Node To Sleep

- This frame contains the duration of the sleeping period
- Once the node receives the OTS, it must return the NTS frame to the sender

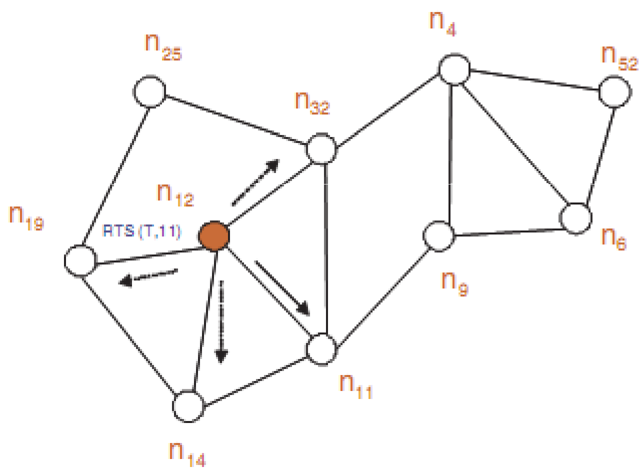
Example

- Node n_{12} wants to access the channel for one data frame transmission to node n_{11}

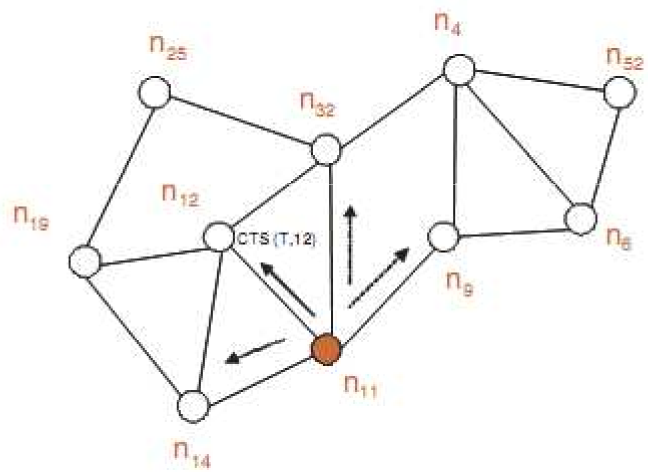


Example

- Send RTS

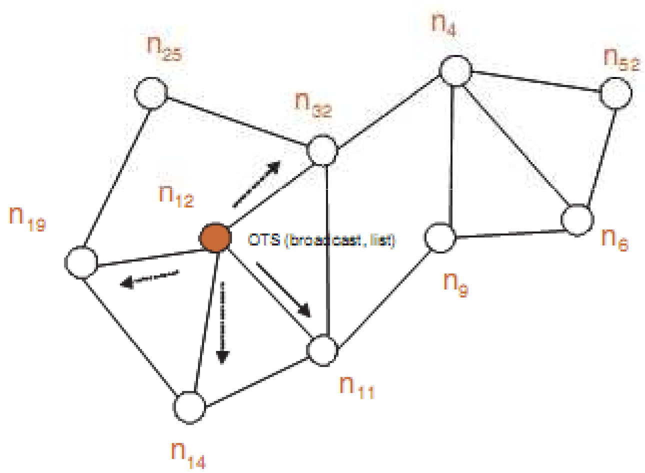


Send CTS

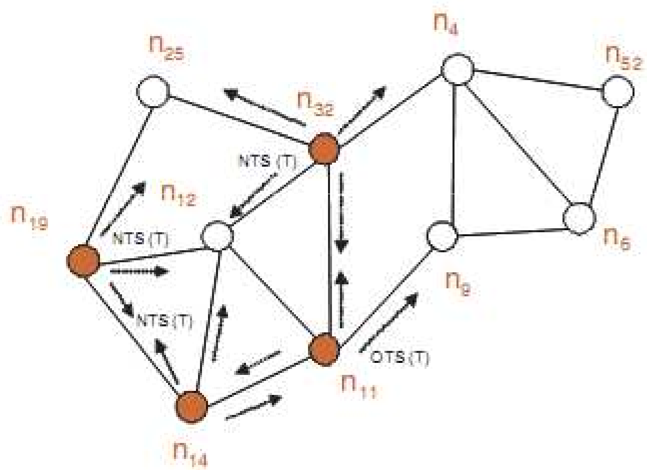


Example

- Send OTS

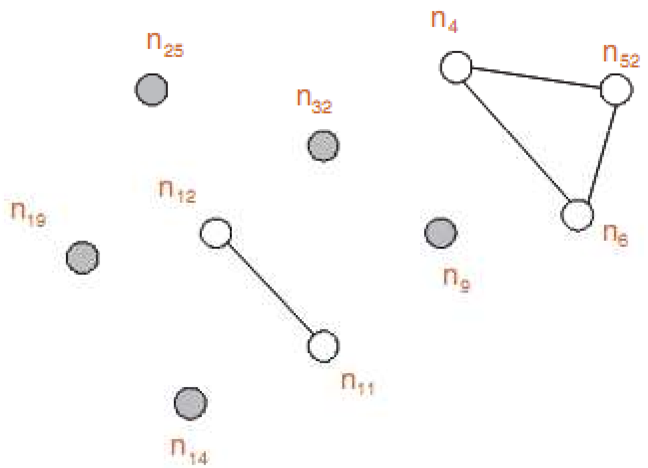


Send NTS



Example

- Node n_{25} is also allowed to sleep, since its neighbors are all asleep.



The drawback of O-MAC

- The size of OTS and number of NTS packets increases with the number of neighbors, resulting in a large overhead to the O-MAC protocol.
- The percentage of useful data delivery during one handshake procedure between the sender and the receiver reduces with the increase in the number of neighbors.

Simulation

- Tool: OPNET modeler simulation
- Compare the performance of O-MAC to those IEEE 802.11 and S-MAC in terms of energy consumption, volume of data collected, and the energy efficiency factor

Simulation

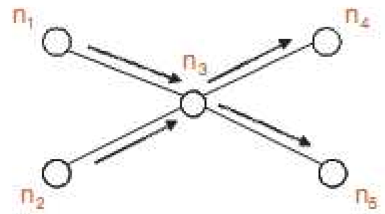
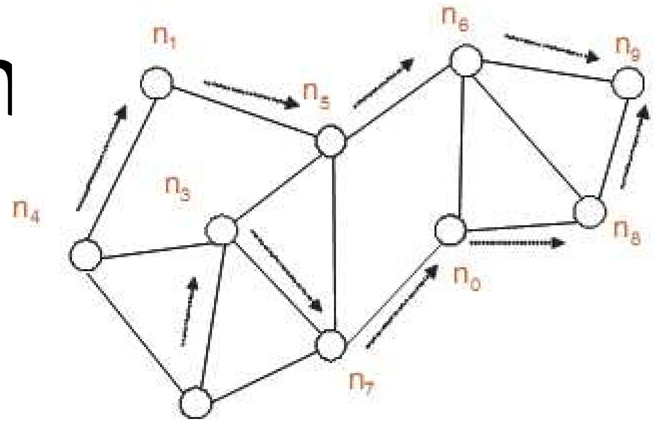
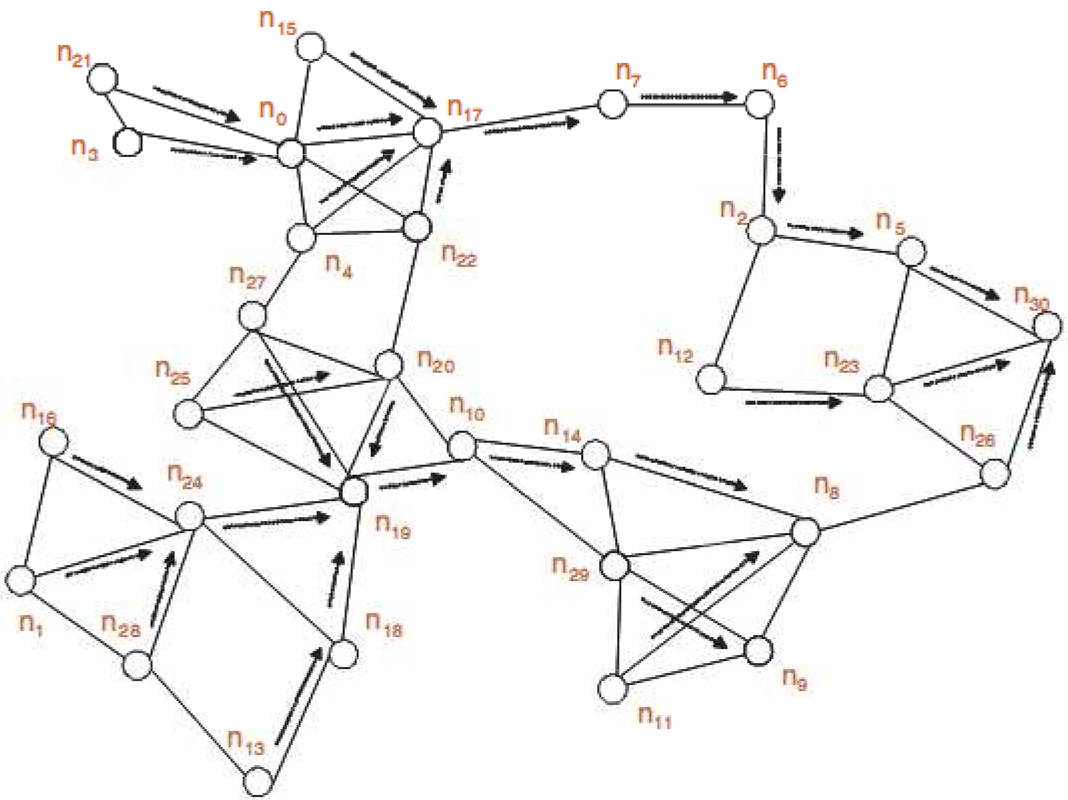
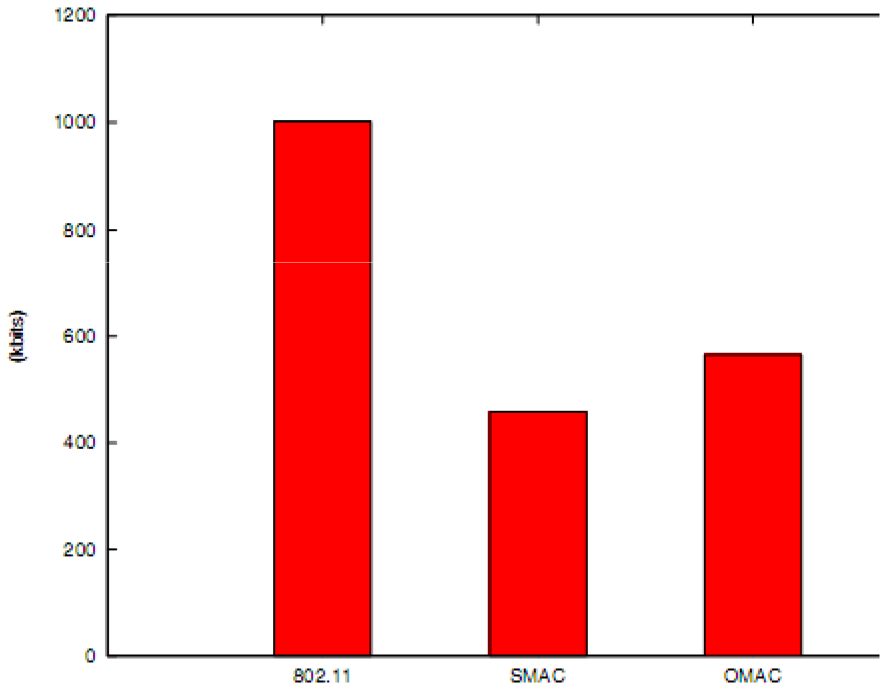


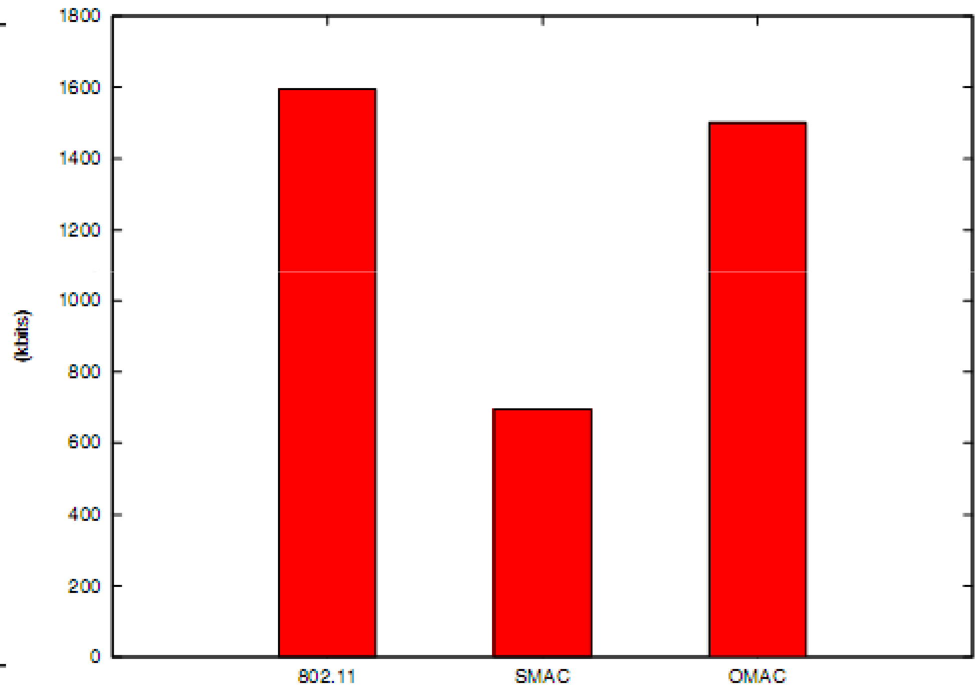
Fig. 7. S-MAC topology



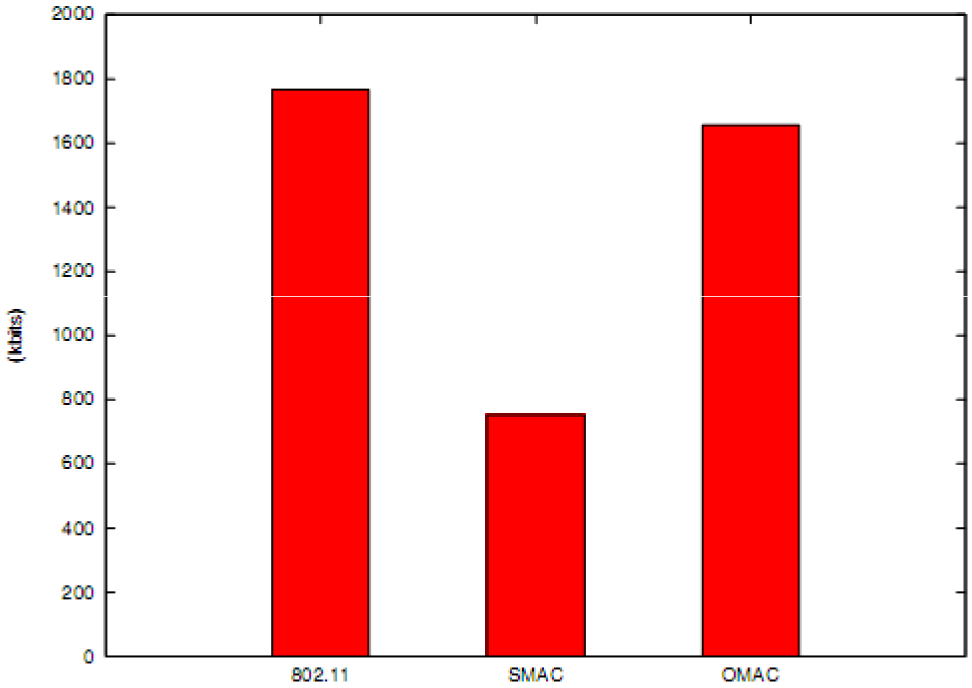


Simulation


1200
1000
800
600
400
200
0
(kbits)
802.11
SMAC
OMAC

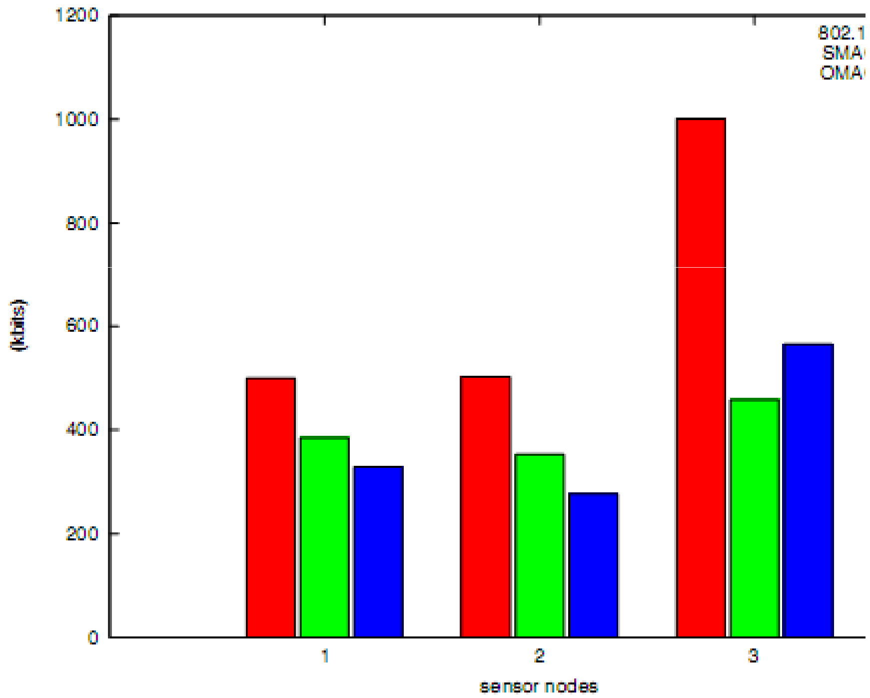

1800
1600
1400
1200
1000
800
600
400
200
0
(kbits)
802.11
SMAC
OMAC

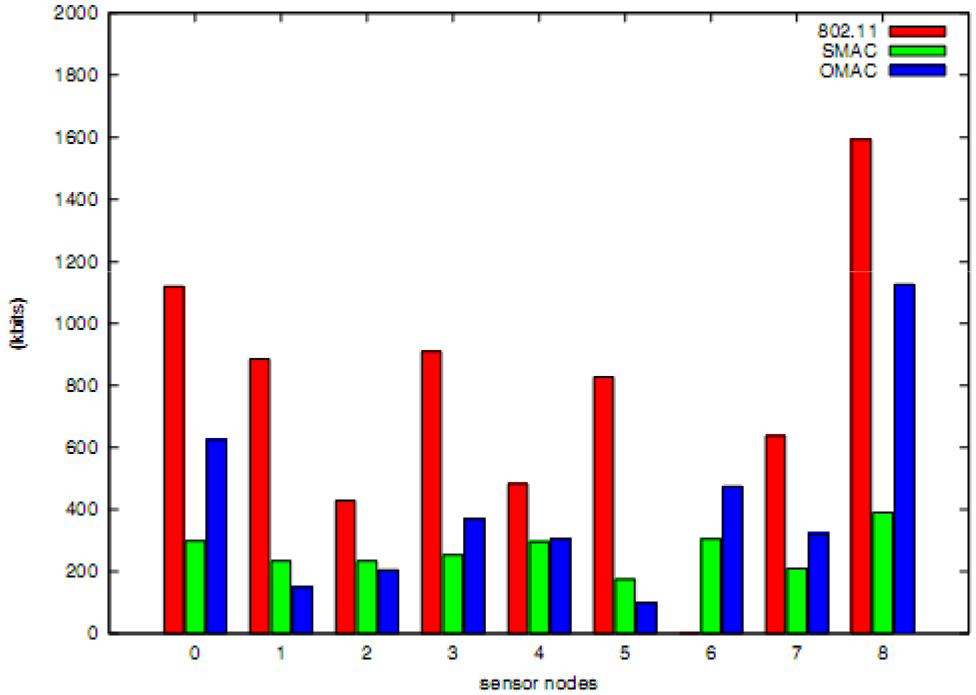
Simulation



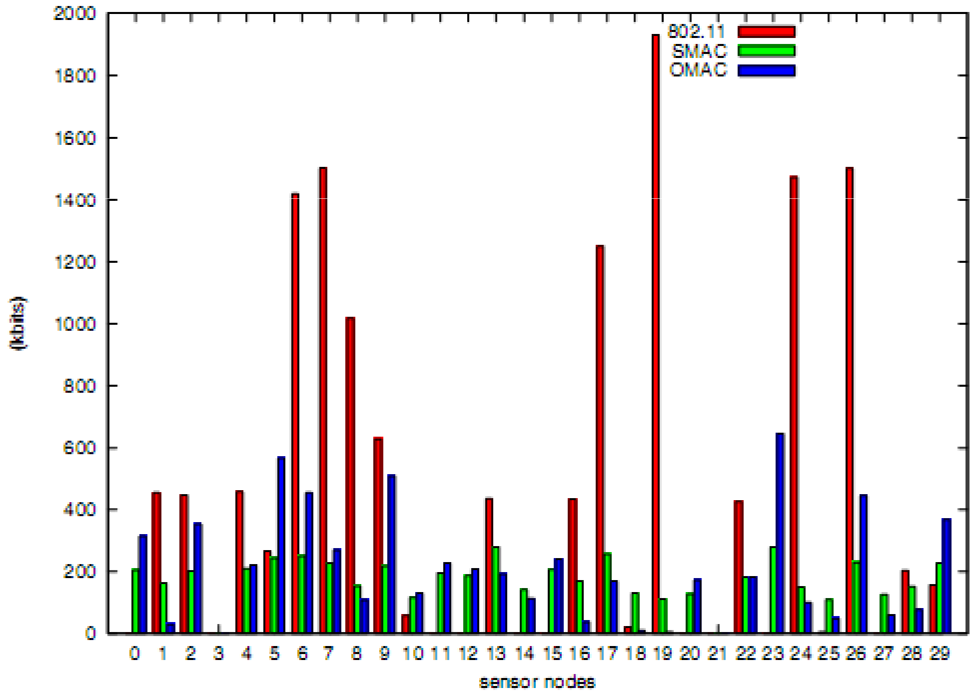
2000
1800
1600
1400
1200
1000
800
600
400
200
0
(kbits)
802.11
SMAC
OMAC

Simulation


1200
1000
800
600
400
200
0
(kbits)
802.1
SMA
OMA
1
2
3
sensor nodes


2000
1800
1600
1400
1200
1000
800
600
400
200
0
(kbits)
802.11
SMAC
OMAC
0
1
2
3
4
5
6
7
8
sensor nodes

Simulation



802.11
SMAC
OMAC
(kbits)
sensor nodes
0
200
400
600
800
1000
1200
1400
1600
1800
2000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29

Conclusion

- Furthermore, we point out that the performance of O-MAC degrades with the node density, due to overheads introduced by the new O-MAC packets.
- Our future direction is to modify the current O-MAC to reduce overheads and treat the problem of throughput degradation when the traffic load increases.