MAC protocol for WSNs (S-MAC)

Wireless Seminars

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Article Reference

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Medium Access Control with Coordinated Adaptive Sleeping for Wireless Sensor Networks

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Introduction

• WSNs usual characteristics:
  ▪ Energy consumption constrain
  ▪ Large number of sensors
  ▪ Multihop networks

• MAC different from traditional Wireless MAC protocols

• Transceiver is the most consuming component

• MAC protocol directly influences its operation
Introduction

- **Sensor MAC (S-MAC)**
  - Main goal → Reduce energy consumption
  - Scalability
  - Collision avoidance

- **Sources of energy waste**
  - Collisions
  - Overhearing *(node picks up packet destined to other nodes)*
  - Control packet overhead *(RTS/CTS and ACK packets)*
  - Idle listening *(listening to receive possible traffic that is not sent)*
S-MAC Design

• Low duty-cycle operation
  ▪ Periodically put nodes into sleep state (radio off)
  ▪ Reduces idle listening

• Neighbouring nodes synchronize together
  ▪ Listen and go to sleep at the same time
  ▪ Schedules are exchanged by SYNC messages
  ▪ A node talks to all its neighbours at their listen time
  ▪ Known as a virtual cluster
S-MAC Design

• Collision avoidance
  ▪ Neighbours that want to talk to a node → Listening period
  ▪ They need to contend for the medium

• Channel is sensed for possible transmissions
  ▪ Physical Carrier Sense

• Duration field included in each packet → NAV
  ▪ Virtual Carrier Sense

• RTS/CTS is used
  ▪ Hidden terminal problem
Coordinated Sleeping

• Choosing a schedule
  ▪ Node listen for at least a synchronization period
    ▪ If any schedule is heard → Chooses its own and follow it
    ▪ If it receives a schedule → It adopts it

• Maintain synchronization
  ▪ Clock drift could cause synchronization errors
  ▪ SYNC packet includes the relative time of the next sleep

• Adaptive listening
  ▪ Node that overheads RTS or CTS wake up at the end of the tx
  ▪ Immediately pass data if it is the next hop
  ▪ Reduce latency
Overhearing and Fragmentation

- **Overhearing**
  - Interfering nodes go to sleep after they heard an RTS or CTS

- **Fragmentation**
  - High cost of retransmit a long message
  - Fragment the long message into small ones
  - Transmit all in a burst (only one RTS/CTS used)
  - Fairness is not so important in WSNs
Implementation

• Implementation on two types of Motes

• TinyOS
  ▪ Efficient event-driven OS for tiny sensor nodes

• Three MAC modules are tested
  ▪ 802.11-like protocol
  ▪ S-MAC without sleep
  ▪ S-MAC with periodic sleep
    • Duty cycle selection
    • Adaptive listen
Experiments

![Graph showing energy consumption vs. message inter-arrival period for different protocols]

- **IEEE 802.11-like protocol without sleep**
- **S-MAC without periodic sleep**
- **S-MAC with periodic sleep**

The graph illustrates the energy consumption (in mJ) for various message inter-arrival periods (S).
Experiments

Latency (S)

Number of hops

10% duty cycle without adaptive listen

10% duty cycle with adaptive listen

No sleep cycles
Experiments

![Graph showing effective data throughput (Byte/S) vs. number of hops for different duty cycles and adaptive listen settings.]

- No sleep cycles
- 10% duty cycle with adaptive listen
- 10% duty cycle without adaptive listen
Conclusions

• Advantages
  ▪ Scalability
  ▪ Reduced and distributed energy waste
  ▪ Needs moderate resources

• Disadvantages
  ▪ Increases latency
  ▪ Delay accumulated in each hop
  ▪ Not adaptable to traffic load conditions

• S-MAC variants

• Application dependent protocol
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