Lecture 10
WSNs: MAC

Reading:

- "Wireless Sensor Networks," in *Ad Hoc Wireless Networks: Architectures and Protocols*, Chapter 12, section 12.5.
- K. Sohrabi, J. Gao, V. Ailawadhi, and G. Pottie "Protocols for Self-Organization of a Wireless Sensor Network," *IEEE Personal Communications*, Vol. 7, No. 5, Oct. 2000, pp. 16-27.
- W. Ye and J. Heidemann, "Medium Access Control in Wireless Sensor Networks" in *Wireless Sensor Networks*, T. Znati, K. M. Sivalingam and C. Raghavendra (eds.), Kluwer Academic Publishers, May 2004.

Unique WSN MAC Features

- Energy conservation paramount
  - Fairness and throughput less important
  - Avoid collisions
  - Avoid unnecssary receptions
  - Reduce idle power dissipation → let nodes sleep often
    - Tx:Rx:Idle in motes: 1:1:1.41
  - Reduce overhead
- Example protocols
  - Scheduled: TDMA protocols, LEACH
  - Contention-based
    - S-MAC, T-MAC and DMAC
    - TRAMA
    - STEM

Sensor MAC (S-MAC)

- Tries to reduce wastage of energy from all four sources of energy inefficiency
  - Collision – by using RTS and CTS
  - Overhearing – by switching the radio off when the transmission is not meant for that node
  - Control overhead – by message passing
  - Idle listening – by periodic listen and sleep
- In exchange there is some reduction in
  - Per-hop fairness
  - Per-hop latency

Periodic Listen and Sleep

- If no sensing event happens, nodes are idle for a long time
  - Nodes go into periodic sleep mode
  - Set a timer to awake later
  - When timer expires, node wakes up and listens to see if any other node wants to talk to it
- Duration of sleep and listen time can be selected based on the application scenario
- To reduce control overhead, neighboring nodes synchronize through periodic SYNC packets
  - Listen and sleep together

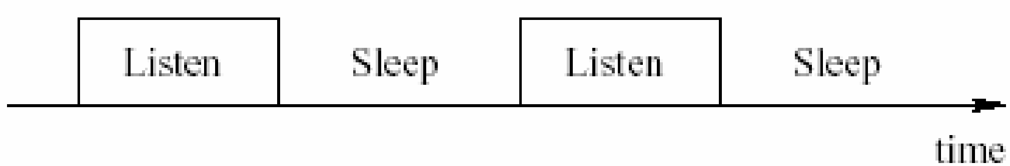


Fig. 1. Periodic listen and sleep.

Synchronization

- Not all neighboring nodes can synchronize together
- Two neighboring nodes (A and B) can have different schedules if they are required to synchronize with different nodes
- If A wants to talk to B, it waits until B is listening
- If multiple neighbors want channel → contention
  - Contention mechanism same as in IEEE802.11 (using RTS and CTS)
- Nodes do not go to periodic sleep until transmission finished

Fig. 2. Neighboring nodes A and B have different schedules. They synchronize with nodes C and D respectively.

Simulation Results

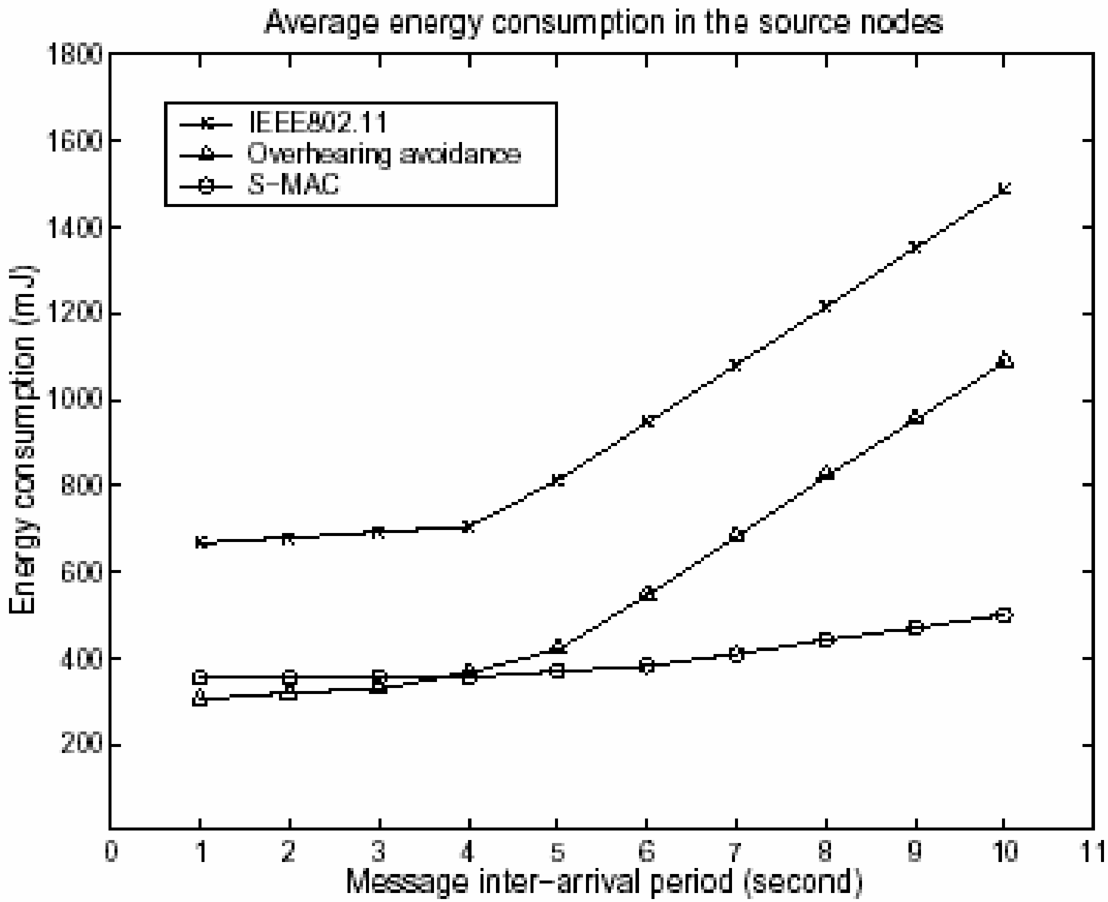


Fig. 7. Measured energy consumption in the source nodes.

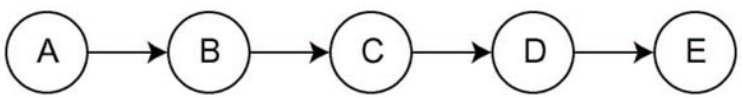
Timeout-MAC (T-MAC)

- Goal: eliminate idle energy by adaptively setting length of active portion of frames
  - Messages transmitted in bursts at beginning of frame
  - If no "activation events", nodes sleep until next frame
    - Radio activity
    - Frame timer expiration
    - Carrier sensing
    - RTS-CTS exchange
- T-MAC useful to accommodate latency bounds while retaining energy efficiency of S-MAC

DMAC

- Useful for data gathering trees rooted at sink
  - Direction of packets arriving at node predictable
- DMAC staggers wakeup times for nodes based on distance to sink
  - Reduces large delays
  - Retains energy saving features
- Nodes synchronized so receive period lines up with upstream neighbor’s send period

Comparison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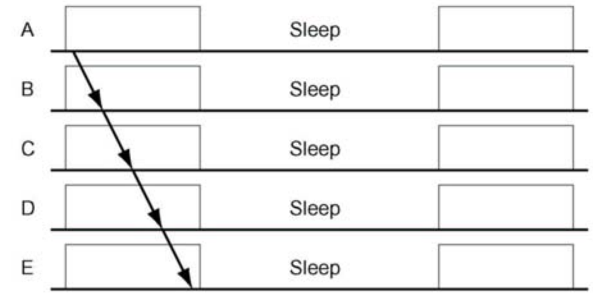
C
D
E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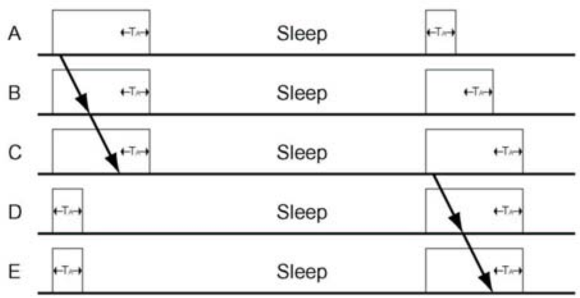
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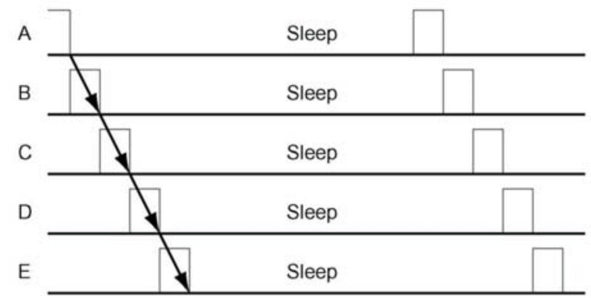
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Traffic-Adaptive Medium Access (TRMA)

- Goal: reduce energy consumption due to collisions
- Nodes learn two-hop neighbor information during contention period
- Contention-free periods
  - Schedule information
  - Data packet exchange
- Adaptive Election Algorithm (AEA)
  - Node calculates priority for itself and all two-hop neighbors for current slot using hashing function
  - If node has highest priority and data to send, it wins slot and sends data
  - If neighbor has highest priority and node is intended receiver, it sets itself to receive mode
  - Otherwise, node sleeps

Sparse Topology and Energy Management (STEM)

- Goal: exploit traffic patterns whereby sensors only transmit data to sink infrequently
- Nodes only activated when traffic is generated (e.g., interesting event sensed)
  - Reactive rather than proactive approach
  - Node wakens downstream neighbors using paging channel
    - STEM-T: tone on paging channel
    - STEM-B: beacon on paging channel

Discussion