MAC Protocols for Wireless Sensor Networks

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Use cases
Basics of Wireless Sensor Networks

- Very small units

- Sensor, processor, memory and wireless device on one microchip

- Battery used for power supply

- Typically there are periodically short messages send

- Energy consumption dominated by the radio transmissions

→ Most time spend sleeping with periodically wakeup
Why not simply use IEEE 802.11 (WLAN)

WLAN:
- Optimized for high speed transmission:
  (maximized throughput, very low Latency, high availability)
- Idle listening for reliability

Wireless Sensor Network:
- Optimized for energy saving
- Different structure, short messages expected, media less frequently used, sleeping schedules energy saving
S-MAC

- Ad-Hoc (multi hop)

- Synchronized wakeup (sync via broadcast)

- Virtual carrier sense, virtual clusters, neighbour detection

- Fragmentation support

- Randomized carrier sense time for starvation avoidance

- Adaptive Listening
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B-MAC

- Ad-Hoc (multi hop)
- Keep it simple
- Low power listening (randomized time added), asynchronous wakeup
- Clear channel assessment
- By default no acknowledgements, no fragmentation
- Configurable by higher layers for application requirements
WiseMAC

- Infrastructure network

- Central access point with connection to other network

- Access point has „unlimited“ energy → Idle listen possible

- Asynchronous

- Table with wakeup schedules
X-MAC

- Ad-Hoc (multi hop)

- Based on B-MAC

- Strobed announcements including destination address

- Two senders → same target: one announcement + both messages
IEEE 802.15.4

- Peer-to-peer and star topology possible
- Carrier sense multiple access (CSMA)
- Collision avoidance (CA)
- Full and reduced function nodes
S-MAC and B-MAC

Test implementation of both with a 20 nodes network

S-MAC:
- Low Latency with adaptive Listening
- Sync overhead increases with data rate

B-MAC:
- Small implementation
- With default configuration faster than S-MAC
- Uses less energy than S-MAC
Advantages of X-MAC

- Less overhearing of preamble communication
- Shorter announce time
X-MAC and WiseMAC

WiseMAC:
- Based on IEEE 802.15.4
- Overhearing minimized
- No message forwarding by nodes
- Minimized listen / transmission time

X-MAC:
- Self configuring (no central instance)
- Ad-Hoc protocol with low overhearing rate
Conclusion

- X-MAC and WiseMAC seem to be efficient solutions

- Still optimization possible

- Processor and sensor sleep (better) combined with network sleep schedules

- Tests of MAC protocols for large networks missing
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References


M. Buettner, G. Yee, E. Anderson and R. Han,“X-MAC: A Short Preamble MAC Protocol For Duty-Circled Wireless Sensor Networks”, Department of Computer Science, University of Colorado at Boulder, CO [USA], May 2006