MAC Layer Protocols in Wireless Sensor Networks

NetSys 230

Zhou Yu
Mac Protocols of WSN

- Most of the WSNs are using five layer protocol model:
  1. application layer
  2. communication layer
  3. network layer
  4. datalink layer *
  5. the physical layer.

  The datalink layer, especially the MAC sublayer, decides how to access the wireless communication channel, and allocate the limited transmission resource. From the layered view, the MAC protocol should provide channel access delay (single-hop) guarantee for Real-time QoS support.
• WSN has some special requirements for MAC protocol:
  (1) Energy Efficiency
  (2) Latency
  (3) Throughput
  (4) Bandwidth utilization
• Traditional MAC protocols focus more on energy saving, throughput and bandwidth utilization.
• Newly developed MAC protocols can support deterministic or probabilistic end-to-end delay bound.
Major difficulties in MAC protocol design

• (1) Energy-efficiency
• (2) Fault tolerance
• (3) Scalability
important attributes in designing MAC protocol

• (1) Network topology
• (2) MAC type
• (3) RT QoS type
classic MAC protocol

- Contention-based
  - (1) S-MAC
  - (2) T-MAC
  - (3) B-MAC
S-MAC

Nodes create a sleep schedule for themselves that determines at what times to activate their receivers and when to set themselves into a sleep mode. Only for a listen period, sensor nodes are able to communicate with other nodes and send some control packets such as SYNC, RTS (Request to Send), CTS (Clear to Send) and ACK (Acknowledgement).
• TDMA-based
  (1) TDMA
  (2) TRAMA
  (3) EAMAC
TDMA

- Time division multiple access (TDMA) is a channel access method for shared medium networks. It allows several users to share the same frequency channel by dividing the signal into different time slots.
• Each of the cluster sensor nodes is managed by the Gateway. The Gateways collect the information from the other sensor nodes within its cluster, performs the data fusion, communicates with the other gateways and finally sends the data to the control center. The assignment of the time slots to the sensor nodes within its cluster is performed by Gateways. The Gateways inform to the other nodes about the time slot when it should listen to other nodes and the time slot when it can transmit own data.
Recent development of MAC protocols

- **CC-MAC**
  - generally based on S-MAC
  - CC control packet is used to assign an appropriate value to clear channel flag (CCF)
  - 1: transmit as well as receive
  - 0: only receive
  - CCC: 0—3, reduce by 1 every hop, 2 or 3—remain 0, 0 or 1 – become 1
PEDAMACS

- TDMA-based MAC protocol
- aims to achieve both energy efficiency and delay guarantee
- AP: high-powered access point can reach all nodes in one hop
- The protocol operates in three phases:
  1. the topology learning phase
  2. the topology collection phase
  3. the scheduling phase
• Dual-Mode MAC
• SUPORTS
• VTS
• CR-SLF
# Comparison of MAC protocols

<table>
<thead>
<tr>
<th>MAC Type</th>
<th>Energy-Efficiency</th>
<th>Fault-Tolerance</th>
<th>Scalability</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-MAC</td>
<td>high</td>
<td>good</td>
<td>good</td>
</tr>
<tr>
<td>T-MAC</td>
<td>high</td>
<td>good</td>
<td>good</td>
</tr>
<tr>
<td>B-MAC</td>
<td>high</td>
<td>good</td>
<td>good</td>
</tr>
<tr>
<td>TRAMA</td>
<td>moderate</td>
<td>good</td>
<td>moderate</td>
</tr>
<tr>
<td>EAMAC</td>
<td>high</td>
<td>bad</td>
<td>moderate</td>
</tr>
<tr>
<td>CC-MAC</td>
<td>high</td>
<td>bad</td>
<td>moderate</td>
</tr>
<tr>
<td>PEDAMACCS</td>
<td>high</td>
<td>moderate</td>
<td>bad</td>
</tr>
<tr>
<td>CR-SLF</td>
<td>low</td>
<td>bad</td>
<td>good</td>
</tr>
<tr>
<td>Dual-Mode MAC</td>
<td>N/A</td>
<td>good</td>
<td>moderate</td>
</tr>
<tr>
<td>SUPORTS</td>
<td>low</td>
<td>good</td>
<td>bad</td>
</tr>
<tr>
<td>VTS</td>
<td>high</td>
<td>bad</td>
<td>moderate</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Network Topology</th>
<th>MAC Type</th>
<th>RT QoS Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-MAC</td>
<td>no</td>
<td>CSMA/CA</td>
</tr>
<tr>
<td>T-MAC</td>
<td>no</td>
<td>CSMA/CA</td>
</tr>
<tr>
<td>B-MAC</td>
<td>no</td>
<td>CSMA/CA</td>
</tr>
<tr>
<td>TRAMA</td>
<td>no</td>
<td>TDMA/CSMA</td>
</tr>
<tr>
<td>EAMAC</td>
<td>cluster structure</td>
<td>TDMA</td>
</tr>
<tr>
<td>CC-MAC</td>
<td>no</td>
<td>CSMA/CA</td>
</tr>
<tr>
<td>PEDAMACCS</td>
<td>no</td>
<td>TDMA</td>
</tr>
<tr>
<td>CR-SLF</td>
<td>chain structure</td>
<td>CSMA</td>
</tr>
<tr>
<td>Dual-Mode MAC</td>
<td>cell structure</td>
<td>FDMA/TDMA</td>
</tr>
<tr>
<td>SUPORTS</td>
<td>sink-based</td>
<td>CSMA</td>
</tr>
<tr>
<td>VTS</td>
<td>no</td>
<td>TDMA</td>
</tr>
</tbody>
</table>
Open issues and future works

• 1. Cross-layer RT protocol design
Multi-dimensional QoS Support

• While offering RT QoS support, there should be a system flexibility to support different applications with respect to their different QoS requirements in the mixed traffics. Generally speaking, they include RT reliable service, best-effort service, bursty event reporting and simple rate-matched service. A flexible integrated architecture with configurable performance metrics in well defined cost functions will be of great help to the future development of protocols WSNs.
Thanks