Energy-efficient MAC layer protocols in ad hoc networks

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Outline

- **Power off mechanism**
- **Multi-channel mechanism**
- **Antenna-based mechanism**
- **Conclusion**

Power off mechanism

- In typical wireless system , receivers have to be powered on at all time to detect any possible signal that target them.
- The node have to monitor the channel and consume power even through the packets are not directed to them , a large amount of energy is consumed unnecessarily
- The node are allowed to stay in doze/sleep state when they are not actively transmitting , receiving , or waiting for a channel .

Power off mechanism – PAMAS[1]

- Power –aware Multi-access Protocol with Signaling
- Use of a separate signal channel – the "busy tone" channel
- A host knows if one or more of its neighbors is receiving because the receivers should transmit a "busy tone" when they begin to receive packets .
- Thus , a host can easily decide when to switch to the sleep mode
- PAMAS achieves power saving from 10% to 70%

Power off mechanism – S-MAC[2]

- S-MAC uses the scheme of periodic listen and sleep to reduce the energy consumption by avoiding idle listening
- SMAC requires synchronization among neighboring hosts
- The latency is increased since a sender must wait for the receiver to wake up before transmission
- It can make trade-off between energy and latency

Power off mechanism

- With a separate wake up radio , the normal data radio can be powered down when it is idle listening state. [3]
- Multiple channel and CSMA/CA are combined in the MAC
- The multi-channel spread spectrum helps reduce collision and retransmissions
- The node periodically broadcast a beacon through the wake-up channel to keep the neighboring nodes awake.

Power off mechanism

- **Power management using multi sleep states[4]**
  - ☐ L different states are used : the first L-1 states are sleep states , while the L-th state corresponds to the active state in which nodes can transmission or receive packets.
  - ☐ The deeper the sleep state , the less power consumption and the longer time to wake up
  - ☐ The sleeping node switch back to active when it receive the signal
  - ☐ This policy avoid to switch back active state periodically

Multi-channel mechanism

- Most MAC protocol assume that there is only one channel shared among different mobile node in ad hoc network

- RTS/CTS don't completely solve the hidden terminal and exposed terminal problem

- This problem is more serious , unnecessary collision should be avoid , since retransmission cause additional power consumption and increase packet delay

Multi-channel mechanism

- **Basic multi-channel scheme [5]**
  - A system composed of one control channel , together with one or more data channel
  - A special case is the "dual channel" scheme in which only one data channel is used along with a control channel
  - DCA (Dynamic channel assignment)[6]

Multi-channel mechanism

- **Busy tone scheme – Busy tone Multiple access (BTMA)[7]**
  - The busy tone provide two function :
    - to acknowledge the request for a channel access
    - to prevent transmission from other node
  - Each neighboring node estimate the channel gain from the busy tone and is allowed to transmit

Multi-channel mechanism

- **Dual Busy Tone Multiple Access protocol (DBTMA)[8]**
  - ☐ Two busy tone : transmit busy tone and receive busy tone
  - ☐ The receive busy tone provide :
    - 1)Acknowledge the sender that channel has been successfully acquired
    - 2) Notify its neighboring nodes of the following transmission and provides continuous protection for the on-going traffic
  - ☐ The transmit busy tone is used to protect the RTS packets

Antenna-based mechanism

- **Three kinds of antennas :**
  - ☐ Omni-antenna
  - ☐ Directional antenna
  - ☐ Smart antenna

Antenna-based mechanism

- **Directional MAC[9]**
  - Each node is equipped with multiple directional antennas
  - The use of omni-directional RTS (ORTS) or directional RTS (DRTS) packet allow the corresponding recipients to determine the direction of the transmitters
  - It relies on an accurate tracking and location technology.

Antenna-based mechanism

- **Directional antenna based MAC with power control (DMACP)[10]**
  - Finding the directions of transmission / reception at mobile nodes
  - An appropriate transmission and reception strategy for control packet to minimize interference among distinct pairs of communicating hosts

Antenna-based mechanism

- The radio transceiver in each mobile node is assumed to be equipped with M directional antenna.[11]

- Each of the antenna has conical radiation pattern , spanning an angle of 2π /M radians

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Conclusion

- The Power saving mechanism is an important rule in future wireless network
- How to cooperate with other mechanism in wireless environment?

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