BLAM: An Energy-Aware MAC Layer Enhancement for Wireless Adhoc Networks

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Outline

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Introduction

- Congestion in ad hoc networks
  - Degrades throughput
  - Wastes the scarce energy
- IEEE 802.11 DCF Protocal
  - Much channel bandwidth and energy are wasted in collisions and collision resolutions

The Challenge of Energy Consumption in ad-hoc networks

- To divide the previous research on power-aware MAC layer into three categories
  - Reservation-Based Power-Aware MAC
  - Switching off Power-Aware MAC
  - Transmission Power Control

Reservation-Based Power-Aware MAC

- Tries to avoid collisions in the MAC layer
- A group of nodes select some type of coordinator (leader) to perform the functions of a centralized base station

Switching off Power-Aware MAC

- Tries to minimize the idle energy consumption by forcing nodes to enter into doze mode.
- The geographical area is partitioned into smaller grids in each of which only one host needs to remain active to relay packets.

Transmission Power Control

- The maximum power is consumed during the transmission mode.
- It is more energy conserving to send the data in a multi-hop fashion using relay nodes rather than sending it directly to the destination.

Battery Level Aware MAC (BLAM)

- In WLANs, the nodes included within the coverage area of a certain host may send control messages that collide with the RTS/CTS frames transmitted by this node.
- The situation might be worse in a multi-hop wireless ad hoc network, because each message potentially encounters collisions at each hop.

Battery Level Aware MAC - Motivation

- BLAM conserves the channel bandwidth and the energy consumption by decreasing the total number of collisions.
- From the network lifetime point of view, the low energy nodes are the most important and most critical nodes.
- Leaving these critical nodes to deplete their energy may cause a network partition and some sources might be unable to reach other destinations

Battery Level Aware MAC - Modifications to IEEE 802.11 DCF

- BLAM modifies the IEEE 802.11 DCF in two ways:
  - Changing the wait time before transmitting fresh data packets
  - Changing the distribution of the random deferring time after an unsuccessful transmission attempt.

Battery Level Aware MAC - Modifications to IEEE 802.11 DCF

- In BLAM, after sensing an idle channel for a DIFS interval, the node waits for a random amount of time before sending the RTS.
- This random wait time is picked from a normal distribution with mean and variance that depend on the current battery level of the node.

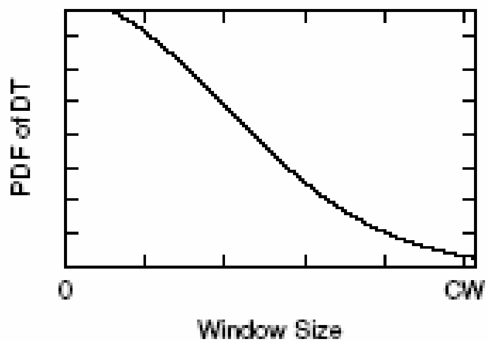
Battery Level Aware MAC - Modifications to IEEE 802.11 DCF

$$Mean = CW_{min} \cdot (1 - R_i)$$

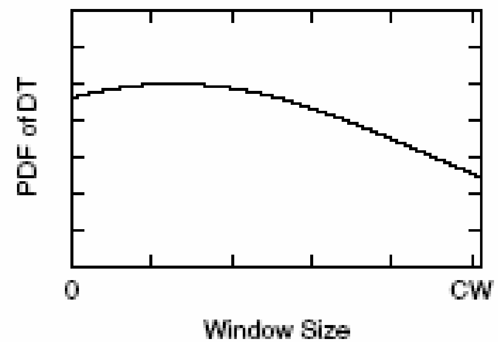
$$Variance = \frac{CW_{min}}{2} \cdot cosine\left(2 \cdot \left|\frac{1}{2} - R_i\right|\right)$$

- where CWmin is the minimum contention window size,and Ri is the relative battery level of node i.
- In BLAM, the random deferring period is picked up from a normal distribution with the mean and variance given by the Equation, but replacing CWmin with the current contention window size CW. As in 802.11, the value of CW will double at each unsuccessful transmission.

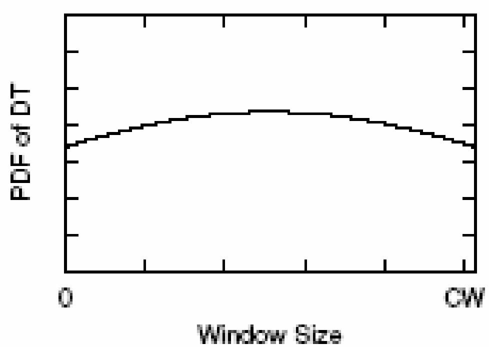
Battery Level Aware MAC - Modifications to IEEE 802.11 DCF



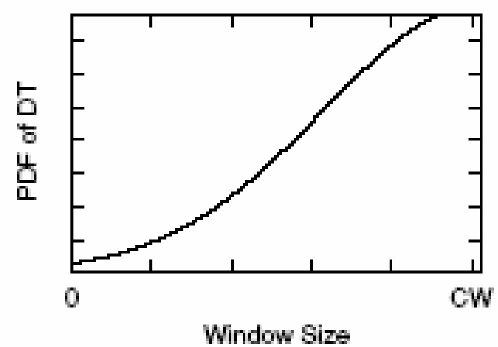
(a) Battery level = 1



(b) Battery level = 0.75



(c) Battery level = 0.5



(d) Battery level = 0

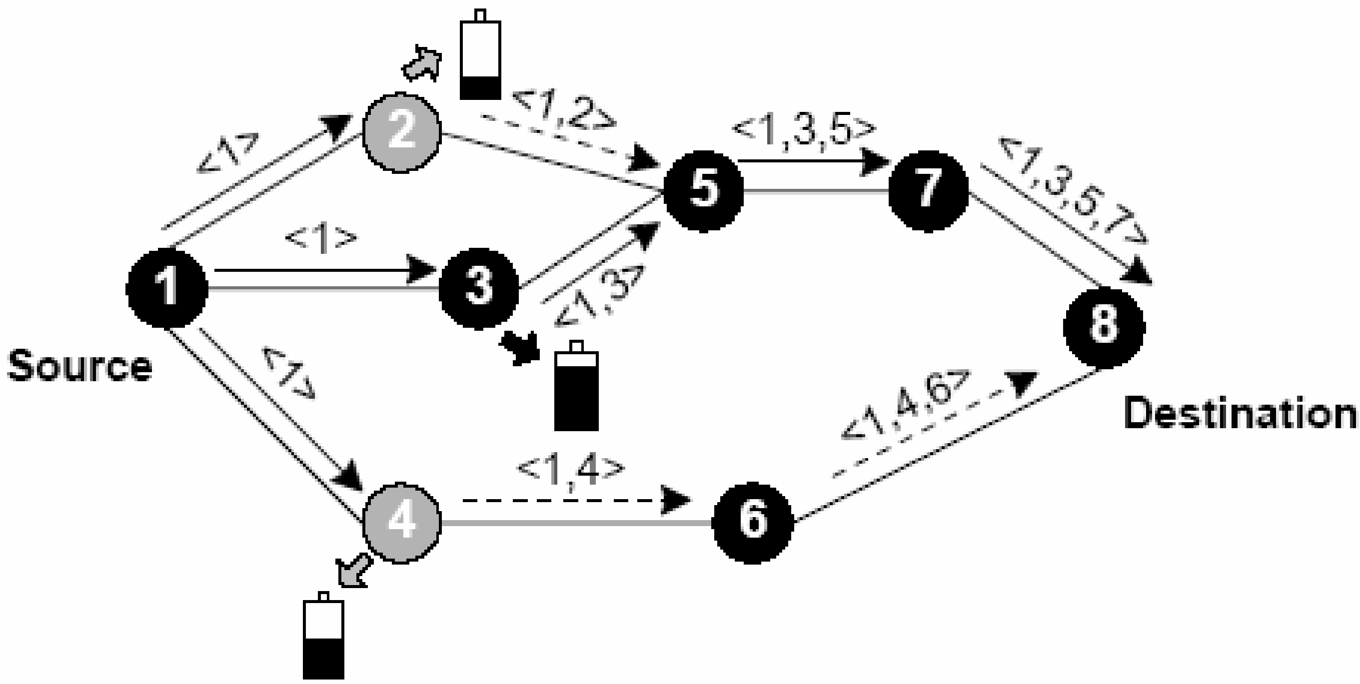
Battery Level Aware MAC - Low-Energy Nodes Priority

- One objection for BLAM may arise because of the low priority assigned to the energy-poor nodes. It might seem more reasonable to give low-energy nodes a higher priority to access the channel so that they send their data immediately before they die.

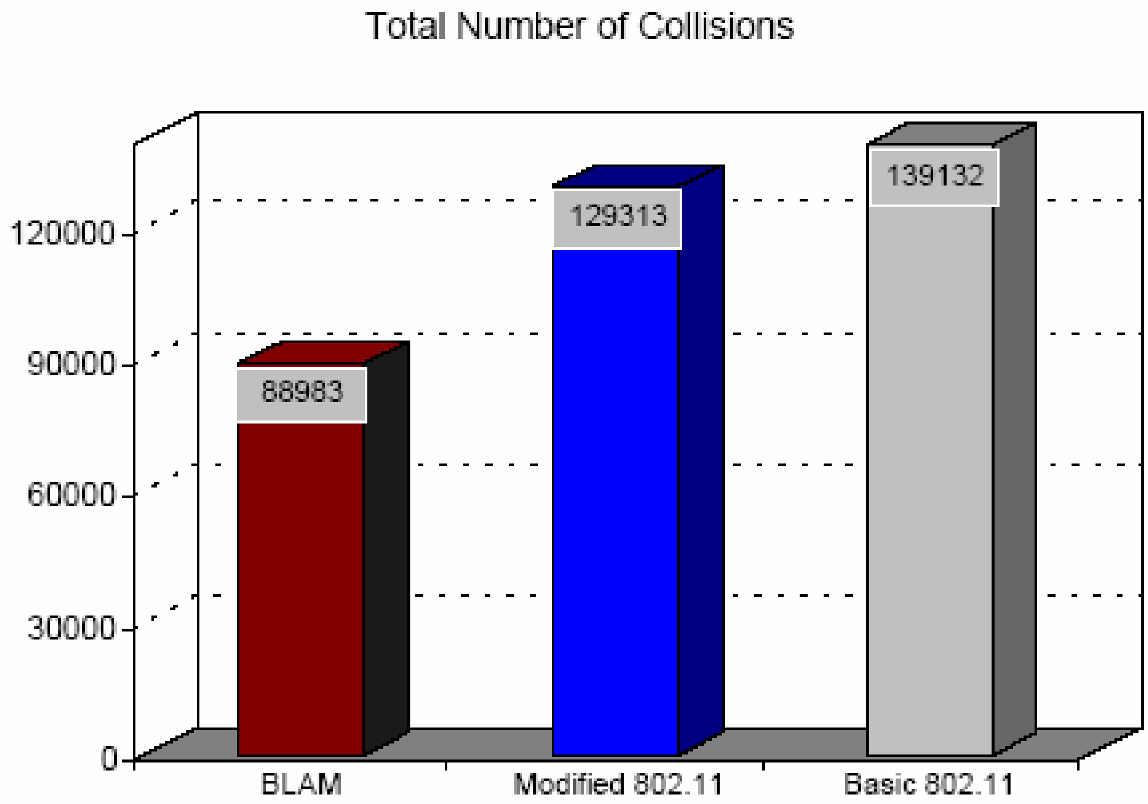
Battery Level Aware MAC - Low-Energy Nodes Priority

- BLAM is balancing the residual energy level among the whole network nodes. it is delaying the network partition event as much as possible.
- As shown in simulation, BLAM has a lower average end-to-end delay per packet (compared to IEEE 802.11) because it eliminated the time wasted in retransmissions.
- During new route discovery, because the energy-poor nodes have a lower chance to access the channel, they will have smaller probability to participate in new forwarding routes.

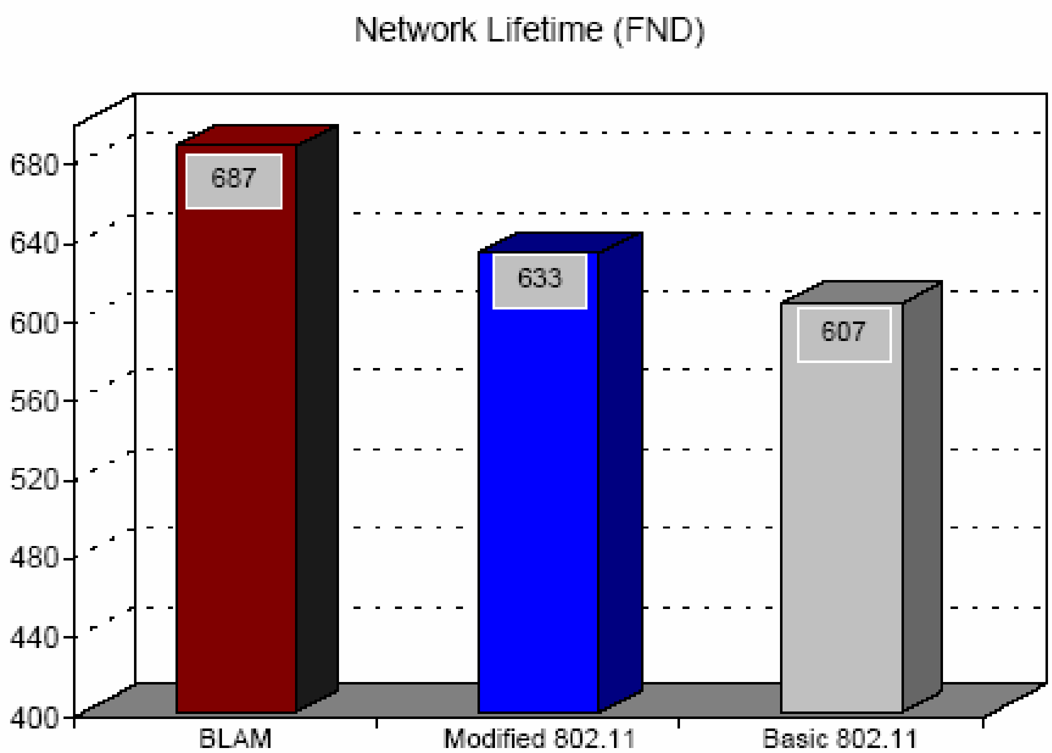
Battery Level Aware MAC - Low-Energy Nodes Priority



Simulation Results

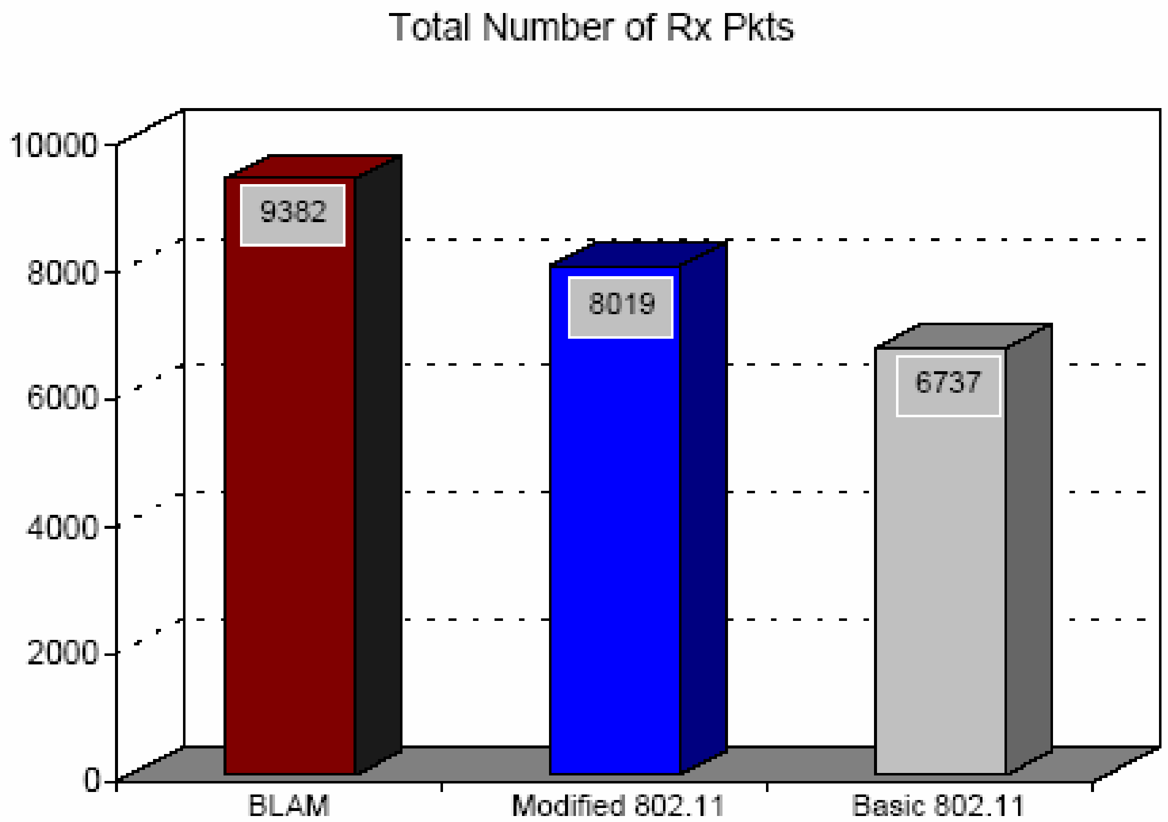


Simulation Results



Network Lifetime (in seconds)

Simulation Results



Total Number of Received Packets

Conclusions and Discussions

- All modifications are localized, that is, the modifications are based on the local host information and are only implemented within the wireless node itself.
- BLAM does not require any communication with a centralized controlling host and does not need any global information from neighbor nodes.

Conclusions and Discussions

- BLAM is designed to extend the useful lifetime of a wireless ad hoc network.
- BLAM modifies the waiting time before fresh data transmission and the deferring time after a collision in order to assign a priority to each node based on its residual energy
- When compared to the IEEE 802.11 DCF, BLAM successfully decreased the total number of collisions by almost 34% and was able to extend the lifetime of the network by 15% and the throughput by about 35%.