Energy Consumption in Ad-Hoc Routing Protocols: Comparing DSR, AODV, and Tora

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Motivation

- Mobile Devices constrained by many things, one of them being battery
- Sending and receiving messages is one of the more power-expensive operations
  - Data packets
  - Control packets of routing protocol
- Wireless Interfaces also consumer substantial amount of power while idle, but putting them into the low-power "sleep" mode has to be done carefully
- Goal: study power consumption of popular MANET routing protocols
  - to understand their energy behaviour, and
  - to draw lessons for the design of more efficient routing protocols

Energy Metrics

- What is an "energy-efficient" routing protocol?
- Possible Metrics:
  - Minimize energy consumed/packet,
  - Maximize time to network partition,
  - Minimize variance in node energy levels,
  - Minimize cost/packet, and
  - Minimize maximum node cost.
- We used: average overall amount of consumed energy
- Note: if minimizing energy consumption was only goal, a trivial optimal solution exists: drop all packets ☺
- Therefore, need to also consider packet delivery ratio

Energy Model

- Assumption: only wireless interface consumes energy (i.e., internal processing of messages etc. is “free”)
- NS2 has (simplistic) energy model: “The energy model in a node has a initial value which is the level of energy the node has at the beginning of the simulation. This is known as initialEnergy. It also has a given energy usage for every packet it transmits and receives. These are called txPower and rxPower”
- Default IDLE energy consumption is zero, send/receive costs independent of packet size, unicast/broadcast, etc.

Energy Model

- Re-implement energy model to correspond to published measurements of actual IEEE 802.11 interface:
  - Consumed energy per packet = m * (packet size) + b
  - m and b are empirical constants that are based on whether the packet is being sent, received, promiscuously handled or discarded. They also depend on the operation type (unicast vs. broadcast).
- Idle power: 0.8 Watts

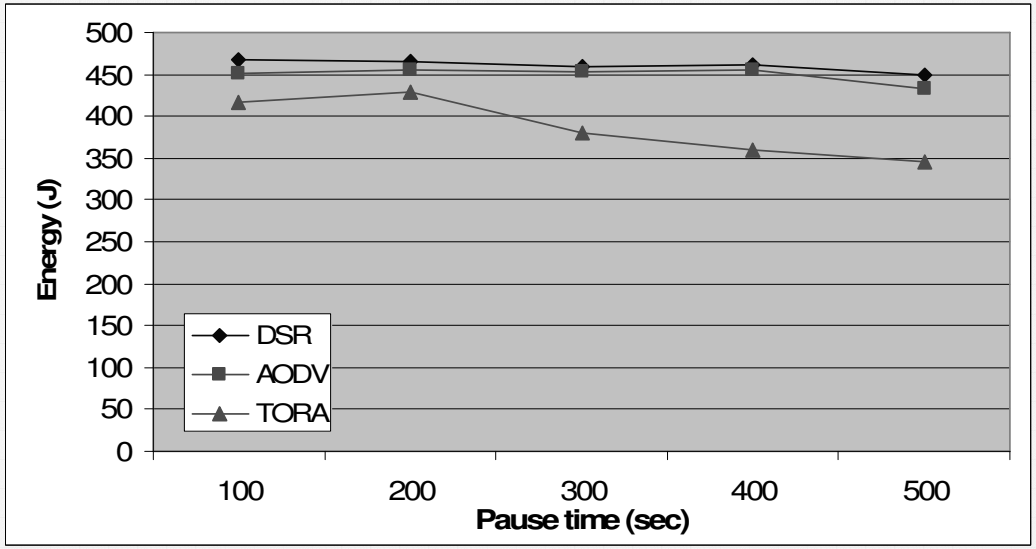
	M (µJoule/byte)	B (µJoule)
Send	1.9	420
Receive	0.42	330
SendBroadcast	1.9	250
Receive Broadcast	0.50	56
Receive Promiscuous	0.388	136
Discard	-0.49	97.2

Routing Protocols and Simulation Environment

- Routing Protocols:
  - AODV: on-demand protocol with traditional routing tables
  - DSR: source routing, route caches, nodes (optionally) listen promiscuously to learn information to update cache
  - TORA: link reversal algorithm, maintains enough info so that link failure not necessarily results in new route discovery, more complex control messages
- Simulation Environment: “the usual”
  - NS2, 50 nodes, 1500 x 300 m, initial power: 1000 Joules
  - CBR sources, 5 packets/s, 512 byte packets, 12 senders
  - Random waypoint model, 20 m/s max speed, variable pause time
  - 600 seconds simulation length, 4 different movement patterns per scenario

Analytical and Simulation Results

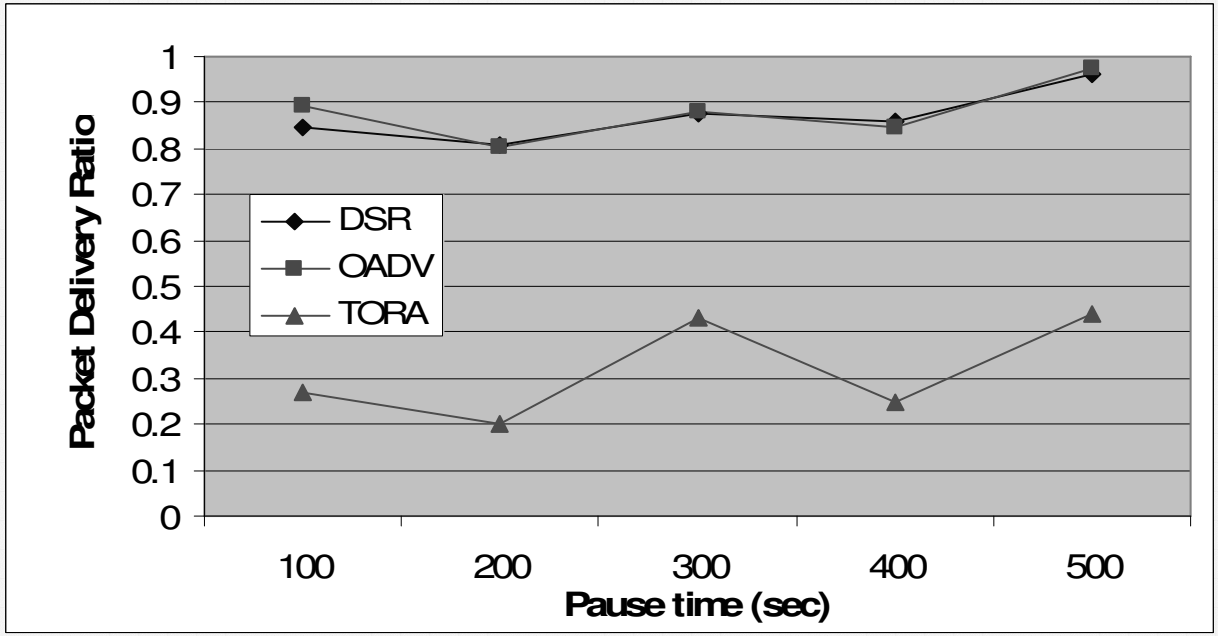
- Functional Comparison Results
  - protocol analysis: predict that AODV and DSR should perform similarly, with TORA being worse
- Simulation Results: not quite that (at first sight)



Average Nodal Energy Consumption for DSR, AODV and TORA

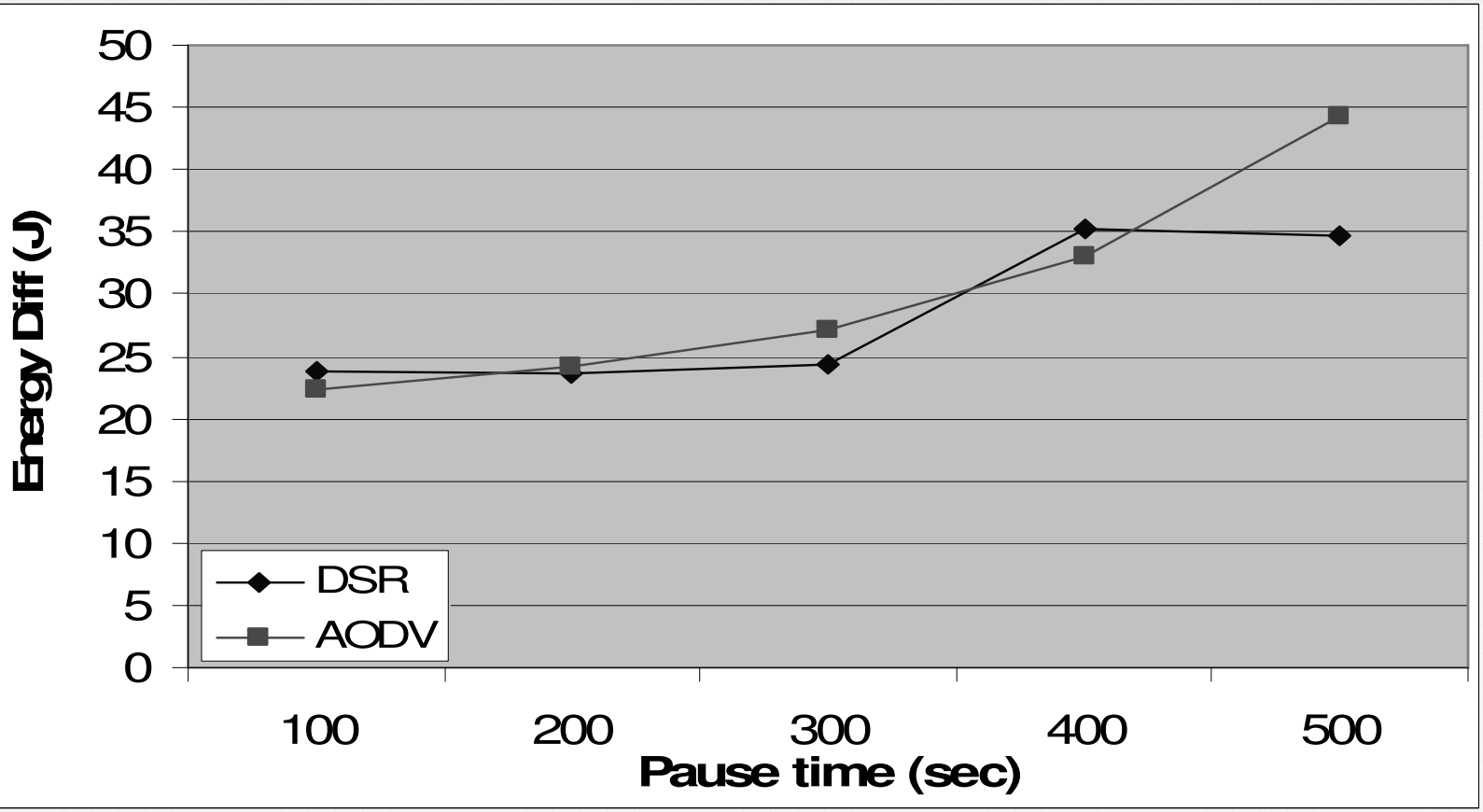
Simulation Results (cont)

- Problem: TORA delivers far fewer packets (i.e., saves energy by not delivering them often enough at the destination!), based on the simulation conditions that we used



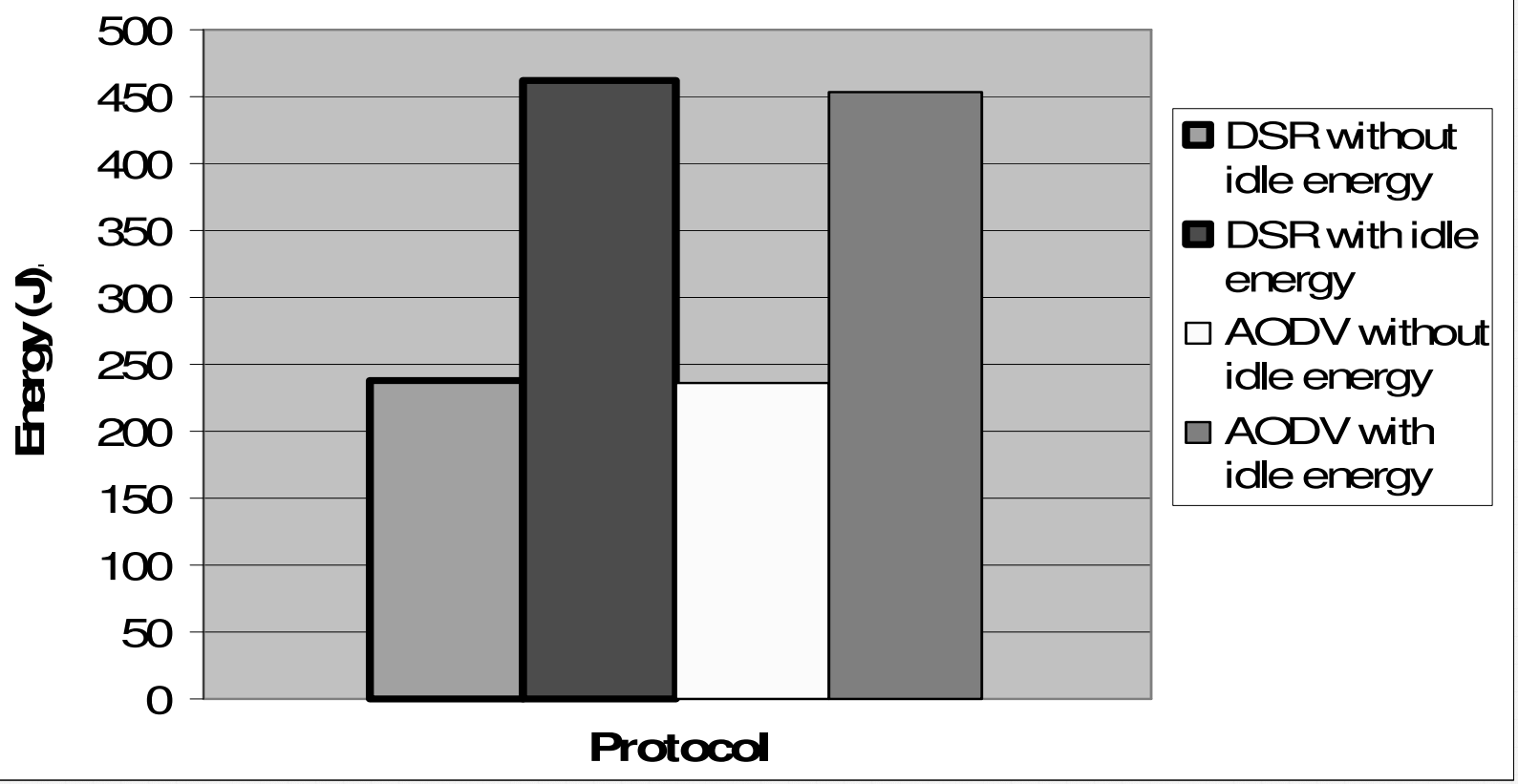
Data Packet Delivery Ratio for DSR, AODV and TORA

Simulation Results: Energy Balance



Difference between Maximum and Minum Nodal Energy Consumption in DSR and AODV

Simulation Results:
Idle Energy Consumption Matters



Energy Consumption with and without Idle Energy in DSR and AODV (Pause Time of 400 sec)

Conclusions and Future Work

- Conclusions:
  - AODV consumes slightly less energy than DSR at comparable packet delivery ratio
  - DSR seems to have slightly more balanced energy consumption between nodes (based on the difference (max - min) of nodal energy consumption)
  - Idle energy is about half of total energy consumed
- Future Work:
  - Design protocol that is energy-efficient and fair (i.e., balanced) – work under way
  - Compare to other published energy efficient routing protocols such as SPAN, etc.