Accurate and Energy-efficient Congestion Level Measurement in Ad Hoc Networks

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Outline

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Introduction

- Congestion in ad hoc networks
  - Degrades throughput
  - Wastes the scarce energy
- Efficient congestion control
  - Accurate estimation
  - Timely estimation

Introduction

- Congestion level measurement is more difficult in ad hoc networks
- Congestion in ad hoc networks have a serious impact on energy efficiency
  - Take remedial actions as soon as congestion rise before the problem deteriorates

Problem Definition and Motivation

- The congestion measurement in ad hoc networks is harder than in wired or other wireless networks
  - Collision
  - Contention
  - Interference

Problem Definition and Motivation

- Three problems in congestion measurement
  - The reduced queue length due to the dropped packets by collisions does not mean that the node has more bandwidth or congestion is alleviated
  - Contention among neighboring nodes makes a node's outgoing channel capacity time-variant
  - A node's outgoing channel capacity is affected by neighboring nodes' interference

Problem Definition and Motivation

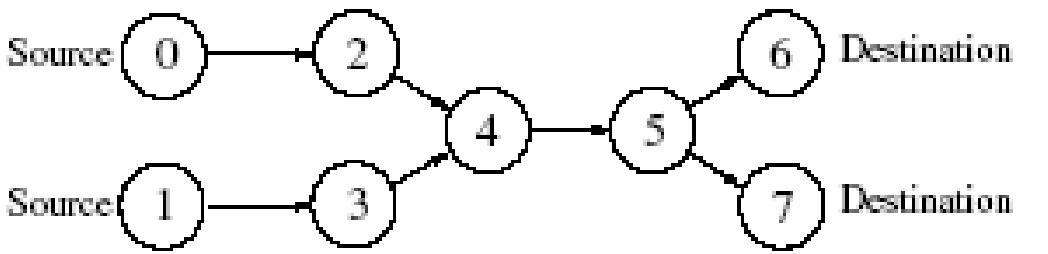
- Two-level congestion measurement
  - Node-level
  - Flow-level
- Energy-efficient
  - Lazy measurement technique

Node-Level Congestion Measurement

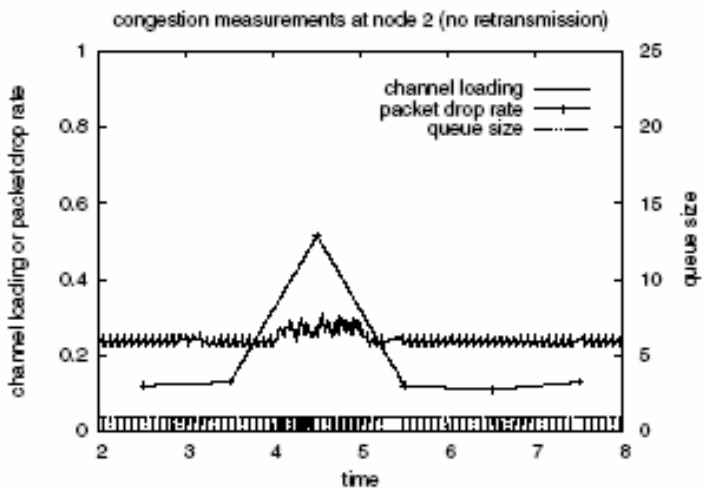
- Unsuccessful transmission lead to a high queue buildup, a high packet drop rate, or a high channel loading
- A combination of three metrics
  - Channel loading
  - Packet drop rate
  - Buffer utilization

Node-Level Congestion Measurement

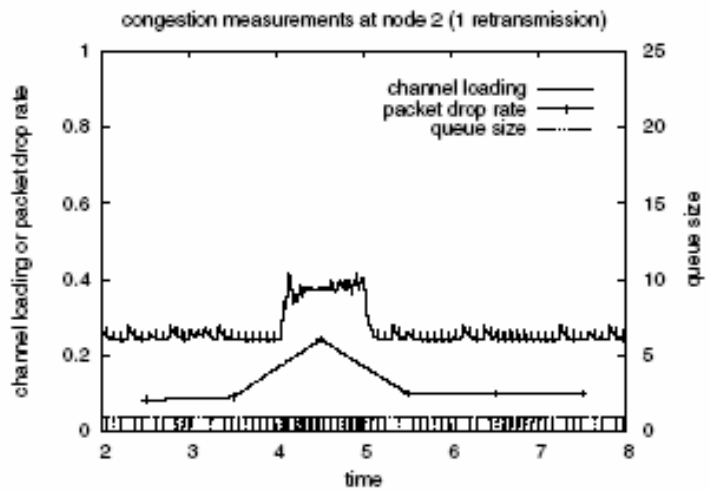
- The impact of various characteristics on the relevance of different congestion level measurement metrics



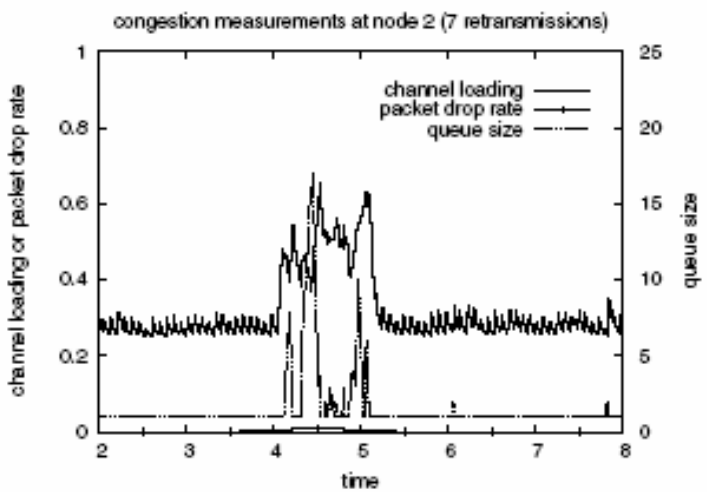
Node-Level Congestion Measurement



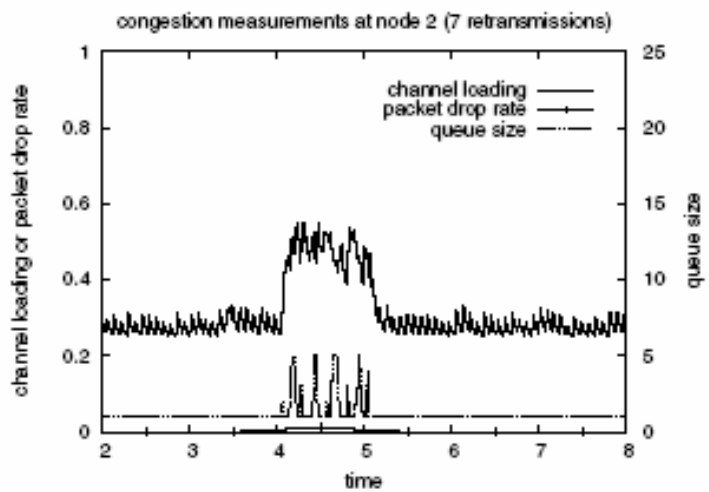
(a) no retransmission (buffer capacity 25)



(b) 1 retransmission (buffer capacity 25)



(c) 7 retransmissions (buffer capacity 25)

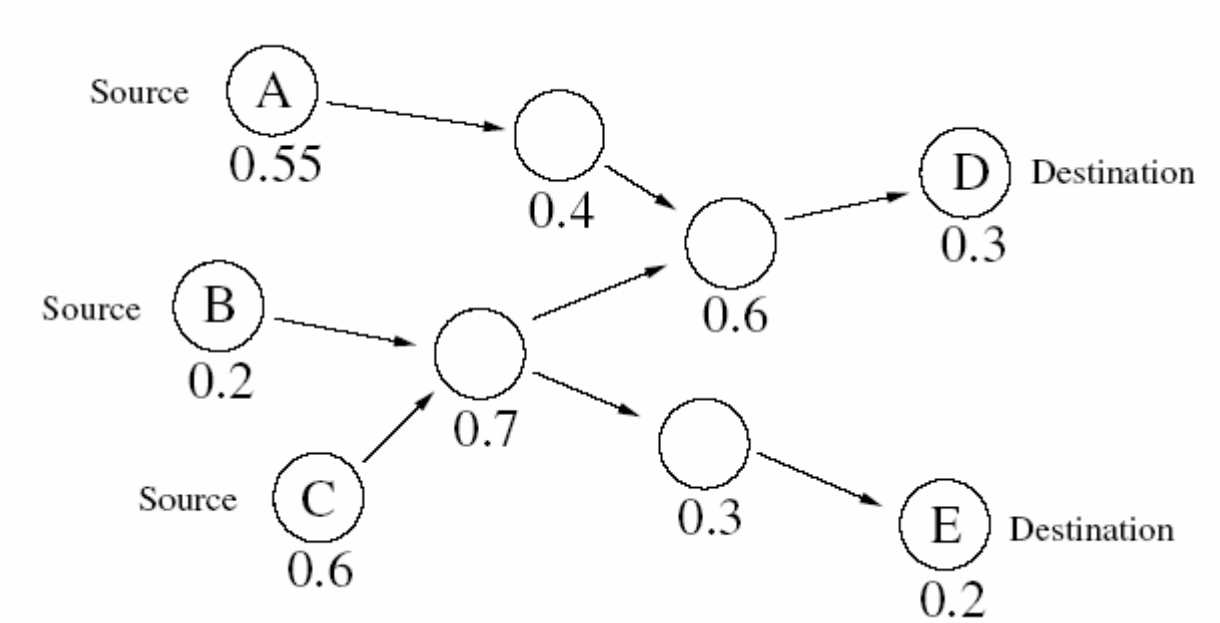


(d) 7 retransmissions (buffer capacity 5)

Flow-Level Congestion Measurement

- The traffic from the originating node is bottlenecked by the most congested node among the nodes along the flow's routing path towards the destination node
- Tradeoff between energy consumption and accurate congestion detection
  - Threshold
  - Compares with its current congestion measurement

Flow-Level Congestion Measurement



Energy-Efficient Congestion Level Measurement

- In ad hoc networks, we cannot afford to measure all three metrics continuously
  - Cause a considerable energy consumption
  - Reduce the network lifetime

Energy-Efficient Congestion Level Measurement

- Buffer Occupancy Measurement
  - Only perform the measuring action when a packet is inserted to or dropped from the buffer
  - Adapts its frequency according to the incoming traffic volume
  - Avoid unnecessary measurements

Energy-Efficient Congestion Level Measurement

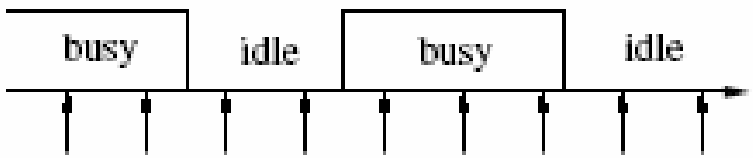
- Packet Drop Rate Measurement
  - Define a fixed period called epoch
  - Maintain the statistics on the number of packet arrivals and packet drops during each epoch
  - Calculate the packet drop rate when a packet is newly enqueued or dropped either by queue overflow or by collisions in each epoch

Energy-Efficient Congestion Level Measurement

- Channel Loading Measurement
  - Fixed-rate Channel Loading measurement
  - Lazy Measurement

Energy-Efficient Congestion Level Measurement

- Fixed-rate Channel Loading measurement

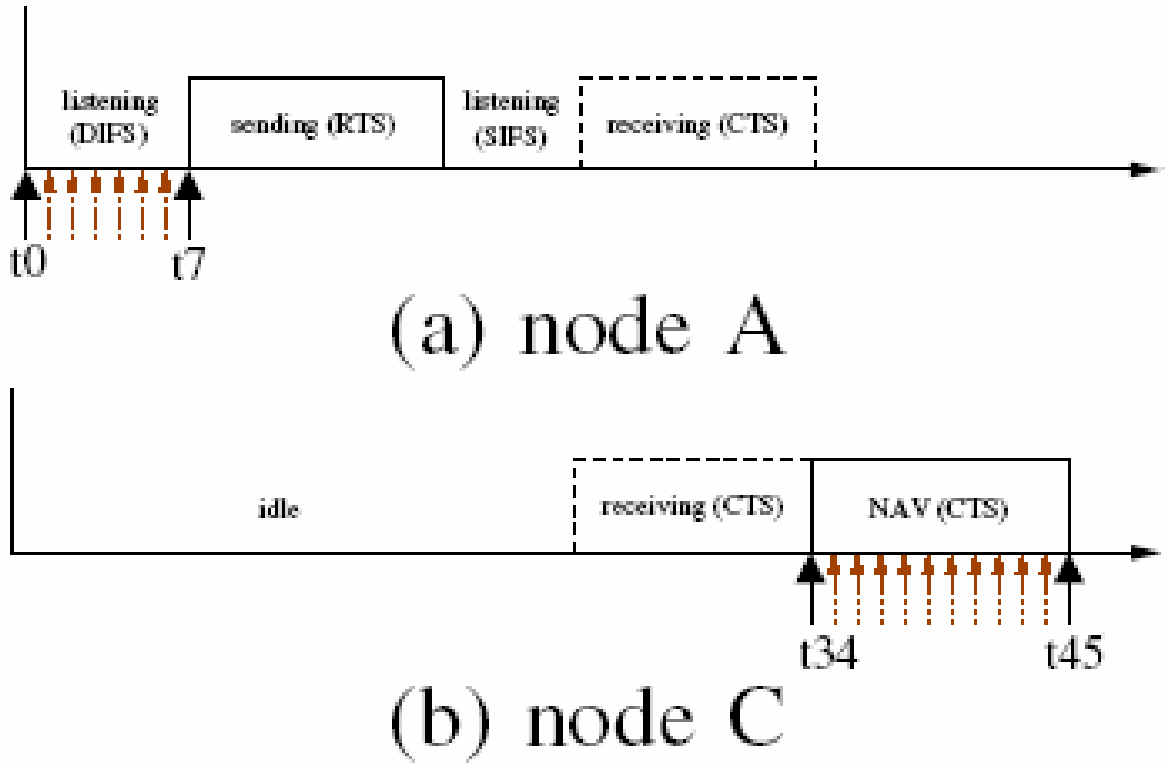


Channel loading measurement using fixed-rate sampling

Energy-Efficient Congestion Level Measurement

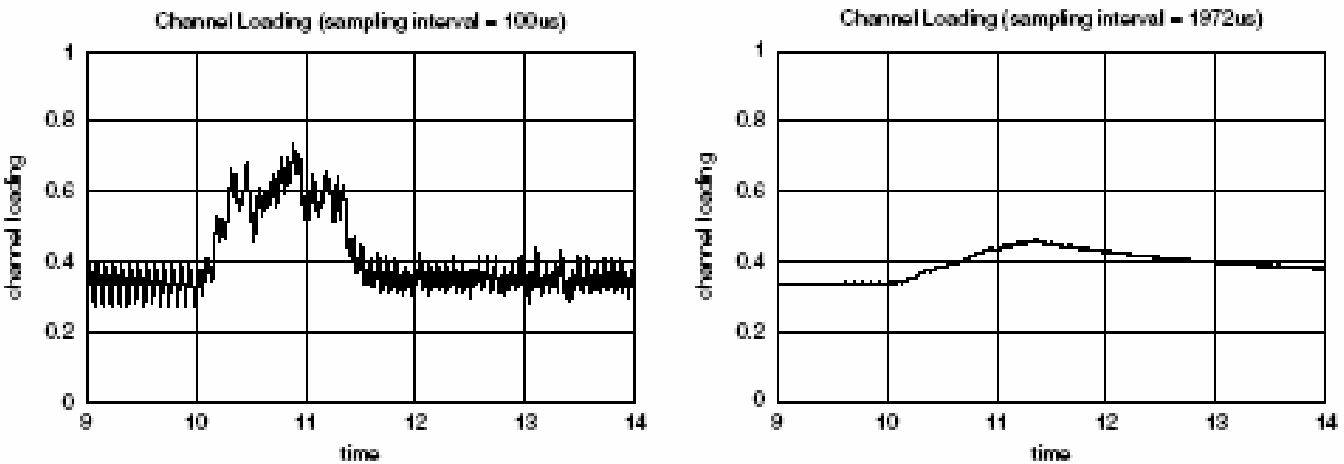
- Lazy Measurement
  - Do not make any measurements during the doze state
  - Sample the channel activity at the end of an idle or a busy period

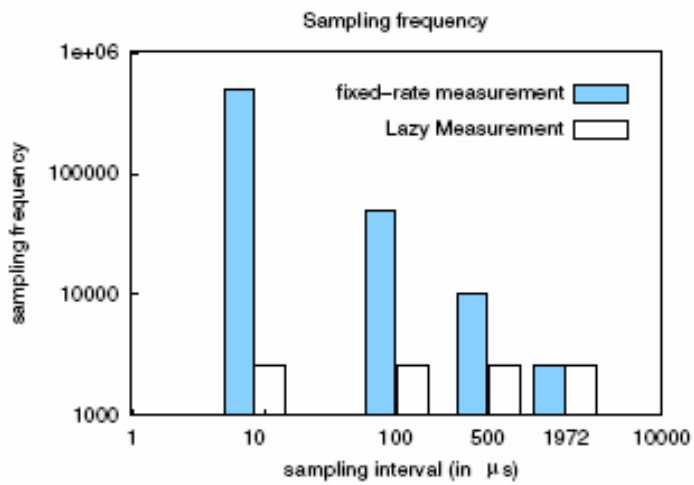
Lazy Measurement



Lazy channel loading measurement in an event-driven fashion

Performance of Lazy Channel Loading Measurement





Sampling frequency with respect to various sampling intervals

Conclusion

- This paper propose a two-level congestion detection scheme that provides an accurate congestion measurements in ad hoc networks
- Lazy channel loading measurement saves a lot of energy needed to accurately measure the channel loading

Reference

- [1] C. Wan, S. Eisenman, A. Campbell, CODA: Congestion Detection and Avoidance in Sensor Networks, ACM SenSys, 2003.
- [2] Y. Sankarasubramaniam, O. Akan, I. Akyildiz,ESRT: Event-to-Sink Reliable Transport in Wireless Sensor Networks," ACM MobiHoc,2003.
- [3] Jaewon Kang, Yanyong Zhang, Badri Nath, Accurate and Energy-efficient Congestion Level Measurement in Ad Hoc Networks, WCNC 2005