Performance Evaluation of Route Failure Detection in Mobile Ad Hoc Networks

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www.ifn.et.tu-dresden.de/TK/

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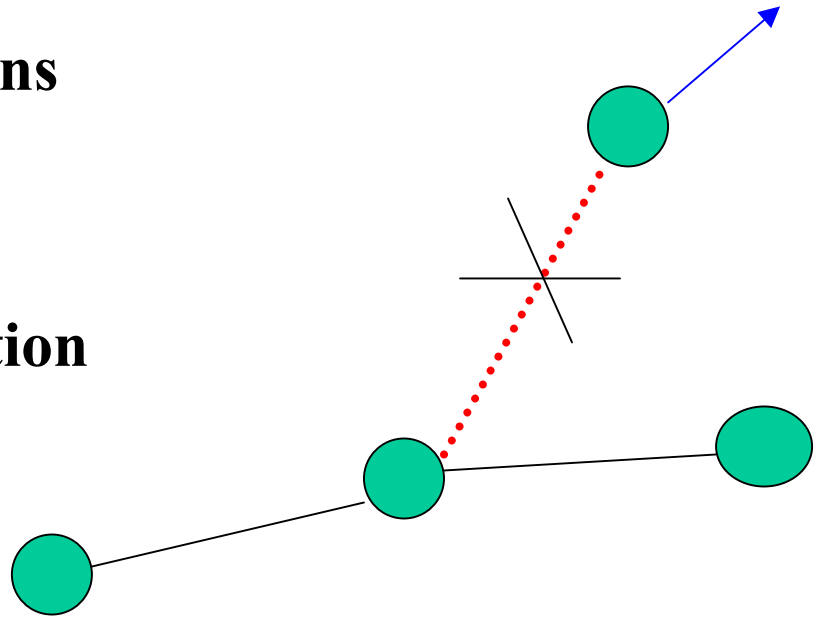
Properties of Ad hoc Network

- **Lack of a centralized entity**
- **Rapid mobile host movements**
- **Communication over the wireless medium**
- **Limited wireless bandwidth**
- **Limited battery power**
- **Multi-hop routing**

Reasons of Route Failures

- **Node mobility**
- **Environment conditions**
- **Node failure**
  - **battery usage**
- **Hard medium contention**

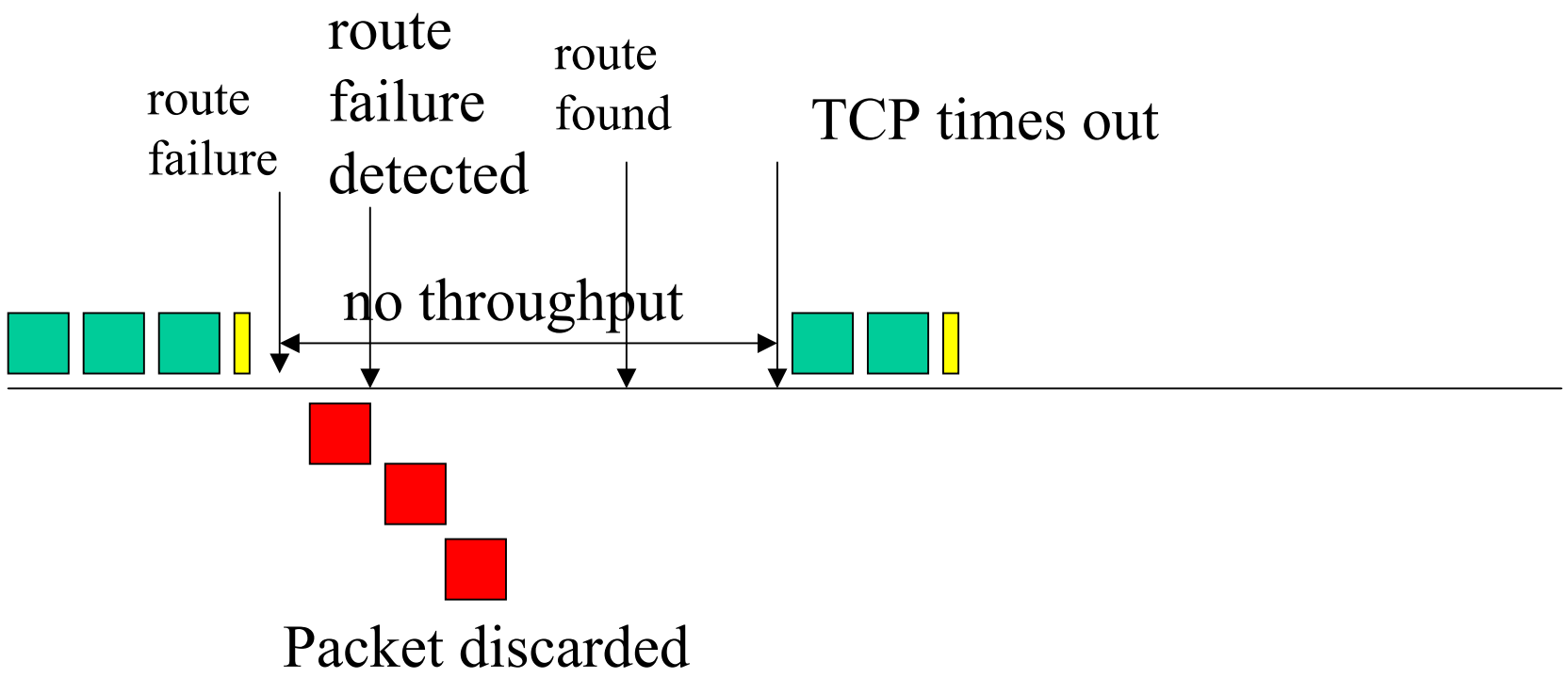


Route Maintenance

- **Link breakage -> Route maintenance**
- **Link breakage detected by:**

  link-layer ACK, AODV "Hello" messages
- **attempt "local repair" - RREQ for destination from intermediate node**
- **Route Error (RERR) message**
  - **Contains list of unreachable destinations**
  - **Sent to "precursors": neighbors who recently sent packet over broken link**
  - **Propagated recursively**

Impact Route Failures on TCP



Optimisation Goals

- **Correct route failure detection**
  - **avoiding “false” decisions**
- **Quick route failure detection**
- **Route failure detection with minimum overhead (energy, bandwidth)**

Link Breakage Detection

- **Link level ACKs**
- **“Hello” messages (beacons)**
- **“passive ACKs”**

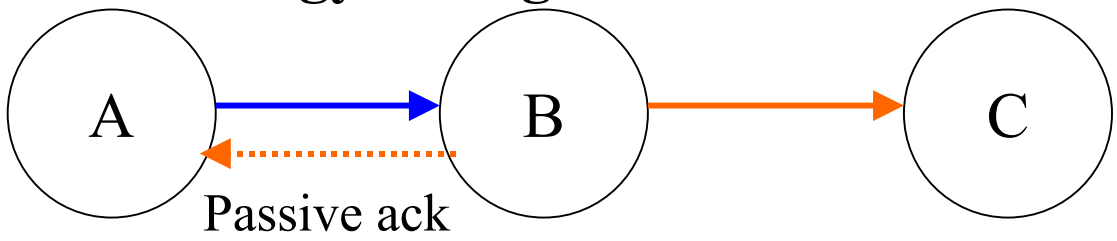
  - used in DSR
- **End-to-end ACKs**
  - **involvement of transport layer**

Hello Messages

- **Each node must periodically send broadcast packets**
- **Each receiving node must also process them**
- **Hello messages cause a large amount of control overhead**
- **Current implementations use periodic hello messages to detect local link connectivity**

Passive ACKs

- **Listen for data to be forwarded**
- **Passive ack:**
  - **a node relays the packet to its neighbours via radio transmission**
  - **previous node hears this transmission and uses it as an ack**
- **All nodes are overhearing (promiscuous)**
- **No energy saving**

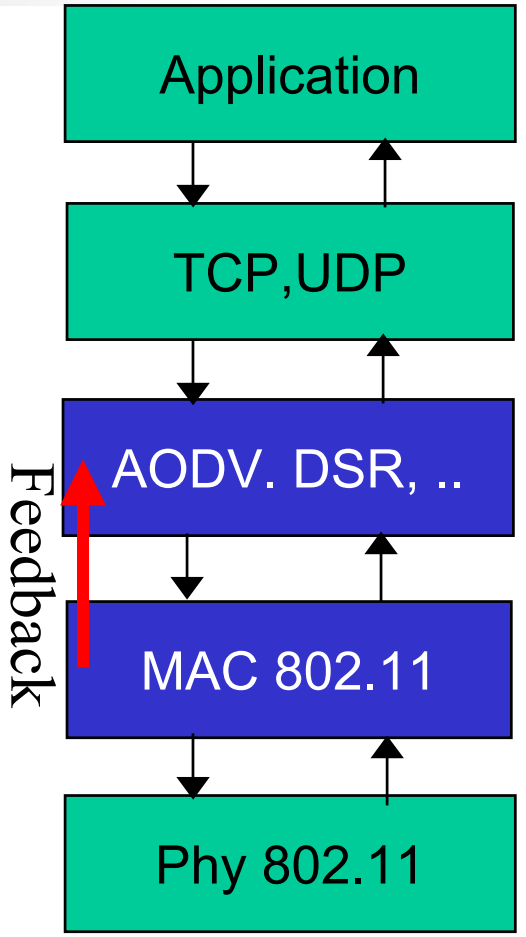


Link Layer Detection

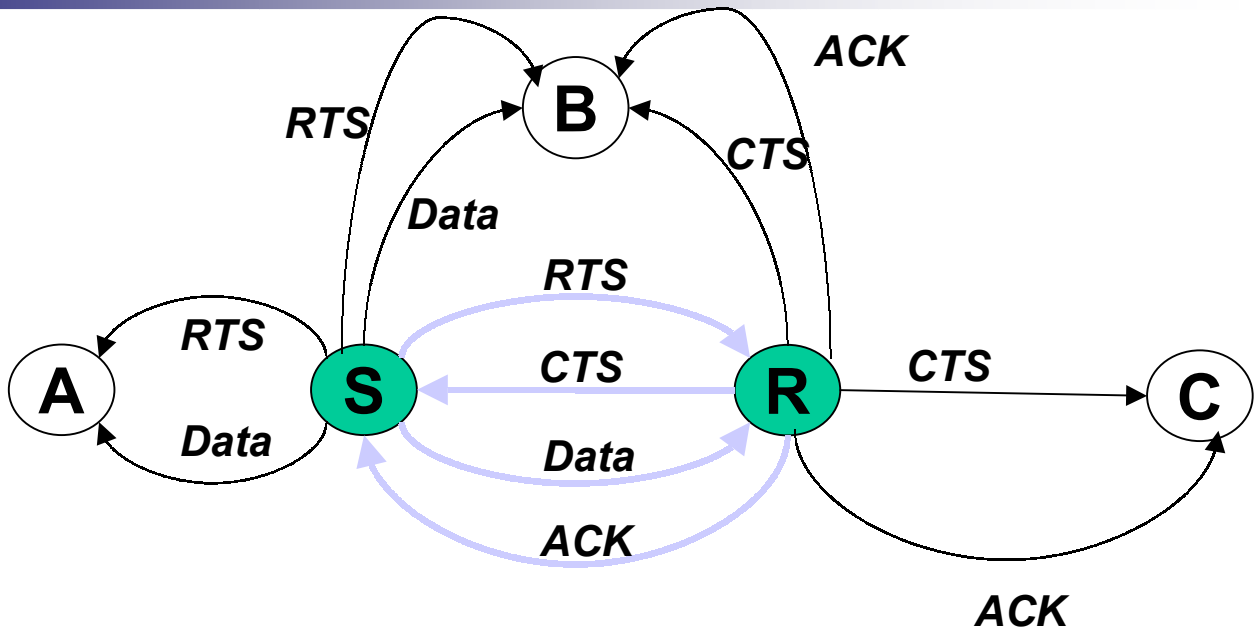
- **Unicast packet is successfully transmitted**
  - **Route failure**
- **Based on IEEE 802.11 MAC**

Problem:

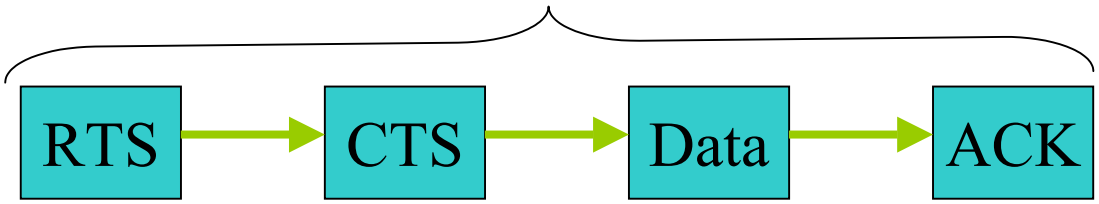
Access link layer feedback information in off the shelf hardware



802.11 DCF Operation

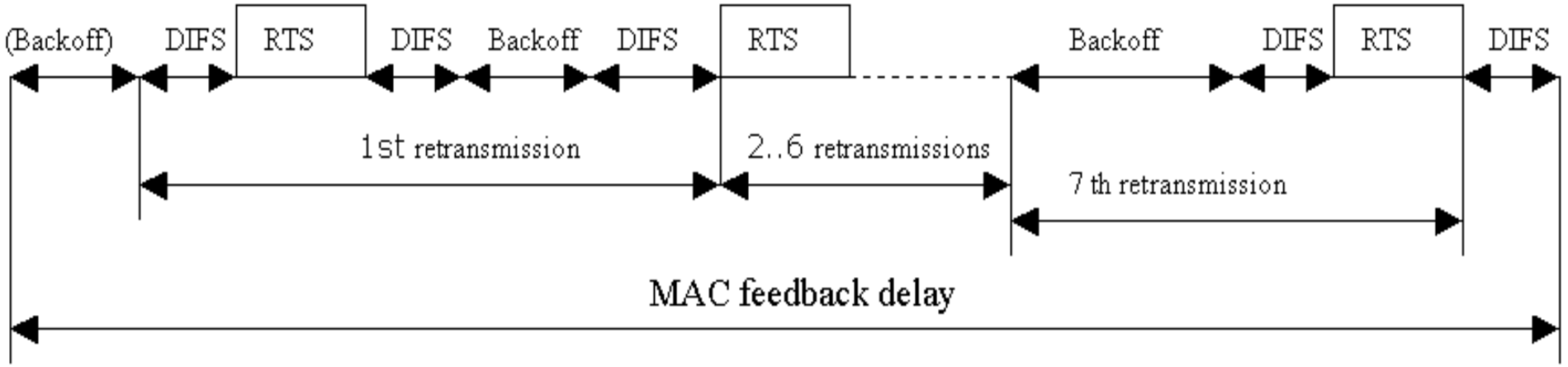


Atomic unit



IEEE 802.11 MAC Feedback

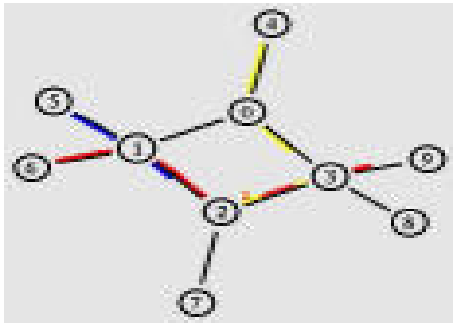
- **After 7 failed RTS retransmissions -> packet loss -> link is failed -> route is failed -> initiating route request**
- **No additional overhead**
- **Unpredicted detection delay**
- **Incorrect detection due to channel contention**



Simulation Parameters

Simulation Parameters (ns-2)

- 50 nodes
- 5, 10, 15, 20, 25, 30, 35 cbr connections (for each 5 runs)
- Static network, mobile network - max speed 20 m/s
- Packet size 512 bytes
- Simulation time 900s (200s war-up)
- Confidence interval 95%



Performance metrics

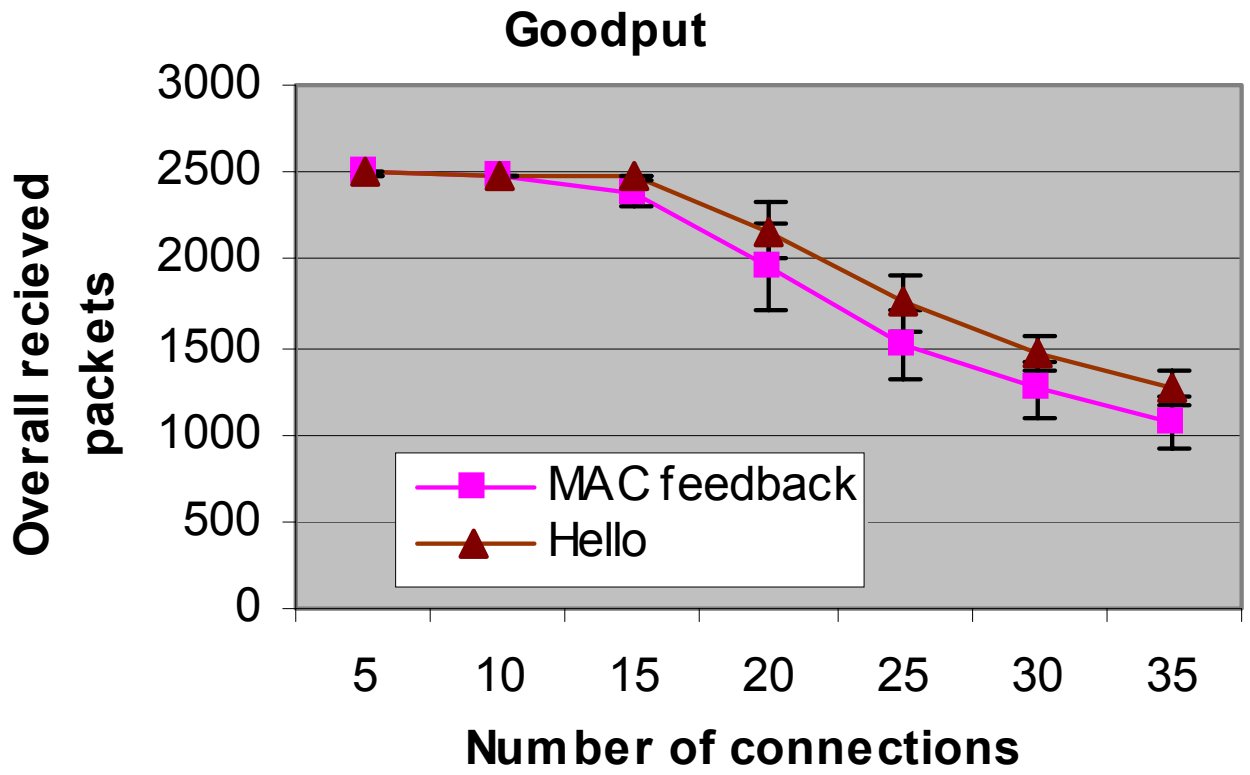
Goodput - number of unique correctly received packets

Energy efficiency - total consumed energy of all nodes to total number of successfully received packets

Energy Model

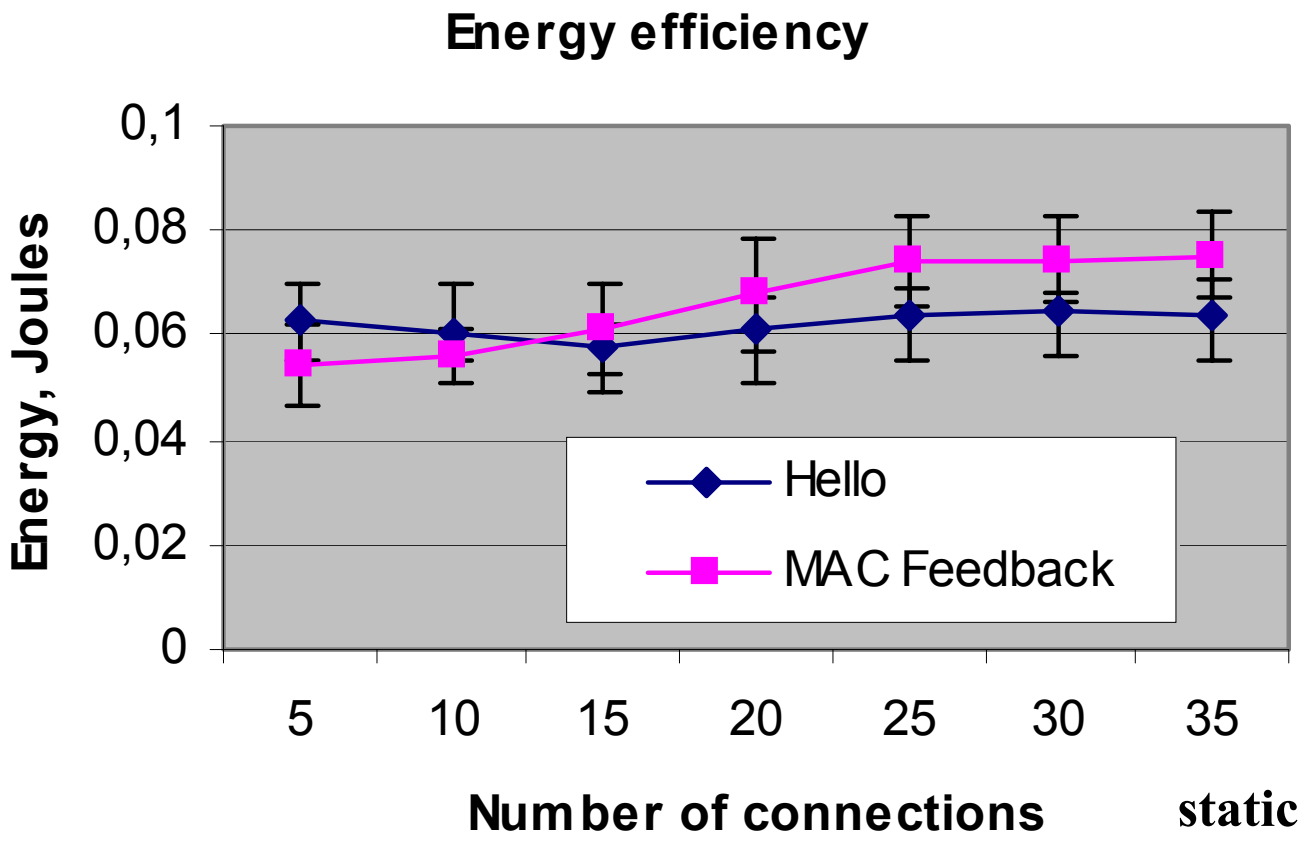
- **Simplified model**
- **Decrease the energy level of the node for every packet transmitted and every packet received**
- **rxPower - receiving power 0.1 Watts**
- **txPower - transmitting power 0.3 Watts**
- **Initial energy 1000 Joules**

Simulations Results

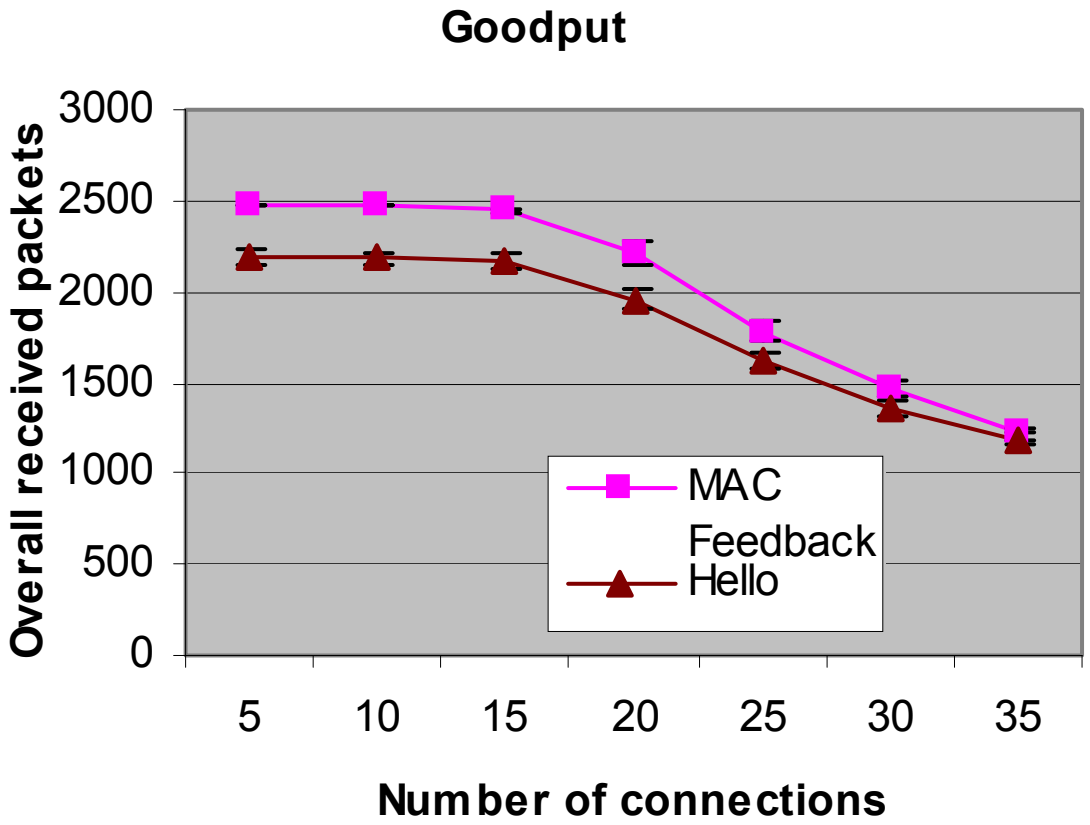


static network

Simulations Results

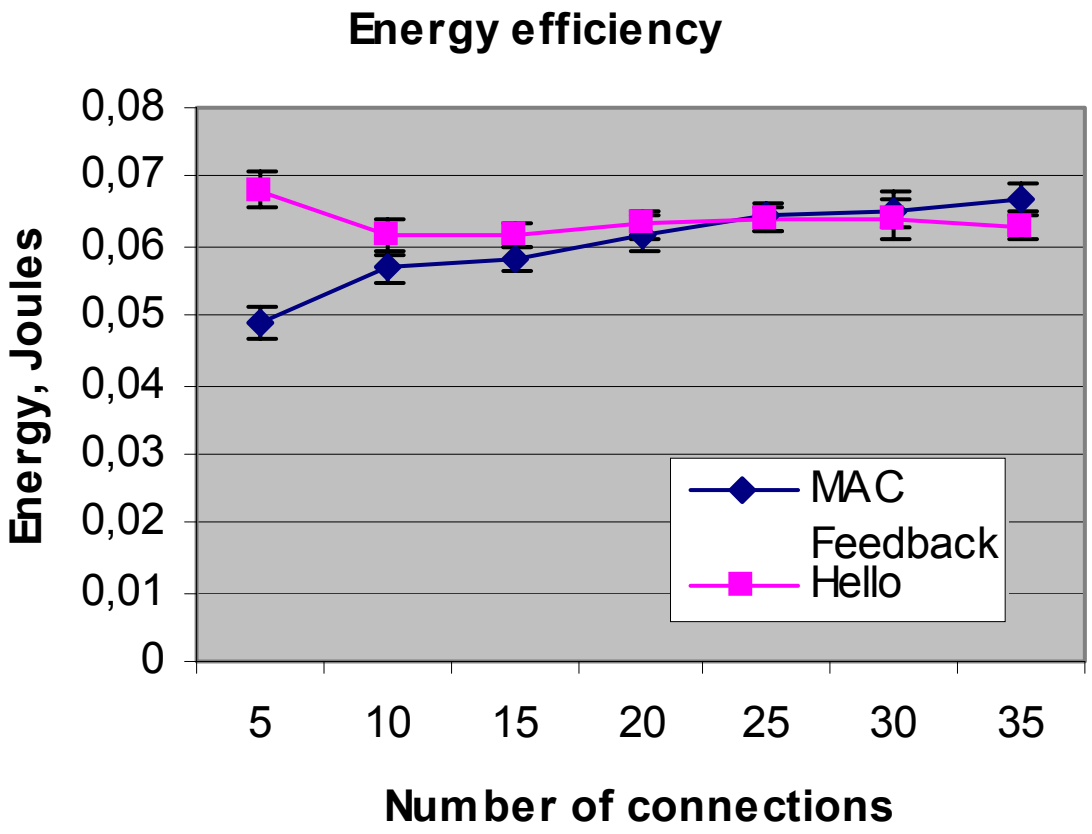


Simulations Results



mobile network

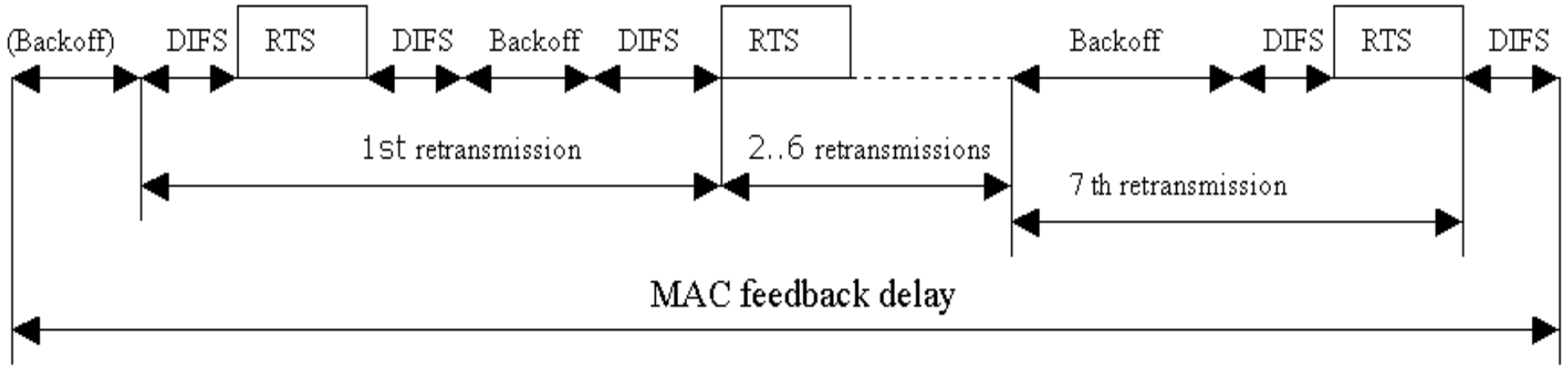
Simulations Results



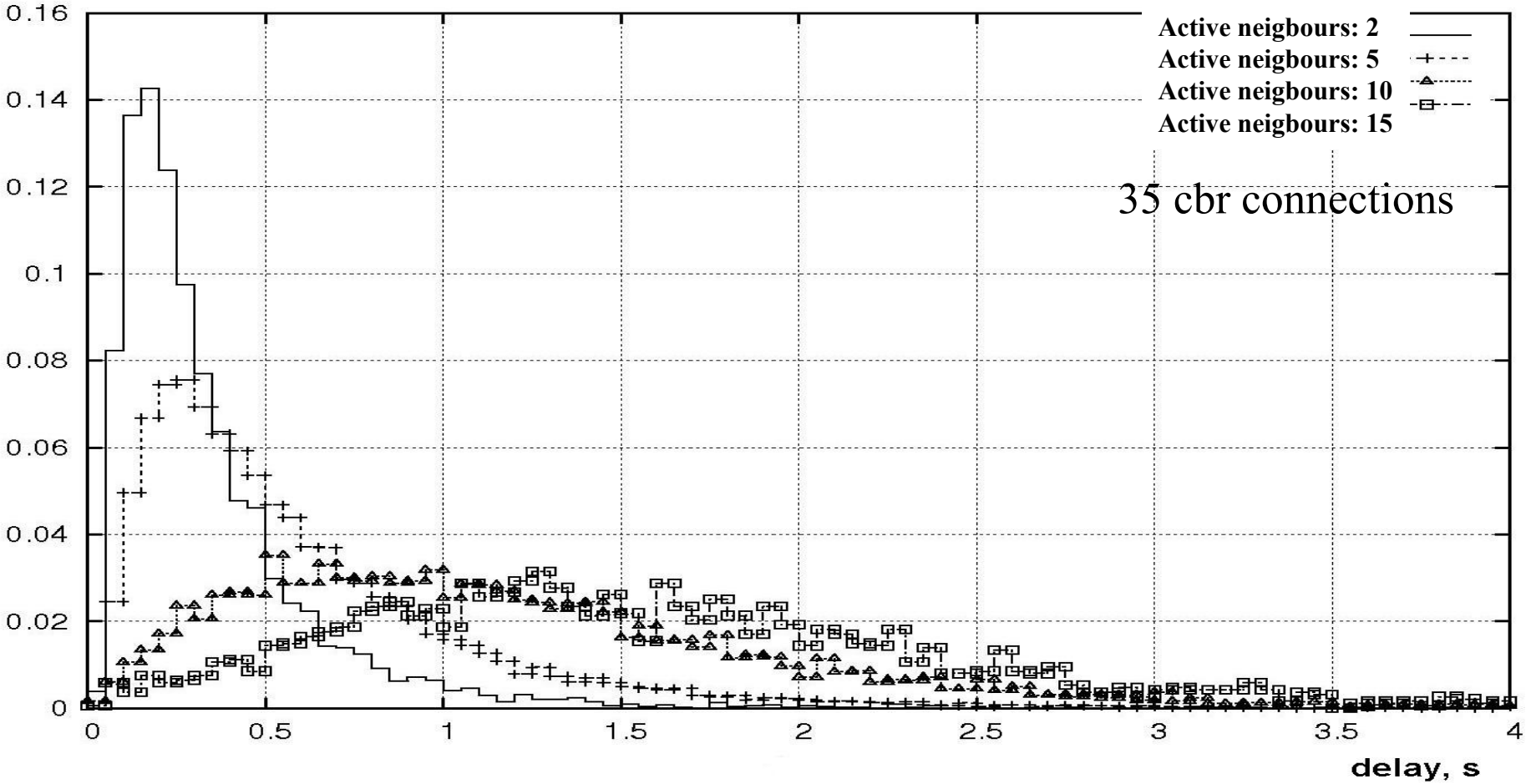
mobile netwok

MAC Feedback: Detection delay

- **After 7 failed RTS retransmissions -> packet loss -> link is failed -> route is failed -> initiating route request**
- **Unpredicted detection delay**

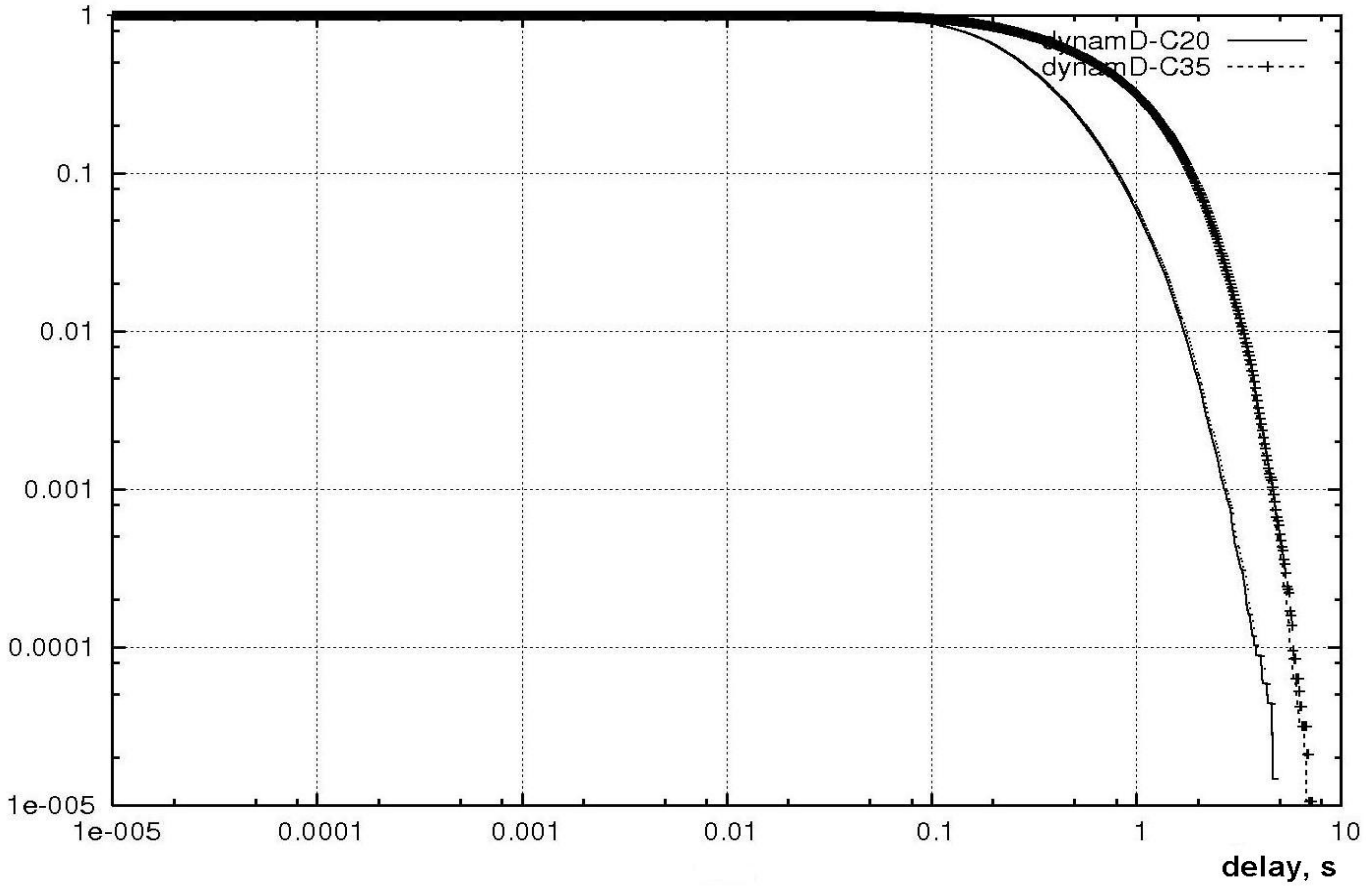


MAC Feedback: Detection Delay



MAC: Detection Delay

Complementary Cumulative Distribution Function



Conclusions - I

Goals

Correct quick route failure detection with minimum overhead (energy, bandwidth)

Route failure detection mechanisms

- **Link level ACKs**
- **"Hello" messages**
- **"passive ACKs" (used in DSR)**
- **end-to-end acks**

Conclusions - II

- **High traffic condition**
  - **detection time of MAC Feedback increases**
  - **number of MAC Feedback „false“ decisions increases**
- **Recommendations from energy efficiency aspect**
  - **for low or moderate traffic – MAC Feedback**
  - **for high traffic – Hello messages**
- **Recommendations from goodput aspect**
  - **static network – Hello messages**
  - **mobile network – MAC Feedback**

Thank you!