TCP in MANETs

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MANETs

- MAC Layer for MANET—Well studied
- Routing in MANET—Well studied
- End to end reliable communication in MANETs?

TCP in MANETs

- Desirable to use TCP
  - Can run most applications without modifications in MANETs
    - Example: ftp, http, etc.
  - TCP is well studied and well understood
- Question:
  - What happens if I run TCP in MANETs?

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TCP Performance in MANETs

- If no mobility, no problem for TCP
- If mobiles move:
  - Frequent route disruptions
  - Packets cannot get through to destination
  - Sender times out; thinks congestion
- TCP cannot distinguish between congestion and route or link failure (mobility)

Existing Approaches in Wireless Networks

- I-TCP [cellular networks]-Badrinath et al.
  - Split end to end connection into two connections; one between correspondent host and Base station and another between base station and MH
- MTCP similar to I-TCP
- Snoop protocol
  - Base station examines IP payload. See duplicate ack? Local retransmission of missed packet [missed packet is cached at base station]
- Technique of Cacres and Iftode
  - After handover, MH does triple ack and enables TCP's triple ack
- SMART
  - Send cumulative ack and sequence number packet that resulted in sending of this ack
  - Sender guesses holes and retransmits missing packets

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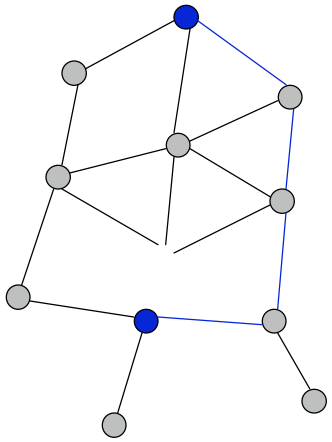
TCP for MANETs

- No base stations
- Nodes may be small (limited resources), mobile, connect using wireless links
- Multi-hop wireless network
- Network topology changes constantly due to mobility



Assumptions

- N mobiles with some MAC protocol and routing protocol
- All links are bidirectional
- Link layer ack to determine if packet made to the next hop mobile (router)
- If a packet cannot be sent to next hop mobile, assume route disruptions
  - Next hop mobile is no longer in range
- All packets carry SRC and DEST addresses

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Critical Issue

- When mobility disrupts a route, routing protocol takes certain amount of time to find new route or repair old route
- During this time, all packet and acks are lost
- Timeouts, congestion control
  - Exponential backoff, shrink congestion window size, slow start recovery

After route reestablishment

- Resume packet transmission
  - During route failures, no need to send packets
    - Will not reach destination
    - Waste of BW
- Slow start recovery => low throughput

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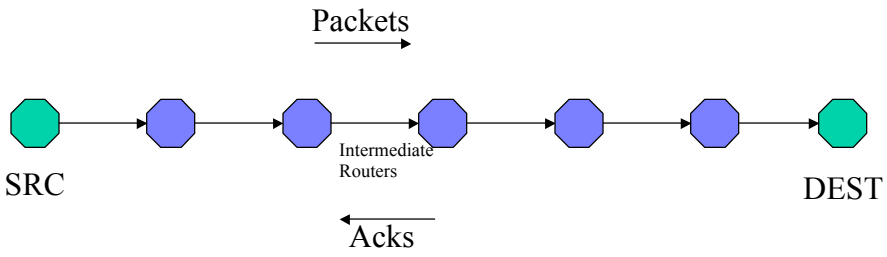
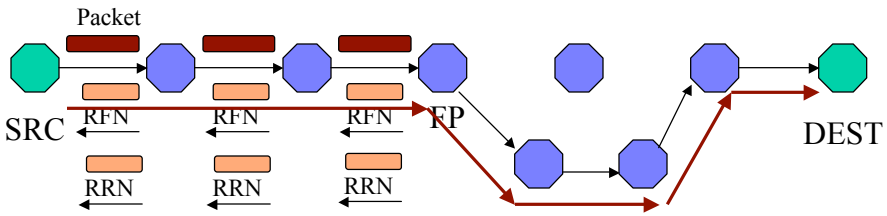
Congestion and Route Failure

- Detect the difference
- Treat them differently

Normal Packet Flow



Example



TCP-F (Feedback based)

- FP: Failure point
  - First router that detects that route has failed
    - (next hops is unreachable)
- On finding that FP cannot transmit packet to next hop:
  - Send Route Failure Notification (RFN) to source (packet has SRC and DEST addresses) on reverse route
  - FP and intermediate routers "remember this"
    - Invalidate route to Dest
    - If alternate route exits, use it (discard RFN)
    - Else forward RFN to source

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TCP-F at Source

- On receiving RFN, source goes into snooze mode:
  - Freeze all timers
  - No new transmissions to DEST
  - Freeze windows and other state variables of TCP
  - Start Route Failure Timer

Route Reestablishment

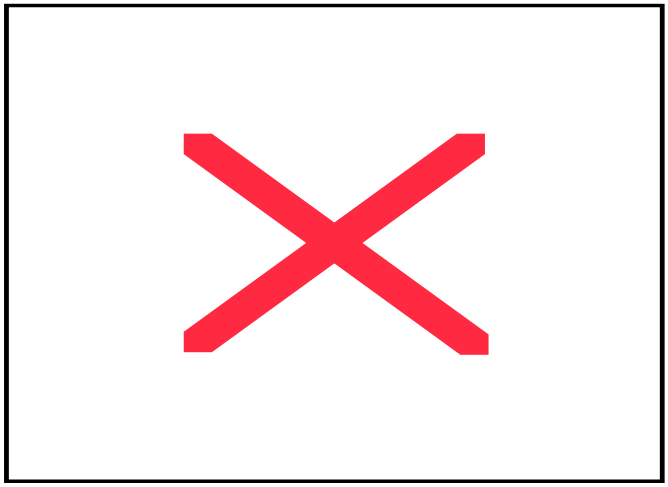
- An intermediate router knows of route to DEST. (It had sent an RFN to SRC.)
- Send Route Reestablishment Notification (RRN) to SRC. (SRC address cached at intermediate host.) Clears cache about SRC
- A node receiving RRN forwards to SRC; clears cache

RRN at SRC

- When source receives RRN, it emerges from snooze mode
- Resume timers and unfreeze windows…
- Start normal operation of TCP

- Why Route Reestablishment timer?

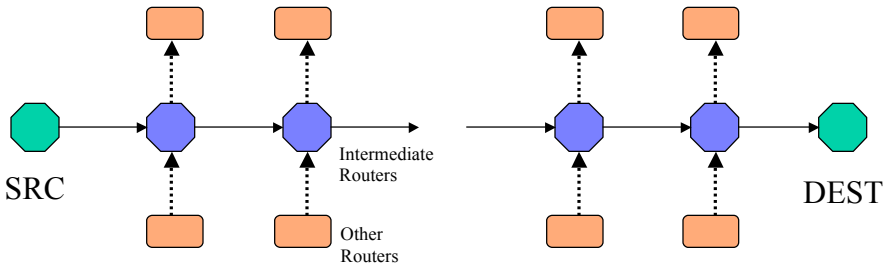
State Diagram (augmentation)



Simulation Parameters

- # of hops between SRC and DEST = 10
- Congestors add other packets for transmission
- Packet size: 200 Bytes
- Effective data rate: 12.8 Kbps
- Window size: 20 packets (4KBytes)
- Failure rate (number of failures during the run)
- Route Reestablishment delay
- Total duration: 100 seconds
- Discrete Event Simulation (written from scratch using TCP code from open source)

Simulated Path



Additional traffic
(simulate congestion)

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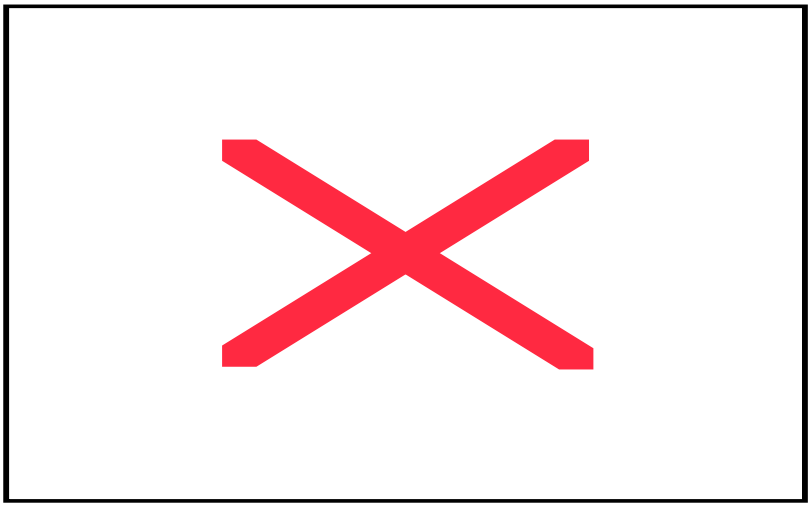
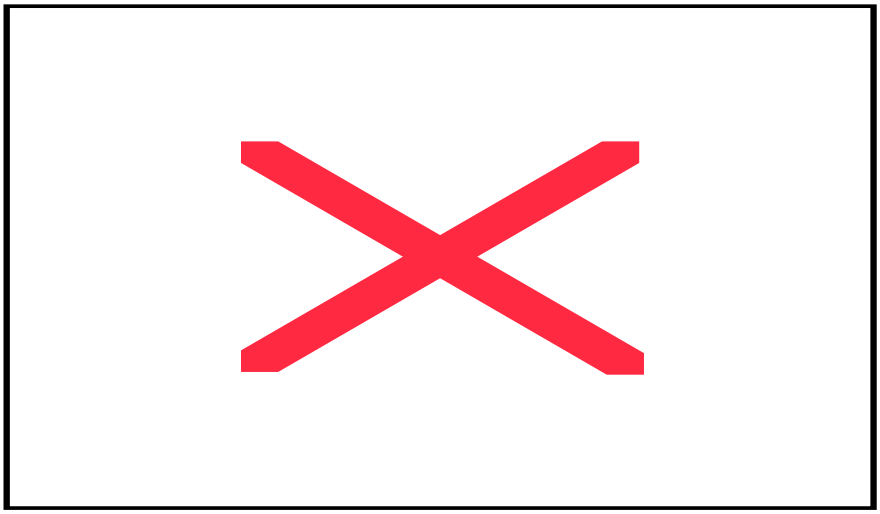
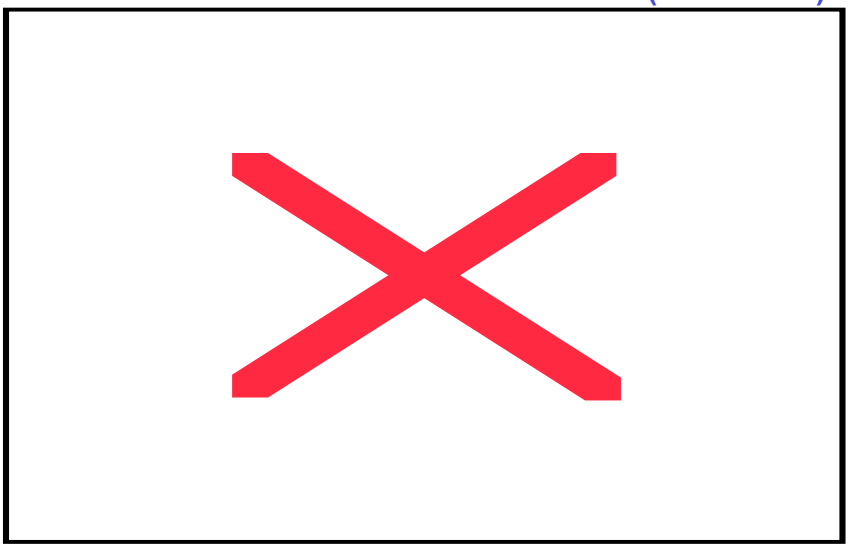
Throughput Comparison (4 failures)



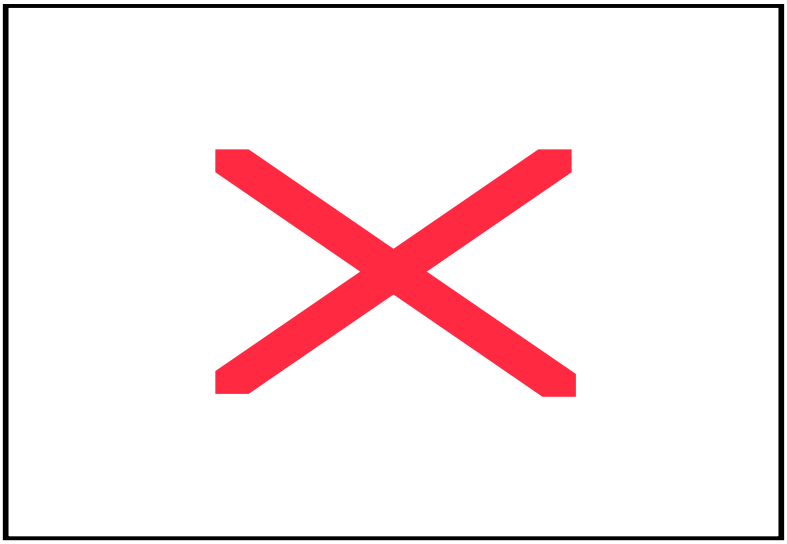
Throughput Comparison (7 failures)



Throughput Comparison (10 failures)



Timeout values



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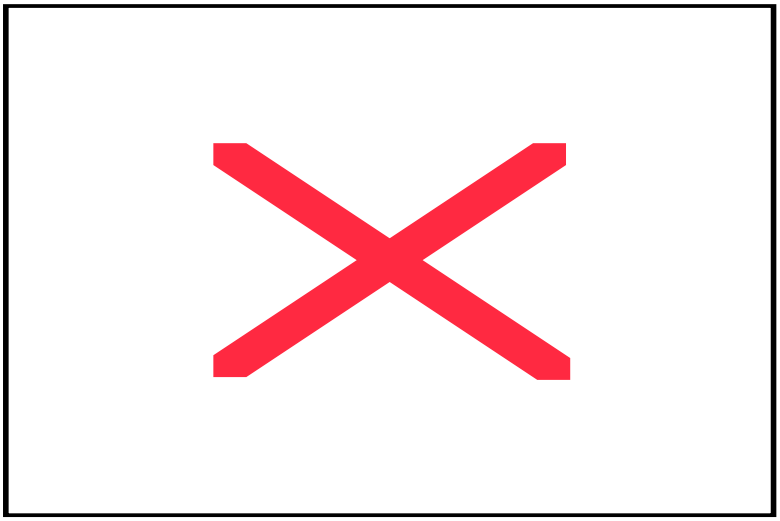
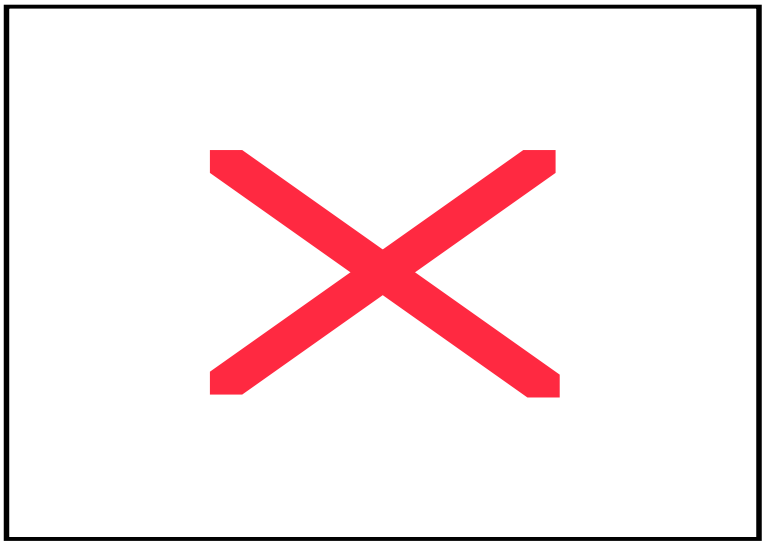
Timeout values



% of Retransmission



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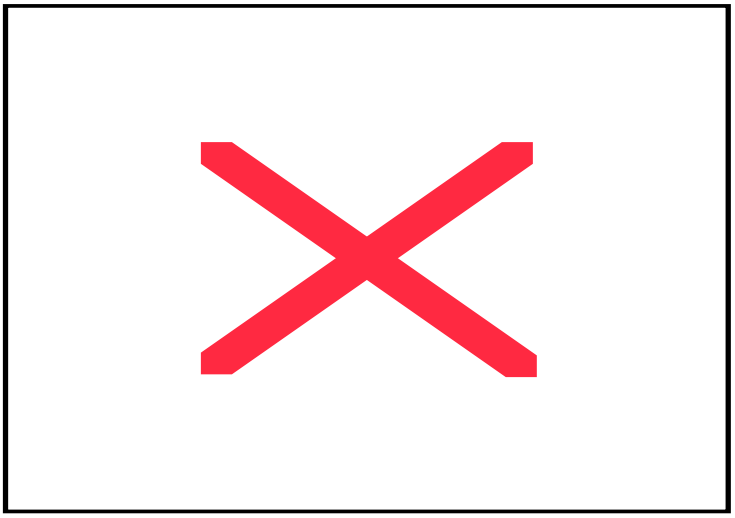
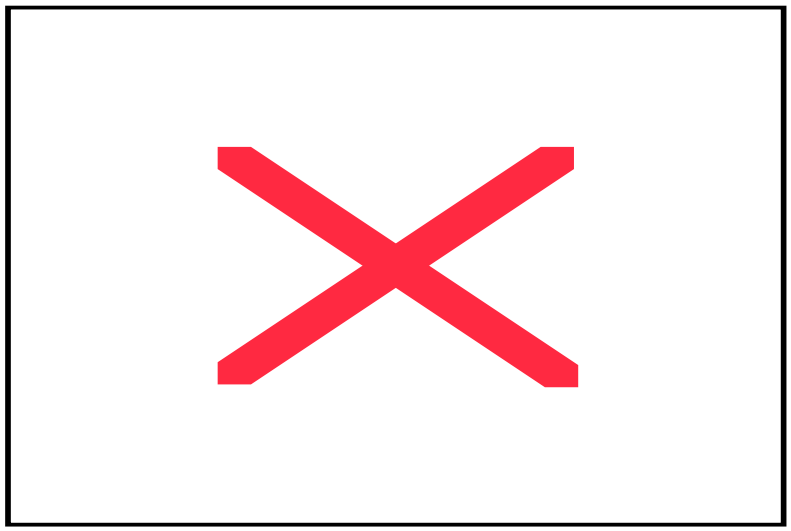
% of Retransmission



S. Venkatesan ACN

% of Retransmission



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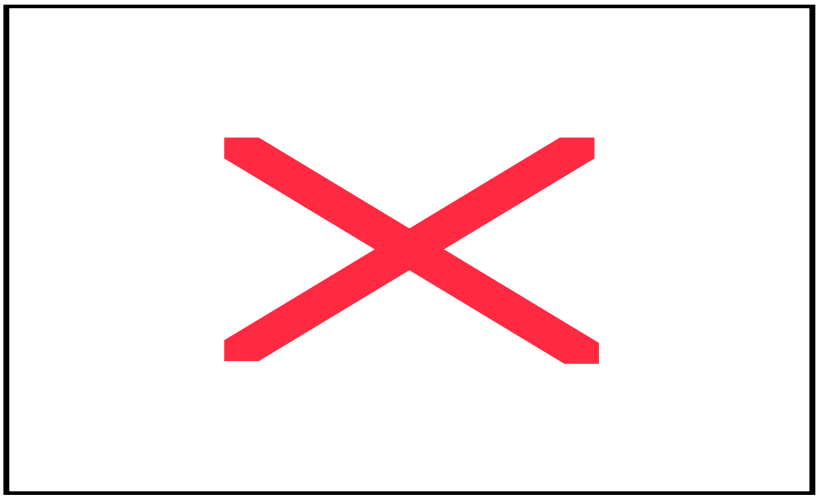
Sequence number of packets



Sequence number of packets