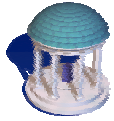


# Quantifying the Effects of Recent Protocol Improvements to TCP: Web Performance



Michele Weigle, Kevin Jeffay, and Don Smith  
MASCOTS 2003

# Conventional Wisdom vs. Our Findings



## Why Different?

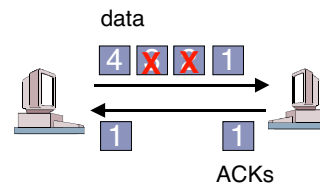
- complex traffic model
- focus on web performance
- large range of RTTs
- two-way congestion

- TCP SACK is <sup>not</sup> better than TCP Reno
- RED is <sup>not clearly</sup> better than Drop Tail
- ECN is <sup>clearly</sup> better than dropping

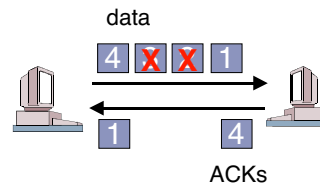
# Evaluation TCP



- TCP Reno
  - \_ cumulative ACKs



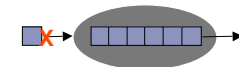
- TCP SACK
  - \_ selective ACKs
  - \_ lets sender infer which packets were lost
  - \_ helps avoid timeouts



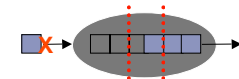
# Evaluation Queuing



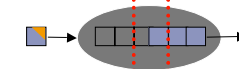
- Drop Tail
  - \_ high loss with bursts of packets



- Adaptive RED
  - \_ Random Early Detection
  - \_ lowers queue size

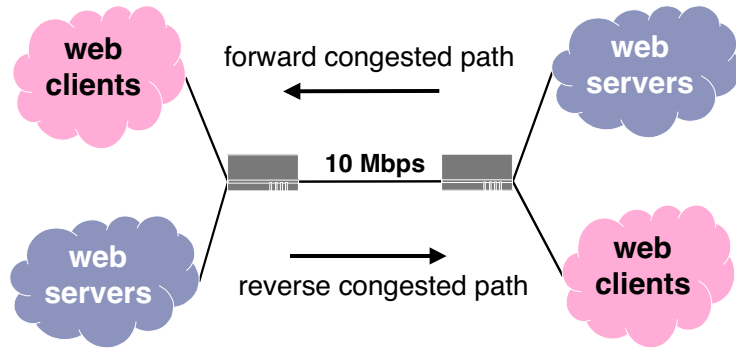


- Adaptive RED with ECN
  - \_ Explicit Congestion Notification
  - \_ marks instead of drops





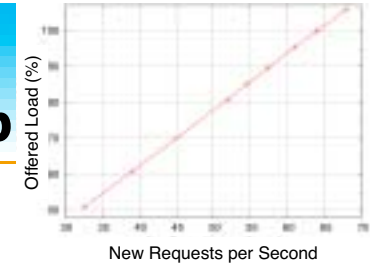
# Network Setup



RTTs vary from 1 ms to 3.5 seconds



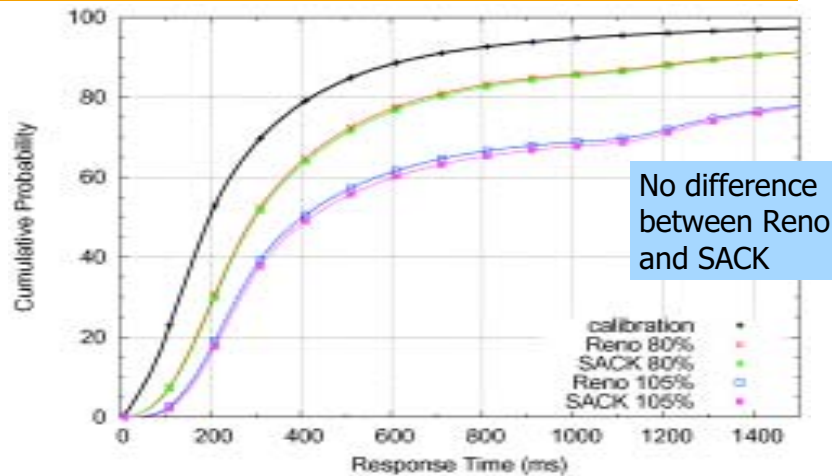
# Simulation Setup



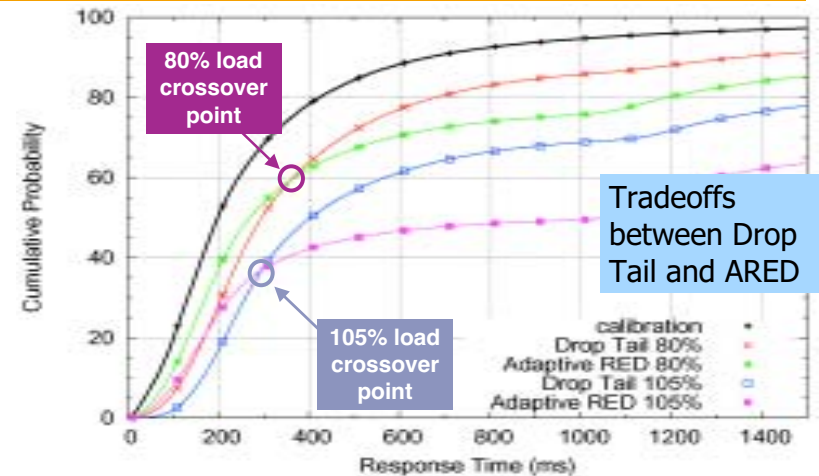
- ns-2
  - two-way web traffic
    - Bell Labs HTTP model
  - 250,000 request-response pairs
  - offered loads of 50-105% of 10 Mbps link
  - each TCP paired with each queuing mechanism
- Main Performance Metric
  - HTTP response time - time between sending HTTP request and receiving HTTP response
    - no major differences below 80% load



# Drop Tail: Reno vs. SACK 80% and 105% load

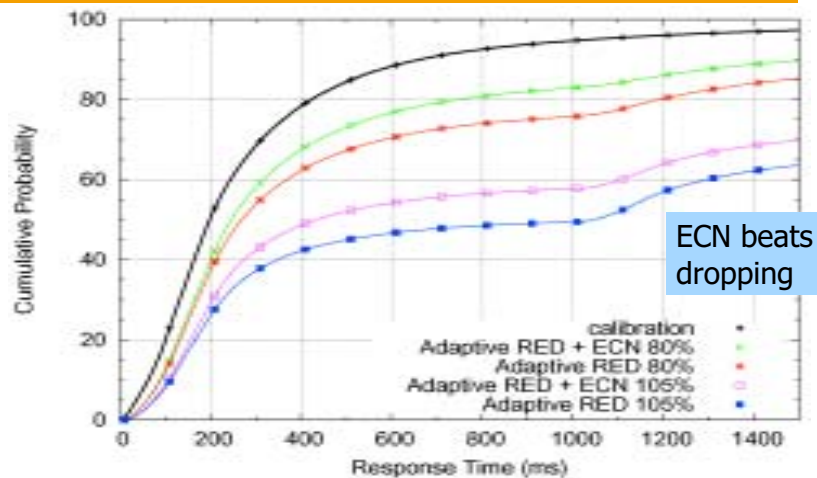


# Drop Tail vs. Adaptive RED 80% and 105% load





## ARED vs. ARED+ECN 80% and 105% load

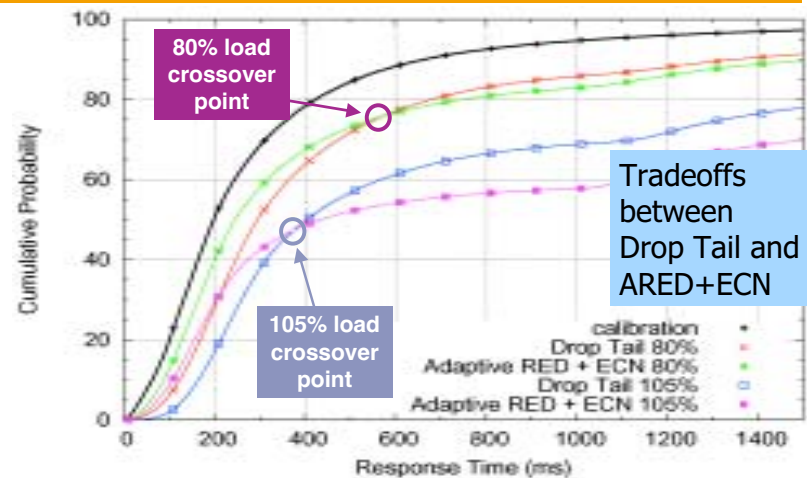


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## Drop Tail vs. ARED+ECN 80% and 105% load



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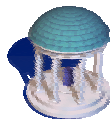


## Our Findings For HTTP Traffic

- **No benefit to using SACK over Reno**
  - not enough flows can take advantage of SACK
- **Complex tradeoffs exist when comparing Drop Tail and ARED (even with ECN)**
- **ARED with ECN performs better than ARED with dropping**
  - drops cause retransmissions, which only increases response times

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<http://www.cs.unc.edu/~mcweigle/>

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