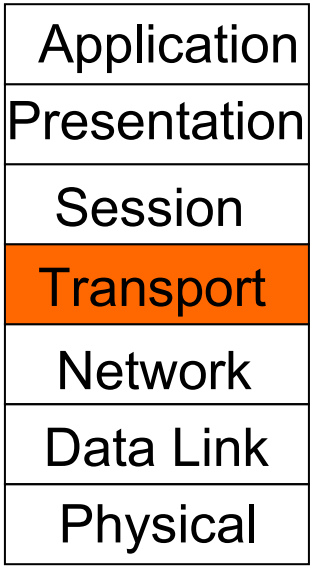
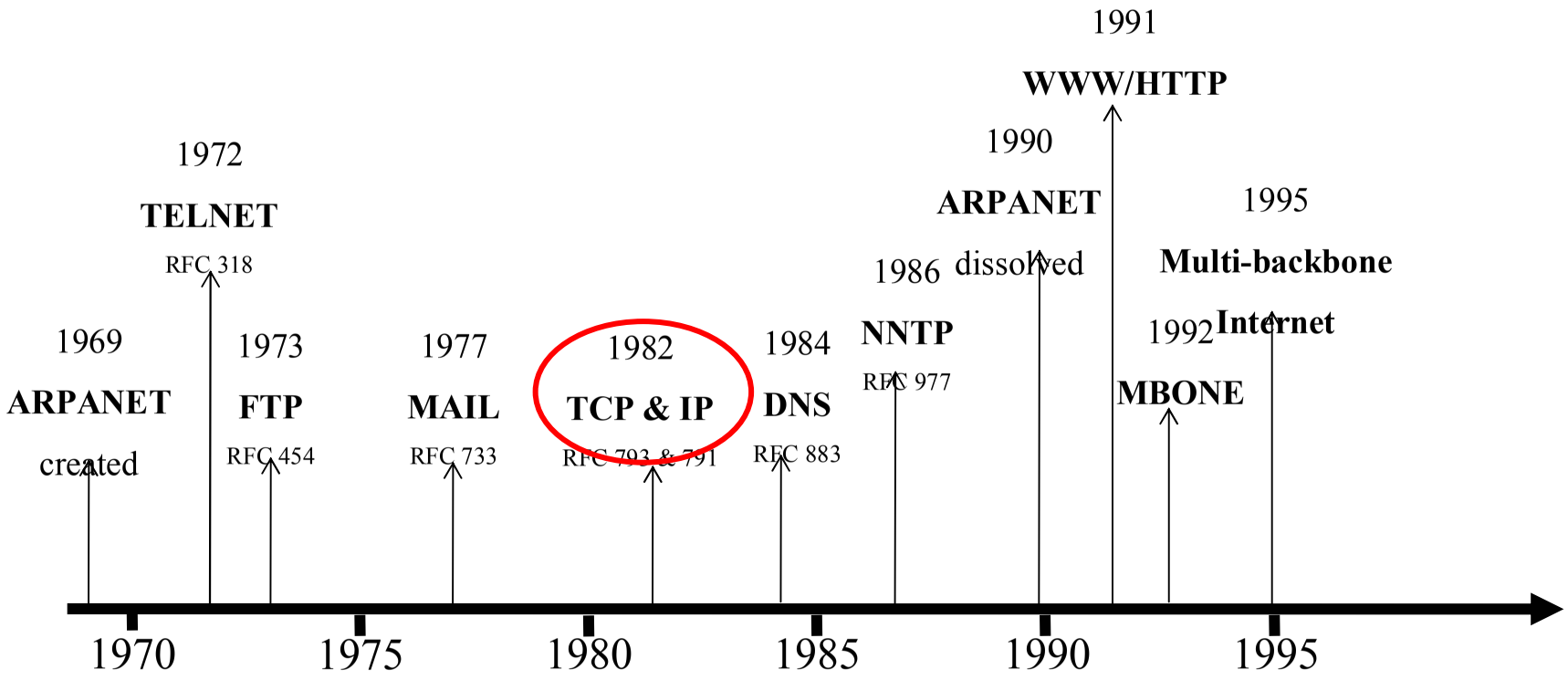
Retransmissions

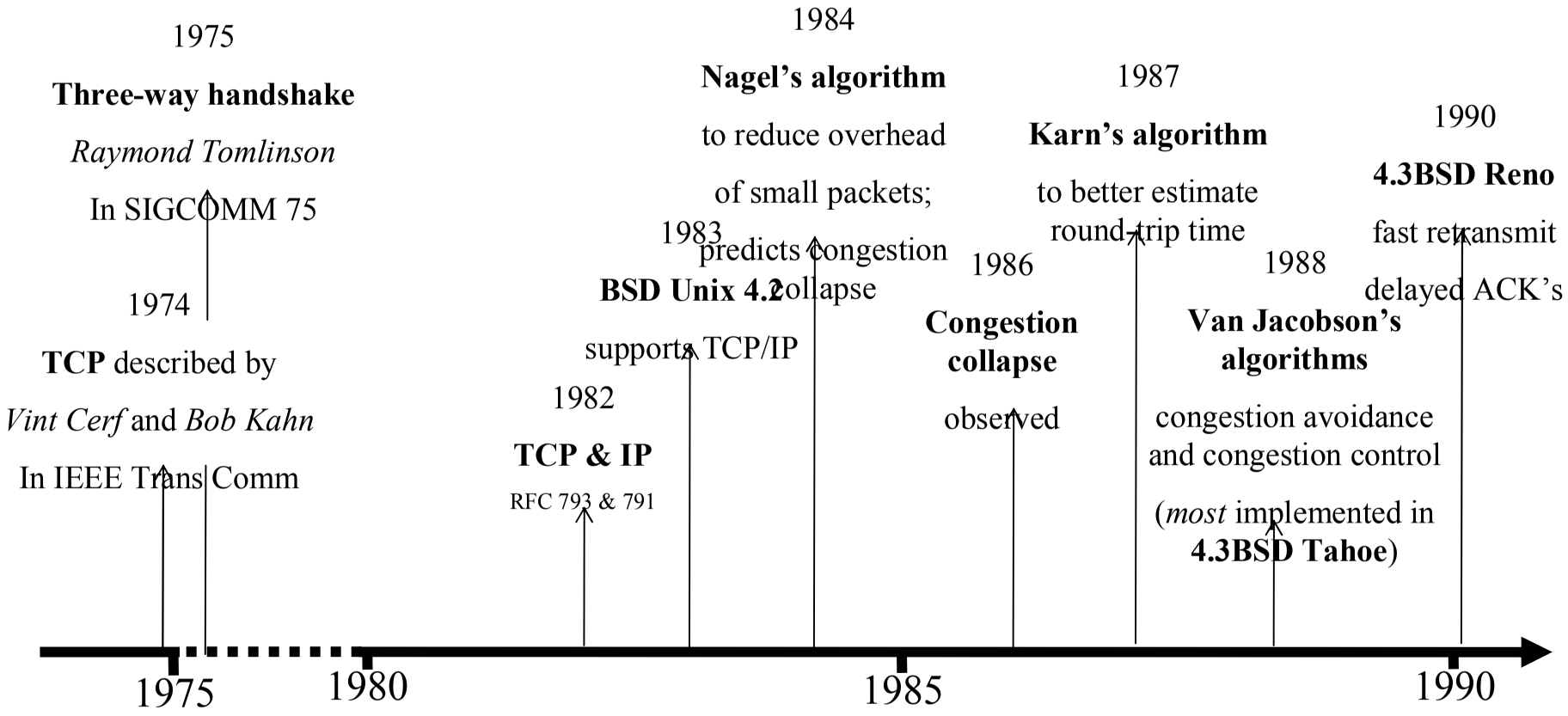
- Focus
  - How do we decide when to retransmit?
- Topics
  - RTT estimation
  - Karn/Partridge algorithm
  - Jacobson/Karels algorithm



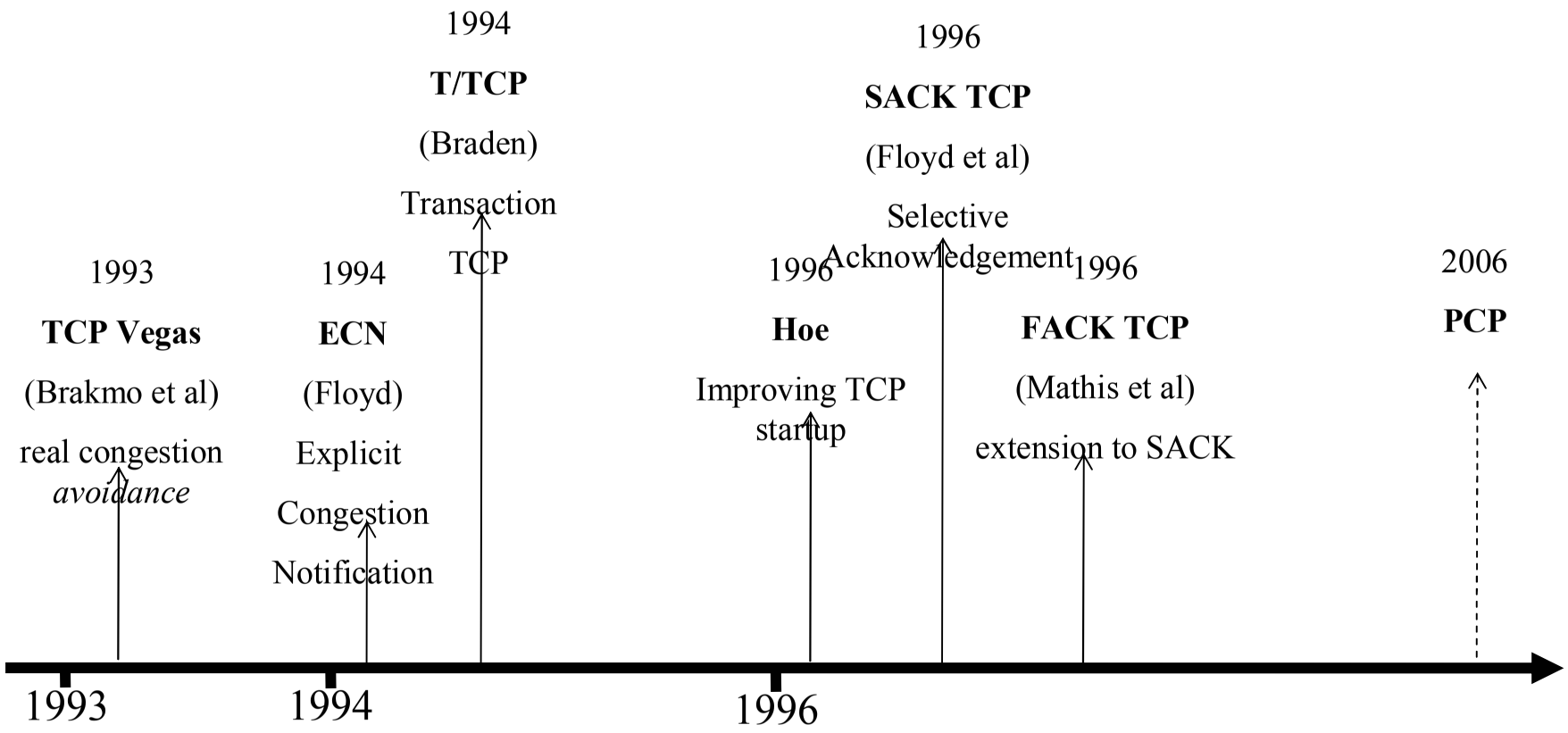
But first, a brief Internet history...



TCP: This is your life...



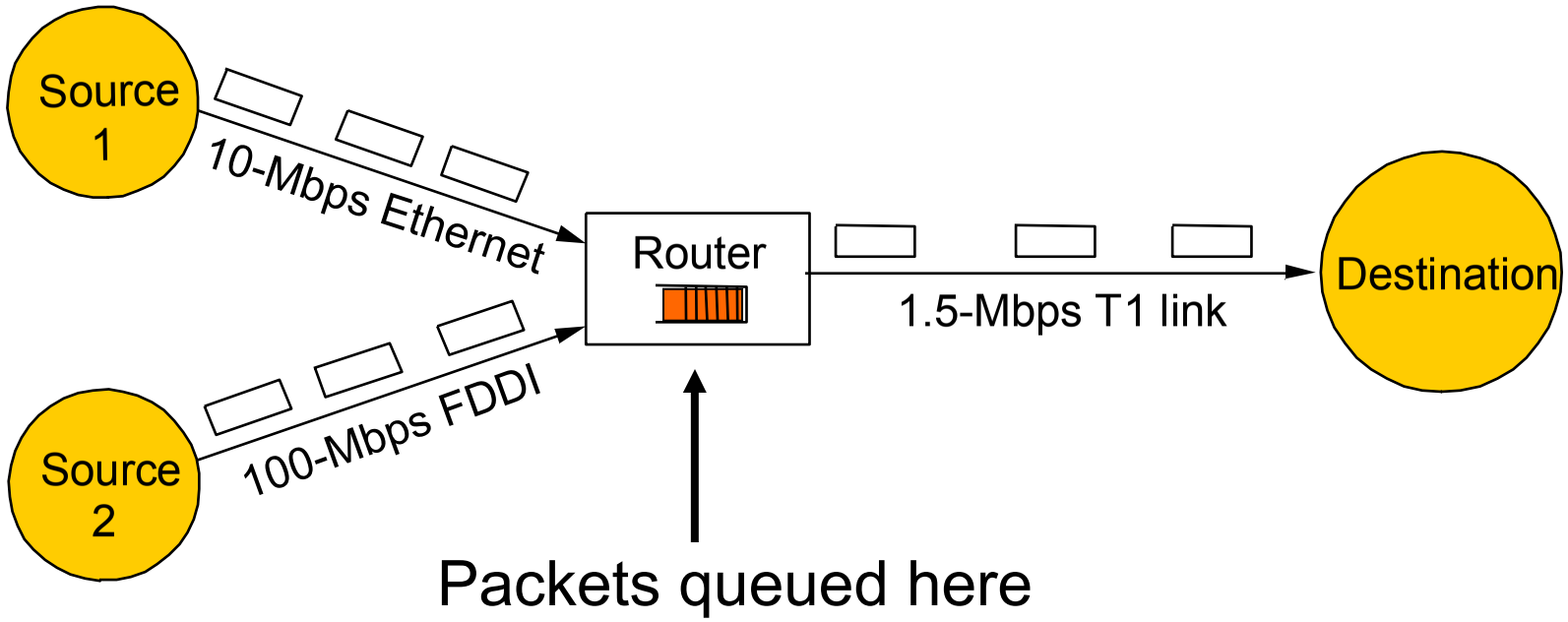
TCP: After 1990



Deciding When to Retransmit

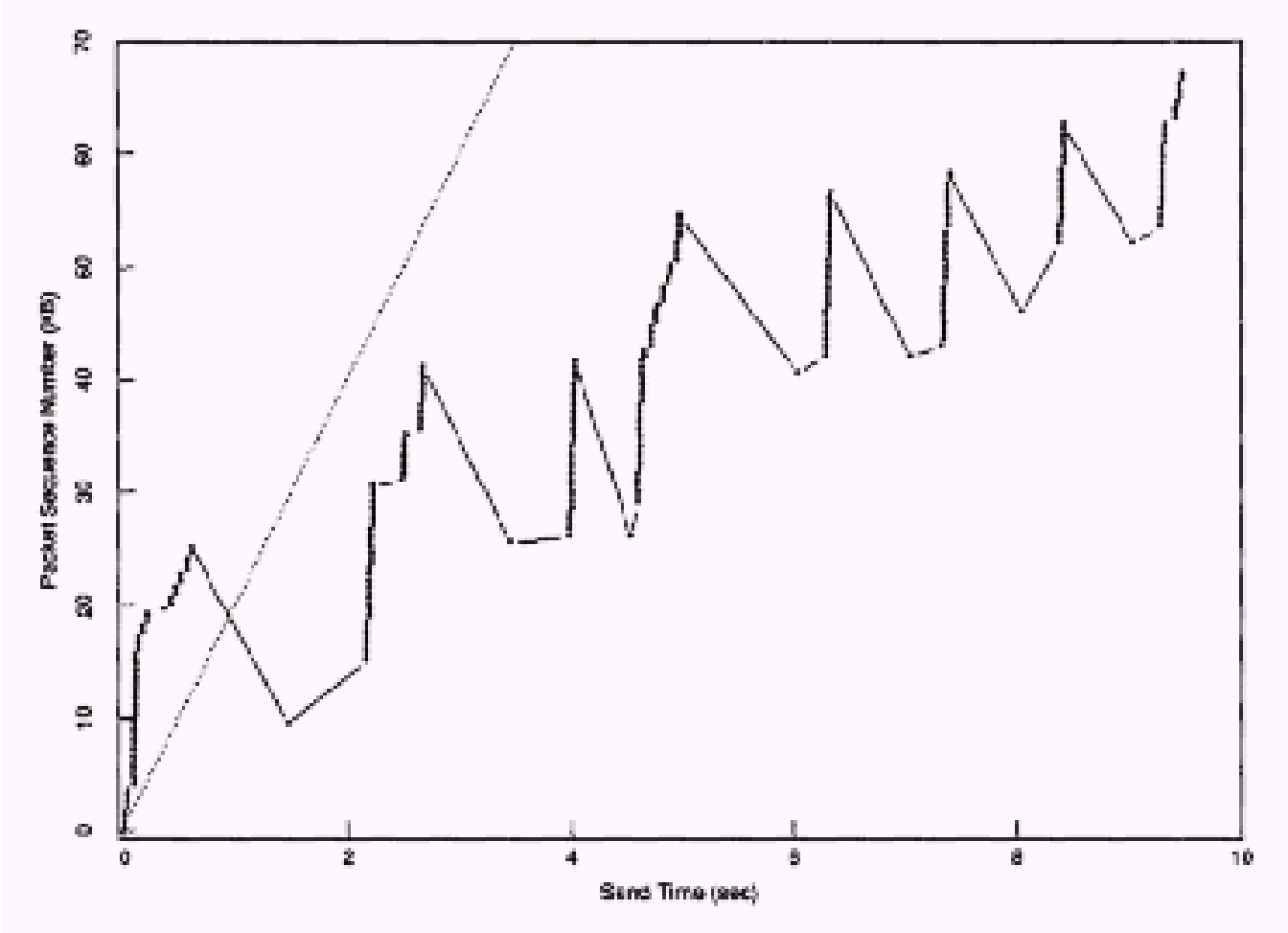
- How do you know when a packet has been lost?
  - Ultimately sender uses timers to decide when to retransmit
- But how long should the timer be?
  - Too long: inefficient (large delays, poor use of bandwidth)
  - Too short: may retransmit unnecessarily (causing extra traffic)
  - A good retransmission timer is important for good performance
- Right timer is based on the round trip time (RTT)
  - Which varies greatly in the wide area (path length and queuing)

A Simple Network Model



- Buffers at routers used to absorb bursts when input rate > output
- Loss (drops) occur when sending rate is persistently > drain rate

Effects of Early Retransmissions



Congestion Collapse

- In the limit, early retransmissions lead to congestion collapse
  - Sending more packets into the network when it is overloaded exacerbates the problem of congestion
  - Network stays busy but very little useful work is being done

- This happened in real life ~1987
  - Led to Van Jacobson's TCP algorithms, which form the basis of congestion control in the Internet today

  [See "Congestion Avoidance and Control", SIGCOMM'88]

Estimating RTTs

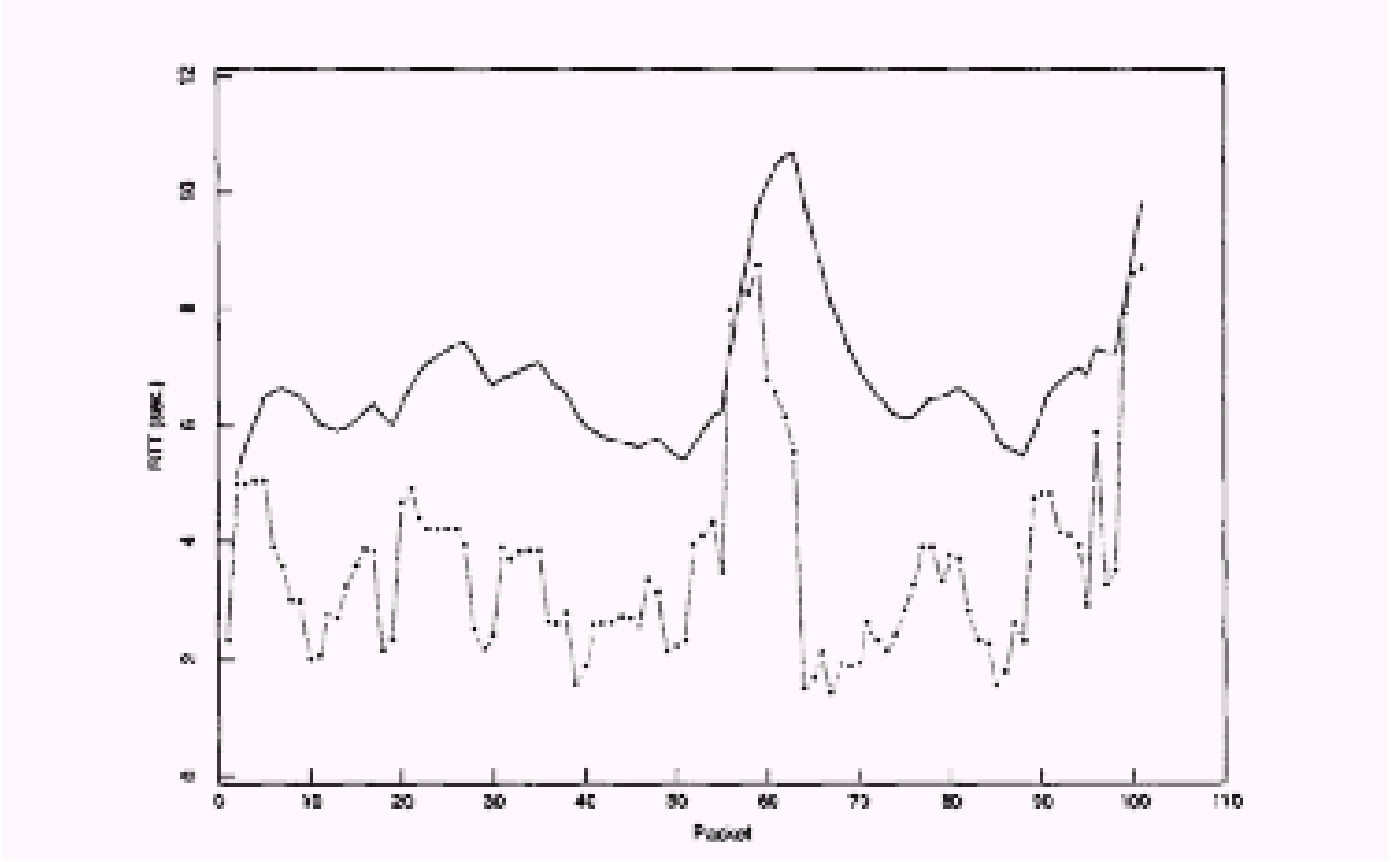
- Idea: Adapt based on recent past measurements

- Simple algorithm:
  - For each packet, note time sent and time ack received
  - Compute RTT samples and average recent samples for timeout

  - EstimatedRTT = α x EstimatedRTT + (1 - α) x SampleRTT

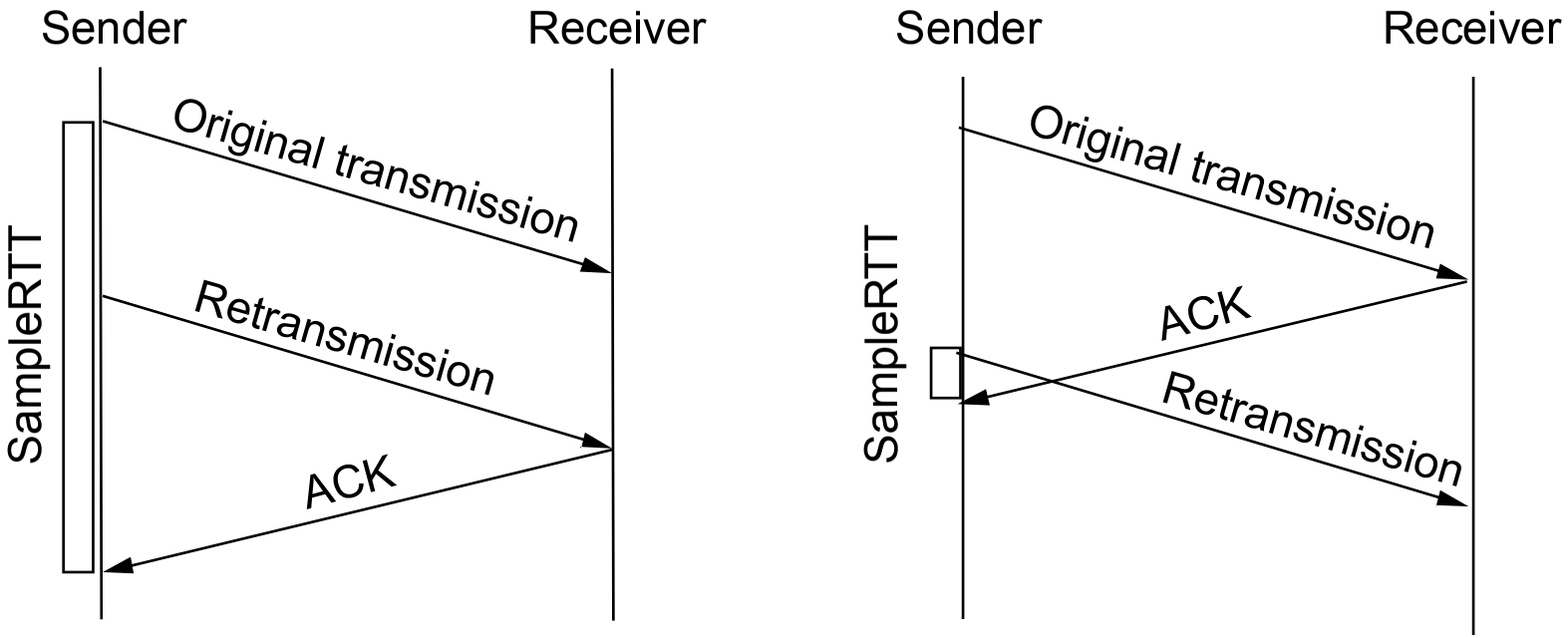
  - This is an exponentially-weighted moving average (low pass filter) that smoothes the samples. Typically, α = 0.8 to 0.9.
  - Set timeout to small multiple (2) of the estimate

Estimated Retransmit Timer



Karn/Partridge Algorithm

- Problem: RTT for retransmitted packets ambiguous



- Solution: Don't measure RTT for retransmitted packets and do not relax backed of timeout until valid RTT measurements

Jacobson/Karels Algorithm

- Problem:
  - Variance in RTTs gets large as network gets loaded
  - So an average RTT isn't a good predictor when we need it most

- Solution: Track variance too.

  - Difference = SampleRTT – EstimatedRTT
  - EstimatedRTT = EstimatedRTT + (δ x Difference)
  - Deviation = Deviation + δ(|Difference|- Deviation)

  - Timeout = μ x EstimatedRTT + ϕ x Deviation
  - In practice, $\delta = 1/8$, $\mu = 1$ and $\phi = 4$

Estimate with Mean + Variance