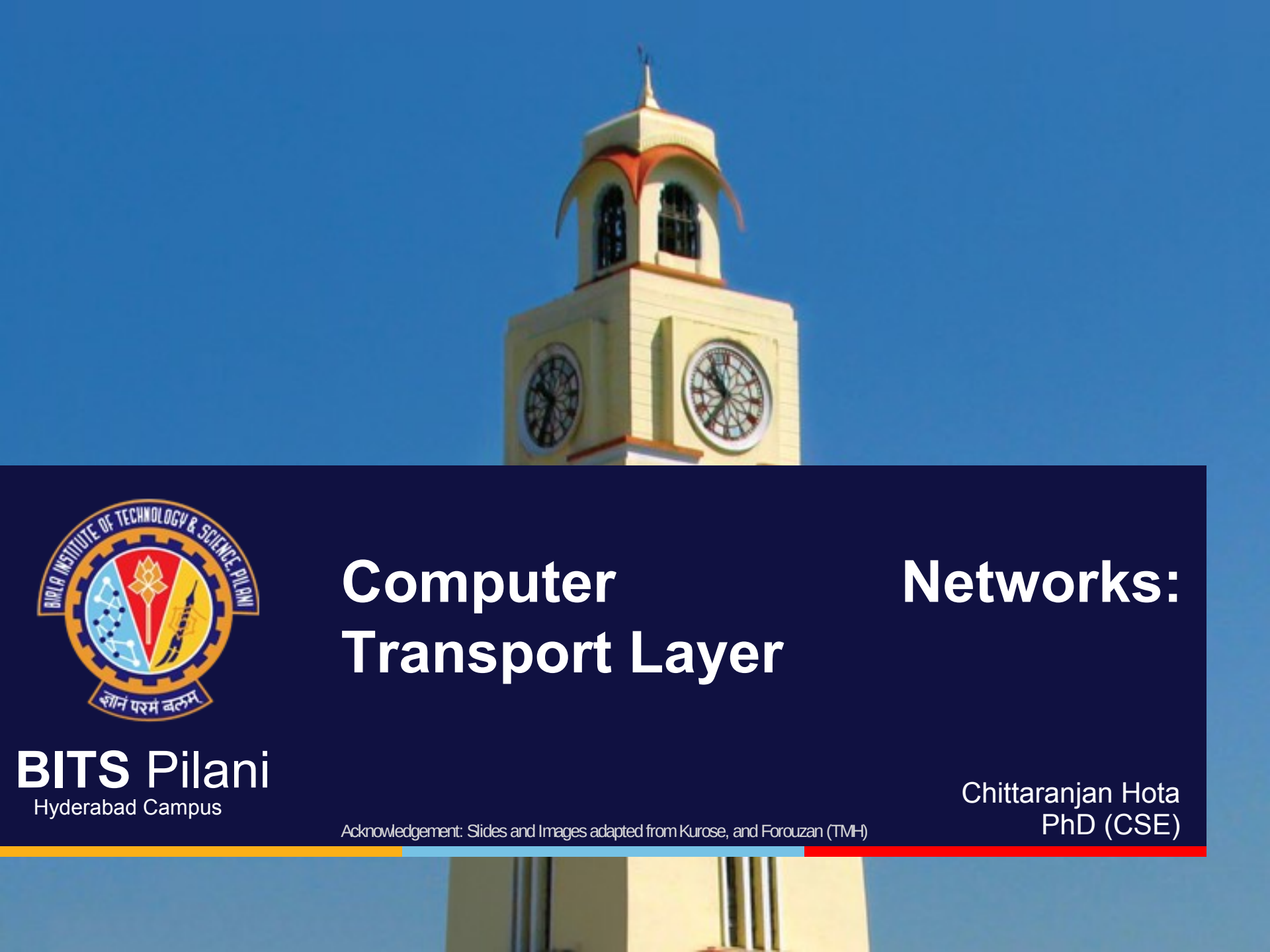


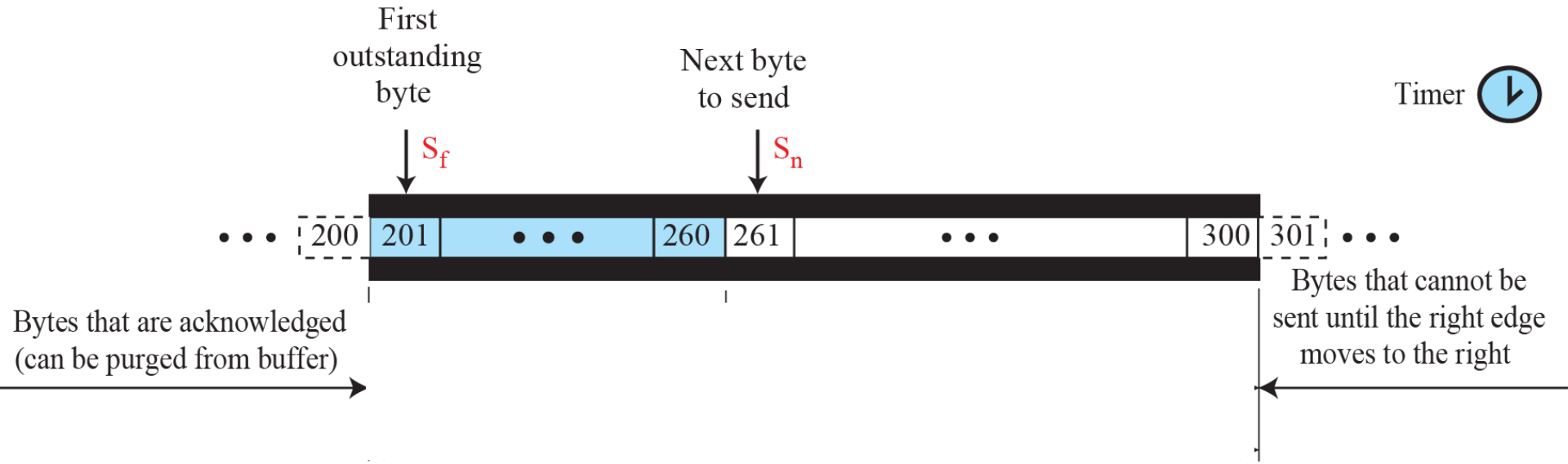
Computer Networks: Transport Layer

BITS Pilani
Hyderabad Campus

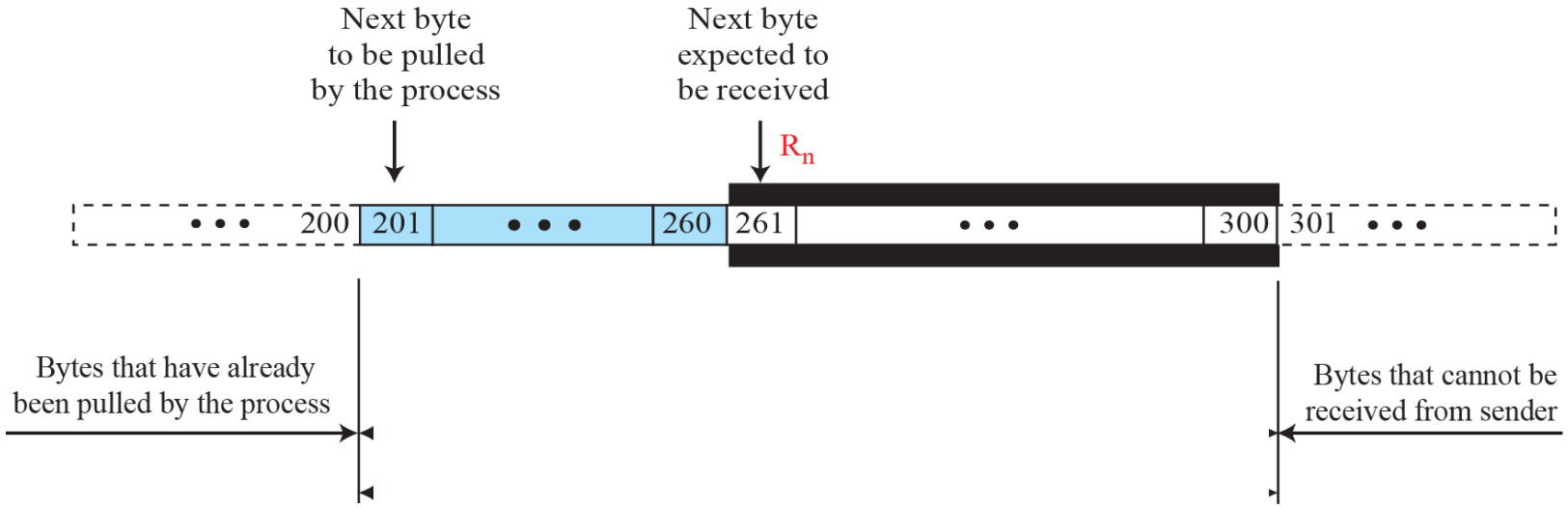
Chittaranjan Hota
PhD (CSE)

Acknowledgement: Slides and Images adapted from Kurose, and Forouzan (TMH)

TCP Flow Control

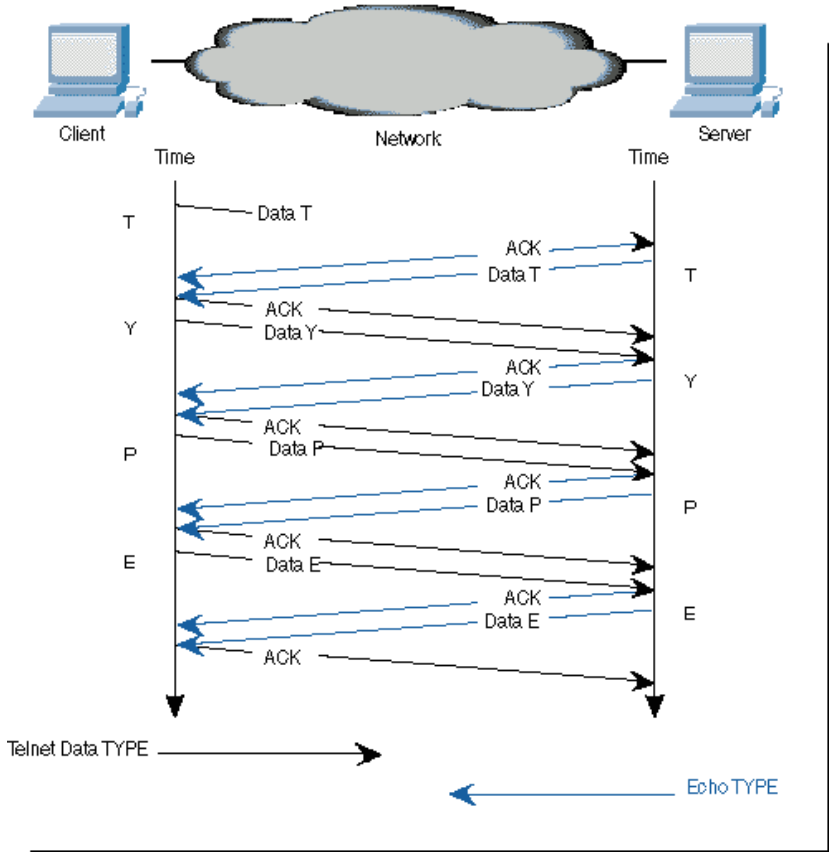


a. Send window

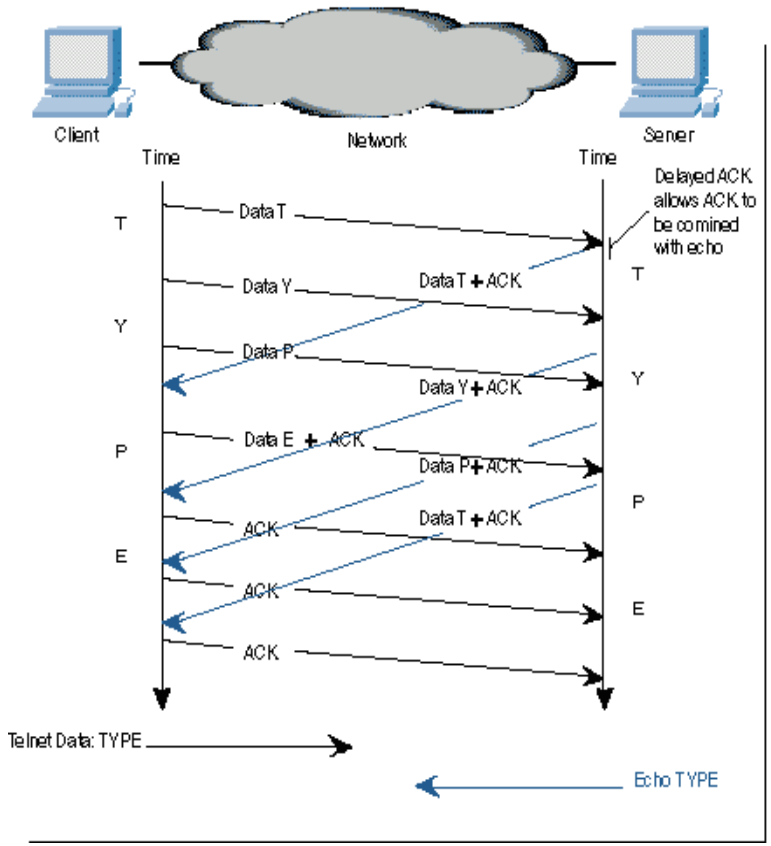


a. Receive window and allocated buffer

Interactive TCP : Network bandwidth



Interactive Exchange



Interactive Exchange with Delayed ACK

[Source: GEOFF HUSTON]

Nagle's Algorithm

When the application produces data to send

    if both the available data and the window ≥ MSS

        send a full segment

    else

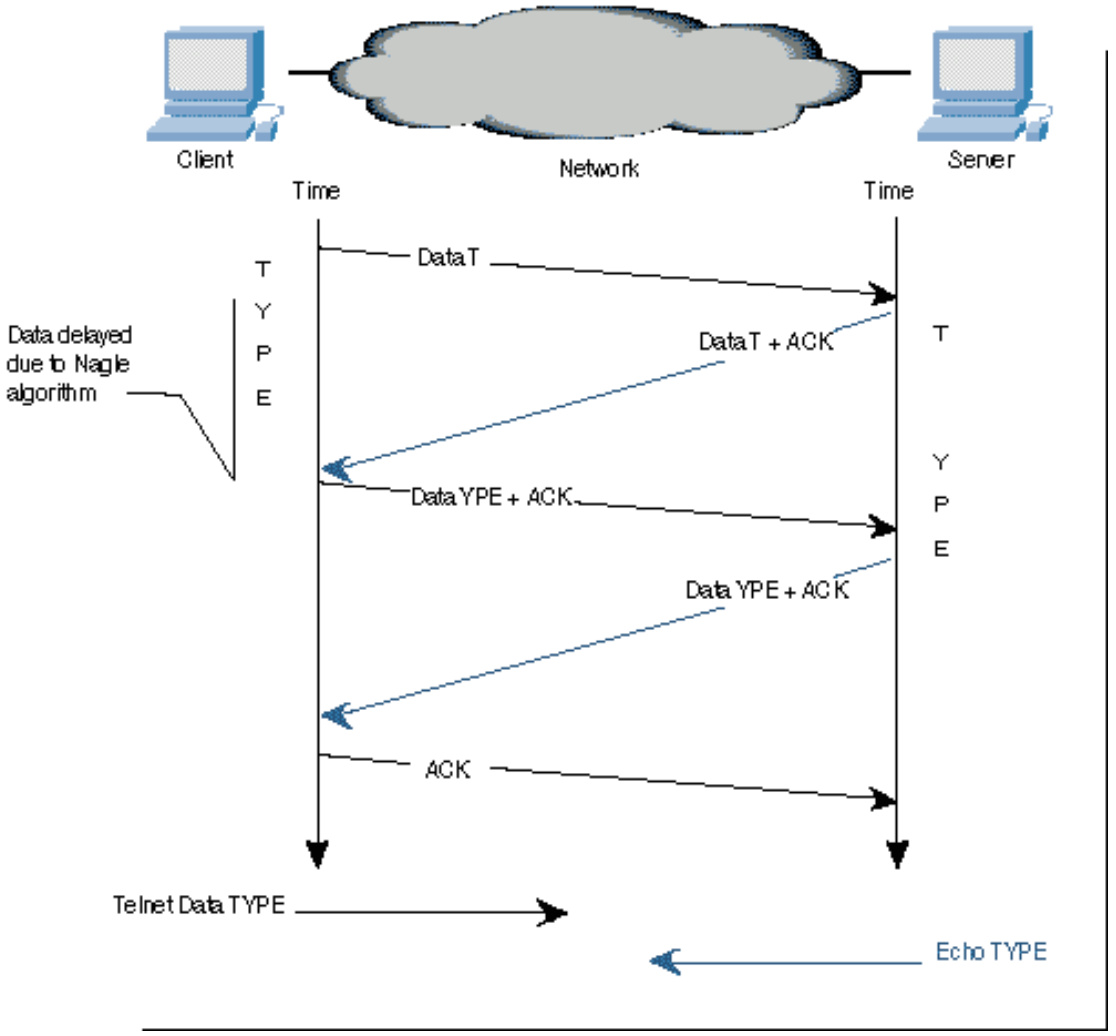
        if there is unACKed data in flight

        buffer the new data until an ACK arrives

        else

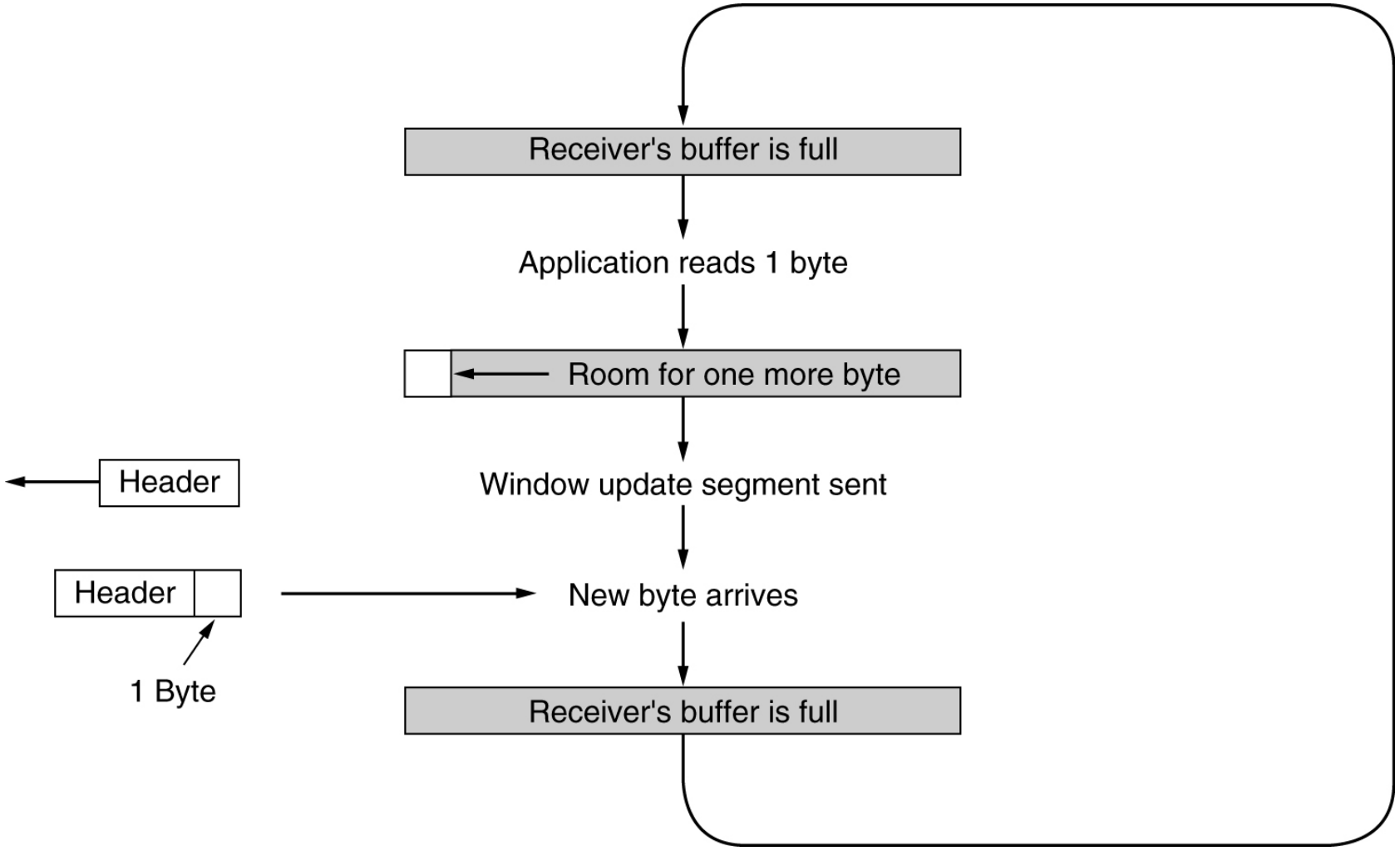
            send all the new data now

Nagle's algorithm for WAN Interactive exchange



[Source: GEOFF HUSTON]

Clarks's Solution to Silly Window Syndrome



TCP Flow Control:
Bandwidth-Delay Product → Advertised Window size

- A link with 100 ms RTT, the number of bytes in such a link at T1 speed is

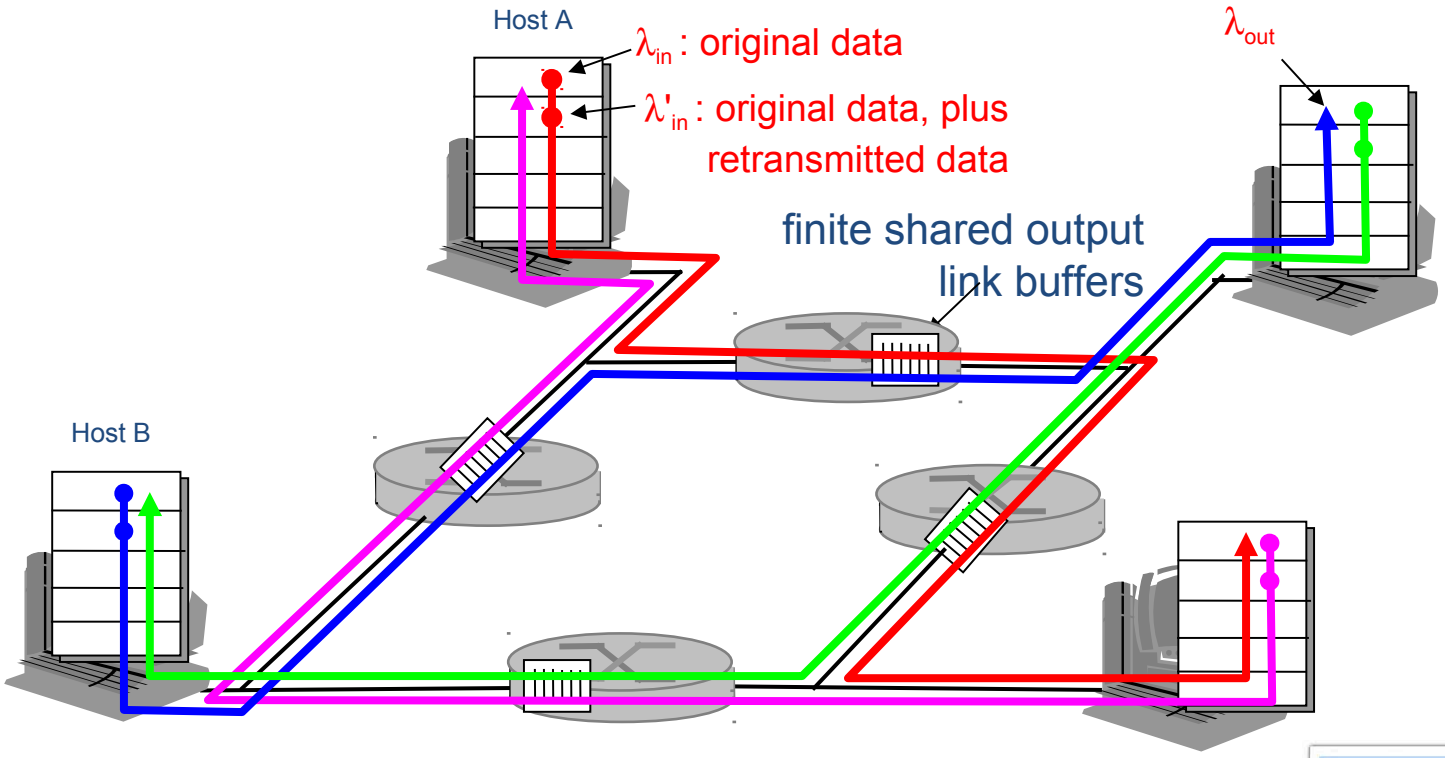
  $1.544*10^6 * .100/8 = 19{,}300$ bytes.

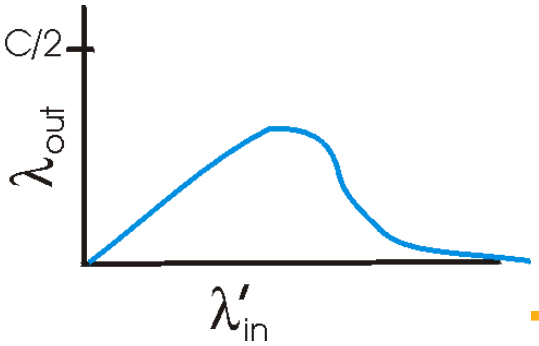
- A T3 line with 45 Mbps, Bandwidth * Delay = 562,500 bytes.

- What is the size of normal advertised window?

- Is it enough to keep a T3 link fully occupied transmitting info?

Congestion in the Network





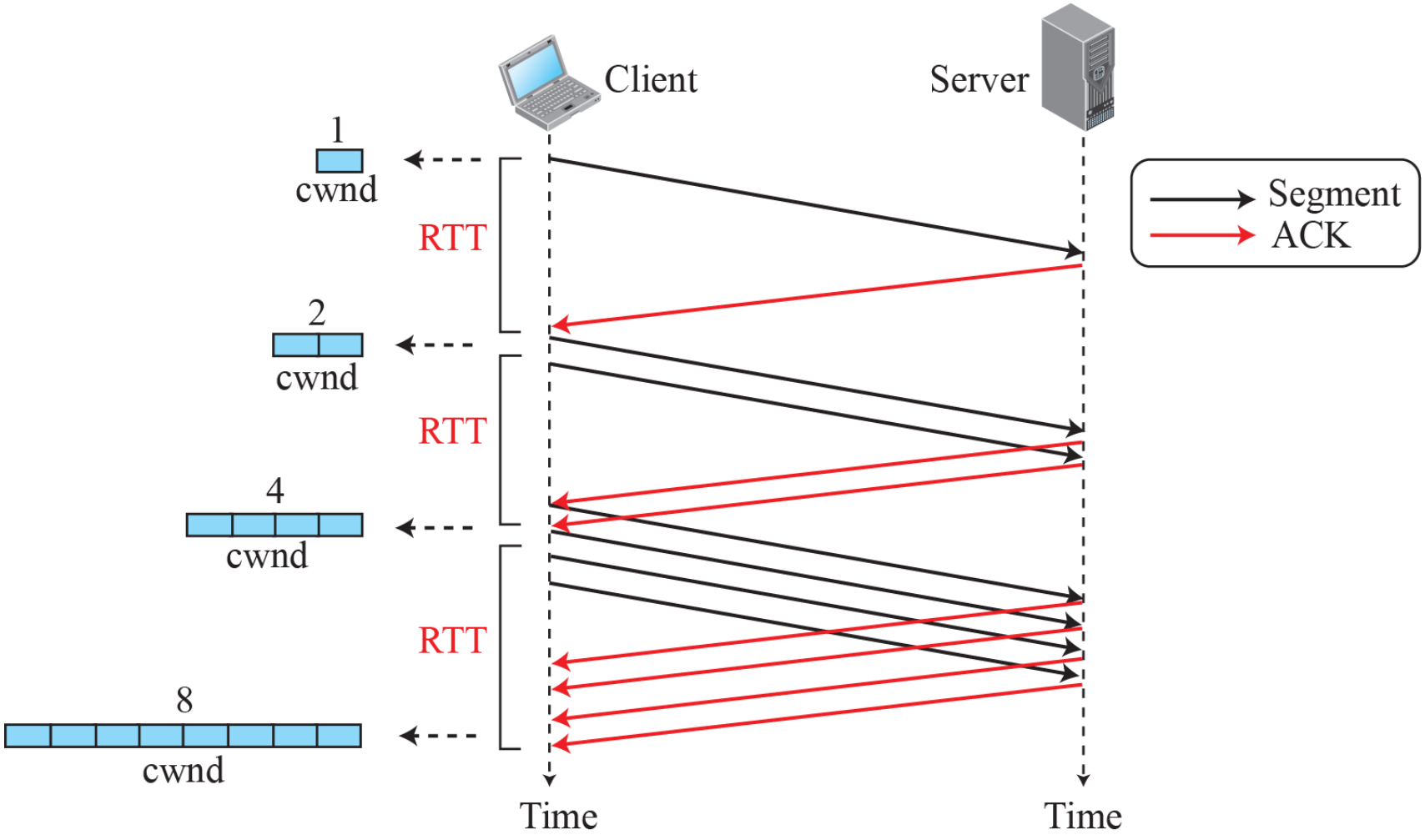
Receiver Window vs. Congestion Window

- Flow control
  - Keep a fast sender from overwhelming a slow receiver
- Congestion control
  - Keep a set of senders from overloading the network

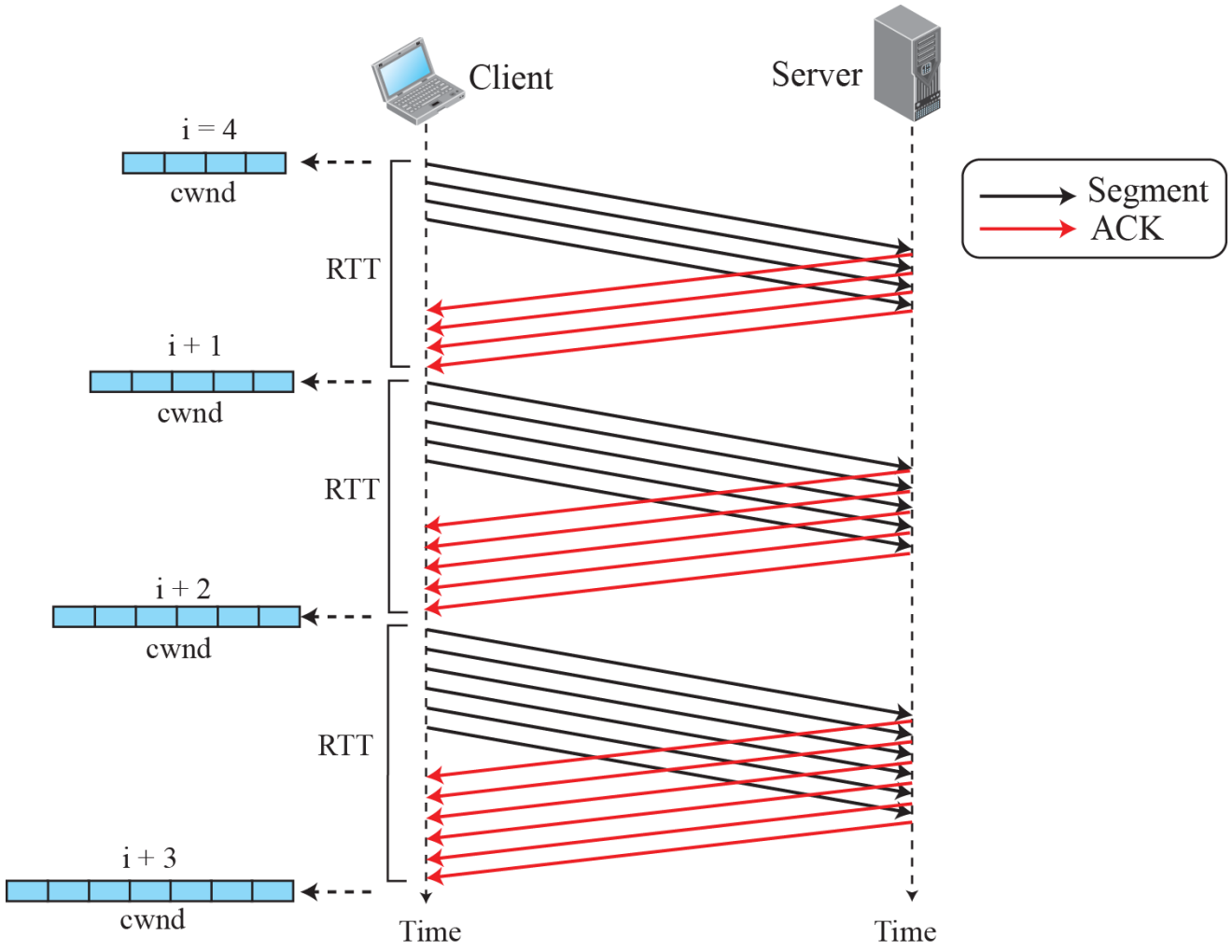
- Different concepts, but similar mechanisms
  - TCP flow control: receiver window
  - TCP congestion control: congestion window
  - TCP window:

    min{congestion window, receiver window}

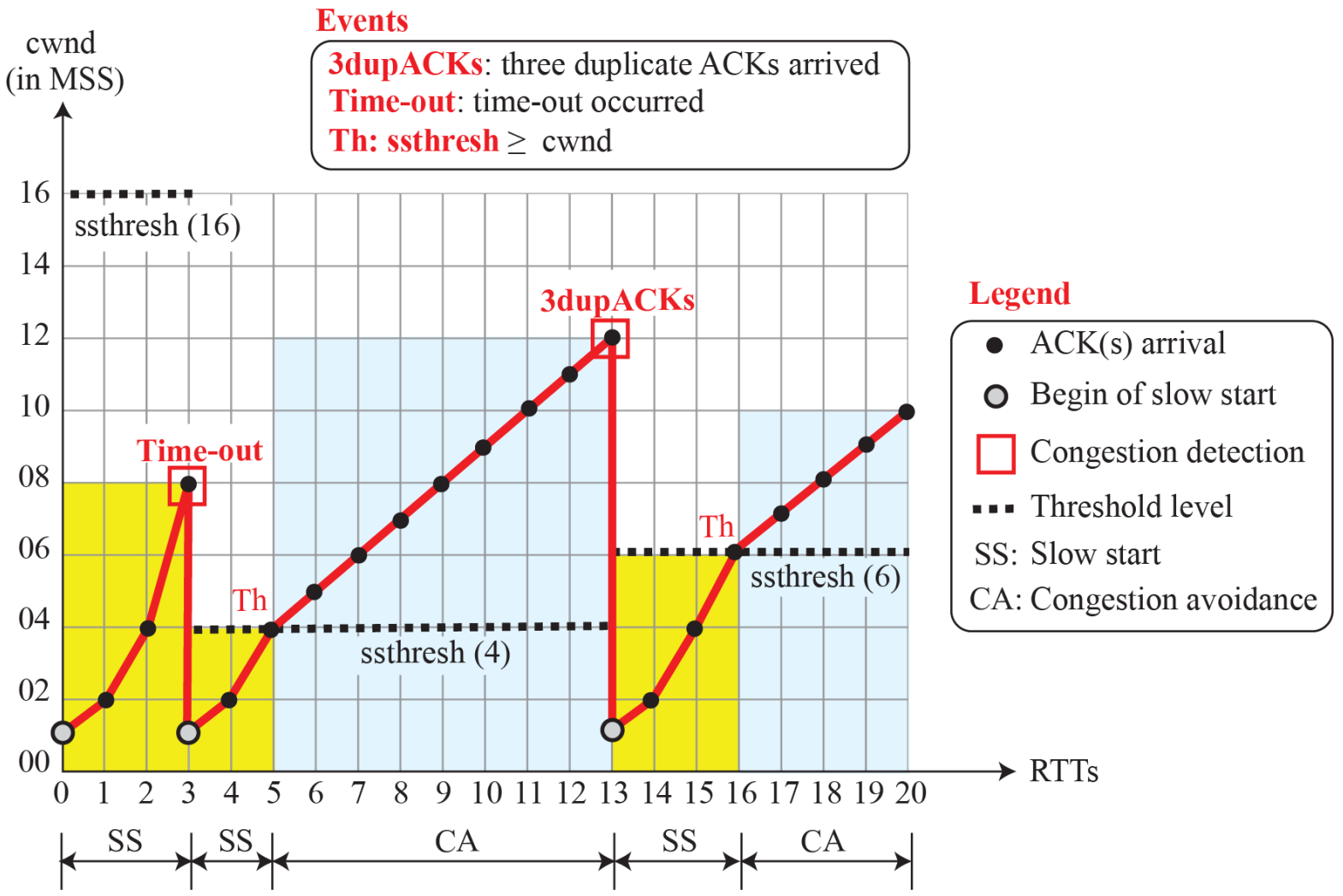
Slow Start: Exponential Increase



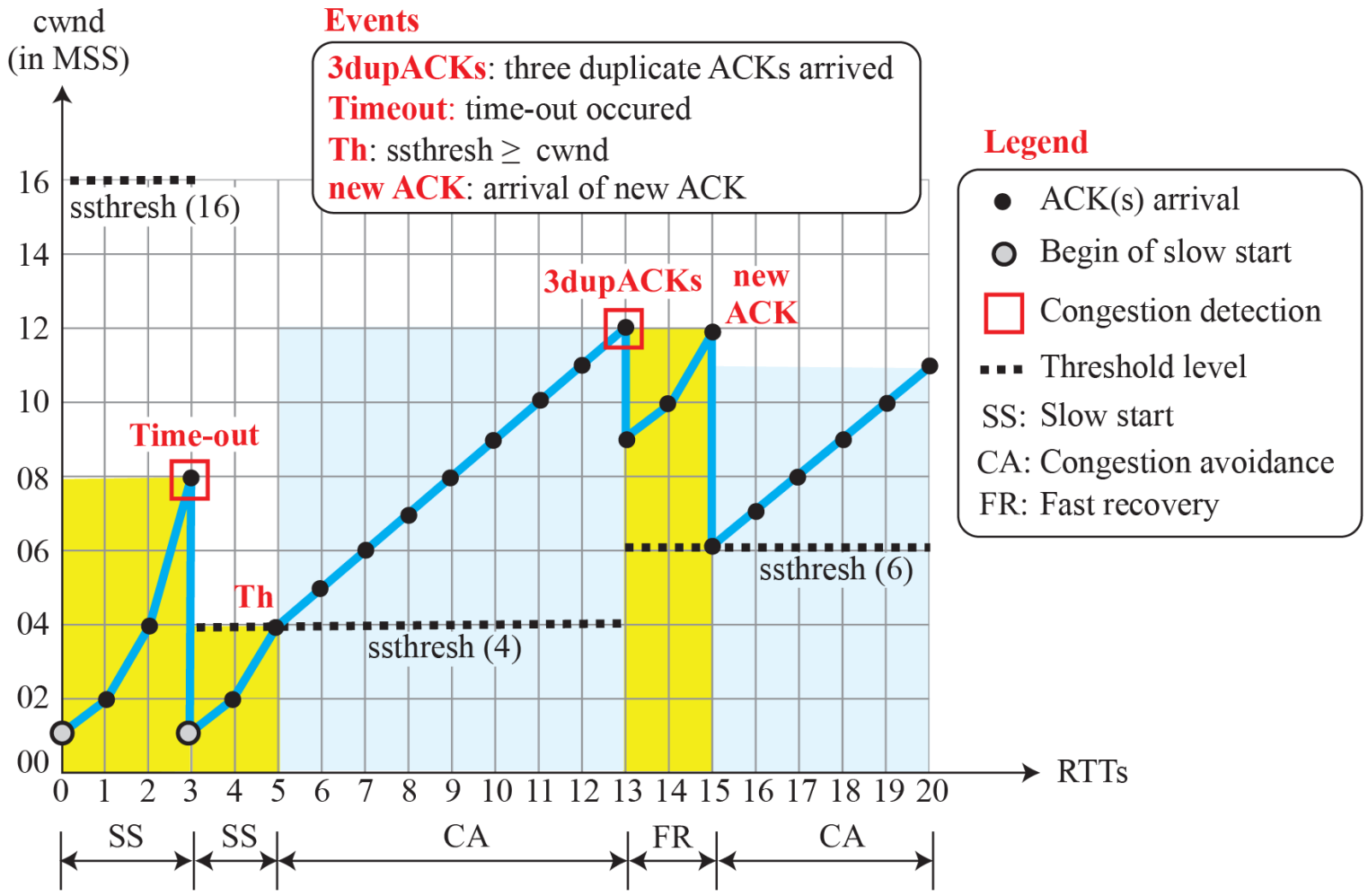
Congestion avoidance: Additive Increase



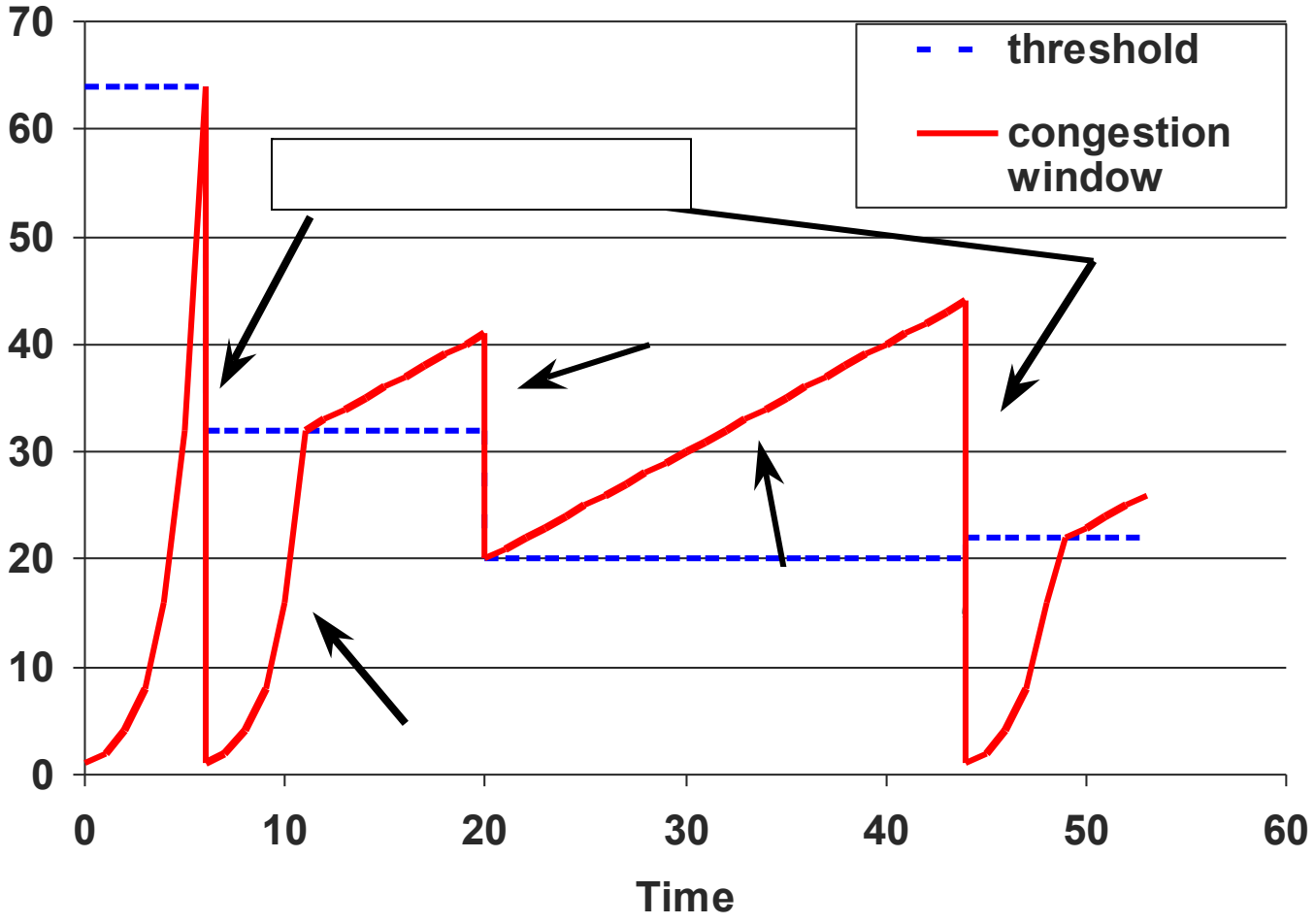
Example of Tahoe TCP



Example of Reno TCP

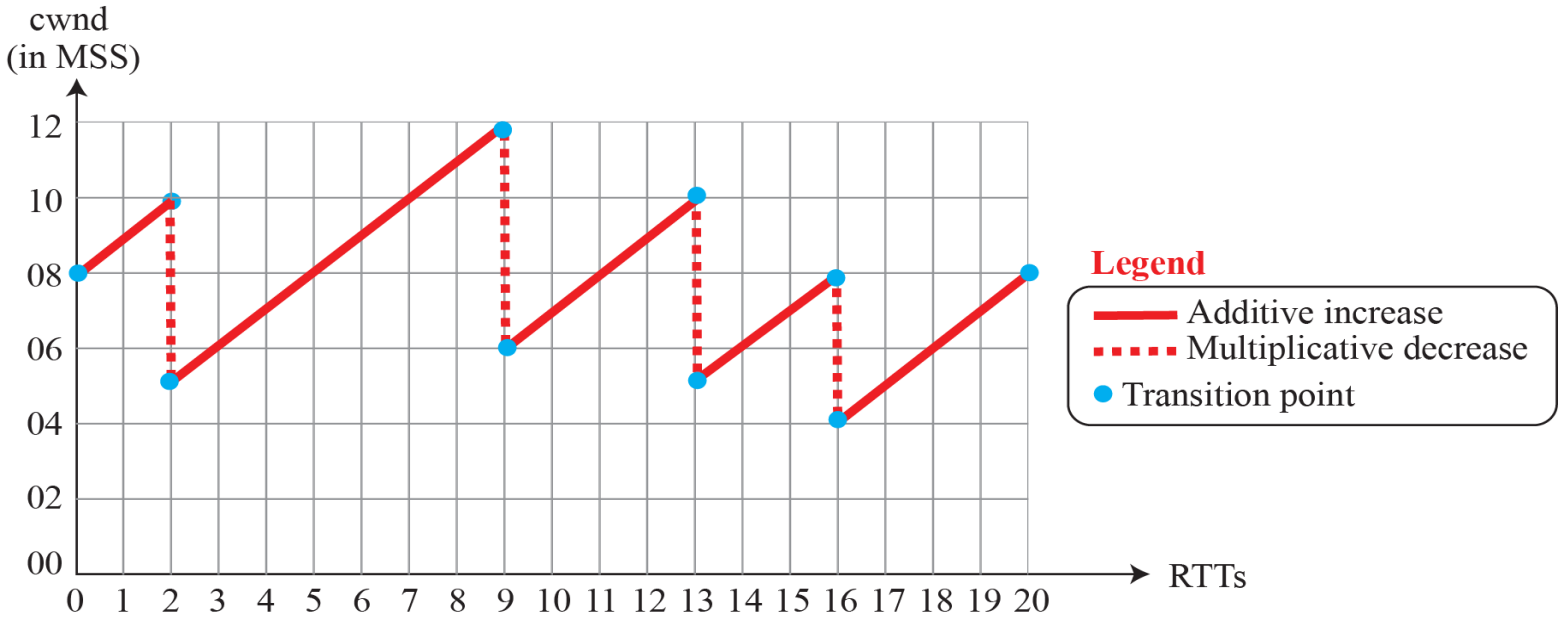


Let us work it out…



TCP Throughput: AIMD

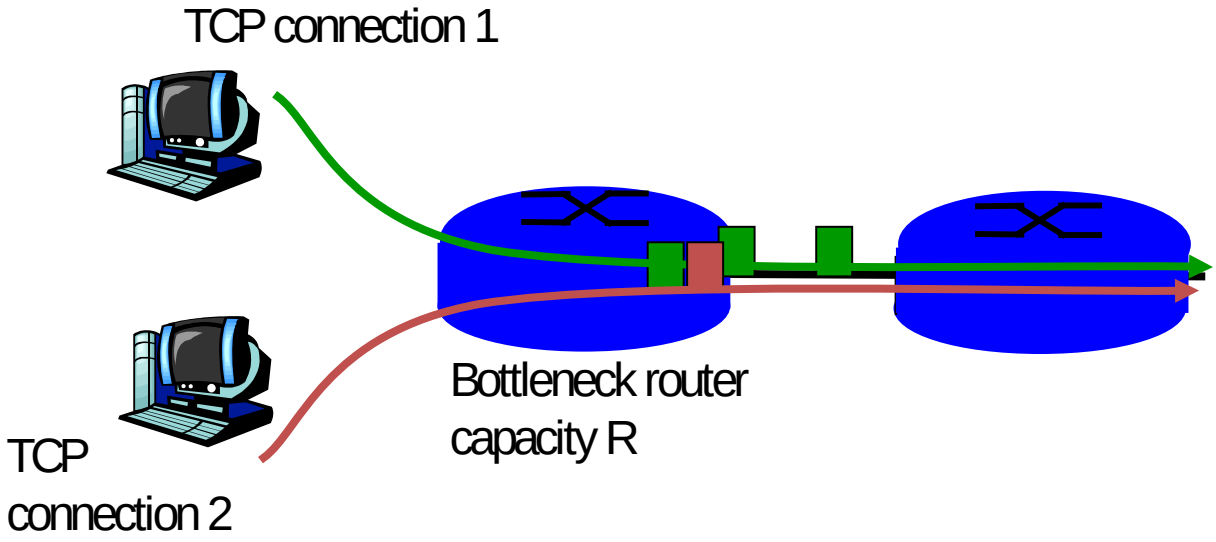
If MSS = 10 KB (kilobytes), RTT=100 ms, what is the throughput in below figure?



Here, Throughput = $(0.75)W_{max}$ / RTT

TCP Fairness

Fairness goal: if K TCP sessions share same bottleneck link bandwidth R, each should have average rate of **R/K**



Why TCP is Fair?