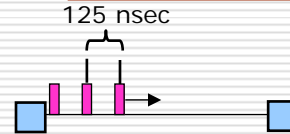


## Packet-Pair Experiment (1)

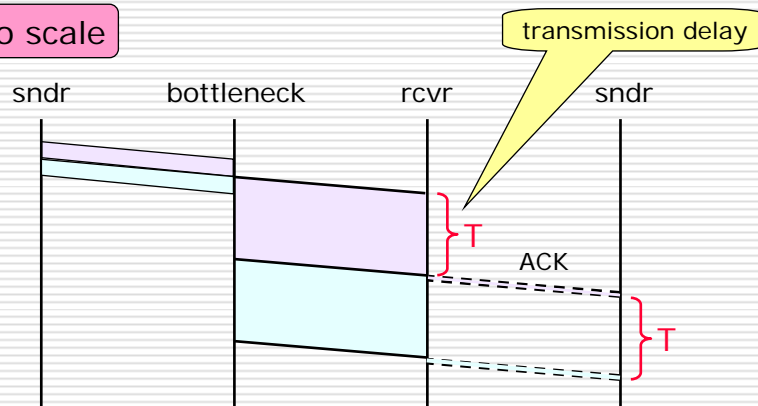
- $R = 8 \text{ Mbps}$  transmission rate
  - » Ideal case
    - constant bit separation
    - ignore overheads
  - »  $T = \text{Interbit time} = 1/R = 1/8 \text{ usec} = 125 \text{ nsec}$ 
    - One bit leaves network interface every 125 nsec
- Signal propagation speed
  - » about  $2c/3$  where
    - $c = \text{speed of light in vacuum}$
  - » bits remain separated by interbit time
- Interpacket time  $T = L/R$ 
  - »  $L$ : packet length
    - 1000-byte payload, 8-byte UDP hdr, 20-byte IP hdr
  - »  $R$ : transmission rate
  - »  $L/R = (8224 \text{ bits})/8 \text{ Mbps} = 1028 \text{ usec}$
- Implication:  $R = L/T$ 
  - » Know  $L$ ; measure  $T$ ; compute  $R$



## Packet-Pair Experiment (2)

- Space-time diagram when  $\text{npkts} = 2$

NOT to scale



ACK link not shown

# Packet-Pair Experiment (3)

datagram: 1498 bytes  
(20 + 8 + 1470)

transmission delay dominates

-0.04 0.81 1.54 1.39 1.48 1.49

```

onl002> pp-sndr -r nlp3 -n 7 -m 2
RTTs (msec):      0.42  0.39  1.30  2.70  4.19  5.73  7.15
Sndr Interpkt Times (usec):      50   16   36   12   6   26
Rcvr Interpkt Times (usec):      37  913 1488 1494 1519 1477
Bandwidth est. at sndr (Mbps):  239.68 749.00 332.89 996.67 1997.33 400.92
Bandwidth est. at rcvr (Mbps):  323.89 13.13  8.05  8.02  7.89  8.11
===
RTTs (msec):      1.41  2.80  4.29  5.78  7.27  8.80 10.30
Sndr Interpkt Times (usec):      33   7   6   5  16   7
Rcvr Interpkt Times (usec):      1497 1497 1497 1498 1548 1499
Bandwidth est. at sndr (Mbps):  363.15 1713.00 1007.33 2386.80 749.00 1713.00
Bandwidth est. at rcvr (Mbps):  8.01  8.01  8.01  8.00  7.74  7.99
onl002>
    
```

- Theory (8 Mbps link)
  - » interbyte time
    - 1 Mbps → 1 usec/byte
  - » transmission delay (1 pkt)
    - 1498 usec interpacket time

RLI: 7.995 Mbps