Transport Layer Contd

COMP90007

Internet Technologies

Examples Regarding QoS Requirements

- Different applications care about different properties
  - We want all applications to get what they need

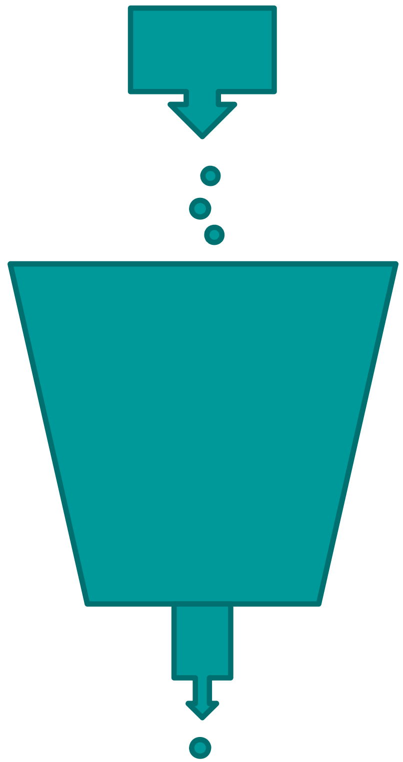
"High" means a demanding the requirement!

Application	Bandwidth	Delay	Jitter	Loss
Email	Low	Low	Low	Medium
File sharing	High	Low	Low	Medium
Web access	Medium	Medium	Low	Medium
Remote login	Low	Medium	Medium	Medium
Audio on demand	Low	Low	High	Low
Video on demand	High	Low	High	Low
Telephony	Low	High	High	Low
Videoconferencing	High	High	High	Low

Techniques for Achieving QoS #1

- **<u>Over-provisioning</u>**
  - more than adequate buffer, router CPU, and bandwidth (expensive and not scalable ...)
- **<u>Buffering</u>**
  - buffer received flows before delivery - increases delay, but smoothes out jitter, no effect in reliability or bandwidth
- **<u>Traffic Shaping</u>**
  - regulate the average rate of transmission and burstiness of transmission
  - **<u>leaky bucket</u>**
  - **<u>token bucket</u>**

Leaky Bucket



Large **bursts** of traffic is buffered and smoothed while sending

E.g. can be done at host sending data

Techniques for Good QoS #2

- **Resource reservation**
  - reserve bandwidth, buffer space, CPU in advance
- **Admission control**
  - routers can decide based on traffic patterns whether to accept new flows, or reject/**reroute** them
- **Proportional routing**
  - traffic for same destination split across multiple routes
- **Packet scheduling**
  - Create queue(s) based on priority etc
  - fair queuing, weighted fair queueing

TCP and Congestion Control

- When networks are overloaded, congestion occurs, potentially affecting all layers
- Although lower layers (data and network) attempt to ameliorate congestion, in reality **TCP impacts congestion most significantly** because TCP offers best methods to reduce the data rate, and hence reduce congestion itself

Congestion Control: Design

- Two different problems exist
  - network capacity and receiver capacity
  - these should be dealt with separately, but compatibly
- The sender maintains two windows actually
  - Window described by the receiver
  - Congestion window
- Each regulates the number of bytes the sender can transmit – the maximum transmission rate is the **minimum of the two windows**

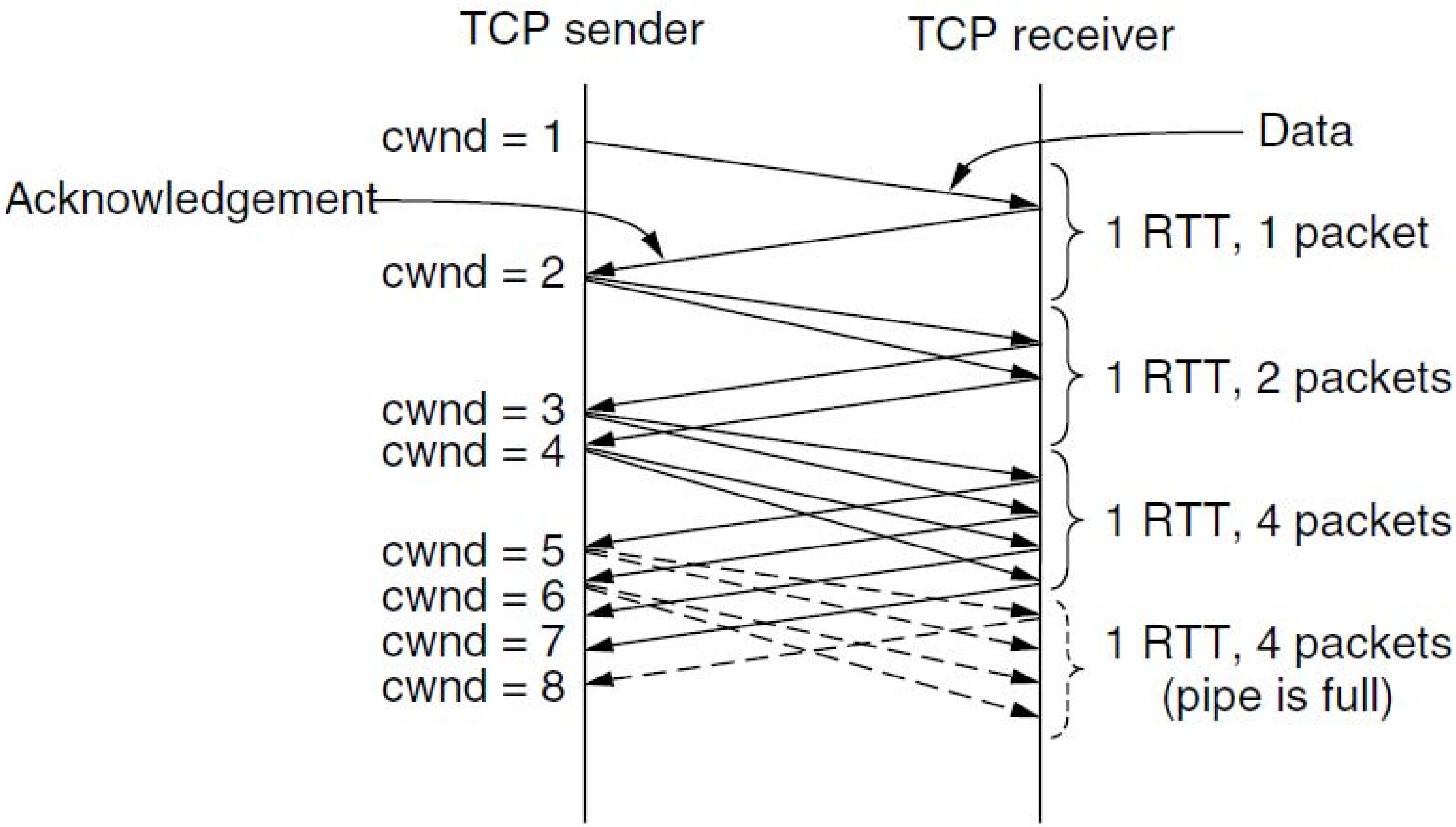
TCP and Congestion Control Contd

- TCP adopts a defensive stance:
  - At connection establishment, a **suitable window size is chosen by the receiver based on its buffer** size
  - If the sender is constrained to this size, then **congestion problems will not occur due to buffer overflow** at the receiver itself, but may still **occur due to congestion within the network**

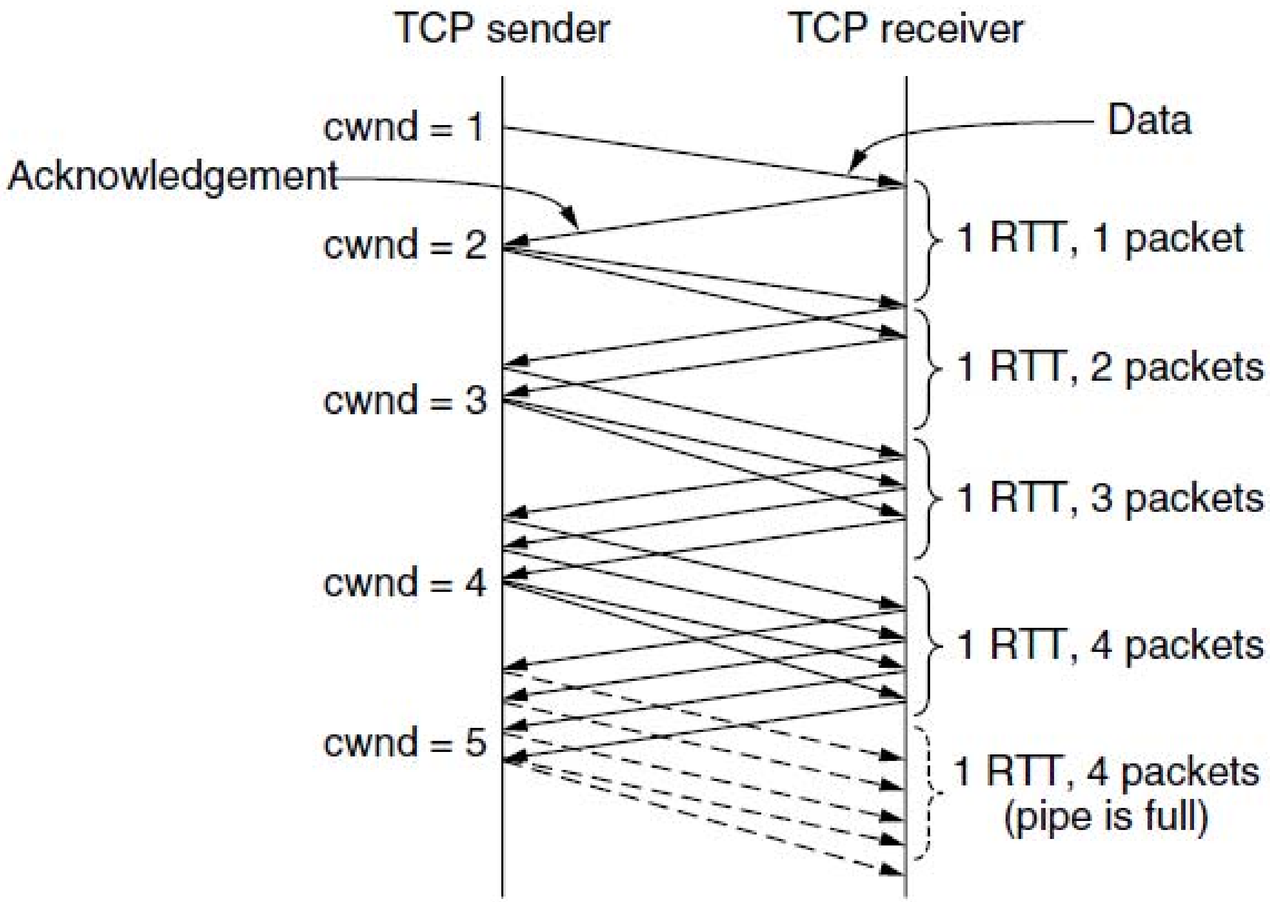
Incremental Congestion Control: Slow Start

- On connection establishment, the **<u>sender initializes the congestion window to a size</u>**, and transmits one segment
- If this segment is acknowledged before the timer expires, **<u>the sender adds another segment's worth of bytes to the congestion window</u>**, and transmits two segments
- As **<u>each new segment is acknowledged</u>**, the congestion window is increased by **<u>one more segment</u>**
- In effect, each set of acknowledgements doubles the congestion window - which **<u>grows until either a timeout occurs or the receiver's specified window is reached</u>**

Slow Start


TCP sender
TCP receiver
cwnd = 1
Data
Acknowledgement
1 RTT, 1 packet
cwnd = 2
1 RTT, 2 packets
cwnd = 3
cwnd = 4
1 RTT, 4 packets
cwnd = 5
cwnd = 6
cwnd = 7
cwnd = 8
1 RTT, 4 packets
(pipe is full)

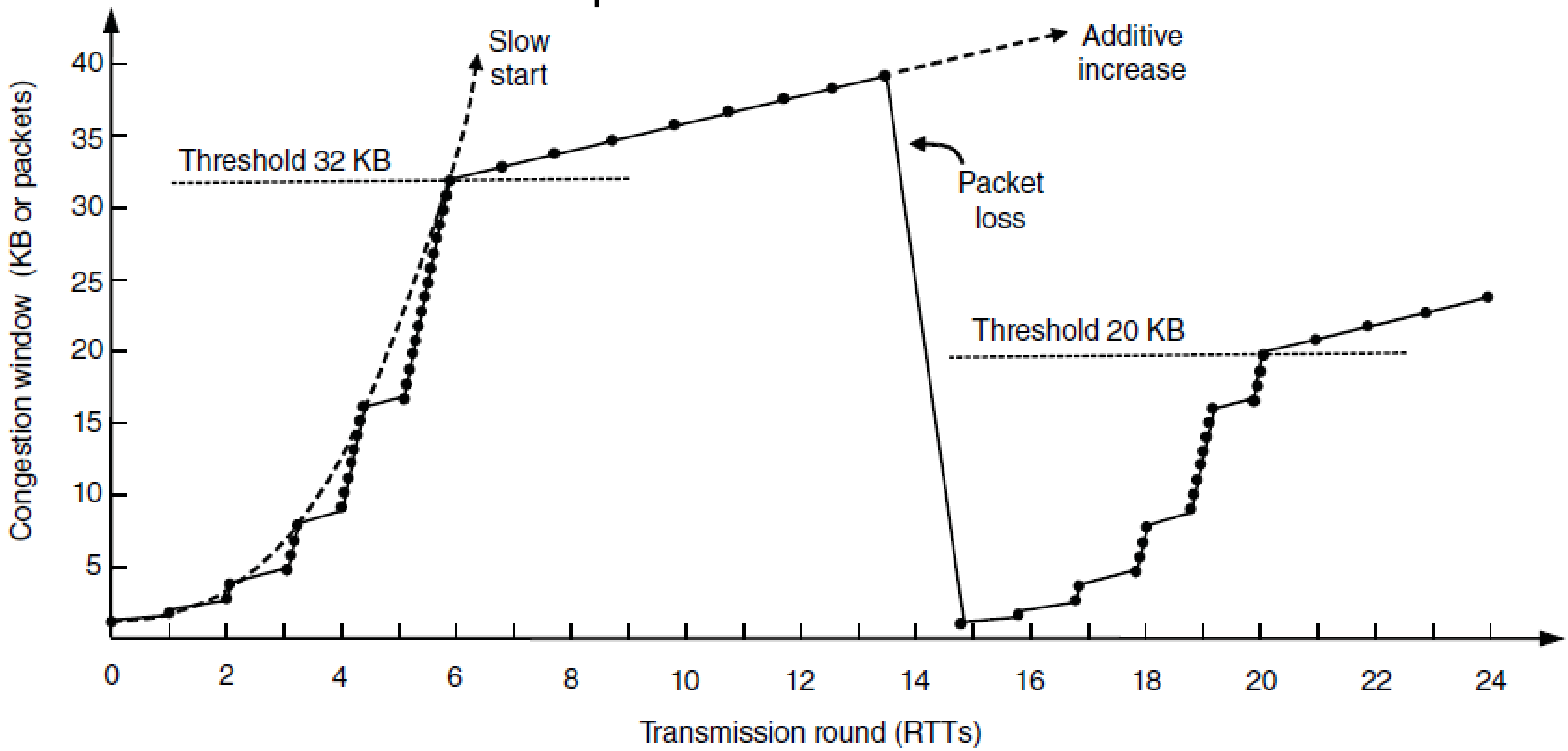
Additive increase



Internet Congestion Control Illustrated

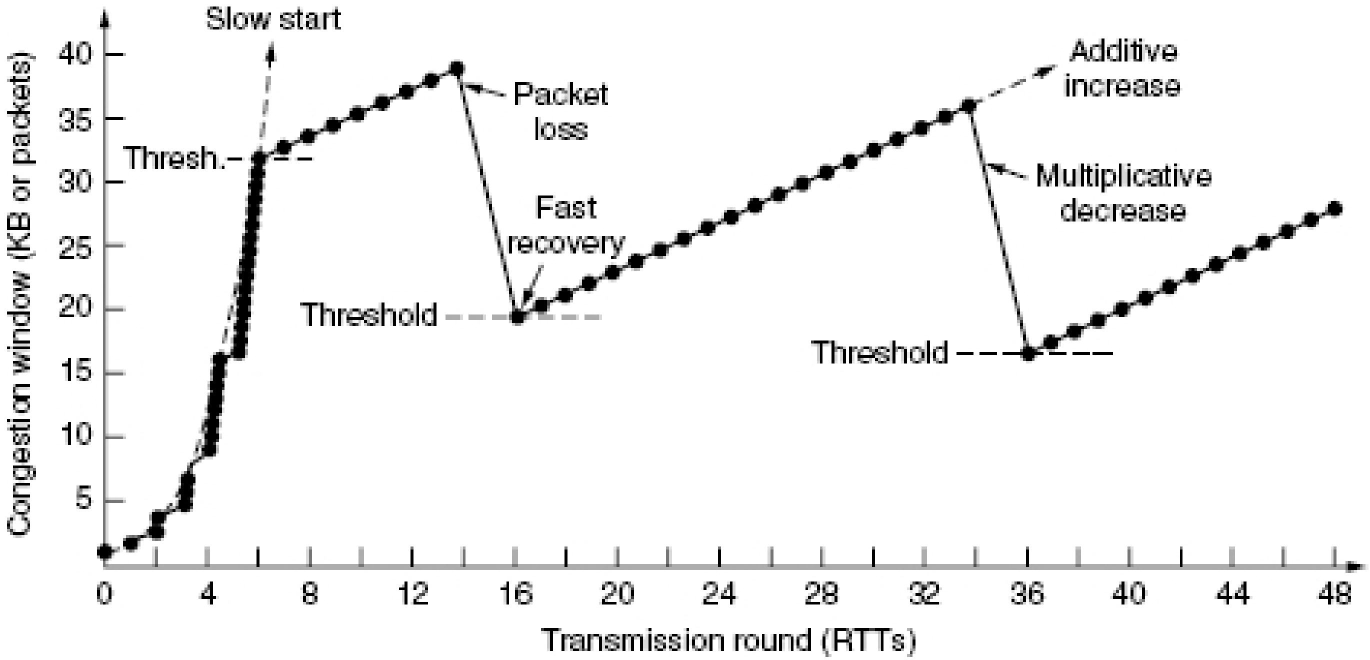
Slow start followed by additive increase (TCP Tahoe)

Threshold is half of previous



Internet Congestion Control Contd

Another one with TCP Reno



Congestion Control And Wireless

- Much harder to deal with
  - Things are increasingly wireless
  - Not everything is wireless, but parts of a path
  - So how does one know where wireless is and act
  - More variety on wireless links
  - SNR varies when people move
  - Delay is different if it is Wifi vs Satellite
  - This is a hot area of research

TCP Timer

- A key worry is when timers go out
- Too early means too many resends
- Too late means reliability comes with a huge cost
- Solutions rely on dynamicity as network conditions change
- One needs to measure network performance and adapt timers