

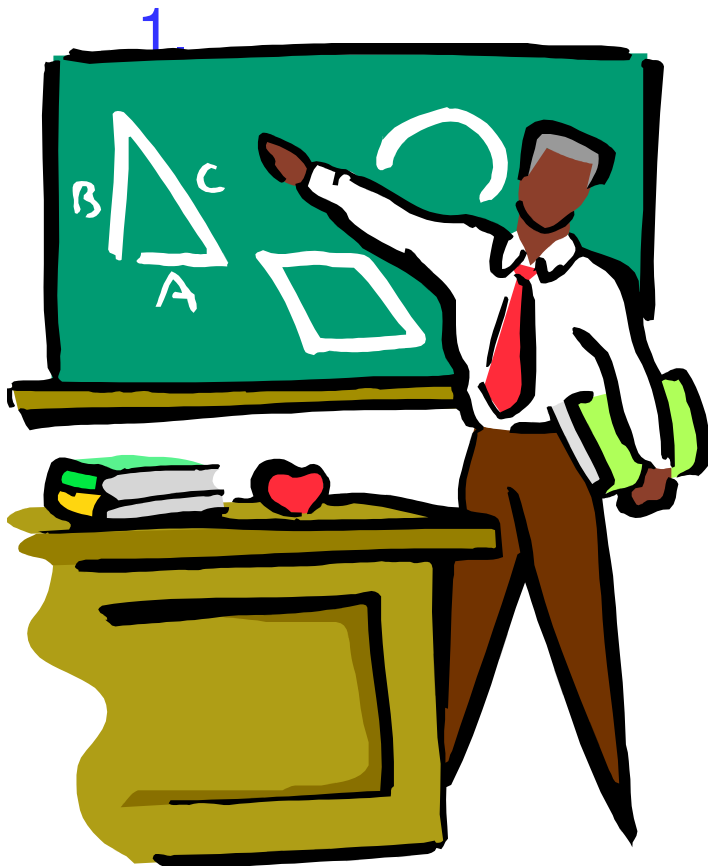


Chapter V

Wireless TCP



Congestion handling in wired TCP: Detailed treatment



- Fundamental assumptions and principles
- Key parameters
- Slow start
- Congestion avoidance
- Fast re-transmit and fast recovery



Fundamental assumptions and principles

- Fundamental assumptions:
 - Few or no error on physical layer:
 - Segment losses are quite exclusively due to network congestion
 - Congestions are detected in two ways:
 - Timeout (Severe congestion)
 - Duplicate ACK (Mild congestion)
- Fundamental principles
 - Never trigger congestion by sending more than what (you think) the network and the receiver could handle
 - Slow down when congestion is detected in order to relieve it



Key parameters

- Receiver window:
 - granted by receiver
- Congestion window (Cwd):
 - computed by the sender
 - Maximum size = Receiver window
- Effective window: $\text{Min}(\text{receiver window}, \text{congestion window})$

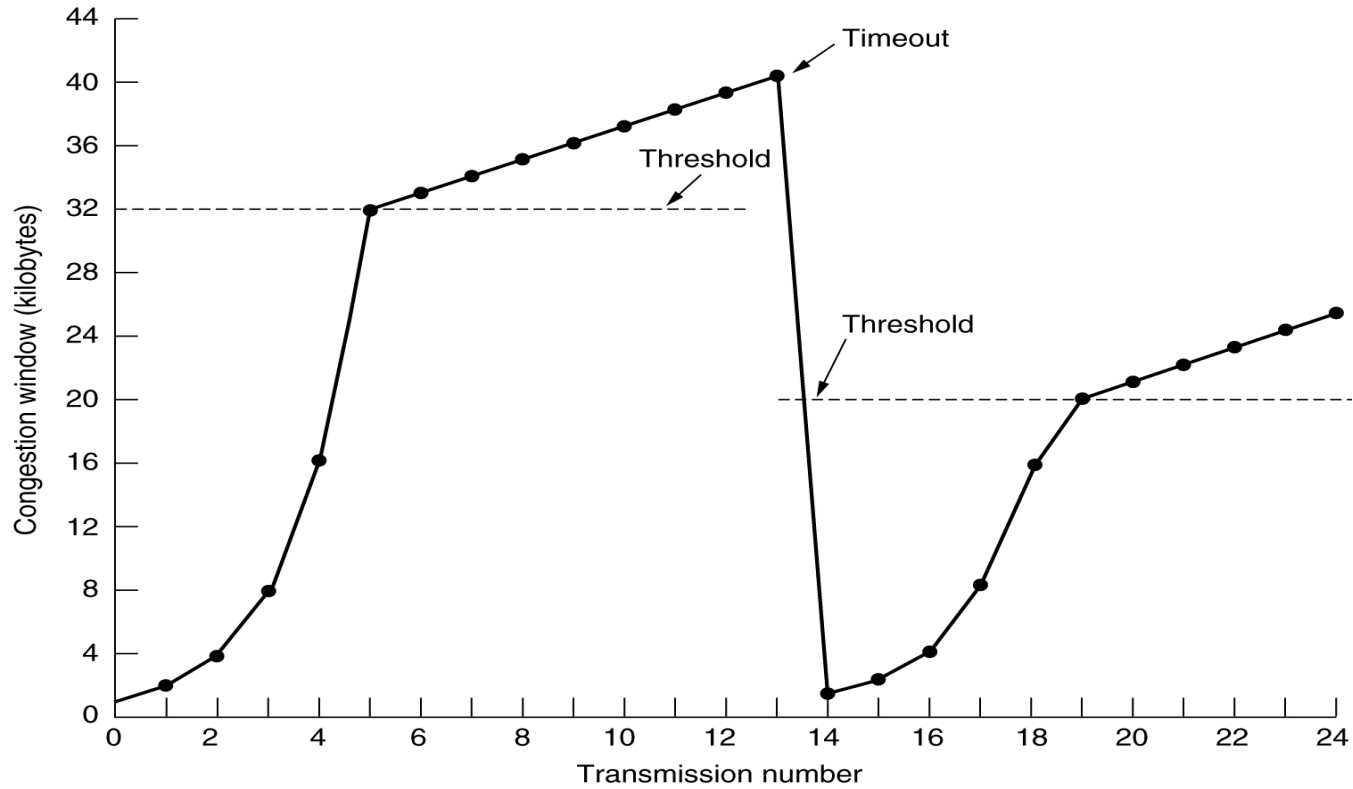


Slow start

- When?
 - A connection is established or a timeout is detected
- What?
 - Determine what the network and the receiver can effectively handle
 - Slow down in case of timeout
- How?
 - Use of threshold (ssthresh) parameter
 - Congestion window reset to 1
 - Threshold set to half of current congestion window
 - Slow start procedure to determine what the network and the receiver can actually handle



Slow start





Congestion avoidance

- Normal state of affairs
 - No inferred congestion
 - Do not trigger it by sending more than what you think the network and the receiver can handle to avoid abnormal situations
 - » Timeout (Slow start)
 - » Duplicate ACK (Fast re-transmit and fast recovery)

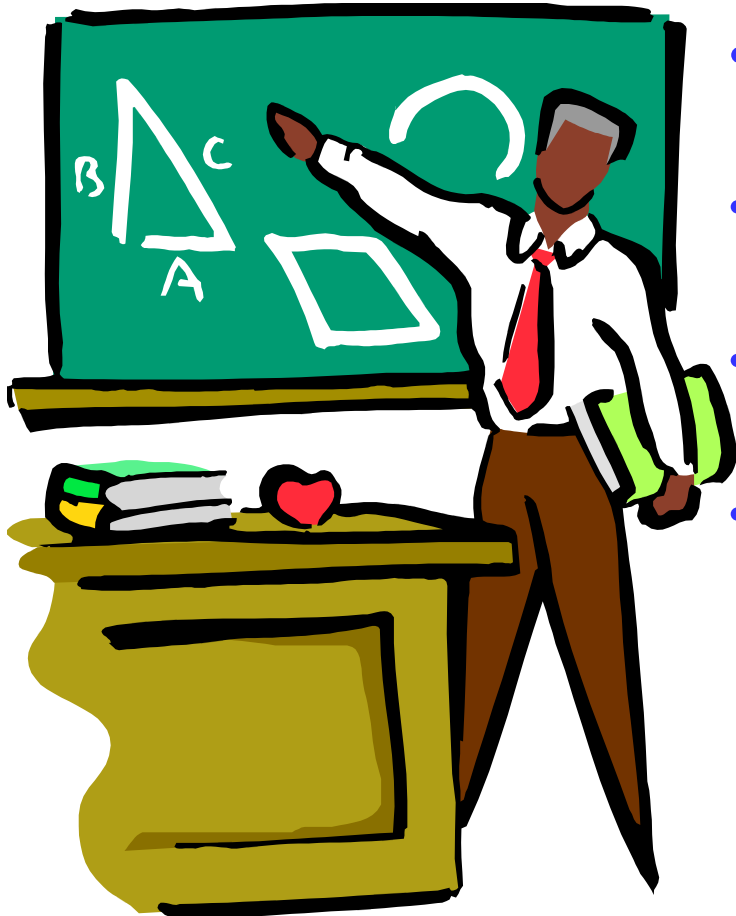


Fast re-transmit and fast recovery

- When?
 - Receipt of 3 duplicate ACK (mild congestion)
- What?
 - Send immediately inferred loss segment (Fast re-transmit)
 - Slow down and determine what the network and the receiver can effectively handle (Fast recovery)
 - Wait for ACK
 - If ACK received
 - » Back to normal state of affairs (Congestion avoidance)
 - Otherwise
 - » Slow start



Wireless TCP



- 1 - Wireless Networks
- 2 - Problems for TCP and taxonomy
- 3. Pro-active approaches
- 4 . Re-active approaches



Wireless networks

- Infrastructure – based wireless networks
 - Rely on pre-installed infrastructure (e.g. base stations / access points)
 - Examples:
 - classical (uni-hop) cellular networks,
 - Wireless Local Area Networks (WLANs) configured in infrastructure mode
- Infrastructure-less wireless networks
 - Deployed on the fly (no base stations / access points)
 - Examples:
 - Mobile ad hoc networks (MANETs)
 - Could be built using WLANs configured in infrastructure-less mode



Wireless networks

- Hybrid wireless networks
 - Made up of:
 - Infrastructure based portion
 - Infrastructure-less portion
 - Classical example:
 - Multi-hop cellular network
 - Classical unihop cellular network (eg. GSM, 3G) portion
 - Mobile ad hoc network (MANET) portion to connect cellular phones that are outside base station coverage
 - Key benefits:
 - » Increased coverage
 - » Improved performance



Wireless networks

- Key characteristics
 - Signal fading
 - Dispersion, reflection and diffraction due to obstacles
 - Mobility
 - Terminal mobility (i.e. keep on-going sessions alive while roaming)
 - Handoff / Handover in infrastructure based – networks
 - Limited power and energy



Problems for TCP and taxonomy of solutions

Problems for TCP

- Random loss of segments mistaken as indication of congestion
 - May be caused by fading
 - Triggering of wrong decisions in TCP state machine
 - » Unnecessary slow start
- Burst loss of segments mistaken as indication of congestion
 - May be caused by mobility (i.e. handoff/handover)
 - Triggering of wrong decision in TCP state machine
 - » Unnecessary slow start
- Packet re-ordering
 - May be caused by mobility (i.e. handoff / handover)
 - Triggering of wrong decisions in TCP state machine
 - » Unnecessary fast re-transmit and fast-recovery



Problems for TCP and Taxonomy of solutions

Several taxonomies exist

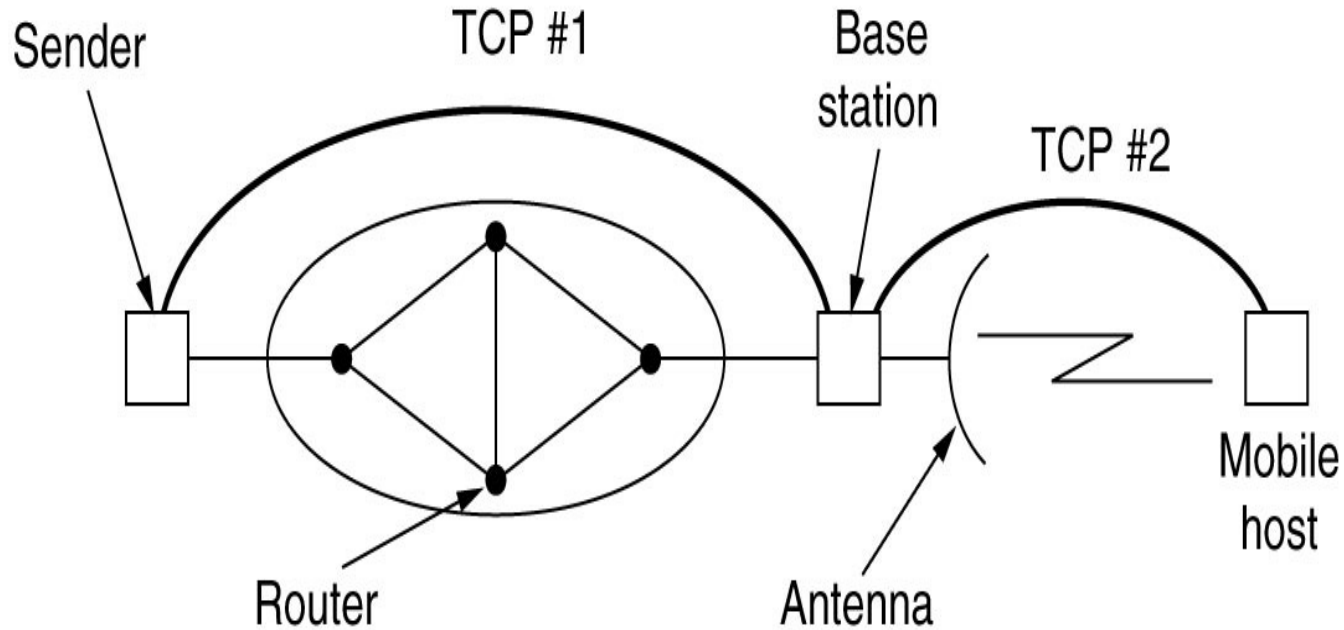
Taxonomy used in this course

- Pro-active
 - Avoid the problem (i.e. TCP segment loss without knowing the exact cause: congestion or random / burst error)
- Re-active
 - Let the problem happens (i.e. TCP segment loss without knowing the exact cause)
 - Figure the exact cause and take appropriate actions



Pro-active approaches

Split TCP (basic form)





Pro-active approaches

Split TCP (Basic form)

- Applicable to networks with a fixed portion and an infrastructure based – wireless portion
 - Split the connection in two (fixed part and wireless part)
 - Cause of segment loss determined by where the loss happens and relevant decisions are taken



Pro-active approaches

Split TCP

- Sample of disadvantages
 - Violation of TCP semantics
 - ACK may arrive before segment reaches receiver because sent by base station
 - Lack of general applicability
 - Link base station – mobile may not be the last mile (e.g. multi hop cellular networks)
 - Inefficient handling of handoff / handovers
 - Need to transfer connection state from old base station to new base station



Re-active approaches

Cross layer approaches

- Let the problem happens (i.e. segment loss without knowing the cause)
- Use information from other layers including non adjacent layers to determine the cause



Re-active approaches

Cross layer approaches

- Example: ILC - TCP
 - Sender side solution
 - Relies on a state manager that collects relevant information from all layers including
 - Link state (bad or good)
 - » Bad link indicates imminent handoff and good link indicates completion of handoff
 - Upon timeout
 - Check link state
 - » Good implies congestion
 - » Bad implies imminence of handoff
 - » Suspend TCP state



Re-active approaches

TCP probing

- Upon timeout or receipt of 3 duplicate ACK
 - Send probe segments until the ACKs of a pair of probes are received within a specified time period
 - » Why?
 - » Determine whether the cause of timeout or duplicate ACKs is congestion or something else (e.g. random loss, burst loss)
 - » How?
 - » Use of round trip time (RTT1, RTT2) of the two probes



Re-active approaches

TCP probing

- How?
 - $RTT1$ and $RTT2 < \text{Best RTT}$
 - No congestion
 - Else
 - Congestion
 - If $RTT2 > \text{Best RTT}$
 - » Severe congestion
 - » Slow restart
 - Else
 - Mild congestion
 - Fast retransmit and fast recovery



References

- A. Tanenbaum, Computer Networks, Fourth Edition, Prentice Hall, 2003 (chapter 6 – section 6.5.12)
- K. Pentikousis, TCP in Wired-Cum-Wireless Environments, IEEE Communications Surveys and tutorials, fourth quarter 2000
- K-C Leung and V. O.K. Li, Transmission Control Protocol (TCP) in Wireless Networks: Issues, Approaches and Challenges, IEEE Communications Surveys and Tutorials, Fourth Quarter 2006