Chapter V
Wireless TCP

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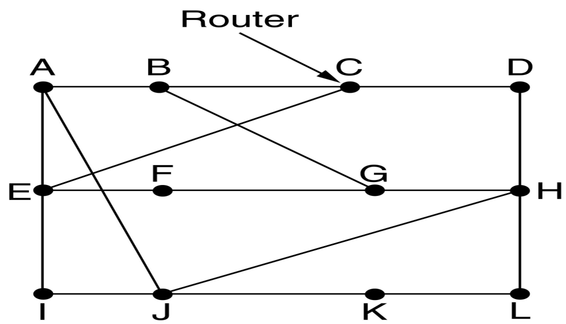
Outstanding issues from last lecture: Routing in Internet

- Distance vector algorithm



(a)

To	A	I	H	K	New estimated delay from J	Line
A	0	24	20	21	8	A
B	12	36	31	28	20	A
C	25	18	19	36	28	I
D	40	27	8	24	20	H
E	14	7	30	22	17	I
F	23	20	19	40	30	I
G	18	31	6	31	18	H
H	17	20	0	19	12	H
I	21	0	14	22	10	I
J	9	11	7	10	0	–
K	24	22	22	0	6	K
L	29	33	9	9	15	K
	JA delay is 8	JI delay is 10	JH delay is 12	JK delay is 6	New routing table for J	

Vectors received from J's four neighbors

(b)

Figure 5.9 – Reference [1]

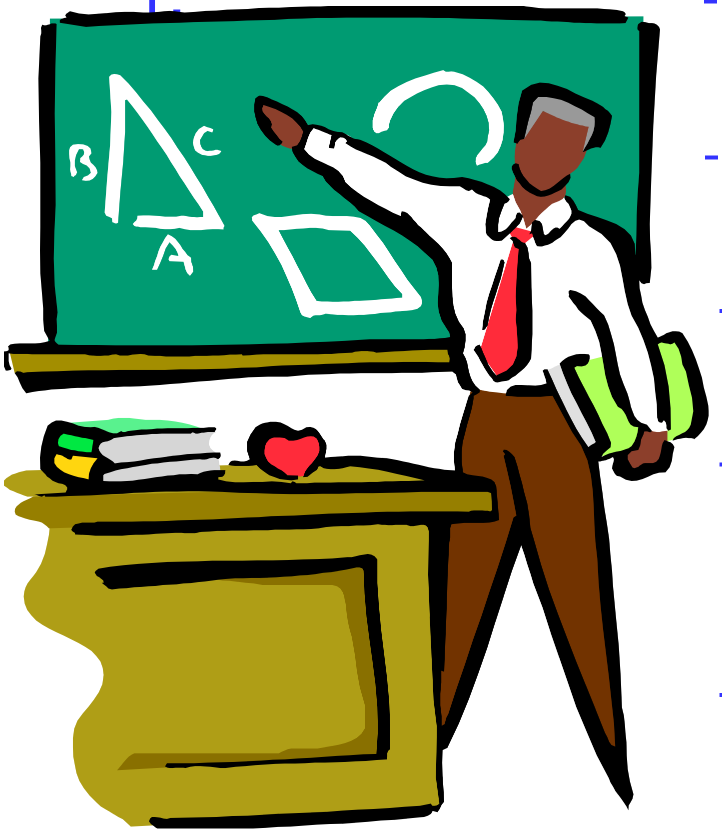
Outstanding issue from last lecture: Routing in Internet

Routing uses the general distance concept from topology mathematics

- Distance from A to B is not necessarily equal to the distance from B to A
  - Depends on metrics (e.g. satellite uplink and downlink)
- Links are not necessarily symmetrical
  - A may have B as adjacent node but B may not have A as adjacent node (e.g. a-symmetrical links)
    - B may have to reach A through a multi hop link

Congestion handling in wired TCP: Detailed treatment

1.



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

Fundamental assumptions 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

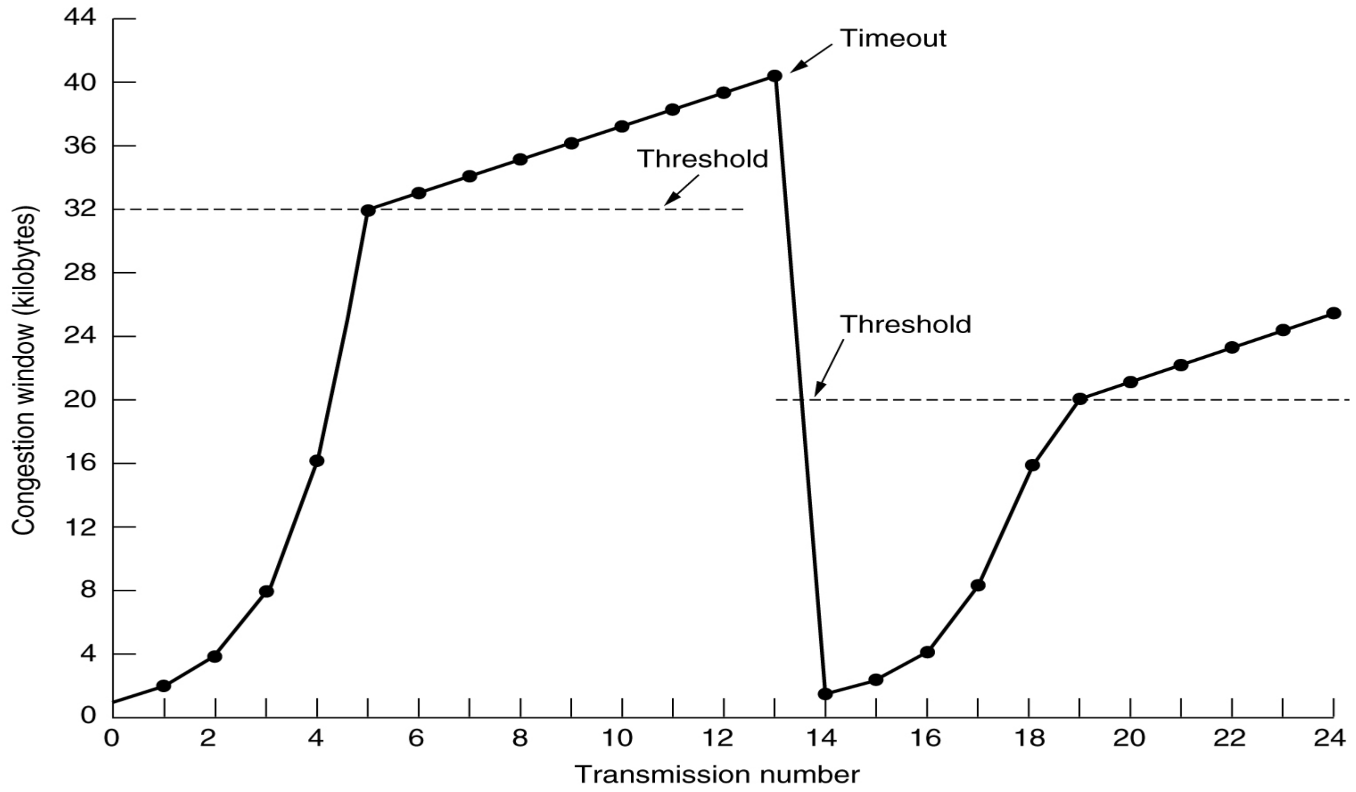
Key parameters

- Receiver window:
  - granted by receiver
- Congestion window (Cwd):
  - computed by the sender
    - Maximum size = Receiver window
- Effective window: Min (receiver window, 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


Timeout
Threshold
Threshold
Congestion window (kilobytes)
0
4
8
12
16
20
24
28
32
36
40
44
0
2
4
6
8
10
12
14
16
18
20
22
24
Transmission number

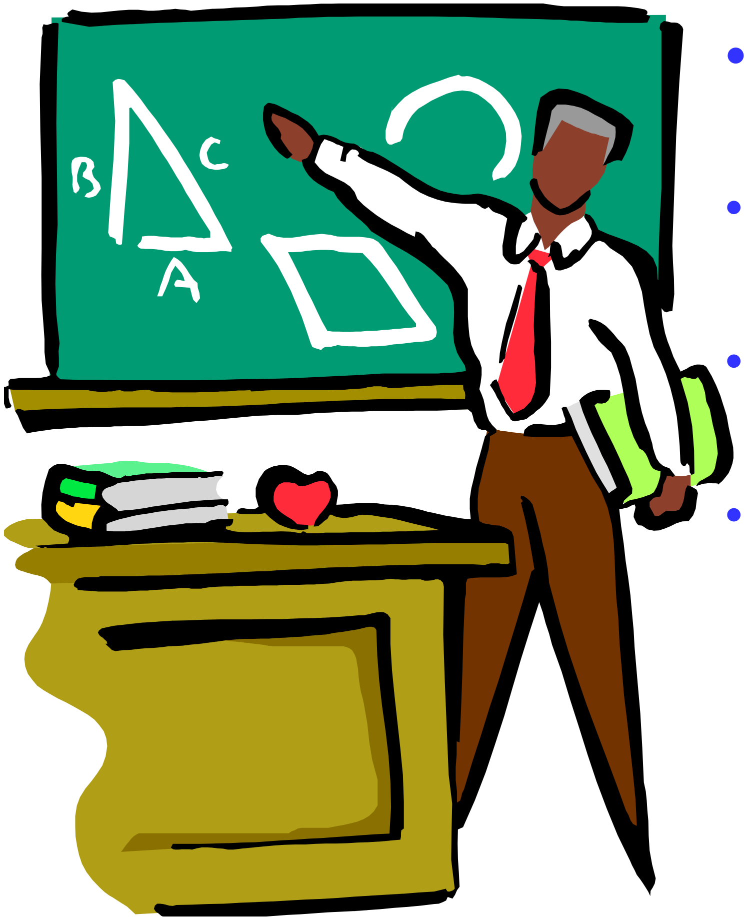
Congestion avoidance

- 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 (unihop) 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

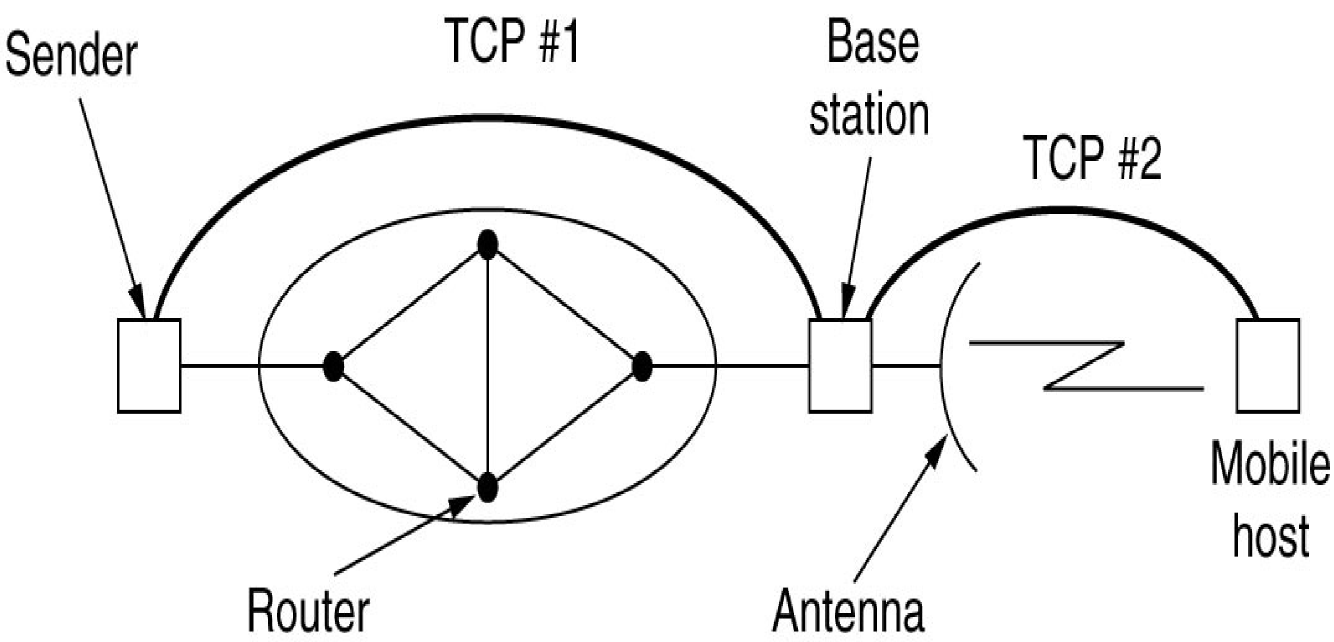
Several taxonomies exist

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 < Best RTT
    - No congestion
  - Else
    - Congestion
      - If RTT2 > 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

Routing in Internet

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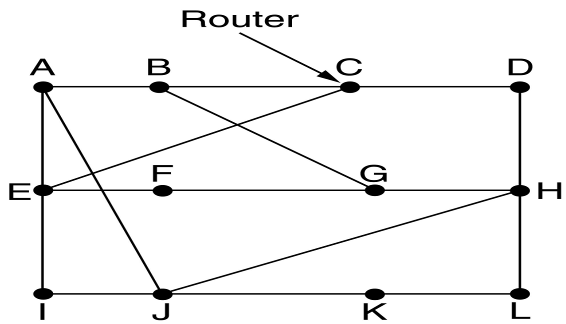

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