Chapter V

Wireless TCP
Outstanding issues from last lecture: Routing in Internet

- Distance vector algorithm

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
2. Key parameters
   - Slow start
3. Congestion avoidance
4. 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**
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 (e.g. 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 happen (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

– K. Pentikousis, TCP in Wired-Cum-Wireless Environments, IEEE Communications Surveys and tutorials, fourth quarter 2000
Routing in Internet

- Distance vector algorithm

![Diagram of a network with routers and distances between nodes.](image)

*Figure 5.9 – Reference [1]*