End-End Layer

Quiz Review Notes 2007

- Network layer provides best effort services
- Packets may be
  - Lost
  - Delayed
  - Reordered
  - Corrupted
  - End-End layer tries to create a more comfortable environment for applications

Techniques for E2E assurances

- At-least once delivery
- At-most once delivery

- Data Integrity
- Flow control

At-least-once delivery

- Add nonce
- Add timer
  - If timer expires before ACK, retransmit and reset the timer
  - Keep trying forever?

  No absolute assurances

Timers

- Fixed timers
  - Not a good idea since RTT depends on congestion
- How do you pick the correct value?
- Too small – too many retransmission
- Too large – wait too long
- Use Adaptive timers
  - Dynamically adjust to currently observed conditions
  - Works better but complex

At-most once delivery

- Need to suppress duplicates
- Receiving side keeps track of already seen packets
- If duplicate request -> resend ACK
- Challenges
  - How long to keep these nonces for
  - What if the server crashes

Data Integrity

- Add checksum

- Why is link-layer check sum not enough?
  - Only protects data while it is in transit

Flow Control

- Lock-Step : Send one segment, wait for ACK before sending another
- Too slow – one packet per RTT
- Send a window of packets
  - Ask receiver how much to send (assume receiver bottleneck)
  - Wait for ACKs before sending next window. Still too slow

Sliding Window

- Add space to window on the fly
- Sender advances window as soon as it receives an ACK
- How big should the window be?
- Wmin = RTT * bottleneck data rate
- What if network is bottleneck – congestion control

Jitter control

- Real-time applications need regular delivery schedule
- Network causes varying transit times – jitter
- Keep a buffer and delay all arriving segments to provide a constant data rate

E2E examples

- E2E – transport + application
- Example transport protocols
- UDP
- TCP
  - Stream of bytes
  - Assurance of delivery, data integrity, order
  - Flow control