Internet Engineering

241-461

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Delivery Address

- Mail to
  - user@domain.name
- We know how to deliver it
- We know the sender MTA
  - The one that currently has the message
- What system is the destination MTA?
- Is it domain.name ?
- Consider user@psu.ac.th
  - What system is psu.ac.th ?
  - There isn't one!
- Must all e-mail
  - be delivered to a specific host?
  - No, don't want that.
    - Need a better way

Mail Exchanges

- Mail Exchange
  - System that takes mail for a domain
  - Delivers to all users in that domain
    - directly or indirectly
- Need method to find Mail Exchange for domain
  - As well as address for hostname
- Domain Name System
  - Translation from domain name to
    - Address (v4 or v6)
    - Mail Exchange
    - Geographic Location
    - System & OS type
    - ...
  - .... Later

Network Requirements

- Reliable Communications
  - Nothing lost
  - Nothing added
  - Nothing out of order
  - Not arriving too quickly
- Clean Termination
  - Last data always arrives
  - End indication follows last data
- Transport Layer
  - TCP
    - Transmission Control Protocol

Reliable ?

- Reliable means
  - It must work
  - We can rely upon it working
  - No need to test
    - service guaranteed
- NO
- Reliable means
  - It works
  - Or we are told it failed

TCP

- RFC 793
  - IETF/ISOC Request For Comments
  - Internet Standards
- Transport Protocol
  - Arranges communications between applications
    - Between peers
      - client & server
      - or equal nodes
  - Recovers from errors
    - Lost data in network
    - Reordered data
    - Duplicated data
  - Delivers original data
    - In order
    - Without errors
  - Or reports Error

Underlying Network

- To come later, but
  - ethernets deal with packets
  - applications (often) deal with files
    - One file ==> many packets
- data stream
    - file or whatever it is
  - must be broken into pieces
  - each sent individually
  - reassembled at receiver
- TCP does this
  - pieces called segments

Handling Loss

- Some segments might be lost in network
  - never arrive at destination
- How does TCP know?
  - TCP works for any data
  - It cannot look at image
    - "Look ma - person with no face"
- TCP sender adds identifiers to segments
  - TCP receiver looks for incoming identifiers
  - Notices any missing
- Identifiers?
  - 1 2 3 4 5 ...

Identify what?

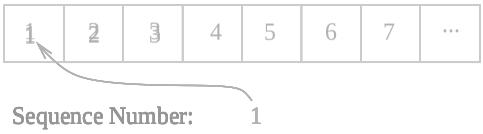
- TCP sends segments
  - So, one identifier for each segment ?
- How big is a segment?
  - Depends upon network underneath
  - Packet might pass through several networks
    - different maximum sizes
- TCP identifies octets
    - octet == byte
  - One identifier for each octet
- Sequence Number

Sequence Numbers

- One number for each octet in data
  - Numbers monotonically increasing
    - They get bigger
      - never smaller
      - not even equal
    - Increase by 1 for each octet
- Data stream might be large
  - Many giga-bytes
- Sequence number will get big
  - If start at 1
  - Will end at big number
    - when transfer completes
- Two problems
  - sequence numbers take more space than data
    - waste lots of network bandwidth
  - we have no idea how big maximum will be

Sequence Numbers (2)

- Two problems
  - sequence numbers take more space than data
    - waste lots of network bandwidth
- Solution
  - Assume data in segment is a unit
    - all arrives
    - in same order
    - or none arrives
  - In segment
    - include sequence number of first octet
      - explicitly
    - calculate sequence numbers for others
      - using addition



Sequence Number: 1

Sequence Numbers (2)

- Two problems
  - sequence numbers take more space than data
    - waste lots of network bandwidth
  - we have no idea how big maximum will be
- Solution
  - Define sequence number space as a circle
    - 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7 0 1 2 ...
  - Sequence continues indefinitely
    - Just like time on a clock
- Issue
  - How big is the circle?