Internet Protocol Stack
CS414

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Existing and New Protocols

- Existing Protocols
  - TCP - reliable transport protocol
  - UDP - unreliable transport protocol
  - IP - Internet Network Protocol
  - IMCP - Internet Message Control Protocol
- New Protocols
  - IPng - IP next generation (IP version 6)
  - RTP - Real-Time Transport Protocol
  - Integrated Services/RSVP - Resource Reservation Protocol
  - RTSP
  - Differentiated Services

Transmission Control Protocol

TCP provides

- reliable, serial communication path between processes exchanging a full-duplex stream of bytes;
- full-duplex TCP connections;
- sequential delivery (no reordering required);
- reliable delivery, achieved through retransmission on timeouts and positive acknowledgement on receipt of information;
- flow control, based on window technique;

Not suitable for multimedia transmission. This lead to TCP improvements.

Techniques for Going Faster

- Prediction of Greg Chesson (talk in 1987): "TCP/IP and OSI might never go faster than 10 Mbps".
- Van Jacobson investigated the problem of making TCP faster.
- Techniques to improve protocol implementation:
  - Memory management - reduce copying
  - Interrupt handling - clocked interrupts

Better Lookup Techniques

- TCP must find the connection block for each segment received;
- IP must find a route to be able to send an IP packet;
  - use caches of frequently used information
  - find lookup algorithms
- **Caches**: maximize hit rate, minimize search and maintanence (conflict)

  - most effective - small caches
  - packets travel in packet trains
  - one-back caches (one-back receiver cache, one-back sender cache); cache of 20 routes showed hit rate of 90 % (Feldmeier)

- **Lookup algorithms**: for transaction processing; hashing using open chaining, where head of each hashed link list keeps a cache of the last accessed control block ;

Prediction

- TCP has many features: retransmission, window sizes, urgent data, however, these features are expensive to implement.
- TCP behavior is highly predictable and one can take advantage by optimizing the frequent path through the TCP code at the sender and receiver;
- Algorithm for TCP receivers: header prediction. which looks for segment that fits the profile of the segment the receiver expects to receive next.

Sequence Numbers

- High delay-bandwidth product has an implication on the TCP window size and sequence space;
- TCP window size is 64 KBytes - we need possibility to negotiate the window size.
- Sequencing uses wrap-around counters to put in sequence numbers. The sequence number space is too small.
- Example: In case of 10 Mbps, the IP packet lifetime was designed with 120 seconds and the sequence space of 32 bits. It takes about 1700 second to send 2^{31} bytes with this throughput.

- Example: In case of Gigabits per second, it takes 17 seconds to send 2^{31} bytes.

Flow and Congestion Control

- High delay-bandwidth product causes long time to tell the sender to slow down;
- Example: From New York to Los Angeles, TCP continues to send packets for about 30 ms (gigabit per second assumed) before it hears request from Los Angeles receiver.
- Slow-start algorithm is the flow and congestion control mechanism.
- Probing algorithm requires the sender to keep congestion window, which is the estimate of how much traffic the network can actually take.
- The congestion window is managed using a two-part algorithm:
  - Sender sends exponentially until segment gets lost.
  - Sender sends exponentially up to half the previous window, then the window grows linearly.

User Datagram Protocol

- UDP is an extension of IP
- UDP supports multiplexing of datagrams
- checksuming
- higher level protocols using UDP must provide: (1) retransmission, (2) packetization, (3) reassembly, (4) flow control, (5) congestion avoidance.
- this protocol is also not suitable for multimedia communication, but many multimedia protocols reside on top of UDP.

Internet Services and Protocols

- Internet protocols changed in order to provide **Integrated Services** (Differential Services).
- Internet Protocol provides unreliable delivery of datagrams in a point-to-point fashion.
- IP provides **types of services**(TOS) which can be used for indication of service quality. TOS specifies:
  - precedence relation,
  - services such as minimize delay, maximize throughput, maximize reliability, minimize monetary cost;

Multicasting

- Most current network protocols provide only *unicast* - point-to-point connectivity. If one wants to reach multiple receivers, partial solution is to do *replicated unicast*.
- A better solution is *multicast* which current IP already provides (mbone routers = multicast routers).

Internet Group Management Protocol

- Protocol for managing Internet multicast groups.
- Host Membership Query messages are sent by multicast routers.
- Host Membership Reports are sent by hosts. Here, either individual host or group can respond.
- Queries are sent infrequently to keep the IGMP overhead low.
- In multimedia communication, IGMP must cooperate with resource management protocols such as RSVP to provide resource reservation.