CS118 Discussion 1B

TCP: Throughput, Loss rate
IP: IP header, subnet, fragmentation

Week 6

Zhiyi Zhang (zhiyi@cs.ucla.edu)

@myself record

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- TCP throughput and Loss Rate
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TCP Throughput and Loss Rate

TCP Throughput

- Clarification of Chapter 3, slide 132
  - The stable phase of TCP is the congestion avoidance and no timeout (but fast recovery happens from time to time)
  - If we consider fast recovery to be periodic, then there is a repeated pattern from W/2 to W. Therefore the average window size is 3/4W
- Average throughput is your (transmitted data in one RTT) / RTT
  - Here transmitted data in one RTT is 3/4W, so avg. TCP throughput is ¾*W/RTT bytes/sec

TCP Loss Rate

- Loss rate = (lost pkts) / (transmitted # pkts)
- Take homework 5, question 3 (a) as an example
  - In congestion avoidance, the window is
    - W/2
    - W/2 + 1 in next RTT
    - W/2 + 2 in next next RTT
    - …
    - W
  - Therefore, the total packets transmitted in these many RTTs is
    - W/2 + (W/2 +1) + … + (W/2 + W/2) = ⅜*W^2 + ¾*W
  - Therefore, the loss rate is
    - L = 1/(⅜*W^2 + ¾*W), O()
- Homework 5, question 3 (b)
  - ¾*W/RTT
  - L = 1/(⅜*W^2 + ¾*W) approximately = 1/(⅜*W^2), so W = (8/3L)^(1/2)
  - So ¾*W/RTT = ¾*(8/3L)^(1/2)*MSS/RTT

Network Layer

Basic functions: Routing (Control Plane)

- Routing
  - To build up the knowledge for routers to know which packet should be forwarded to which next hop
  - To build the knowledge, multiple routers and sometimes external servers need to collaborate
    - Because a single router can only know its direct neighbors
  - Two existing solutions
    - Routers collaborate to set up the knowledge
      - A----B----C----D
      - B tells C that B can reach A
      - C tells D that C can reach A through B
    - Routers get knowledge from a dedicated server
      - A----B----C----D
      - All of them are connected to a SDN server
      - The server have the god view to set up the knowledge

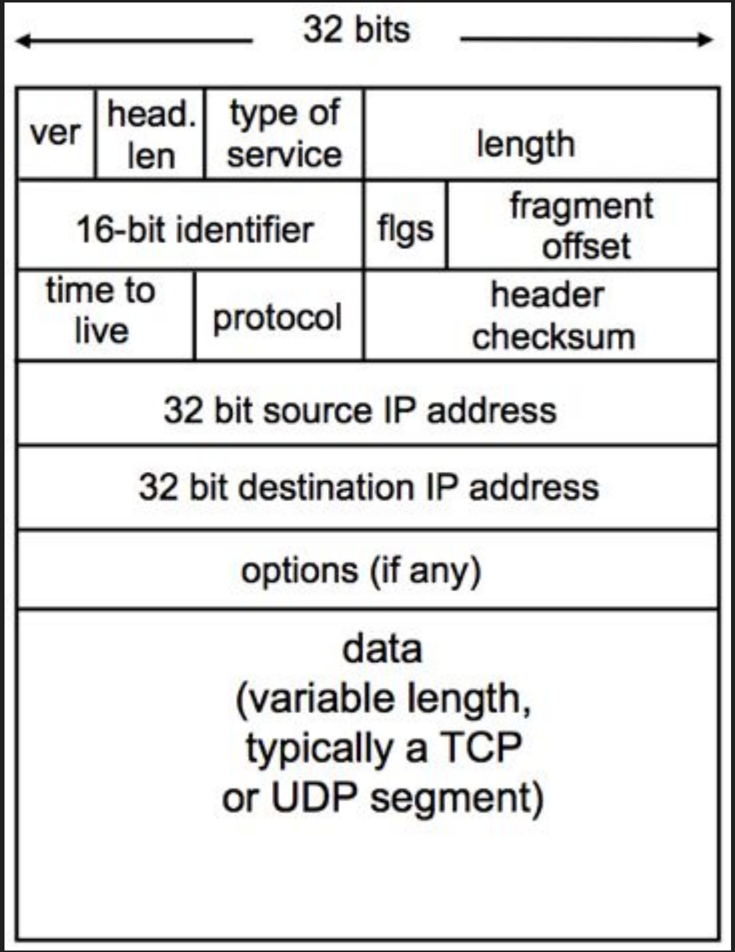
Basic functions: Forwarding (Data Plane)

- Forwarding
  - Forward packets based on the knowledge gained from routing
  - Each router handles its own business
    - When I receive a pkt, I forward it to its next hop
    - Router at the next hop will do his business for further forwarding

IP

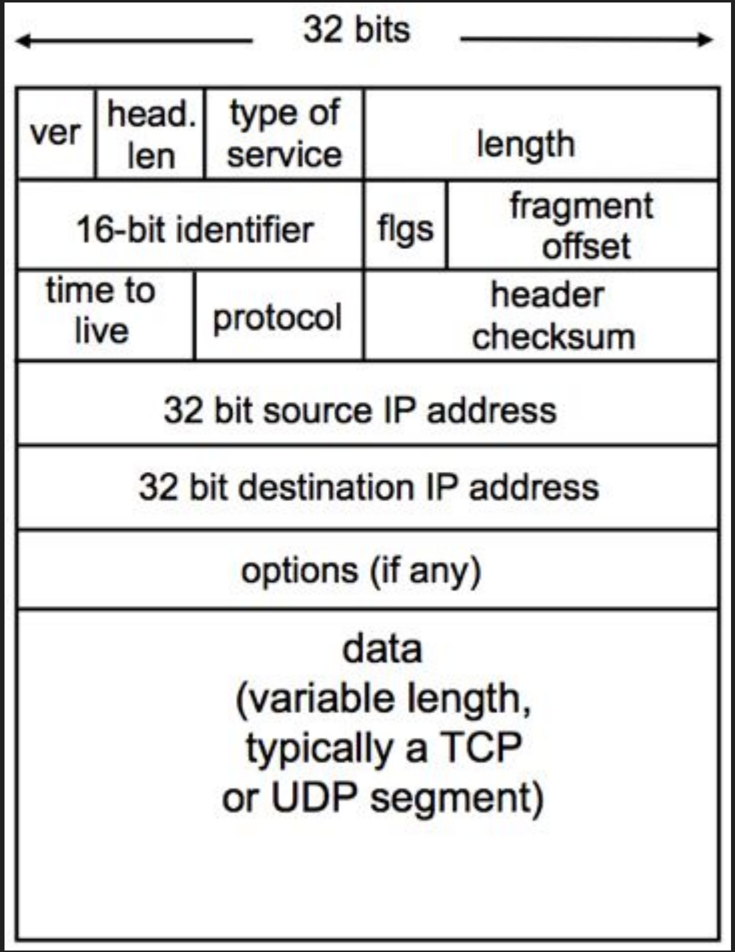
IP Header

- Version: 4 bits
  - IPv4
- Header length (IHL): 4 bits
  - Indicate the length of the header
  - **In the unit of 4 bytes**
  - Maximum IP header? 4 * (1111)binary = 60 bytes
- Type of Service: 8 bits
  - Not really used in many cases
  - Read RFC 791 for details
- Total Length: 16 bits
  - Total length of the packet, including header and payload
  - **In the unit of 1 byte**



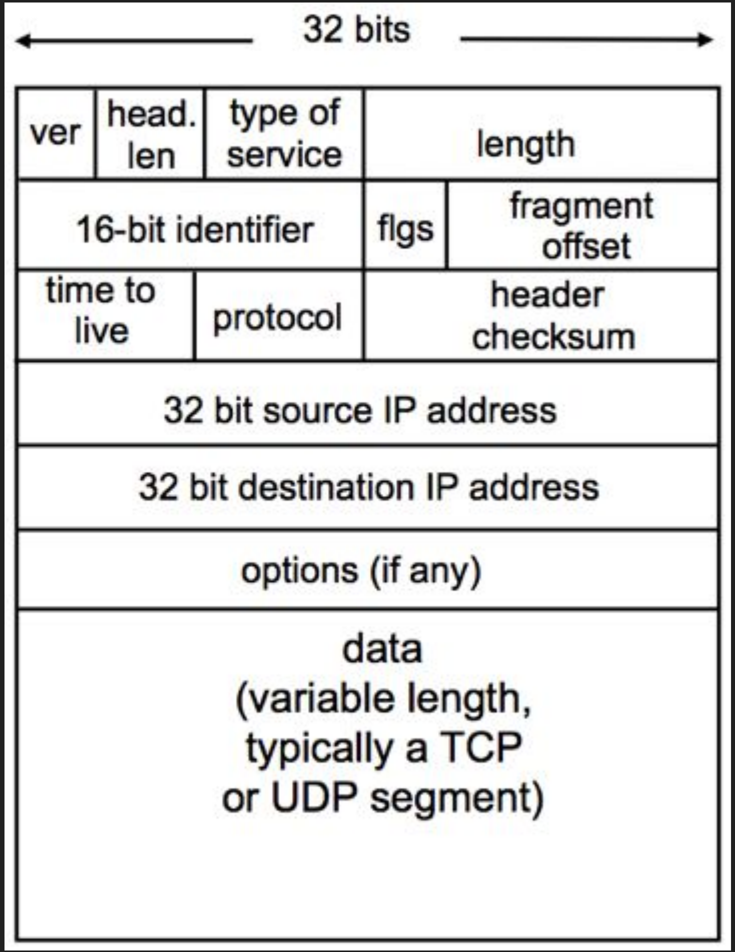
IP Header (cont'd)

- Identifier: 16 bits
  - Identify fragments that belong to the same segment
- Flags: 3 bits
  - 1st: reserved to be 0
  - 2nd: DF (don't fragment)
    - No fragmentation
  - 3rd: MF (More fragments)
    - This is not the last fragment
- Offset: 13 bits
  - **In the unit of 8 bytes**
  - Indicate where in the datagram this fragment belongs.
- TTL: 8 bits
  - Time to live



IP Header (cont'd)

- Protocol: 8 bits
  - Indicate the next level protocol
  - Usually it's TCP or UDP
- Header checksum: 16 bits
- Source IP address: 32 bits
- Destination IP address: 32 bits



IP Address

How to identify hosts in Internet Protocol?

- IP address to identify a host (interface)
  - (IPv4) 32 bits string
  - (IPv4) Usually represented in the format of 8 bits (0 - 255), 8 bits, 8 bits, 8 bits
    - E.g., check your own IP address by ifconfig command
    - Is your IP address globally unique?
      - No. Why?
      - 192.168.0.111 (private address, NAT)
      - E.g., set up a forwarding server using amazon cloud
    - Is UCLA website's IP address globally unique?
      - Yes. Why?
- IP prefix or network ID to identify a collection of hosts/ a network
  - In the format of <network address>/<subnet mask>
  - Used for IP aggregation -- reduce the size of a router's forwarding table

IP address

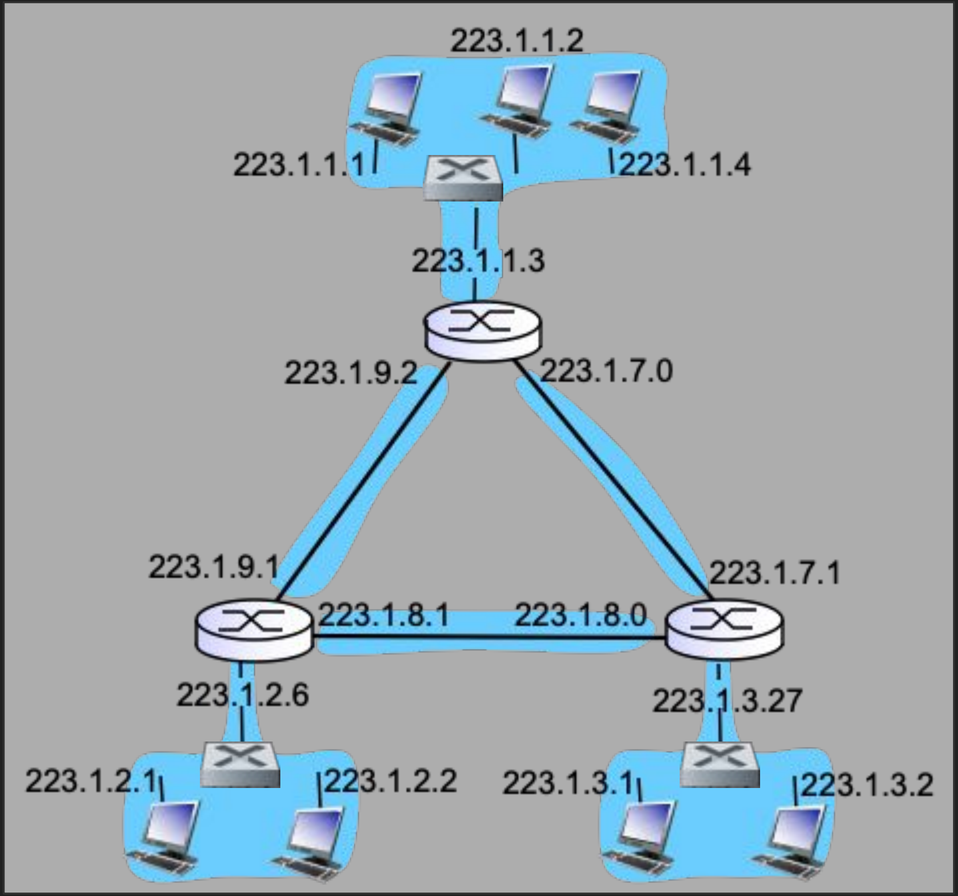
- Each interface has an IP address
  - E.g., your Laptop's Ethernet network interface card (NIC) has an IP address -- IP based on ethernet
  - E.g., your Laptop's WiFi NIC has an IP address -- wifi router
  - E.g., a router with 10 interfaces has 10 IP addresses
- Contains two parts:
  - Network ID: is different from network to network. But is the same within the same network
    - E.g., in your home, all devices have network ID: 192.168.X.X/16 : (255.255.0.0)
    - In this case, 192.168.0.0/16 is the network ID
    - Usually, backbone routers forward packets with network ID
  - Host ID: is different from host to host within the same network
    - E.g., in your home, your IP 192.168.0.10 has host ID 0.10 if the network mask is 255.255.0.0
    - E.g., in your home, your IP 192.168.0.10 has host ID 10 if the network mask is 255.255.255.0
    - Your home router forwards packets with full IP address

Class of IP addresses

Class	Leading bits	Size of *network number* bit field	Size of *rest* bit field	Number of networks	Addresses per network	Total addresses in class	Start address	End address	Default subnet mask in dot-decimal notation	CIDR notation
Class A	0	8	24	128 (2^7)	16,777,216 (2^{24})	2,147,483,648 (2^{31})	*0.0.0.0*	*127.255.255.255*[a]	*255.0.0.0*	*/8*
Class B	10	16	16	16,384 (2^{14})	65,536 (2^{16})	1,073,741,824 (2^{30})	*128.0.0.0*	*191.255.255.255*	*255.255.0.0*	*/16*
Class C	110	24	8	2,097,152 (2^{21})	256 (2^8)	536,870,912 (2^{29})	*192.0.0.0*	*223.255.255.255*	*255.255.255.0*	*/24*
Class D (multicast)	1110	not defined	not defined	not defined	not defined	268,435,456 (2^{28})	*224.0.0.0*	*239.255.255.255*	not defined	not defined
Class E (reserved)	1111	not defined	not defined	not defined	not defined	268,435,456 (2^{28})	*240.0.0.0*	*255.255.255.255*[b]	not defined	not defined

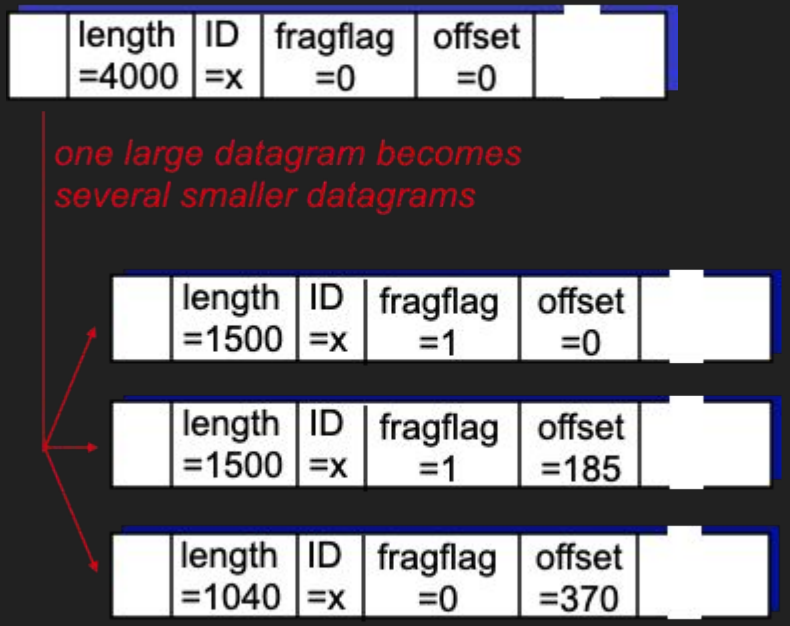
Subnets

- Divided by router's interface
  - E.g., the upper router in the picture connects three subnets
    - 223.1.1.0/24
    - 223.1.9.0/24
    - 233.1.7.0/24
- IP address network ID can be further divided by increasing the network mask length
  - E.g., under 223.1.1.0/24, I can further have subnets with network ID
    - 223.1.1.0/25 -> CS
    - 223.1.1.128/25 -> EE



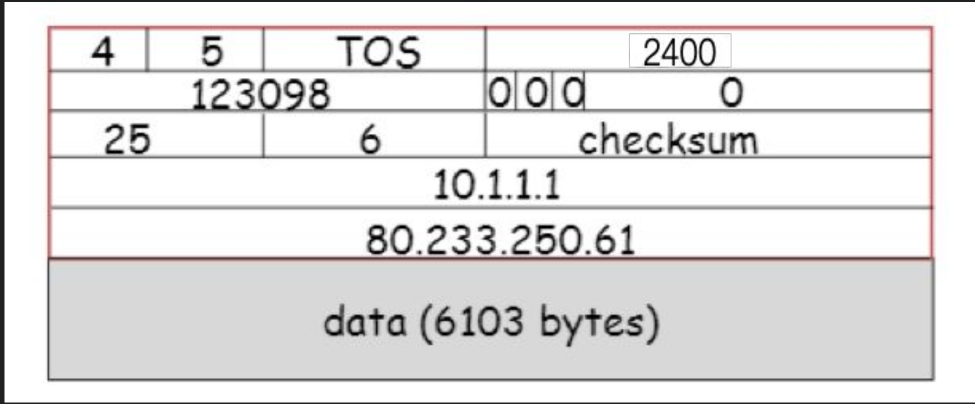
IP Fragmentation

Learn from an example



- Identifier = x
- Packet Length = 1500
  - Header: 20
  - Payload: 1480
- Fragflag
  - MF = 1 for the first two packets
  - MF = 0 for the last packet
- Offset
  - Original packet's payload: 4000 - 20 = 3980
  - Fragment 1's payload: 0 - 1479; offset = 0
  - Fragment 2's payload: 1480 - 2959: offset = 1480/8 = 185
  - Fragment 3's payload: 2960 - 3979: offset = 2960/8 = 370

An example question



- Background
  - MTU: 1450 Bytes
- Questions
  - What’s the packet header length?
    - 5 * 4 = 20 bytes
  - What’s the total length for the first packet?
    - 20 bytes (header) + 1430?
    - **No. because offset is in the unit of 8, 1430 mod 8 != 0**
    - Therefore: 20 bytes (header) + 1424 bytes (payload) = 1444 bytes
  - What’s the total length of the second packet?
    - 20 bytes (header) + (2400 - 20 - 1424) = 20 bytes (header) + 956 bytes (payload) = 976 bytes