

Name ..... ID ..... Section ..... Seat No .....

# Sirindhorn International Institute of Technology Thammasat University

**Final Exam Answers: Semester 2, 2012**

**Course Title:** ITS413 Internet Technologies and Applications

**Instructor:** Steven Gordon

**Date/Time:** Thursday 28 February 2013; 13:30–16:30

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## **Instructions:**

- This examination paper has 16 pages (including this page).
- Conditions of Examination: Closed book; No dictionary; Non-programmable calculator is allowed
- Students are not allowed to be out of the exam room during examination. Going to the restroom may result in score deduction.
- Turn off all communication devices (mobile phone, etc.) and leave them at the front of the examination room.
- Write your name, student ID, section, and seat number clearly on the front page of the exam, and on any separate sheets (if they exist).
- The examination paper is not allowed to be taken out of the examination room. A violation may result in score deduction.
- Reference material at the end of the exam may be used.

Internet Technologies and Applications, Semester 2, 2012

Prepared by Steven Gordon on 18 February 2013

ITS413Y12S2E02, Steve/Courses/2012/s2/its413/final-exam.tex, r2692

## Question 1 [15 marks]

The following algorithms/events change the value of the Congestion Window ( $cwnd$ ) in TCP congestion control:

- Additive Increase
  - Slow Start
  - Loss detected by Timeout
  - Loss detected by Duplicated ACKs
- (a) The following equations describe how the new Congestion Window is calculated. Match the correct algorithm/event above to the equation below by writing the name of the algorithm/event: [4 marks]

i.  $cwnd_{new} = \text{minimum}(ssthresh, cwnd_{old})$  *Loss detected by Duplicate ACKs*

ii.  $cwnd_{new} = MSS$  *Loss detected by timeout*

iii.  $cwnd_{new} = cwnd_{old} + \frac{MSS * MSS}{cwnd_{old}}$  *Additive Increase*

iv.  $cwnd_{new} = cwnd_{old} + MSS$  *Slow Start*

- (b) In addition to the congestion window, TCP also has an advertised window. Explain the purpose of the two windows. [2 marks]

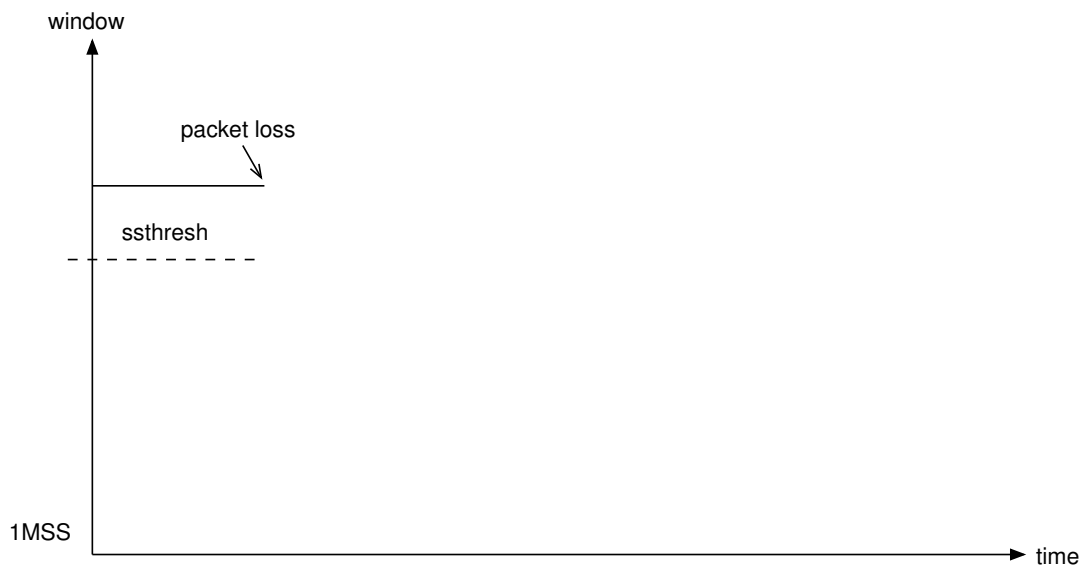
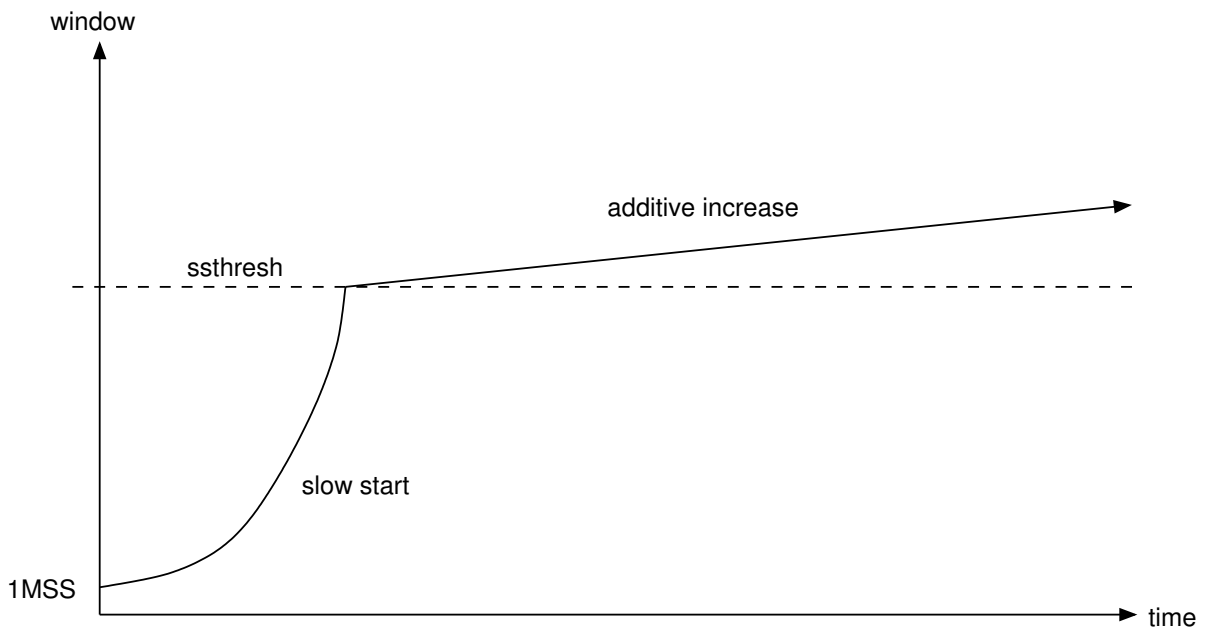
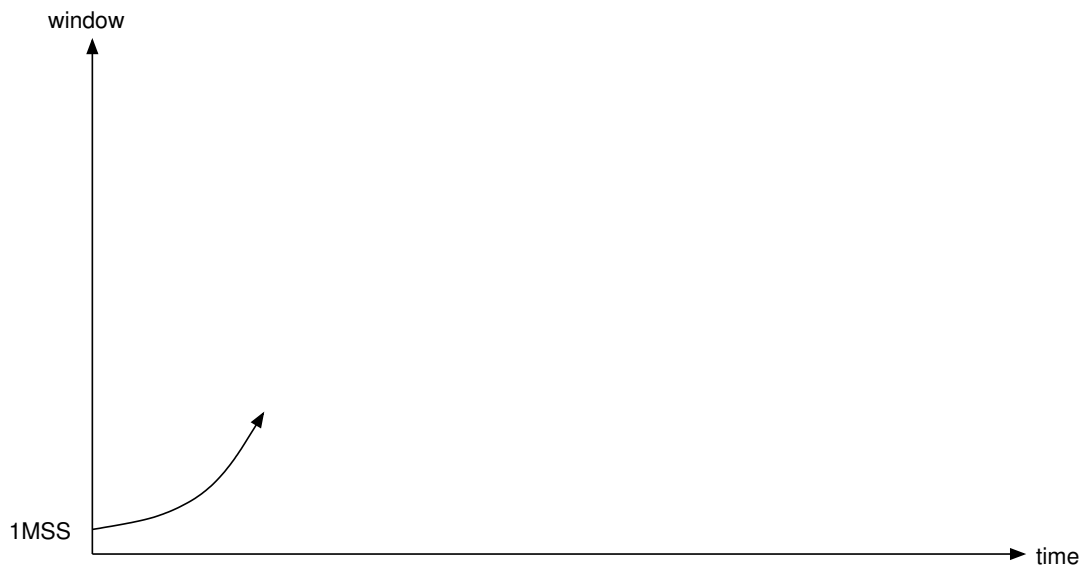
**Answer.** *Advertised Window is used by the receiver to limit the rate at which the sender sends so that the buffer at the receiver does not overflow (flow control). Congestion Window is used by the sender to determine how much can be sent so that congestion doesn't occur in the network.*

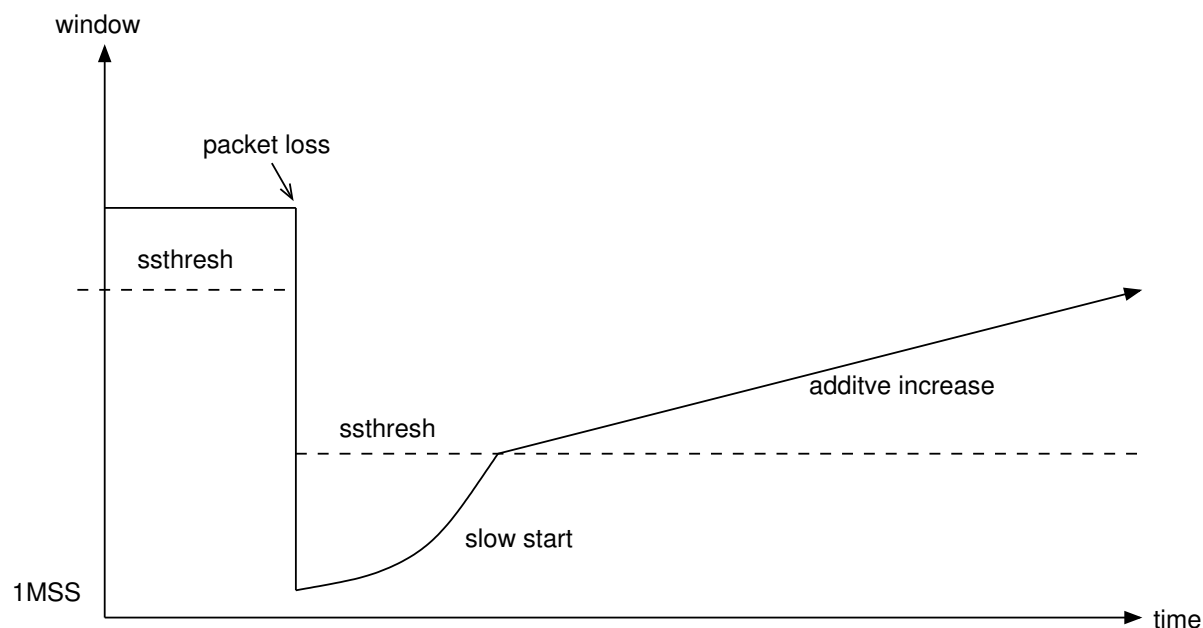
- (c) How does the TCP source calculate the window from the congestion and advertised windows? [1 mark]

**Answer.** *Minimum of the congestion and advertised window.*

The following cases require you to draw a plot of the value of TCP source window over time. The plot does not have to be exact or to scale, but should clearly show the different phases (additive increase, slow start, responses to loss, etc.) and how they differ. That is, the shape of the plot should be clear. You should also show the slow start threshold on your plot. As a guide, the initial values of the window are given. You should assume the time on the horizontal axis is a long period, meaning the slow start threshold should be reached within that time.

- (d) Buffer space at receiver is infinite. No packet loss. [3 marks]
- (e) Buffer space at receiver is finite and greater than slow start threshold. Loss due to timeout occurs. Note that the diagram below shows the current value of the window when the loss occurs as a solid line. [3 marks]





- (f) Explain why TCP source responds differently when there is a loss due to a timeout compared to when there is a loss due to a 3rd duplicate ACK. [2 marks]

**Answer.** *If a single packet is lost, then the loss due to 3rd duplicate ACK should be detected before a timeout occurs. However if many packets are lost or packets are significantly delayed, then the 3rd duplicate ACK may not be received before the timeout. In other words, loss due to 3rd duplicate ACK normally means there is less congestion than if a loss due to timeout occurs. Therefore, in the event of a loss due to timeout (ie. large congestion), TCP decreases its congestion window significantly in order to avoid further congestion.*

## Question 2 [8 marks]

Consider the network from Client to Server, via three Routers, as shown below. Link data rates and one-way delays are the same in each direction. Ignore other delays.

C --- link1 --- R1 --- link2 --- R2 --- link3 --- R3 --- link4 --- S

- Link1: 15Mb/s capacity; 2ms one way delay
- Link2: 20Mb/s capacity; 5ms one way delay
- Link3: 10Mb/s capacity; 8ms one way delay
- Link4: 15Mb/s capacity; 5ms one way delay

(a) What is the value of the RTT? [1 mark]

**Answer.** *40ms*

(b) If UDP is used to send data from client to server, what is the maximum throughput that can be achieved? (ignoring header overheads) [1 mark]

**Answer.** *10 Mb/s*

(c) What is the Bandwidth Delay Product of the path? [2 marks]

**Answer.** *400,000 bits*

(d) How big should the server buffer be to achieve maximum TCP throughput? [2 marks]

**Answer.** *Greater than or equal to 400,000 bits*

(e) What is the maximum TCP throughput if the server buffer is 40,000 Bytes? [2 marks]

**Answer.** *8 Mb/s*

### Question 3 [11 marks]

Consider a company using VoIP for all internal phone calls. All computers are connected via switched 100Mb/s Fast Ethernet. The VoIP application uses the G.711 codec. The G.711 voice codec takes 100 samples of voice per second, with each sample 80 Bytes. A VoIP application using G.711 and RTP sends 2 voice samples per RTP packet (that is, 160 Byte payload).

- (a) At what rate does the G.711 voice codec generate voice data? [2 marks]

**Answer.** *100 samples per second, with each sample 80 bytes, means 8,000 Bytes per second or 64kb/s.*

- (b) How many packets per second does the VoIP application send? [2 marks]

**Answer.** *100 samples per second and 2 samples per packet, means 50 packets per second.*

- (c) Draw a protocol stack for a computer using the VoIP application. Consider all the protocols used by the VoIP application. [2 marks]

**Answer.** *VoIP Application RTP UDP IP Ethernet DLL Ethernet PHY*

- (d) What is the bandwidth (or throughput) consumed on the company LAN to support each two-way voice call? [3 marks]

**Answer.** *50 packets per second. Each packet contains 160 bytes of data, 20 byte IP header, 8 byte UDP header, 12 byte RTP header and 18 byte Ethernet header/trailer. 218 bytes per packet, means 10,900 Bytes per second for each direction, so 21,800 Bytes per second per call.*

- (e) The G.729 codec has a sample size of 10 Bytes (instead of 80 Bytes in G.711—sampling rate is the same as G.711). Explain an advantage and disadvantage of using G.729 in the company network (compared to using G.711). [2 marks]

**Answer.** *The smaller sample size. Advantage: the smaller sample size (and same sampling rate) mean lower LAN bandwidth is needed to send the data (allowing room for more voice calls or other traffic). Disadvantage: the smaller sample size will mean the quality reconstructed at the receiver will be poorer.*

**Question 4** [8 marks]

Explain the following delivery mechanisms and give an example application (or application protocol) that is commonly used by the mechanism.

- (a) Unicast [2 marks]

**Answer.** *Send from a single source to a single destination. Example: web browser (client to server).*

- (b) Broadcast [2 marks]

**Answer.** *Send from a single source to all hosts in a network. Example network management (DHCP).*

- (c) Multicast [2 marks]

**Answer.** *Send from a single source to selected hosts in a network. Example: video streaming*

- (d) Anycast [2 marks]

**Answer.** *Send from a single source to any one of a selected group of hosts. Example: DNS*

## Question 5 [11 marks]

Two challenges of using P2P systems for sharing resources are: searching and data transfer. This question is only about searching.

- (a) In Napster-like P2P systems an index is stored on a central server. What is the index (that is, what important information does it contain)? [2 marks]

**Answer.** *The index maps resources or keys to peers. That is, it contains a list of keys of resources and the corresponding peers that maintain the resource.*

- (b) Where is the index information stored in a FastTrack P2P system? [2 marks]

**Answer.** *A super-peer stores the index information for its local peers.*

- (c) Explain how searching works in a FastTrack P2P system. As a guide, you should clearly explain the steps for all typical cases of where the queried resource may be located (e.g. the conditions when a response to a query is returned). You should state which nodes send the queries, and to what destinations and using what method. [3 marks]

**Answer.** *A peer sends a query to its local super-peer. If the super-peer maintains an index for the resource, it immediately returns a response. If the super-peer does not have the resource in the index, then the super-peer floods the query to all other super-peers. The super-peers that maintain the index will send a response.*

- (d) Explain an advantage that FastTrack has compared to Gnutella. [2 marks]

**Answer.** *Searching can be faster because the super-peers maintain some index information and can immediately respond, whereas in Gnutella no index information is stored about other peers. As a result of the above, another advantage is that the number of messages (overhead) is reduced.*

- (e) Explain a disadvantage that FastTrack has compared to Gnutella. [2 marks]

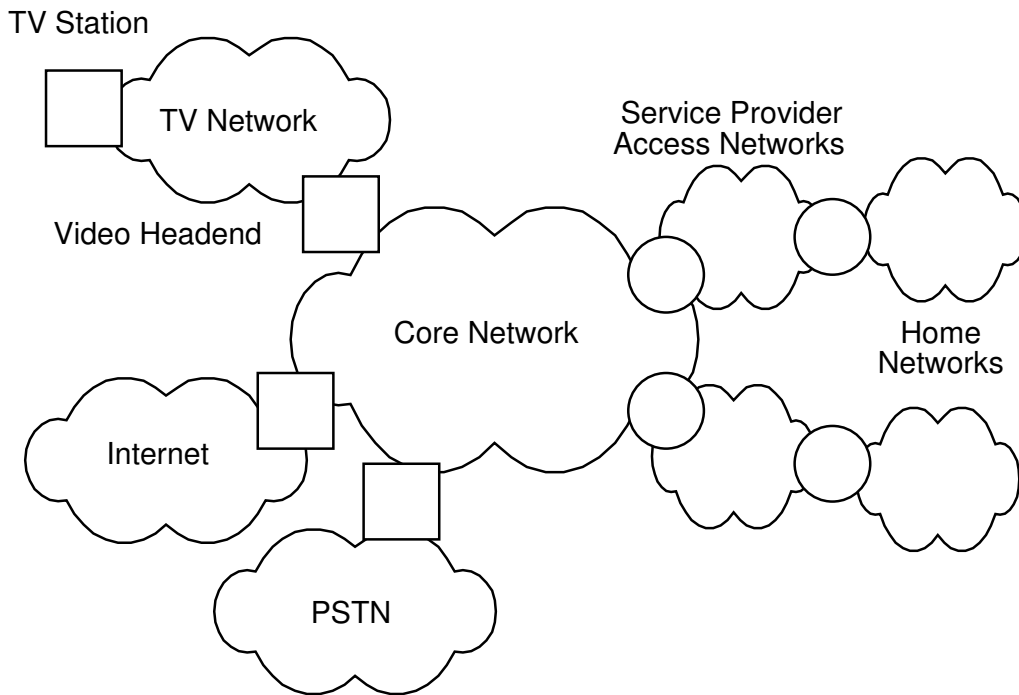
**Answer.** *In FastTrack if a super-peer fails, then its local peers cannot search. Whereas in Gnutella if one peer fails then the others can still search.*



## Question 6 [9 marks]

Consider an IPTV network operated by a single network operator.

- (a) Draw a diagram illustrating the network topology of the entire network, showing at least: core network, service provider access network, home network, PSTN, Internet, TV network. Also identify the video headend, and two subscribers on separate access networks. [4 marks]



- (b) Explain the difference between ADSL2+, FTTH and FTTN, as options for the service provider access network in an IPTV network. State the transmission media they use and an advantage the technology has (compared to the other two). [3 marks]

i. ADSL2+

**Answer.** *ADSL2+ uses copper line to the home from a telephone exchange serving a small suburb. The advantage of ADSL2+ is that it uses existing telephone networks.*

ii. FTTH

**Answer.** *FTTH delivers optical fibre direct to a home, avoiding copper lines. The advantage of ADSL2+ is that it uses existing telephone networks. FTTH delivers the highest speed but at the highest of installing optical fibre all the way to each home.*

iii. FTTN

**Answer.** *FTTN uses optical fibre to a special node that is closer to homes, then uses copper to the homes. It serves 100's of users. FTTN increases speeds (because the copper link is shorter) compared to ADSL2+ but requires extra cost for the nodes.*

- (c) Explain why and how normal TV and video-on-demand are treated differently when delivered across a service providers core network. [2 marks]

**Answer.** *With normal TV each channel is viewed by many people at the same time. Therefore the content can be delivered using multicast across the core network, rather than using multiple unicast streams to each subscriber. With video-on-demand it is unlikely multiple subscribers will watch the same video at the same time, and therefore multicast cannot be used—a separate stream is needed for each user.*

## Question 7 [10 marks]

Consider BitTorrent for data transfer in P2P systems.

- (a) What is the difference between a seed and a leecher in a BitTorrent swarm? [1 mark]

**Answer.** *A seed has a copy of an entire torrent, while a leecher has only a subset of the pieces of the torrent.*

- (b) Consider three files,  $A$ ,  $B$  and  $C$ , are to be shared in a single torrent  $T$ . Explain the relationship between the files, torrent, blocks and pieces. [2 marks]

**Answer.** *The files are considered as a single torrent. The torrent is divided into multiple, fixed size pieces. The pieces are divided into multiple, fixed size blocks.*

- (c) Where can a peer find the IP address of a tracker of a swarm it wants to join to obtain torrent  $T$ ? [1 mark]

**Answer.** *In the .torrent file for the torrent  $T$ .*

- (d) What application-level protocol is used for communications between the peer and the tracker? [1 mark]

**Answer.** *HTTP*

- (e) Where can a peer find the IP addresses of other peers in a swarm to obtain torrent  $T$ ? [1 mark]

**Answer.** *From the tracker (it maintains a list of peers in the swarm).*

- (f) Assume a peer may maintain 30 TCP connections to remote peers at a time. Some of the remote peers may be choked while the others are unchoked. Explain what this means. [2 marks]

**Answer.** *The choked remote peers cannot download data from the peer, whereas the unchoked remote peers can download data from the peer.*

- (g) Which of the following P2P systems is closest to BitTorrent: Napster, Gnutella, FastTrack? Explain your answer. [2 marks]

**Answer.** *Napster. For locating peers, BitTorrent still relies one or several a central server, the tracker.*

## Question 8 [8 marks]

- (a) Name two TCP congestion control algorithms available for the Linux kernel? [2 marks]

**Answer.** *Reno, Cubic*

Explain what the following command(s) do when run in Linux. Be specific with your answer, mentioning the relevant values. Assume the computer(s) which the commands are run on are setup correctly. [1.5 marks each]

- (b) `iperf -c 1.2.3.4 -u -b 10M -t 50`

**Answer.** *Starts the iperf client to connect to server 1.2.3.4 for a 50 second test using UDP and sending at 10Mb/s.*

- (c) `iperf -s -w 20000`

**Answer.** *Starts the iperf server to listen for TCP connections; the server uses a buffer size of 20000 Bytes.*

- (d) `sudo tc qdisc add dev eth0 root netem delay 100ms 5ms`

**Answer.** *Delays each packet by an average of 100ms (plus or minus 5ms) that is sent via interface eth0.*

- (e) `sudo iptables -A INPUT -m statistic --mode random --probability 0.03 -j DROP`

**Answer.** *Drops 3 percent of packets coming into the computer.*

## Reference Material

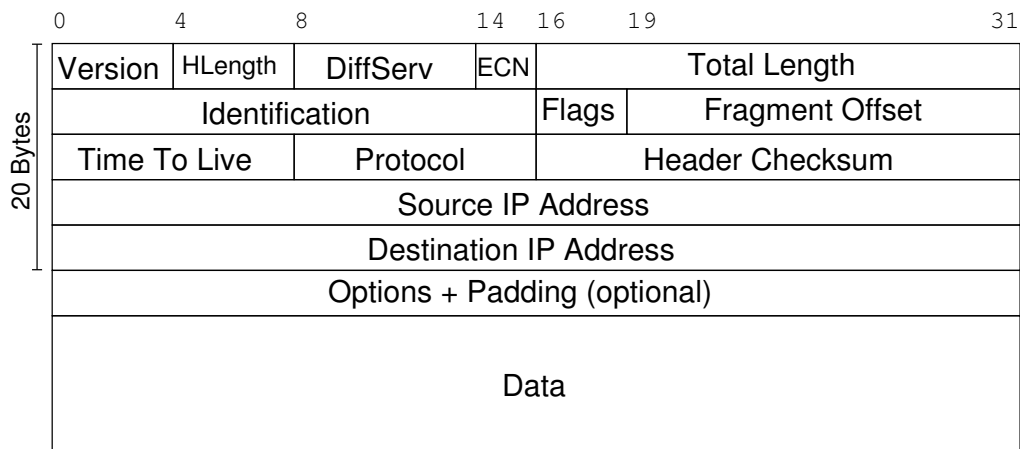


Figure 1: IP Datagram Format. Flags: Reserved, Don't Fragment, More Fragments

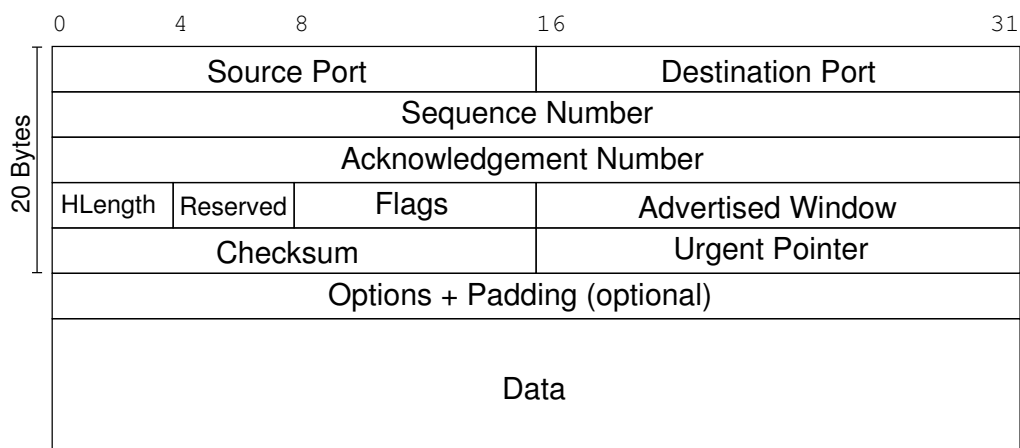


Figure 2: TCP Segment Format. Flags: CWR, ECE, URG, ACK, PSH, RST, SYN, FIN

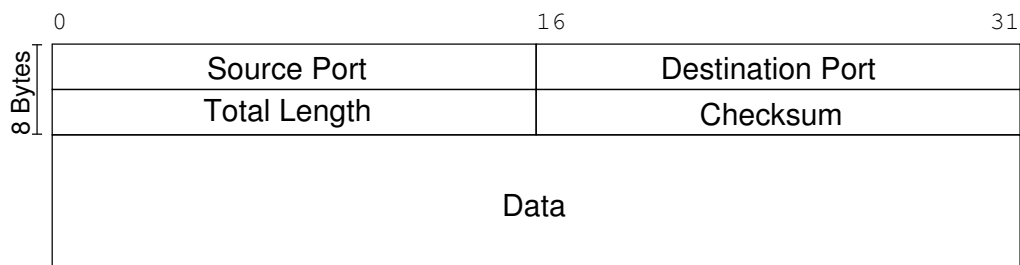


Figure 3: UDP Datagram Format

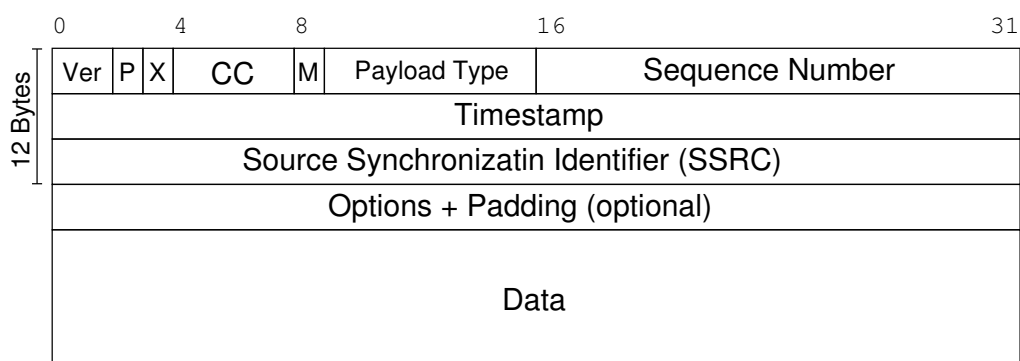


Figure 4: RTP Packet Format. P: Padding; X: Extension; CC: CSRC count; M: Marker