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

Sirindhorn International Institute of Technology
Thammasat University

Final Exam: Semester 2, 2011

Course Title: ITS413 Internet Technologies and Applications

Instructor: Steven Gordon

Date/Time: Thursday 12 April 2012; 9:00–12:00

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.
- Students are not allowed to have communication devices (e.g. mobile phone) in their possession.
- 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).
- Reference material at the end of the exam may be used.

Question 1 [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]

(b) Broadcast [2 marks]

(c) Multicast [2 marks]

(d) Anycast [2 marks]

Question 2 [10 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+

ii. FTTH

iii. FTTN

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

(d) What protocol should be used for a subscriber to change channels when viewing normal TV across the IPTV network? Explain your answer. [1 mark]

Question 3 [8 marks]

Consider a national IP network owned and operated by a single operator (ISP).

(a) Explain the difference between soft QoS and hard QoS. [2 marks]

Assume packets coming from hosts are classified and marked at the first operator-owned router they arrive at (such a router on the edge of the operators network is called an *edge router*). The packets are then sent across the operators core network to the eventual destination hosts. Routers inside the core network apply QoS control on the packets according to their marking(s).

(b) Explain how an edge router can classify packets, referring to specific protocols and header fields. [2 marks]

(c) Explain how packets may be marked by the edge router, referring to specific protocols and header fields. [2 marks]

(d) A router can provide priority to packets in or entering its transmit (output) queue using a forwarding or *queuing scheme* and a *dropping scheme*. Explain the difference between the two. [2 marks]

Question 4 [13 marks]

Consider a university using an IP network to stream black and white video from various security cameras back to a central office (with security guards and recording equipment). There is no audio recorded. Each camera has a dedicated 100Mb/s Ethernet link to one of many 24-port site switches. Each site switch has a 100Mb/s Ethernet link to a 48-port switch in the central office. The switch in the central office has a 100Mb/s Ethernet link to a server that records and displays the video. Cameras record video at a resolution of 1024x768 and frame rate of 1 frame per second; they stream raw black and white video (no compression is used). RTP is used to transport the video: the maximum payload in each RTP packet is 128 Bytes. Assume the Ethernet data link and physical layers contribute 12 Bytes of header per frame. RTSP is used to control the cameras (e.g. a user in the central office sends a message to start the camera streaming).

(a) How many security cameras can be supported on the network? [6 marks]

(b) Although the security cameras do not support compression, the server can compress the received video before saving to a hard disk. There is one 10GB hard disk allocated for each camera. The compression reduces the file size by a factor of 100. How many hours of video can be recorded for a single security camera? [2 marks]

(c) Consider the network connecting the cameras to the central office and server. The cameras and site switches cannot be upgraded, but other equipment can be. Explain how you could modify the network to support more cameras. [2 marks]

Some applications/services use different protocols for sending data compared to controlling the data transfer (such as controlling streaming sessions). The different protocol stacks can be divided into the *data plane* and *control plane*.

(d) Draw two protocol stacks for the video streaming application on the camera: one for the *data plane* and the other for the *control plane*. [3 marks]

Question 5 [6 marks]

Consider the times at which six packets were transmitted by a source and received by the destination (all times are relative to an initial clock value and measured in milliseconds (ms); the clocks at source and destination are synchronised):

Packet 1 Transmit time: 20; Receive time: 42

Packet 2 Transmit time: 40; Receive time: 62

Packet 3 Transmit time: 60; Receive time: 80

Packet 4 Transmit time: 80; Receive time: 103

Packet 5 Transmit time: 100; Receive time: 119

Packet 6 Transmit time: 120; Receive time: 140

(a) What is the average delay experienced in the network? [1 mark]

(b) What is the jitter experienced in the network? [1 mark]

(c) Playback buffers are often used to compensate for jitter. Explain how a playback buffer can be used in this case, and how it reduces the effect of jitter. [1 mark]

(d) Using a playback buffer, what is the preferred playback time of each of the 6 packets? [2 marks]

(e) One disadvantage of playback buffers is the additional complexity/memory needed. What is another disadvantage of using a playback buffer? Use the example six packets to explain. [1 mark]

Question 6 [8 marks]

(a) Explain the role of an indexer in a Bittorrent network. [1 mark]

(b) Explain the role of a tracker in a Bittorrent network. [1 mark]

(c) What application protocol does a Bittorrent client use to communicate with a tracker? [1 mark]

Assume a peer, N_1, has joined a swarm and established two connections to peers N_2 and N_3. Peer N_1 wants to download a torrent with 100 pieces: $P_1, P_2, P_3, \ldots, P_{100}$. Each piece has 10 blocks (e.g. piece P_1 has blocks $B_{1,1}, B_{1,2}, \ldots, B_{1,10}$; piece P_2 has blocks $B_{2,1}, B_{2,2}, \ldots, B_{2,10}$). Peers N_2 and N_3 already have the following pieces:

N_2**:** $P_5, P_{10}, P_{11}, P_{13}, P_{20}, P_{23}, P_{30}, P_{39}, P_{64}$

N_3**:** All pieces *except* pieces P_5, P_{20}, P_{30}

In the Peer Exchange Protocol, after an initial *Handshake*, each peer exchanges a *Bitfield* message which indicates the pieces they have available. Then a peer may send a *Request* message to request a specific block, and receive a *Piece* message containing a specific block.

(d) Assuming only peers N_1, N_2 and N_3 are in the swarm, what is the availability of the torrent? Explain you answer. [1 mark]

(e) If there were another two seed peers in the swarm, N_4 and N_5, what would the availability be? [1 mark]

(f) In the *Bitfield* message sent from N_2 to N_1, what values will be included? [1 mark]

Each peer maintains four variables for each other peer it is connected to: *am_choking*, *am_interested*, *peer_choking*, *peer_interested*. Consider the values that peer N_1 maintains for the other two peers:

N_2**:** *am_choking=False*, *am_interested=True*, *peer_choking=False*, *peer_interested=True*

N_3**:** *am_choking=False*, *am_interested=True*, *peer_choking=True*, *peer_interested=False*

(g) Will N_3 send a *Request* message to N_1? Explain your answer. [1 mark]

(h) Can N_1 download pieces from N_3? Explain your answer. [1 mark]

Question 7 [8 marks]

Consider the following scenarios of TCP sessions and give the expected throughput for the specified session. Explain each answer.

(a) Application A on computer 1 sending data to application B on computer 2. Computers connected via network with RTT of 10ms and bottleneck capacity of 20MB/s. The TCP socket used by application A has a send buffer size of 1MB, while the TCP socket used by application B has a receive buffer size of 100KB. Ignore the impact of congestion control (no packet losses). What is the approximate throughput for which A can send to B? [2.5 marks]

(b) Same as part (a), except the RTT is 5ms, the send buffer size is 2MB and the receive buffer size is 200KB. [2.5 marks]

(c) Application A on computer 1 sending data to application B on computer 2 using three TCP connections (RTT of each connection is 10ms). Application C on computer 3 sending data to application D on computer 4 using two TCP connections (RTT of each connection is 10ms). Computers 1 and 3 are on the same subnet; computers 2 and 4 are on the same subnet. The path between the two subnets has a bottleneck capacity of 20MB/s. What is the approximate throughput for which A can send data to B? [3 marks]

Question 8 [8 marks]

Consider the three P2P systems: Napster, Gnutella and Fasttrack. For the following features, indicate which P2P system is best characterised by the feature. Either write the name of only one of the three systems ("Napster", "Gnutella" or "Fasttrack") or write the word "None" to indicate none of the three P2P systems have that feature.

(a) Uses a central index server _____

(b) Super-peers _____

(c) Single point of failure _____

(d) Fully distributed _____

(e) Search queries are flooded _____

(f) Selected peers store index data _____

(g) Content stored on central server _____

(h) Fastest search _____

Question 9 [11 marks]

Consider a P2P system using a Chord-based Distributed Hash Table. There are a maximum of 32 peers in the system. There are currently 10 peers in the system, with IDs:

1, 4, 10, 12, 15, 19, 21, 23, 24, 29

There are 13 resources that have already been inserted into the system. Their keys are:

0, 1, 4, 7, 9, 13, 15, 18, 22, 23, 24, 27, 28

(a) What is the length of the hash value used in this P2P system? [1 mark]

(b) Which peer stores the resource with key [2 marks]:

i. 15? _____

ii. 27? _____

(c) Which other peers does peer 1 have routes to? [3 marks]

(d) If peer 1 is searching for resource with key 27, which peers is the search query message sent via to reach the destination? [2 marks]

Consider the same Chord-based DHT in use in a larger P2P system with more than 100,000 nodes. An alternative is to use Fasttrack (instead of Chord), with 100 super-peers.

(e) Compare Chord against Fasttrack in terms of search overhead (i.e. the number of copies of single query sent in the network). [1.5 marks]

(f) Compare Chord against Fasttrack in terms of failure resistance. [1.5 marks]

Reference Material

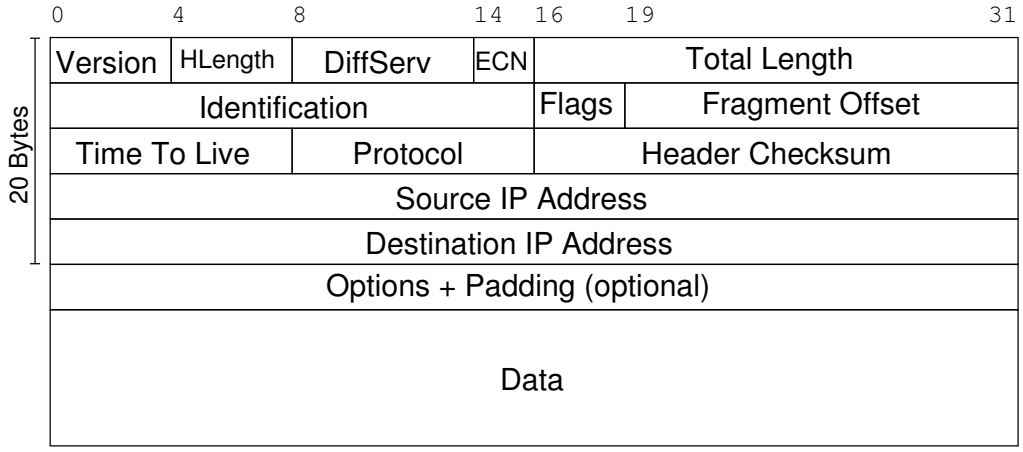

Figure 1: IP Datagram Format. Flags: Reserved, Don't Fragment, More Fragments

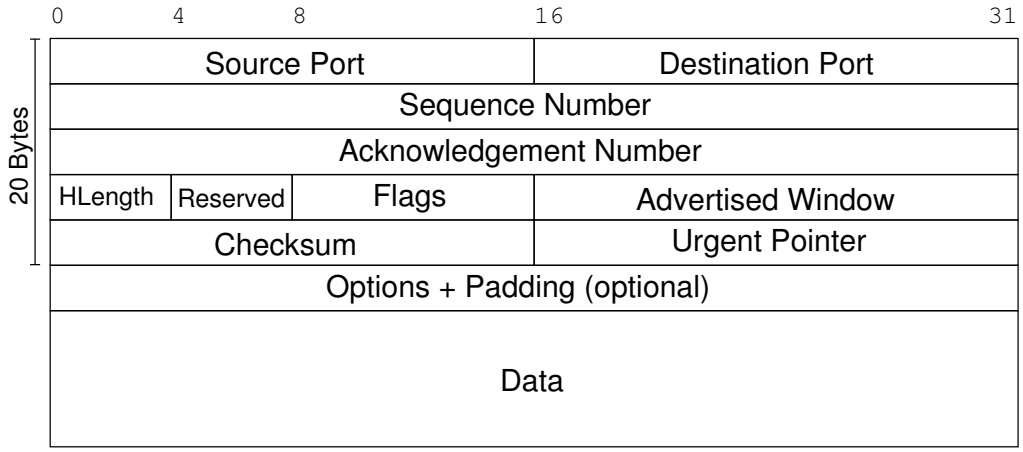

Figure 2: TCP Segment Format. Flags: CWR, ECE, URG, ACK, PSH, RST, SYN, FIN

Figure 3: UDP Datagram Format

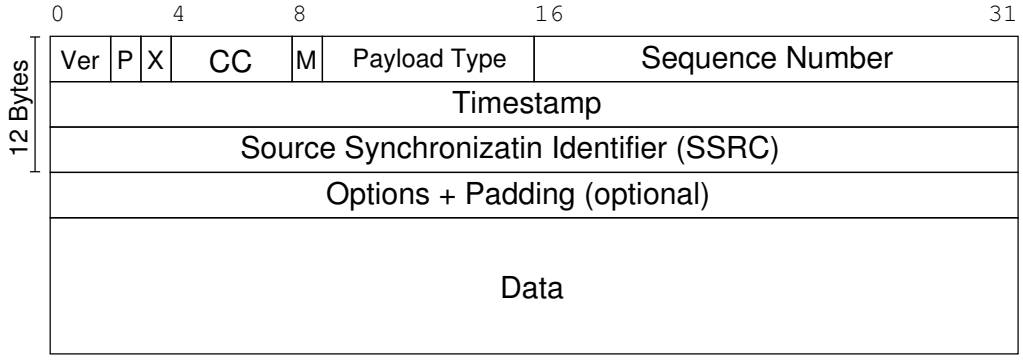

Figure 4: RTP Packet Format. P: Padding; X: Extension; CC: CSRC count; M: Marker