1. (8 points) Using any layer of your choice in the TCP/IP stack we are covering this semester, distinguish between a service and a protocol.

For example, in transport layer, the TCP protocol provides a connection-oriented and reliable service to its application.

(A protocol defines the format and the order of messages exchanged between two or more communicating entities).

2. (10 points) Instagram uploads photos over HTTP. Assume someone publishes a series of 9 different photos to their Instagram feed. Explain how the photos would be uploaded using a non-persistent HTTP connection. Now explain how the same resource is downloaded using a persistent HTTP connection.

Non-persistent:

1. The client makes a TCP connection to Instagram at port 80 (the standard port for HTTP)
2. The client uploads the first photo using the TCP connection, delivers it to the server using one - or more - TCP packets.
3. When all packets have been reliably delivered to the server, the server and client close their sides of the connection.

This process is repeated for the 8 subsequent images.

Persistent:

The same connection can be used to deliver multiple images. So, when client makes a TCP connection to Instagram at port 80, and ask html page using the TCP connection;

When all packages have been reliably delivered to the client, the connection will not close;

The 9 subsequent images will send to client by same TCP connection.

3. (4 points) The web server www.yell-key.com has IP address 216.239.36.21. A client at address 108.15.99.240 connects to the yell-key site site. Assuming the client has an arbitrary port number > 1024, what is a possible socket pair comprising this connection?

[108.15.99.240:6623] & [216.239.36.21:80

4. (9 points) RFCs (Request for Comment) are used for describing network protocols. Access RFC 3550 from the website http://www.rfc-editor.org/

• What is the protocol specified in RFC 3550 and what is this protocol used for?

RTP: A Transport Protocol for Real-Time Applications

RTP provides end-to-end network transport functions suitable for applications transmitting real-time data, such as audio, video or simulation data, over multicast or unicast network services.

• What network protocol does this protocol run over - TCP or UDP?

UDP

• Are RTP sequence numbers used for reliability?

Yes

5. (9 points) Assume host A sends four TCP segments to a receiver B. B will send an ACK to A after correct receipt of a single segment (i.e. it sends an ACK for each segment it receives.) The first and fourth segments arrive, however the second segment is dropped

by a router.

• How will B acknowledge receipt of the segments it has received so far?

B will send a cumulative acknowledgment with sequence number n, indicating that all packets with a sequence number up to and including n have been correctly received.

• B then receives the third segment. How will it acknowledge receipt of it?

B will send another cumulative acknowledgment with new sequence number

• In terms of acknowledgements, how will B ultimately handle the second (missed) segment?

If B using Go-Back-N protocol, it will discard subsequent frames, and sending no ACKs. The pipeline will empty and the sender will begin retransmitting all unacknowledged frames upon timeouts.

If B using Selective Repeat protocol, it will buffer incoming frames.

When a frame arrives, its sequence number of checked to see if it falls between the sending window. If so, it is buffered. Sequential frames are delivered to the network layer.

6. (10 points) Bob and Alice are telling Knock-Knock jokes. Bob's initial sequence number is 20, Alice starts with 62. The following table lists the time each segment is sent and the length of each segment in parentheses: