CS 348: Computer Networks	Mid-semester Exam	09:30 AM to 11:30 AM
Spring 2023-24, IIT Dharwad	February 19, 2023	Total Marks: 50

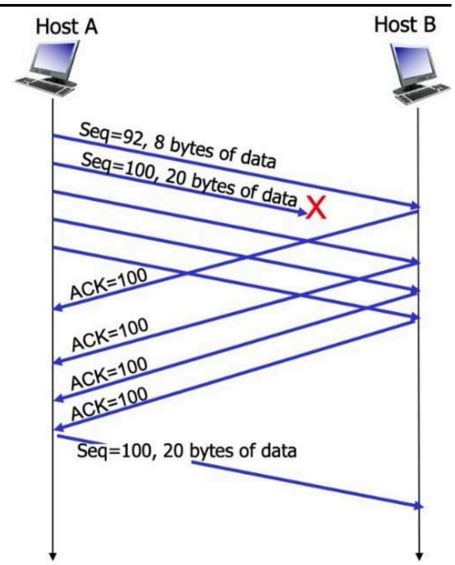
Name: ____ **Roll No.** __________________________

Instructions

- One or more option(s) may be correct for all MCQs. Full marks will be awarded only if all correct options are selected. No partial marks will be awarded.
- This is a question paper-cum-answer sheet, which must be submitted to the invigilator at the end of the exam. Answers are only to be written in the space provided.
- Extra sheets may be used for rough work, which need not be submitted.
- No notes, books, cheat-sheet, calculator, etc. are allowed in this exam.

Q1. [*1 mark*] Consider TCP's Fast Retransmit optimization (see adjoining figure). Of course, the sender doesn't know for sure that the segment with sequence # 100 is actually lost (it can't see into the channel). Suppose the channel can lose, but will not corrupt, messages. Which of the following statements are true?

a. If the channel cannot reorder messages, even a single duplicate ACK would indicate that a segment loss has happened for sure.
b. If the channel can reorder messages, a triple duplicate ACK can occur even though a message is not lost.



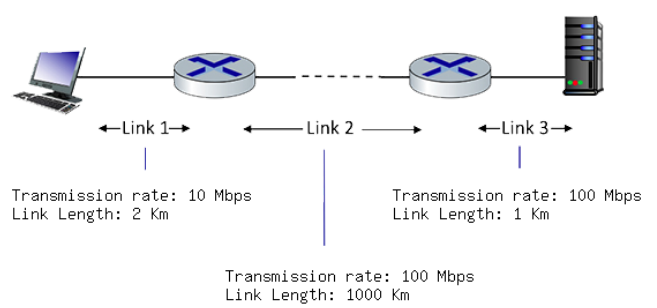
Ans. a, b

Q2. [1 mark] Which of the following is/are stateful protocol(s)?

a. HTTP
b. SMTP
c. DNS
d. BitTorrent
e. UDP
f. TCP

Ans. f

Q3. [*1 mark*] Consider the network shown in the adjoining figure, with three links, each with the specified transmission rate and link length. Assume the length of a packet is 8000 bits. The speed of light propagation delay on each link is 3×10^8 m/s. What is the transmission delay at link 2?



Ans. 8000 / 100,000,000 = 80μs

Q4. [*1 mark*] True or False: When computing the Internet checksum for two numbers, a single flipped bit in each of the two numbers will always result in a changed checksum.

Ans. False

Q5. [*1 mark*] Which of the following pieces of information will appear in a server's application-level HTTP reply message?

a. A sequence number
b. A checksum
c. The server's IP address
d. A response code
e. The name of the Web server (e.g., gaia.cs.umass.edu)
f. A response phrase associated with a response code

Ans. d, f

Q6. [*1 mark*] When an application uses a TCP socket, what transport services are provided to the application by TCP?

a. *Throughput guarantee*. The socket can be configured to provide a minimum throughput guarantee between sender and receiver.
b. *Flow Control*. The provided service will ensure that the sender does not send so fast as to overflow receiver buffers.
c. *Best effort service*. The service will make a best effort to deliver data to the destination but makes no guarantees that any particular segment of data will actually get there.
d. *Real-time delivery*. The service will guarantee that data will be delivered to the receiver within a specified time bound.
e. *Loss-free data transfer*. The service will reliably transfer all data to the receiver, recovering from packets dropped in the network due to router buffer overflow.
f. *Congestion control*. The service will control senders so that the senders do not collectively send more data than links in the network can handle.

Ans. b, e, f

Q7. [*1 mark*] What is the purpose of the If-Modified-Since field in a HTTP GET request message?

a. To allow the server to indicate to the client that it (the client) should cache this object.
b. To inform the HTTP cache that it (the cache) should retrieve the full object from the server, and then cache it until the specified time.
c. To indicate to the server that the server should replace this named object with the new version of the object attached to the GET, if the object has not been modified since the specified time
d. To indicate to the server that the client wishes to receive this object, and the time until which it will cache the returned object in the browser's cache.
e. To indicate to the server that the client has cached this object from a previous GET, and the time it was cached.

Ans. e

Q8. [*1 mark*] Which of the following characteristics apply to HTTP only (and do not apply to SMTP)?

a. Operates mostly as a "client push" protocol.
b. Uses CRLF.CRLF to indicate end of message.
c. Uses a blank line (CRLF) to indicate end of request header.
d. Uses server port 25.
e. Has ASCII command/response interaction, status codes.
f. Uses server port 80.
g. Is able to use a persistent TCP connection to transfer multiple objects.
h. Operates mostly as a "client pull" protocol.

Ans. c, f, h

Q9. [*1 mark*] What is the value of caching in the local DNS name server?

a. DNS caching provides the ability to serve as authoritative name server for multiple organizations.
b. DNS caching provides prioritized access to the root servers, since the DNS request is from a local DNS cache.
c. DNS caching results in less load elsewhere in DNS, when the reply to a query is found in the local cache.
d. DNS caching provides for faster replies, if the reply to the query is found in the cache.

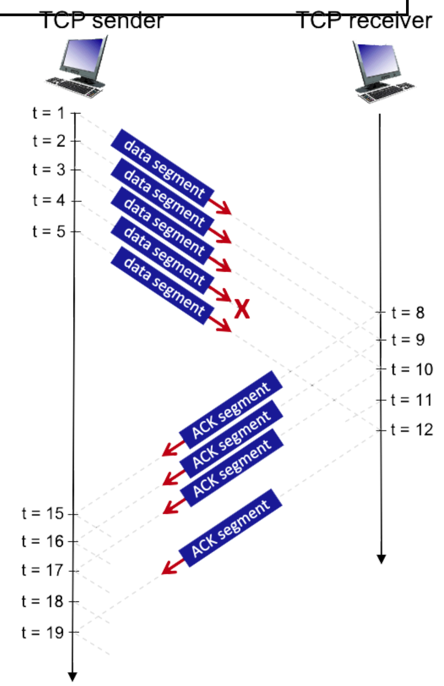
Ans. c, d

Q10. [*2 marks*] Match the functionality of a protocol with the name of the email protocol (if any) that implements that functionality.

a. Pushes email from a mail client to a mail server.	i. IMAP
b. Pulls mail from one mail server to another mail server.	ii. Neither SMTP nor IMAP does this.
c. Pulls email to a mail client from a mail server.	iii. SMTP
d. Pushes mail from one mail server to another mail server.	

Ans. a-iii, b-ii, c-i, d-iii

Q11. [*2 marks*] Consider the adjoining figure in which a TCP sender and receiver communicate over a connection in which the segments can be lost. The TCP sender wants to send a total of 10 segments to the receiver and sends an initial window of 5 segments at t = 1, 2, 3, 4, and 5, respectively. Suppose the initial value of the sequence number is 91 and every segment sent to the receiver each contains 840 bytes. The delay between the sender and receiver is 7 time units, and so the first segment arrives at the receiver at t = 8, and an ACK for this segment arrives at t = 15. As shown in the figure, 1 of the 5 segments is lost between the sender and the receiver, but none of the ACKs are lost. Assume there are no timeouts and any out of order segments received are thrown out.



What is the sequence number of the segment sent at t = 18?

Ans. No segment sent, as sender is waiting for last 5 ACKs viz., its maximum window size.

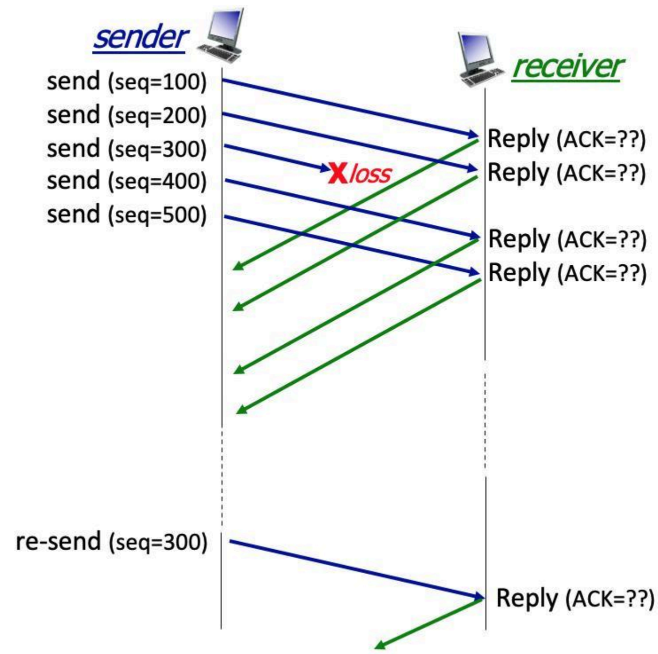
Q12. [*2 marks*] Match the function of a server to a given type of DNS server in the DNS server hierarchy.

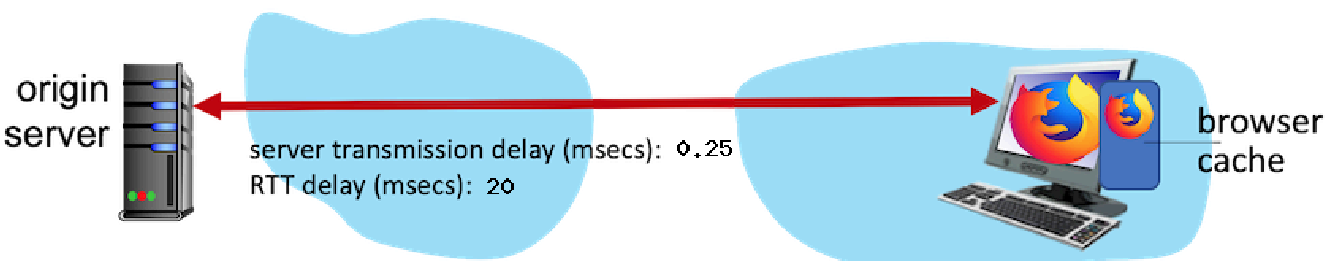
a. Provides authoritative hostname to IP mappings for the organization's named hosts.	i. Top Level Domain (TLD) servers
b. Replies to DNS query by local host, by contacting other DNS servers to answer the query.	ii. Authoritative DNS server
c. Responsible for a domain (e.g., *.com, *.edu); knows how to contact authoritative name servers.	iii. DNS root servers

d. Highest level of the DNS hierarchy, knows how to reach servers responsible for a given domain (e.g., *.com, *.edu).	iv. Local DNS server

Ans. a-ii, b-iv, c-i, d-iii

~~**Q13.** [*2 marks*] Consider an HTTP server and client as shown in the figure below. Suppose that the RTT delay between the client and server is 20 msecs; the time a server needs to transmit an object into its outgoing link is 0.25 msecs; and any other HTTP message not containing an object has a negligible (zero) transmission time. Suppose the client again makes 60 requests, one after the other, waiting for a reply to a request before sending the next request.~~





~~How much time elapses (in milliseconds) between the client transmitting the first request, and the completion of the last request?~~

~~**Ans.**~~ This question is DISQUALIFIED.

Q14. [*2.5 marks*] Suppose that as shown in the adjoining figure below, a TCP sender is sending segments with 100 bytes of payload. The TCP sender sends five segments with sequence numbers 100, 200, 300, 400, and 500. Suppose that the segment with sequence number 300 is lost. The TCP receiver will buffer correctly-received but not-yet-in-order segments for later delivery to the application layer (once missing segments are later received).

a.	After receiving segment 100, the receiver responds with an ACK with value:	i.	400
b.	After receiving segment 200, the receiver responds with an ACK with value:	ii.	300, a duplicate ACK
c.	After receiving segment 500, the receiver responds with an ACK with value:	iii.	200
d.	After receiving the retransmitted segment 300, the receiver responds with an ACK with value:	iv.	600
e.	The TCP receiver does not respond in the example, with an ACK with value:	v.	300

Ans. a-iii, b-v, c-ii, d-iv, e-i

Q15. [*2 marks*] Compute the Internet checksum value for these two 16-bit words: 11110101 11010011 and 10110011 01000100.

Ans.

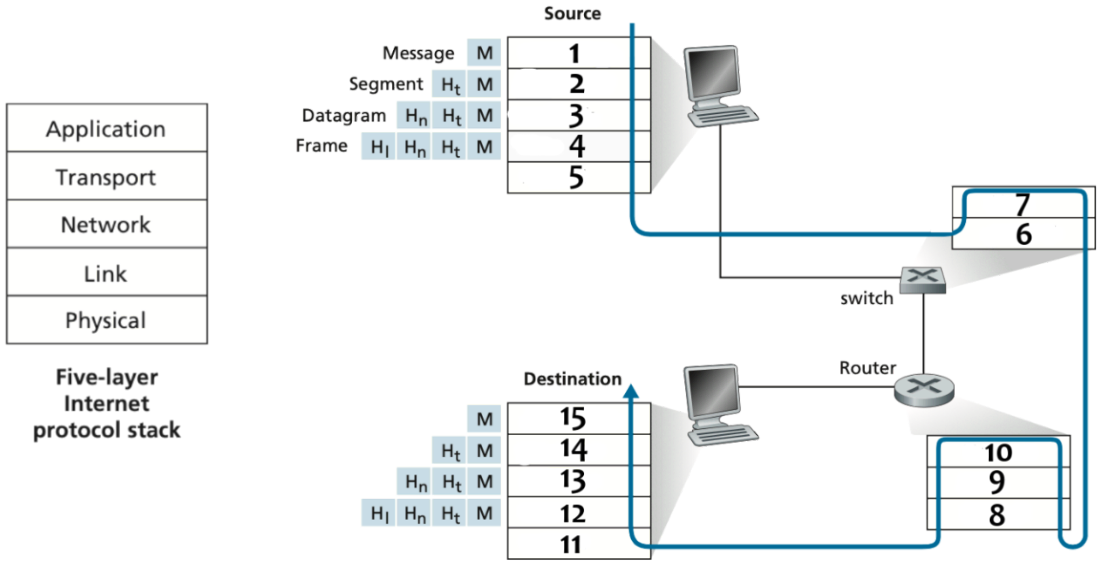
```
 1111010111010011
 1011001101000100
 ----------------
11010100100010111    [1 mark for summation]
                1
 ----------------
 1010100100011000    [0.5 mark for wraparound of overflowing bit]
 ----------------
 0101011011100111    [0.5 mark for computing one's complement]
```

Q16. [*2 marks*] Match the definition/function of an element or approach in a networked streaming video system, with its name.

a. A unit of video, each of which may be encoded at multiple different rates, stored in different files.	i. Chunk
b. A file containing the location and encoding rate of files corresponding to video segments in a video.	ii. Manifest
c. An approach that allows a client to adapt the encoding rate of retrieved video to network congestion conditions.	iii. DASH
d. A CDN approach that stores content in access networks, close to clients.	iv. Video frame
	v. Enter deep
	vi. Over The Top (OTT)

Ans. a-i, b-ii, c-iii, d-v

Q17. [*2.5 marks*] In the scenario below, imagine that you're sending an http request to another machine somewhere on the network.



Name the layers corresponding to boxes 6 to 10, respectively.

Ans. Physical, Link, Physical, Link, Network

Q18. [*2.5 marks*] Match the description of a TCP connection management message with the name of the message used to accomplish that function.

a. A message from client to server initiating a connection request.	i. SYN mesage
b. A message from server to client ACKing receipt of a SYN message and indicating the willingness of the server to establish a TCP connection with the client.	ii. FIN message
c. A message indicating that the sending side is initiating the protocol to terminate a connection.	iii. RESET message
d. A message sent in response to a request to terminate a connection, ACKing that the side receiving this message is also willing to terminate the connection	iv. SYNACK message
e. A general purpose error message used during connection set up or tear down to let the other side know that an error has occurred, and that the referenced connection should be shut down.	v. FINACK message

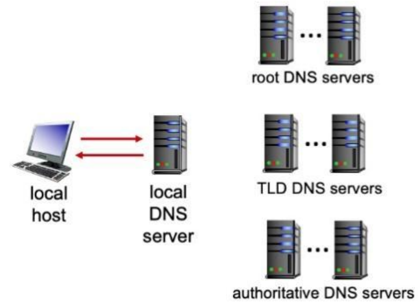
Ans. a-i, b-iv, c-ii, d-v, e-iii

Q19. [*2.5 marks*] Consider the purposes/goals/use of different reliable data transfer protocol mechanisms. For the given purpose/goal/use match it to the RDT mechanism that is used to implement the given purpose/goal/use.

a. Let's the sender know that a packet was NOT received correctly at the receiver.	i. Retransmission
b. Used by sender or receiver to detect bits flipped during a packet's transmission.	ii. ACK
c. Allows for duplicate detection at receiver.	iii. Sequence numbers
d. Let's the sender know that a packet was received correctly at the receiver.	iv. Checksum
e. Allows the receiver to eventually receive a packet that was corrupted or lost in an earlier transmission.	v. NAK

Ans. a-v, b-iv, c-iii, d-ii, e-i

Q20. [*3 marks*] Suppose that the local DNS server caches all information coming in from all root, TLD, and authoritative DNS servers for 20 time units. (Thus, for example, when a root server returns the name and address of a TLD server for .com, the cache remembers that this is the TLD server to use to resolve a .com name). Assume also that the local cache is initially empty, that iterative DNS queries are always used, that DNS requests are just for name-to-IP-address translation, that 1 time unit is needed for each server-to-server or host-to-server (one way) request or response, and that there is only one authoritative name server (each) for any .edu or .com domain.



Consider the following DNS requests, made by the local host at the given times:

a. t=0, the local host requests that the name gaia.cs.umass.edu be resolved to an IP address.
b. t=1, the local host requests that the name icann.org be resolved to an IP address.
c. t=5, the local host requests that the name cs.umd.edu be resolved to an IP address. (Hint: be careful!)
d. t=10, the local host again requests that the name gaia.cs.umass.edu be resolved to an IP address.
e. t=12, the local host requests that the name cs.mit.edu be resolved to an IP address.
f. t=30, the local host again requests that the name gaia.cs.umass.edu be resolved to an IP address. (Hint: be careful!)

State the time units required to resolve each of the six DNS requests.

Ans. 8, 8, 6, 2, 6, 8, respectively

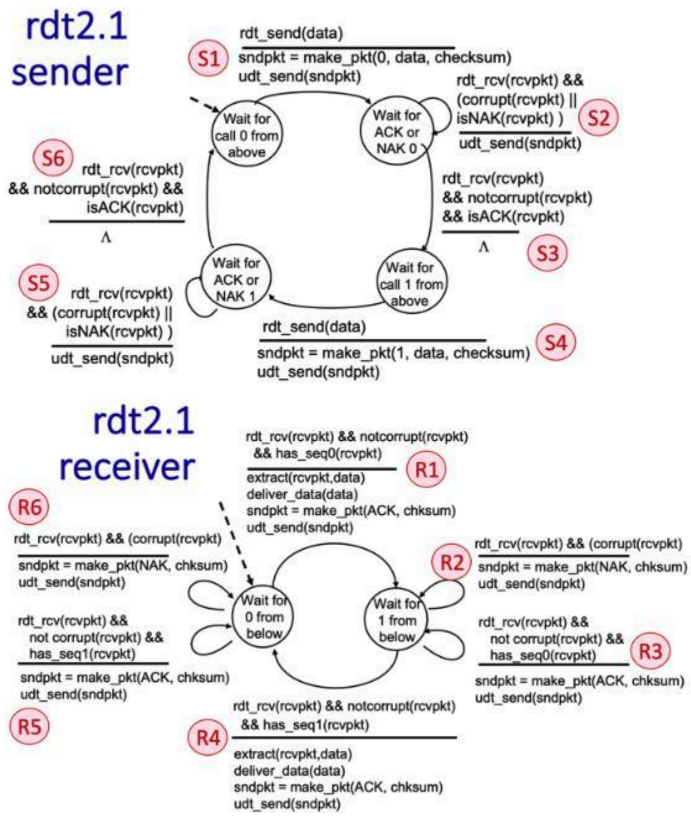
Q21. [*4 marks*] For the given function of a field in the TCP segment, select the name of that field from the pull-down list.

a. This field contains the port number associated with the sending socket for this TCP segment.	i. Source port number
b. This field contains application data that was written into a socket by the sender of this TCP segment.	ii. Data (or payload).
c. This field contains the index in the sender-to-receiver byte stream of the first byte of that data in the payload carried in this segment.	iii. Checksum
d. This field contains the index in the byte stream of the next in-order byte expected at the receiver	iv. Sequence number
e. If set, this segment cumulatively ACKs all data bytes up to, but not including, the byte index in the ACK value field of this segment.	v. ACK number field
f. This field contains the number of available bytes in the TCP receiver's buffer.	vi. ACK bit
g. This field contains the Internet checksum of the TCP segment and selected fields in the IP datagram header.	vii. Header length field

h. This field contains the number of bytes in the TCP header.	viii. Receiver advertised window

Ans. a-i, b-ii, c-iv, d-v, e-vi, f-viii, g-iii, h-vii

Q22. [*4 marks*] Consider the rdt2.1 sender and receiver FSMs shown below, with labeled transitions S1 through S6 at the sender, and transitions R1 through R6 at the receiver. The sender and receiver start in the “Wait for call 0 from above” and “Wait for 0 from below” states, respectively.



Suppose that no channel errors occur. A sequence of interleaved sender and receiver transitions is given below. Transitions S1 and S4 are already provided. Choose the sender or receiver transition for the unlabeled transitions x1, x2, x3, and x4 below to indicate the time-ordered sequence of transitions (interleaved sender and receiver transitions) that will result in two messages being delivered at the receiver, with the sender and receiver returning to their initial states (again, given that no channel errors occur).

S1, x1, x2, S4, x3, x4

Ans.
x1 = R1
x2 = S3
x3 = R4
x4 = S6

Q23. [*8 marks*] Suppose within your Web browser you click on a link to obtain a Web page. The IP address for the associated URL is not cached in your local host, so a DNS lookup is necessary to obtain the IP address. Suppose that four DNS servers are visited before your host receives the IP address from DNS. The first DNS server visited is the local DNS cache, with an RTT delay of RTT0 = 5 msecs. The second, third and fourth DNS servers contacted have RTTs of 23, 31, and 32 msecs, respectively. Initially, let's suppose that the Web page associated with the link contains exactly one object, consisting of a small amount of HTML text. Suppose the RTT between the local host and the Web server containing the object is RTTHTTP = 24 msecs.

a. [*2 marks*] Assuming zero transmission time for the HTML object, how much time (in msec) elapses from when the client clicks on the link until the client receives the object?
b. [*2 marks*] Now suppose the HTML object references 7 very small objects on the same server. Neglecting transmission times, how much time (in msec) elapses from when the client clicks on the link until the base object and all 7 additional objects are received from web server at the client, assuming non-persistent HTTP and no parallel TCP connections?
c. [*2 marks*] Suppose the HTML object references 7 very small objects on the same server, but assume that the client is configured to support a maximum of 5 parallel TCP connections, with non-persistent HTTP.
d. [*2 marks*] Suppose the HTML object references 7 very small objects on the same server, but assume that the client is configured to support a maximum of 5 parallel TCP connections, with persistent HTTP.

Ans.

a. The time from when the Web request is made in the browser until the page is displayed in the browser is: RTT0 + RTT1 + RTT2 + RTT3 + 2*RTTHTTP = 5 + 23 + 31 + 32 + 2*24 = 139 msecs. Note that 2 RTTHTTP are needed to fetch the HTML object - one RTTHTTP to establish the TCP connection, and then one RTTHTTP to perform the HTTP GET/response over that TCP connection.
b. The time from when the Web request is made in the browser until the page is displayed in the browser is: RTT0 + RTT1 + RTT2 + RTT3 + 2*RTTHTTP + 2*7*RTTHTTP = 5 + 23 + 31 + 32 + 2*24 + 2*7*24 = 475 msecs. Note that two RTTHTTP delays are needed to fetch the base HTML object - one RTTHTTP to establish the TCP connection, and one RTTHTTP to send the HTTP request, and receive the HTTP reply. Then, serially, for each of the 7 embedded objects, a delay of 2*RTTHTTP is needed - one RTTHTTP to establish the TCP connection and then one RTTHTTP to perform the HTTP GET/response over that TCP connection.
c. Since there are 7 objects, there's a delay of 91 msec for the DNS query, two RTTHTTP for the base page, and 4*RTTHTTP for the objects since the requests for 5 of these objects can be run in parallel (2 RTTHTTP) and the rest can be done after (2 RTTHTTP). The total is 91 + 48 + 48 + 48 = 235 msec. As in 2 above, 2 RTTHTTP are needed to fetch the base HTML object - one RTTHTTP to establish the TCP connection, and one RTTHTTP to send the HTTP request and receive the HTTP reply containing the base HTML object. Once the base object is received at the client, the 7 HTTP GETS for the embedded objects can proceed in parallel. Each (in parallel) requires two RTTHTTP delays - one RTTHTTP to set up the TCP connection, and one RTTHTTP to perform the HTTP GET/response for an embedded object.
d. Since there are 7 objects, there's a delay of 91 msec for the DNS query. There's also a delay of two RTTHTTP for the base page, and 2 RTTHTTP for the first five objects, and 1 RTTHTTP for the next two. The total is 91 + 48 + 48 + 24 = 211 msec. As in 2 and 3 above, two RTTHTTP delays are needed to fetch the base HTML object - one RTTHTTP to establish the TCP connection, and one RTTHTTP to send the HTTP request, and receive the HTTP reply containing the base HTML object. However, with persistent HTTP, this TCP connection will remain open for future HTTP requests, which will therefore not incur a TCP establishment delay. Once the base object is received at the client, the maximum of five requests can proceed in parallel, each retrieving one of the 7 embedded objects. Each (in parallel) requires only one RTTHTTP delay to setup TCP connection and another RTTHTTP to perform the HTTP GET/response for an embedded object. Once these first five objects have been retrieved, (if necessary) the remaining embedded objects can be retrieved (in parallel). This second round of HTTP GET/response to retreive the remaining embedded objects takes only one more RTTHTTP, since the TCP connection has remained open.