

- Do the Wireshark exercise found here, which will introduce you to the Wireshark tool:
  - List 3 different protocols that appear in the protocol column in the unfiltered packet-listing window in step 7 above.
    - HTTP
    - UDP
    - ARP
  - How long did it take from when the HTTP GET message was sent until the HTTP OK reply was received?
    - .29384sec
  - What is the internet address of the gaia.cs.umass.edu? What is the internet address of your computer?
    - Gaia.cs.umass.edu
      - 129.119.245.12
    - Mine:
      - 128.61.88.199
  - Print the two HTTP messages (GET and OK) referred to in question 2 above.

C:\Users\BA LKRI~1\AppData\Local\Temp\wireshark\_C2084376-19DA-413B-BF6E-C D2464678D80\_20190126132839\_a06244.pcapng 6257 total packets, 14 shown

No.	Time	Source	Destination	Protocol	Length	Info
2653	13:28:43.235469	128.61.88.199	128.119.245.12	HTTP	464	GET /wireshark-labs/INTRO-wireshark-file1.html HTTP/1.1
				Frame 2653:	464 bytes on wire (3712 bits), 464 bytes captured (3712 bits) on interface 0	Ethernet II, Src: AsustekC_c7:e1:6d (08:62:66:c7:e1:6d), Dst: Cisco_eb:f1:80 (68:ef:bd:eb:f1:80)
				Internet Protocol Version 4,	Src: 128.61.88.199, Dst: 128.119.245.12	Transmission Control Protocol, Src Port: 56879, Dst Port: 80, Seq: 1, Ack: 1, Len: 410
				Hypertext Transfer Protocol		
2675	13:28:43.264853	128.119.245.12	128.61.88.199	HTTP	492	HTTP/1.1 200 OK (text/html)
				Frame 2675:	492 bytes on wire (3936 bits), 492 bytes captured (3936 bits) on interface 0	Ethernet II, Src: Cisco_eb:f1:80 (68:ef:bd:eb:f1:80), Dst: AsustekC_c7:e1:6d (08:62:66:c7:e1:6d)
				Internet Protocol Version 4,	Src: 128.119.245.12, Dst: 128.61.88.199	Transmission Control Protocol, Src Port: 80, Dst Port: 56879, Seq: 1, Ack: 411, Len: 438
				Hypertext Transfer Protocol		
				Line-based text data: text/html (3 lines)		
				<html>\n		
				Congratulations! You've downloaded the first Wireshark lab file!\n		
				</html>\n		

2.

1. Is your browser running HTTP version 1.0 or 1.1? What version of HTTP is the server running?
    - i. My Browser: HTTP 1.1
    - ii. Server: HTTP 1.1
    - iii. Marked in Red
  2. What languages (if any) does your browser indicate that it can accept to the server?
    - i. Accept-Language: en-US\r\n
    - ii. Marked in Yellow
  3. What is the IP address of your computer? Or the gaia.cs.umass.edu server?
    - i. Me: 128.61.88.199
    - ii. Sever: 128.119.245.12
    - iii. Marked in Green
  4. What is the status code returned from the server to your browser?
    - i. 202 OK
    - ii. Marked in Blue
  5. When was the HTML file that you are retrieving last modified at the server?
    - i. Sat, 26 Jan 2019 06:59:01 GMT\r\n
    - ii. Marked in Orange
  6. How many bytes of content are being returned to your browser?
    - i. File Data: 128 bytes
    - ii. Marked in Purple
  7. By Inspecting the raw data in the packet content window, do you see any headers within the data that are not displayed in the packet-listing window? If so, name one.
    - i. All the data can be found in the raw data.

8. Do you see an “IF-MODIFIED-SINCE” line in the HTTP GET?
  - i. No
9. Did the server explicitly return the contents of the file? How can you tell?
  - i. Yes last line of the server’s first response has the line “Line-based text data”
  - ii. Marked in Blue

```
No.    Time          Source        Destination       Protocol Length Info
 2910 16:02:51.235161  128.119.245.12   128.61.88.199   HTTP     784   HTTP/1.1 200 OK (text/html)
Frame 2910: 784 bytes on wire (6272 bits), 784 bytes captured (6272 bits) on interface 0
Ethernet II, Src: Cisco_eb:f1:80 (68:ef:bd:eb:f1:80), Dst: AsustekC_c7:e1:6d (08:62:66:c7:e1:6d)
Internet Protocol Version 4, Src: 128.119.245.12, Dst: 128.61.88.199
Transmission Control Protocol, Src Port: 80, Dst Port: 57712, Seq: 1, Ack: 410, Len: 730
Hypertext Transfer Protocol
HTTP/1.1 200 OK\r\n
[Expert Info (Chat/Sequence): HTTP/1.1 200 OK\r\n]
Response Version: HTTP/1.1
Status Code: 200
[Status Code Description: OK]
Response Phrase: OK
Date: Sat, 26 Jan 2019 21:02:51 GMT\r\n
Server: Apache/2.4.6 (CentOS) OpenSSL/1.0.2k-fips PHP/5.4.16 mod_perl/2.0.10 Perl/v5.16.3\r\n
Last-Modified: Sat, 26 Jan 2019 06:59:01 GMT\r\n
ETag: "173-58056fa80933b"\r\n
Accept-Ranges: bytes\r\n
Content-Length: 371\r\n
Keep-Alive: timeout=5, max=100\r\n
Connection: Keep-Alive\r\n
Content-Type: text/html; charset=UTF-8\r\n
\r\n
[HTTP response 1/2]
[Time since request: 0.029583000 seconds]
[Request in frame: 2900]
[Next request in frame: 4021]
[Next response in frame: 4035]
File Data: 371 bytes
Line-based text data: text/html (10 lines)
```

10. Do you see an “IF-MODIFIED-SINCE:” line in the HTTP GET? If so what information follows the “IF-MODIFIED-SINCE:” head?
  - i. Yes that follows the header is: Sat, 26 Jan 2019 06:59:01 GMT\r\n
  - ii. Marked in Blue

```
No.    Time          Source        Destination       Protocol Length Info
 2704 17:25:30.285957  128.61.88.199   128.119.245.12   HTTP     591   GET /wireshark-labs/HTTP-wireshark-file2.html
HTTP/1.1
Frame 2704: 591 bytes on wire (4728 bits), 591 bytes captured (4728 bits) on interface 0
Ethernet II, Src: AsustekC_c7:e1:6d (08:62:66:c7:e1:6d), Dst: Cisco_eb:f1:80 (68:ef:bd:eb:f1:80)
Internet Protocol Version 4, Src: 128.61.88.199, Dst: 128.119.245.12
Transmission Control Protocol, Src Port: 54227, Dst Port: 80, Seq: 426, Ack: 731, Len: 537
Hypertext Transfer Protocol
GET /wireshark-labs/HTTP-wireshark-file2.html HTTP/1.1\r\n
[Expert Info (Chat/Sequence): GET /wireshark-labs/HTTP-wireshark-file2.html HTTP/1.1\r\n]
Request Method: GET
Request URI: /wireshark-labs/HTTP-wireshark-file2.html
Request Version: HTTP/1.1
Host: gaia.cs.umass.edu\r\n
Connection: keep-alive\r\n
Cache-Control: max-age=0\r\n
Upgrade-Insecure-Requests: 1\r\n
User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/71.0.3578.98 Safari/537.36\r\n
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,image/webp,image/apng,*/*;q=0.8\r\n
Accept-Encoding: gzip, deflate\r\n
Accept-Language: en-US,en;q=0.9\r\n
If-None-Match: "173-58056fa80933b"\r\n
If-Modified-Since: Sat, 26 Jan 2019 06:59:01 GMT\r\n
\r\n
[Full request URI: http://gaia.cs.umass.edu/wireshark-labs/HTTP-wireshark-file2.html]
[HTTP request 2/2]
[Prev request in frame: 1301]
[Response in frame: 2722]
```

11. What is the HTTP status code and phrase returned from the server in response to this second HTTP GET?

Did the server explicitly return the contents of the file? Explain.

- i. The status code is: 304 Not Modified
- ii. The server did not explicitly return the contents of the files as they were already loaded on to the browser's cache.
- iii. Marked in Green

No.	Time	Source	Destination	Protocol	Length	Info
2722	17:25:30.314809	128.119.245.12	128.61.88.199	HTTP	293	HTTP/1.1 304 Not Modified
Frame 2722: 293 bytes on wire (2344 bits), 293 bytes captured (2344 bits) on interface 0						
Ethernet II, Src: Cisco_eb:f1:80 (68:ef:bd:eb:f1:80), Dst: AsustekC_c7:e1:6d (08:62:66:c7:e1:6d)						
Internet Protocol Version 4, Src: 128.119.245.12, Dst: 128.61.88.199						
Transmission Control Protocol, Src Port: 80, Dst Port: 54227, Seq: 731, Ack: 963, Len: 239						
Hypertext Transfer Protocol						
HTTP/1.1 304 Not Modified\r\n						
[Expert Info (Chat/Sequence): HTTP/1.1 304 Not Modified\r\n]						
Response Version: HTTP/1.1						
Status Code: 304						
[Status Code Description: Not Modified]						
Response Phrase: Not Modified						
Date: Sat, 26 Jan 2019 22:25:30 GMT\r\n						
Server: Apache/2.4.6 (CentOS) OpenSSL/1.0.2k-fips PHP/5.4.16 mod_perl/2.0.10 Perl/v5.16.3\r\n						
Connection: Keep-Alive\r\n						
Keep-Alive: timeout=5, max=99\r\n						
ETag: "173-58056fa80933b"\r\n						
\r\n						
[HTTP response 2/2]						
[Time since request: 0.028852000 seconds]						
[Prev request in frame: 1301]						
[Prev response in frame: 1320]						
[Request in frame: 2704]						

12. How many HTTP GET request messages did your browser send? Which packet number in the trace contains the Get message for the Bill of Rights?

- i. One GET request was sent
- ii. Packet no: 1782
- iii. Marked in Red

No.	Time	Source	Destination	Protocol	Length	Info
1782	17:39:13.639147	128.61.88.199	128.119.245.12	HTTP	479	GET /wireshark-labs/HTTP-wireshark-file3.html HTTP/1.1
1813	17:39:13.669554	128.119.245.12	128.61.88.199	HTTP	535	HTTP/1.1 200 OK (text/html)

13. Which packet number in the trace contains the status code and phrase associated with the response to the HTTP GET request?

- i. Packet No. 1813 contains 200 OK
- ii. Marked in Green

No.	Time	Source	Destination	Protocol	Length	Info
+ 1782	17:39:13.639147	128.61.88.199	128.119.245.12	HTTP	479	GET /wireshark-labs/HTTP-wireshark-file3.html HTTP/1.1
- 1813	17:39:13.669554	128.119.245.12	128.61.88.199	HTTP	535	HTTP/1.1 200 OK (text/html)

```

> Transmission Control Protocol, Src Port: 80, Dst Port: 54304, Seq: 4381, Ack: 426, Len: 481
✓ [4 Reassembled TCP Segments (4861 bytes): #1809(1460), #1810(1460), #1812(1460), #1813(481)]
  [Frame: 1809, payload: 0-1459 (1460 bytes)]
  [Frame: 1810, payload: 1460-2919 (1460 bytes)]
  [Frame: 1812, payload: 2920-4379 (1460 bytes)]
  [Frame: 1813, payload: 4380-4860 (481 bytes)]
  [Segment count: 4]
  [Reassembled TCP length: 4861]
  [Reassembled TCP Data: 485454502f312e3120323030204f4b0d0a446174653a2053...]
✓ Hypertext Transfer Protocol
  ✓ HTTP/1.1 200 OK\r\n
    ✓ [Expert Info (Chat/Sequence): HTTP/1.1 200 OK\r\n]
      [HTTP/1.1 200 OK\r\n]
      [Severity level: Chat]
      [Group: Sequence]
      Response Version: HTTP/1.1
      Status Code: 200
      [Status Code Description: OK]
      Response Phrase: OK
      Date: Sat, 26 Jan 2019 22:39:13 GMT\r\n

```

14. What is the status code and phrase in the response?

- i. The status code: 200
- ii. Phrase: OK
- iii. The previous screen shot has the status code and phrase marked in green.

15. How many data-containing TCP segments were needed to carry the single HTTP response and the text of the Bill of Rights?

- i. 4 segments were needed
- ii. Marked in Orange

No.	Time	Source	Destination	Protocol	Length	Info
1782	17:39:13.639147	128.61.88.199	128.119.245.12	HTTP	479	GET /wireshark-labs/HTTP-wireshark-file3.html HTTP/1.1
1813	17:39:13.669554	128.119.245.12	128.61.88.199	HTTP	535	HTTP/1.1 200 OK (text/html)

Transmission Control Protocol, Src Port: 80, Dst Port: 54304, Seq: 4381, Ack: 426, Len: 481  
 [4 Reassembled TCP Segments (4861 bytes): #1809(1460), #1810(1460), #1812(1460), #1813(481)]  
 [Frame: 1809, payload: 0-1459 (1460 bytes)]  
 [Frame: 1810, payload: 1460-2919 (1460 bytes)]  
 [Frame: 1812, payload: 2920-4379 (1460 bytes)]  
 [Frame: 1813, payload: 4380-4860 (481 bytes)]  
 [Segment count: 4]  
 [Reassembled TCP length: 4861]  
 [Reassembled TCP Data: 485454502f312e3120323030204f4b0d0a446174653a2053...]

Hypertext Transfer Protocol  
 HTTP/1.1 200 OK\r\n  
 [Expert Info (Chat/Sequence): HTTP/1.1 200 OK\r\n]  
 [HTTP/1.1 200 OK\r\n]  
 [Severity level: Chat]  
 [Group: Sequence]  
 Response Version: HTTP/1.1  
 Status Code: 200  
 [Status Code Description: OK]  
 Response Phrase: OK  
 Date: Sat, 26 Jan 2019 22:39:13 GMT\r\n

16. How many HTTP GET request messages did your browser send? To which Internet addresses were these GET requests sent?

- i. 3 HTTP GET request messages
- ii. All 3 requests were sent to: 128.119.245.12
- iii. Marked in Red

No.	Time	Source	Destination	Protocol	Length	Info
1287	18:14:40.145228	128.61.88.199	128.119.245.12	HTTP	479	GET /wireshark-labs/HTTP-wireshark-file4.html HTTP/1.1
1311	18:14:40.174785	128.119.245.12	128.61.88.199	HTTP	1127	HTTP/1.1 200 OK (text/html)
1314	18:14:40.184134	128.61.88.199	128.119.245.12	HTTP	450	GET /pearson.png HTTP/1.1
1330	18:14:40.213655	128.119.245.12	128.61.88.199	HTTP	745	HTTP/1.1 200 OK (PNG)
1336	18:14:40.216979	128.61.88.199	128.119.245.12	HTTP	464	GET /kurose/cover_5th_ed.jpg HTTP/1.1
1447	18:14:40.317029	128.119.245.12	128.61.88.199	HTTP	632	HTTP/1.1 200 OK (JPEG JFIF image)

17. Can you tell whether your browser download the two images serially, or whether they were downloaded from the two websites in parallel? Explain.

- i. The images were downloaded serially, because the images were transmitted through two separate TCP connections.
- ii. Marked in Yellow

No.	Time	Source	Destination	Protocol	Length	Info
	2054 18:37:53.295383	128.119.245.12	128.61.88.199	HTTP	745	HTTP/1.1 200 OK (PNG)
Frame 2054:	745 bytes on wire (5960 bits), 745 bytes captured (5960 bits) on interface 0	Ethernet II, Src: Cisco_eb:f1:80 (68:ef:bd:eb:f1:80), Dst: AsustekC_c7:e1:6d (08:62:66:c7:e1:6d)	Internet Protocol Version 4, Src: 128.119.245.12, Dst: 128.61.88.199	Transmission Control Protocol, Src Port: 80, Dst Port: 54637, Seq: 3994, Ack: 822, Len: 691		
	Source Port: 80	Destination Port: 54637	[Stream index: 19]	[TCP Segment Len: 691]		
	Sequence number: 3994 (relative sequence number)	[Next sequence number: 4685 (relative sequence number)]	Acknowledgment number: 822 (relative ack number)	0101 .... = Header Length: 20 bytes (5)		
	Flags: 0x018 (PSH, ACK)	Window size value: 245	[Calculated window size: 31360]	[Window size scaling factor: 128]		
	Checksum: 0x9a0a [unverified]	[Checksum Status: Unverified]	Urgent pointer: 0	[SEQ/ACK analysis]		
	[Timestamps]	TCP payload (691 bytes)	TCP segment data (691 bytes)			
[3 Reassembled TCP Segments (3611 bytes): #2052(1460), #2053(1460), #2054(691)]						
Hypertext Transfer Protocol						
Portable Network Graphics						
No.	Time	Source	Destination	Protocol	Length	Info
	2179 18:37:53.394850	128.119.245.12	128.61.88.199	HTTP	632	HTTP/1.1 200 OK (JPEG JFIF image)
Frame 2179:	632 bytes on wire (5056 bits), 632 bytes captured (5056 bits) on interface 0	Ethernet II, Src: Cisco_eb:f1:80 (68:ef:bd:eb:f1:80), Dst: AsustekC_c7:e1:6d (08:62:66:c7:e1:6d)	Internet Protocol Version 4, Src: 128.119.245.12, Dst: 128.61.88.199	Transmission Control Protocol, Src Port: 80, Dst Port: 54639, Seq: 100741, Ack: 411, Len: 578		
	Source Port: 80	Destination Port: 54639	[Stream index: 22]	[TCP Segment Len: 578]		
	Sequence number: 100741 (relative sequence number)	[Next sequence number: 101319 (relative sequence number)]	Acknowledgment number: 411 (relative ack number)	0101 .... = Header Length: 20 bytes (5)		
	Flags: 0x018 (PSH, ACK)	Window size value: 237	[Calculated window size: 30336]	[Window size scaling factor: 128]		
	Checksum: 0x68d0 [unverified]	[Checksum Status: Unverified]	Urgent pointer: 0	[SEQ/ACK analysis]		
	[Timestamps]	TCP payload (578 bytes)	TCP segment data (578 bytes)			
[70 Reassembled TCP Segments (101318 bytes): #2074(1460), #2075(1460), #2076(1460), #2077(1460), #2078(1460), #2079(1460), #2080(1460), #2081(1460), #2083(1460), #2084(1460), #2098(1460), #2099(1460), #2100(1460), #2101(1460), #2102(1460), ]						
Hypertext Transfer Protocol						
JPEG File Interchange Format						

18. What is the server's response (status code and phrase) in response to the initial HTTP GET message from your browser?

- The server's response to the initial GET message is: 401 Unauthorized
- Marked in Red

No.	Time	Source	Destination	Protocol	Length	Info
+>	1711 18:48:33.101949	128.61.88.199	128.119.245.12	HTTP	495	/wireshark-labs/protected_pages/HTTP-wireshark-file5.html HTTP/1.1
-<	1726 18:48:33.131647	128.119.245.12	128.61.88.199	HTTP	771	HTTP/1.1 401 Unauthorized (text/html)
	10318 18:48:46.777981	128.61.88.199	128.119.245.12	HTTP	554	GET /wireshark-labs/protected_pages/HTTP-wireshark-file5.html HTTP/1.1
	10338 18:48:46.809541	128.119.245.12	128.61.88.199	HTTP	544	HTTP/1.1 200 OK (text/html)
	10416 18:48:46.947266	128.61.88.199	128.119.245.12	HTTP	466	GET /favicon.ico HTTP/1.1
	10430 18:48:46.976585	128.119.245.12	128.61.88.199	HTTP	538	HTTP/1.1 404 Not Found (text/html)

19. When your browser's sends the HTTP GET message for the second time, what new field is included in the HTTP GET message?

- An authorization header is has been included with the Credentials that were inputted
- Marked in Blue

No.	Time	Source	Destination	Protocol	Length	Info
10318	18:48:46.777981	128.61.88.199	128.119.245.12	HTTP	554	GET /wireshark-labs/protected_pages/HTTP-wireshark-file5.html HTTP/1.1
Frame 10318: 554 bytes on wire (4432 bits), 554 bytes captured (4432 bits) on interface 0						
Ethernet II, Src: AsustekC_c7:e1:6d (08:62:66:c7:e1:6d), Dst: Cisco_eb:f1:80 (68:ef:bd:eb:f1:80)						
Internet Protocol Version 4, Src: 128.61.88.199, Dst: 128.119.245.12						
Transmission Control Protocol, Src Port: 49507, Dst Port: 80, Seq: 1, Ack: 1, Len: 500						
Hypertext Transfer Protocol						
GET /wireshark-labs/protected_pages/HTTP-wireshark-file5.html HTTP/1.1\r\n						
Host: gaia.cs.umass.edu\r\n						
Connection: keep-alive\r\n						
Authorization: Basic d2lyZXNoYXJrLXN0dWRlbnRzOm5ldHdvcms=\r\n						
Credentials: wireshark-students:network						
Upgrade-Insecure-Requests: 1\r\n						
User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/71.0.3578.98 Safari/537.36\r\n						
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,image/webp,image/apng,*/*;q=0.8\r\n						
Accept-Encoding: gzip, deflate\r\n						
Accept-Language: en-US,en;q=0.9\r\n						
\r\n						
[Full request URI: http://gaia.cs.umass.edu/wireshark-labs/protected_pages/HTTP-wireshark-file5.html]						
[HTTP request 1/2]						
[Response in frame: 10338]						
[Next request in frame: 10416]						

$$3) d_{end-end} = N(d_{proc} + d_{trans} + d_{prop})$$

a)  $N = 3$  toll booths

$$d_{proc} = 0$$

$$d_{trans} = \frac{10 \text{ cars}}{(1 \text{ car}/12 \text{ sec})} = 120 \text{ sec} = 2 \text{ min}$$

$$d_{prop} = \frac{L}{R} = \frac{150 \text{ km}}{100 \frac{\text{km}}{\text{hr}}} = 1.5 \text{ hr}$$

$$3(0 + 2 \text{ min} + 90 \text{ min}) = 276 \text{ min} = \boxed{4.6 \text{ hr}}$$

b)  $N = 3$  toll booths

$$d_{proc} = 0?$$

$$d_{trans} = \frac{8 \text{ cars}}{(1 \text{ car}/12 \text{ sec})} = 96 \text{ sec} = 1.6 \text{ min}$$

$$d_{prop} = \frac{150 \text{ km}}{100 \frac{\text{km}}{\text{hr}}} = 1.5 \text{ hr}$$

$$3(0 + 1.6 \text{ min} + 90 \text{ min}) = 274.8 \text{ min} = \boxed{4.58 \text{ hr}}$$

4) givens

64 kbps (stream)

$$\frac{56(8) \text{ bits}}{64 \times 10^6 \frac{\text{bits}}{\text{sec}}} = .007 \text{ sec}$$

56 bytes (packets)

2 Mbps

10 msec

$$\frac{56(8) \text{ bits}}{2 \times 10^6 \frac{\text{bits}}{\text{sec}}} = .000224 \text{ sec}$$

$$0.007 + 10 \times 10^{-3} + 0.000224 = \cancel{0.007224} \boxed{0.017224 \text{ sec}}$$

$$5) \text{ } d_{\text{end-to-end}} = n(d_{\text{proc}} + d_{\text{trans}} + d_{\text{prop}})$$

$$d_{\text{trans}} = 3 \left( \frac{12,000 \text{ bits}}{2,000,000 \frac{\text{bits}}{\text{sec}}} \right) = 0.018 \text{ sec}$$

$$d_{\text{proc}} = 3 (0.003 \text{ sec}) = 0.009$$

$$d_{\text{prop}} = \frac{6,000,000}{260,000,000} + \frac{4000000}{260,000,000} + \frac{1000,000}{260,000,000} = 0.04$$

$$d_{\text{end-to-end}} = 0.04 + 0.009 + 0.018 = 0.067 \text{ sec}$$

6) Packets containing ACK = 200 bits = 25 bytes = 0.025 kb

Packets containing DATA = 100,000 bits = 12,800 bytes = 12.8 kb

$$\begin{aligned} \text{non-persistent} &= 3 \left( \frac{200 \text{ bits}}{150 \frac{\text{bits}}{\text{sec}}} \right) + \left( \frac{100,000 \text{ bits}}{150 \frac{\text{bits/sec}}{\text{sec}}} \right) \\ &+ 3 \left( \frac{200 \text{ bits}}{\frac{150}{10}} \right) + \left( \frac{100,000}{\frac{150}{10}} \right) = 7,377 \text{ sec} \end{aligned}$$

$$\begin{aligned} \text{persistent} &= 3 \left( \frac{200 \text{ bits}}{15 \frac{\text{bits}}{\text{sec}}} \right) + \left( \frac{100,000 \text{ bits}}{15 \frac{\text{bits/sec}}{\text{sec}}} \right) + 10 \left( \frac{100,000 \text{ bits}}{150 \frac{\text{bits}}{\text{sec}}} \right) \\ &= 7337 \text{ sec} \end{aligned}$$

Yes there is a significant improvement of 40 sec from non-persistent to persistent

$$\text{Cost} = 2415 (8) / 20 = 9660$$

$$= 0.1 \times 5$$

$$\text{Cost} = 2415 (8) / 20 = 9660$$