CS 494/594 Internetworking Protocols: Homework 1 (Spring 2019)
Portland State University
Due Date: 4/18/2019, IN CLASS

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Circle One: **494** 594

Instructions: Please embed your homework answers in the space provided below.
Submit a hard copy IN CLASS.
Please DO NOT email your homework to the instructor or TA.
Do not slip your homework in the instructor's mailbox or under her office door.

For 594 Students:
Please review the following papers in addition to submitting the homework.
DO NOT ATTACH YOUR REVIEWS TO YOUR HOMEWORK.

1) Please see the links provided on the course Piazza page on John Ousterhout's Guidelines for Paper Reviews, as well as some excellent sample reviews.
2) Besides submitting a hard copy of your reviews in class, please post your reviews on Piazza, so that other students can learn from you. I would prefer that you include your name with your reviews. However, you have the option to post your reviews anonymously to other students so that your identity is only visible to the instructor.

The papers:
- "The Design Philosophy of the DARPA Internet Protocols", David Clark, ACM SIGCOMM 1988.
- "End-to-end arguments in system design", Saltzer, Reed and Clark, ACM TOCS, 1984.
- "The Internet Governance Ecosystem", Vint Cerf, CACM, April 2014.

1. (20 points) Packet Switching Vs. Circuit Switching
Consider an Internet audio chat application which transmits data at a fixed rate of 640 kbps (e.g., the sender generates anywhere 640,000 bits of data every second). Also, when such an application starts, it will stay on for an hour. Is this application more suited to run over a packet- switched network, or a circuit-switched network? Briefly explain your answer.

Circuit switching is more efficient.

Because circuit switching is original developed for efficient communication. Circuit switching establishes fixed path between 2 nodes. That means resources for communication. Plus, the application is guaranteed to run for an hour, circuit switching resources aren't wasted and data flow is continuous for an hour. For Packet switching's packet, it is not arriving in order always. This can create problems in audio chats where of message matter.

2. (20 points) Internet Design

In his SIGCOMM 1988 paper, David Clark describes the design goals that guided the development of the Internet protocols. Can you describe a positive artifact that is a result of the priority accorded to different design goals at the inception? Can you describe a negative artifact that is a result of the priority accorded to different design goals at the inception? How could this problem be addressed?

One positive artifact is network which was designed to operate in a military context, the first goal is survivability, and accountability as a last goal. That focus on the possibility of a hostile environment implicitly.

One negative artifact is TCP did not seem suitable transport for XNET.

There are some ways to solve problem. Designers were working with a specific set and ordering of goals in mind. Resource management decisions or accounting must be done on each packet separately. More attention to such thing as accounting, resource management and operation of regions with separate administrations are needed.

3. (20 points) Network Delays

a. (10 points) Suppose two hosts, `ada` and `grace`, are separated by 1.0 x 10^3 km and are connected by a direct link of rate $R = 10$ *Mbps*. Suppose the propagation speed over the link is 2.5×10^8 m/s. Consider sending a file of 100 Mbytes from `ada` to `grace`. Suppose the file is sent continuously as one large message. What is the maximum number of bits that will be in the link at any given time? Note: *1 Mbps = 1,000,000 bps* & *1 Mbyte =* $(1024)^2$ *bytes*.

Distance D: 1,000,000 m

R: 10,000,000 bps

Speed S: 2.5* 10^8 m/s

d_prop = D/S = 0.004 sec

Bandwidth-delay product: R * d_prop = 40,000 bits

The bandwidth-delay product is the maximum number of bits that can be in the link. 40,000 < 10,000,000, thus the maximum number of bits in the link at any a given time is 40,000

b. (10 points) Consider a router buffer preceding an outbound link. In this problem, you will use Little's formula, a famous formula from queueing theory. Let *N* denote the average number of packets in the buffer plus the packet being transmitted. Let a denote the rate of packets arriving at the link. Let *d* denote the average total delay (i.e., the queueing delay plus the transmission delay) experienced by a packet. Little's formula is $N = A \times d$. Suppose that on average, the buffer contains *10* packets, and the average packet queueing delay is *10* milliseconds. The link's transmission rate is *100 packets/sec.*
Using Little's formula, compute the average packet arrival rate, assuming there is no packet loss.

N = A * d
A = N/d

Average number of packet N = 10
Link transmission rate l = 100 packet/sec
= 1 packet/0.01sec
Queueing delay q = 0.01 sec
Average total delay d = l + q = 0.01 + 0.01 = 0.02 sec
A = 10 packets/(0.02sec) = 500 packets/sec

4. (20 points) Network Tools: `traceroute`

The program `traceroute` allows you to find out the path (i.e., a sequence of routers) that a packet will follow to a specific destination. The routers along the path are often identified by name. Use trace route to find the number of hops from your host computer to four destinations, including at least one outside the US. List your answers below.

```
C:\WINDOWS\system32>tracert apple.com

Tracing route to apple.com [17.178.96.59]
over a maximum of 30 hops:

  1     4 ms     4 ms     4 ms  10.0.0.1
  2    17 ms    18 ms    14 ms  96.120.60.229
  3    14 ms    15 ms    14 ms  ae-227-rur01.beaverton.or.bverton.comcast.net [68.87.219.81]
  4    42 ms    14 ms    13 ms  ae-2-rur02.beaverton.or.bverton.comcast.net [68.85.243.154]
  5    29 ms    16 ms    14 ms  ae-51-ar01.troutdale.or.bverton.comcast.net [68.87.216.105]
  6    20 ms    20 ms    21 ms  be-33490-cr01.seattle.wa.ibone.comcast.net [68.86.92.217]
  7    18 ms    19 ms    21 ms  be-10846-pe01.seattle.wa.ibone.comcast.net [68.86.86.90]
  8    19 ms    18 ms    18 ms  50.248.119.62
  9    43 ms    47 ms    42 ms  17.1.0.178
 10    42 ms    42 ms    41 ms  17.1.0.188
 11    41 ms    42 ms    41 ms  17.1.1.113
 12    44 ms    40 ms    53 ms  17.1.1.220
 13     *        *        *     Request timed out.
 14    42 ms    40 ms    41 ms  17.1.1.21
 15    42 ms    42 ms    40 ms  17.0.157.53
 16    41 ms    42 ms    40 ms  17.111.0.131
 17    42 ms    42 ms    42 ms  17.111.65.215
 18  17.111.65.215  reports: Destination net unreachable.

Trace complete.
```

```
C:\WINDOWS\system32>tracert google.com

Tracing route to google.com [172.217.3.206]
over a maximum of 30 hops:

  1     3 ms     3 ms     4 ms  10.0.0.1
  2    16 ms    15 ms    13 ms  96.120.60.229
  3    25 ms    16 ms    16 ms  ae-227-rur02.beaverton.or.bverton.comcast.net [68.87.219.89]
  4    15 ms    18 ms    15 ms  ae-51-ar01.troutdale.or.bverton.comcast.net [68.87.216.105]
  5    20 ms    18 ms    20 ms  be-33490-cr01.seattle.wa.ibone.comcast.net [68.86.92.217]
  6    27 ms    19 ms    18 ms  be-10846-pe01.seattle.wa.ibone.comcast.net [68.86.86.90]
  7    23 ms    26 ms    23 ms  50.242.150.242
  8    24 ms    21 ms    23 ms  108.170.245.97
  9    19 ms    23 ms    18 ms  108.170.233.153
 10    21 ms    20 ms    19 ms  sea15s12-in-f206.1e100.net [172.217.3.206]

Trace complete.
```

```
C:\WINDOWS\system32>tracert psu.com

Tracing route to psu.com [104.31.85.240]
over a maximum of 30 hops:

  1     5 ms     4 ms     5 ms  10.0.0.1
  2    17 ms    16 ms    14 ms  96.120.60.229
  3    18 ms    16 ms    18 ms  ae-227-rur02.beaverton.or.bverton.comcast.net [68.87.219.89]
  4    16 ms    16 ms    18 ms  ae-51-ar01.troutdale.or.bverton.comcast.net [68.87.216.105]
  5    15 ms    14 ms    16 ms  69.252.236.134
  6    17 ms    15 ms    27 ms  104.31.85.240

Trace complete.
```

This is destination outside of US.

```
C:\WINDOWS\system32>tracert baidu.com

Tracing route to baidu.com [123.125.114.144]
over a maximum of 30 hops:

  1     5 ms     5 ms     6 ms  10.0.0.1
  2    19 ms    16 ms    15 ms  96.120.60.229
  3    15 ms    15 ms    18 ms  ae-227-rur01.beaverton.or.bverton.comcast.net [68.87.219.81]
  4    14 ms    13 ms    13 ms  ae-2-rur02.beaverton.or.bverton.comcast.net [68.85.243.154]
  5    16 ms    16 ms    16 ms  ae-51-ar01.troutdale.or.bverton.comcast.net [68.87.216.105]
  6    20 ms    18 ms    24 ms  be-33490-cr01.seattle.wa.ibone.comcast.net [68.86.92.217]
  7    34 ms    44 ms    36 ms  be-10825-cr01.9greatoaks.ca.ibone.comcast.net [68.86.85.198]
  8    45 ms    43 ms    44 ms  be-11525-cr02.losangeles.ca.ibone.comcast.net [68.86.84.149]
  9    44 ms    40 ms    43 ms  be-11599-pe01.losangeles.ca.ibone.comcast.net [68.86.84.194]
 10    96 ms   100 ms    96 ms  219.158.33.209
 11   245 ms   249 ms   241 ms  219.158.98.149
 12   241 ms   244 ms     *     219.158.103.37
 13   251 ms     *      253 ms  219.158.8.117
 14   291 ms     *      286 ms  219.158.112.45
 15     *      280 ms   282 ms  202.96.12.94
 16   289 ms     *      285 ms  124.65.57.206
 17     *      282 ms   282 ms  123.125.248.94
 18     *        *        *     Request timed out.
 19     *        *        *     Request timed out.
 20   286 ms     *      284 ms  123.125.114.144

Trace complete.
```

5. (20 points) Wireshark Labs: Getting Started

1.

GQUIC, TCP, DNS

Apply a display filter ... <Ctrl-/> Expression... +

No.	Time	Source	Destination	Protocol	Length	Info
36	1.842914	10.0.0.31	172.217.3.164	GQUIC	70	Payload (Encrypted), PKN: 6, CID: 12869985625539727834
37	1.868253	10.0.0.31	172.217.3.164	GQUIC	70	Payload (Encrypted), PKN: 7, CID: 12869985625539727834
38	1.949802	172.217.3.170	10.0.0.31	GQUIC	811	Payload (Encrypted), PKN: 4
39	1.949812	172.217.3.170	10.0.0.31	GQUIC	124	Payload (Encrypted), PKN: 5
40	1.951108	10.0.0.31	172.217.3.170	GQUIC	70	Payload (Encrypted), PKN: 5, CID: 4363012485546953320
41	2.969389	fe80::3e7a:8aff:fe9…	ff02::1	ICMPv6	174	Router Advertisement from 3c:7a:8a:91:87:b2
42	3.183247	10.0.0.31	128.119.245.12	TCP	54	62272 → 80 [FIN, ACK] Seq=1 Ack=1 Win=256 Len=0
43	3.183340	10.0.0.31	128.119.245.12	TCP	54	62273 → 80 [FIN, ACK] Seq=1 Ack=1 Win=255 Len=0
44	3.185842	2601:1c0:4500:cd15:…	2001:558:feed::1	DNS	97	Standard query 0xcd5a AAAA gaia.cs.umass.edu
45	3.217021	2601:1c0:4500:cd15:…	2001:558:feed::2	DNS	97	Standard query 0xcd5a AAAA gaia.cs.umass.edu
46	3.251381	2001:558:feed::2	2601:1c0:4500:cd15:…	DNS	150	Standard query response 0xcd5a AAAA gaia.cs.umass.edu SOA unix1.…

2.

No.	Time	Source	Destination	Protocol	Length	Info
87	23:29:26.557832	10.0.0.31	203.205.146.59	HTTP	760	POST /mmtls/00001c86 HTTP/1.1
101	23:29:26.788377	203.205.146.59	10.0.0.31	HTTP	1082	HTTP/1.1 200 OK
116	23:29:27.641192	10.0.0.31	203.205.219.54	HTTP	564	POST / HTTP/1.1
124	23:29:27.814833	203.205.219.54	10.0.0.31	HTTP	262	HTTP/1.1 200 OK (application/multipart-formdata)
129	23:29:27.894923	10.0.0.31	128.119.245.12	HTTP	646	GET /wireshark-labs/INTRO-wireshark-file1.html HTTP/1.1
134	23:29:27.993950	128.119.245.12	10.0.0.31	HTTP	293	HTTP/1.1 304 Not Modified

3.

Source: 10.0.0.31
Destination: 128.119.245.12

4.

GET

```
No.     Time               Source                Destination           Protocol Length Info
    129 23:29:27.894923    10.0.0.31             128.119.245.12        HTTP     646    GET /wireshark-labs/INTRO-wireshark-file1.html 
HTTP/1.1
Frame 129: 646 bytes on wire (5168 bits), 646 bytes captured (5168 bits) on interface 0
Ethernet II, Src: Microsof_1d:d6:11 (bc:83:85:1d:d6:11), Dst: ArrisGro_91:87:b2 (3c:7a:8a:91:87:b2)
Internet Protocol Version 4, Src: 10.0.0.31, Dst: 128.119.245.12
Transmission Control Protocol, Src Port: 62377, Dst Port: 80, Seq: 1, Ack: 1, Len: 592
Hypertext Transfer Protocol
    GET /wireshark-labs/INTRO-wireshark-file1.html HTTP/1.1\r\n
    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/73.0.3683.103 Safari/537.36\r\n
    Accept: text/html,application/xhtml+xml,application/xml;q=0.9,image/webp,image/apng,*/*;q=0.8,application/signed-exchange;v=b3\r\n
    Accept-Encoding: gzip, deflate\r\n
    Accept-Language: zh,en-US;q=0.9,en;q=0.8,zh-CN;q=0.7\r\n
    If-None-Match: "51-586c7b2e5f423"\r\n
    If-Modified-Since: Thu, 18 Apr 2019 05:59:01 GMT\r\n
    \r\n
    [Full request URI: http://gaia.cs.umass.edu/wireshark-labs/INTRO-wireshark-file1.html]
    [HTTP request 1/1]
    [Response in frame: 134]
```

OK

```
No.     Time               Source                Destination           Protocol Length Info
    124 23:29:27.814833    203.205.219.54        10.0.0.31             HTTP     262    HTTP/1.1 200 OK  (application/multipart-formdata)
Frame 124: 262 bytes on wire (2096 bits), 262 bytes captured (2096 bits) on interface 0
Ethernet II, Src: ArrisGro_91:87:b2 (3c:7a:8a:91:87:b2), Dst: Microsof_1d:d6:11 (bc:83:85:1d:d6:11)
Internet Protocol Version 4, Src: 203.205.219.54, Dst: 10.0.0.31
Transmission Control Protocol, Src Port: 80, Dst Port: 62376, Seq: 1, Ack: 511, Len: 208
Hypertext Transfer Protocol
    HTTP/1.1 200 OK\r\n
    Content-Length: 54\r\n
    Content-Type: application/multipart-formdata\r\n
    Date: Thu, 18 Apr 2019 06:29:27 GMT\r\n
    Server: HTTP Load Balancer/1.0\r\n
    \r\n
    [HTTP response 1/1]
    [Time since request: 0.173641000 seconds]
    [Request in frame: 116]
    [Request URI: http://qbwup.imtt.qq.com/]
    File Data: 54 bytes
Media Type
```