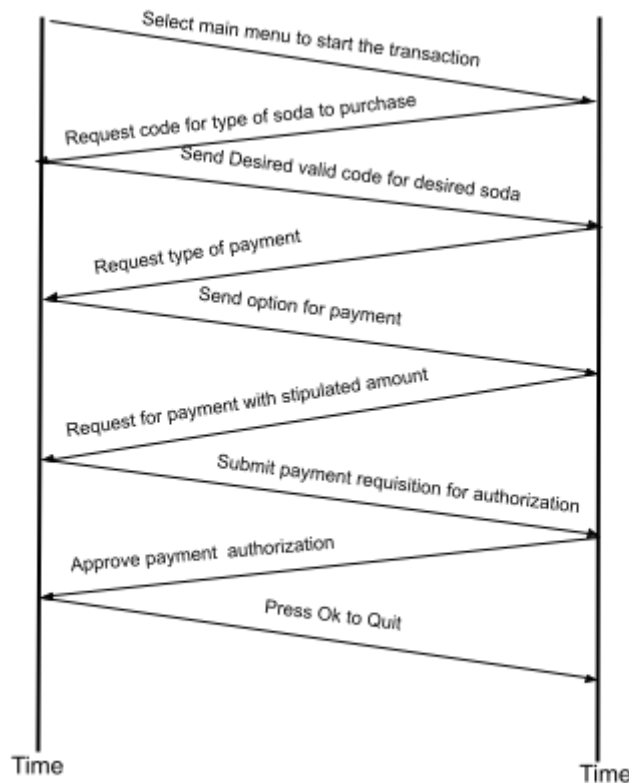


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Section: 2

Assignment 2

1. Application Level Protocols: Design and describe an application level protocol for a soda vending machine? Draw the operation of your protocol similar to Figure 1.2 from course textbooks shown below.



2. Explain the following terms briefly

a.

- **Network edge:** It refers to the area where a device or local network interfaces with the internet. The edge is close to the devices. It is where an enterprise network connects to third-party network services. Edge computing is a distributed architecture that processes data closer to end-users. Examples routers, routing switches, integrated access devices (IADs), etc.
- **Network core:** It is a mesh of packet switches and links that interconnects the Internet's end systems

- **Store and forward:** Before it can be transmitted on the next link, the entire packet must arrive at the router.
- **Bandwidth:** It is how much data *could* theoretically be transferred from a source at any given time.
- **Throughput:** measures how many packets arrive at their destinations successfully. It is measured in a bit for seconds (bps).

**b. Advantage of Circuit Switch:**

- Decreases the delay the user experiences before and during a call
- The call will be done with a steady bandwidth, dedicated channel, and consistent data rate
- Packets are always delivered in the correct order

**Advantage of Packet Switching:**

- More efficient than circuit switching
- Data packets are able to find the destination without the use of a dedicated channel
- Reduces lost data packets because packet switching allows for resending of packets
- More cost-effective since there is no need for a dedicated channel for voice or data traffic.<sup>1</sup>

**3. Packets Transmission and Delays**

Consider the following scenario. A link with capacity of 3Mbps is shared by multiple users.

a.

i. Total bandwidth available : 3 Mbps = 3000 Kbps

Each user request: 15 Kbps

Total users that can be supported  $\frac{3000 \text{ Kbps}}{15 \text{ Kbps}} = 200 \text{ users}$

ii. Total bandwidth available : 3 Mbps

Each user request: 1.50 Mbps =

Total users that can be supported  $\frac{3 \text{ Mbps}}{1.5 \text{ Mbps}} = 2 \text{ users}$

$$\text{iii. } p_r(n) = (4 \text{ choose } n) p^n (1 - p)^{(4-n)}$$

$$p_r(4) = \frac{4!}{(4-4)! 4!} (0.1)^4 (1 - 0.1)^{(4-4)}$$

$$p_r(4) = 0.0001$$

$$\text{iv. } p_r(2) = \frac{4!}{(4-2)! 2!} (0.1)^2 (1 - 0.1)^{(4-2)}$$

$$p_r(2) = 0.0486$$

b. Suppose a packet with size 5M bits will be transmitted over a link of transmission rate 500Kbs, with distance 7,500km, with propagation speed of  $2.5 \times 10^8$  km/s.

**i. Propagation delay**

$d_{prop}$  : propagation delay

$$d_{prop} = \frac{d}{s}$$

d: length of physical link = 7,500 km

s: propagation speed =  $2.5 \times 10^8$  km/s

$$d_{prop} = \frac{7,500 \text{ km}}{2.5 \times 10^8 \text{ km/s}} = 30 \mu\text{s}$$

**ii. Transmission delay**

$d_{tran}$  : transmission delay

$$d_{tran} = \frac{L}{R}$$

L : packet length (bits)

R : link transmission rate (bps)

$$d_{tran} = \frac{5 \text{ Mbit}}{500 \text{ Kbs}} = 10 \mu\text{s}$$

c. Suppose a router with infinite buffer capacity. Answer the following questions with yes/no:

i. No, packet loss occurs when memory to hold queued packets fills up, but in this case the packets queue in the router buffer is infinite.

ii. Yes, because the delays not only depend on the router and its capacity, there is an influence for link of transmission, distance, etc.

d. Consider a scenario where 10 packets arrive to a router where currently there is no queue. Given each packet has a length of 100Kbits and transmission rate of 10Kbs. What will be the average queuing delay?

The queuing delay for the first packet is 0 for the second packet it is  $L/R$ ; for third packet it is  $2L/R$  etc. The last packet (number  $N$ ) has already been transmitted when the second batch (i.e. group) of packet arrives.

It takes  $NL/R$  seconds to transmit the  $N$  packets. The first of the  $N$  packets has no queuing delay. The second packet has a queuing delay of  $L/R$  seconds. The  $n$ -th packet has a delay of  $(n-1)L/R$

$$\frac{1}{N} \sum_{n=1}^N (n-1) \frac{L}{R} = \frac{1}{2} (N-1) \frac{L}{R}$$

$$\text{Queuing delay} = \frac{1}{2} (10-1) \frac{100Kbits}{10Kbs} = 45 s$$

4. The traceroute program relies on a protocol  $X$  to calculate the delay between source and the different routers in the path of destination.

a. What is the name of protocol  $X$ ?

i. Traceroute uses Internet Control Message Protocol (ICMP) echo packets

ii. Which field in the IP header is utilized by traceroute to send packets to particular router in the path?

Traceroute uses the TTL (Time to Live) field in the IP packet header. Normally, TTL is used to prevent packet from being forwarded forever when there is a routing loop. Whenever an IP packet is forwarded by a router, the TTL is decreased by one. When the TTL is zero, the IP packet will be discarded<sup>2</sup>.

b. Use the traceroute program for 3 hostnames. Provide screenshots and answer the following question

i. Can you identify the Internet Service Provider (ISP) from the hostnames?

<p>host: <a href="http://www.notion.so">www.notion.so</a></p> <p>ISP: line 3,4, and 5</p>	<pre>C:\Users\Katerin Perdom&gt;tracert www.notion.so  Tracing route to www.notion.so [104.18.23.110] over a maximum of 30 hops:    1  1 ms  1 ms  1 ms  10.0.1.1   2  17 ms 12 ms 13 ms cpe-66-65-96-1.nyc.res.rr.com [66.65.96.1]   3  17 ms 14 ms 12 ms agg46.nyclnryg02h.nyc.rr.com [68.173.201.122]   4  20 ms 16 ms 17 ms agg101.nyquny9101r.nyc.rr.com [68.173.198.34]   5  19 ms 12 ms 22 ms bu-ether25.nycmny837aw-bcr00.tbone.rr.com [107.14.19.22]   6  13 ms 19 ms 25 ms 66.109.5.119   7  17 ms 15 ms 16 ms mxs.biz.rr.com [24.30.200.33]   8  16 ms 19 ms 17 ms 172.70.112.4   9  22 ms 16 ms 16 ms 104.18.23.110  Trace complete.</pre>
<p>Host <a href="http://www.youtube.com">www.youtube.com</a></p> <p>ISP Line 3,4 and 5</p>	<pre>C:\Users\Katerin Perdom&gt;tracert www.youtube.com  Tracing route to youtube-ui.l.google.com [142.250.80.78] over a maximum of 30 hops:    1  1 ms  1 ms  1 ms  10.0.1.1   2  15 ms 17 ms 18 ms cpe-66-65-96-1.nyc.res.rr.com [66.65.96.1]   3  13 ms 20 ms 17 ms agg46.nyclnryg01h.nyc.rr.com [68.173.201.120]   4  22 ms 16 ms 17 ms agg101.nyclnryg01r.nyc.rr.com [68.173.198.32]   5  24 ms 17 ms 18 ms bu-ether19.nwrknjmd67w-bcr00.tbone.rr.com [66.109.6.78]   6  37 ms 24 ms 17 ms 66.109.5.138   7  18 ms 14 ms 16 ms 74.125.50.134   8  19 ms 18 ms 13 ms 108.170.236.98   9  21 ms 20 ms 15 ms 142.251.65.103  10  12 ms 14 ms 22 ms lga34s35-in-f14.1e100.net [142.250.80.78]  Trace complete.</pre>
<p>Host getpocket.com</p> <p>ISP: line 3,4, and 5</p>	<pre>C:\Users\Katerin Perdom&gt;tracert getpocket.com  Tracing route to getpocket.com [13.225.71.90] over a maximum of 30 hops:    1  1 ms  1 ms  1 ms  10.0.1.1   2  19 ms 14 ms 12 ms cpe-66-65-96-1.nyc.res.rr.com [66.65.96.1]   3  13 ms 14 ms 13 ms agg46.nyclnryg02h.nyc.rr.com [68.173.201.122]   4  24 ms 15 ms 20 ms agg101.nyquny9101r.nyc.rr.com [68.173.198.34]   5  19 ms 18 ms 12 ms bu-ether25.nycmny837aw-bcr00.tbone.rr.com [107.14.19.22]   6  14 ms 16 ms 16 ms 66.109.5.119   7  14 ms 12 ms 13 ms 99.82.176.74   8  *      *      *      Request timed out.   9  34 ms 18 ms 12 ms 150.222.110.35  10  *      *      *      Request timed out.  11  *      *      *      Request timed out.  12  *      *      *      Request timed out.  13  *      *      *      Request timed out.  14  *      *      *      Request timed out.  15  15 ms 12 ms 13 ms server-13-225-71-90.ewr53.r.cloudfront.net [13.225.71.90]  Trace complete.</pre>

ii. Why does the delay for the same router fluctuates (remember traceroute send 3 packets)?

Traceroute program sends three UDP packets to each hop to simply calculate the round trip average. because the traceroute output shows you those three values in its output. It program is sending a different random UDP port number. This is to identify the reply belonged to which packet, the messages send by the hops and destination contains the header of original packet we send, hence traceroute program can accurately calculate

the round trip time (For each three UDP packets send to each hop), as it can easily identify the reply and correlate.

5. Explain how Web architectures were developed and refined to increasingly support applications with informational, interactive, transactional, and delivery requirements? Please relate to specific architectures, their corresponding protocols, and describe the improvements that were made over time.

Web architecture is the conceptual structure of the World Wide Web. It was realized in the 1990s so that people and machines could communicate with each other within a certain space. It is used to exchange information, distribute, and share information in a network. At the time, the web was primarily comprised of static HTML-based websites, or hypertexts that could be retrieved by a browser. Later, dynamic websites and distributed web services were added.

The internet changed and expanded constantly by numerous developers, programmers and various consortia.

Architectures as a **client-server model**. Clients and servers shared the tasks and services that the system was supposed to perform. The internet protocol family, which consists of around 500 different network protocols, is usually used as the basis for the WWW, but comprises the TCP/TCP/IP reference model.

Protocols for data transfer: HTTP (Hypertext Transfer Protocol) or HTTPS (Hypertext Transfer Protocol Secure) is used in the web. Other applications, such as mail servers, use SMTP (Simple Mail Transfer Protocol) or POP (Post Office Protocol). Determining the protocols used depends on the application.

**Three-tier model** includes an application logic between the client and the server, which handles the data processing and allows a certain degree of interaction. Dynamic websites are distinguished by the fact that content is changed on the client side without requiring new communication between the server and the client.

Protocols like Hypertext Markup Language (HTML), the Hypertext Transfer Protocol (HTTP), and the TCP/IP networking protocol suite. HTML works well for structuring and presenting information using a web browser application. TCP/IP is an effective networking protocol that transfers data between applications over the Internet and has little impact on web database application developer<sup>4</sup>.

**Service-oriented architecture** (SOA) in each IT system can, in turn, consist of subsections whose individual components are linked to one another via a fixed structure or architecture. Distributed web services, which are implemented as service-oriented architectures (SOA), provide numerous functions and modular functional units that can be supplemented. Protocols

Finally, internet of Things or Semantic Web can be considered a research area in this context. If the Web architecture was represented as an evolutionary timeline, IoT and Semantic Web would be the top of the development<sup>3</sup>.

Improvements over time



1-tier architecture

- Configuration setting, user interface environment, data logic, and marketing logic system are existed on the same system (Eg. MP3 player, MS office).

2-tier architecture

- Easy to design all applications, maximum user satisfaction, implementation of homogeneous environment, best performance. Problems with poor performance, less security, less portability, etc.

3-tier architecture

- Best performance data integrity, improved security to 2-tier architecture, hide database structure.

4-tier architecture

- Delivers the flexible and reusable application. Problems with complex structures<sup>5</sup>.

## 6. Real-Time Messaging Applications

List at least four mainstream real-time messaging applications. Document the protocols they use (along with references to corresponding IETF RFCs) and explain in detail how they differ. Please provide references and/or links to all documentation sources used to answer this question.

	Description	Protocol
Telegram	free and open-source, cross-platform, cloud-based instant messaging software	MTPROTO protocol is used by Telegram when users do not opt-in for end-to-end encryption (E2EE) <sup>6</sup>
Whatsapp	Voice over IP service owned by Facebook. The WhatsApp protocol uses SSL along with	It uses a customer version of open standard Extension Messaging and Presence

	some customized protocols	(XMPP) <sup>9</sup>
Discord	VoIP, instant messaging, and digital distribution platform. Users communicate with voice calls, video calls, text messaging, media, and files in private chats or as part of communities called "servers"	TLS for text chat, etc  DTLS for voice over browser  xsalsa20 for voice over a desktop app
Agora	Audio, video, and sending messages (such as text and photos)	RTMP Real-Time Messaging Protocol. Widely used protocol that enables live video streaming <sup>11</sup>

## 7. Email Applications

List at least five mainstream email applications. Document the protocols they use (along with references to corresponding IETF RFCs) to send and receive emails and explain in detail how they differ. Please provide references and/or links to all documentation sources used to answer this question.

Spark	Spark is an emails application for iOS, macOS, and Android devices by Readdle.	IMAP protocol <sup>12</sup> , Internet Message Access Protocol is a protocol for accessing email or bulletin board messages from a (possible shared ) mail server or service <sup>13</sup> .
Mozilla Thunderbird	Thunderbird is a free email application that's easy to set up and customize <sup>15</sup>	<ul style="list-style-type: none"> <li>• POP. Basic email retrieval protocol.</li> <li>• IMAP. Thunderbird has implemented many of the capabilities in IMAP, in addition to adding their own extensions and the de facto standards by Google and Apple</li> <li>• LDAP address auto-completion.</li> <li>• S/MIME: Inbuilt support for email encryption and signing using X.509 keys provided by a centralized certificate authority.</li> <li>• OpenPGP: Inbuilt support for email</li> </ul>



		encryption and signing since version 78.2.1, while older versions used extensions such as Enigmail <sup>14</sup> .
eM Client	Email client for windows and macOS, for professionals and home users alike <sup>16</sup>	POP3, SMTP, IMAP or CalDAV
Mailbird	Desktop email for windows users <sup>18</sup> .	<ul style="list-style-type: none"> <li>• POP3 – a basic retrieval protocol that supports offline email use.</li> <li>• IMAP– another retrieval protocol that allows using webmail accounts in Mailbird.</li> <li>• SMTP – a protocol for email transmission<sup>17</sup>.</li> </ul>
KMail	KMail is a state-of-the-art <b>email client</b> that integrates well with widely used email providers like GMail	POP3, IMAP, Microsoft Exchange (EWS) and more <sup>19</sup> .

8.

- a. Explain what the following utilities are used for: traceroute, ping, nslookup, ipconfig, dig?

**Pig:** this tool can determine whether a device is reachable from another device, also help identify latency and packet loss between the two devices. It can be used both locally on the internal network, and externally to test connectivity across the internet<sup>20</sup>.

**Traceroute:** this tool displays the path and transit delay of a packet from your machine to a chosen IP address or DNS name on the local network or across the internet. It breaks down each hop of a packet's journey from source to destination, displaying IP and DNS information of each hop<sup>21</sup>.

**Nslookup:** It performs DNS queries and receives: domain names or IP addresses, or any other specific DNS Records<sup>22</sup>.

**Ipconfig:** display all current TCP/IP network configuration values and refreshes Dynamic Host Configuration Protocol (DHCP) and Domain Name System (DNS) setting<sup>23</sup>.

**Dig:** is a tool for querying DNS nameservers for information about host addresses, mail exchanges, name servers, and related information<sup>24</sup>.

b. Identify at least three more utilities and explain what they are used for.

**Nmap:** or Network Mapper, is command-line based tool for network discovery, networking mapping, and networking auditing. Basically, it uses IP packets to determine what hosts, ports, services, and IP addresses are available and open on a network, both LAN and WAN<sup>25</sup>.

**Netstat:** is a tool that displays very detailed information and statistics about the device you are using and how it is connected to the local and wider network. It can be used to retrieve inbound and outbound TCP connections, routing tables, and a number of network interface statistics<sup>26</sup>.

**ARP:** or Address Resolution Protocol, is a standard networking protocol that links network addresses to a physical address, or to put it another way, IP addresses to MAC addresses. It is an essential part of how networks communicate<sup>27</sup>.

c. For each one of the utilities introduced in 8.a. and 8.b., provide a detailed usage scenario along with corresponding screenshots as needed to fully document your example.

<b>Ping</b>	<pre>C:\Users\Katerin Perdom&gt;ping google.com  Pinging google.com [142.251.35.174] with 32 bytes of data: Reply from 142.251.35.174: bytes=32 time=13ms TTL=117 Reply from 142.251.35.174: bytes=32 time=14ms TTL=117 Reply from 142.251.35.174: bytes=32 time=15ms TTL=117 Reply from 142.251.35.174: bytes=32 time=11ms TTL=117  Ping statistics for 142.251.35.174:     Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),     Approximate round trip times in milli-seconds:         Minimum = 11ms, Maximum = 15ms, Average = 13ms</pre>
-------------	---

## Traceroute

```
C:\Users\Katerin Perdom>tracert www.linkedin.com

Tracing route to 1-0005.1-msedge.net [13.107.42.14]
over a maximum of 30 hops:

  0  1 ms  <1 ms  1 ms  10.0.1.1
  1  *      14 ms  13 ms  cpe-66-65-96-1.nyc.res.rr.com [66.65.96.1]
  2  18 ms  18 ms  13 ms  agg46.nyclnyrg01h.nyc.rr.com [68.173.201.120]
  3  28 ms  13 ms  14 ms  agg101.nyclnyrg01r.nyc.rr.com [68.173.198.32]
  4  15 ms  14 ms  14 ms  bu-ether19.nwrknjmd67w-bcr00.tbone.rr.com [66.109.6.78]
  5  18 ms  20 ms  22 ms  66.109.10.179
  6  13 ms  13 ms  21 ms  ae68-0.ier02.ewr30.ntwk.msn.net [104.44.198.161]
  7  *      *      *      Request timed out.
  8  17 ms  14 ms  16 ms  13.104.141.203
  9  *      *      *      Request timed out.
 10  *      *      *      Request timed out.
 11  *      *      *      Request timed out.
 12  *      *      *      Request timed out.
 13  19 ms  13 ms  13 ms  13.107.42.14

Trace complete.
```

## nslookup

```
C:\Users\Katerin Perdom>nslookup www.linkedin.com
Server: Unknown
Address: 10.0.1.1

Non-authoritative answer:
Name:    1-0005.dc-msedge.net
Addresses: 2620:1ec:22::14
          13.107.43.14
Aliases: www.linkedin.com
          www-linked-in-com.1-0005.1-msedge.net

C:\Users\Katerin Perdom>nslookup -q=MX www.linkedin.com
Server: Unknown
Address: 10.0.1.1

Non-authoritative answer:
www.linkedin.com      canonical name = www-linked-in-com.1-0005.1-msedge.net
www-linked-in-com.1-0005.1-msedge.net canonical name = 1-0005.dc-msedge.net
```

ipconfig

```
C:\Users\Katerin Perdomo>ipconfig /all

Windows IP Configuration

Host Name . . . . . : MSI
Primary Dns Suffix . . . . . :
Node Type . . . . . : Hybrid
IP Routing Enabled. . . . . : No
WINS Proxy Enabled. . . . . : No
DNS Suffix Search List. . . . . : nyc.rr.com


Ethernet adapter vEthernet (WSL):

Connection-specific DNS Suffix . . :
Description . . . . . : Hyper-V Virtual Ethernet Adapter
Physical Address. . . . . : 00-15-5D-86-74-2D
DHCP Enabled. . . . . : No
Autoconfiguration Enabled . . . . : Yes
Link-local IPv6 Address . . . . . : fe80::3c1b:dc85:9c99:f348%26(Preferred)
IPv4 Address. . . . . : 172.31.192.1(Preferred)
Subnet Mask . . . . . : 255.255.240.0
Default Gateway . . . . . :
DHCPv6 IAID . . . . . : 436213085
DHCPv6 Client DUID. . . . . : 00-01-00-01-27-F8-DD-A5-34-2E-B7-D0-CC-58
DNS Servers . . . . . : fec0:0:0:ffff::1%1
                       fec0:0:0:ffff::2%1
                       fec0:0:0:ffff::3%1
NetBIOS over Tcpip. . . . . : Enabled
```

dig

```
katerine-perdomo@katerinemorocha-HP-Pavilion-15-Notebook-PC: ~
File Edit View Search Terminal Help
(base) katerine-perdomo@katerinemorocha-HP-Pavilion-15-Notebook-PC:~$ dig linux.org

; <<>> DiG 9.11.3-1ubuntu1.15-Ubuntu <<>> linux.org
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 26234
;; flags: qr rd ra; QUERY: 1, ANSWER: 2, AUTHORITY: 0, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 65494
;; QUESTION SECTION:
;linux.org.                IN      A

;; ANSWER SECTION:
linux.org.                 300     IN      A       104.21.47.125
linux.org.                 300     IN      A       172.67.147.165

;; Query time: 50 msec
;; SERVER: 127.0.0.53#53(127.0.0.53)
;; WHEN: Sun Sep 26 18:01:33 -05 2021
;; MSG SIZE rcvd: 70

(base) katerine-perdomo@katerinemorocha-HP-Pavilion-15-Notebook-PC:~$
```

nmap	<pre> katerine-perdomo@katerinemorocha-HP-Pavilion-15-Notebook-PC: ~ File Edit View Search Terminal Help The following packages were automatically installed and are no longer required:   libappindicator1 libindicator7 Use 'sudo apt autoremove' to remove them. 0 upgraded, 0 newly installed, 0 to remove and 168 not upgraded. (base) katerine-perdomo@katerinemorocha-HP-Pavilion-15-Notebook-PC:~\$ nmap linux .org  Starting Nmap 7.60 ( https://nmap.org ) at 2021-09-26 18:04 -05 Nmap scan report for linux.org (172.67.147.165) Host is up (0.11s latency). Other addresses for linux.org (not scanned): 104.21.47.125 2606:4700:3035::ac43: 93a5 2606:4700:3031::6815:2f7d Not shown: 993 filtered ports PORT      STATE SERVICE 21/tcp    open  ftp 80/tcp    open  http 443/tcp   open  https 554/tcp   open  rtsp 7070/tcp  open  realserver 8080/tcp  open  http-proxy 8443/tcp  open  https-alt  Nmap done: 1 IP address (1 host up) scanned in 17.12 seconds (base) katerine-perdomo@katerinemorocha-HP-Pavilion-15-Notebook-PC:~\$ </pre>
netstat	<pre> katerine-perdomo@katerinemorocha-HP-Pavilion-15-Notebook-PC: ~ File Edit View Search Terminal Help (base) katerine-perdomo@katerinemorocha-HP-Pavilion-15-Notebook-PC:~\$ netstat -t Active Internet connections (w/o servers) Proto Recv-Q Send-Q Local Address           Foreign Address         State tcp        0      0 localhost:52812         localhost:8191          ESTABLISHED tcp        0      1 katerinemorocha-H:50768 32.121.122.34.bc.g:http SYN_SENT tcp        0      0 localhost:8191          localhost:52786         ESTABLISHED tcp        0      0 localhost:8191          localhost:52794         ESTABLISHED tcp        0      0 localhost:52816         localhost:8191          ESTABLISHED tcp        0      0 localhost:8191          localhost:52810         ESTABLISHED tcp        0      0 localhost:52792         localhost:8191          ESTABLISHED tcp        0      0 localhost:8191          localhost:52816         ESTABLISHED tcp        0      0 localhost:8191          localhost:52792         ESTABLISHED tcp        0      0 localhost:52794         localhost:8191          ESTABLISHED tcp        0      0 localhost:52786         localhost:8191          ESTABLISHED tcp        0      0 localhost:8191          localhost:52818         ESTABLISHED tcp        0      0 localhost:52788         localhost:8191          ESTABLISHED tcp        0      0 localhost:52810         localhost:8191          ESTABLISHED tcp        0      0 katerinemorocha-H:41819 relay-d7627e96.net:http ESTABLISHED tcp        0      0 localhost:8191          localhost:52814         ESTABLISHED tcp        0      0 localhost:8191          localhost:52788         ESTABLISHED tcp        0      0 localhost:52818         localhost:8191          ESTABLISHED tcp        0      0 localhost:52814         localhost:8191          ESTABLISHED tcp        0      0 localhost:8191          localhost:52812         ESTABLISHED (base) katerine-perdomo@katerinemorocha-HP-Pavilion-15-Notebook-PC:~\$ </pre>

## ARP

```
katerine-perdomo@katerinemorocha-HP-Pavilion-15-Notebook-PC: ~  
File Edit View Search Terminal Help  
-D, --use-device      read <hwaddr> from given device  
-A, -p, --protocol    specify protocol family  
-f, --file            read new entries from file or from /etc/ethers  
  
<HW>=Use '-H <hw>' to specify hardware address type. Default: ether  
List of possible hardware types (which support ARP):  
  ash (Ash) ether (Ethernet) ax25 (AMPR AX.25)  
  netrom (AMPR NET/ROM) rose (AMPR ROSE) arcnet (ARCnet)  
  dlci (Frame Relay DLCI) fddi (Fiber Distributed Data Interface) hippi (HIPPI)  
)  
  irda (IrLAP) x25 (generic X.25) eui64 (Generic EUI-64)  
(base) katerine-perdomo@katerinemorocha-HP-Pavilion-15-Notebook-PC:~$ arp-scan  
  
Command 'arp-scan' not found, but can be installed with:  
  
sudo apt install arp-scan  
  
(base) katerine-perdomo@katerinemorocha-HP-Pavilion-15-Notebook-PC:~$ arp -a  
_gateway (10.0.1.1) at a4:e9:75:f1:b2:86 [ether] on wlo1  
(base) katerine-perdomo@katerinemorocha-HP-Pavilion-15-Notebook-PC:~$ arp -v  
Address                HWtype  HWaddress      Flags Mask    Iface  
_gateway                ether    a4:e9:75:f1:b2:86  C             wlo1  
Entries: 1      Skipped: 0      Found: 1  
(base) katerine-perdomo@katerinemorocha-HP-Pavilion-15-Notebook-PC:~$
```

9.

- a. How is peer churn managed in P2P applications such as file-sharing, conferencing, and content distribution?

A peer-to-peer P2P **file transfer** service allows the user to share computer files through the internet. These services are set up to allow users to search for and download files to their computers, and to enable users to make files available for others to download from their computers.

Peer-to-peer file transfer services are highly decentralized, creating a network of linked users. This allows a user to search through the files of all of the linked computers to find the desired file<sup>28</sup>.

Peer-to-peer **video conferencing** is a form of video conferencing that's directly between two people, no cloud or outside server required. One individual and their computer acts as the server and can initiate a call to another individual's computer by sending them their IP address information<sup>29</sup>.

A Peer-to-peer content distribution system is comprised of terminals that are installed with Peer-to-peer connection capabilities, the "master peer" to which manages these terminals. The management server instructs a peer to acquire content, entrusting the determination of the source for actual acquisition of the content to the decisions made by that peer<sup>30</sup>.

- b. Provide specific examples of P2P applications, explain how they specifically handle churn, and estimate the performance improvements achieved in each case. Please provide references and/or links to all documentation sources used to answer this question.

Gnutella (P2P file transfer) builds, at the application level, a virtual network with its own routing mechanisms. The topology of this virtual network and the routing mechanisms used have a significant influence on application properties such as performance, reliability, and scalability.

Gnutella nodes (servents), perform tasks normally associated with both servers and clients. They provide client-side interfaces through which users can issue queries and view search results, accept queries from other servants, check for matches against their local data set, and respond with corresponding results. These nodes are also responsible for managing the background traffic that spreads the information used to maintain network integrity. First, each message has a randomly generated identifier. Second, each node keeps a short memory of the recently routed messages, used to prevent re-broadcasting and implement back-propagation. Third, messages are flagged with time-to-live (TTL) and "hops passed" fields<sup>31</sup>

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A handwritten signature in black ink, appearing to read "Kaden Perday". The signature is written in a cursive, flowing style.

Affirmation of my Independent Effort: