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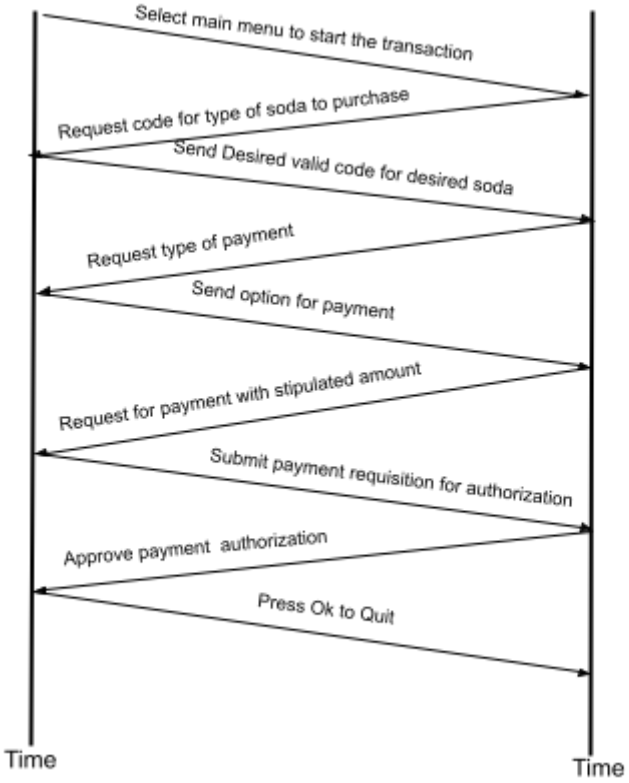
Section: 2
Assignment 2

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.[1]

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 $\frac{3000\ Kbps}{15\ Kbps} = 200$users

   ii. Total bandwidth available : 3 Mbps

   Each user request: 1.50 Mbps =

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

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

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

$p_r(4)\ =\ 0.0001$

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 x 10 km/s.

i. **Propagation delay**

dprop : propagation delay

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

d: length of physical link = 7,500 km/s

s: propagation speed = 2.5x 10 km/s

$d_{prop}\ =\ \frac{7{,}500\ km}{2.5{\times}10\ km/s}\ =\ 300\ s$

ii. **Transmission delay**

dtran : transmission delay

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

L : packet length (bits)

R : link transmission rate (bps)

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

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 no only depend on the router and it 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

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

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

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?

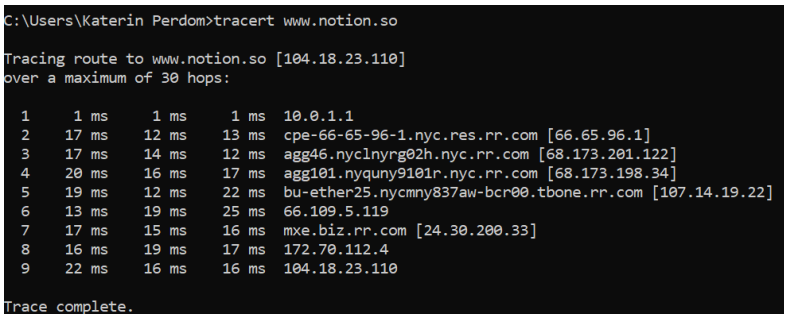
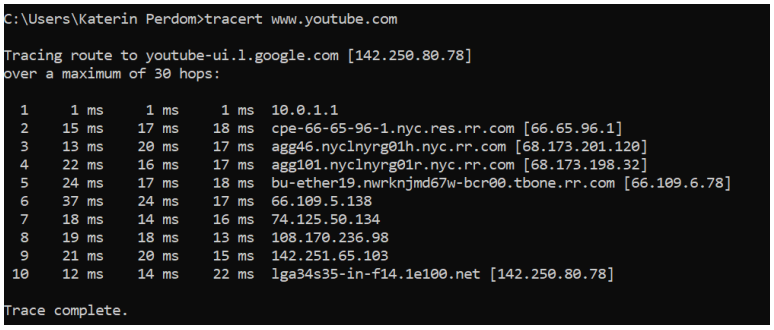
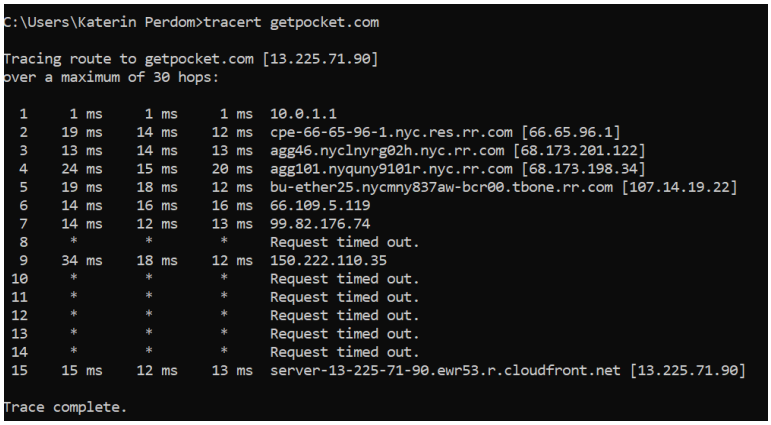
   i. Traceroute uses Internet Control Message Protocol (ICMP) echo packets

   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[2].

   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?

host: www.notion.so ISP: line 3,4, and 5	
Host www.youtube.com ISP Line 3,4 and 5	
Host getpocket.com ISP: line 3,4, and 5	

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 is 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, distrigute, 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 change and expanded constantly by numerous developers, programmers and varias 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 protocol, 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.

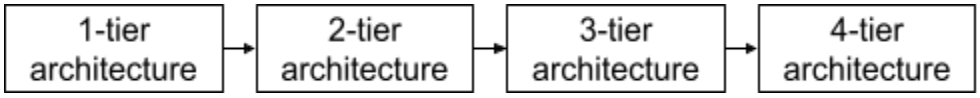
Three-tier model include an application logic between the client and the server, which handles the data processing and allows a certain degree of interaction. Dynamic websites are distinguished by the fact that content is changed on the client side without requiring new communication between the server 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[4].

Service-oriented architecture (SOA) in each IT system can, in turn, it is 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 developmen[3].

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[5].

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)[6]
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)[9]
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[11]

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[12], Internet Message Access Protocol is a protocol for accessing email or bulletin board messages from a (possible shared) mail server or service[13].
Mozilla Thunderbird	Thunderbird is a free email application that's easy to set up and customize[15]	● POP. Basic email retrieval protocol. ● 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 ● LDAP address auto-completion. ● S/MIME: Inbuilt support for email encryption and signing using X.509 keys provided by a centralized certificate authority. ● OpenPGP: Inbuilt support for email

		encryption and signing since version 78.2.1, while older versions used extensions such as Enigmail[14].
eM Client	Email client for windows and macOS, for professionals and home users alike[16]	POP3, SMTP, IMAP or CalDAV
Mailbird	Desktop email for windows users[18].	● POP3 – a basic retrieval protocol that supports offline email use. ● IMAP– another retrieval protocol that allows using webmail accounts in Mailbird. ● SMTP – a protocol for email transmission[17].
KMail	KMail is a state-of-the-**art email client** that integrates well with widely used email providers like GMail	POP3, IMAP, Microsoft Exchange (EWS) and more[19].

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[20].

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[21].

Nslookup: It performs DNS queries and receives: domain names or IP addresses, or any other specific DNS Records[22].

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

Dig: is a tool for querying DNS nameservers for information about host addresses, mail exchanges, name servers, and related information[24].

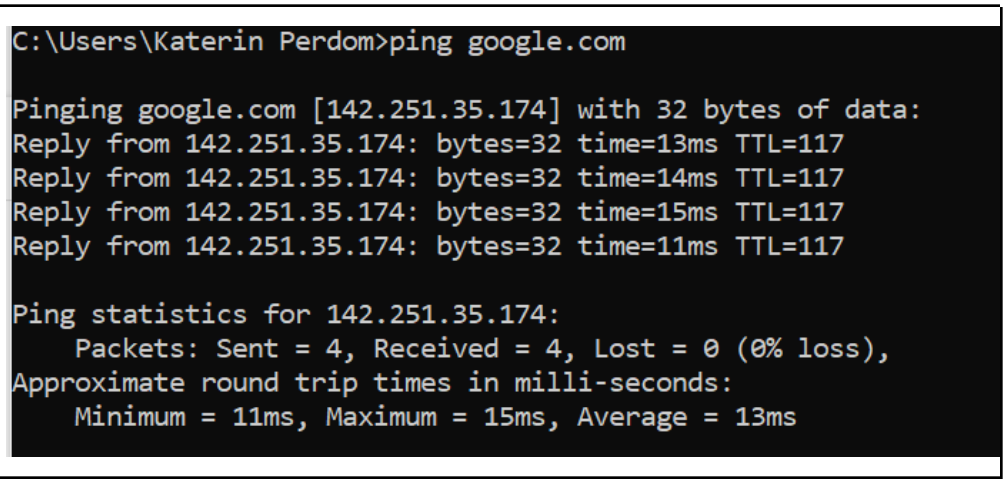
b. Identify at least three more utilities and explain what they are used for.

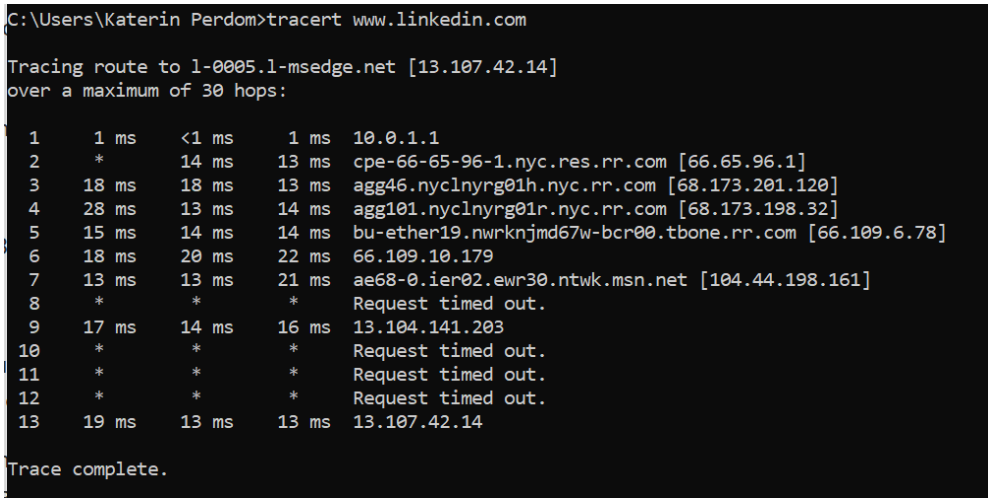
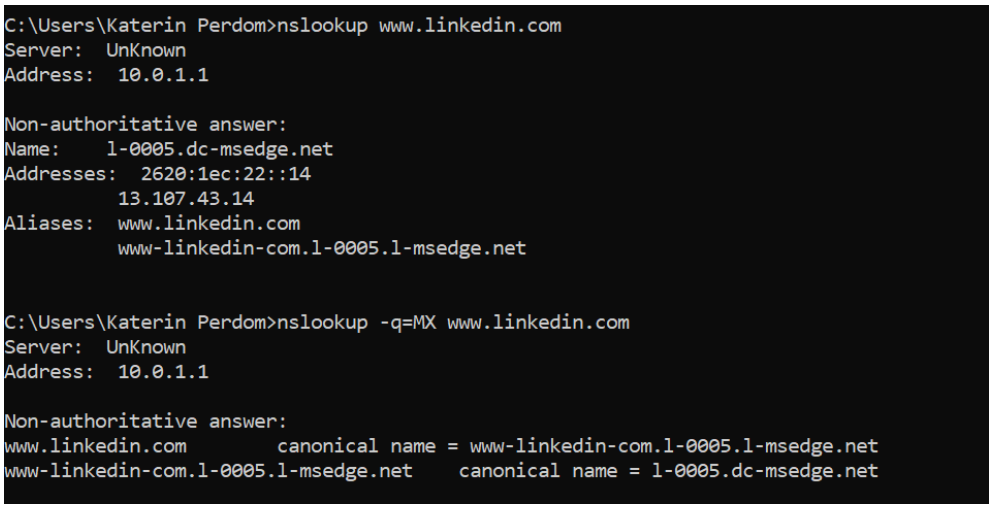
Nmap: or Network Mapper, is command-line based tool for network discovery, networking mapping, and networking auditing. Basically, it uses IP packets to determine was hosts, ports, services, and IP addresses are available and open on a network, both LAN and WAN[25].

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[26].

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[27].

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.

Ping	

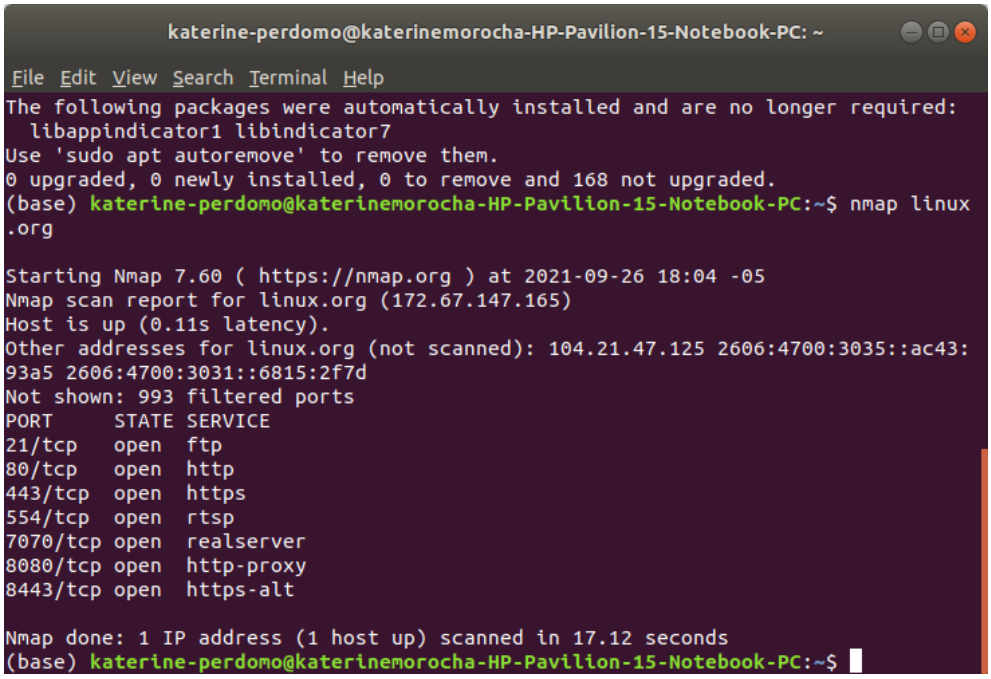
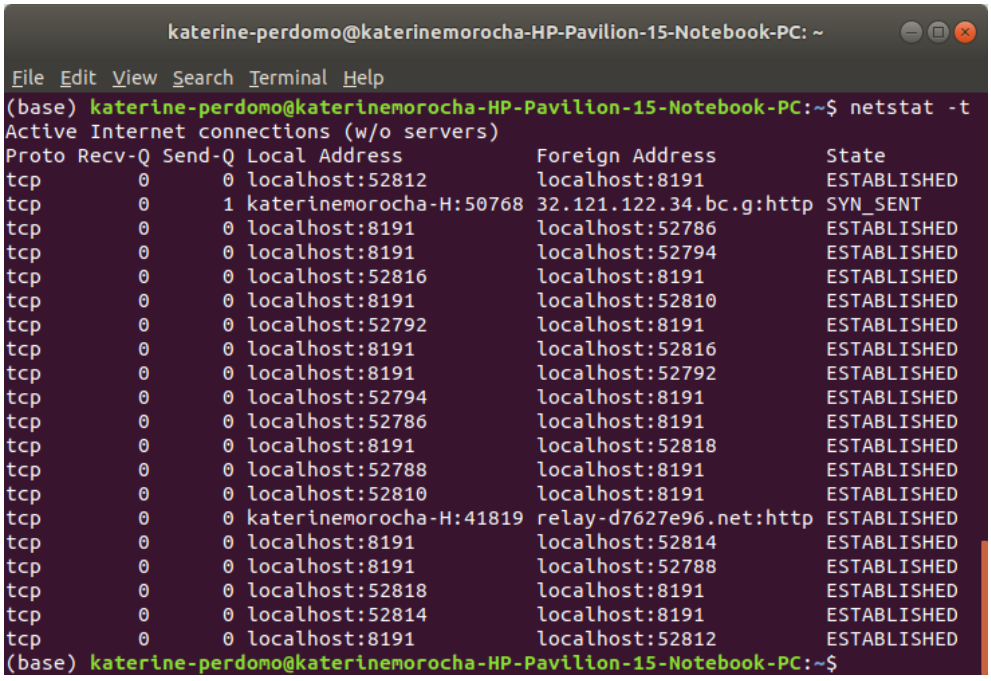
Traceroute	
nslookup	

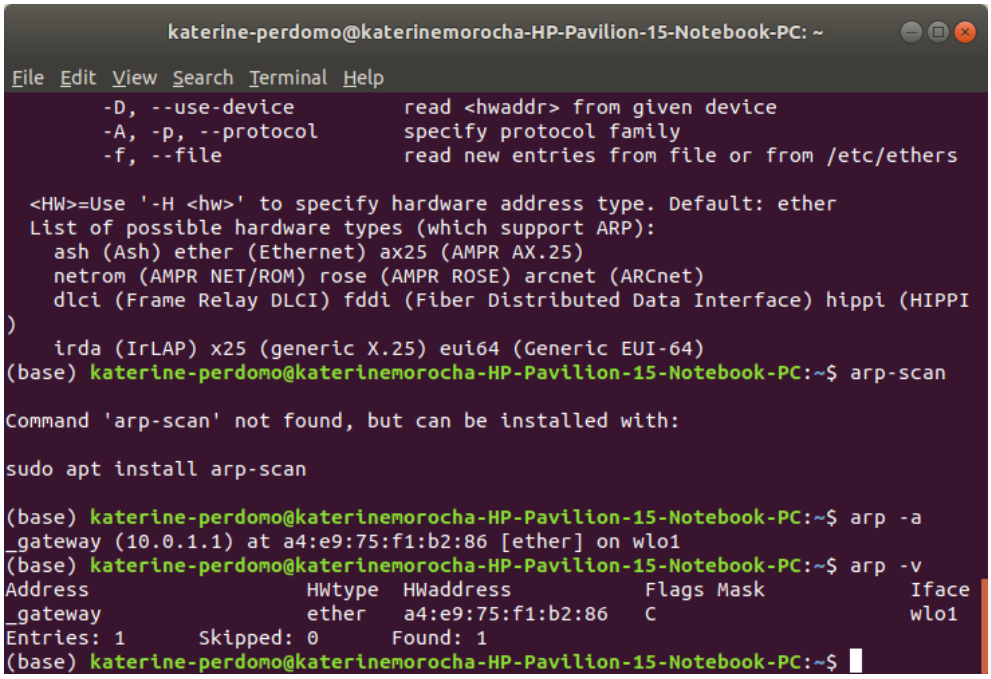
ipconfig

```
C:\Users\Katerin Perdom>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	
netstat	

ARP	

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 fles throught 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 other 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[28].

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[29].

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[30].

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 ths virtual network and the routing mechanisms used have a significant influence on application properties such as performance, reliability, and scalability.

   Gnutella nodes (servents), perform task 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[31]

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10. https://api.slack.com/rtm
11. https://www.agora.io/en/blog/real-time-messaging-protocol-explained/
12. https://support.readdle.com/spark/troubleshooting/cannot-set-up-a-custom-email-address
13. https://www.gartner.com/en/information-technology/glossary/imap-internet-message-access-protocol
14. https://en.wikipedia.org/wiki/Mozilla_Thunderbird
15. https://www.thunderbird.net/en-US/
16. https://www.emclient.com/
17. https://en.wikipedia.org/wiki/Mailbird
18. https://www.getmailbird.com/

19. https://apps.kde.org/kmail2/
20. https://activereach.net/support/knowledge-base/connectivity-networking/network-utilities/#Ping
21. https://activereach.net/support/knowledge-base/connectivity-networking/network-utilities/#Traceroute
22. https://www.cloudns.net/blog/10-most-used-nslookup-commands/
23. https://en.wikipedia.org/wiki/Ipconfig
24. https://mediatemple.net/community/products/dv/204644130/understanding-the-dig-command
25. https://activereach.net/support/knowledge-base/connectivity-networking/network-utilities/#Nmap
26. https://activereach.net/support/knowledge-base/connectivity-networking/network-utilities/#Netstat
27. https://activereach.net/support/knowledge-base/connectivity-networking/network-utilities/#ARP
28. https://www.nsf.gov/oig/_pdf/brochures/peer.pdf
29. https://www.ringcentral.com/us/en/blog/peer-to-peer-video-conference/
30. https://www.nec.com/en/global/techrep/journal/g06/n01/pdf/t060104.pdf
31. https://people.cs.uchicago.edu/~matei/PAPERS/gnutella-rc.pdf

Affirmation of my Independent Effort: