Anatomy of a Web Connection: A Brief Analysis

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Date: 3/03/2021

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1 Introductory note

As the web is being used more and more, it is important for us to understand what is behind all of this. The simple action of opening the browser implies the use of many technologies working behind the request. These operations can have multiple social and economic implications. All of this will be mentioned later in this document.

2 Summary/Abstract and Objectives

This assignment has been requested by the teacher Manuel de Oliveira Duarte to the APSEI [1] class scoping the "behind the scenes" of a simple network connection between an online server and the simple user. The goal is to really understand how this requests work and what it implies. There are two main objectives for this assignment:

- To provide a plausible identification of the technologies, processes, actors and business models involved in an web connection.
- To identify possible social and economic implications associated with the identified technologies, processes, actors and business models.

3 Technologies, protocols and networks

In order to fully understand what will be explained, the proper explanation of each concept is absolutely needed.

3.1 OSI Model

The OSI Model [2], published in 1984 by ISO [3], is used to describe the functions of a networking system. The objective is to unify the connection between different products and software using universal rules. This model is used to describe the network basic architecture and splits the communication system in seven different layers (from higher to lower) [1]:

- Application Layer - identifies communication partners, resource availability, and synchronizes communication.
- Presentation Layer - translates data from the application layer. Also handles encryption and decryption information.
- Session Layer - controls conversions between different computers and handles authentication and reconnections.
- Transport Layer - delivery data packages between hosts and systems. Usually uses TCP as the protocol.
- Network Layer - routes information between networks.
- Data Link Layer - node-to-node data transfer where data is packaged into frames.
- Physical Layer - Transmitting bits from the sending to the receiving device.

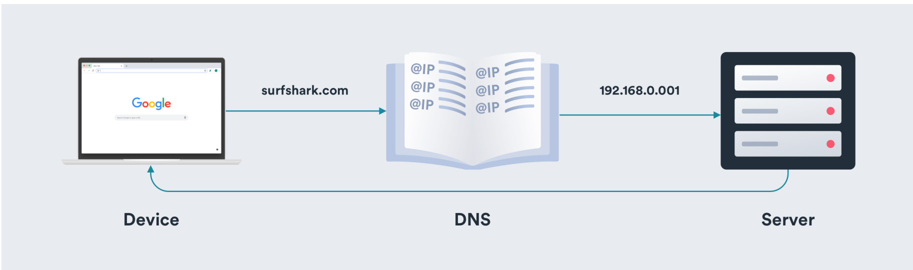
[1] Aspetos Profissionais e sociais da Engenharia Informática
[2] Open Systems Interconnection Model
[3] Internal Organization for Standardization

3.2 Web Browsers

A Web Browser is an application that allows users to access websites (WWW[4]). When a request is made from a user to a certain website, the browser's job is to find the web server where it is hosted, fetch the information, render and display it on the user's device. Although it is a very simple concept, it is much complex these days. There are multiple technologies, frameworks and protocols behind a simple request to a website.

3.3 DNS

DNS [5] is a hierarchical naming system for computers and services [2]. It connects URLs with their IP addresses. This allows users to access a certain IP address with words instead, making the web an human place. When a name is searched in a browser, the DNS allows the browser to match the name with its IP, making it possible to locate the service and extract the website content.



3.4 HTTP

HTTP [6] is a communication protocol in the Application layer of the OSI Model [3]. It provides a universal way to transfer documents in the web. It is used as a server-client model. A request is made to the web server, who responds with a status code. In case of a successful request, the status code is 200 and the website information is transferred.

3.5 TCP

TCP [7] is a standard protocol that defines how two entities should communicate. It determines how to split the data into packages, manages the flow control and acknowledges the arrival of them. In the OSI Model, TCP is in both the transport and the session layer.

[4] World Wide Web
[5] Domain Name System
[6] Hyper Text Transfer Protocol
[7] Transmission Control Protocol

3.6 ICMP

ICMP [8] is located in the OSI model's network layer and its main functionality is to determine whether data is reaching its supposed destination or not. It is commonly used to report errors between routers, that for some reason couldn't make a successful transfer of the data.

3.7 TCP/IP

TCP[9]/IP are a communication standard that defines the messages in an exchange between two devices. It split the messages into size controlled data packets in order to control the lost packets. This protocol is divided in 4 layers:

- Application layer - programs that need this protocol. It is usually where the common user interacts, for example in email and messaging systems. This type of layer usually is located in the presentation and application layers of the OSI Model.
- Transport Layer - Objective is to create a reliable connection between the 2 devices. This is where the packets are divided. This can be done both in local and remote networks.
- Internet Layer - Objective is to ensure that the packets get to its destination properly and as fast as possible.
- Data Link Layer - It controls the packets on a lower level, defining how it works on the hardware.

3.8 The *traceroute* command

This command allows us to check the path from our computer to a certain host. ICMP messages are used and it is possible to define a certain time limit of each packet (using the "-m max_ttl" option).

The command used was: **$**traceroute -I www.cmu.edu

[8] Internet Control Message Protocol
[9] Transmission Control Protocol

4 Traceroute logs

4.1 Home

Results running the command at home:

```
↑91% ➜ traceroute -I www.cmu.edu
traceroute to www.r53.cmu.edu (128.2.42.52), 64 hops max, 72 byte packets
 1  nosdrive (192.168.1.1)  3.821 ms  1.006 ms  0.804 ms
 2  * a89-152-40-2.cpe.netcabo.pt (89.152.40.2)  47.221 ms  28.278 ms
 3  10.137.240.226 (10.137.240.226)  9.319 ms  9.888 ms  37.416 ms
 4  10.255.184.98 (10.255.184.98)  8.465 ms  9.224 ms  45.461 ms
 5  be4976.rcr21.opo01.atlas.cogentco.com (149.6.108.45)  9.091 ms  33.417 ms  9.013 ms
 6  be2314.ccr32.bio02.atlas.cogentco.com (154.54.61.105)  25.219 ms  23.700 ms  42.915 ms
 7  be2332.ccr42.dca01.atlas.cogentco.com (154.54.85.245)  96.197 ms  95.326 ms  96.057 ms
 8  be2820.rcr21.pit02.atlas.cogentco.com (154.54.83.54)  137.910 ms  105.419 ms  105.199 ms
 9  te0-0-2-3.nr11.b015486-0.pit02.atlas.cogentco.com (154.24.50.198)  113.204 ms  110.282 ms  123.834 ms
10  38.140.44.154 (38.140.44.154)  301.408 ms  104.953 ms  129.382 ms
11  core0-pod-i-cyh.gw.cmu.net (128.2.0.249)  104.553 ms  119.555 ms  112.584 ms
12  pod-d-dcns-core0.gw.cmu.net (128.2.0.210)  119.093 ms  143.128 ms  114.232 ms
13  www-cmu-prod-vip.andrew.cmu.edu (128.2.42.52)  119.664 ms  105.211 ms  105.569 ms
```

Figure 1: traceroute results at home

4.2 UA (using a VPN)

Results running the command from UA's network (using a VPN):

```
•100% ➜ traceroute -I www.cmu.edu
traceroute to www.r53.cmu.edu (128.2.42.52), 64 hops max, 72 byte packets
 1  fw-vsvpn.ua.pt (193.137.173.235)  21.048 ms  38.732 ms  18.890 ms
 2  gt1-vrfinternet-r.core.ua.pt (193.137.173.244)  40.926 ms  25.687 ms  28.223 ms
 3  nx2-ibgp.core.ua.pt (10.0.34.1)  20.079 ms  19.649 ms  21.998 ms
 4  router42.porto.fccn.pt (193.136.4.26)  20.218 ms  35.757 ms  19.639 ms
 5  router43.porto.fccn.pt (193.137.4.2)  39.578 ms  27.546 ms  21.048 ms
 6  router60.backbone2.lisboa.fccn.pt (193.136.4.1)  37.337 ms  26.544 ms  27.005 ms
 7  router1.lisboa.fccn.pt (194.210.6.203)  26.070 ms  29.114 ms  30.460 ms
 8  fccn.mx2.lis.pt.geant.net (62.40.124.97)  28.664 ms  25.879 ms  34.941 ms
 9  ae0.mx1.mad.es.geant.net (62.40.98.107)  43.194 ms  73.682 ms  57.510 ms
10  ae3.mx1.par.fr.geant.net (62.40.98.65)  73.537 ms  53.170 ms  55.297 ms
11  et-2-1-5.102.rtsw.newy32aoa.net.internet2.edu (198.71.45.236)  126.517 ms  147.794 ms  126.053 ms
12  et-4-0-0.4079.rtsw.phil.net.internet2.edu (162.252.70.103)  127.806 ms  143.235 ms  127.265 ms
13  * * *
14  162.223.17.79 (162.223.17.79)  533.853 ms  139.144 ms  133.956 ms
15  core255-pod-i-dcns.gw.cmu.net (128.2.255.193)  148.825 ms  137.578 ms  138.336 ms
16  pod-d-cyh-core255.gw.cmu.net (128.2.255.202)  187.516 ms  140.486 ms  136.649 ms
17  www-cmu-prod-vip.andrew.cmu.edu (128.2.42.52)  137.769 ms  143.168 ms  148.027 ms
```

Figure 2: traceroute results from UA

5 Interpretation of traceroute's each hop

5.1 Home traceroute analysis

Hop	Device or Media	Local	Network/Operator/Owner	Technologies/Protocols	OSI Layer
0	Personal Computer (192.168.1.6)	Águeda, Portugal	Nos Comunicacoes S.A.	HTTP	7 - Application
					6 - Presentation
				Port: XXXX	5 - Session
				ICMP	4 - Transport
				IPv4	3 - Network
				Ethernet-IEEE802.3 or WiFi-IEEE802.11x	2 - Data Link
				UTP (Ethernet) or Free-Space Radio	1 - Physical
	TRANSPORT	Águeda	Free-Space Radio (Public Domain Unlicenced)		
1	Router "nosdrive" (192.168.1.1)	Águeda, Portugal	Nos Comunicacoes S.A.	IPv4	3 - Network
				Ethernet-IEEE802.3 or WiFi-IEEE802.11x	2 - Data Link
				UTP (Ethernet) or Free-Space Radio	1 - Physical
	TRANSPORT	Aveiro-Porto	NOS Optical Fibre (Gigabit ethernet)		
2	Router "a89-152-40-2.cpe.netcabo.pt" (89.152.40.2)	Porto, Portugal	NOS Comunicações S.A.	IPv4	3 - Network
				10 Gigabit ethernet	2 - Data Link
				10GBASE (IEEE 802.3)	1 - Physical
	TRANSPORT	Porto	NOS Optical Fibre (Gigabit ethernet)		
3	10.137.240.226 (private network)	Porto, Portugal	NOS Comunicações S.A.	IPv4	3 - Network
				10 Gigabit ethernet	2 - Data Link
				10GBASE (IEEE 802.3)	1 - Physical
	TRANSPORT	Porto	NOS Optical Fibre (Gigabit ethernet)		
4	10.255.184.98 (private network)	Porto, Portugal	NOS Comunicações S.A.	IPv4	3 - Network
				10 Gigabit ethernet	2 - Data Link
				10GBASE (IEEE 802.3)	1 - Physical
	TRANSPORT	Porto	NOS Optical Fibre (Gigabit ethernet)		
5	Router "be4976.rcr21.opo01.atlas.cogentco.com" (149.6.108.45)	Porto, Portugal	Congent Communications	IPv4	3 - Network
				10 Gigabit ethernet	2 - Data Link
				GE, OTN, SDH, SONET, etc	1 - Physical
	TRANSPORT	Porto - Bilbao (Spain)	Congent Optical Fibre (40λX40GB / DWDM)		
6	Router "be2314.ccr32.bio02.atlas.cogentco.com" (154.54.61.105)	Bilbao, Spain	Congent Communications	IPv4	3 - Network
				10 Gigabit ethernet	2 - Data Link
				GE, OTN, SDH, SONET, etc	1 - Physical
	TRANSPORT	Bilbao - Virginia (USA)	Congent Optical Fibre (40λX40GB / DWDM)		
7	Router "be2332.ccr42.dca01.atlas.cogentco.com" (154.54.85.245)	Virginia, USA	Congent Communications	IPv4	3 - Network
				10 Gigabit ethernet	2 - Data Link
				GE, OTN, SDH, SONET, etc	1 - Physical
	TRANSPORT	Virginia - Pennsylvania (USA)	Congent Optical Fibre (40λX40GB / DWDM)		
8	Router "be2820.rcr21.pit02.atlas.cogentco.com" (154.54.83.54)	Pittsburgh, USA	Congent Communications	IPv4	3 - Network
				10 Gigabit ethernet	2 - Data Link
				GE, OTN, SDH, SONET, etc	1 - Physical
	TRANSPORT	Pennsylvania	Congent Optical Fibre (40λX40GB / DWDM)		
9	Router "te0-0-2-3.nr11.b015486-0.pit02.atlas.cogentco.com" (154.24.50.198)	Pittsburgh, USA	Congent Communications	IPv4	3 - Network
				10 Gigabit ethernet	2 - Data Link
				GE, OTN, SDH, SONET, etc	1 - Physical
	TRANSPORT	Pennsylvania	Congent Optical Fibre (40λX40GB / DWDM)		
10	Router (38.140.44.154)	Pittsburgh, USA	Congent Communications	IPv4	3 - Network
				10 Gigabit ethernet	2 - Data Link
				GE, OTN, SDH, SONET, etc	1 - Physical
	TRANSPORT	Pennsylvania	Congent Optical Fibre (40λX40GB / DWDM)		
11	Router "core0-pod-i-cyh.gw.cmu.net" (128.2.0.249)	CMU, Pittsburgh, USA	Carnegie Mellon University	IPv4	3 - Network
				Gigabit Ethernet (IEEE 802.3-2008)	2 - Data Link
				Gigabit Ethernet (IEEE 802.3-2008)	1 - Physical
	TRANSPORT	CMU	OPTICAL FIBRE Campus Backbone (Gigabit Ethernet)		
12	Router "pod-d-dcns-core0.gw.cmu.net" (128.2.0.210)	CMU, Pittsburgh, USA	Carnegie Mellon University	IPv4	3 - Network
				Gigabit Ethernet (IEEE 802.3-2008)	2 - Data Link
				Gigabit Ethernet (IEEE 802.3-2008)	1 - Physical
	TRANSPORT	CMU	OPTICAL FIBRE Campus Backbone (Gigabit Ethernet)		
13	Router "www-cmu-prod-vip.andrew.cmu.edu" (128.2.42.52)	CMU, Pittsburgh, USA	Carnegie Mellon University	HTTP	7 - Application
					6 - Presentation
				Port: XXXX	5 - Session
				ICMP	4 - Transport
				IPv4	3 - Network
				Ethernet-IEEE802.3 or WiFi-IEEE802.11x	2 - Data Link
				UTP (Ethernet) or Free-Space Radio	1 - Physical

5.2 UA traceroute analysis

Hop	Device or Media	Local	Network/Operator/Owner	Technologies/Protocols	OSI Layer
0	Personal Computer (192.168.1.6)	UA	UA Ethernet Network / HTTP STIC / Aveiro University	HTTP	7 - Application
					6 - Presentation
				Port: XXXX	5 - Session
				ICMP	4 - Transport
				IPv4	3 - Network
				WiFi-IEEE802.11x	2 - Data Link
				UTP (Ethernet) or Free-Space Radio	1 - Physical
	TRANSPORT	UA	Free-Space radio (Public Domain Unlicensed) and/or UTP (Ethernet)		
1	fw-vsvpn.ua.pt (193.137.173.235)	STIC UA	UA Ethernet Network / HTTP STIC / Aveiro University	IPv4	3 - Network
				Fast Ethernet (802.2; 802.3)	2 - Data Link
				100BASE-T (802.3)	1 - Physical
	TRANSPORT	UA	OPTICAL FIBRE Campus Backbone (Gigabit Ethernet)		
2	Router "gt1-vrfinternet-r.core.ua.pt" (193.137.173.244)	STIC UA	UA Ethernet Network / HTTP STIC / Aveiro University	IPv4	3 - Network
				Gigabit Ethernet (IEEE 802.3-2008)	2 - Data Link
				Gigabit Ethernet (IEEE 802.3-2008)	1 - Physical
	TRANSPORT	UA	OPTICAL FIBRE Campus Backbone (Gigabit Ethernet)		
3	Router "nx2-ibgp.core.ua.pt" (10.0.34.1) (Private network)	STIC UA	UA Ethernet Network / HTTP STIC / Aveiro University	IPv4	3 - Network
				Gigabit Ethernet (IEEE 802.3-2008)	2 - Data Link
				Gigabit Ethernet (IEEE 802.3-2008)	1 - Physical
	TRANSPORT	UA - Porto	OPTICAL FIBRE FCCN Backbone (40λX40GB / DWDM)		
4	Router "router42.porto.fccn.pt" (193.136.4.26)	Estação Campanhã, Porto	RCTS IP / FCCN / FCCN	IPv4	3 - Network
				10 Gigabit ethernet	2 - Data Link
				GE, OTN, SDH, SONET, etc	1 - Physical
	TRANSPORT	Porto	UTP/Optical Fibre In-building cabling (Ethernet / GigaBit Ethernet)		
5	Router "router43.porto.fccn.pt" (193.137.4.2)	Porto, Portugal	RCTS IP / FCCN / FCCN	IPv4	3 - Network
				10 Gigabit ethernet	2 - Data Link
				10GBASE (IEEE 802.3aX)	1 - Physical
	TRANSPORT	A1 / Linha do Norte	OPTICAL FIBRE Comercial Carrier Backbone (nλXmGB / DWDM)		
6	Router "router60.backbone2.lisboa.fccn.pt" (193.136.4.1)	Lisbon, Portugal	RCTS IP / FCCN / FCCN	IPv4	3 - Network
				10 Gigabit ethernet	2 - Data Link
				GE, OTN, SDH, SONET, etc	1 - Physical
	TRANSPORT	Lisbon	UTP/Optical Fibre In-building cabling (Ethernet / GigaBit Ethernet)		
7	Router "router1.lisboa.fccn.pt" (194.210.6.203)	Lisbon, Portugal	RCTS IP / FCCN / FCCN	IPv4	3 - Network
				10 Gigabit ethernet	2 - Data Link
				10GBASE (IEEE 802.3aX)	1 - Physical
	TRANSPORT	Lisbon	UTP/Optical Fibre In-building cabling (Ethernet / GigaBit Ethernet)		
8	Router "fccn.mx2.lis.pt.geant.net" (62.40.124.97)	Lisbon, Portugal	GEANT	IPv4	3 - Network
				10 Gigabit ethernet	2 - Data Link
				10GBASE (IEEE 802.3aX)	1 - Physical
	TRANSPORT	Lisbon - Madrid	GEANT OPTICAL FIBRE Comercial Carrier Backbone (nλXmGB / DWDM)		
9	Router "ae0.mx1.mad.es.geant.net" (62.40.98.107)	Madrid, Spain	GEANT	IPv4	3 - Network
				10 Gigabit ethernet	2 - Data Link
				GE, OTN, SDH, SONET, etc	1 - Physical
	TRANSPORT	Madrid - Paris	GEANT OPTICAL FIBRE Comercial Carrier Backbone (nλXmGB / DWDM)		
10	Router "ae3.mx1.par.fr.geant.net" (62.40.98.65)	Paris, France	GEANT	IPv4	3 - Network
				10 Gigabit ethernet	2 - Data Link
				GE, OTN, SDH, SONET, etc	1 - Physical
	TRANSPORT	Paris - New Jersey	Internet2 OPTICAL FIBRE (nλXmGB / DWDM)		
11	Router "et-2-1-5.102.rtsw.newy32aoa.net.internet2.edu" (198.71.45.236)	New Jersey, USA	Internet2	IPv4	3 - Network
				10 Gigabit ethernet	2 - Data Link
				GE, OTN, SDH, SONET, etc	1 - Physical
	TRANSPORT	New Jersey	Internet2 OPTICAL FIBRE (nλXmGB / DWDM)		
12	Router "et-4-0-0.4079.rtsw.phil.net.internet2.edu" (162.252.70.103)	New Jersey, USA	Internet2	IPv4	3 - Network
				10 Gigabit ethernet	2 - Data Link
				GE, OTN, SDH, SONET, etc	1 - Physical
	TRANSPORT	New Jersey	Internet2 OPTICAL FIBRE (nλXmGB / DWDM)		
13	Timeout	-	-	-	3 - Network
					2 - Data Link
					1 - Physical

...

TRANSPORT		New Jersey - Pennsylvania	KINBER OPTICAL FIBRE (nλXmGB / DWDM)		
14	Router (162.223.17.79)	Harrisburg, USA	KINBER	IPv4	3 - Network
				10 Gigabit ethernet	2 - Data Link
				GE, OTN, SDH, SONET, etc	1 - Physical
TRANSPORT		Harrisburg - Pittsburgh	OPTICAL FIBRE Campus Backbone (Gigabit Ethernet)		
15	Router "core255-pod-i-dcns.gw.cmu.net" (128.2.255.193)	CMU, Pittsburgh, USA	Carnegie Mellon University	IPv4	3 - Network
				Gigabit Ethernet (IEEE 802.3-2008)	2 - Data Link
				Gigabit Ethernet (IEEE 802.3-2008)	1 - Physical
TRANSPORT		CMU	OPTICAL FIBRE Campus Backbone (Gigabit Ethernet)		
16	Router "pod-d-cyh-core255.gw.cmu.net" (128.2.255.202)	CMU, Pittsburgh, USA	Carnegie Mellon University	IPv4	3 - Network
				Gigabit Ethernet (IEEE 802.3-2008)	2 - Data Link
				Gigabit Ethernet (IEEE 802.3-2008)	1 - Physical
TRANSPORT		CMU	OPTICAL FIBRE Campus Backbone (Gigabit Ethernet)		
17	Router "www-cmu-prod-vip.andrew.cmu.edu" (128.2.42.52)	CMU, Pittsburgh, USA	Carnegie Mellon University	HTTP	7 - Application
					6 - Presentation
				Port: XXXX	5 - Session
				ICMP	4 - Transport
				IPv4	3 - Network
				Ethernet-IEEE802.3 or WiFi-IEEE802.11x	2 - Data Link
				UTP (Ethernet) or Free-Space Radio	1 - Physical

5.3 Each hop analysis

Each hop had a different IP address, therefore a different router. With that in mind, I located each IP using multiple IP trackers in the Web. Although most of the times the results were similar, some IP addresses were a bit difficult to trace, because the trackers gave different information. Consequently, some IP addresses are the result of multiple tracking systems - the most logical and common location was used.

This trackers allowed to retrieve important information about each hop, like location, Company, etc. There were even some that the information wasn't possible to get, due to security measures and private networks.

5.4 Why are some hops timed out?

Although it only happened once in this case, sometimes we can get multiple timed out requests whenever using the traceroute command. This is not just coincidental - some routers are programmed to not respond to ICMP requests, as these are pretty common and can put the network at risk. Furthermore, there can be routers that have a very low priority to this kind of requests. If they are overflowed at the time of the request, they will take too long to respond and we will get a time out.

5.5 Are the logs always the same for each location?

For different locations, the logs are very different for obvious reasons. But the important question here is to understand if they differ for the same location.

After executing the traceroute command multiple times for both in home and at UA, I quickly realized that there can be slight differences in each time for the same location. After gathering possible reasons for this, I got to 2 main reasons:

- There are multiple paths from the initial location to the destination. This means that some of the transitions have a plurality of options to go to with the same costs, making the choice random.
- Although some transition choices have 1 option that has the lowest cost, other option with highest cost can still be picked due to network overload. This means that the network is always as balanced as possible. If the router with the lowest path is very busy, the path will change for the next lowest cost router, making the full path different.

5.6 What are the social and economic implications?

I believe the majority of people isn't even aware of the existence of this topic. People don't really think what is behind of a simple google search, or an access to a specific website. Nowadays, the internet is something that can literally give you any information, you can easily find anything. And this is only because of the advance of the technologies, which some where already mentioned. The fact that the entire process of requesting a web server is done in milliseconds is mind blowing. The number of hops, protocols, technologies and processes that are simultaneously working just to get a simple web page is very impressive to me.

As was shown earlier, accessing the CMU [10] through UA took a lot more steps than from a general home network. This is because of all the hops that a student needs to go through reserved networks of the education communities. The idea here is to separate the common user from the educational communications. In one hand, this can be beneficial - the education communities can communicate "separately" and therefore have a better collaboration between schools and universities. On the other hand, there is the equality argument - why should people that are under this educational networks be in such a disadvantage and go through all those extra steps? Well, is difficult to 100% agree with one or the other. Although they have more hops to go through, they are more protected. The educational network does have some extra policies to protect students, professors and the university's community. Therefore, I don't think this is a bad thing. Also, this separate networks for education are freeing the other networks.

On a economic point of view, it is truly amazing how all these companies are working together to make the internet as we know it. There are companies from all over the world working together, despite all the social, cultural and economic differences between regions. This shows how important it is today to maintain such a big and complex system. Although they are working together, they don't do it "for the greater good". They still need to be profiting as much as possible with these arrangements. Almost all the companies that manage and maintain the infrastructures needed are private. We can't be 100% sure that this can't become a problem. Also, would the internet prices be lower if these infrastructures were owned by the government? There are a lot of economic questions raised by this. On the other hand, if they indeed were owned by the government, wouldn't it be more exposed to cultural and social problems between different countries? Say, for example, there were some international conflicts between USA and Russia (which has happened several times). The government could easily interfere with it. China are also a good example of this. Part of the internet is blocked by the "Great Firewall", which was implemented by the government. An entire population is being kept from information daily. In my opinion, this is much worrying than people think. Still related to the economics of it, the market of the companies can also affect the whole internet connection. Social crisis can lead to large variations of the market value, which can lead to the bankruptcy of some companies and instabilities on the system.

On a more social point of view, as was already partially mentioned, the social and cultural differences between different nations are huge. The fact that all these companies work together despite all their differences is something genuinely beautiful. In a way, the internet is not only connecting people but also uniting entire countries.

Since COVID is sadly still in our lives, I couldn't leave it aside. The internet has suffered a huge load boost with the pandemic, mainly because people are now forced to work from home and have spend a bigger part of the day on the internet. This has forced, once again, companies to work together to scale their services and infrastructures in order to keep up with the world. And for me it is very impressive that they have done a successful job with it.

[10] Carnegie Mellon University

6 Conclusion

This report made me study and discover a lot of things that I had no knowledge in. I was able to find the path between my computer and the CMU [11] and use logical assumption to discover the technologies, protocols, infrastructures, companies and players in each hop. Besides that, I was able to work with the traceroute command and understand a bit more how to find more information on each IP address.

Although all of these acknowledgements were very important, I think that the most valuable thing in this assignment was the social and economic implications. It allowed me to really think by myself and try to find possible answers and reasons to explain.

7 References

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