Department of Computer Science
Computer Networks
Due: Sunday 1st September 23.59

Your name: Ólafur Ammendrup Ólafsson
TA Name:
Time Taken:
Estimated Time: 10 hours

This is an individual assignment and should be submitted as a pdf using Canvas.

For those who like to dabble in the dark arts, the latex version is also available. You may submit in any legible form you wish.

Marks are awarded for question difficulty. While there is typically a relationship between difficulty and length of answer, it may not be a strong one. Always justify your answer if necessary, especially with somewhat open ended design questions.

Optional: Please include a rough estimate of how long it took you do the assignment so that we can calibrate the work being assigned for the course. (The estimated time is provided purely as a guideline.)

Question:	1	2	3	Total
Points:	12	7	11	30
Score:				

Introduction

Network Transport Times

1 . . . . . *12 points*

(a) (2 points) traceroute and ping are command line tools to show the network path to another host.
Perform a traceroute to each of the following hosts. For each host, give at least one intermediate countries the network packets are going through.

1. mel1.speedtest.telstra.net

```
United Kingdom    (166.63.223.21)
China             (202.84.141.145)
Australia         (203.50.13.93)
```

2. 130.69.0.0

```
United States     (195.2.8.46)
Japan             (129.250.4.143)
United Kingdom    (166.63.223.21)
```

(b) (2 points) What does a "* * *" line in the traceroute response mean?

```
The asterisk is displayed when the sender doesn't recieve a reply
within the expected interval
```

(c) (2 points) Using the ping command, what is the round trip time (RTT) to the following hosts?

1. mel1.speedtest.telstra.net

```
Minimum = 332ms
Avg     = 334ms
Maximum = 337ms
```

2. per1.speedtest.telstra.net

```
Minimum = 358ms
Avg     = 360ms
Maximum = 365ms
```

(d) (2 points) Both the hosts are in Australia, one is in Melbourne, the other in Perth. If the speed of light in a vacuum is 300,000,000 m/s and the core index of refraction of fiber-optic cable in the Australian backbone is 1.50, approximately how far is Perth from Melbourne?

(e) (4 points) CA Technologies provides a site which allows you to ping a publicly accessible Internet host from different hosts worldwide in order to measure local response time for your users.

`https://asm.ca.com/en/ping.php`

Use this site to ping:

- www.ru.is
- www.mit.edu

By examining the difference in ping response times for www.ru.is, in what country is this host actually located?

```
Dublin, Ireland has the lowest average ping response time of 0.456ms
indicating that Ireland is the country in which the host is located.
This website confirms it: https://check-host.net/ip-info?host=www.ru.is
```

In what countries does MIT appear to be located?

```
Australia, Germany, Ireland, France, UK,
China, India, Denmark, US, Malaysia, Thailand,
Turkey and Vietnam
```

What service is MIT using to do this?

```
MIT uses statistical multiplexing to do this
```

Network Throughput

2 ..... *7 points*

(a) (2 points) You need to transfer a geophysical dataset of 100TB stored on disk in Iceland to the Norwegian Metrology Office. How long will it take to transfer this dataset to Norway assuming a 1Gbps connection, and 15% protocol overhead?

```
8000 Gb in TB
100 TB = 800,000 Gb = 800,000 seconds
1Gbps with 15% overhead = 850Mbps

800,000 / 0.85 = 941.176,4705 sek = 10.89 days
```

(b) (2 points) Ref: `https://en.wikipedia.org/wiki/Linear_Tape-Open`

An industry standard tape (circa 2018) can hold 12TB of data on a single cartridge. Assuming a best case scenario of 3 hours ground transport time to Keflavik airport and 3 hours from Oslo to destination company, with a scheduled flight time also of 3 hours. How much data do you need before it is quicker to send the data by tape than transfer it over the network? (Ignore time to read and write the tape.)

```
Tape = 12TB in 3 + 3 + 3 = 9 hrs.
850 Mbps = 0.00010625TBps
0.00010625 * 60 * 60 = 0.3825TBph
0.3825 * 9 = 3.4425 TB in 9 hours

When dealing with data over 3.4425TB in size, it is quicker to send the
data by tape rather than transferring it over the network.
```

(c) (2 points) Tannenbaum in Computer Networks wisely advises never to overlook the speed of sending data by existing transport networks - planes in this case. However, his example overlooks the time taken to create the tapes in the first place.
Assuming that the maximum writing and reading speed for a tape is 900(MB/s), how long does it actually take to transfer the data to Norway including the time to read and write the tapes?

```
If a tape can hold 12 TB then we would need 9 tapes for 100TB.

1 MBps = 0.0036 TBph
900 MBps = 3.24 TBph
So each tape (save for the last one) would take 12/3.24 = 3.7 hours
to write, 9 hours to transfer, then another 3.7 hours to read.
Let's assume that to save travel costs, we will only send data by plane
when all of the tapes are ready, instead of sending each tape as soon
as it's ready on its own private plane.

Last tape only needs to store 4 TB, 12/4 = 3, so it would take
3.7/3 = 1.23 hours to read/write


Tape 1-9 time to write: 3.7 * 8 + 1.23 = 30.83
Time to transfer: 9
Tape 1-9 time to read: 3.7 * 8 + 1.23 = 30.83

So transferring the data would take 30.83 * 2 + 9 = 70.66 hours.
```

(d) (1 point) What is the new break even amount for sending data by planes?

```
70.66 / 9 = 7.8511
7.8511 * 3.4425 = 27.02TB
```

Network Engineering

3 ..... *11 points*

An ISP is statistically multiplexing its customers over 10Gb links. You have been asked to calculate how many customers it can afford to assign to each link, and maintain a reasonable level of service to each one.

Nominally, each customer is being sold a 1Gb link.

(a) (1 point) If each customer is to be guaranteed access to 1Gb at any time, how many customers can the ISP provision per 10Gb link.

```
If each customer is guaranteed access to 1Gb at any time, then only
one customer can have access to each Gb. Since the link is 10 Gb
then that makes a total of 10 customers.
```

(b) (2 points) Assume that the 10Gb link costs the ISP 200,000 ISK/month, and the ISP needs to make 20% profit to cover all overheads. What is the smallest number of customers that the ISP provision for each 10Gb link, and still meets its profit targets, if the ISP charges each customer 7,000ISK for their Internet service?

```
20% profit = 240,000 ISK
240,000 / 7,000 = 34.2
The ISP needs to provision at least 35 customers.
```

(c) (2 points) What is the maximum speed each customer will be able to download data at, assuming all customers are maximising their network connection?

```
35 / 10 = 3.5
1 / 3.5 = 0.285
1000 Mb * 0.285 = 285.7Mbps
```

(d) (4 points) The ISP decides that on average each customer will use their link 10% of the time, evenly distributed over the day. Assuming this is correct, how many customers can the ISP now provision and still maintain the illusion that they have access to 1Gb each?

```
100 Customers
```

(e) (2 points) If the ISP has a mixture of business and household customers, how should it assign the different types of customer to its links to improve performance?

```
Most people work during the day and won't use their household internet
until after work. To maximize performance, the ISP should ideally have
one household customer and one business customer per 1Gb link. That way,
```

```
the business customer would have full access to the 1Gb during business
hours and the household customer would have full access after business
hours.
```

Bonus Question: 1 Bonus Mark

Referring back to question 1, and the time taken for a packet to travel to and across Australia. Using traceroute create a table of round trip times to the two hosts in question 1, and to and from one of the London switches performed at least four different times of the day (it does not have to be the same day), separated by at least 2 hours from each other. That is you are capturing the time from Iceland to London, and from London to Australia for the same route.

Include your measurements in a table. With reference to these measurements:

What is the fastest and slowest time of day to send traffic to Australia?

Where is the congestion occurring that slows down the traffic?