HW1

1. a

   a) Various factors influence the rate of an ethernet cable including but not limited to: the material used inside of the cable, the length of the cable, the design (structure of internals) of the cable, frequency, and much more
   Sources: https://www.telco-data.com/blog/cat-cables/
   https://tripplite.eaton.com/products/ethernet-cable-types
   b)
   802.11 was the original developed in 1997 and supported speeds up to 1Mbps, it is defunct
   802.11a was developed in 1999 and supported speeds up to 54Mbps, was a slight upgrade
   802.11b was also developed in 1999 and used the 2.4Ghz band. It was much cheaper and had a max speed of 11Mbps. The issue was that it is unregulated to it has interference from other devices using the same band
   802.11g was developed in 2003 and uses the same band. It is also backwards compatible. It has max speeds of 54Mbps (Wifi 3)
   802.11n was developed in 2009 (Wifi 4) and has a max speed of 600Mbps while also having a longer range due to MIMO technology (multiple antennas and signals). It is more expensive though
   802.11ac was developed in 2014 (WiFi 5) and has a new 5Ghz band with speeds that are more than 1Gbps. It keeps the 2.4Ghz band for backwards compatibility
   802.11ax (Wifi 6) is the fastest and is up to 10x faster than Wifi 5. It also operates on both freq
   https://www.fs.com/blog/80211-wireless-standards-explained-35.html
   c) Wired networks are generally faster with higher bandwidth but usually have less devices connected (wiring becomes a pain) but are usually more reliable. A wired network is like a server that needs the ultrafast and reliable speeds. Wireless networks usually have many devices connected at once and they are much easier to set up. An example being a school network where guests and students want to connect
2. a

   a) Layered approaches have a multitude of benefits including increased modularity, allowing different protocols to be made without having to redesign the full system, it standardizes the system and makes things essentially plug and play, it provides seperation of concerns where some layers are conserned about some things and it doesn't matter as much for others, and more. We interact with the application layer the most.
   b) Without standardized protocols, it would make it really hard to communicate as

someone may be on a different protocol and would create numerous incompatibilities because device A will send it in one way but device B won't know how to handle it.

3. a) A circuit switching network dedicates a physical path between the source and the destination. The entire bandwidth is reserved. Packet switching is when the data is split up into "packets" where the packets are all traveling independent of one another but all end at the same point. Packet switching is better for more bursty traffic where there are periods of nothing happening because resources aren't being wasted. It is worse when it gets overwhelmed because the packets get queued which delays their arrival and then packets can get lost. Circuit switching on the otherhand will consume resources when not busy but the pro is that you are guaranteed latency because it will take a certain amount of time for the data to travel that route
   Source: https://apposite-tech.com/packet-switching-vs-circuit-switching/
   b) The network edge refers to the endpoints of a network. The network edge consists of devices that want to connect with and use the internet. Examples include my computer, a smart fridge, my phone, etc. The network core is how data is passed and includes the infrastructure and middlepoints needed to connect 2 edge devices. This includes intermediary servers to pass packets (like CDNs), routers, firewalls, network towers, etc.
4. (Assumes KiloBITS not kiloBYTES) 25Kb = .025 Mb
   a) .025 / 50 Mbps = .0005 seconds = .5ms
   b) .025 / 100 Mbps = .00025 seconds = .25ms
   c) .25+.5 = .75ms
5. a) When circuit switching, each user gets a "slice" of the bandwidth. Since each user needs 2Mbps and 20Mbps is the bandwidth of the link, then 20/2 = 10 users at once, maximum
   b) If there are 20 users and each user is active 25% of the time, then P(X=20) = $(.25)^{20} \approx 9.9 * 10^{-11}\%$
   c) This is a binomial distribution so formula:

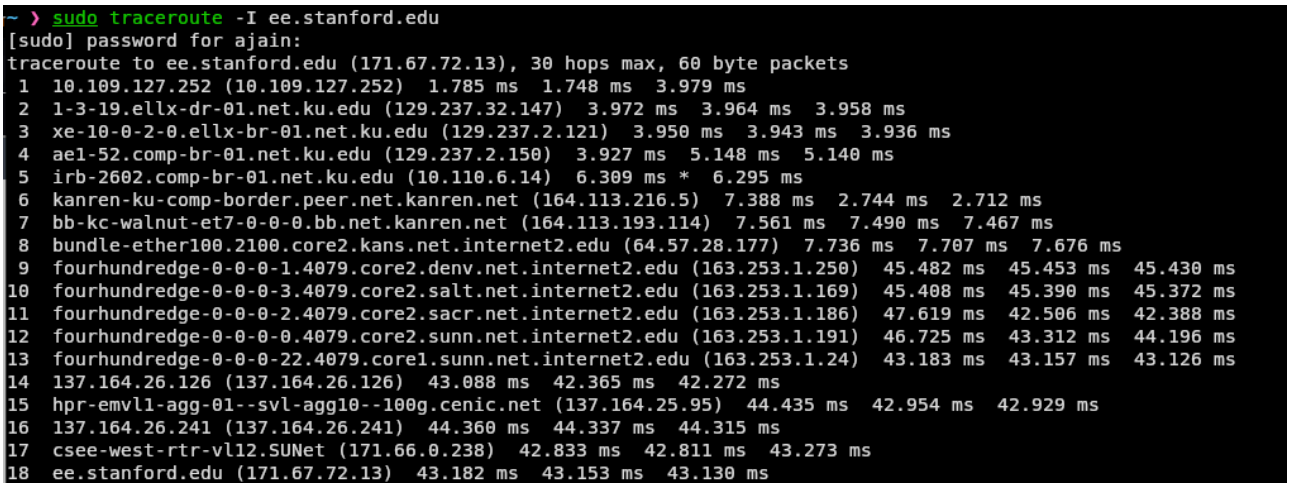
$$P(X = k) = \binom{n}{k} p^k (1-p)^{n-k}$$

   Here we want P(X > 10) so sum of P(X=11), P(X=12), ... P(X=20). This is equivalent to

$$P(X > 10) = \sum_{k=10}^{20} \binom{20}{k} .25^k .75^{20-k} = .00394$$

   so, $\approx .394\%$

6.



```
~ ❯ sudo traceroute -I ee.stanford.edu
[sudo] password for ajain:
traceroute to ee.stanford.edu (171.67.72.13), 30 hops max, 60 byte packets
 1  10.109.127.252 (10.109.127.252)  1.785 ms  1.748 ms  3.979 ms
 2  1-3-19.ellx-dr-01.net.ku.edu (129.237.32.147)  3.972 ms  3.964 ms  3.958 ms
 3  xe-10-0-2-0.ellx-br-01.net.ku.edu (129.237.2.121)  3.950 ms  3.943 ms  3.936 ms
 4  ae1-52.comp-br-01.net.ku.edu (129.237.2.150)  3.927 ms  5.148 ms  5.140 ms
 5  irb-2602.comp-br-01.net.ku.edu (10.110.6.14)  6.309 ms *  6.295 ms
 6  kanren-ku-comp-border.peer.net.kanren.net (164.113.216.5)  7.388 ms  2.744 ms  2.712 ms
 7  bb-kc-walnut-et7-0-0-0.bb.net.kanren.net (164.113.193.114)  7.561 ms  7.490 ms  7.467 ms
 8  bundle-ether100.2100.core2.kans.net.internet2.edu (64.57.28.177)  7.736 ms  7.707 ms  7.676 ms
 9  fourhundredge-0-0-0-1.4079.core2.denv.net.internet2.edu (163.253.1.250)  45.482 ms  45.453 ms  45.430 ms
10  fourhundredge-0-0-0-3.4079.core2.salt.net.internet2.edu (163.253.1.169)  45.408 ms  45.390 ms  45.372 ms
11  fourhundredge-0-0-0-2.4079.core2.sacr.net.internet2.edu (163.253.1.186)  47.619 ms  42.506 ms  42.388 ms
12  fourhundredge-0-0-0-0.4079.core2.sunn.net.internet2.edu (163.253.1.191)  46.725 ms  43.312 ms  44.196 ms
13  fourhundredge-0-0-0-22.4079.core1.sunn.net.internet2.edu (163.253.1.24)  43.183 ms  43.157 ms  43.126 ms
14  137.164.26.126 (137.164.26.126)  43.088 ms  42.365 ms  42.272 ms
15  hpr-emvl1-agg-01--svl-agg10--100g.cenic.net (137.164.25.95)  44.435 ms  42.954 ms  42.929 ms
16  137.164.26.241 (137.164.26.241)  44.360 ms  44.337 ms  44.315 ms
17  csee-west-rtr-vl12.SUNet (171.66.0.238)  42.833 ms  42.811 ms  43.273 ms
18  ee.stanford.edu (171.67.72.13)  43.182 ms  43.153 ms  43.130 ms
```

a) yes it reached with 18 total hops

b) `sudo traceroute -I ee.stanford.edu -q 10`

c) I have the code and the results in the folder. Overall, doing it from home had less hops which I was actually surprised by. I figured since there is more traffic at school it would have better routing but I guess it is the opposite