Homework 4

INFSCI 1070/TELCOM 2000

1. Protocols require *mechanisms* to implement *functions*. Most often, these mechanisms are fields within protocol headers. Since these have to be transmitted from sender to receiver along with the data, we can think of them as imposing a cost. Thus, functions have to be “paid for” in lost transmission capacity. One simple way to compute this is to compute the *bit efficiency* of a protocol. The bit efficiency can be defined as the ratio of end user information bits and the total transmitted bits and is normally computed on a single packet. That is:

Bit Efficiency = (End user information bits)/(Total bits sent)

1. Cost
   1. IPv4 contains two 32 bit addresses (one for the sender and one for the receiver) (and 8 bytes of additional fields). If the user information is 1000 bits, what is the bit efficiency of an IPv4 packet.

**1000/(32\*2+64) = 7.8125 bits**

* 1. IPv6 contains two 128 bit addresses (as well as 4 bytes of additional information). If the user information is 1000 bits, what is the bit efficiency of this packet?

**1000/(128\*2+32) = 3.472 bits**

* 1. Compare these bit efficiencies. What is the “cost” (in terms of efficiency loss) of the additional functionality of IPv6? What benefits do we obtain for this additional cost?

**For less efficient bit transmission, IPv6 handles packets more efficiently which increases performance, security, simplifies network configuration, and data flow can be directed.**

1. For reliable communication, TCP/IP adds a “three way handshake” and a separate message to close a connection as well as 20 bytes of additional overhead per packet. By comparison, UDP only adds 8 bytes of overhead per packet.

For this problem, assume a 10Mbps LAN (106 bps) that has a 1msec (10-3 sec) propagation time, what is the total time to transmit a 1 Megabit message (assuming you send this in 1000 bit segments). Please keep in mind that IP adds 20 bytes of overhead per packet, and Ethernet adds 16 bytes per packet)

* 1. What is the utilization (Throughput/bit rate) when TCP on this link for this message?

TCP = transmission control protocol; interconnects devices

Throughput = useful data/total time =

Useful data: 1Megabit = 10^6 bits

20^6+(20\*8)+(20\*8) = 1000320/10^6 = 1.00032 trans time

10^6/1.00032 = **999680bps**

Bit rate = bits/seconds = 106 bps

(account for the overhead added by TCP *and* the one by IP)

* 1. What is the utilization of UDP on this link for this message?

UDP = user datagram protocol; low latency, loss tolerating connections

Throughput = useful data/total time

20^6+(8\*8)+(20\*8) = 1000224/10^6 = 1.000224 trans time

10^6/1.000224 = **9997776bps**

Bit rate = bits/seconds = 106 bps

(account for the overhead added by UDP *and* the one added by IP)

1. INFSCI 1070: How do changes in bit rate of the link and propagation time affect the outcome of (b)?

**Packet overhead causes throughput to decrease, and therefore decreases the utilization. In this case, the utilization of UDP on this link would decrease by if the bit rate decreased or if the propagation time increased.**

2 a) In the first half of the semester, we encountered several places where redundancy was very important. What are at two different benefits to redundancy in a network?

**Mitigate risk of unplanned outages, and ensure that operation continues by reducing effects of a point of failure**

b) Give an example of a network where each of the dynamics in (a) is important. What are the nodes? The edges? Explain why.

**Water systems; the nodes are structures that need the water to function such as homes or public buildings, and the edges are the piping and plumbing that interconnects everyone. If one node fails, the other connected nodes cannot fail or else a significant amount of people will be inconvenienced.**

**Another example would be electric grids; the nodes are buildings and the edges are the wires connecting the nodes.**

c) On the next page is a (simplified) road network of Pittsburgh. What are at least three places you see redundancy in this network?

**Any of the bridges across the Allegheny or Monongahela serve as a point of redundancy to each other, as they simply decrease the traffic to one specific route and decrease distance to certain groups**

d) The city is considering installing another bridge to increase redundancy and save commuter time/money

Suppose they only care about people coming from Oakland!

Each day:

1000 people go to Fox Chapel

500 people go downtown

200 go to Beechview

100 go to the South Hills.

Roads never close, but bridges sometimes do! Suppose each “hop" between nodes in the network costs a driver 1 cent in commute time per person taking that route.

* 1. On a normal day, how much does it cost a commuter to get from Oakland to each of those locations, assuming they take the route with the fewest hops?

**1000 people to Fox Chapel -> 5 hops**

**Two equally short routes to get to Oakland, assuming that they all take the same route, it should cost (1000\*5) = 5000 cents/driver, otherwise, it depends on commuter choice and which end of Fox Chapel they are at**

**If they are split half and half, it would be 500\*5 = 2500 cents**

**500 people to downtown -> 3 hops**

**(500\*3) = 1500 cents/driver**

**add shared link with South Hill, Beechview commuters to go southward of Oakland (200+100) = 300 cents**

**200 to Beechview -> 5 hops**

**Two equally short routes to get to Oakland, assuming that they all take the same route, it should cost (200\*5) = 1000 cents/driver**

**If sharing with Downtown commuters (200\*5) + (500\*1) = 1500 cents**

**If sharing with South Hill commuters (200\*5) + (100\*1) = 1100 cents**

**add shared link with Downtown, South Hill commuters to go southward of Oakland (500+100) = 600 cents**

**100 to South Hills -> 2 hops**

**(100\*2) = 200 cents/driver**

**If sharing with Beechview commuters (100\*2) + (200\*1) = 300 cents**

**add shared link with Downtown, Beechview commuters to go southward of Oakland (500+200) = 700 cents**

* 1. For each of bridges A-F, who is affected if it goes down? What is each of those people’s new route cost if they take the route that now has the shortest number of hops? (remember that a route becomes more costly when people use it)

**If bridge A fails, very few commuters will be affected, since the bridge does not affect the route to Oakland.**

**If bridge B fails, Fox Chapel commuters will be affected. They initially had two routes, using bridges F and B, or only using bridge E. Now that the amount of people using the road is the full 1000 commuters, the cost will reliably be 5000 cents**

**If bridge C fails, South Hills commuters will be affected. They will move from using bridge C to using bridge D, increasing their commute to 4 hops, which then increases the cost to (200\*3) Beechview commuters + (100\*3) South Hills to Oakland = 900 cents + shared link with Downtown, Beechview commuters = 900+700 = 1300 cents**

**If bridge D fails, Beechview commuters will be affected. Instead of taking bridge D, they will have to use bridge A, increasing the route to 6 hops; if they share with Downtown commuters, (200\*6) + (500\*2) = 2400 cents + shared link with Downtown, South Hills = 2400 + 600 = 3000 cents**

* 1. Suppose Prob(bridge A floods) = Prob(bridge B iced over) = Prob(bridge C hit by a barge) = Prob(bridge D catches fire) = Prob(bridge E on marathon route) = Prob(bridge F under construction) = p. If the only consideration was Oakland commuters, where should the city put the bridge?

**Bridge A would be the smarter choice here, as it is the only bridge that connects all three pieces of land, which is essential to allow commuters to travel from Oakland.**

* 1. Now, suppose you are a city planner. Is this the way you would make this decision? What other (non-financial) factors might you consider?

**Some non-financial factors may be convenience or wear and tear of the bridge. It would be very inconvenient for South Hills commuters to travel through Downtown and then back east again to return from Oakland, and the bridge would not be able to withstand the stress of so many commuters using the road daily.**

