Homework 1

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> 1. You set up a communication channel between two medieval castles by letting a trained raven repeatedly carry a scroll from the sending castle to the receiving castle, 160 kilometers away. The raven flies at an average speed of 40 km/h, and carries one scroll at a time. Each scroll contains 1.8 terabytes of data. Calculate the data rate of this channel when sending
> (i) 1.8 terabytes of data;
> (ii) 3.6 terabytes of data;
> (iii) an infinite stream of data.

Time cost for a single trip $t = \frac{160}{40}\mathrm{h} = 4\mathrm{h}$.

Therefore for n sending, the data rate will be $\frac{1.8n\ \mathrm{TB}}{(2n-1)t} = \frac{n}{2n-1} \cdot 0.45\mathrm{TB/h} = \frac{n}{2n-1}\mathrm{Gb/s}$.

So the answer is:

(i) Data rate = 1Gb/s

(ii) Data rate = 0.67Gb/s

(iii) Data rate = $\lim\limits_{n\to\infty} \frac{n}{2n-1}\mathrm{Gb/s} = 0.5\mathrm{Gb/s}$.

> 2. A factor in the delay of a store-and-forward packet-switching system is how long it takes to store and forward a packet through a switch. If switching time is 20 μsec, is this likely to be a major factor in the response of a client-server system where the client is in New York and the server is in California? Assume the propagation speed in copper and fiber to be 2/3 the speed of light in vacuum.

The distance between the 2 places is about 4000km.

For a **response**, there will be a signal sent from the client to the server, and another one sent back from the server to the client.

Therefore the time cost in copper and fiber will be $\frac{2\times 4000\times 1000}{\frac{2}{3}\times 3\times 10^8}\mathrm{s} = 0.02\mathrm{s} \gg 20\mu\mathrm{s}$. So the switching time is ***not*** the major factor in the response.

> 3. A client-server system uses a satellite network, with the satellite at a height of 40000 km. What is the best-case delay in response to a request?

For such a response, there will be totally 4 travels between the ground and the satellite: client to satellite, satellite to server, server back to satellite, satellite back to the client.

Therefore the total time cost will be $\frac{4\times 40000\times 1000}{3\times 10^8}\mathrm{s}=0.533\mathrm{s}$.

> 4. Five routers are to be connected in a point-to-point subnet. Between each pair of routers, the designers may put a high-speed line, a medium-speed line, a low-speed line, or no line. If it takes 50 ms of computer time to generate and inspect each topology, how long will it take to inspect all of them?

There can be totally $C_5^2=10$ pairs of routers, each pair has 4 different kind of connection. So there will be totally 4^{10} kinds of topology, taking totally $4^{10}\times 50\mathrm{ms}=5.24\times 10^5\mathrm{s}$ to inspect all of them.

> 5. A group of 2^{n-1} routers are interconnected in a centralized binary tree, with a router at each tree node. Router i communicates with router j by sending a message to the root of the tree. The root then sends the message back down to j. Derive an approximate expression for the mean number of hops per message for large n, assuming that all router pairs are equally likely.

The mean number of hops from i to the root is equivalent to that from the root to j, which is equal to the mean number of the nodes' levels, which is

$$\frac{\sum_{i=0}^{n-1} i\cdot 2^i}{\sum_{i=0}^{n-1} 2^i}=\frac{n\cdot 2^n-2^{n+1}+2}{2^n-1}=n-2+\frac{n}{2^n+1}\simeq n-2$$

So the mean number of hops from i to j is $2(n-2)=n-4$.

> 6. A disadvantage of a broadcast subnet is the capacity wasted when multiple hosts attempt to access the channel at the same time. As a simplistic example, suppose that time is divided into discrete slots, with each of the n hosts attempting to use the channel with

> probability p during each slot. What fraction of the slots will be wasted due to collisions?

When there is no host trying to use the channel ($p_0 = (1-p)^n$), the channel is not wasted; when there is only 1 host broadcasting ($p_1 = np(1-p)^{n-1}$), the channel is also working well. When there is more than 2 hosts trying, there will be a collision. So the fraction is:

$$p = 1 - (1-p)^n - np(1-p)^{n-1}$$

> 7. In some networks, the data link layer handles transmission errors by requesting that damaged frames be retransmitted. If the probability of a frame's being damaged is p, what is the mean number of transmissions required to send a frame? Assume that acknowledgements are never lost.

The possibility of one frame be transmitted for i times (i.e. damaged for $i-1$ times) is $p^{i-1}(1-p)$.

So the mean number of transmissions is $\sum_{i=1}^{\infty} ip^{i-1}(1-p) = \frac{1}{1-p}$.

> 8. How long was a bit in the original 802.3 standard in meters? Use a transmission speed of 10 Mbps and assume the propagation speed of the signal in coax is 2/3 the speed of light in vacuum.

We can get the equation that $\dfrac{1\mathrm{b}}{10\mathrm{Mb/s}} = \dfrac{l}{\frac{2}{3} \times 3 \times 10^8 \mathrm{m/s}}$, where l stands for the length of a bit in the question. So we can solve that $l = 20\mathrm{m}$.

> 9. Ethernet and wireless networks have some similarities and some differences. One property of Ethernet is that only one frame at a time can be transmitted on an Ethernet. Does 802.11 share this property with Ethernet? Discuss your answer.

No. For wireless networks, Frequency Division Multiplexing can be used which allows different frames being transmitted at a time.

> 10. List two advantages and two disadvantages of having international standards for network protocols.

Advantages: i) It will be able to use a same software in different network environments as they all use the same protocol. ii) It will make the work of the software engineers easier.

Disadvantages: i) Different network protocols fit different environments or usages, a single standard may do harm to the performance. ii) It is hard to change the existing standards in practice.

> 11. Suppose the algorithms used to implement the operations at layer k is changed. How does this impact operations at layers k - 1 and k + 1?

Another implement (as long as it is correct) inside a layer will not change the service provided and the message requested. So it will not impact k - 1 and k + 1 layer.

> 12. Suppose there is a change in the service (set of operations) provided by layer k. How does this impact services at layers k − 1 and k + 1?

It will not impact layer k - 1 either, but as the service provided is changed, so the k + 1 layer will be impacted as it uses the service of the k layer.