1.264 Lecture 35 (Solutions)

Telecom: Fiber optics

Next class: Green chapter 18-21. Exercise due <u>before</u> class
Course evaluation at http://web.mit.edu/subjectevaluation/

Optical networking exercise

- **Long spans possible**
  - **0.2 db/km loss implies 1% of signal carries 100 km without amplification**
    - **DB= 100 km * 0.2 db/km= 20 db**
    - **Loss= $10^{(DB/10)} = 10^2 = 100$**
    - **Signal= 1/loss= 0.01**
  - **400 km spans common on land, longer undersea**
- **Exercise:**
  - **With 0.15 db/km loss, what is signal strength 200 km from origin?**

Optical networking solution

- **Long spans possible**
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  - **400 km spans common on land, longer undersea**
- **Exercise solution:**
  - **With 0.15 db/km loss, what is signal strength 200 km from origin?**
  - **DB= 200 km * 0.15 db/km= 30 db**
  - **Loss= $10^{DB/10}$= 10^3= 1000**
  - **Signal= 1/loss= 0.001**

Exercise

- **Suppose 10 real time video channels (training, videoconference, customer contact…) are active in each of the 48 lower states in the US and made available to your company's facilities in each state (You may be FedEx, UPS…)**
  - **Real time channel is 6 Mbps**
  - **Assume the location in each state uses every channel, so all 48 * 10 channels must be sent to each state**
  - **All locations are in metro areas**
- **How much bandwidth into each state is required?**
  - **Can one 40 Gbps network handle it?**
  - **If not, how many networks must be used?**
- **Once the data gets to a metro area, can a 1 Gbps Carrier Ethernet handle all the traffic?**

Solution

- **48 states * 10 channels * 6 Mbps= 2880 Mbps= 2.88 Gbps**
  - **One carrier can handle it, though it takes almost 10% of its capacity**
  - **In a metro area, 1 Gbps is not enough. At least 3 1 GB networks are needed.**
  - **This fill the entire capacity of these three networks. The carrier providing them must dedicate three sets of core and edge routers, plus spares.**

Exercise

- **A supplier is based in the interior of the Congo.**
  - **It currently uses satellite communications at 128 kbps to access the Internet. It pays $500 per month per link.**
  - **A fiber optic link becomes available that provides up to 45 Mbps, in 1.5 Mbps increments. The first 1.5 Mbps chunk costs $100 per month, and each increment costs $50**
  - **It both sends and receives 100,000 XML messages per 8 hour day (orders, catalog, shipment, etc.). Half the messages are 10,000 bytes; the other half are 1 MB (with graphics)**
  - **How many satellite links did it need, at what cost?**
    - **If it needed more than 2, satellite was infeasible. It would have needed custom software to extract minimal data to/from XML messages handled by proxy elsewhere**
  - **How much fiber bandwidth does it need, at what cost?**
  - **What if it only sent and received 1,000 XML msgs per day?**

Solution

- **Bandwidth up= bandwidth down, as is common in business communications**
  - Bits/day= 50,000*8*(10,000 + 1,000,000)= 404 Gb
  - Time= 8*3600= 28,800 seconds
  - Bandwidth= 404 Gb/ 28800 sec=~ 14 Mb/sec
- **This is infeasible with satellites**
  - With 1,000 versus 100,000 messages, the bandwidth is 140 kb/sec. It would need 2 satellite links, at $1,000/mo.
- **With fiber this requires 15 Mb/sec at $100 + 9*$50, or $550 per month**
  - No proxy server or custom software are required, and the supplier is fully integrated via Internet/Web

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