1.264 Lecture 32 (Solutions)

Telecom: Basic technology

Next class: Green chapter 4, 6, 7, 10. Exercise due <u>before</u> class

Exercise 1

- **Communications at warehouse**

  A warehouse scans its inventory with RFID readers that read every item every 15 minutes. There are 100,000 items in inventory. The sweep takes one minute to complete, so the data is bursty. The data is sent to the data center 3 km away as it is read. Each RFID tag transmits 256 bits of information, and is read four times per sweep (either by different readers or multiple times by the same reader). TCP/IP and HTTP headers double the size of the data.

  - What is the total bandwidth required?
  - Would 10 Mbps Ethernet work?
  - Would 100 Mbps Ethernet work?
  - Would cellular 500 kbps link work?
  - Maximum Ethernet copper cable length is 100 meters.
    - How would you connect points 3 kilometers apart if you have right of way?
    - Don't have right of way?

Solution

- **Communications at warehouse**
  - **What is the bandwidth required?**
    - **100 000 x 4 x 256 bits / 60 sec x 2 ~= 3.4 Mbps**
  - **Would 10 Mbps Ethernet LAN work?**
    - **Yes**
  - **Would 100 Mbps Ethernet LAN work?**
    - **Yes**
  - **Would cellular 500 kbps link work?**
    - **No. Bandwidth too low.**
    - **Unless you send data over 15 minutes, which is possible if you store it and/or process it (with a server) at warehouse**
    - **This is a typical business/ops decision affected by telecom**
  - **The maximum Ethernet copper cable length is 100 meters. How would you connect points 3 kilometers apart?**
    - **If you have right of way: use fiber adapter and fiber optic cable**
    - **If you don't have right of way: obtain carrier Ethernet service**
    - **Or use 4G wireless, if available, but this will be expensive**

Exercise 2

- **Why do we bother with wired telecommunications?**
  - **Why not use wireless everywhere?**
- **Why do companies design and manage their own networks?**
  - **Local area network**
  - **Wide area network**
- **When do companies build their own network, versus lease facilities, versus buy carrier solution? Why?**
- **For each these companies, indicate whether they probably build their own, lease facilities or buy a carrier solution, and briefly explain why:**
  - **MBTA, UPRR, MITFCU, Bertucci, Citibank, NBC, AA**

Solution

- **Why do we bother with wired telecommunications?**
  - Bandwidth hugely greater; reliability, latency much better
- **Why do companies design and manage their own networks?**
  - Local area network: Inexpensive, easy, no exotic skills reqd
  - Wide area network: Security, control, quality of service
- **When do companies build their own network, versus lease facilities, versus buy carrier solution?**
  - MBTA: Builds own. Has row, hard to manage
  - UPRR: Builds own. Has row, easy to manage
  - MITFCU: Carrier: Small, lease expensive, no row
  - Bertucci: Carrier: Small, lease expensive, no row
  - Citibank: Lease: Large, manage own facilities, no row
  - NBC: Lease + satellite: Large, manage own net, no row
  - AA: Lease: Large, manage own facilities, no row

Exercise 3: Bandwidth

- **A wireless LAN has analog bandwidth=2 MHz and SNR= 30. Compute the digital bandwidth (Mbps)**

- **This LAN must connect 9 devices, each transmitting to the LAN access point at 2 Mbps.**
  - **The LAN should operate at 70% capacity or less**
  - **Is the LAN capacity sufficient?**

- **If the SNR is raised to 36, what is the digital bandwidth? Is this sufficient?**
  - **This can be done by increasing signal strength or lowering the noise**

Solution

- **A wireless LAN has analog bandwidth=2 MHz and SNR= 30. Compute the digital bandwidth (Mbps)**
  - **20 Mbps= 2 MHz * 30/3**
- **This LAN must connect 9 devices, each transmitting to the LAN access point at 2 Mbps.**
  - **The LAN should operate at 70% capacity or less**
  - **Is the LAN capacity sufficient?**
  - **Capacity required= 9 * 2= 18 Mbps**
  - **Practical capacity= 20 Mbps*0.7= 14 Mbps. Not sufficient**
- **If the SNR is raised to 36, what is the digital bandwidth?**
  - **At SNR=36, digital bandwidth= 24 Mbps= 2 MHz*36/3**
  - **Practical capacity= 24 Mbps*0.7= 16.8 Mbps. Almost ok.**

Exercise 4: Transmission

- **What is the bandwidth (digital) of an E1 channel? Ignore the framing bits. Give the result in both kbps and Mbps.**

- **How many E1 channels can be carried in an STS-1 (or OC-1) channel?**
  - **Round down by about 10% to allow for overhead.**
  - **The result must be an integer.**

- **How many voice calls (64 kbps) can be carried on the STS-1 channel over the E1s it contains?**

Solution

- **What is the bandwidth (digital) of an E1 channel? Ignore the framing bits.**
  - **32 * 64 kbps= 2048 kbps, or 2.048 Mbps**
- **How many E1 channels can be carried in an STS-1 (or OC-1) channel?**
  - **Round down by about 10% to allow for overhead.**
  - **The result must be an integer.**
  - **Bandwidth after overhead= 0.9*51.84= 46.66 Mbps**
  - **Channels= 46.66/2.048= 22+**
  - **Round down to either 22 or 20.**
- **How many voice calls (64 kbps) can be carried on the STS-1 channel over the E1s it contains?**
  - **20 * 32= 640 (or 22 * 32= 704)**

1.264J / ESD.264J Database, Internet, and Systems Integration Technologies
Fall 2013