Performance & Framing

CS 640, 2015-01-29

Announcements

- No office hours today

Outline

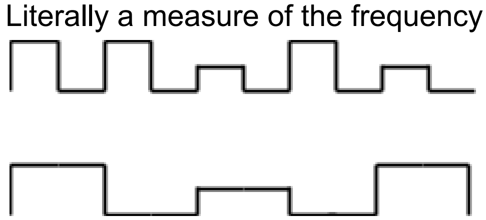
- Performance
- Framing

Recap

- ****What were the key physical layer design issues we discussed last time?**
    - Network of networks -- hosts connected to switches; networks connected to each other via routers
    - Packing switching (vs. circuit switching)
    - Statistical multiplexing (vs. frequency or time division multiplexing)
    - 4-bit/5-bit encoding (vs. non-return to zero, non-return to zero inverted, and Manchester)

Performance

- ****What performance issues did the NOVA video discuss? Why do we care about performance?**
- Two possible perspectives:
    - Individual links
    - Entire end-to-end path (sequence of links)
- Bandwidth
    - Number of bits transmitted per unit of time -- e.g., 1 Mbps is 1 million bits per second
    - Or, how long it takes to transmit each bit -- e.g., 1us per bit for 1 Mbps
    - Literally a measure of the frequency band -- i.e., width of a signal



    - One measure of bandwidth for a link or path
        - Bandwidth of a path is the minimum bandwidth among all links in the path
    - Typical bandwidths
        - Desktops & servers -- 1Gbps or 10Gbps
        - Campus backbone -- 40Gbps or 100Gbps
        - Wireless (802.11n) -- 300Mbps max
        - Cellular (4G LTE) -- 5-12Mbps download, 2-5Mbps download
- Latency
    - Amount of time it takes to transmit a message from one node to another
    - Latency = Propagation Delay + Transmit Delay + Queueing Delay
    - Propagation -- how long it takes for the start of a signal to reach the destination
        - Propagation Delay ~ Distance / Speed of Light

                - Speed of Light is 2.3 x 10^8 m/s in copper and 2.0 x 10^8 m/s in optical fiber
        - Transmit delay -- how long it takes to emit the bits
            - Think of this as the time from when the sender starts signaling to the time the sender ends signaling
            - Time required to send a signal for a given number of bits depends on the bandwidth -- e.g., takes 1us for 1 Mbps
            - Transmit Delay = Size / Bandwidth
            - Make sure your units match
                - E.g., measure size in bits and bandwidth in bits, or size in Mb and bandwidth in Mbps
                - Remember to convert bytes (big B) to bits (little b) by multiplying by 8, or dividing to go the other way
        - Queueing delay -- how long bits are stored at intermediate end points before being sent along the next link
            - Queuing Delay = Sum of queuing delay at each intermediate node
        - Example -- latency to send HTTP request for NY times web page
            - Distance from Madison to New York = 1500 km
            - Size of request = 170 B
            - Queueing delay = 30 ms
            - Bandwidth = 10 Mbps
            - Propagation delay = (1500 * 1000) m / (2.0 x 10^8) m/s = 0.0075 s
            - Transmit delay = (170 * 8) b / (1 * 1000 * 1000) bps = 0.000136 s
            - Latency = 0.0075 s + 0.000136 s + 0.030 s = 0.037636 s
- Jitter
    - Variation in latency between subsequent packets
    - Problematic for real-time traffic -- e.g., voice/video calls
- **** Which performance metric matters more?**
    - Small amounts of data, latency dominates
        - Transmit delay is small, so mostly affected by queueing delay
        - E.g., sending key strokes when using SSH, or sending request for web page
    - Large amounts of data, bandwidth dominates
        - Transmit delay is large, so it is of greater concern
        - E.g., sending streaming video
    - Look at the formulas
        - Latency = (Size / Bandwidth) + Queueing
        - sec = (bit / (bit / sec)) + sec
        - sec = (bit * (sec / bit)) + sec
        - Latency = (Size * Constant) + Constant
- Delay x bandwidth product
    - Number of bits in transit in a link at a given point in time
    - Think of link as a pipe where latency is length and bandwidth is diameter
    - Example
        - Latency = 0.037 s
        - Bandwidth = 10Mbps
        - Delay x bandwidth = 370Kb

- Max amount of data may not always be in transit

Link Layer

- Framing -- where does one packet begin and end (in a signal of bits)?
- Error detection -- how do we identify errors in transmission?
- Access control -- when and who sends a signal?
    - Key concern in old-style wired NWs -- not a problem with full-duplex point-to-point links
    - Still an important issue in wireless NWs since they share the medium (air)
- Queueing -- how to we store packets while waiting to send? what happens if the queue is full?
    - We'll talk about this right before spring break
- Bridging & switching -- how do we connect multiple links?
- Addressing -- how do we identify physical endpoints?

Framing

- ****How do we identify where in the signal one packet (i.e., frame) begins and ends?**
- Sentinel
    - Use special characters to indicate frame start and end
        - SYN (synchronize) character
        - SOH (state of header) character
        - Link layer header
        - STX (start of transmission) character
        - Body of message (network, transport, and application headers and application data) -- escape any of the special characters that happen to appear in the body of the message
        - ETX (end of transmission) character
        - CRC (cyclic redundancy check) -- used to detect transmission errors
    - Ethernet uses a version of the sentinel approach
        - Start frame with sequence of bits -- used to denote start of frame and to help receiver align signal to byte boundaries
- Byte counting
    - Include the number of bytes that are in the frame after the SYN character
        - SYN character
        - Byte count
        - Link layer header
        - Body of message
        - CRC
    - Disadvantage: corrupted count field can cause too much or too little data to be read; framing will be off until next SYN character is seen
- Clock-based
    - Look for instances of start and end characters based on a fixed frame size and a fixed transmission rate
    - Advantage: very efficient because you only need to check for special characters at set intervals, not every byte
    - Implemented in SONET (Synchronous Optical Network) -- standard used for long distance optical fiber links