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Assignment 3

1. **List services provided by the link layer and describe them briefly.**
   - *Framing and Link Access:* The Link Layer provides a frame structure and channel access protocol to define rules for frame transmission. If there is a Link Access Protocol, the multiple access problem is addresses where multiple nodes transmit through the same channel.
   - *Reliable Delivery:* Along with protocols like TCP, the link layer provides local error correction on the link instead of retransmission by Transport or Application Layer Protocols.
   - *Flow Control:* Flow control protocols prevent sender nodes from sending packets to receiver nodes with a high chance of being overwhelmed.
   - *Error Detection:* The Link Layer provides error detection for bits in header fields through techniques like Cyclic Redundancy Check (CRC), checksums, or other methods.
   - *Half or Full-Duplex Transmission*: Nodes at the Link Layer can be configured for half-duplex or one-way transmission, of full-duplex (two-way transmission).

2. **Describe specifications of CAT5 twisted pair cable.**

CAT5 Ethernet Cables are shielded Twisted Pair cables based on the previous CAT1 through CAT4 specifications and is used for most varieties of Ethernet over twisted pair. It supports up to 100 MHz bandwidth and supports category 5 applications such as 10 and 100 Base-T standard (twisted pair Ethernet up to 100m at 100 MHz), Fiber Distributed Data Interface (FDDI) networks, and Asynchronous Transfer Mode (ATM) switching. More below at: http://www.farnell.com/datasheets/1311845.pdf

3. **What is Attenuation? Explain it and find a theory how to measure it.**

Attenuation occurs when a signal loses strength during transmission and is represented in decibels (dB), but can also be expressed in voltage. Attenuation determines connection efficiency; i.e. if there is less attenuation per unit distance, then the cable is more efficient. One way of dealing with this is by installing signal repeaters to increase the available range of communication. In wireless networks, there is added dB depending on the mediums between the router and the receiver. For instance, the human body adds approx. 3 dB, while a metal door adds 6 dB. For circuit connections, Attenuation can be expressed by the following:

For Signal Power (P): $A_p = 10 * log_{10}(\frac{P_{source}}{P_{destination}})$

For Signal Voltage (V): $A_V = 20 * log_{10}(\frac{V_{source}}{V_{destination}})$

4. **A frame in a LAN contains three identifiers. List each ID and their main purpose.**
   - *Header*: The Ethernet frame header contains the source and destination MAC addresses which allow for specific delivery to a client on the network. The header has a preamble which is responsible for syncing the Network Interface Cards (NICs) to prevent asynchronous bit errors. Following the Preamble is the SFD (Start Frame Delimiter) which denotes the start of the MAC addresses.
   - *Type Field*: The Type field indicates the size of the payload in octets ($\leq$1500Bytes), where if it has a value of 1536 or more, it is used as an EtherType field that indicates protocols encapsulated in the payload. There is also sometimes a Tag Protocol ID (TPID) that denotes if the frame has either of the IEEE 802.1q/ad tags, which if exist, indicates virtual LAN membership and IEEE 802.1p priority (for multicast filtering and frame extension).
   - *Frame Check Sequence (FCS)*: The FCS is a 32 bit Cyclic Redundancy Check (CRC) used to detect data errors on the receiver's side. It is a remainder from polynomial binary division using a divisor agreed upon by both sender and receiver. If there is no remainder after division by the receiver, then the check is cleared.

5. **Define "little a" as ratio between a propagation delay (T_p) and a transmission delay (T_x) of a communication link. Explain if $a < 1$ and what kind of network is this: $a = T_p / T_x$?**

The "little a" ratio is best defined when looking at CS/CDMA Efficiency. The textbook (p.458) defines this in the formula:

$$E = \frac{1}{1+5T_p/T_x} \text{ or } E = \frac{1}{1+5a}$$

We can infer then that efficiency is inversely proportional to "little *a*". "Little *a*" is simply the ratio of propagation delay to transmission delay. Since propogation delay is a function of distance between routers, we can infer that this formula is meant for LANs since each link in a network has its own efficiency contributing to the overall network efficiency. When T_p approaches 0, the Efficiency approaches 100%. Similarly, if T_x becomes extremely large, then the efficiency approaches 1. This gives us three cases:

1. If $a > 1$: delay is mostly propagation delay and the link has too many bits being fed into the link per unit of transmission time (high congestion!)
2. If $a = 1$: delays are equal and balanced
3. If $a < 1$: delay is mostly transmission delay and the link can be fed more bits per unit of time to strive for case 2 above.

For LANs, we strive for $a \leq 1$ for max efficiency where $\boldsymbol{a = T_p / T_x}$ as to minimize attenuation in the link.

Works Cited

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