Network Performance

Slide Set 5

Key Terms

- **Bandwidth / Capacity of the network**
- **Throughput – Actual Rate of data passing a certain point in the network**
- **Latency (Delay) - delay incurred by a data from start to finish**
  - **Transmission Delay**
  - **Propagation Delay**
  - **Queuing/Buffer Delay**
  - **Processing Delay, etc…**

Bandwidth/Capacity

Bandwidth can have two contexts in networking:

The first, Bandwidth measured in Hertz, refers to the range of frequency that a channel or link can have i.e. highest frequency – lowest frequency.

The second, bandwidth measured in bits per second, refers to the maximum rate of data that can be carried by a channel or link. This is often referred to as the Capacity to avoid confusion.

Bandwidth/Capacity

The Capacity of a channel or link is directly proportional to the Bandwidth available.

<u>The higher the Bandwidth, the higher the capacity</u>

This is shown by either the Nyquist and Shannon-Hartley Theorems below:

Nyquist: C = 2Blog2 M where M = no. of signal levels

Shannon-Harteley: C = B log2 (1 + S/N) where S/N is the Signal power to Noise power ratio.

Throughput

Throughput is the actual rate of data passing a particular point in the network. It is measured in bits per second just like Capacity.

The throughput is always less or equal to the capacity of a channel or link.

The throughput can never exceed the capacity of a channel.

For example, in wireless LAN 802.11g, the capacity is 54 Mbps, but the throughput at a certain distance from the transmitter will always be less than 54 Mbps.

Latency

Latencies are the delays present in a communication system.

Some of these latencies are negligible but some are not.

The one-way latency is the sum of all the delays added up from source to destination.

The two-way latency is also referred as to the <u>Round-Trip-Time</u> (RTT) or <u>response time</u>.

Transmission Delay

Transmission Delay or Transmit time is the time needed to inject the data on the network for ongoing transmission. It is directly proportional to the size of data and inversely proportional to the bandwidth of the channel or link.

$$\text{Transmit Time} = \frac{\text{Size of data (in bits)}}{\text{Bandwidth (in bits per second)}}$$

Propagation Delay

Propagation Delay or Travel time is the time taken for the data signal to travel from source to destination. It is directly proportional to the distance between source and destination and inversely proportional to the speed of the signal.

$$\text{Propagation Delay} = \frac{\text{Distance (in meters)}}{\text{Speed (in m/s)}}$$

Queuing/Buffer Delay

Queuing Delay or Buffer Delay is the time taken to 'absorb' the data at the receiver It is usually assumed to be equal to the transmit time if the same amount of data is received and bandwidth is unchanged.

$$\text{Buffer Time} = \frac{\text{Size of data (in bits)}}{\text{Bandwidth (in bits per second)}}$$

Processing Delays

Processing Delay is the time taken to process some information in order to take a decision.

Processing delays such as: Switching delay, Error detection delay, when intermediate devices such as hubs, bridges, switches and routers are present.

These delays depend of the speed of the processing unit, the type and amount of memory, as well as, the switching technology used within those devices.

Switching Delay

Switching Delay = Time taken to move data from incoming port to appropriate outgoing port.

In a switch, this is the time taken to decide which appropriate outgoing port to forward a frame after inspecting the forwarding table.

In a router, this is the time taken to decide which appropriate outgoing port to route a packet after inspecting the routing table.

Error Detection Delay

Error Detection Delay = Time taken to check for errors withing a frame or packet header.

Error detection delay **only** takes place in a switch operating in **Store-N-Forward** mode **because it buffers the frame completely**.

Note: No error detection in switches operating in cut-through mode.

In a router, error detection occurs for both the frame content and the packet header as well.

Switch Buffer time in Cut-through mode

In cut-through mode, the switch does not buffer the entire frame before it starts switching and retransmitting the frame via the appropriate output port.

The buffer time is therefore less than that of a switch operating in Store-N-Forward mode.

Buffer time at switch in cut-through mode =

$$\frac{\text{Minimum Buffer bits}}{\text{Bandwidth in bps}}$$

Performance Statistics

- The main network performance parameter is the **response time** as seen previously.
- Another parameter is **availability**; the percent of time the network is available. **Downtime** is the percent of time the network is not available.
- Failure statistics include:
  - **Mean time between failures (MTBF)** indicates the reliability of a network component.
  - **Mean time to repair (MTTR)** equal to the mean time to diagnose plus the mean time to respond plus the mean time to fix a problem.

MTTRepair = **MTTDiagnose** + **MTTRespond** + **MTTFix**

Availability

$$\text{Availability} = \frac{uptime}{uptime + downtime} = \frac{MTBF}{MTBF + MTTR}$$

Availability	Lost Time (hours)	Lost Time (minutes)	Lost Time (seconds)
60.00%	3504		
65.00%	3066		
70.00%	2628		
75.00%	2190		
85.00%	1314		
90.00%	876		
95.00%	438		
96.00%	350.4		
97.00%	262.8		
98.00%	175.2		
99.00%	87.6		
99.50%	43.8		
99.90%	8.76	525.6	
99.99%	0.876	52.6	3153.6
99.999%	0.0876	5.3	315.36
99.9999%	0.00876	0.5	31.536
99.99999%	0.000876	0.1	3.1536
1 year = 365 days/yr * 24 hrs/day = 8760 hrs/yr			

Just as a remind

Reliability

$$\text{Reliability} = e^{-T/\Phi}$$

$$\text{Reliability} = e^{-\Lambda T}$$

$$\text{Reliability} = e^{-N}$$

Reliabililty	Failures per year	Failures per 10 years	Failures per 100 years
10.00%	2.30		
20.00%	1.61		
30.00%	1.20		
40.00%	0.92		
50.00%	0.69		
60.00%	0.51		
70.00%	0.36		
80.00%	0.22	2.23	
90.00%	0.11	1.05	
95.00%	0.05	0.51	
99.00%	0.01	0.10	1.01
99.50%	0.005	0.05	0.50
99.90%	0.001	0.01	0.10
99.99%	0.0001	0.001	0.01
99.999%	0.00001	0.0001	0.001
99.9999%	0.0000010	0.00001	0.0001
99.99999%	0.00000010	0.000001	0.00001
1 yr mission = 365 days/yr * 24 hrs/day = 8760 hrs/yr			

Where $\Phi = MTBF$, Λ = *Failure Rate*

N = *number of failures*, T = *mission time*