Computer Networking Formulae

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Contents

1 Computer Networking and the Internet

1.1 Queuing Delay

$$d_{queue} = \frac{L \cdot a}{R} \cdot \frac{L}{R} \cdot \left(1 - \frac{L \cdot a}{R}\right)$$

Where **L** is the length of the packet, **a** is the average rate of packets per second, and **R** is the transmission rate of the link.

1.2 Transmission Delay

$$d_{transmission} = \frac{L}{R}$$

Where **L** is the length of the packet, and **R** is the transmission rate of the link.

1.3 Propagation Delay

$$d_{propagation} = \frac{d}{s}$$

Where **d** is the length of the link, and **s** is the propagation speed of the link.

1.4 Nodal Delay

$$d_{nodal} = d_{processing} + d_{queue} + d_{transmission} + d_{propagation}$$

1.5 End-to-End Delay

$$d_{end-to-end} = N \cdot (d_{processing} + d_{queue} + d_{transmission} + d_{propagation})$$

Where **N** is the number of nodes. This can be used if all nodes have the same nodal delay.

$$d_{end-to-end} = \sum_{1}^{N} d_{nodal\ i}$$

Where **N** is the number of nodes, and $d_{nodal\ i}$ is the nodal delay of the ith node.

1.6 End-to-End Throughput

$$t_{end-to-end} = \frac{F}{T}$$

Where **F** is the length of the packet, and **T** is the transfer rate of the link.

2 Application Layer

2.1 Client-Server File Distribution

$$D_{CS} = \max\left\{\frac{NF}{u_s}, \frac{F}{d_{min}}\right\}$$

Where **F** is the length of the packet, **d** is the length of a link, **N** is the number of clients, u_s is the server's upload rate.

2.2 P2P File Distribution

$$D_{P2P} = \max\left\{\frac{F}{u_s}, \frac{F}{d_{min}}, \frac{NF}{u_s + \sum_{i=1}^{N} u_i}\right\}$$

Where **F** is the length of the packet, **d** is the length of a link, **N** is the number of peers, u_s is the server's upload rate, and u is the peer's upload rate.

3 Transport Layer

3.1 Estimating the RTT

$$RTT_{est} = (1 - \alpha) \cdot RTT_{est} + \alpha \cdot RTT_{sample}$$

Where RTT_{est} is the currently computed estimate, and RTT_{sample} is the RTT measurement.

3.2 Estimating the Timeout

$$T = RTT_{est} + 4 \cdot ((1 - \beta) \cdot RTT_{dev} + \beta \cdot |RTT_{sample} - RTT_{est}|)$$

Where RTT_{est} is the currently computed estimate, and RTT_{sample} is the RTT measurement.

4 Network Layer

4.1 Output Port Queuing

$$Buff = RTT \cdot \frac{C}{N}$$

Where **C** is the link capacity, and **N** is the number of packets.

4.2 Weighted Fair Queuing

$$W_a = \frac{W_i}{\sum_i i}$$

Where **W** is the weight of the ith packet, and **i** is the number of the packet.

5 Link Layer

5.1 Successful Transmission in ALOHA

$$S = p(1-p)^{2(N-1)}$$

Where **W** is the weight of the ith packet, and **i** is the number of the packet.

5.2 Successful Transmission in Slotted ALOHA

$$S = Np(1-p)^{N-1}$$

Where **N** is the number of active nodes, and **p** is the probability.

5.3 Bit Errors

$$BER = \frac{N_{err}}{N_{tot}}$$

Where N_{err} is the number of bit errors, and N_{tot} is the number of bit errors.

5.4 Cyclic Redundancy Check

$$R = (D \cdot 2^r)\%(G)$$

Where **D** is a piece of data where a CRC field is added, **r** is the length of the CRC field, and **G** is the generator – bit pattern of $r + 1$ bits.

6 Wireless Networks

6.1 Power Difference

$$P_{rx}(d) \approx \beta \cdot P_{tx} \cdot \frac{1}{d^{\alpha}}$$

Where P_{rx} is the received power, β is the multiplicative attenuation factor, P_{tx} is the transmitted power, $\mathbf{d}$ is the distance between transmitter and receiver, and α is the path loss exponent.

6.2 Received Signal Strength Indicator

$$RSSI = 10\ log_{10}\left(\frac{P_{rx}}{1\ mW}\right)$$

Where P_{rx} is the received power