COMP2322 Computer Networking Homework One

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Question 1

a) For $i \in \{1,2,3\}$, denote the propagation delay for the i-th link as d^i_{prop}, such that $d^i_{prop} = \frac{d_i}{s_i}$. Also, denote the transmission delay for the i-th link by $d^i_{trans} = \frac{L}{R_i}$. Recall that the nodal delay satisfies that $d^i_{nodal} = d^i_{prop} + d^i_{trans} + d^i_{proc}$. Thus, the total end-to-end delay for the packet equals to $\sum_{i\in\{1,2,3\}} d^i_{nodal} = \sum_{i\in\{1,2,3\}}(d^i_{prop} + d^i_{trans} + d^i_{proc}) = \sum_{i\in\{1,2,3\}}(\frac{d_i}{s_i} + \frac{L}{R_i}) + 2 \cdot d_{proc} = \frac{d_1}{s_1} + \frac{d_2}{s_2} + \frac{d_3}{s_3} + \frac{L}{R_1} + \frac{L}{R_2} + \frac{L}{R_3} + 2 \cdot d_{proc}$.

b) The total end-to-end delay for the packet equals to $\frac{4200\,\mathrm{km}+2400\,\mathrm{km}+3000\,\mathrm{km}}{3\times10^8\,\mathrm{m/s}} + 3\times\frac{1000\,\mathrm{bytes}}{4\,\mathrm{Mbps}} + 2\times 1\,\mathrm{msec} = 40\,\mathrm{msec}$.

Question 2

a) If $R_s < R_c$, the bottleneck is the first link and the packet inter-arrival time is $\frac{L}{R_s}$. However, if $R_s > R_c$, the bottleneck is the second link and the packet inter-arrival time is $\frac{L}{R_c}$.

b) If $R_c < R_s$, the second packet will queue at the input queue of the second link. The time taken from the first packet's departure from the server to its arrival at the second link is $\frac{L}{R_s} + \frac{L}{R_c} + d_{prop}$, and the time taken from the first packet's departure from the server to the second packet's arrival at the packet switch is $\frac{L}{R_s} + \frac{L}{R_s} + d_{prop}$, which equals to the sum of the time of transmission delay of the two packets on the first link and the propagation delay. As $\frac{L}{R_s} + \frac{L}{R_c} + d_{prop} < \frac{L}{R_s} + \frac{L}{R_s} + d_{prop}$, the first packet does not finish its transmission onto the second link before the second packet arrives at the packet switch, and the second packet will queue at the input queue of the second link.

c) If the server sends the second packet T seconds after sending the first packet, the time taken from the first packet's departure from the server to the second packet's arrival at the packet switch is $\frac{L}{R_s} + \frac{L}{R_s} + d_{prop} + T$. To ensure that no queueing occurs, it must satisfy that $\frac{L}{R_s} + \frac{L}{R_s} + d_{prop} + T \geq \frac{L}{R_s} + \frac{L}{R_c} + d_{prop}$. That is, $T \geq \frac{T}{R_c} - \frac{T}{R_s}$.