

Processing Delay: Time to examine packet’s header, determine where to direct the packet, check for bit-level errors in the packet, etc.

Queuing Delay: Packet waits to be transmitted onto link. Depends on number of earlier packets. Queuing delay is 0 if queue empty. be zero. Queuing delay long if traffic heavy.

Transmission Delay: Length of the packet = L bits, transmission rate of the link from router A to router B = R bits/sec, Transmission delay is $\frac{L}{R}$.

Propagation Delay: Time for bit to propagate from start of link to other router. Depends on medium of link.

Traffic Intensity: Average rate packets arrive at queue = α packets/sec. Transmission rate (bits pushed out of queue) is R bits/sec. All packets consist of L bits. Average rate bits arrive at queue is $L\alpha$ bits/sec. Assume queue can hold infinite bits, $\frac{L\alpha}{R}$ is traffic intensity.

End-to-End Delay:
 $d_{end-end} = N(d_{proc} + d_{trans} + d_{prop})$, $d_{trans} = \frac{L}{R}$
where L is packet size.

Internet Protocol Stack

Application Layer: Support data exchange. FTP, SMTP, HTTP.

Transport Layer: Handle delivery reliability, multiplex within host. TCP, UDP.

Network Layer: Forward packets from source to destination. IP, routing protocols.

Link Layer: Transfer data between directly connected network elements. Ethernet protocol.

Physical Layer: Bits “on the wire”.