# 【CN】Day7

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| Class | |
| Type | |
| Materials | Overview of Delay, and Queing Delay and Packet Loss |
| Reviewed | ☐ |

## 【Ch1】Computer Networking and the Internet

### 1.4 Delay, Loss, and Throughput in Packet-Switched Networks

Computer networks necessarily constrain throughput between end systems, introduce delays between end systems, and can actually lose packets.

#### 1.4.1 Overview of Delay in Packet-Switched Networks

Recall that a packet starts in a host, passes through a series of routers, and ends its journey in another host.

As a packet travels from one node to the subsequent node along this path, the packet suffers from several types of delays at each node along the path.

The most important of these delays are the nodal processing delay, queuing delay, transmission delay, and propagation delay.

*Types of Delay*

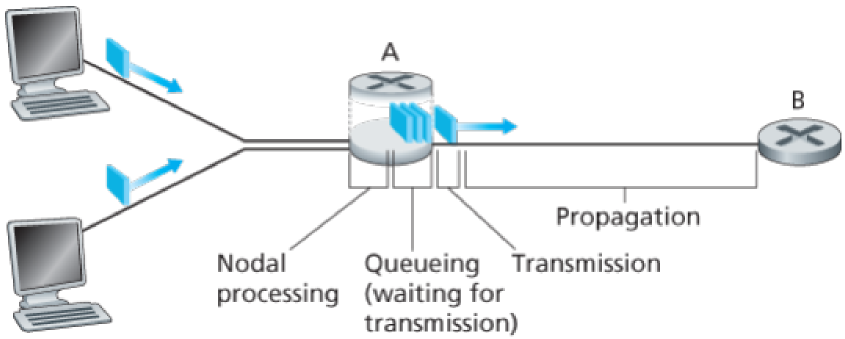


**Figure 1.16 The nodal delay at router A**

A packet is sent from the upstream node through router A to router B.

When the packet arrives at router A, router A examines the packet's header to determine the appropriate outbound link for the packet and then directs the packet to this link.

The packet can be transmitted if there are no other packets being transmitted and if there are no other packets preceding in the queue.

*Processing Delay*

The time required to examine the packet's header and determine where to direct the packet is part of the processing delay.

The processing delay can also include other factors, such as the time needed to check for bit-level errors in the packet that occurred in transmitting the packet's bits from the upstream node to router A.

*Queuing Delay*

At the queue, the packet experiences a queuing delay as it waits to be transmitted onto the link.

The length of the queuing delay will depend on the number of earlier-arriving packets that are queued and waiting for transmission onto the link.

If the traffic is heavy and the queue is long, then the queuing delay will be long.

*Transmission Delay*

Our packet can be transmitted only after all the packets that have arrived before it have been transmitted.

The transmission delay is L/R(L is the length of the packets and R the transmission rate). This is the amount of time required to push all of the packet's bits into the link.

*Propagation Delay*

Once a bit is pushed into the link, it needs to propagate to router B. The time required to propagate from the beginning of the link to router B is the propagation delay.

The total nodal delay is given by

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

### 1.4.2 Queuing Delay and Packet Loss

*When is the queuing delay large and when is it insignificant?*

The answer depends on the rate at which traffic arrives at the queue, the transmission rate of the link and the nature of the arriving traffic.

Let us denote `a` the average rate at which packets arrive at the queue(a is in packet/sec). `R` is the transmission rate(bits/sec), which is the rate at which bits are pushed out of the queue. Assume each packet consists of `L` bits.

The ratio `La/R`(the rate of bits arriving at the queue to the rate of bits leaving the queue), called the traffic intensity, often plays an important role in estimating the extent of the queuing delay.

If La/R >1, then the average rate at which bits arrive at the queue exceeds the rate at which the bits can be transmitted from the queue. Thus, one of the golden rules in traffic engineering is: Design our system so that the traffic intensity is no greater than 1.

*Packet Loss*

In reality a queue preceding a link has finite capacity.

With no place to store such a packet, a router will drop that packet; that is, the packet will be lost.

The fraction of lost packets increases as the traffic intensity increases.