CSCI 466: Networks

Network Performance
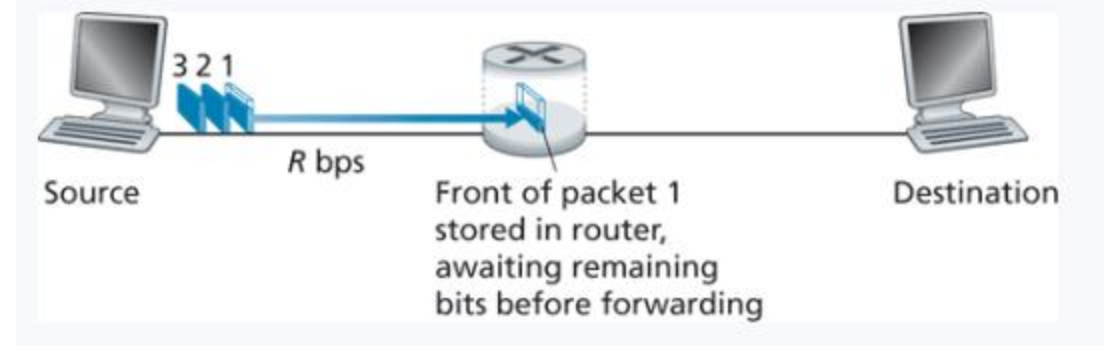
Reese Pearsall
Fall 2024
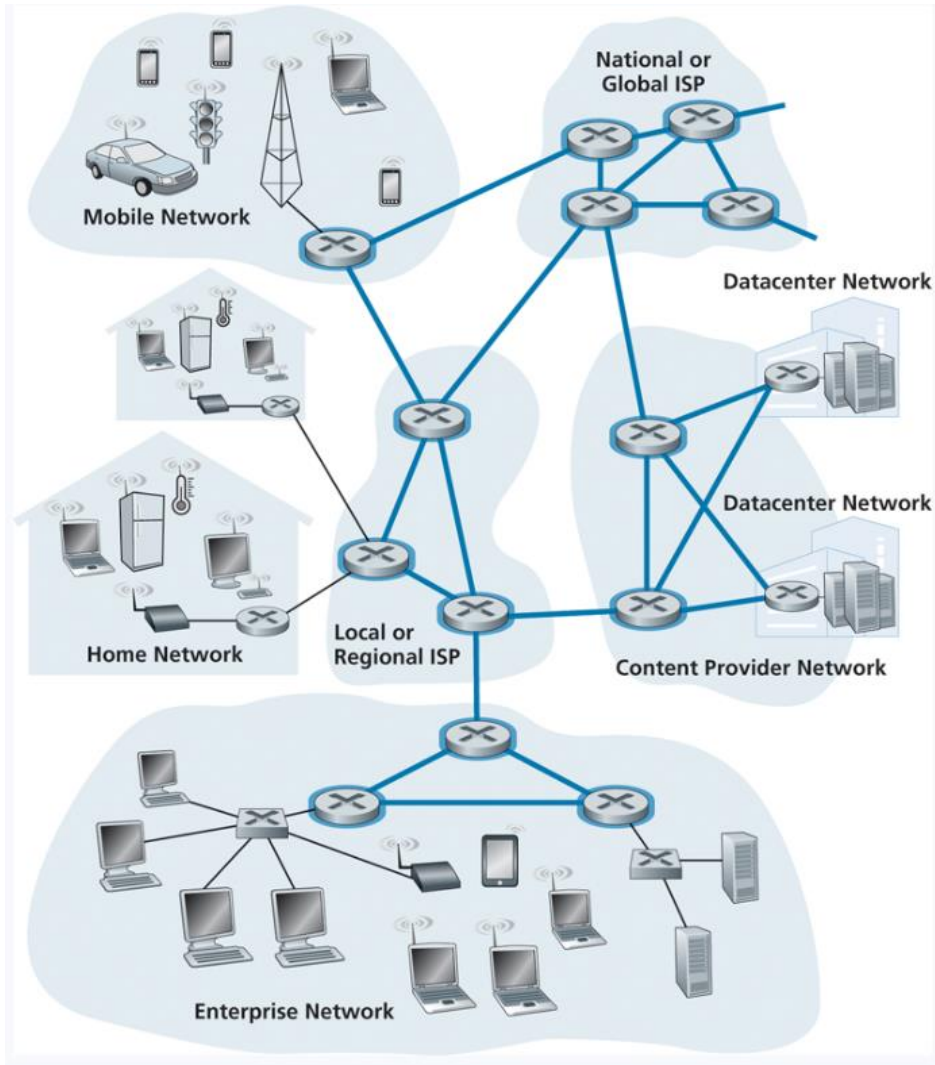
Montana
STATE UNIVERSITY
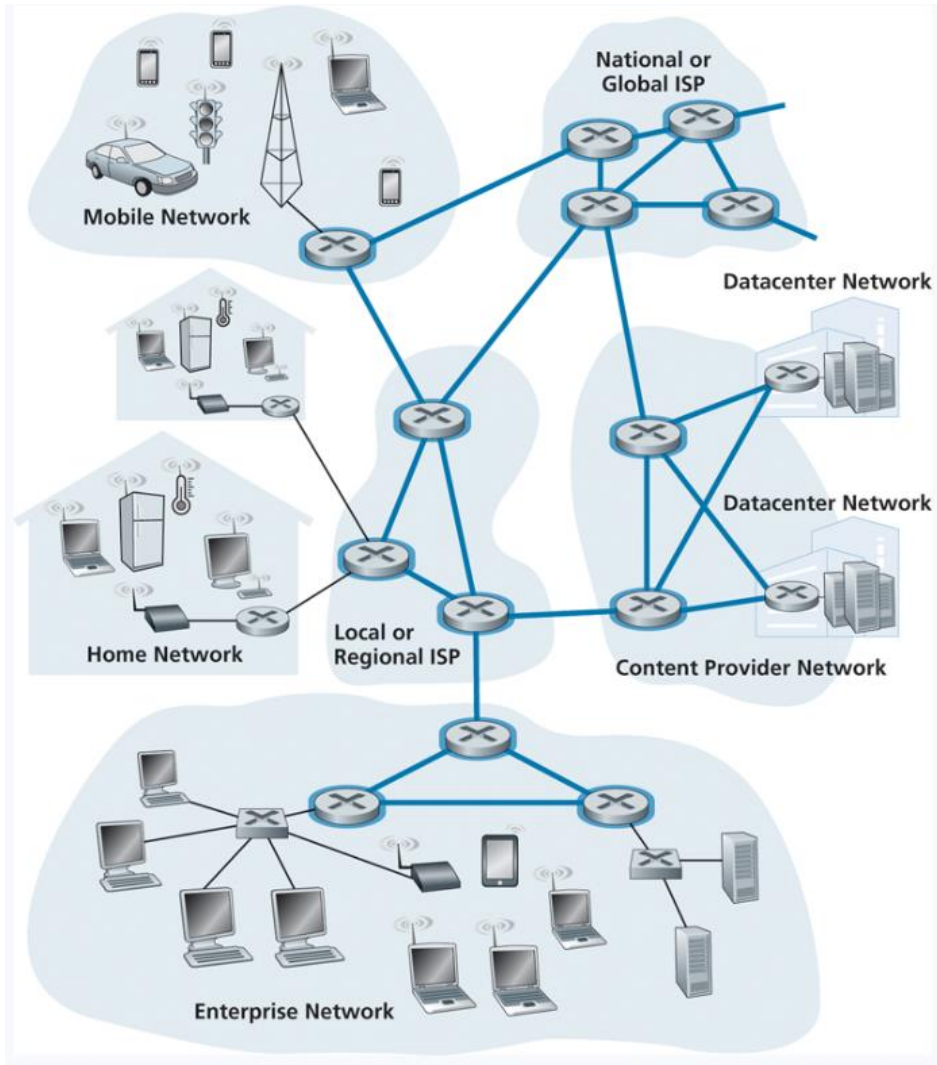
Data Forwarding

Packet Switching

Uses **store-and-forward** transmission

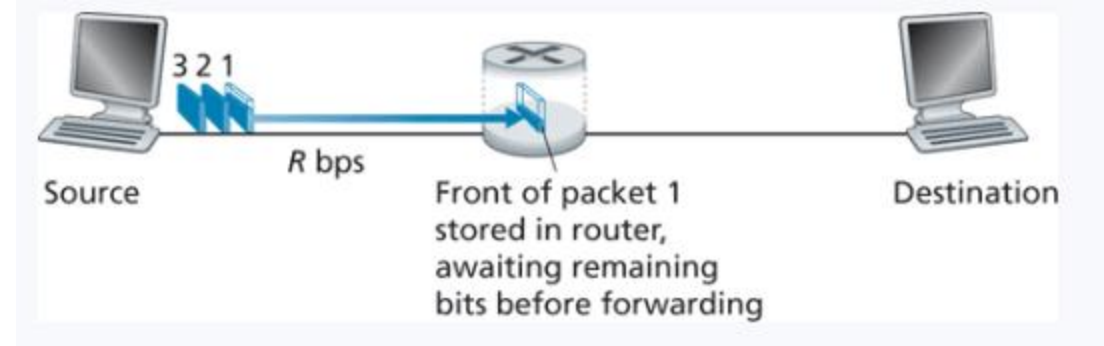Time to transmit L bits over a link with transmission rate of R:

$$L/R$$

Data Forwarding

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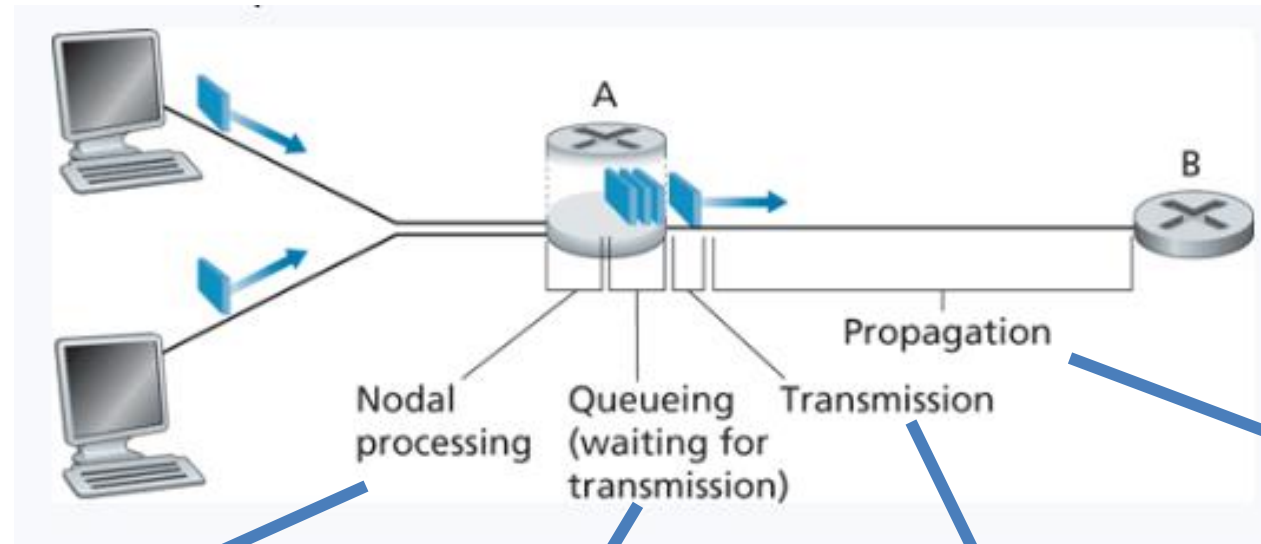Uses **store-and-forward** transmission

Time to transmit L bits over a link with transmission rate of R:

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We have many forms of delay though…

Network Delay

Propagation Delay- time needed to propagate to destination (dependent on the medium)

Transmission delay- Amount of time required to push all the packet's bits into the link

Queueing Delay- Time the packet sits in the queue

Processing delay- time required to examine the packet's header and determine where to direct the packet

Nodal Delay = Processing delay + Queueing delay + Transmission delay + Propagation delay

Network Delay

https://www2.tkn.tu-berlin.de/teaching/rn/animations/propagation/

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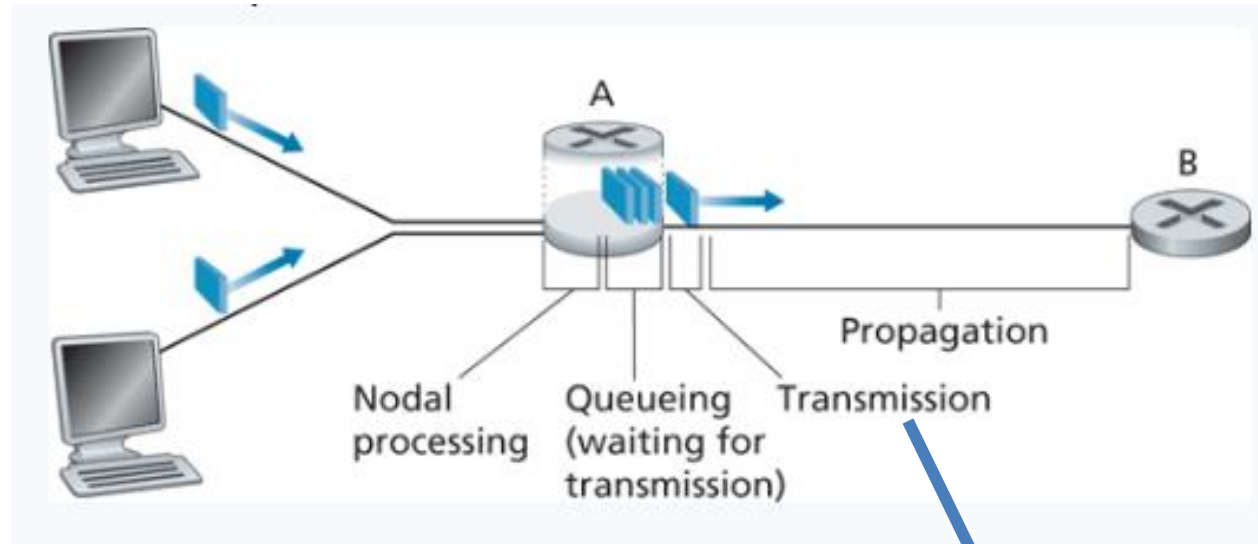
Network Delay

Transmission delay- Amount of time required to push all the packet's bits into the link

Transmission Delay = L / R

L = length of packet (bits)   **R** = transmission rate of link

Network Delay
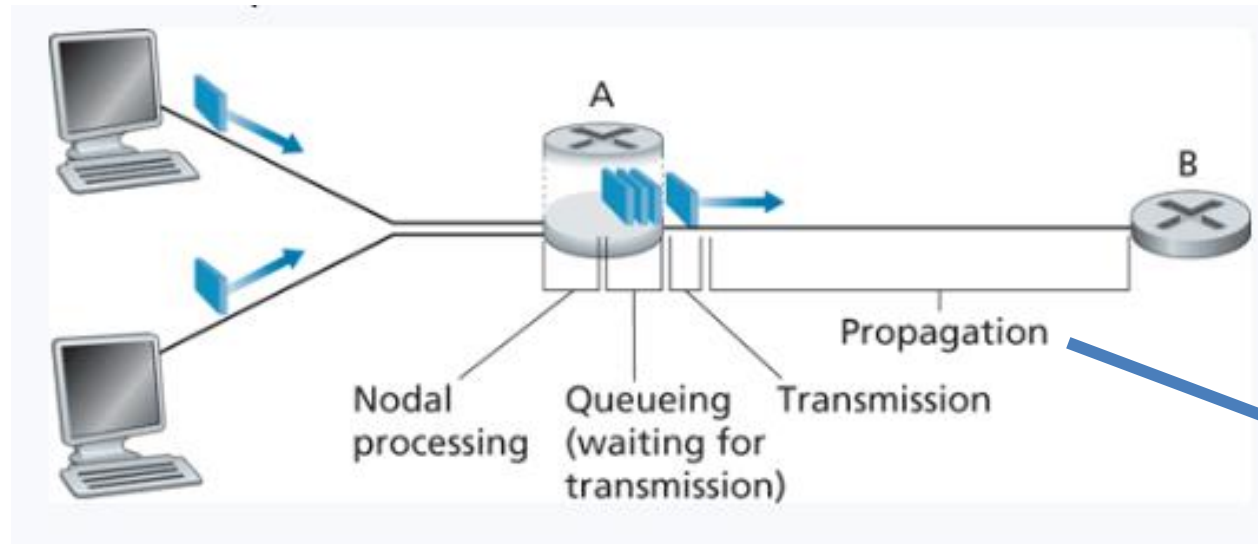
Propagation Delay- time needed to propagate to destination (dependent on the medium)

Nodal processing | Queueing (waiting for transmission) | Transmission | Propagation

Propagation = d / s

d = distance between host and router **s** = propagation speed of medium

Network Delay Example Problem

Link 1

Link 2

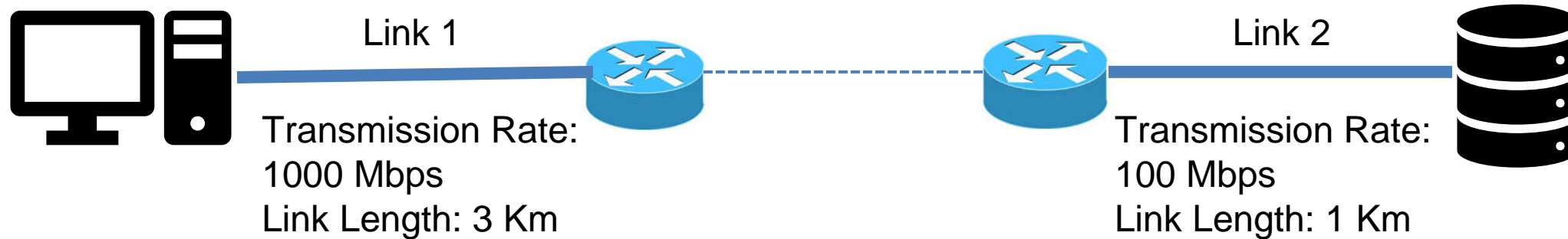Transmission Rate:
1000 Mbps
Link Length: 3 Km

Transmission Rate:
100 Mbps
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Length of Packet = 12000 bits.   Propagation Speed of links = 3 * 10^8 m/s

What is the transmission delay of link 1?

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$D_{transmission} = L / R$

$D_{transmission} = 12000 / (1000 * 100000)$

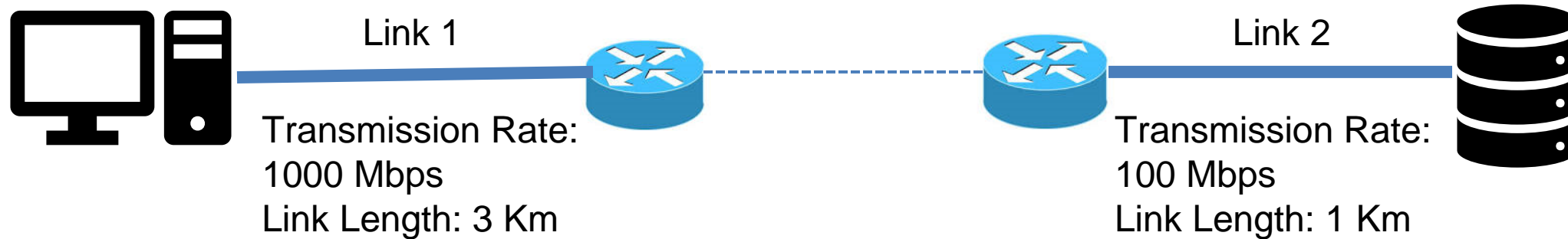*Must convert Mbps to bps!*

Data Transfer Rate

1	=	1000000
Megabit per second		Bit per second

Formula multiply the data transfer rate value by 1e+6

Network Delay Example Problem

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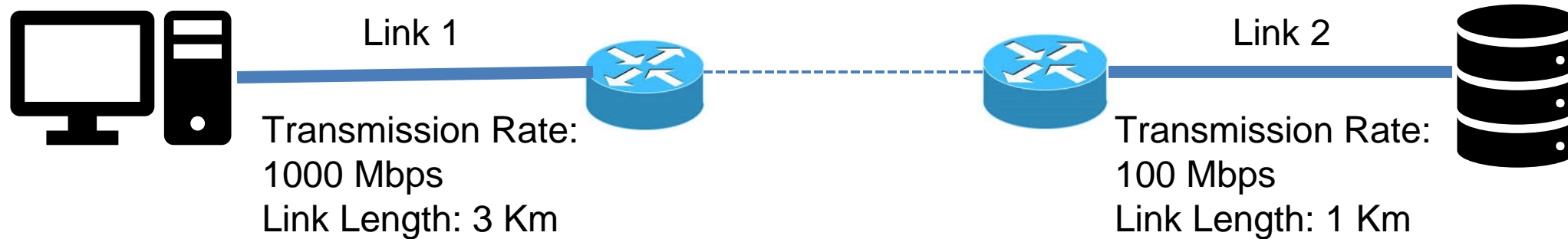What is the transmission delay of link 1?

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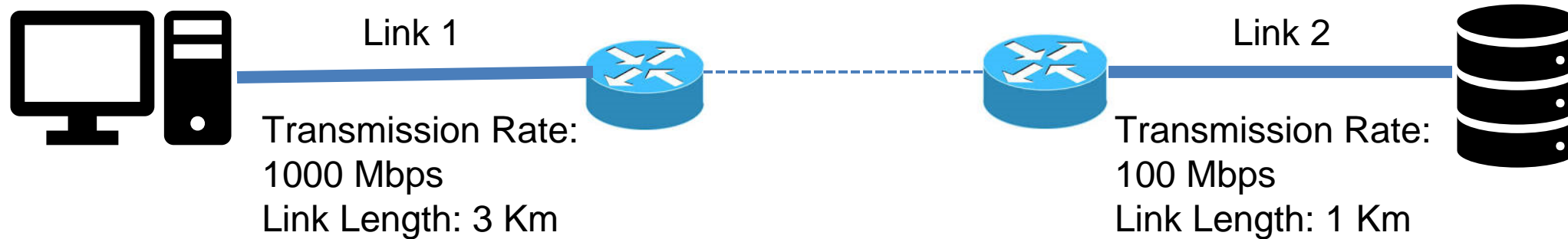$D_{transmission}$ = 12000 / 1000000000

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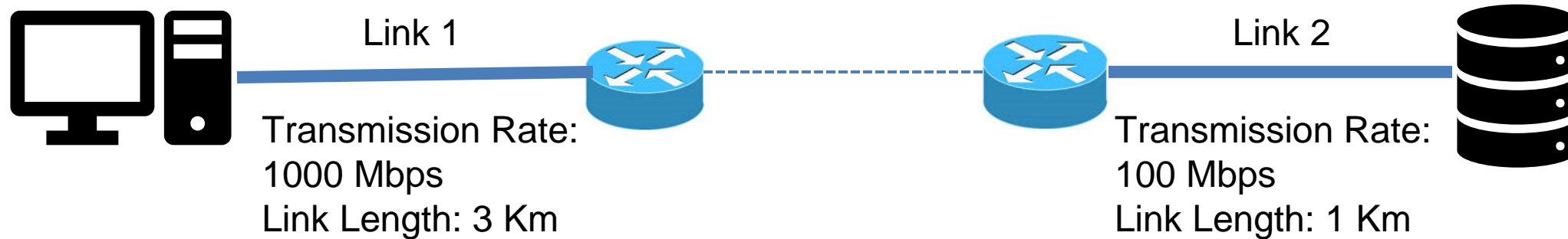
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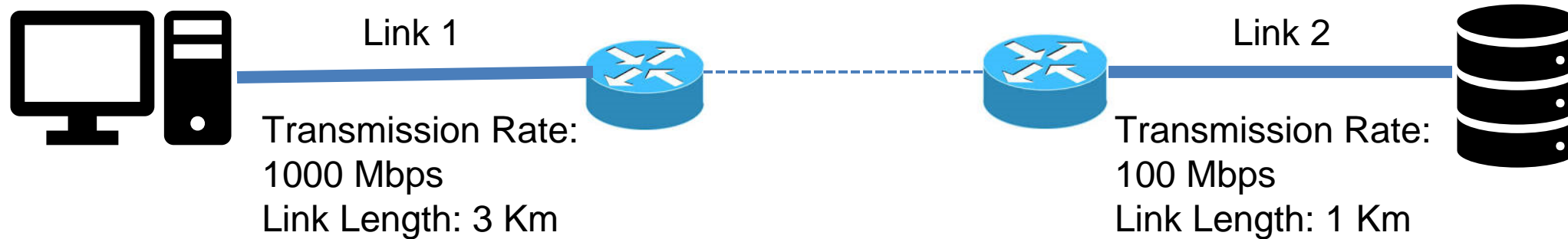# Network Delay Example Problem

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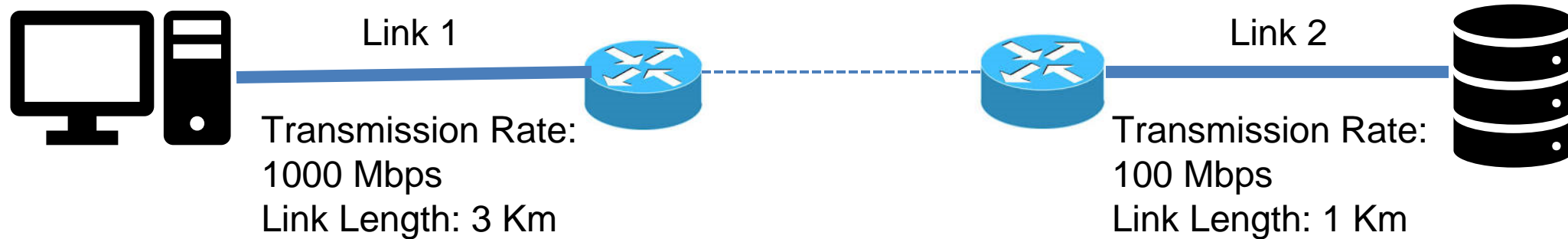
Must convert Km to m!

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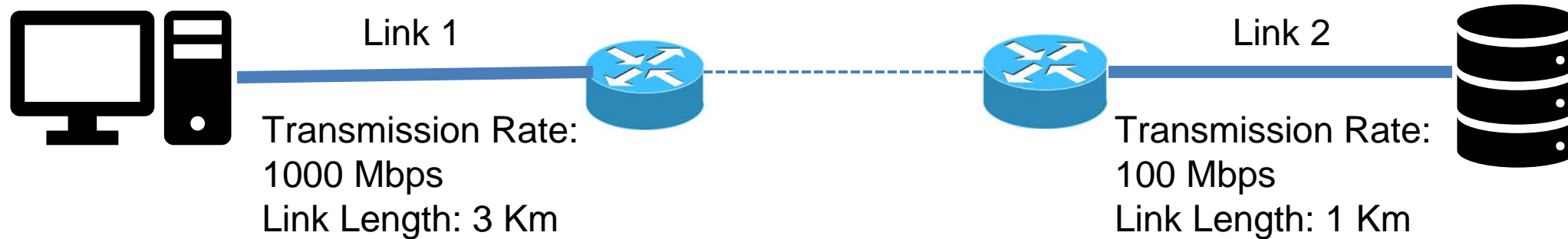$D_{propagation} = d / s$

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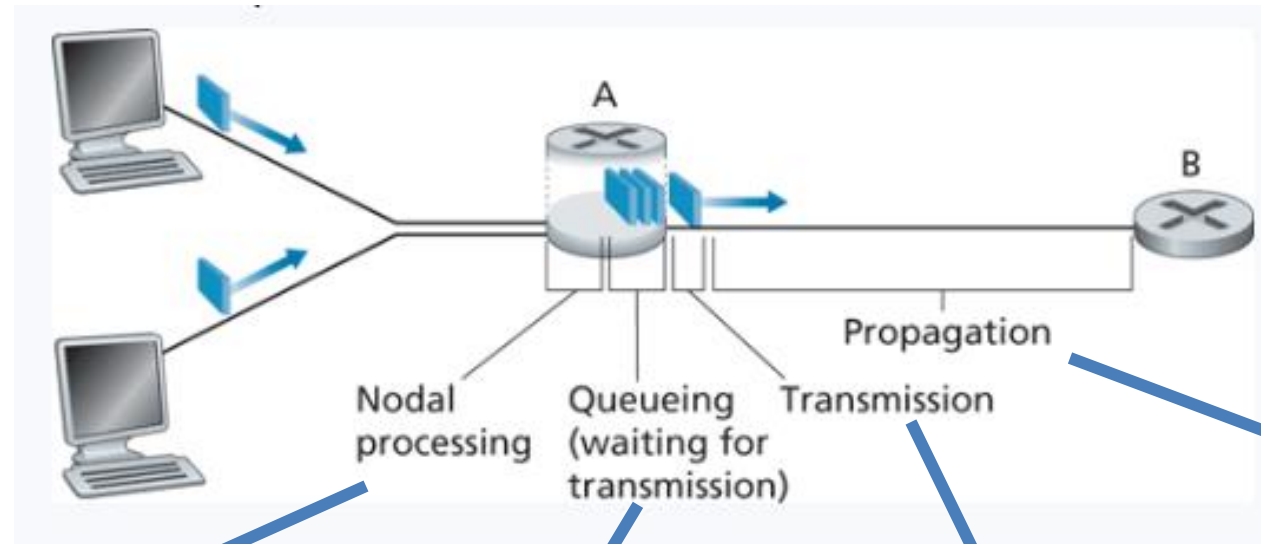
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Network Delay

Propagation Delay- time needed to propagate to destination (dependent on the medium)
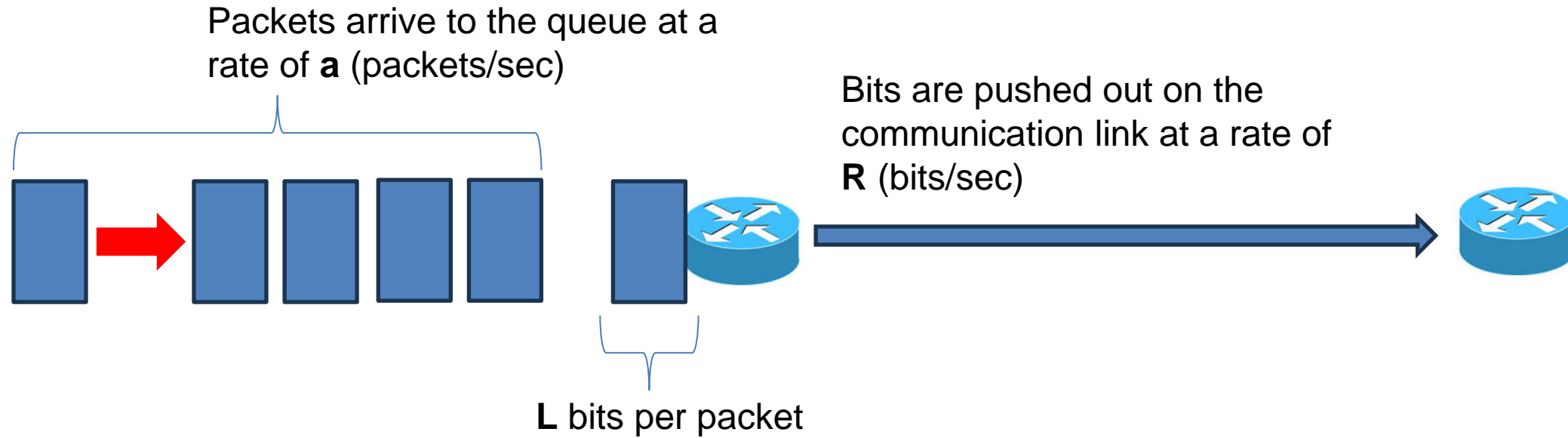
Transmission delay- Amount of time required to push all the packet's bits into the link

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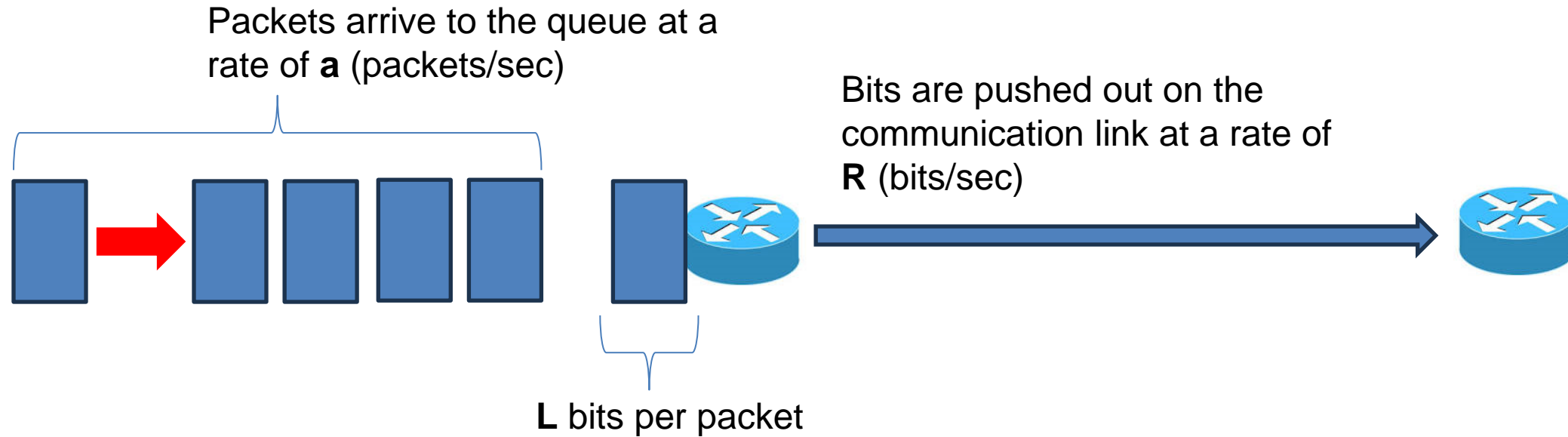**Processing delay-** time required to examine the packet's header and determine where to direct the packet

*In an **uncongested** network with N links between source and destination*

End-to-end Delay= N(Processing delay + Transmission delay + Propagation delay)

Queueing Delay

Packets arrive to the queue at a rate of **a** (packets/sec)

Bits are pushed out on the communication link at a rate of **R** (bits/sec)

L bits per packet

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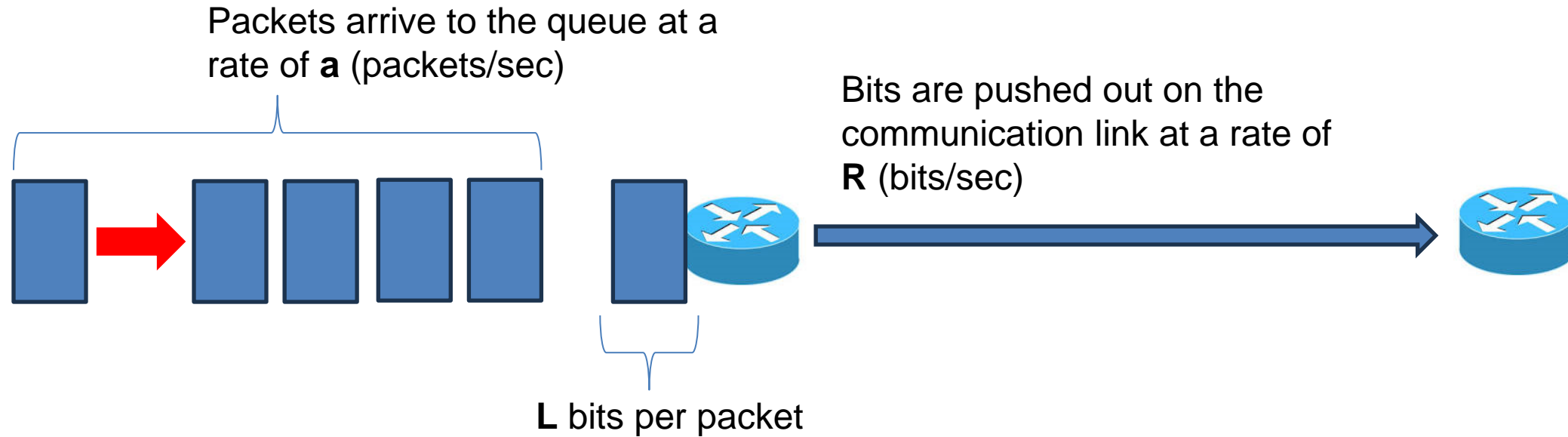**Traffic Intensity** $= \dfrac{L * a}{R}$

Ratio of **average bits that arrive at queue** to **how quick we can process one bit**

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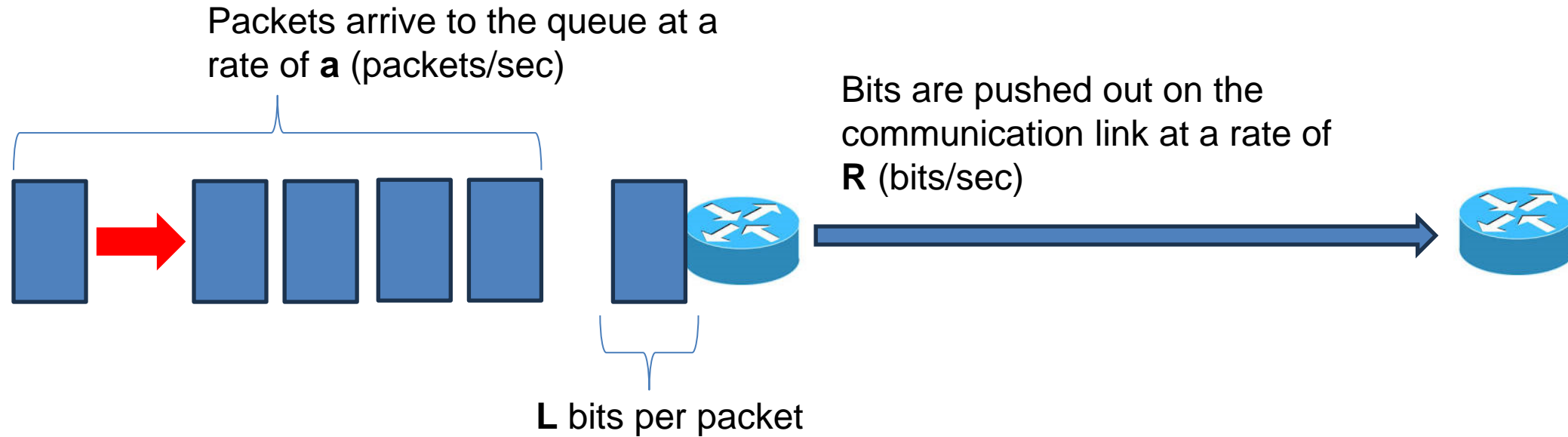
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If traffic intensity > 1 ?

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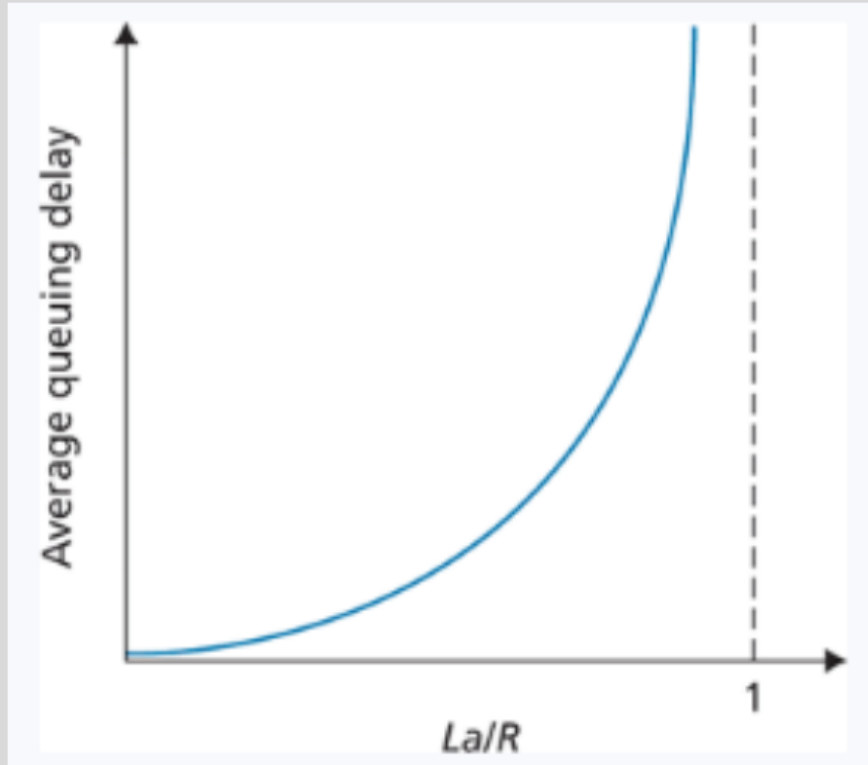
$$\text{Traffic Intensity} = \frac{L * a}{R}$$

Ratio of **average bits that arrive at queue** to **how quick we can process one bit**

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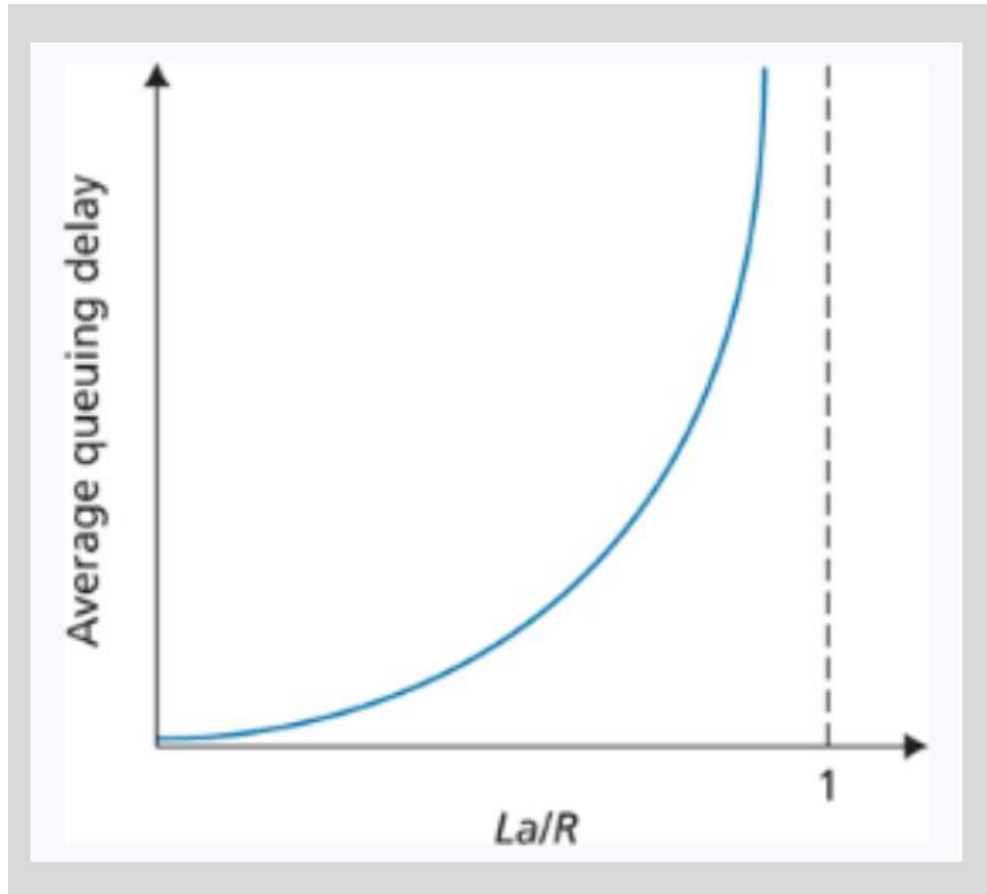Bits arrive to the queue faster than we can process them

Bad!

Queueing Delay

As **traffic intensity** grows, the **average queueing delay** will increase rapidly

The **arrival rate** of packets is typically random, so Queueing Delay is difficult to predict.

Packet Loss
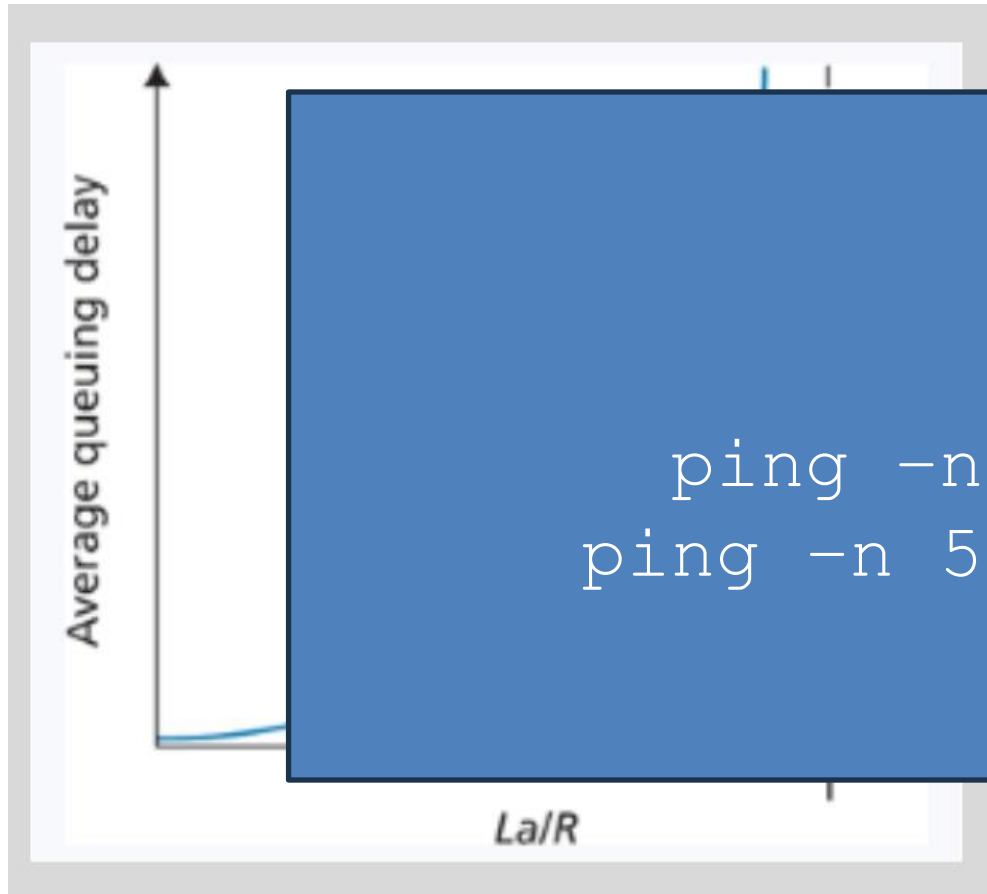

Queues have finite space.

If a router has no place to store the packet, the packet will be **dropped** or **lost**

The number of lost packets will increase as **traffic intensity** increases

In addition to delay, the **probability of packet loss** is helpful to calculate
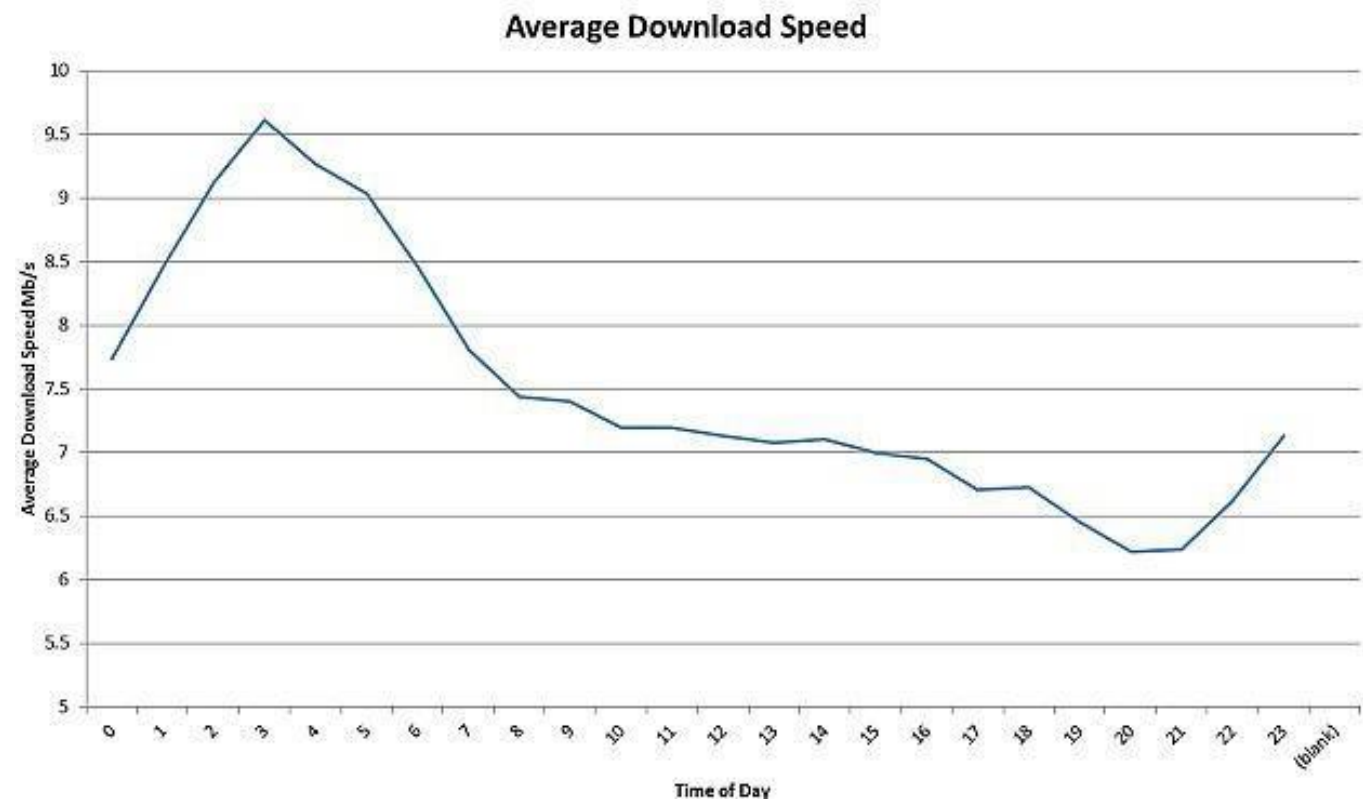
Packet Loss

Average queuing delay

La/R

Queues have finite space.

store the

dropped or **lost**

s will increase
ses

robability of
calculate

Ping Test

```
ping -n 10 8.8.8.8
ping -n 5 131.255.7.26
```

Throughput

Average Download Speed
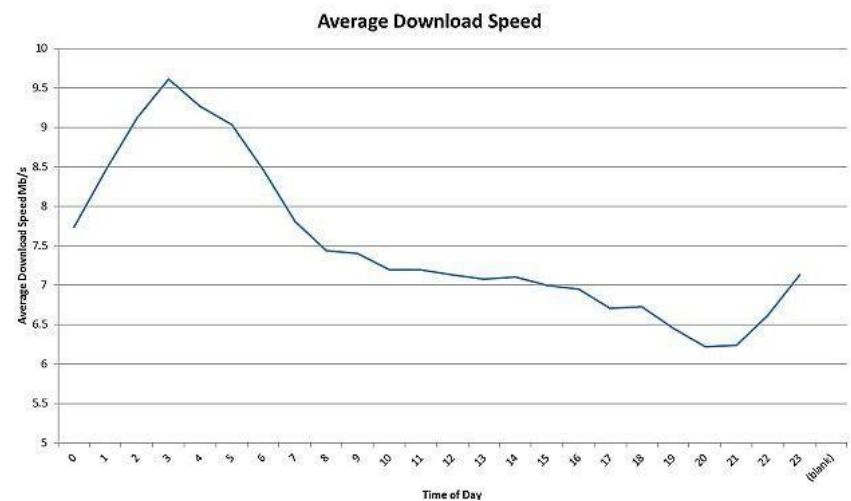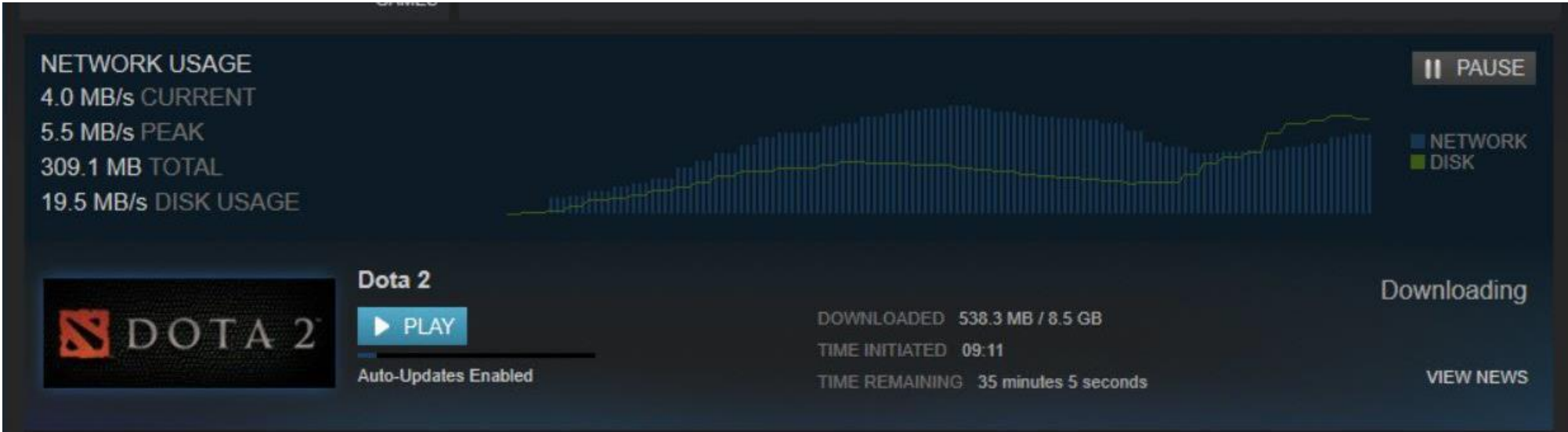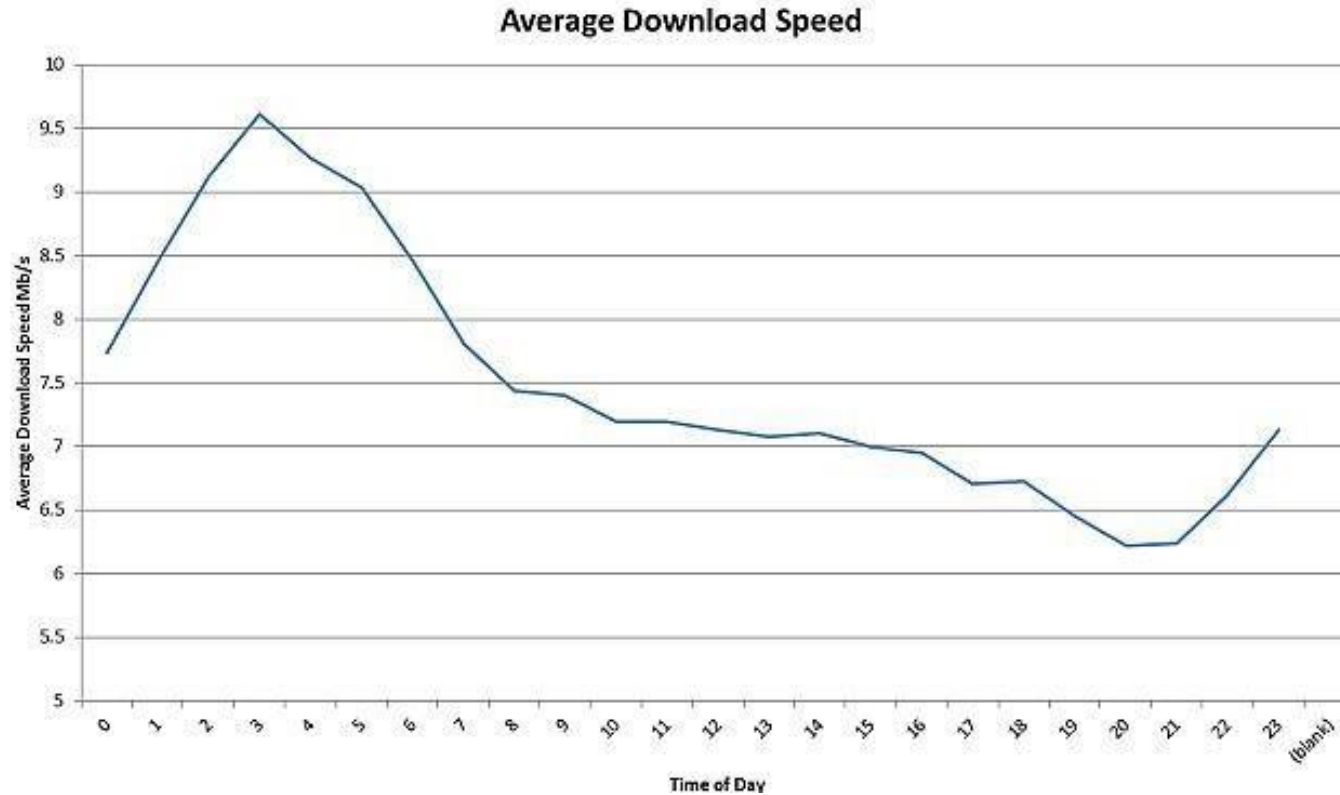

Throughput is the amount of data transferred from one place to another within a given time period

Throughput

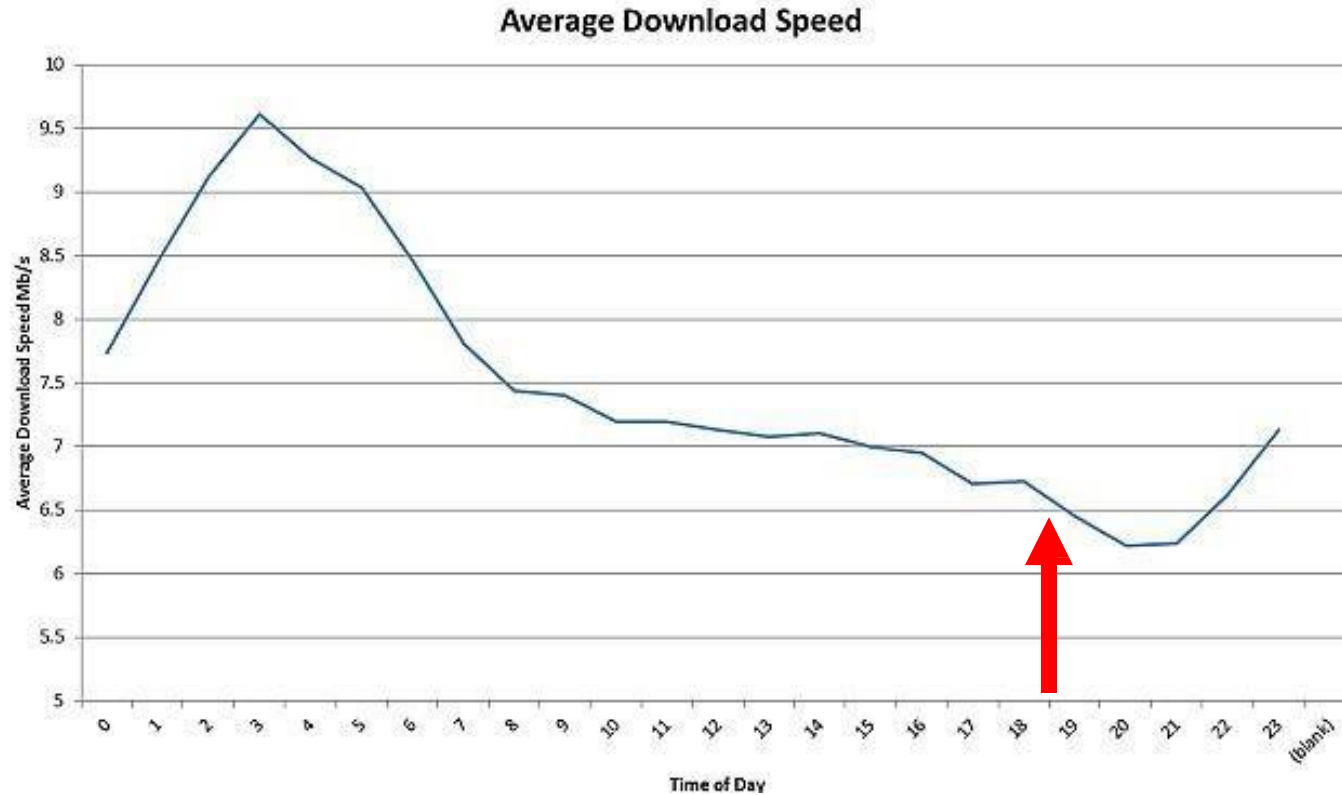**Throughput** is the amount of data transferred from one place to another within a given time period
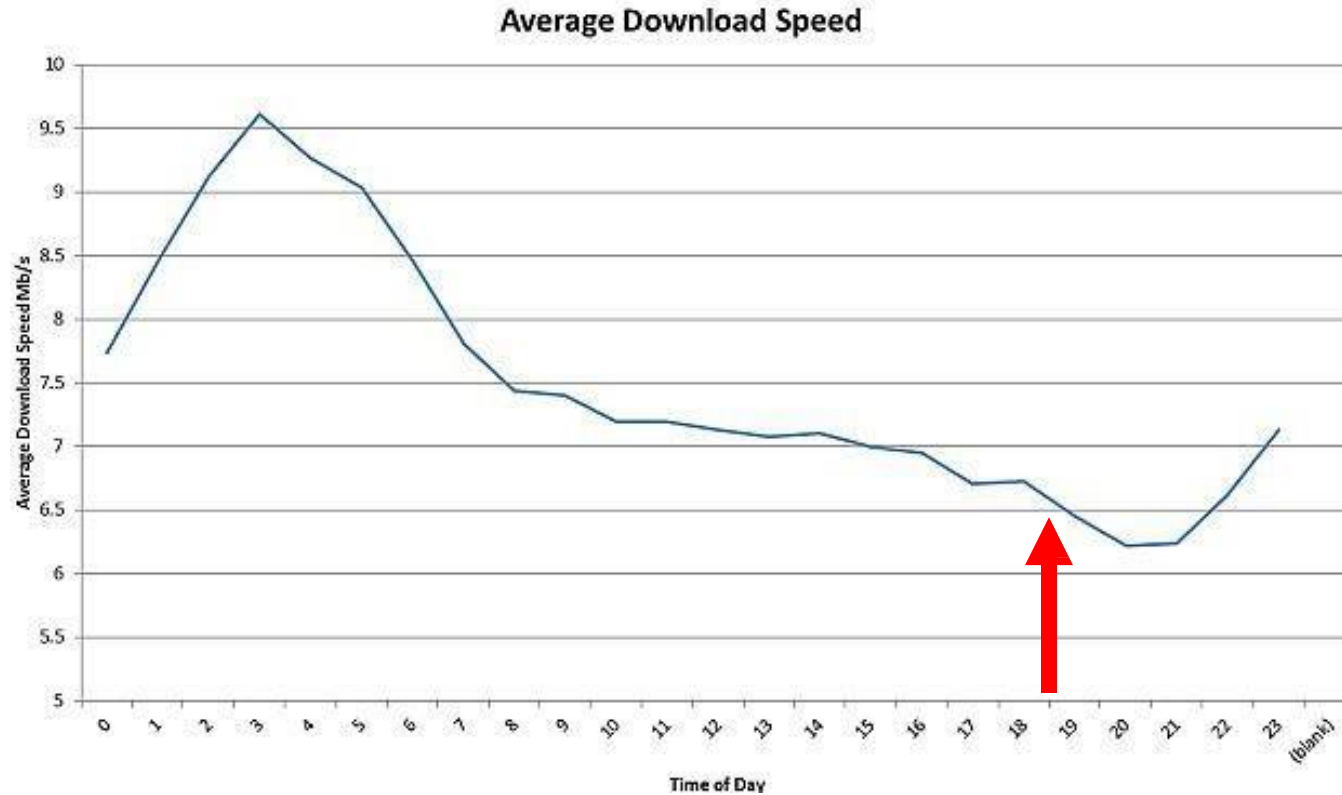
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The instantaneous throughput at 7:00 PM is roughly 6.5 Mbps

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In general, if F bits takes T seconds to transfer from one endpoint to another, the **average throughput** is:
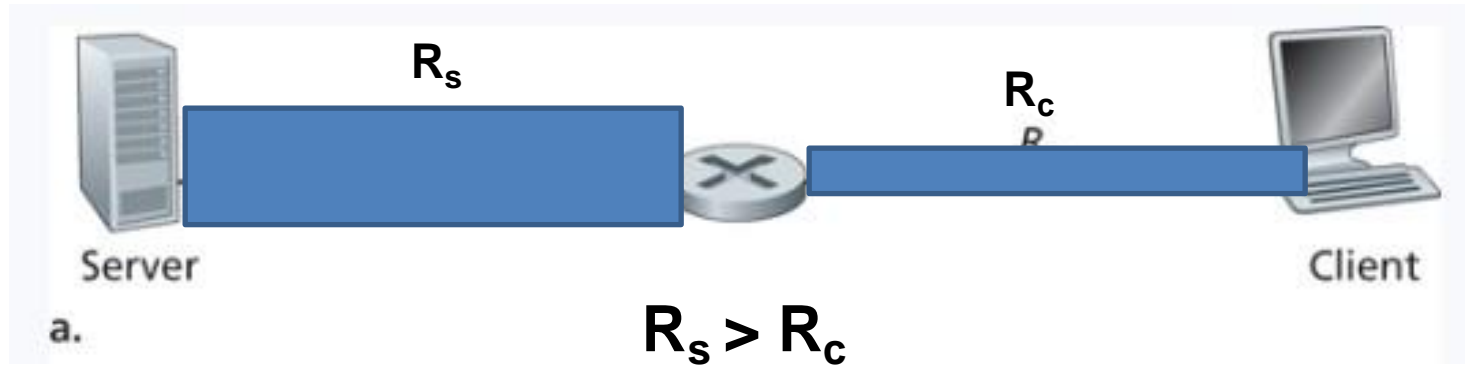
$$\frac{F}{T}$$
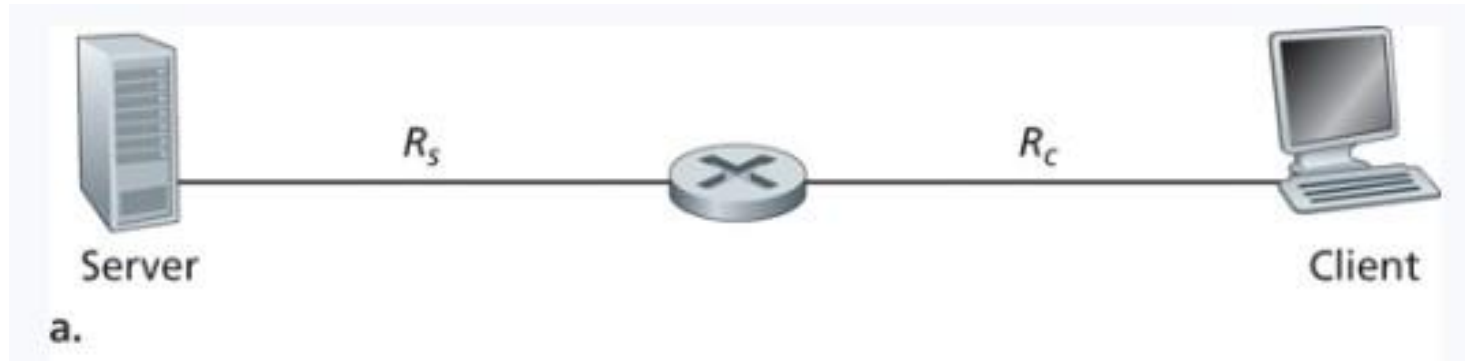
Throughput

R_s = transmission rate for server to router R_c = transmission rate for client to router
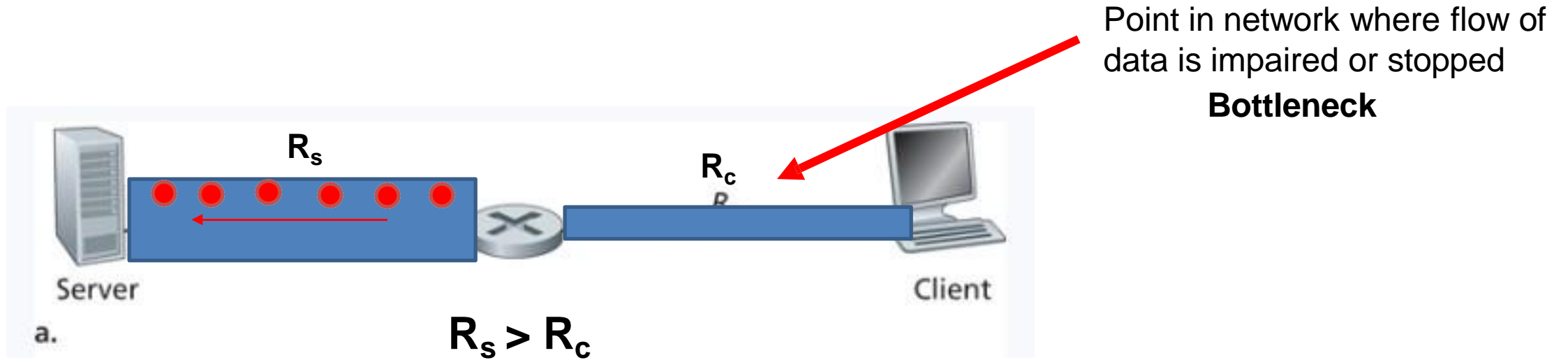
Throughput for server to client?
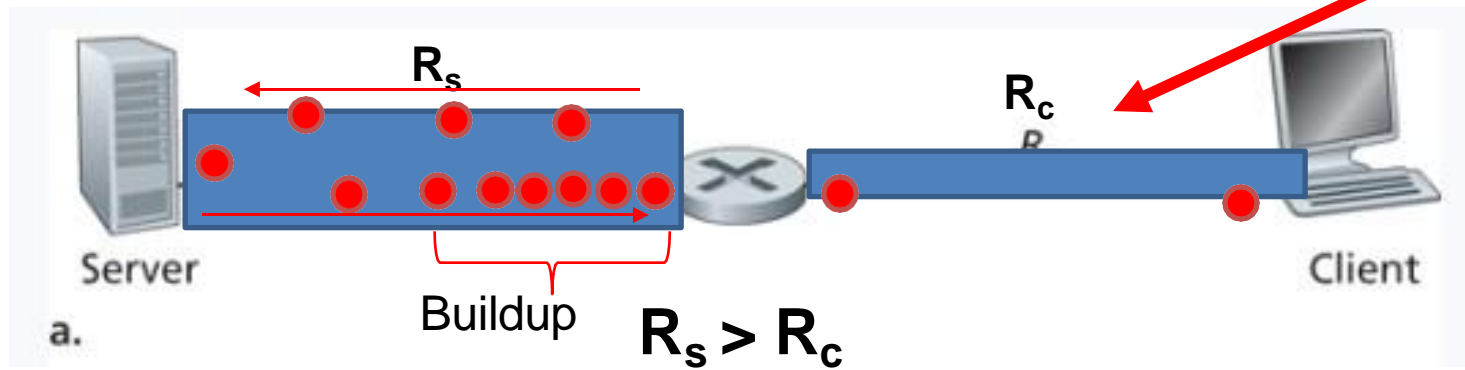
Throughput

a.

$$R_s > R_c$$

R_s = transmission rate for server to router R_c = transmission rate for client to router

Throughput for server to client?

Throughput

Point in network where flow of data is impaired or stopped
Bottleneck

$R_s > R_c$

R_s = transmission rate for server to router R_c = transmission rate for client to router

Throughput for server to client?

Throughput

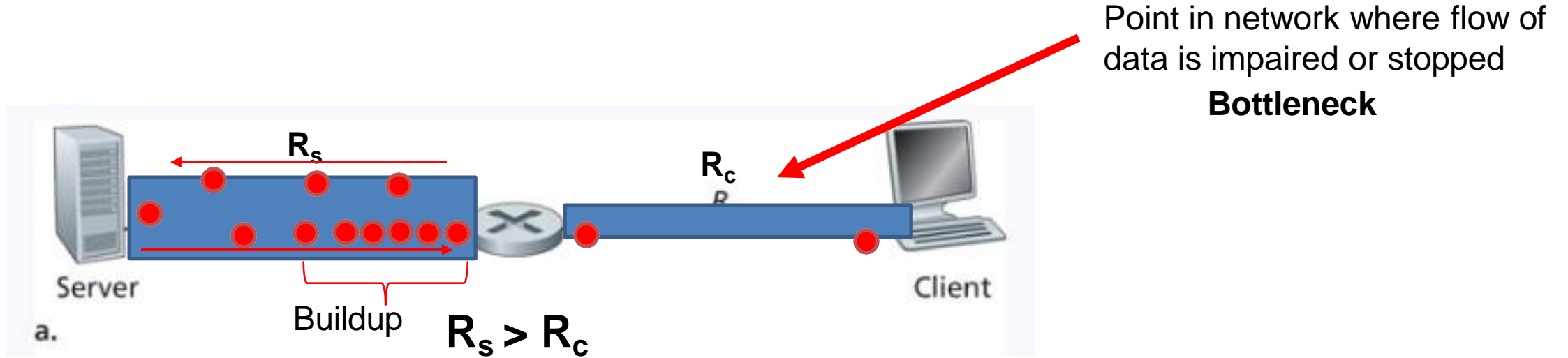Point in network where flow of data is impaired or stopped
Bottleneck

$R_s > R_c$

Buildup

R_s = transmission rate for server to router R_c = transmission rate for client to router

Throughput for server to client?

Throughput

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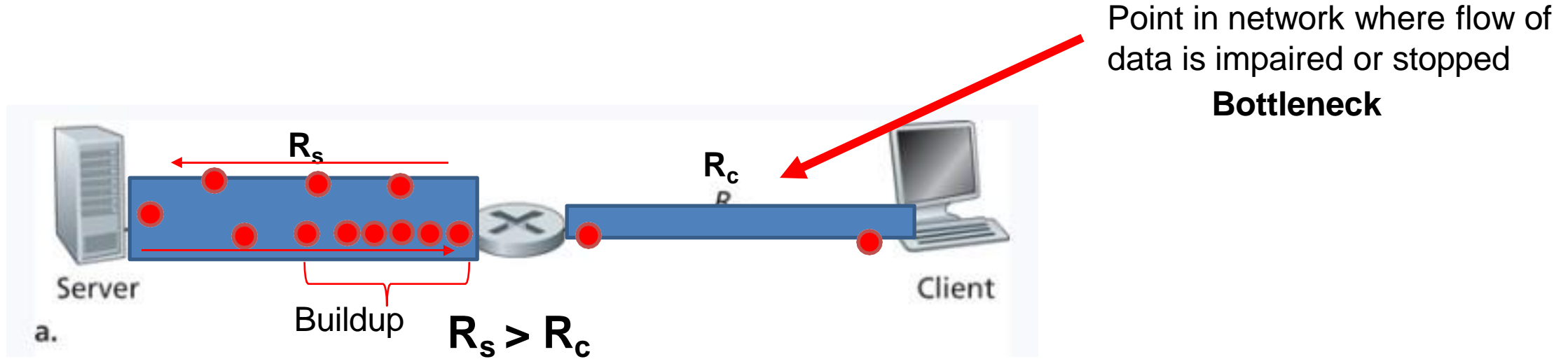**Bottleneck**

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Throughput for server to client?

Dependent on the bottleneck link!

Throughput

Point in network where flow of data is impaired or stopped

Bottleneck

R_s

R_c

Server

Client

a.

Buildup

$R_s > R_c$

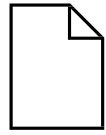R_s = transmission rate for server to router R_c = transmission rate for client to router
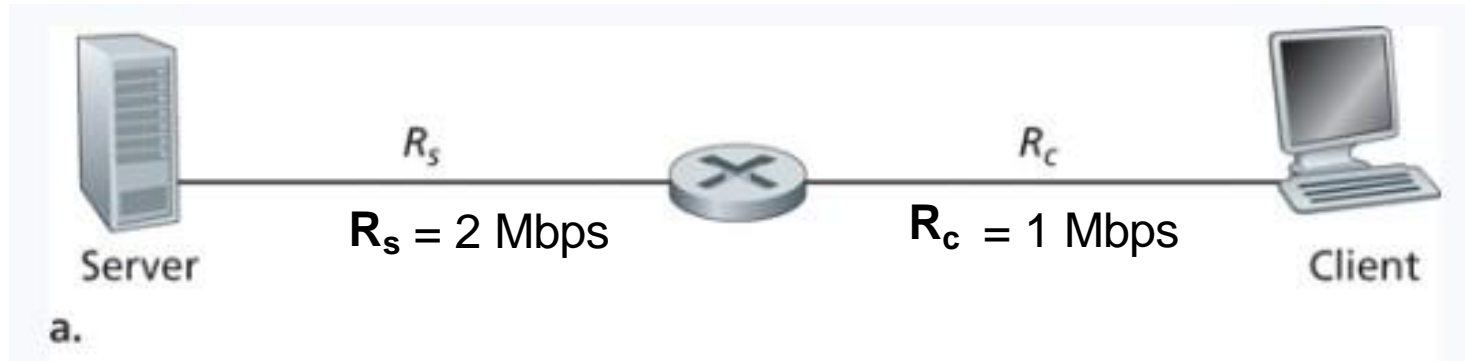
Throughput for server to client?

$$\frac{F}{\min\{R_s, R_c\}}$$

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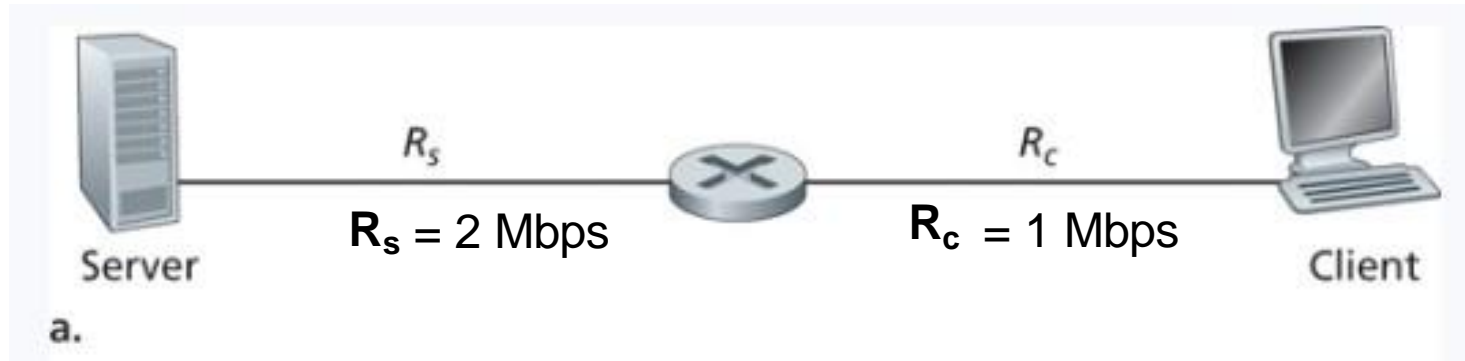
Throughput

F = 32,000,000 bits

R_s = transmission rate for server to router R_c = transmission rate for client to router

Time needed to transfer file?

Throughput

F = 32,000,000 bits = 32 Mb

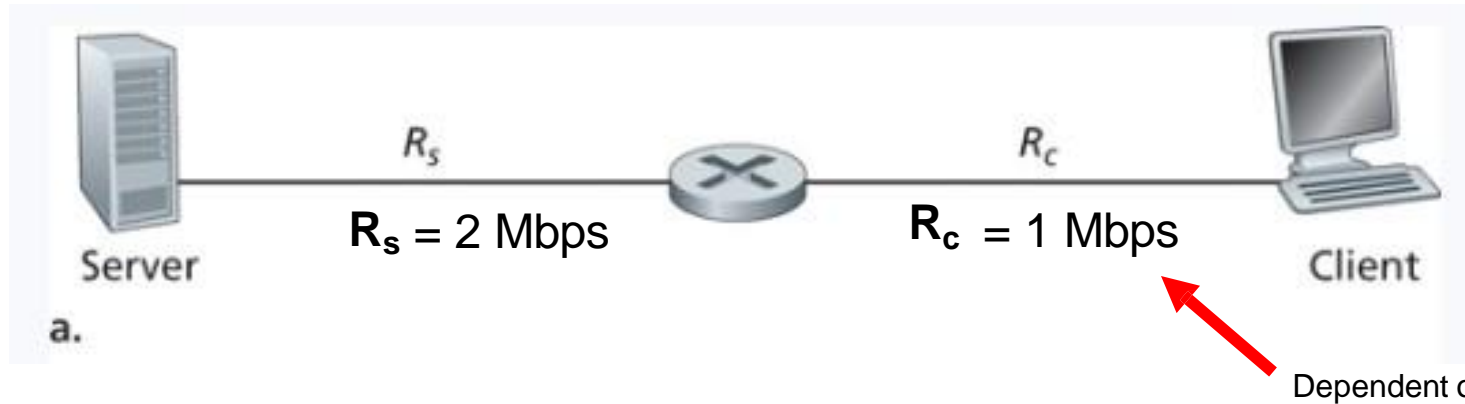R_s = 2 Mbps R_c = 1 Mbps

Server   a.   Client

R_s = transmission rate for server to router R_c = transmission rate for client to router

Time needed to transfer file?

Throughput

F = 32,000,000 bits = 32 Mb

R_s

R_s = 2 Mbps

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R_c = 1 Mbps
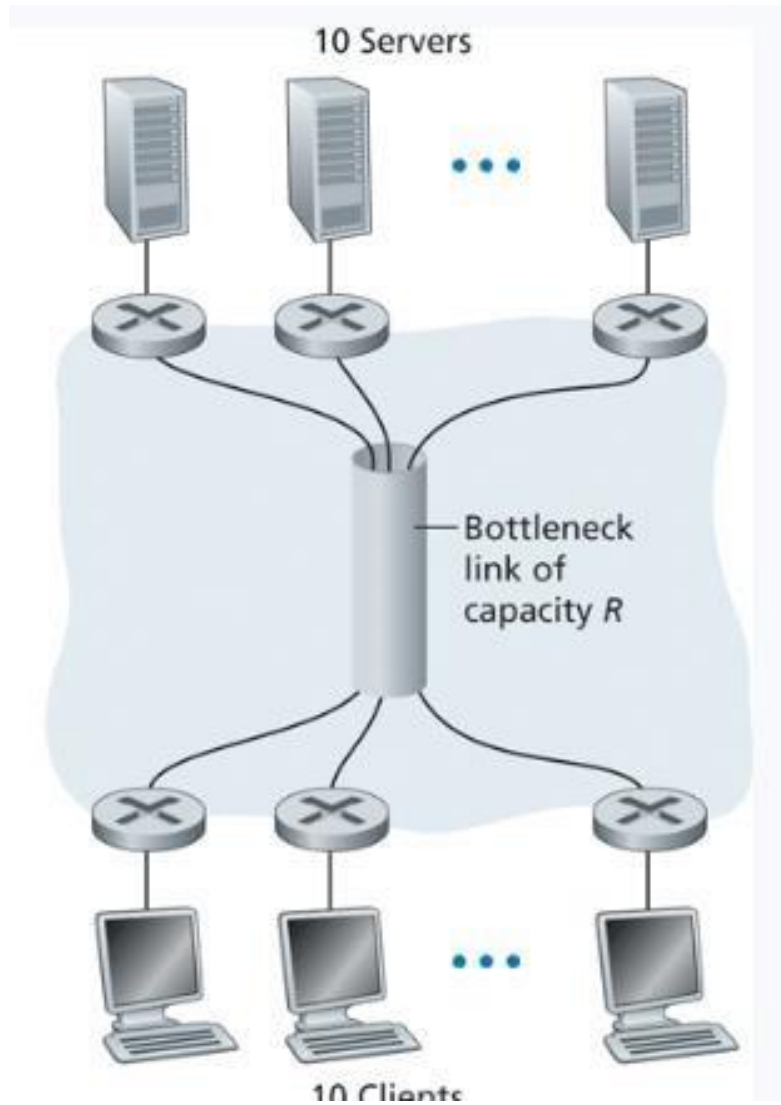
Server

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Dependent on the bottleneck

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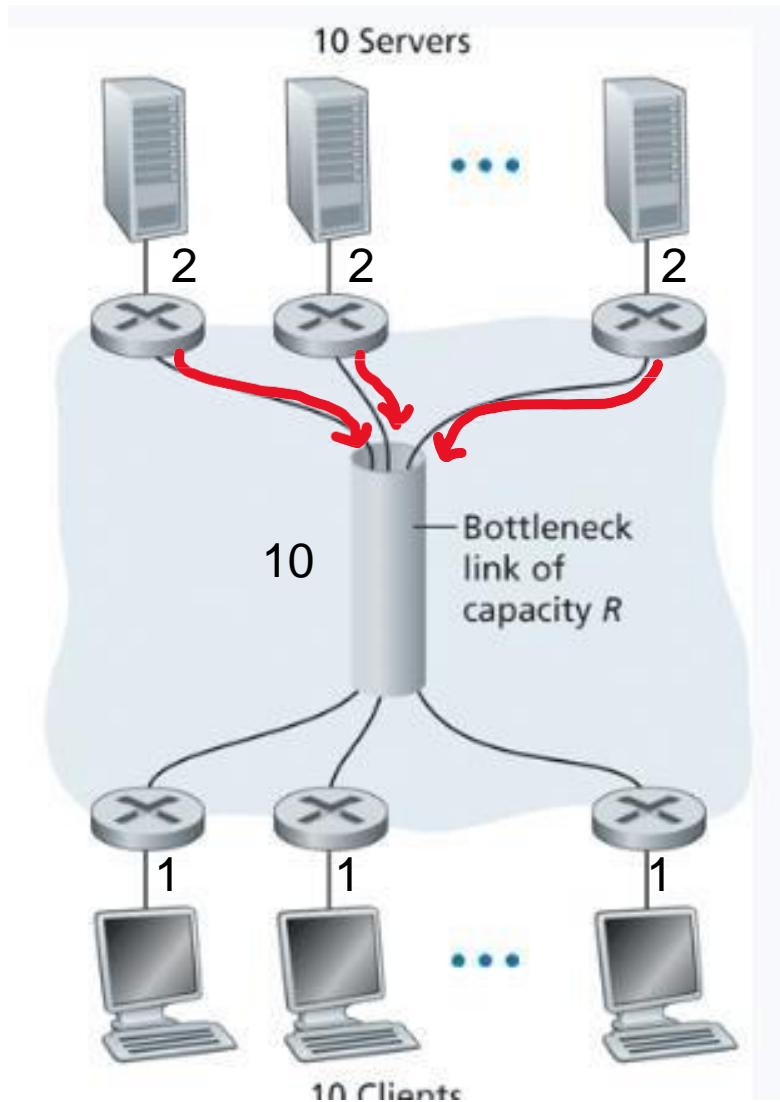
Throughput

10 Servers

Bottleneck link of capacity R
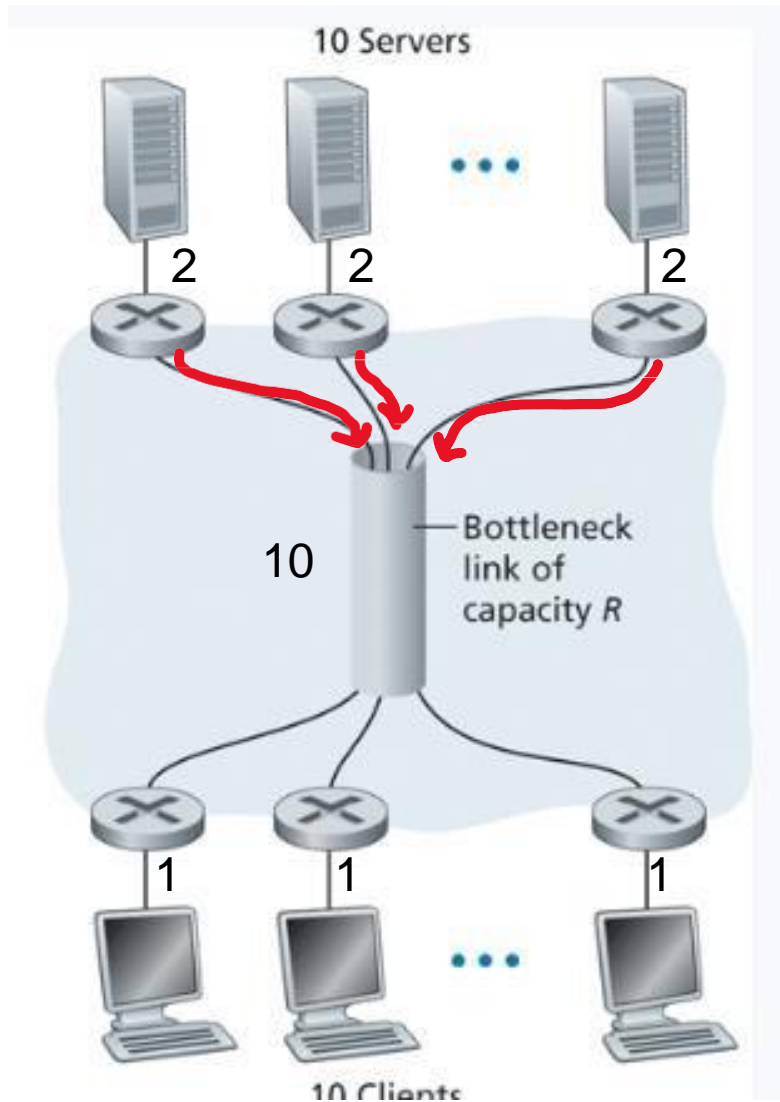
10 Clients

Throughput

Link is shared across 10 servers

So each link supports 0.5 Mbps

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Sometimes, the bottleneck won't be the link with the slowest transmission rate