CSCI 466: Networks

Lecture 4: Network Performance

Reese Pearsall

Fall 2023

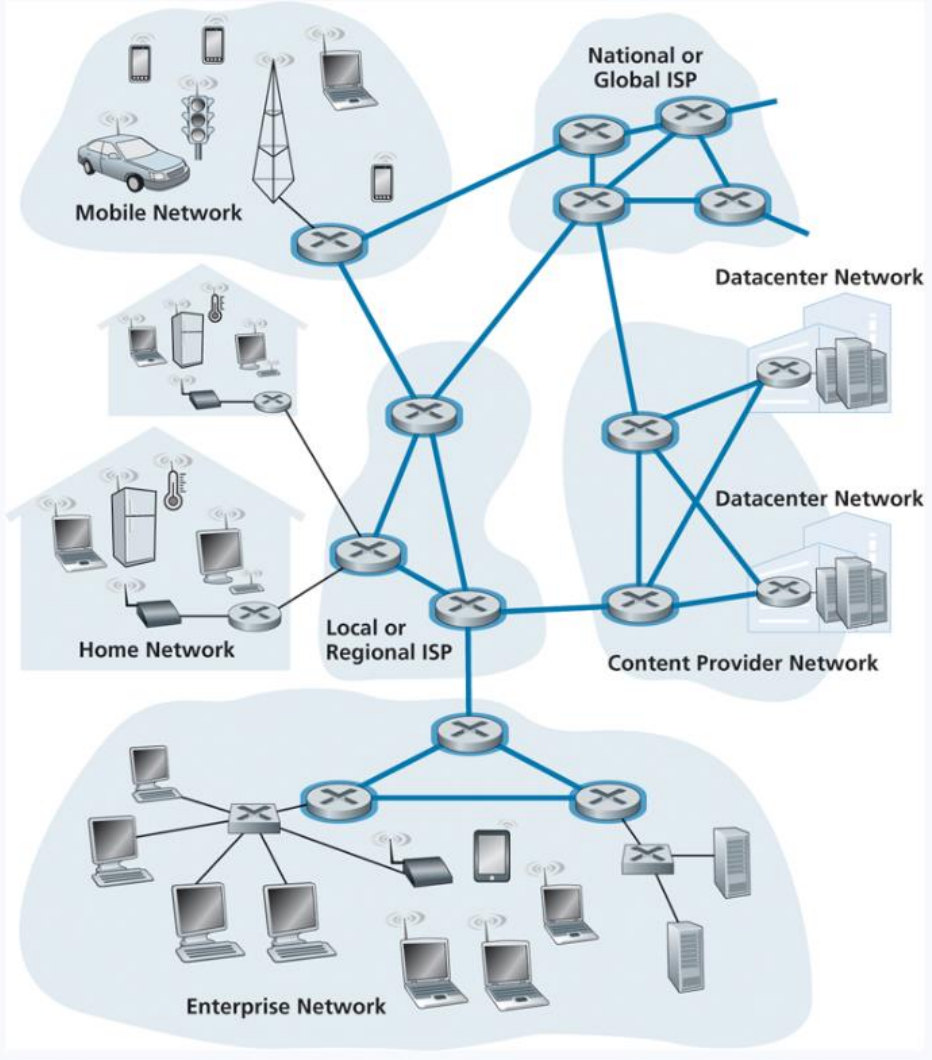
Announcements

Quiz on Friday (no lecture)

- Network Edge
- Network Core
- Access Networks
- OSI Model
- Data Forwarding
- Network Performance

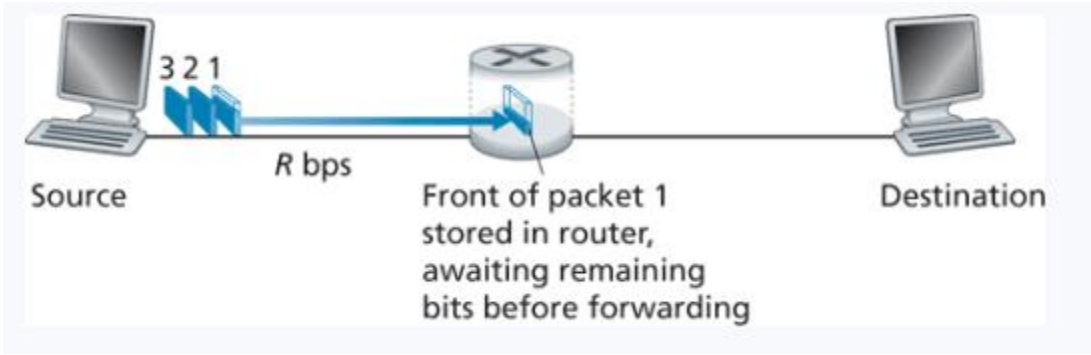
No class on Monday (Holiday)

Data Forwarding



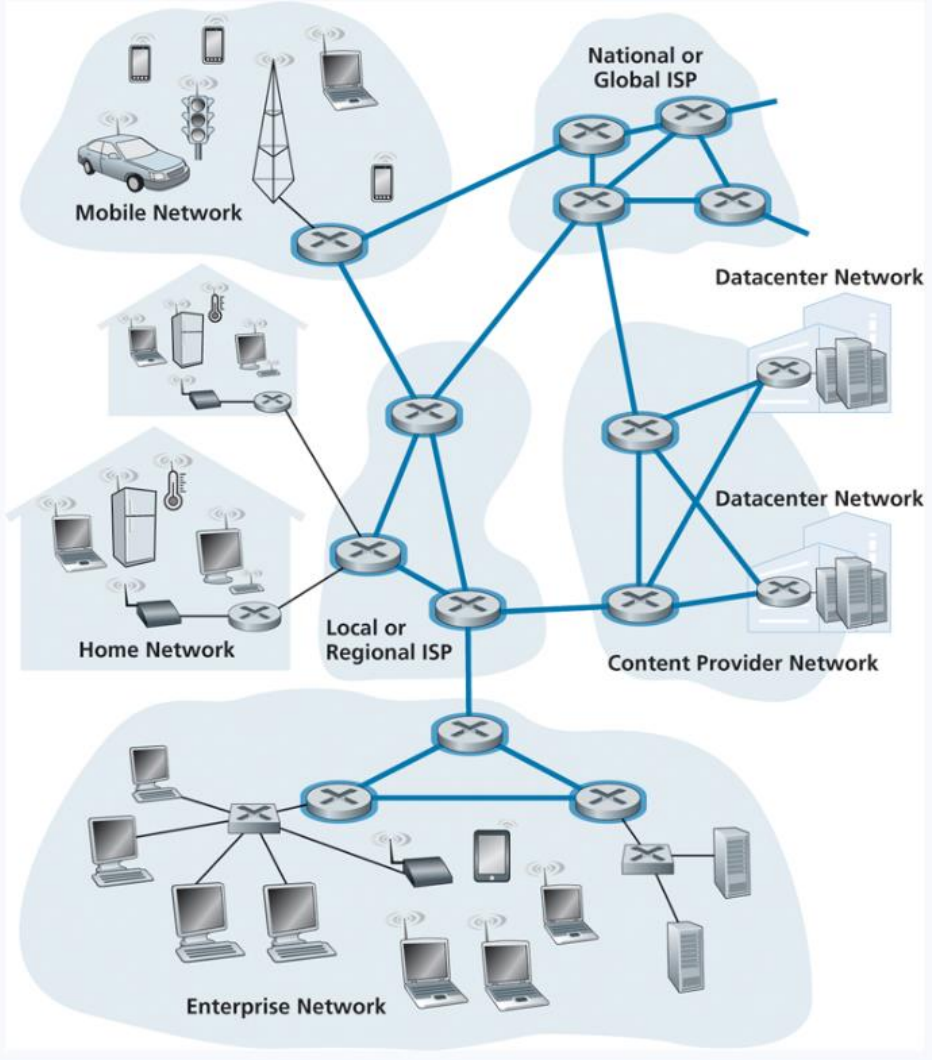
Packet Switching

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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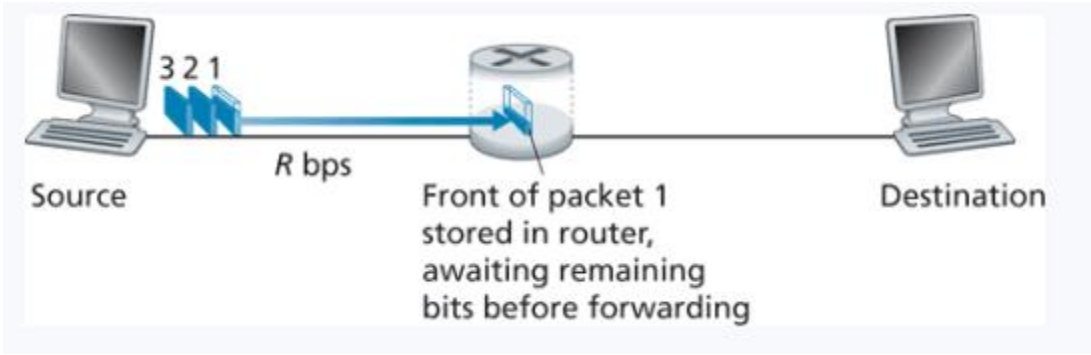
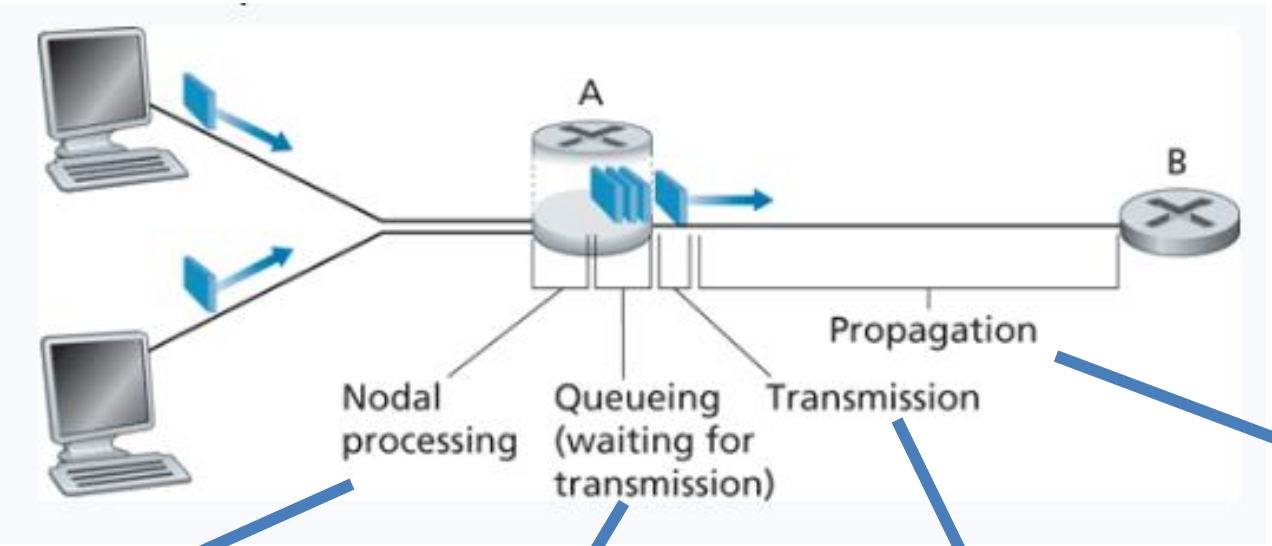


Time to transmit *L* bits over a link with transmission rate of *R*: L/R

We have many forms of delay though…

Network Delay



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

Queueing Delay- Time the packet sits in the queue

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

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

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

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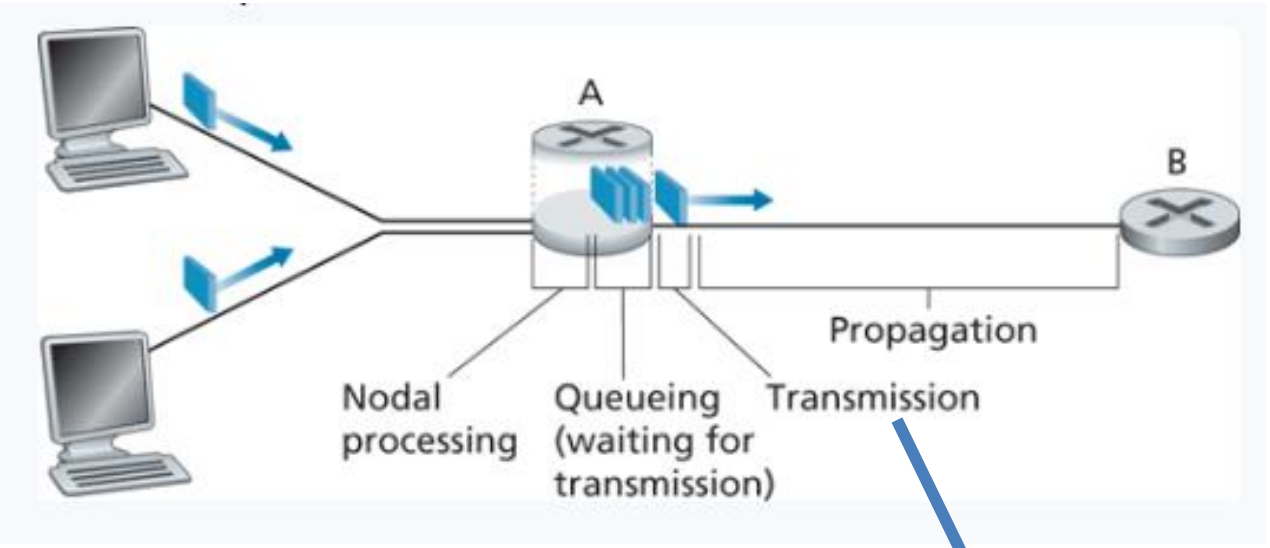
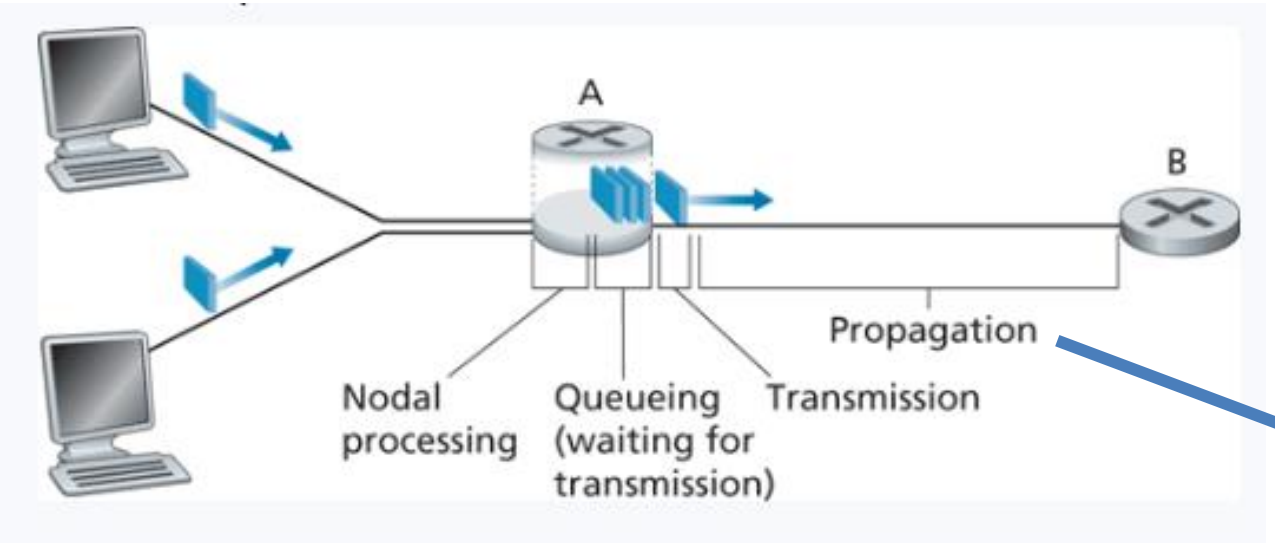


Transmission delay- Amount of time required to push all the packet's bits into the link

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)

Propagation = d / s

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

Network Delay Example Problem

Transmission Delay = L / R

Propogation Delay = d / s

Transmission Rate:
1000 Mbps
Link Length: 3 Km

Transmission Rate:
100 Mbps
Link Length: 1 Km

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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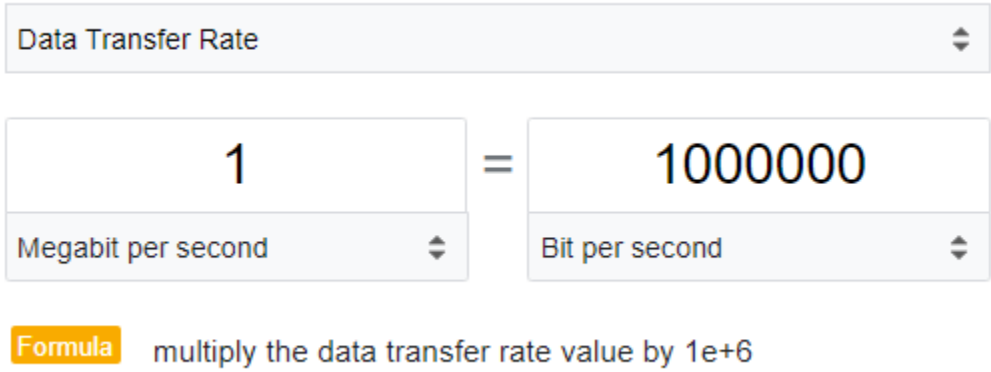
$D_{transmission} = L / R$

$D_{transmission} = 12000 / (1000 * 100)$

Must convert Mbps to bps!



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What is the Propagation delay of link 1?

$D_{propagation} = d / s$

$D_{propagation} = (3 * 1000) / 3 * 10^8$

Must convert Km to m!

Network Delay Example Problem

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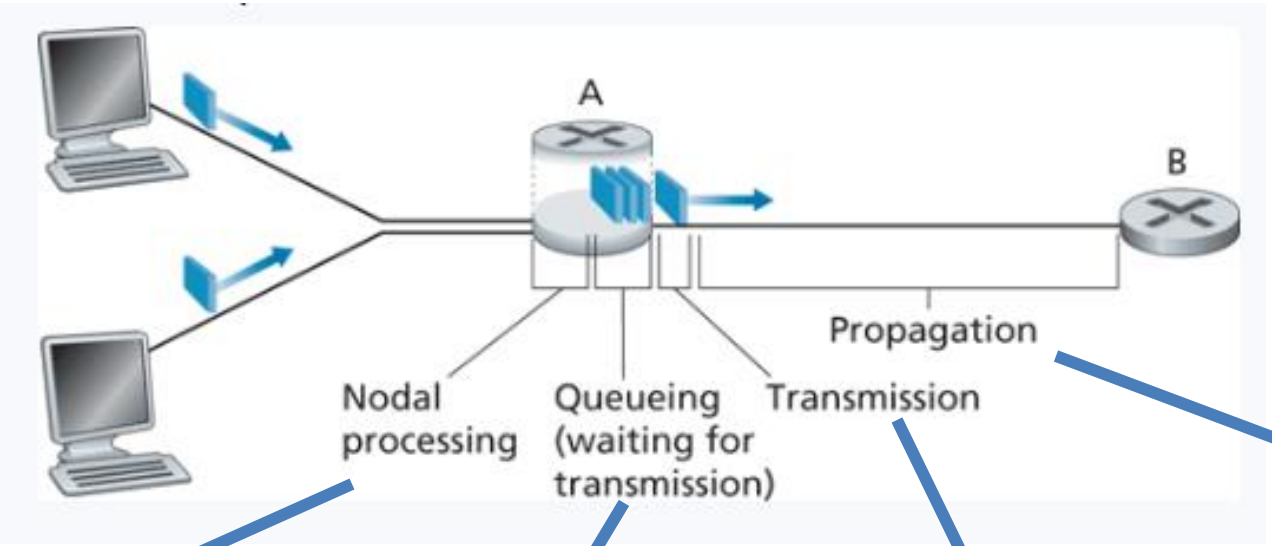
Network Delay



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

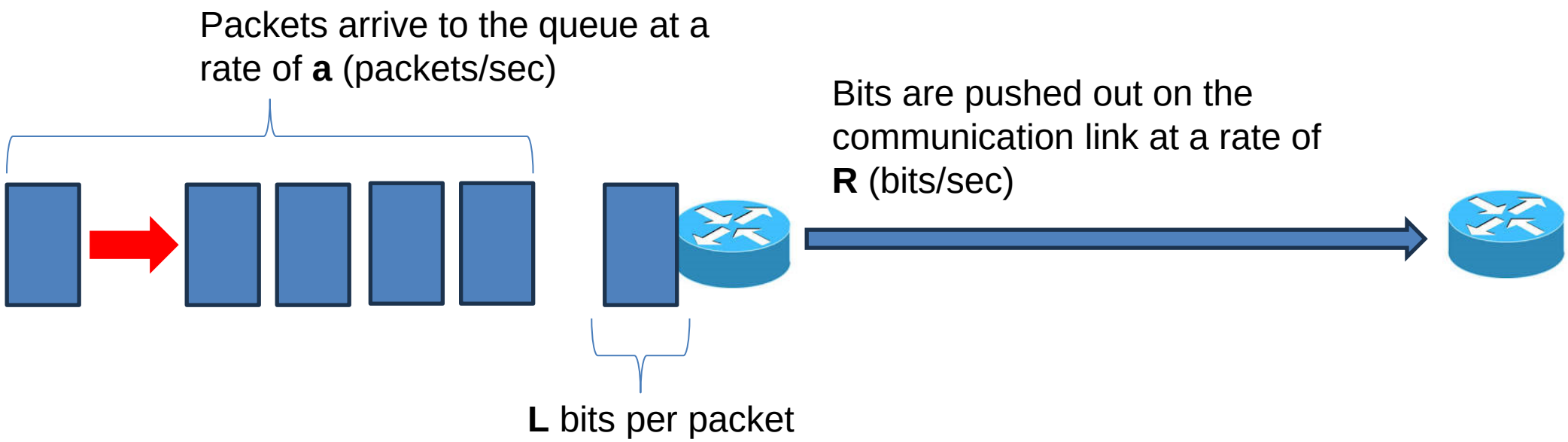
Queueing Delay- Time the packet sits in the queue

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

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

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

Queueing Delay



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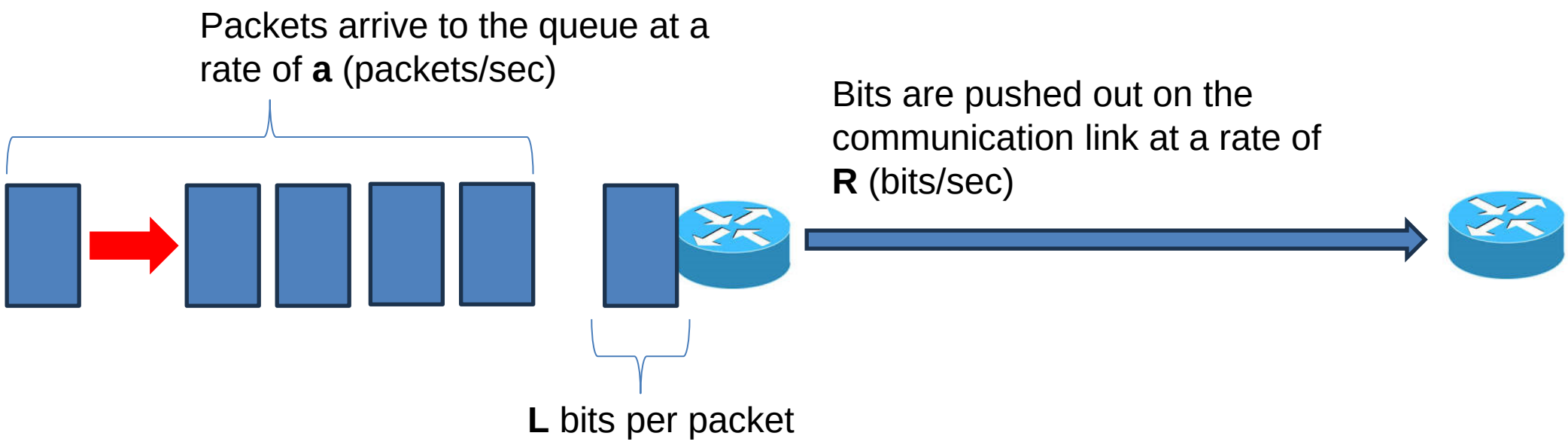
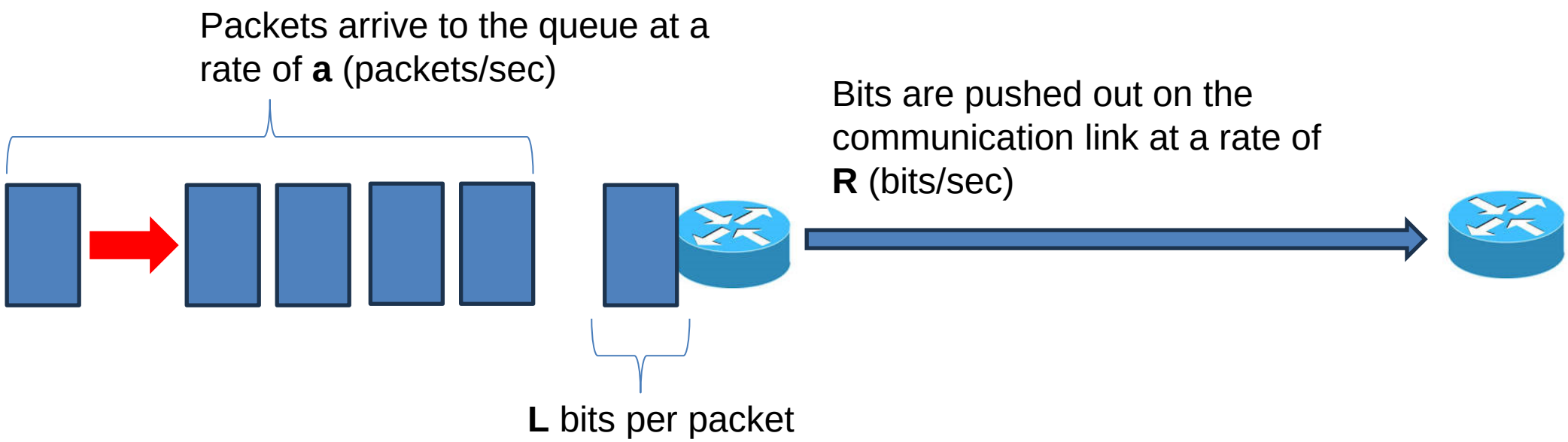


$$\textbf{Traffic Intensity} = \frac{L * a}{R}$$

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

Queueing Delay



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If traffic intensity > 1 ?

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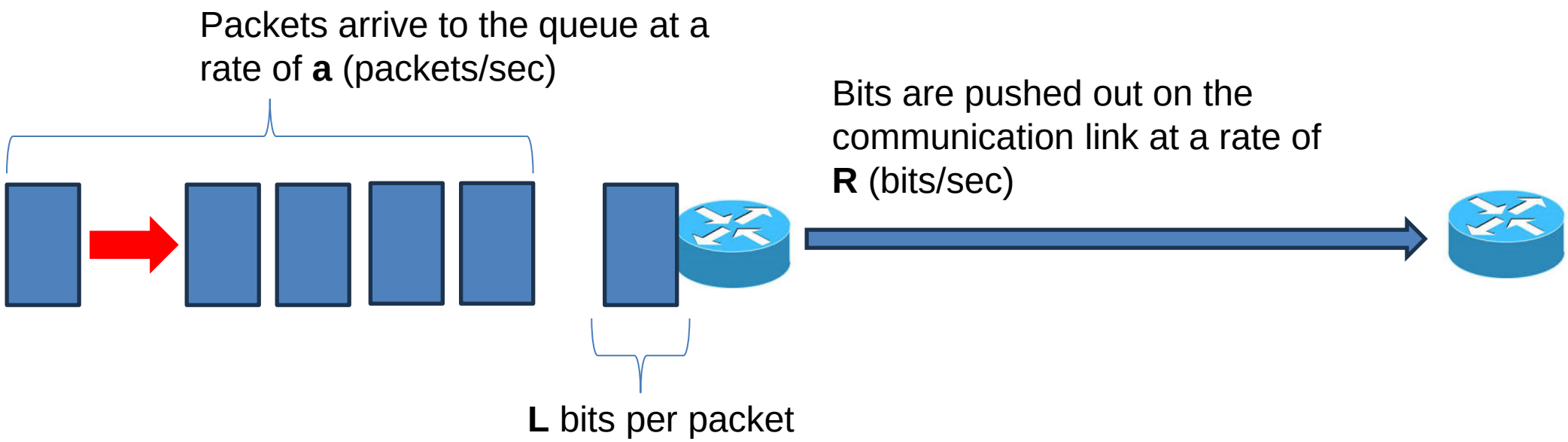


Traffic Intensity $= \frac{L * a}{R}$

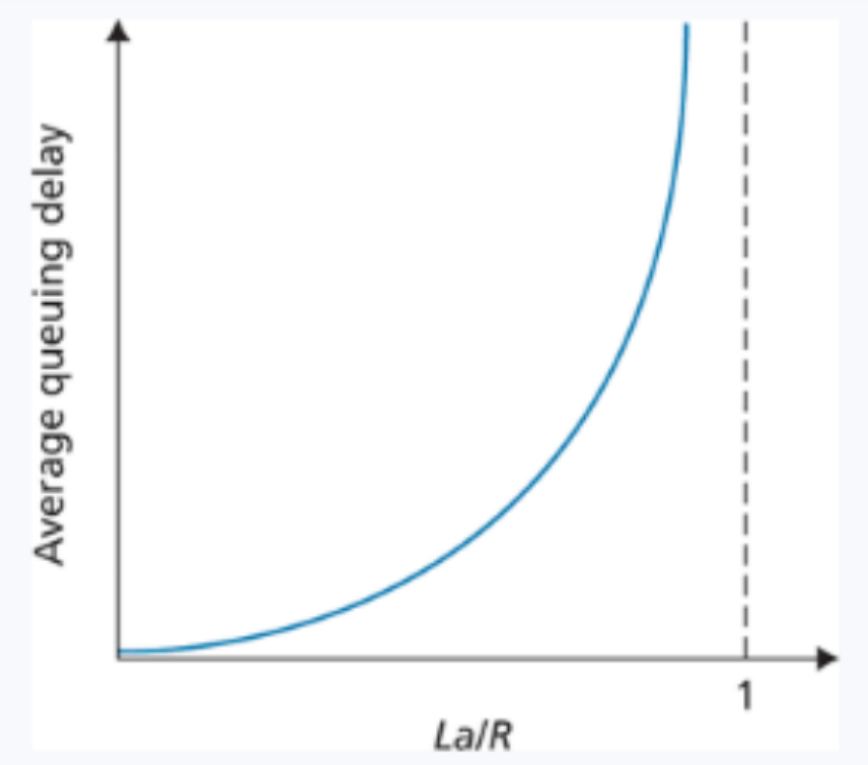
Ratio of **average bits that arrive at queue** to **how quick we can process one bit**

If traffic intensity > 1 ?

Bits arrive to the queue faster than we can process them

Bad!

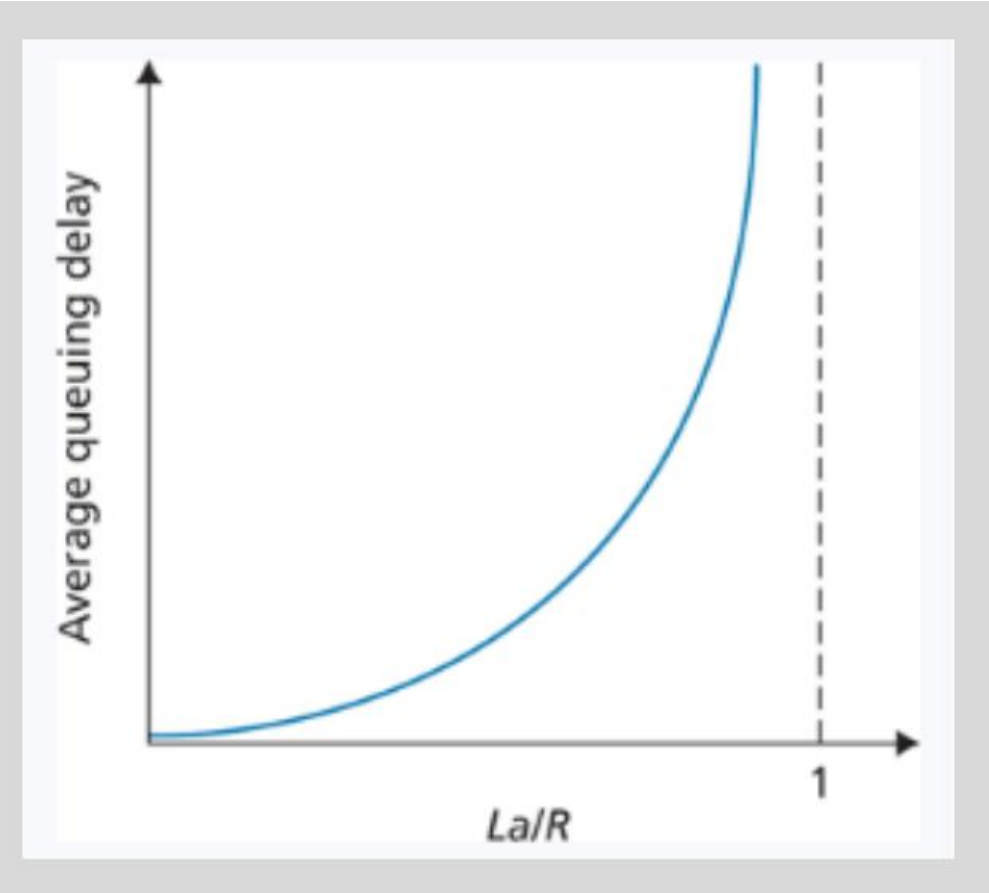
Queueing Delay



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



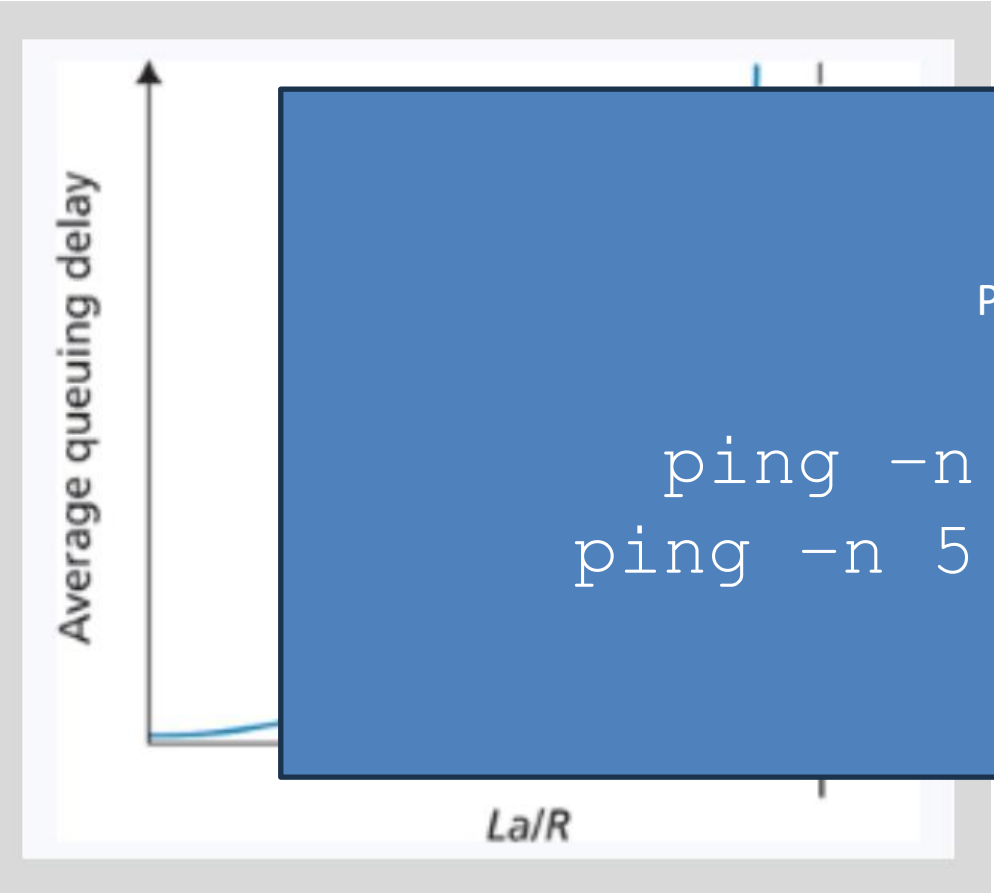
Queues have finite space.

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



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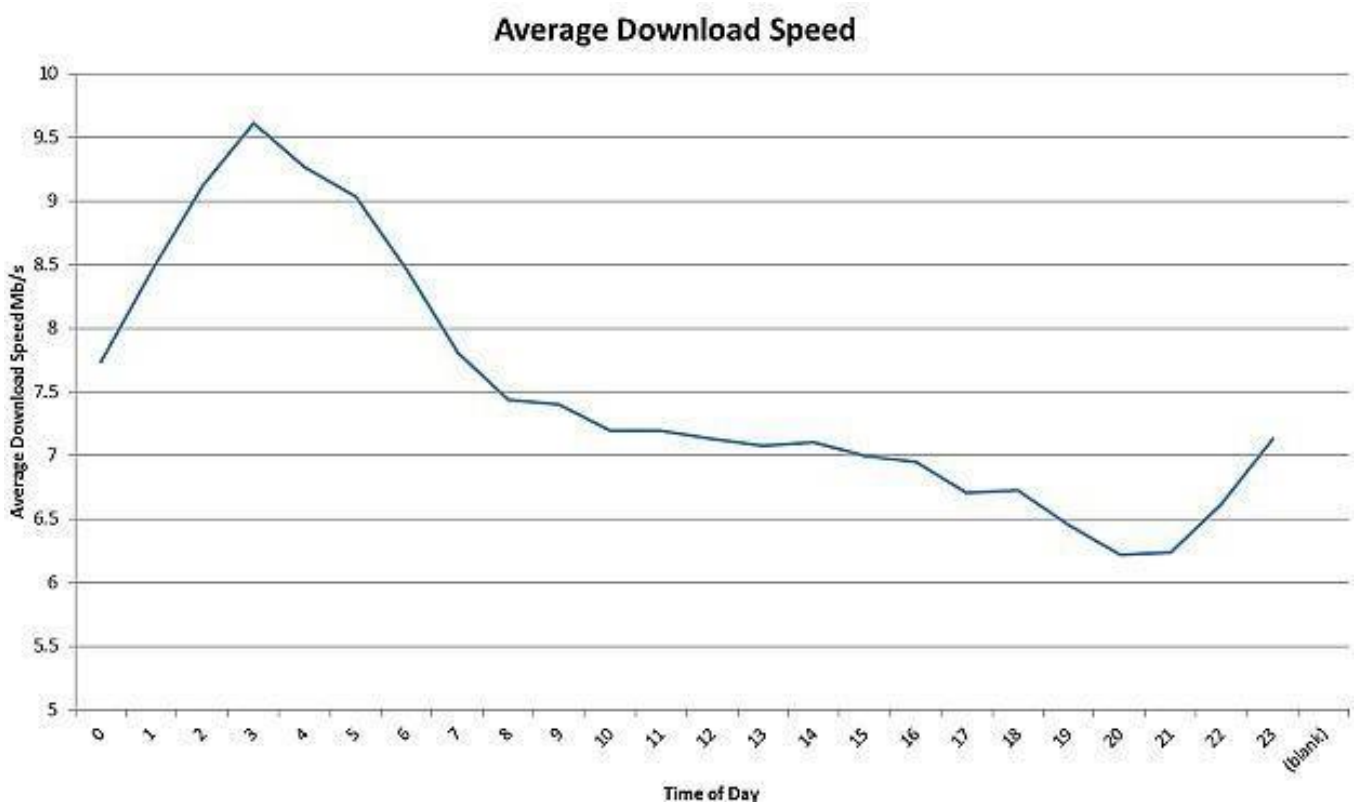
Ping Test

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

Throughput



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

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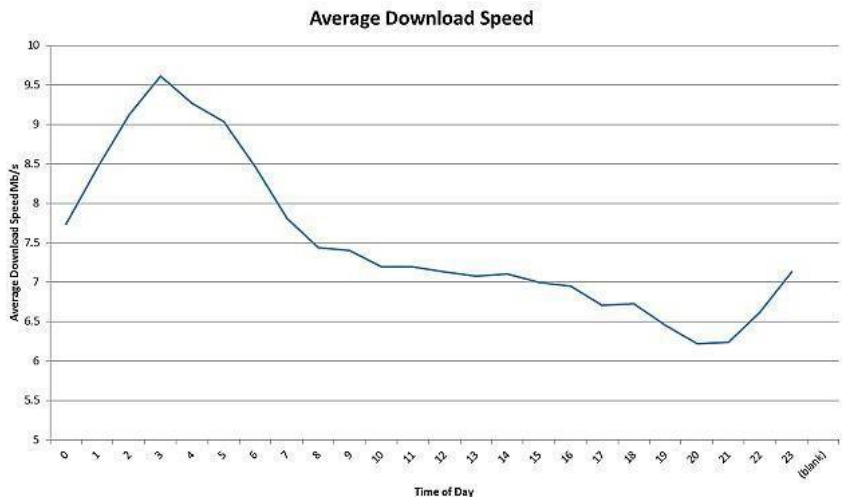

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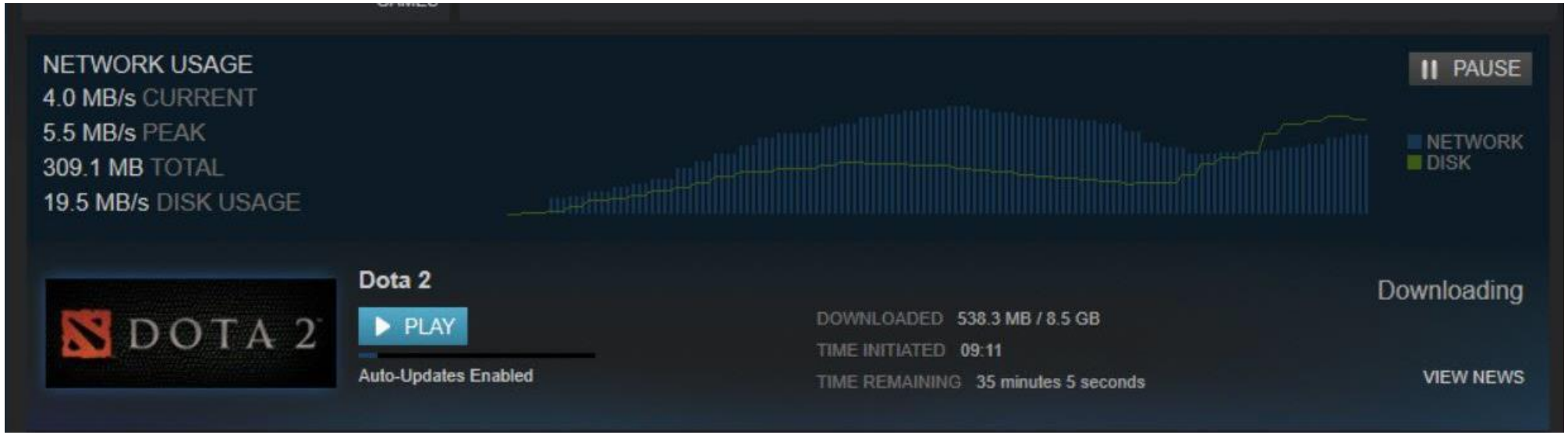

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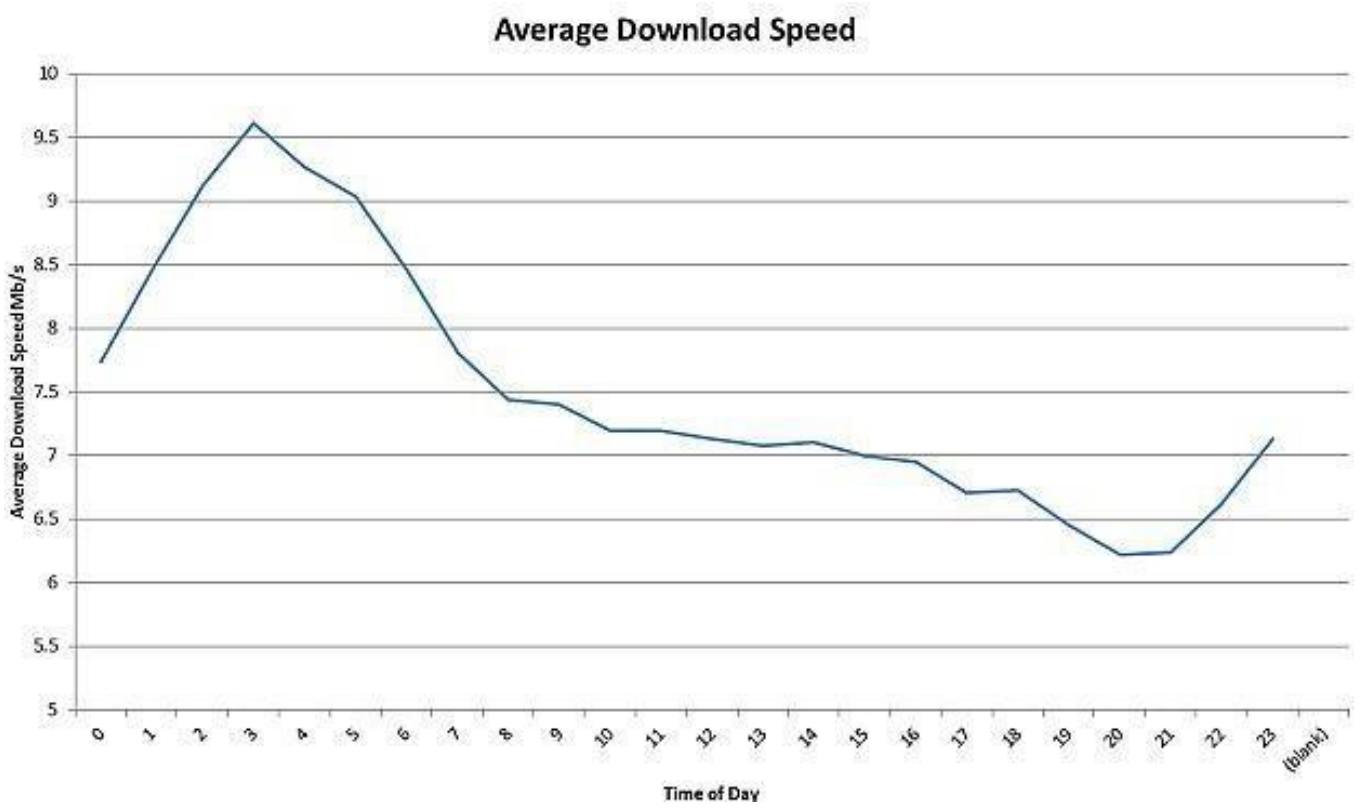

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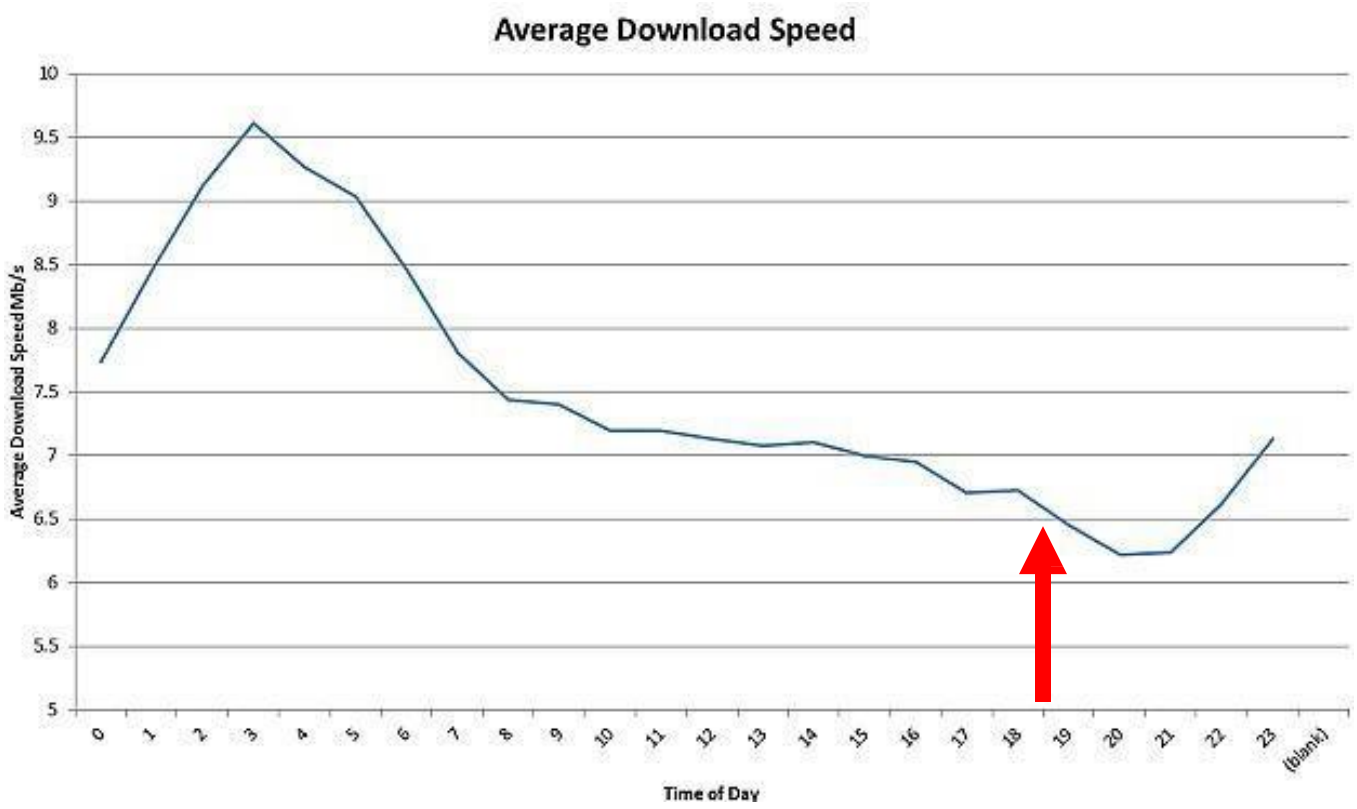
Instantaneous throughput is the throughput for a given point in time

Throughput



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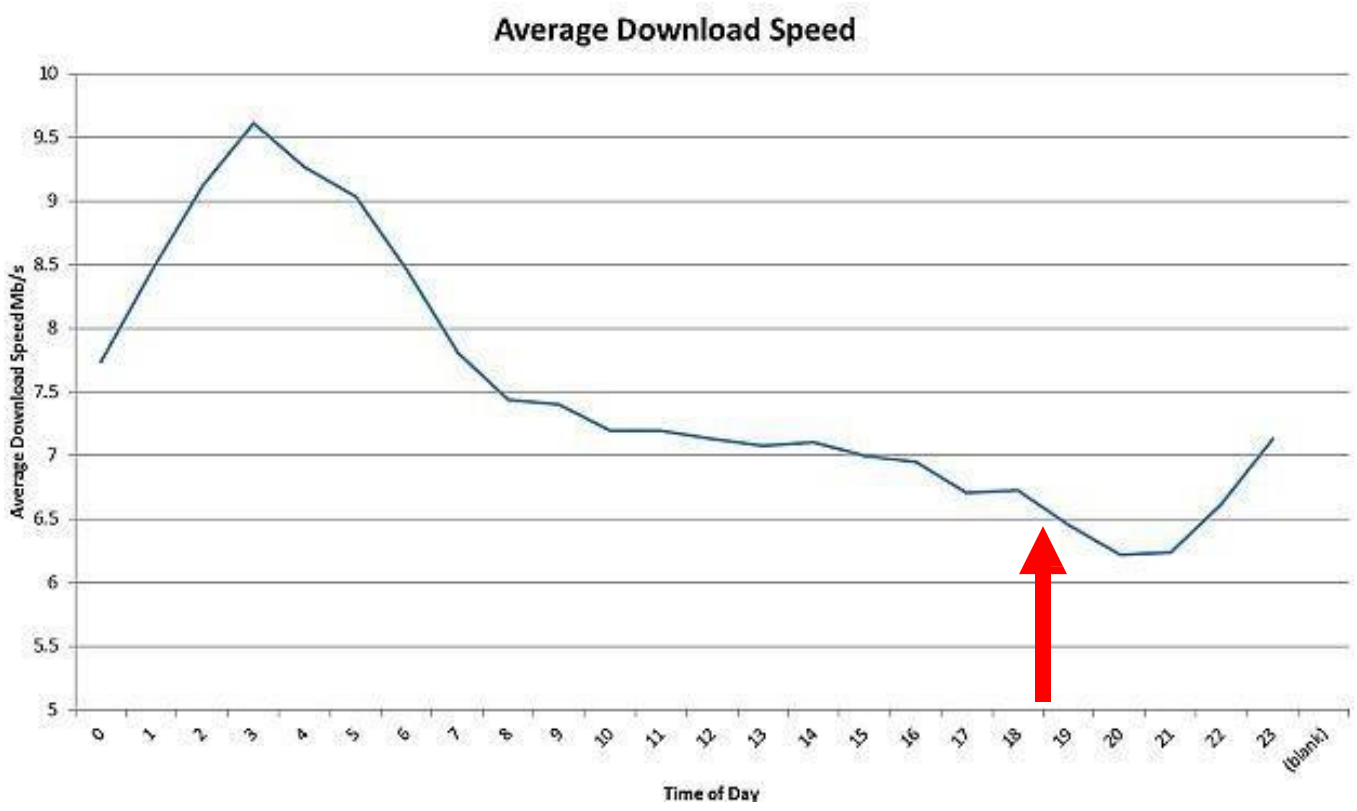
The instantaneous throughput at 7:00 PM is roughly 6.5 Mbps

Throughput



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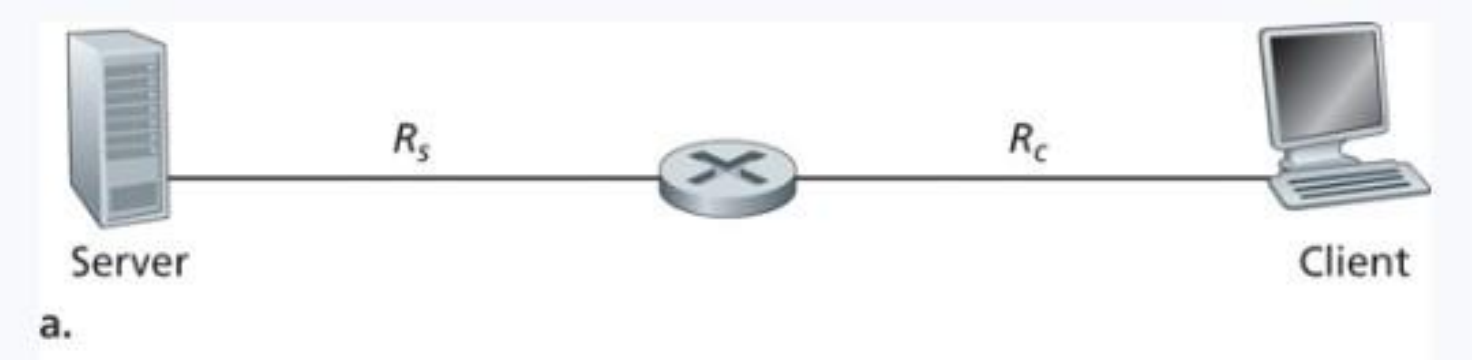
Throughput is the amount of data transferred from one place to another within a given time period

Instantaneous throughput is the throughput for a given point in time

In general, if F bits takes T seconds to transfer from one endpoint to another, the **average throughput** is:

$$\frac{F}{T}$$

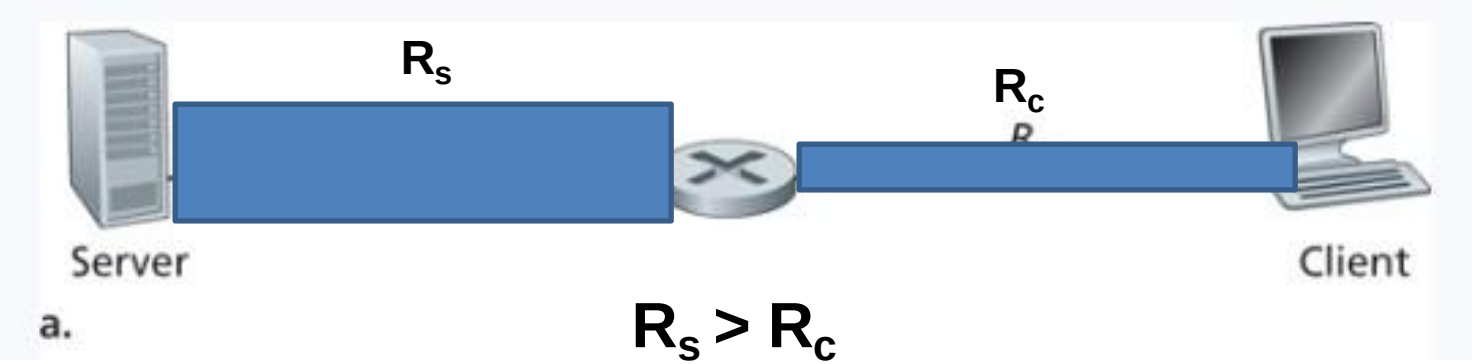
Throughput



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

Throughput for server to client?

Throughput



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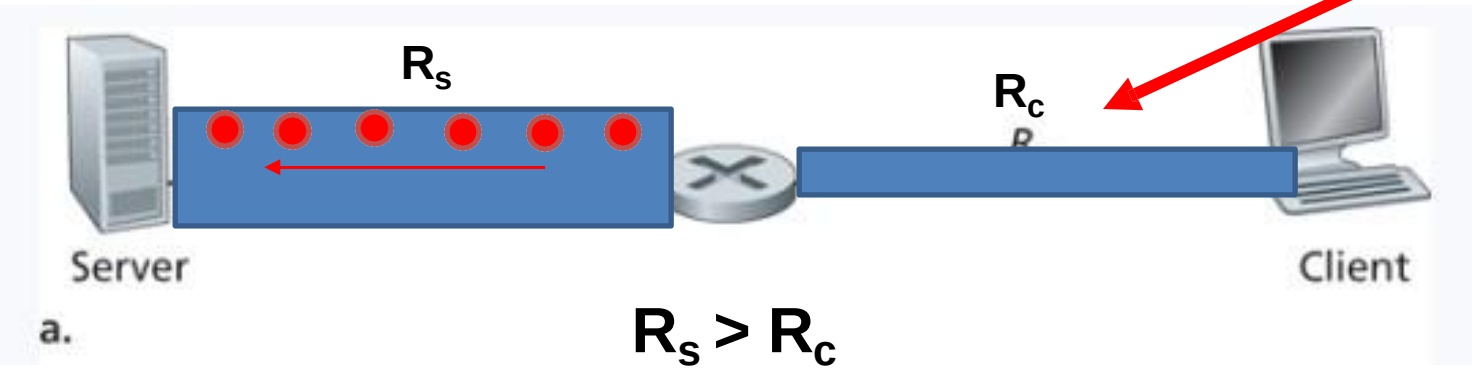

Point in network where flow of data is impaired or stopped

Bottleneck

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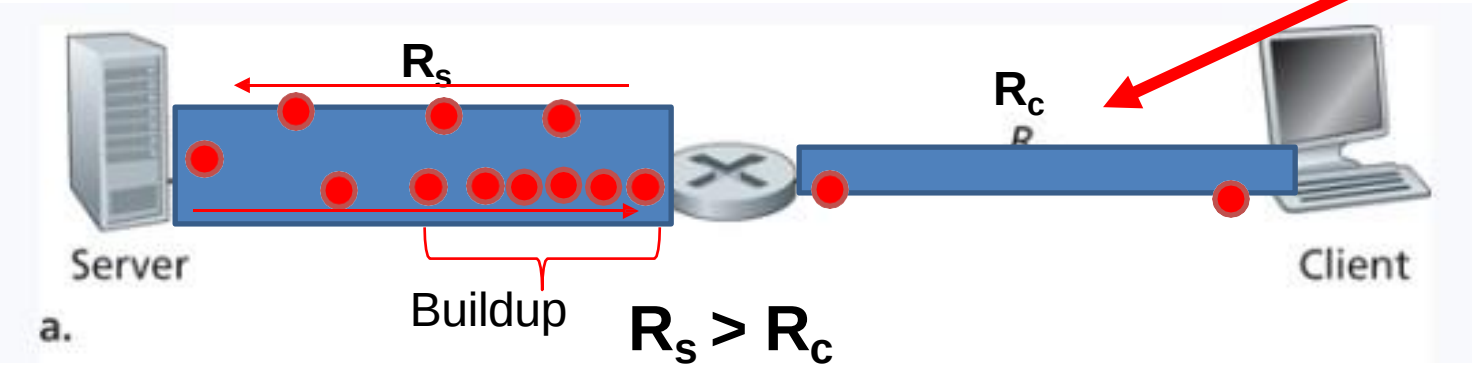

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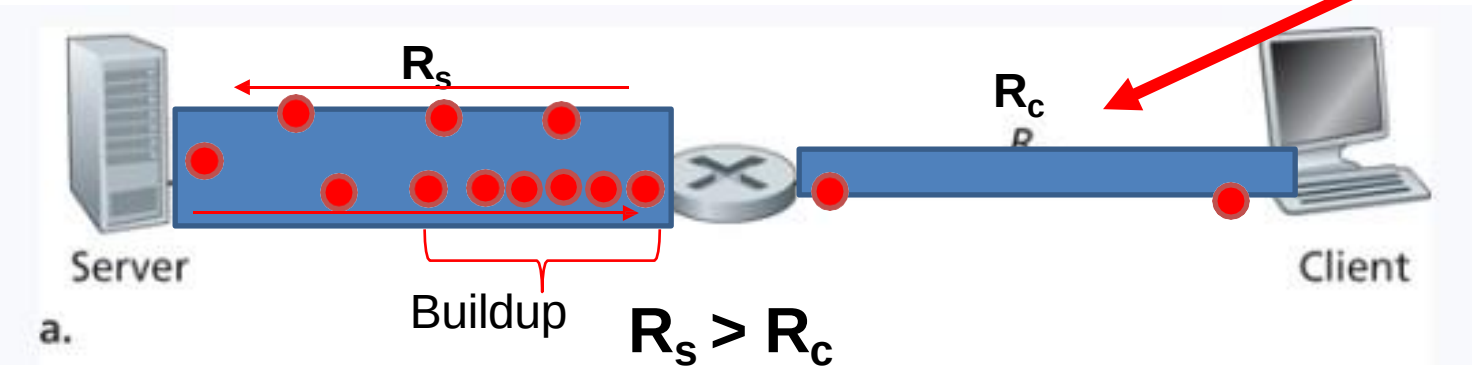

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Dependent on the bottleneck link!

Throughput

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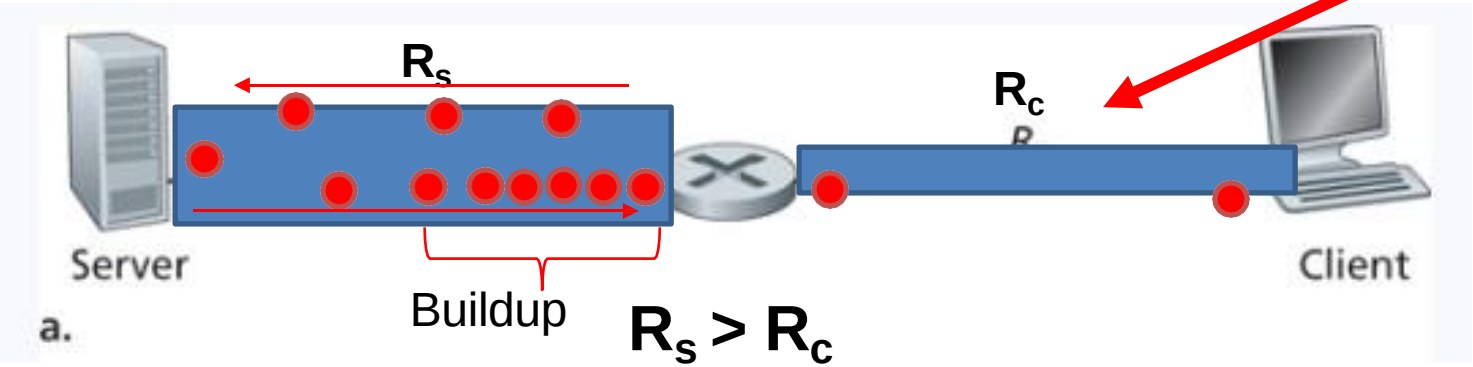

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Throughput for server to client?

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

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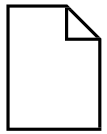
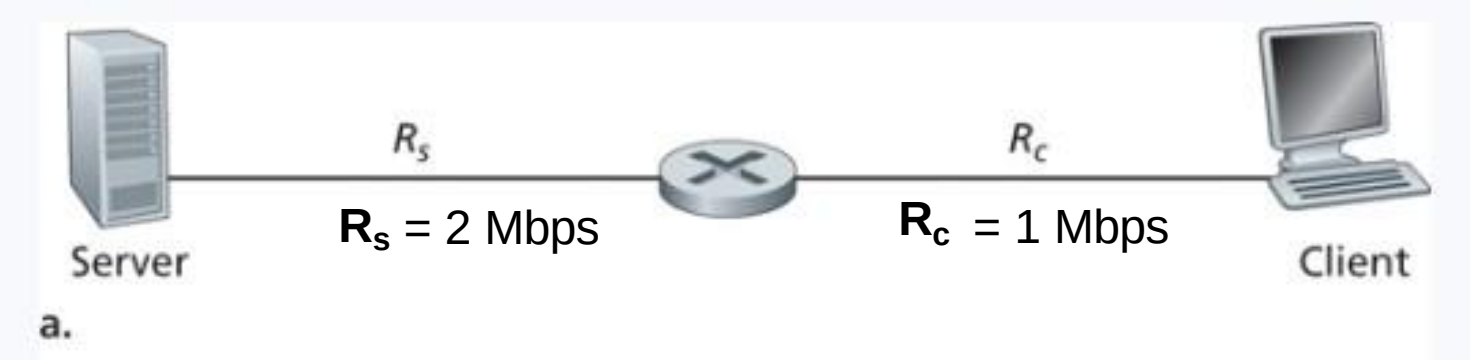


F = 32,000,000 bits



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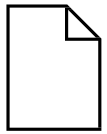
Time needed to transfer file?

Throughput



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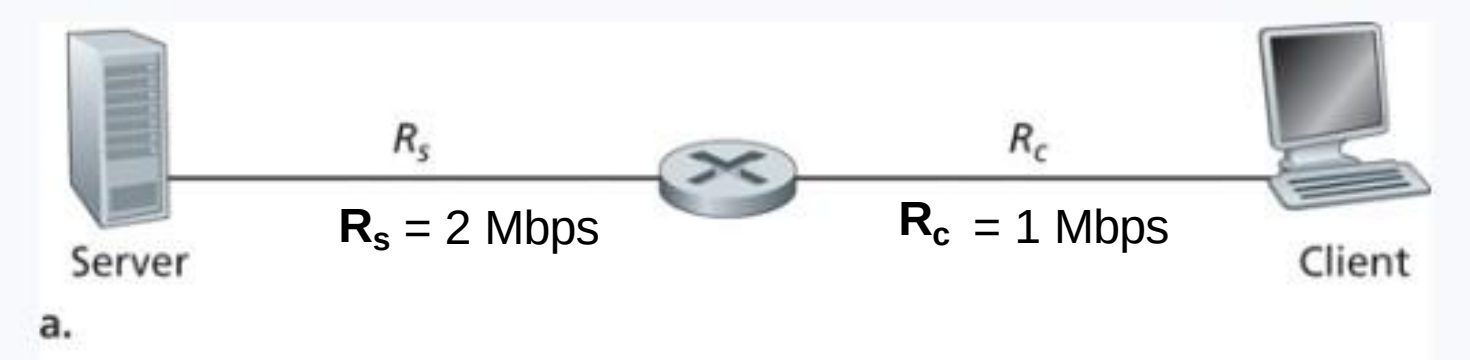

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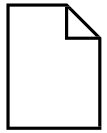

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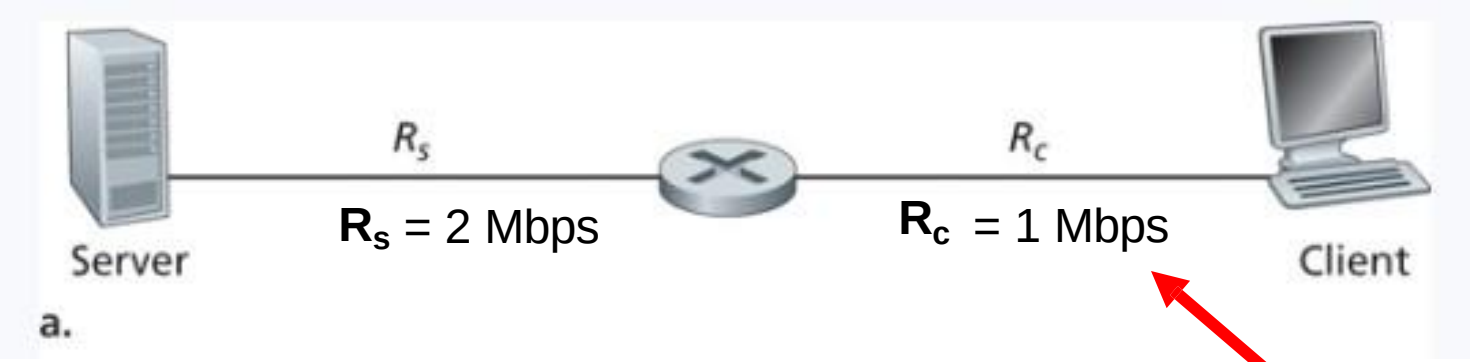

Dependent on the bottleneck

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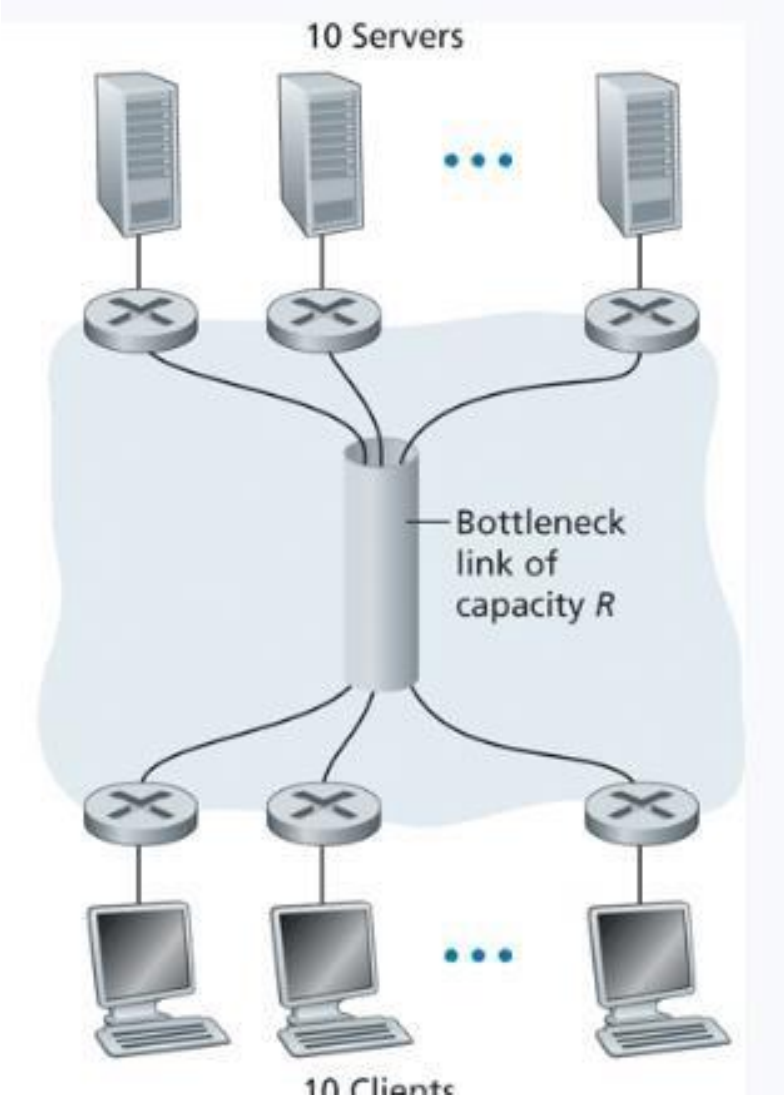
Time needed to transfer file?

32 seconds

Throughput



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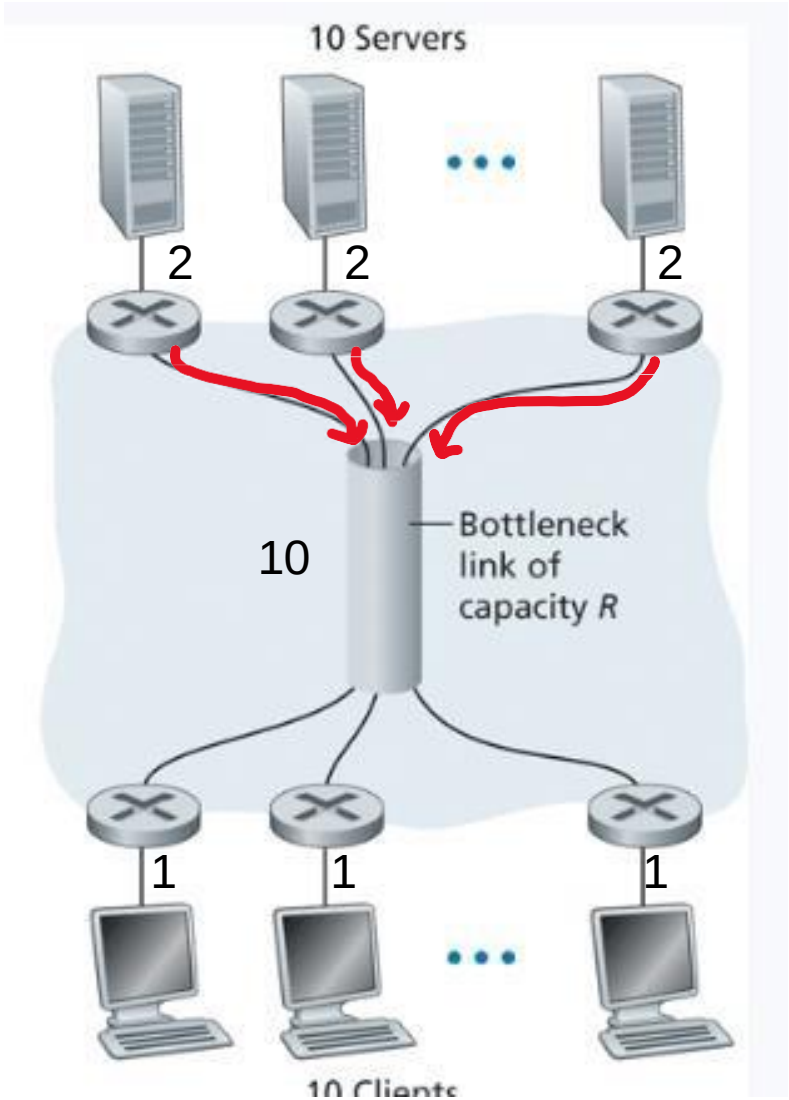
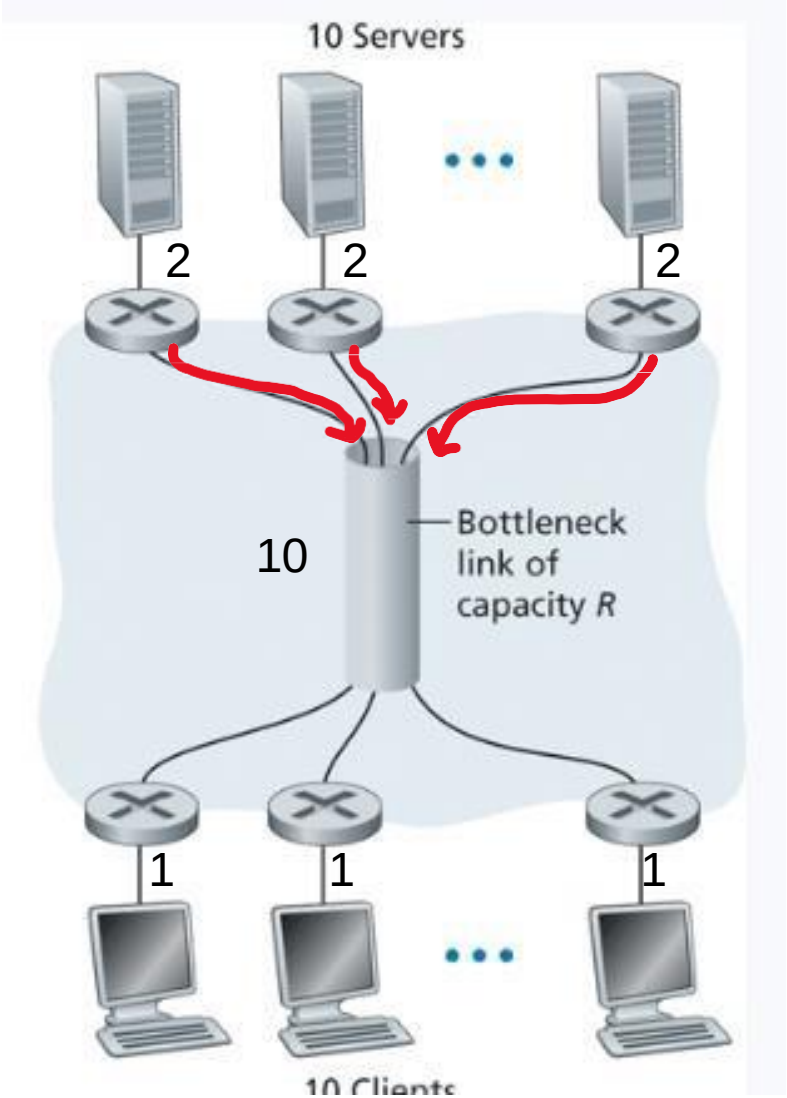


Link is shared across 10 servers

So each link supports 0.5 Mbps

Throughput



Link is shared across 10 servers

So each link supports 0.5 Mbps

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