EECS 489 - FA 24
Discussion 2

Assignment 1 and Performance Metrics

Outline

- Assignment 1: Overview
- Performance Metrics

Assignment 1

Assignment 1

Due: Monday, Sept. 18 @ 11:59 p.m.

- Only two weekends left
- **No late days for P1!!!**

Assignment 1

- **Part 1:** Mininet Tutorial
  - Allows you to simulate a network locally
  - We will use mininet for all four assignments, so get familiar now!
- **Part 2:** iPerfer
  - Write iPerfer tool to measure bandwidth between two hosts over.
- **Part 3:** Experiments
  - Run some experiments with a given network topology and explain the results qualitatively (hand-graded).
- **Part 4:** Create custom mininet topology
  - Very simple; just modify the existing topology we give you

What is Mininet?

Simulated network with custom topology (links and hosts) that is run locally!

All hosts share same files (so you can run the same code from different hosts), but they appear to be completely independent machines with unique IP addresses.

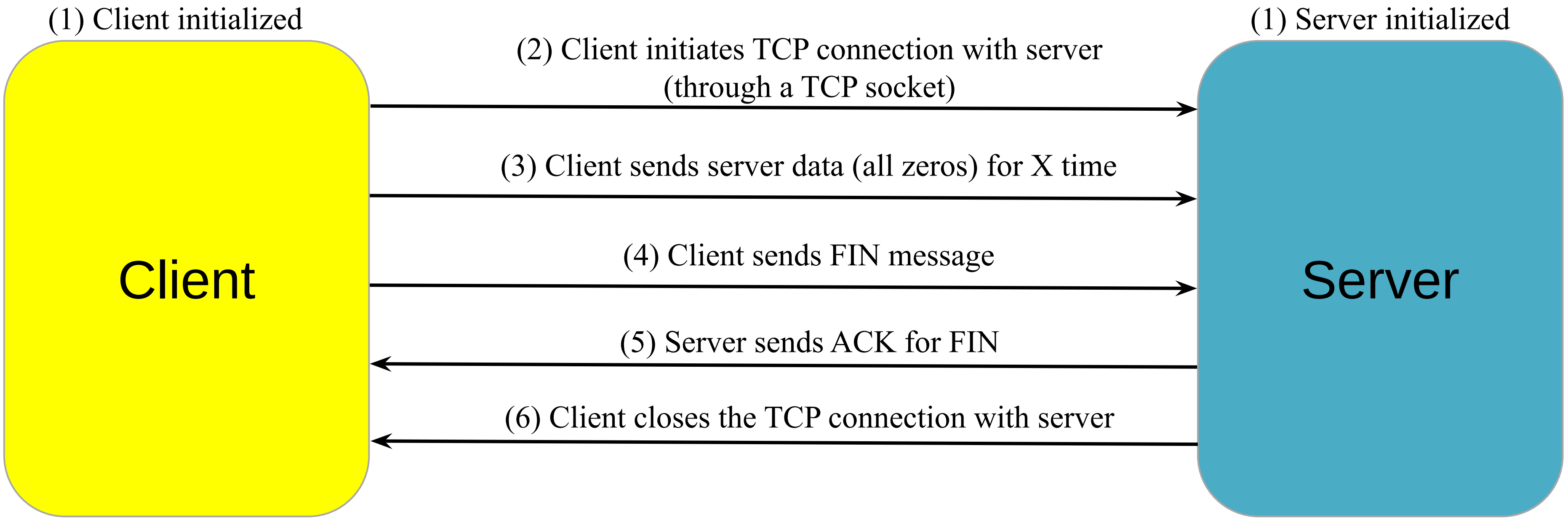
Useful commands:

- `nodes` (show all hosts)
- `dump` (show all info)
- `net` (show all interfaces)
- `h1 bash` (enter terminal inside of host h1)
- `h1 ping h2` (ping h2 from h1)
- `ifconfig` (check own IP address inside of a host terminal)

https://mininet.org/

https://edstem.org/us/courses/61627/discussion/5197510

iPerfer: Protocol



(7) Client prints summary stats and exits program.

Only one measurement each time the code is run!

(7) Server prints summary stats and exits program.

iPerfer: Running as Server

To operate `iPerfer` in server mode, it should be invoked as follows:

```
$ ./iPerfer -s -p <listen_port>
```

- `-s` indicates this is the `iPerfer` server which should consume data
- `listen_port` is the port on which the host is waiting to consume data; the port should be in the range `1024 ≤ listen_port ≤ 65535`

> For simplicity, you can assume these arguments will appear exactly in the order listed above.

iPerfer: Running as Client

To operate `iPerfer` in client mode, it should be invoked as follows:

```
$ ./iPerfer -c -h <server_hostname> -p <server_port> -t <time>
```

- `-c` indicates this is the `iPerfer` client which should generate data
- `server_hostname` is the hostname or IP address of the `iPerfer` server which will consume data
- `server_port` is the port on which the remote host is waiting to consume data; the port should be in the range 1024 ≤ `server_port` ≤ 65535
- `time` is the duration in seconds for which data should be generated. We will only test this with an integer value (i.e feel free to use time.h)

Assignment 1: Tips & Tricks

iPerfer:

- Only one measurement is done each time the code is run!
- Server and client are the same executable, just with slightly different command-line flags.
- Feel free to use sockets code from Discussion 1, or **<u>your</u>** socket-related code from other classes.
- Don’t worry too much about command-line parsing – to make it simpler, we’ve guaranteed that arguments are always in the same order!

General:

- Work through Mininet tutorial slowly and carefully — this will save you a lot of time and pain later, both for this project and for projects 2-4.
- Read the spec carefully — it has a lot of notes on common problems that people run into and how you can fix them.

Assignment 1: Other

- The assignment should be done in C++, although a lot of the socket code will look like C.
- Don’t worry about the Autograder complaining that it expects a .c file.

Performance Metrics

Latency and Throughput

Latency: How much time does it take for a single bit of information to travel from Host A to Host B?

- Often measured by RTT/2 on average
- RTT: Round-trip time
- **We want this to be as small as possible**

Throughput: How much data (per unit of time) can be transferred between Host A and Host B?

- Throughput = (Amount of Data Transferred) / (Time to Transfer Data)
- **We want this to be as large as possible**

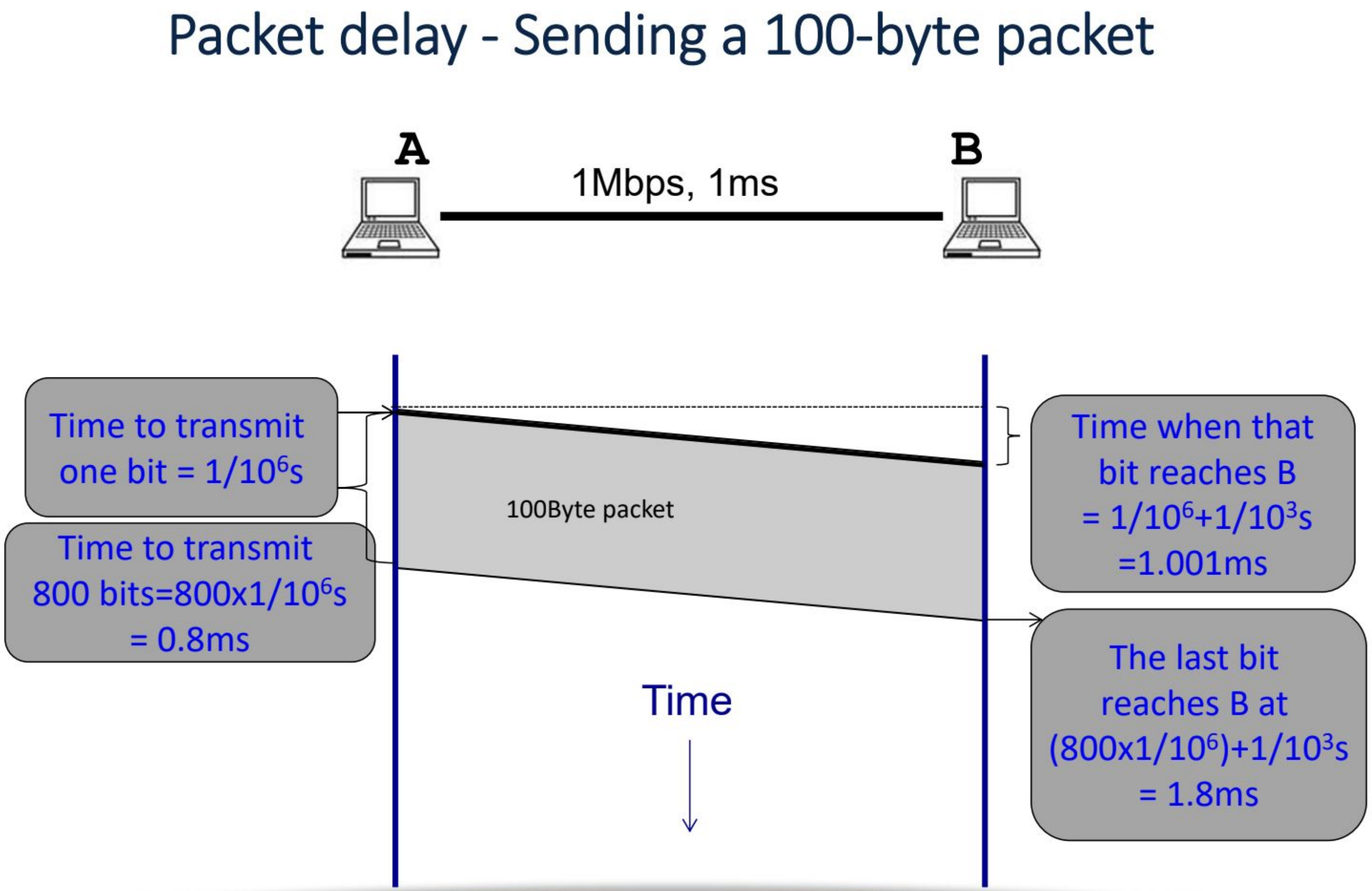
What is an example of something that is high latency, high throughput?
What about low latency, low throughput?

Measuring Time to Transfer Data

Time to Transfer Data = Transmission Delay
+ Propagation Delay
+ Queueing Delay
+ Processing Delay

- **Transmission Delay:** How long does it take to transfer all data into a link?
  - This is a one-time cost for every data transfer, and is an inherent property of the link.
- **Propagation Delay:** How long does it take for one bit to cross the link?
  - This is just the latency of the link.
- **Queueing Delay:** How long does the data spend in queues waiting to be processed by intermediate routers?
  - Not always negligible, but we can ignore for now
- **Processing Delay:** How much time is spent processing the packet for forwarding?
  - Usually negligible

Data Transfer Example



Useful Constants

- **Speed of Light:** $3.0 * 10^8$ m/s
- **Kilo-:** 10^3
- **Mega-:** 10^6
- **Giga-:** 10^9
- **Milli-:** 10^{-3}
- **Micro-:** 10^{-6}
- **Nano-:** 10^{-9}
- Kb → Kilo**bit**, KB → Kilo**byte**

Performance Metrics - Q1

Suppose a 100-Mbps point-to-point link is being set up between Earth and a new lunar colony. The distance from the moon to Earth is approximately 385,000 km, and data travels over the link at the speed of light = $3 * 10^8$ m/s.

(a) Calculate the minimum RTT (Round-Trip Time) for the link.

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(a) Calculate the minimum RTT (Round-Trip Time) for the link.

Propagation Delay = 385,000 km / ($3 * 10^5$ km/s) = **1.283 seconds**

RTT = 2 * propagation delay = 2 * 1.28333 = **2.567 seconds**

Performance Metrics - Q1

Suppose a 100-Mbps point-to-point link is being set up between Earth and a new lunar colony. The distance from the moon to Earth is approximately 385,000 km, and data travels over the link at the speed of light = $3 * 10^8$ m/s.

(b) Suppose Mission Control on Earth wishes to download a 25MB image from a camera on the lunar base.What is the minimum amount of time that will elapse between when the request for the data goes out and the transfer is finished? What is the throughput of the download? Assume there is no queueing or processing delay.

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Min Time Elapsed = (Time for request to reach moon) + (Time for moon to send back 25MB of data)

= RTT/2 + RTT/2 + Transmission Delay

= RTT + (25 MB / 100Mbps)

= 2.567s + (200 Mb / 100 Mbps)

= **4.567 seconds**

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(b) Suppose Mission Control on Earth wishes to download a 25MB image from a camera on the lunar base. What is the minimum amount of time that will elapse between when the request for the data goes out and the transfer is finished? What is the throughput of the download, in Mbps? Assume there is no queueing or processing delay.

Throughput = (25 MB) / (Propagation Delay + Transmission Delay)

= (200 Mb) / (1.283s + 2s)

= **60.91 Mbps**

Performance Metrics - Q1

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(c) What is the maximum number of bits in-flight at any given time on the link?

Performance Metrics - Q1

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(c) What is the maximum number of bits in-flight at any given time on the link?

Bits-in-Flight = Bandwidth * Propagation Delay

= (100Mbps) * (1.283s)

= **$1.283 * 10^8$ seconds**

Performance Metrics - Q2

Calculate the time from first bit sent to last bit received for the following:

(a) You are sending a 5 Kb packet over a 10 Mbps link. There is a **store-and-forward switch** in the middle of the link, which begins retransmitting the packet as soon as it has finished receiving the packet. Assume each section of the link (source → switch, switch → destination) introduces a propagation delay of 100 microseconds.

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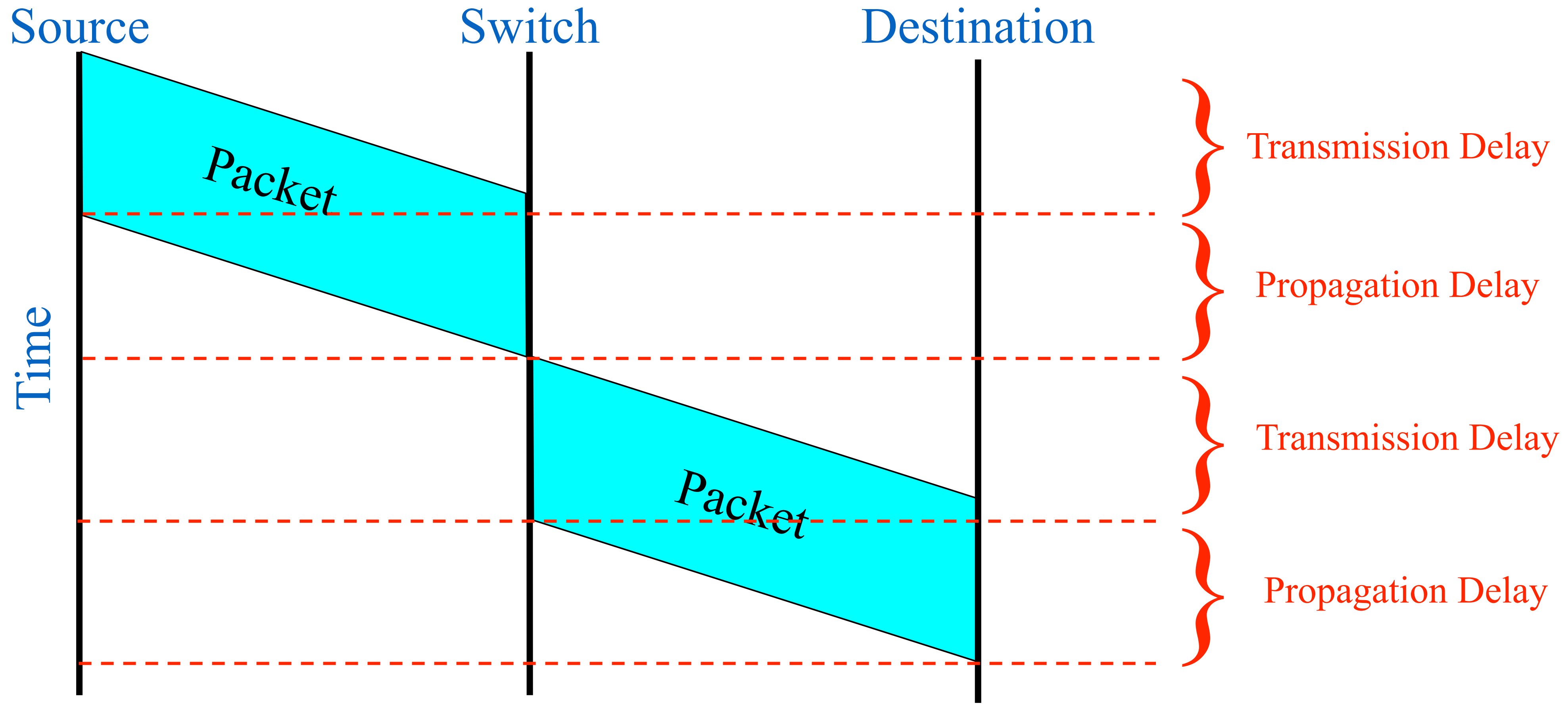
Total Time = 2 * (Transmission + Propagation)

= 2 * ((5Kb / 10Mbps) + 1.0 * 10^{-4} s)

= 2 * (5.0 * 10^{-4} s + 1.0 * 10^{-4} s)

= **1.2 * 10^{-3} seconds = 1.2 ms**

Performance Metrics - Q2



Performance Metrics - Q2

Calculate the latency (from first bit sent to last bit received) for the following:

(b) A 10-Mbps link with a single **cut-through switch** in the path, and a packet size of 5,000 bits. Assume that each section of the link introduces a propagation delay of 100 microseconds, and that the switch begins retransmitting immediately after the first 200 bits have been received.

Performance Metrics - Q2

Calculate the latency (from first bit sent to last bit received) for the following:

(b) A 10-Mbps link with a single **cut-through switch** in the path, and a packet size of 5,000 bits. Assume that each section of the link introduces a propagation delay of 100 microseconds, and that the switch begins retransmitting immediately after the first 200 bits have been received.

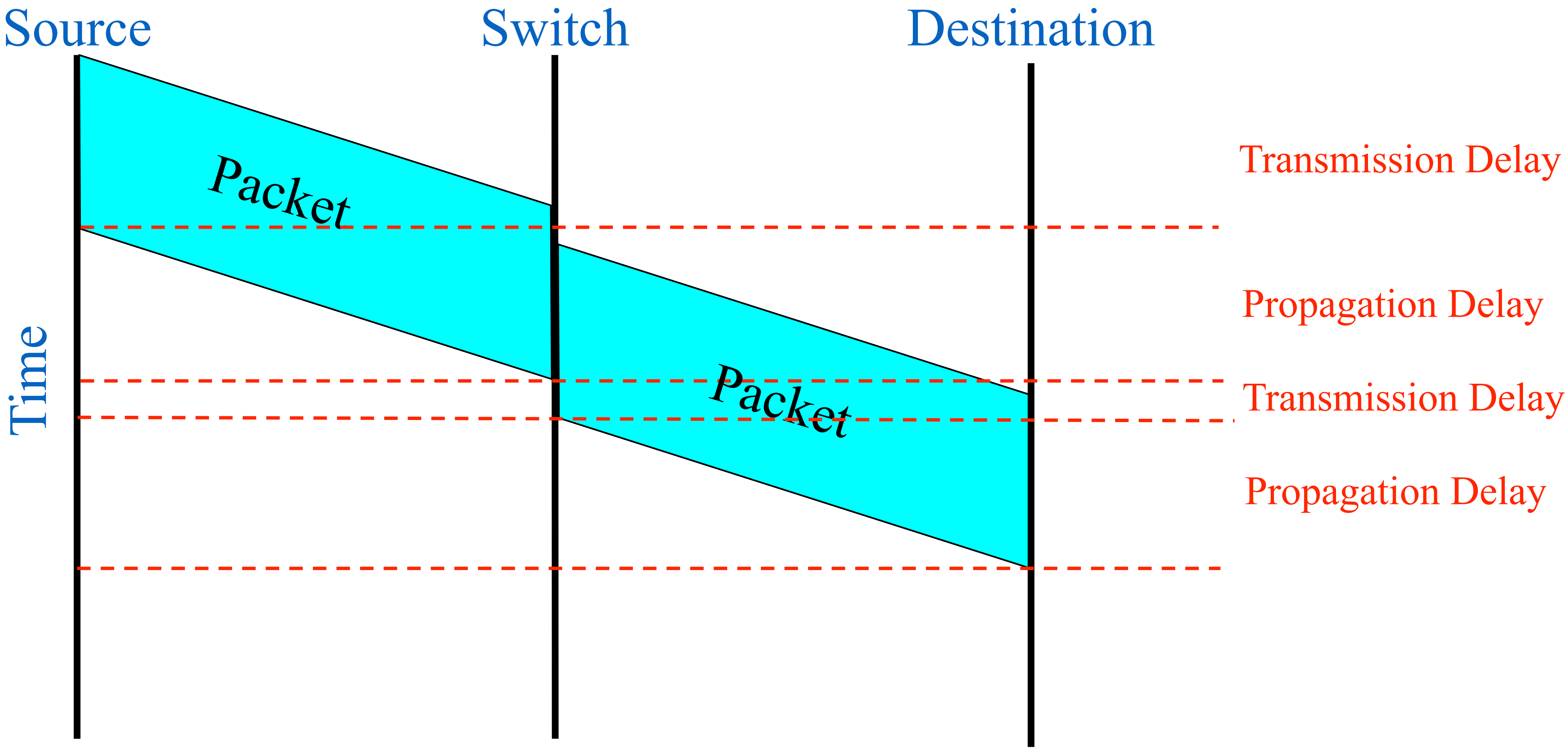
Total Time = (Transmission + Propagation) + (Transmission for 200 bits + Propagation)

$= (5\ \text{Kb} / 10\ \text{Mbps}) + (1.0 * 10^{-4}\ \text{s}) + (200 / 10\ \text{Mbps}) + (1.0 * 10^{-4}\ \text{s})$

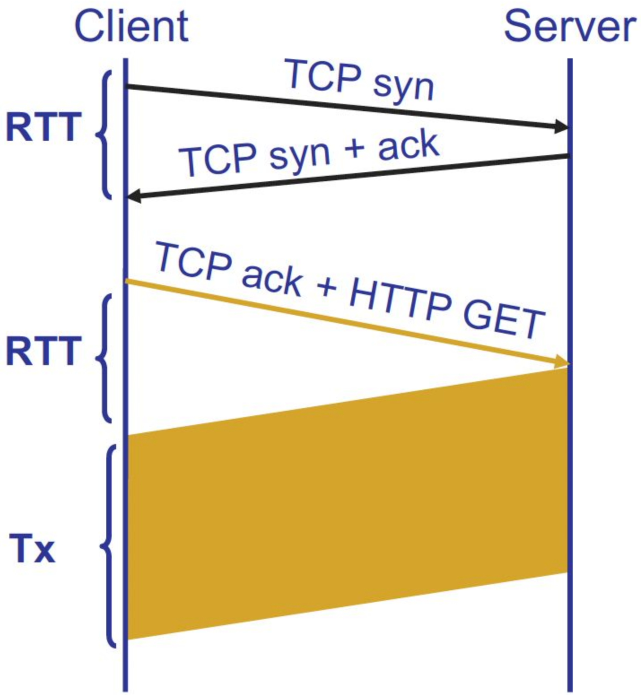
$= (5.0 * 10^{-4}\ \text{s}) + (1.0 * 10^{-4}\ \text{s}) + (0.2 * 10^{-4}\ \text{s}) + (1.0 * 10^{-4}\ \text{s})$

= **0.72 ms**

Performance Metrics - Q2



Performance Metrics - Q3

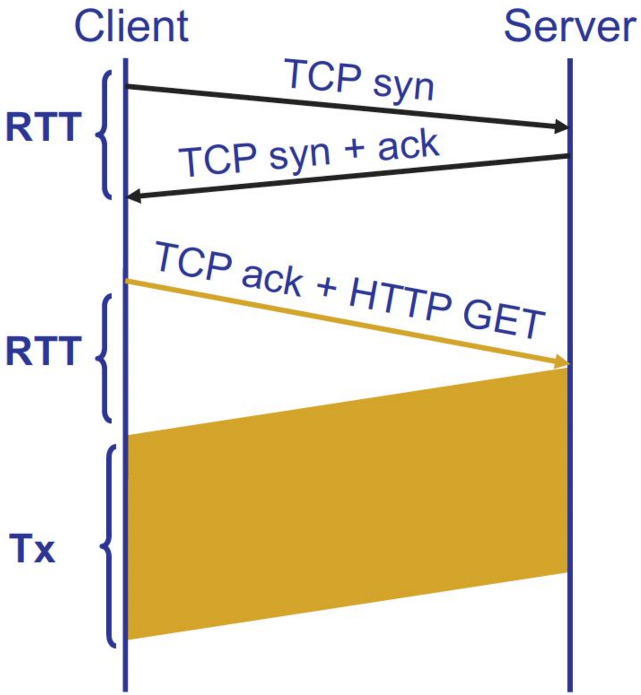


What is the object request response time if propagation delay = 0.15ms, transmission delay = 0.5ms?

Note: We ignore the transmission delay for the TCP syn/ack because the size of those messages is negligible compared to the size of the object, so the transmission delay can be treated as negligible.

Note: Ignore the gap on the client side between "TCP syn + ack" and "TCP ack + HTTP GET" – this is just a flawed diagram.

Performance Metrics - Q3



What is the object request response time if propagation delay = 0.15ms, transmission delay = 0.5ms?

RTT = 2 * propagation delay = 0.3ms
Total = 2 * RTT + transmission delay = **1.1ms**