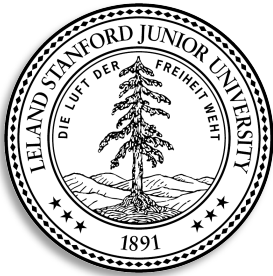# CS144
An Introduction to Computer Networks

Physical Links

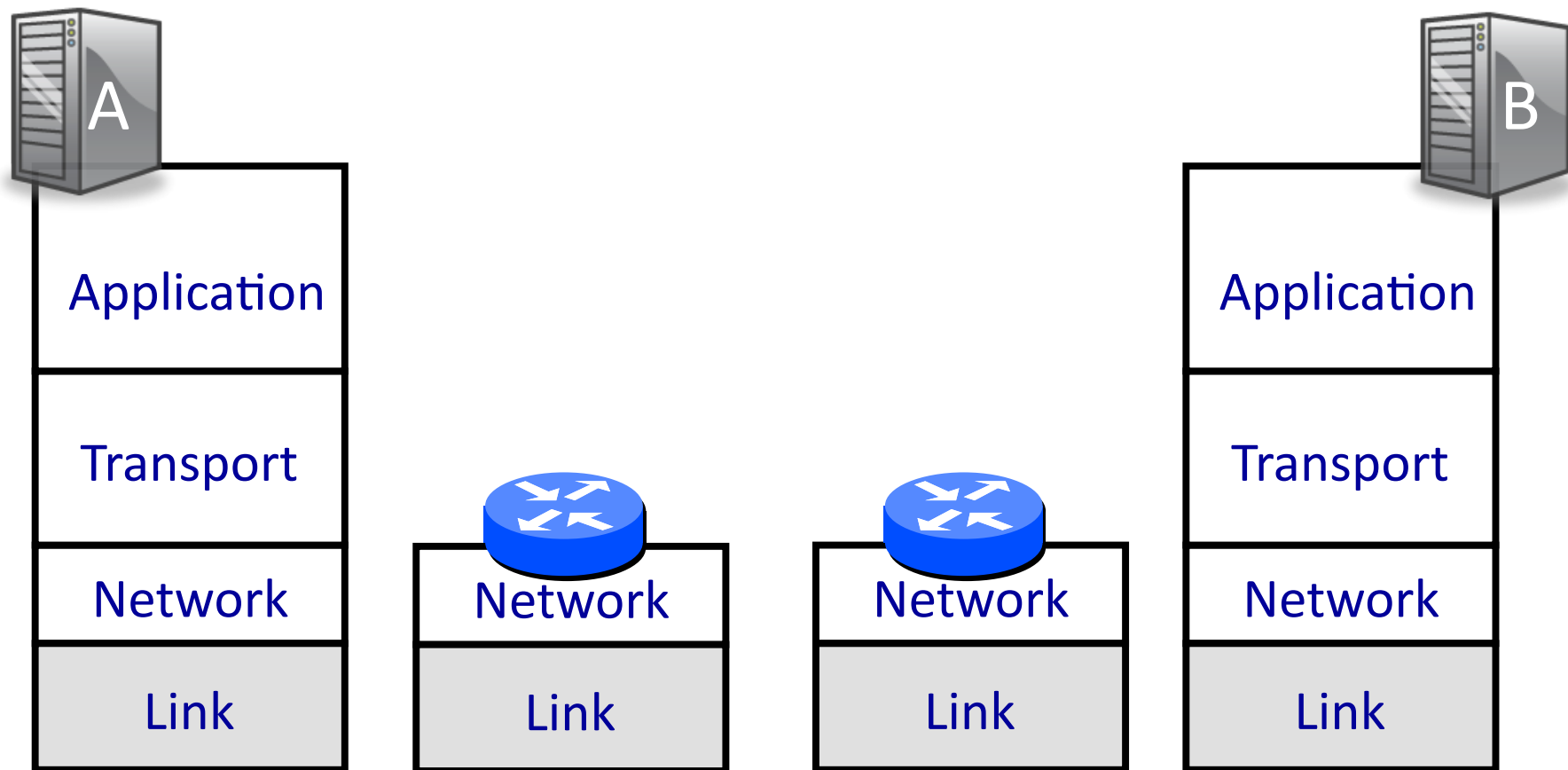*CSMA/CD and Ethernet*
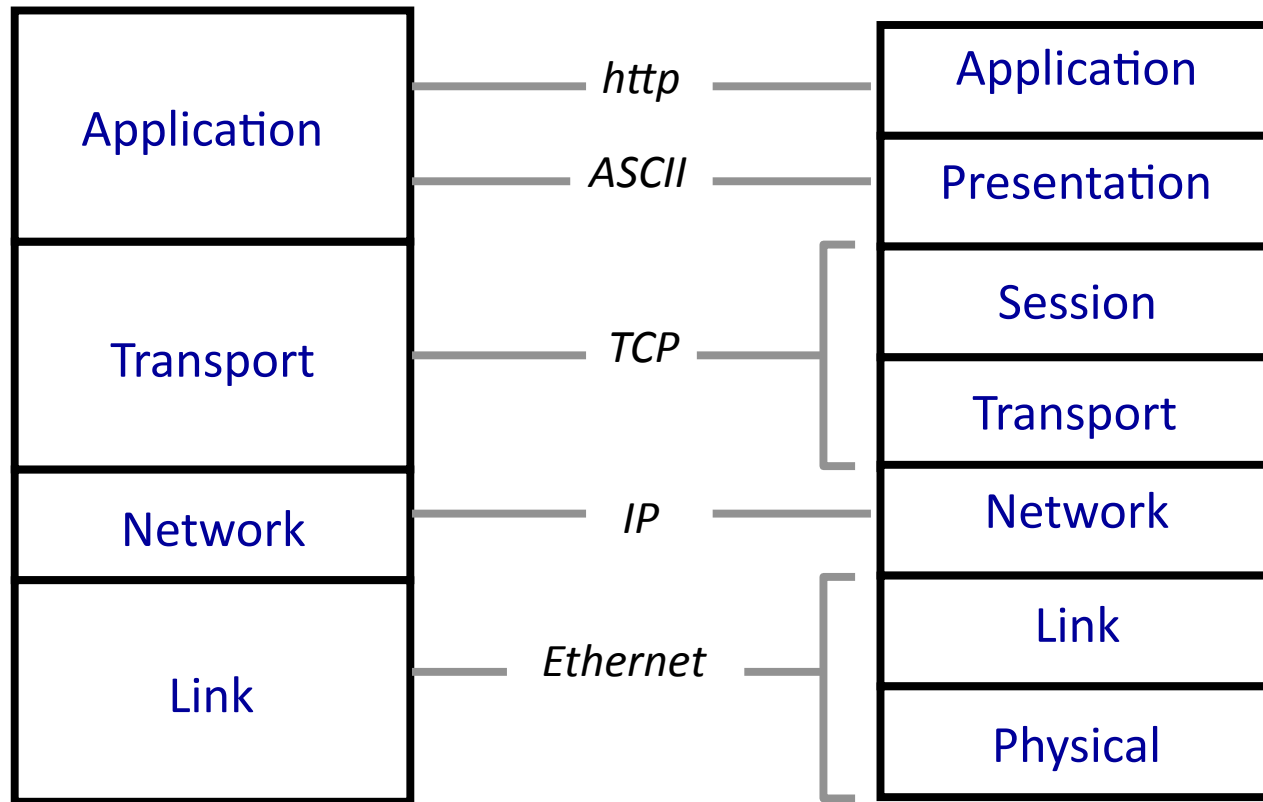
Nick McKeown

Professor of Electrical Engineering
and Computer Science, Stanford University

The Link Layer

Application | Application

Transport | Transport

Network | Network | Network | Network

Link | Link | Link | Link

Why is Ethernet often referred to as "Layer 2"?

The 4-layer Internet model		The 7-layer OSI Model
Application	http	Application
	ASCII	Presentation
Transport	TCP	Session
		Transport
Network	IP	Network
Link	Ethernet	Link
		Physical

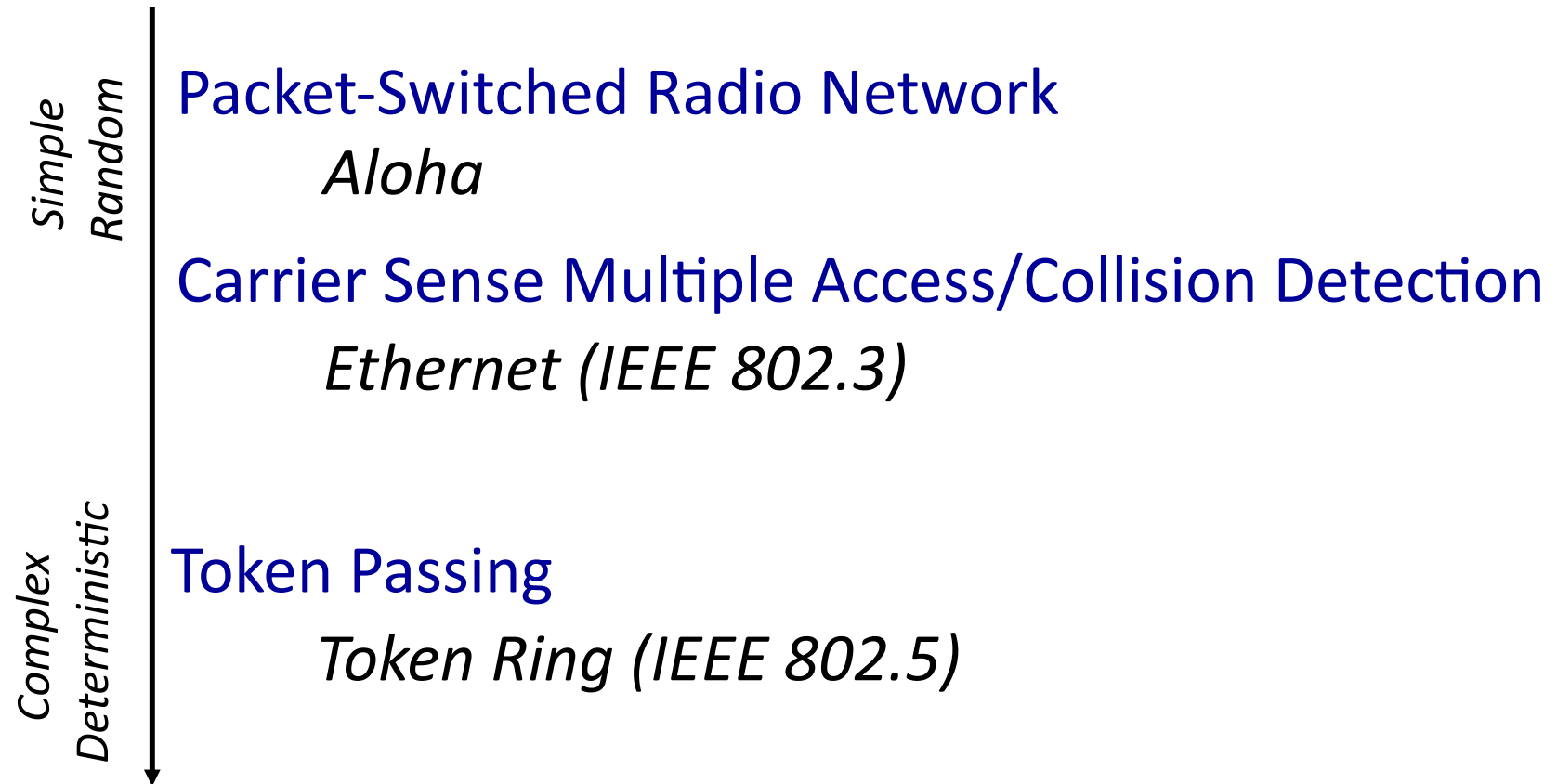The 4-layer Internet model   The 7-layer OSI Model

The origins of Ethernet

Sharing a "medium"

- Ethernet is an example of multiple hosts sharing a common cable ("medium").

- To share the medium, we need to decide who gets to send, and when.

- There is a general class of "Medium Access Control Protocols", or MAC Protocols.

- We will take a look at some examples.

Examples of MAC Protocols

Simple Random

Packet-Switched Radio Network
Aloha

Carrier Sense Multiple Access/Collision Detection
Ethernet (IEEE 802.3)

Complex Deterministic
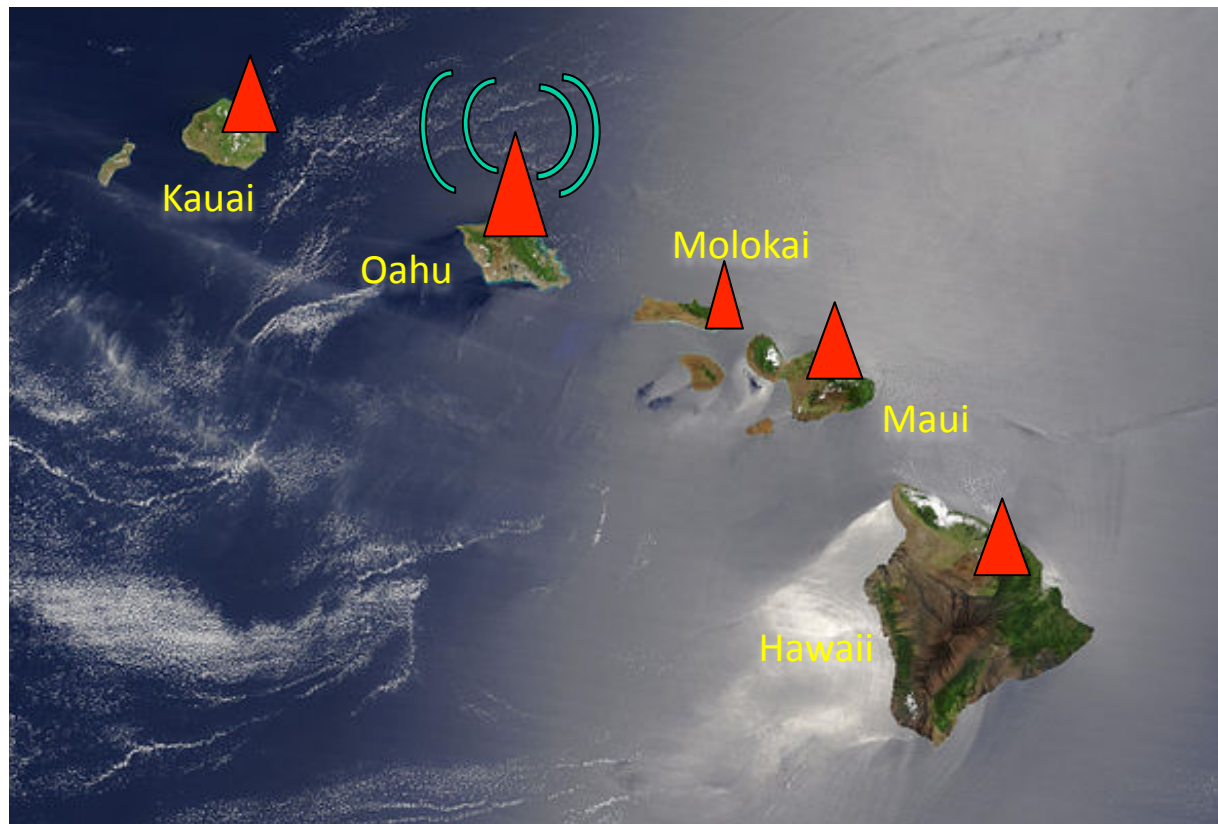
Token Passing
Token Ring (IEEE 802.5)

Goals of MAC Protocols

Medium Access Control protocols arbitrate access to a common shared channel among a population of users
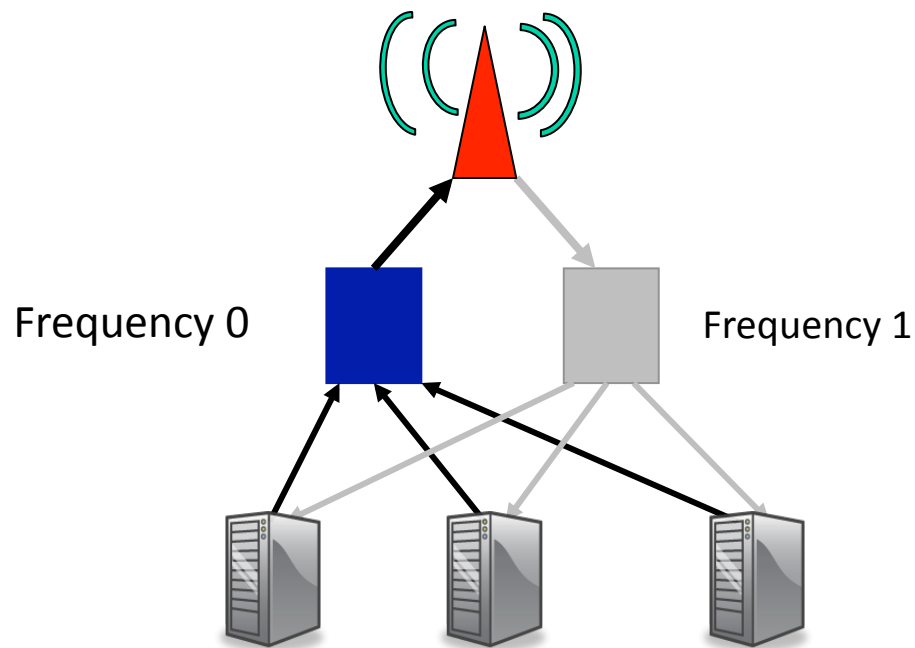
1. High utilization of the shared channel
2. Fair among end hosts
3. Simple and low cost to implement
4. Robust to errors; fault tolerant

Aloha Network (1968)

Aloha

Frequency 0   Frequency 1

Original Aloha MAC protocol
1. If you have data to send, transmit it.
2. If your transmission "collides" with another, retry later.

Aloha Protocol

- Aloha protocol is very simple
- (Quite) robust against failure of a host.
- The protocol is distributed among the hosts.
- Under low-load, we can expect the delay to be small.
- Under high-load, a lot of time "wasted" sending packets that collide.

Improving performance:
1. Listen for activity ("carrier sense") before sending a packet.
2. Detect collisions quickly and stop transmitting.
3. After collision, pick random waiting time based on the load.

CSMA/CD Protocol

All hosts transmit & receive on one channel
Packets are of variable size.

When a host has a packet to transmit:

1. Carrier Sense: Check the line is quiet before transmitting.
2. Collision Detection: Detect collision as soon as possible. If a collision is detected, stop transmitting; wait a random time, then return to step 1.
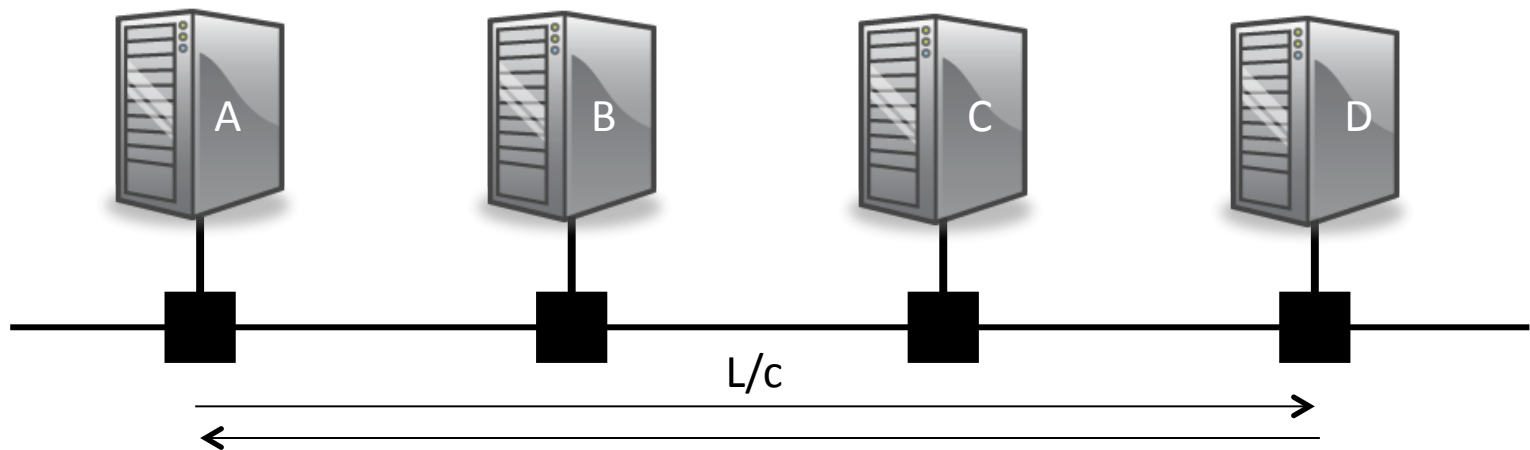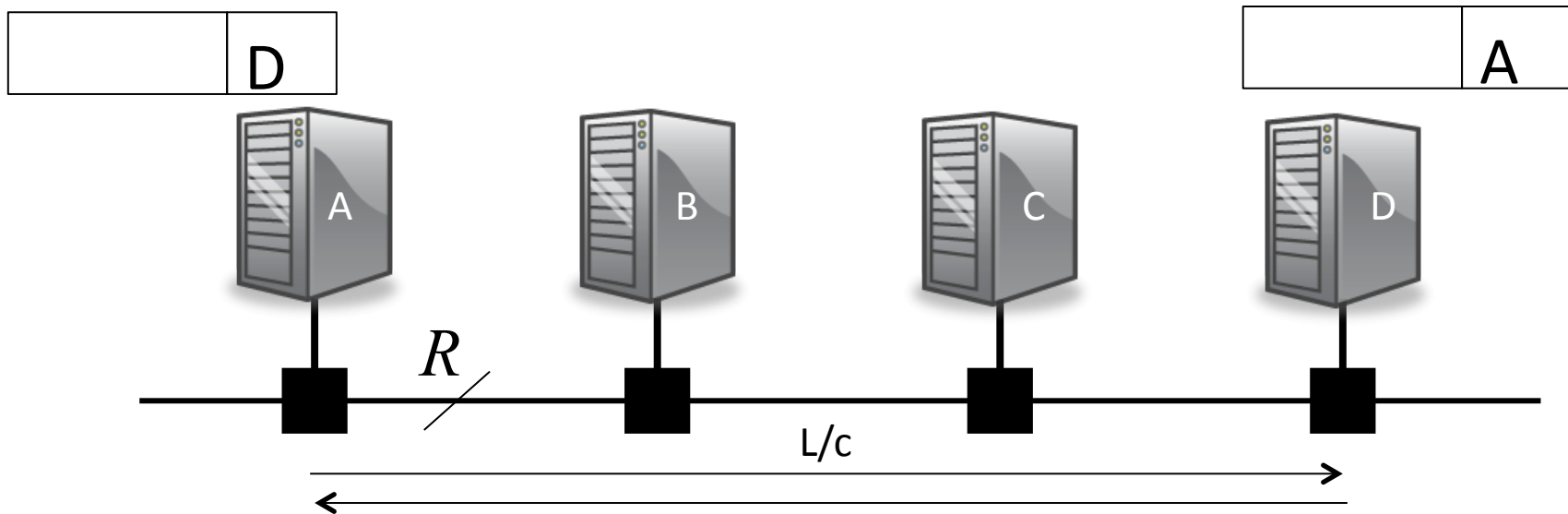
binary exponential backoff

CSMA/CD operation

CSMA/CD Packet size requirement

L/c

CSMA/CD Packet size requirement

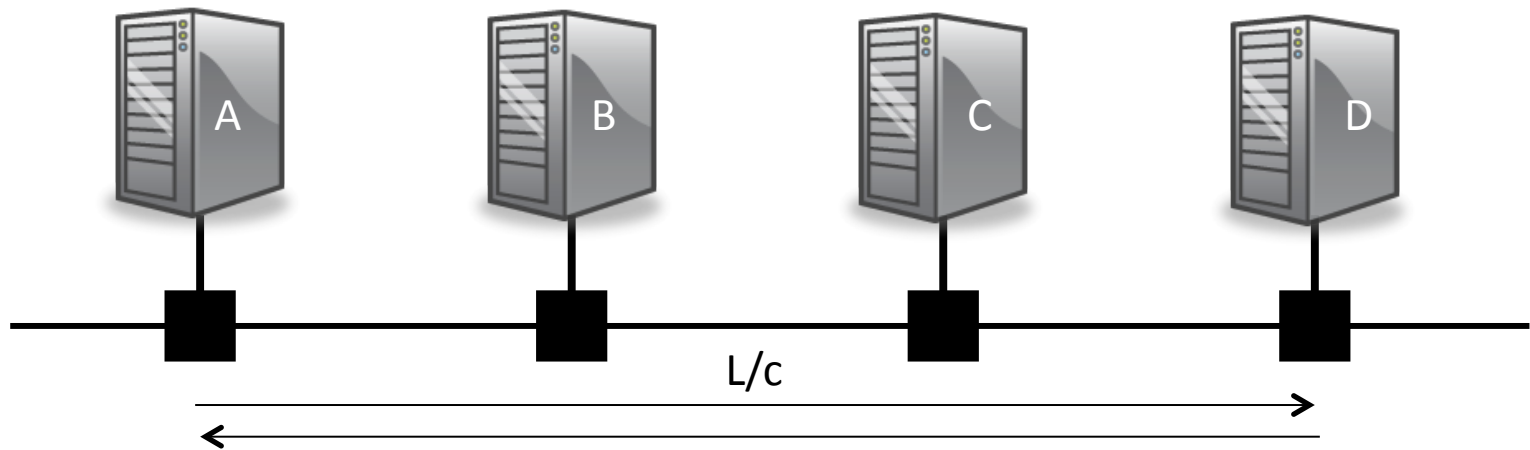For an end host to detect a collision before it finishes transmitting a packet, we require:

$$\frac{P}{R} \geq \frac{2L}{c}$$

where P is the size of a packet.

CSMA/CD Packet size requirement

Example:

$R = 10$Mb/s, $L = 10,000$m, $c = 2 \times 10^8$ m/s.

L/c

$$\frac{P}{R} \geq \frac{2L}{c}$$

$$\therefore P_{\min} = \frac{2LR}{c} = \frac{2 \times 10^{11}}{2 \times 10^8} = 1,000 \; bits.$$

<end>