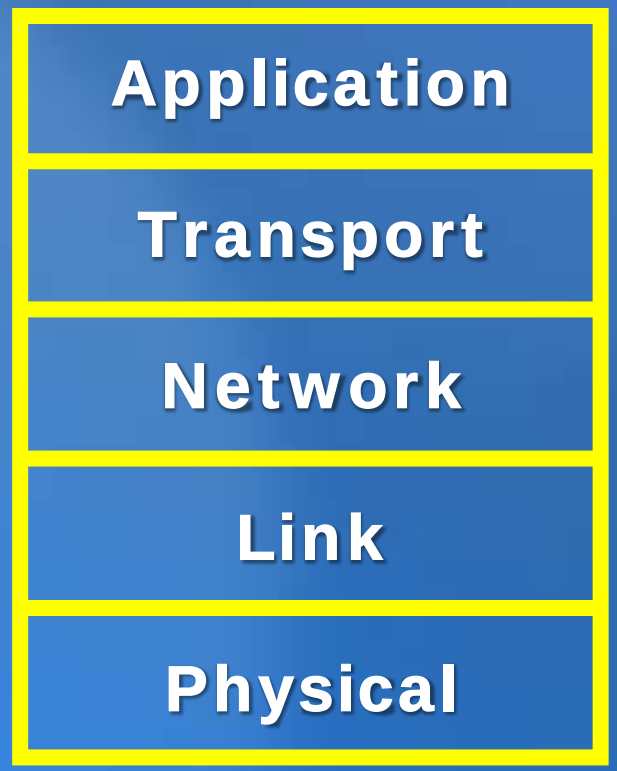
IP Protocol Stack

Internet protocol stack



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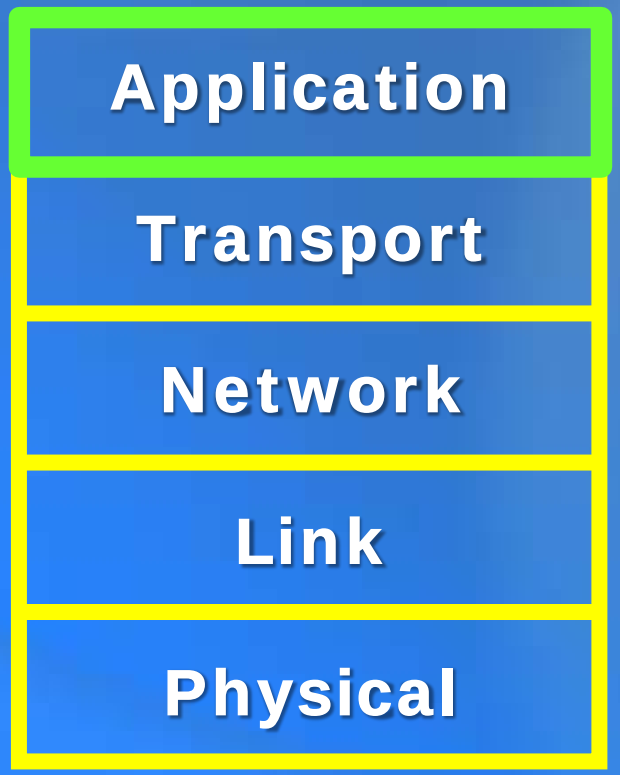


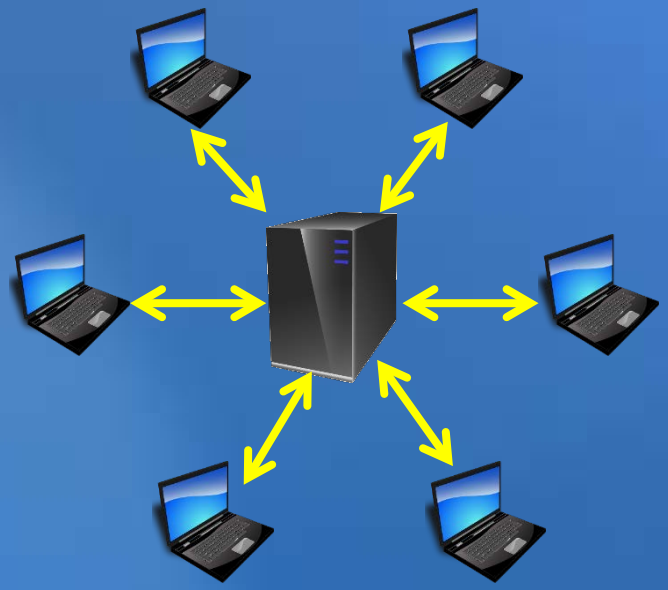
Application Layer

- The applications we run
  - e-mail
  - web browsing
  - instant messaging
  - P2P file sharing
  - multi-user network games
  - video streaming
  - video conferencing
  - Voice over IP
- Runs in hosts

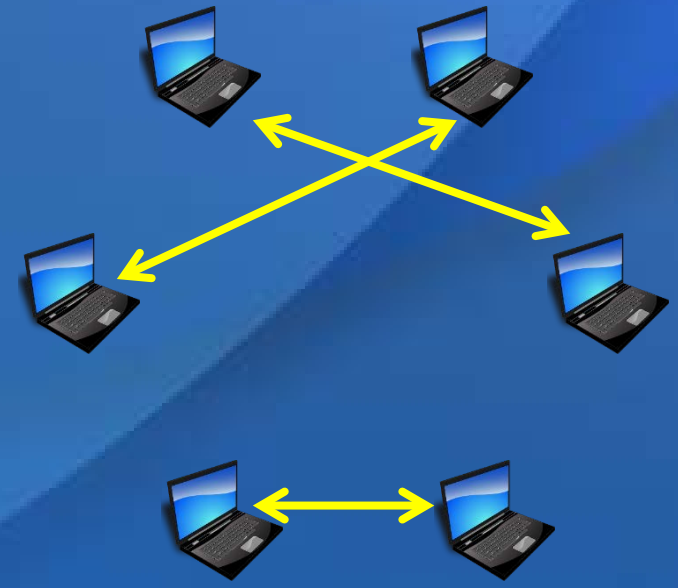
Application architectures

Client-server

- HTTP
- DNS



Peer-to-peer (P2P)



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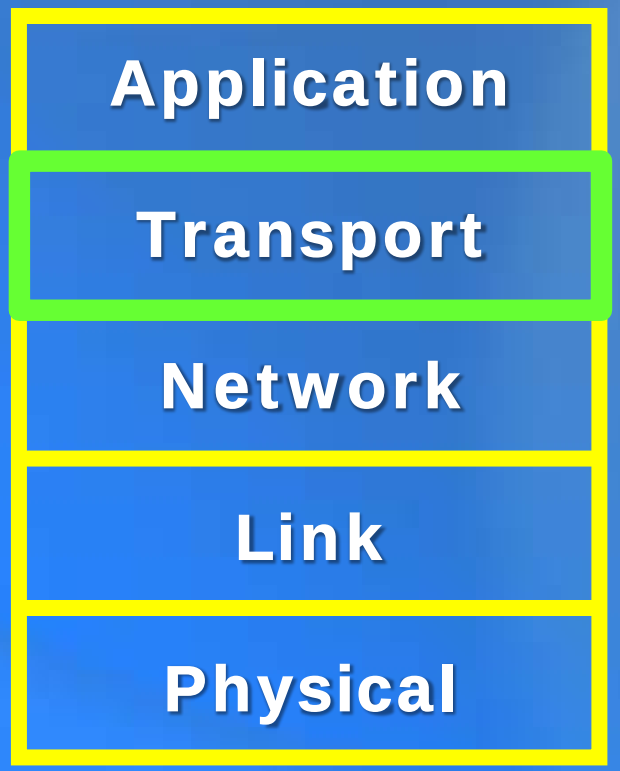


Transport layer

- provides for logical communication between applications (processes) running on different hosts

Functions

- **Multiplexing / Demultiplexing**
- Error Detection
- **Reliable Data Transfer**
- Flow Control
- Congestion Control
- Connection Management

Transport-layer protocols

User Datagram Protocol (UDP)

- simple extension of IP in network layer
- includes error detection
- segments passed to receiver may be missing or out of order

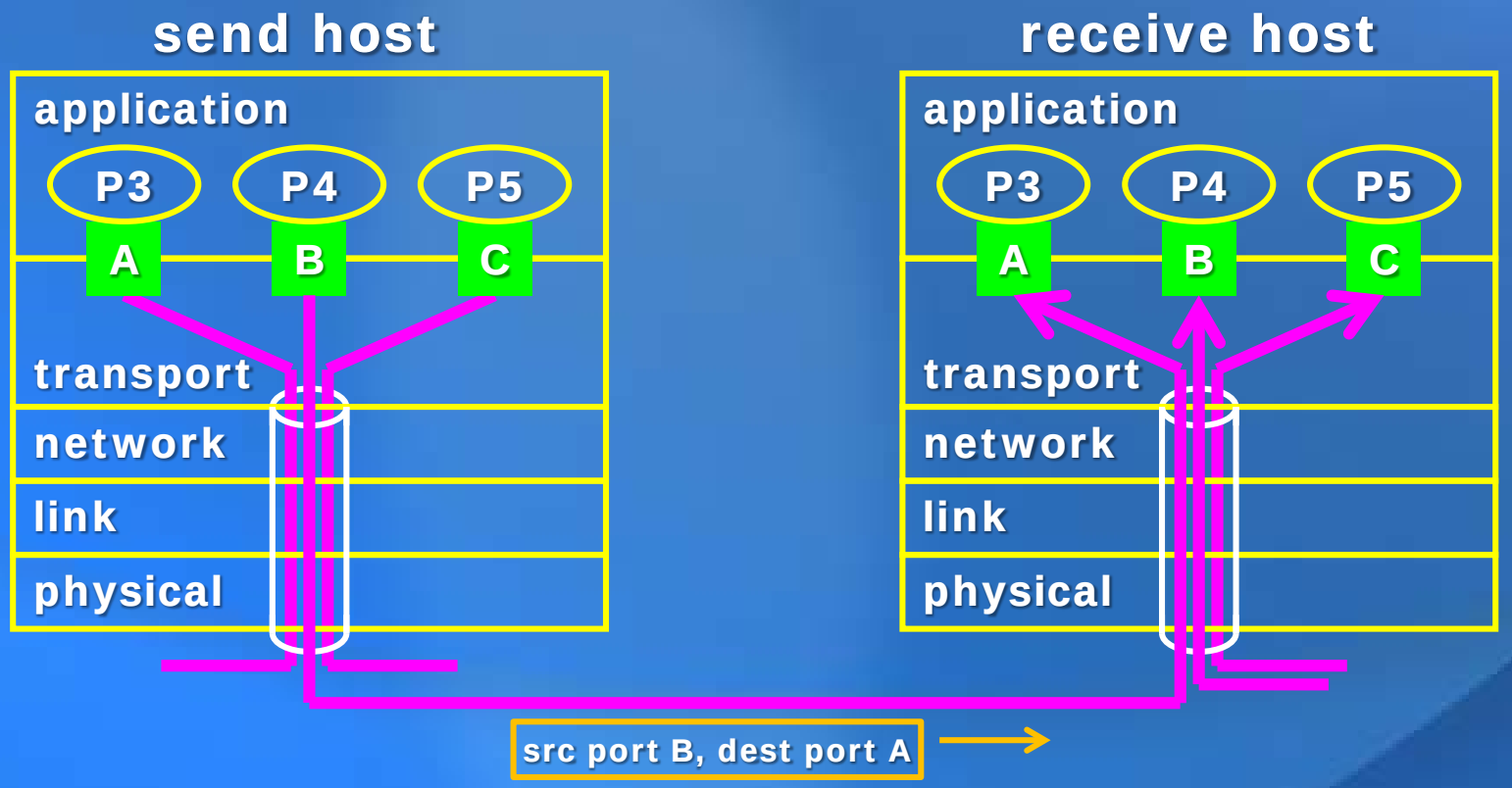
Transmission Control Protocol (TCP)

- segments passed to receiver reliably and in order
- additional services

Multiplexing / Demultiplexing

Send host transport layer gathers messages from multiple sockets

Receive host transport layer delivers segments to correct sockets



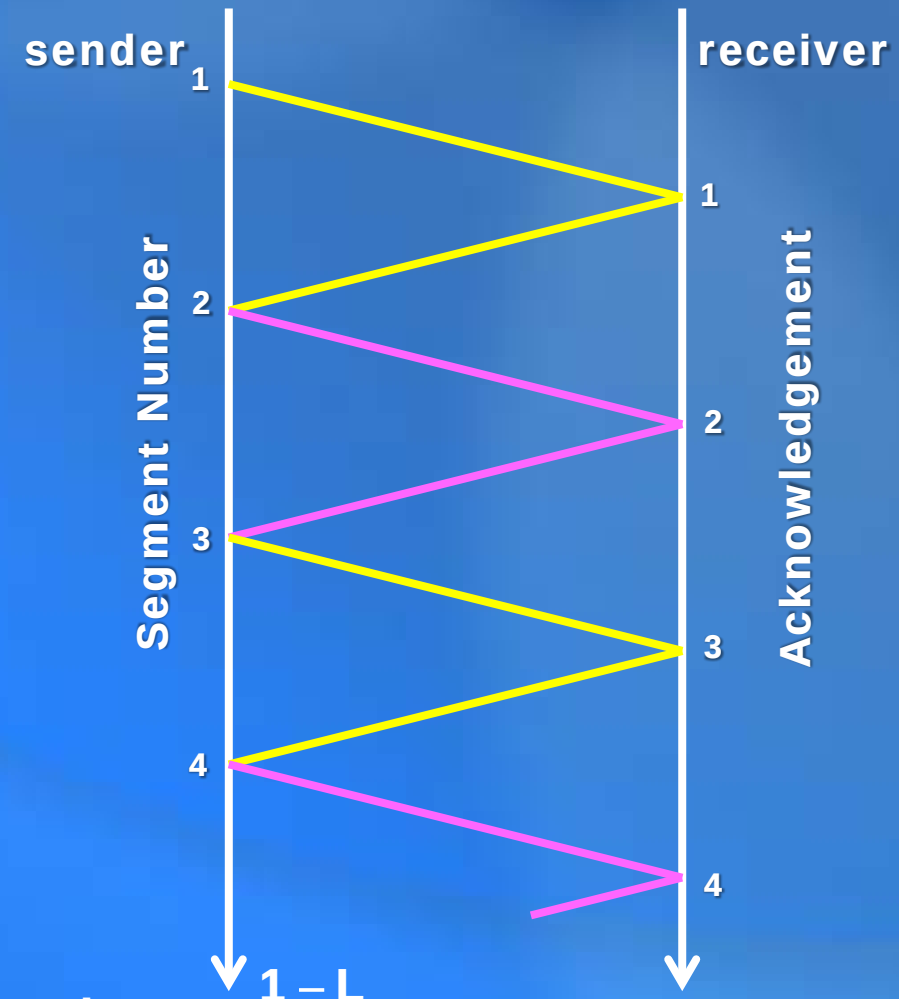
Process P

Socket C

Door between application (process) and transport layer

Reliable Transport

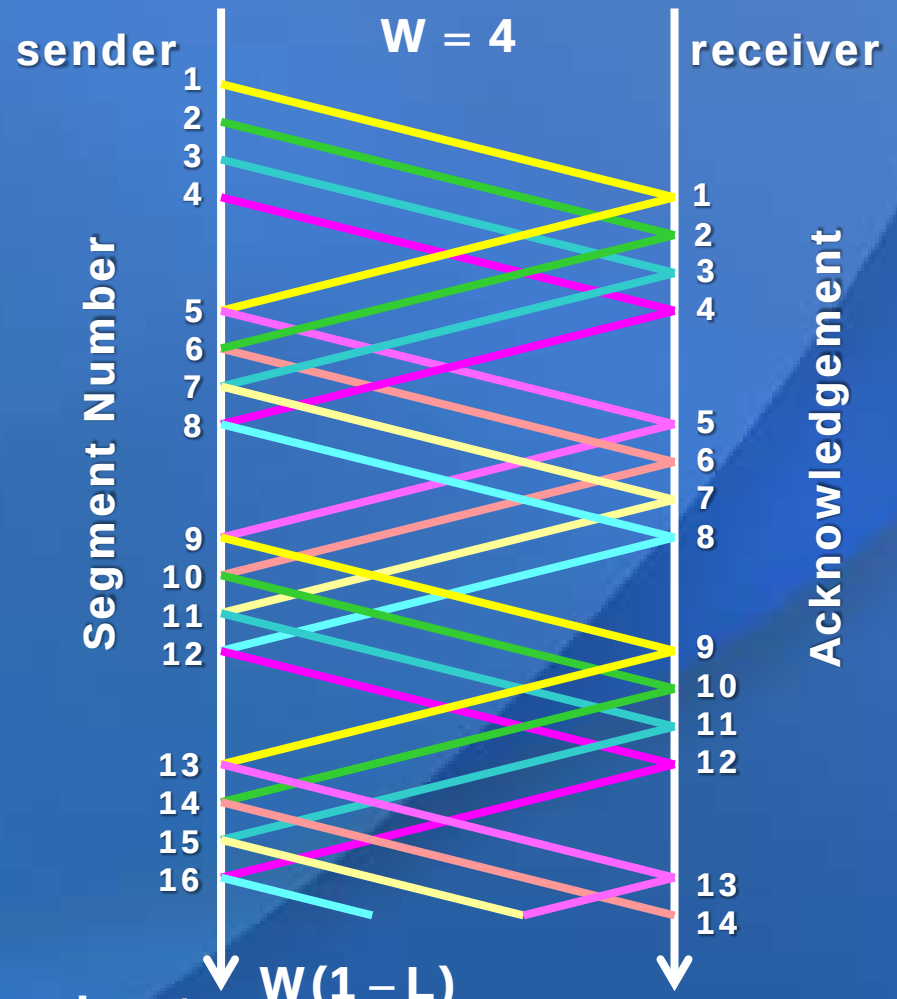
Stop and Wait



$$\text{Throughput} = \frac{1 - L}{RTT}$$

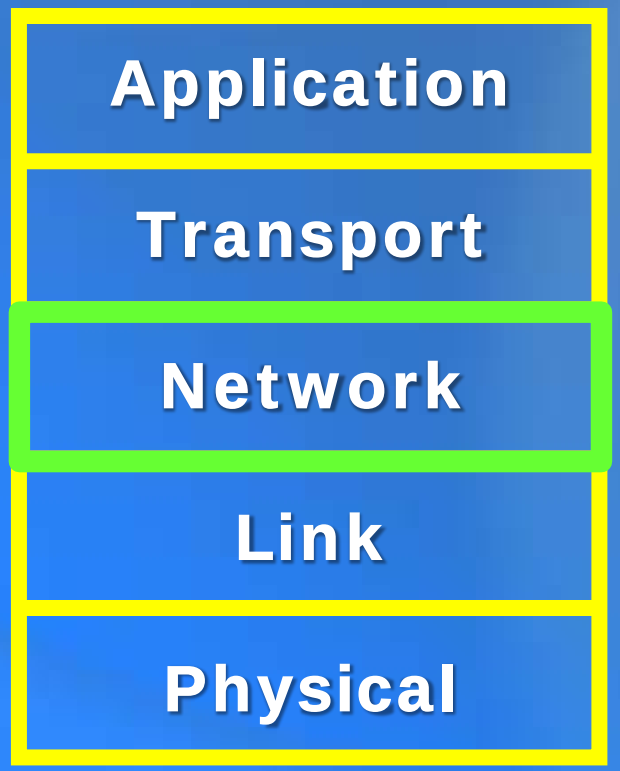
L = loss probability

Sliding Window



$$\text{Throughput} = \frac{W(1 - L)}{RTT}$$

Internet protocol stack



Network layer

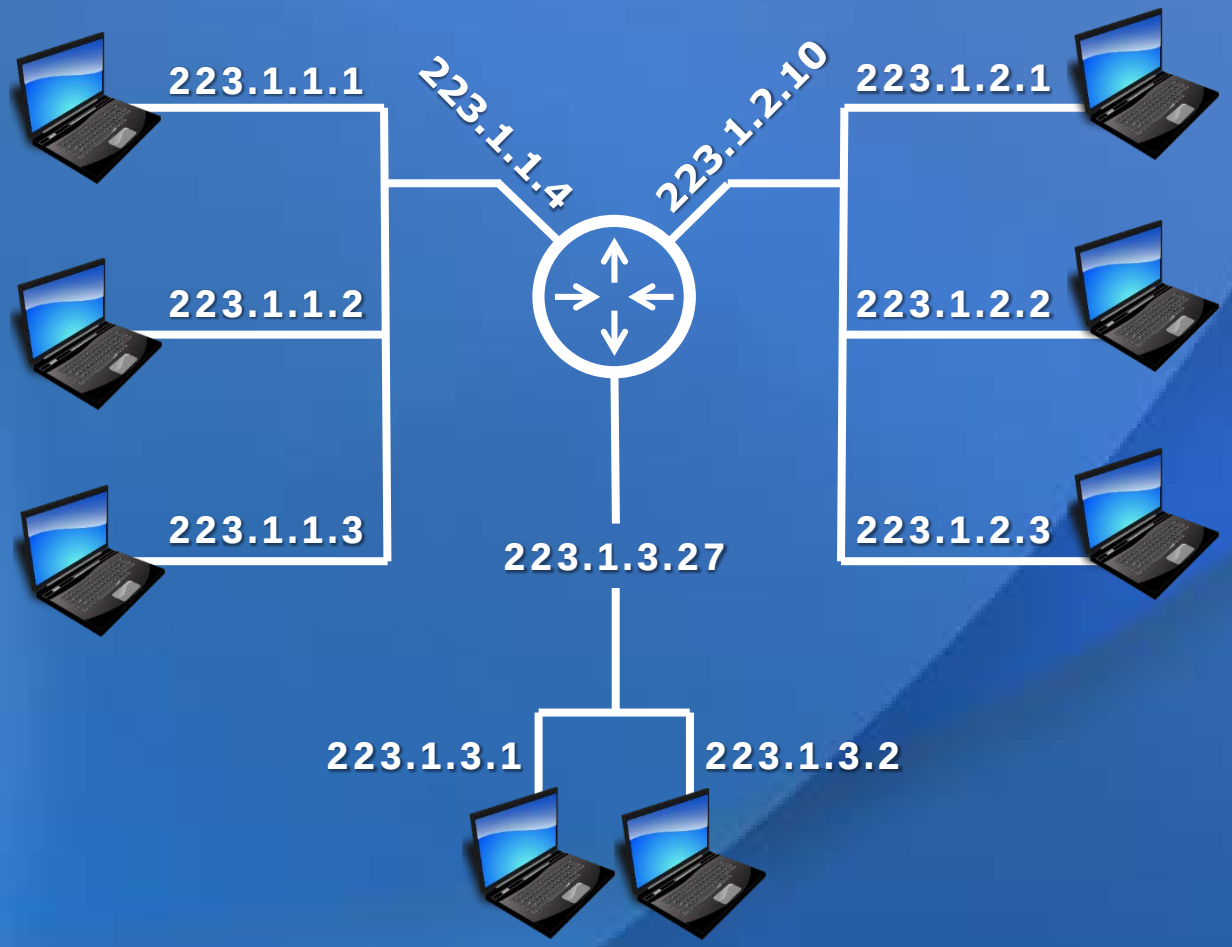
- delivers packets from source to destination over a network
- e.g. Internet Protocol (IP)

Functions

- Encapsulation
- Addressing
- Forwarding
- Routing

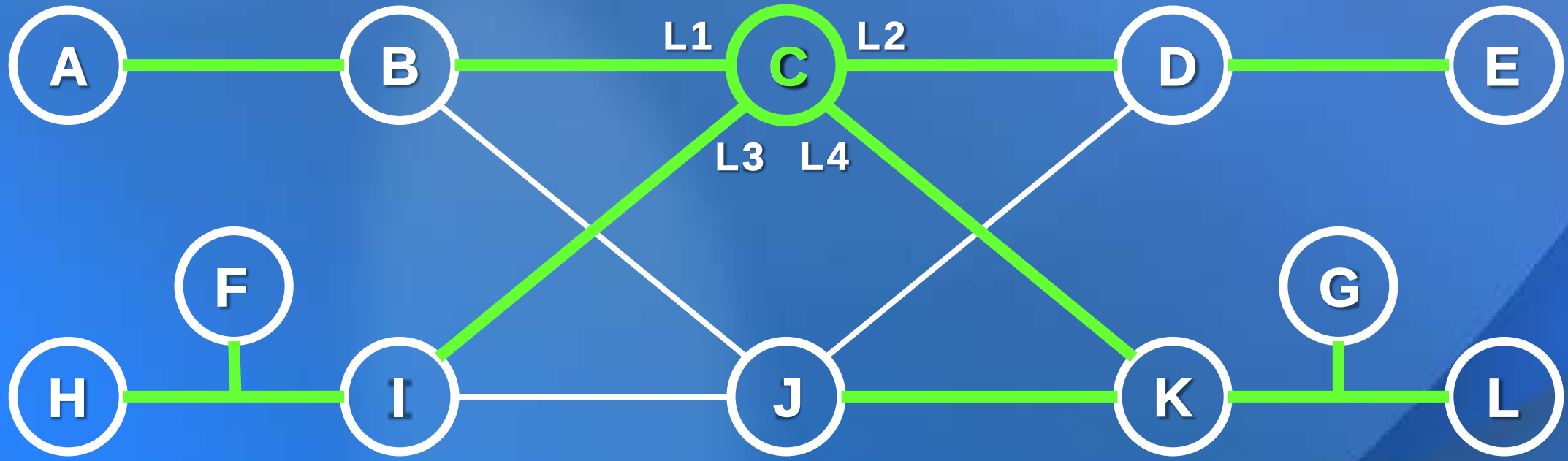
IP Addresses

- An IP (Internet Protocol) address is a unique global address for a network interface
- Network interface: connection between host/ router and physical link
  - routers typically have many interfaces
  - host typically has one or two interface (e.g. wired/wireless)



Forwarding

Given best path from node C to every other node

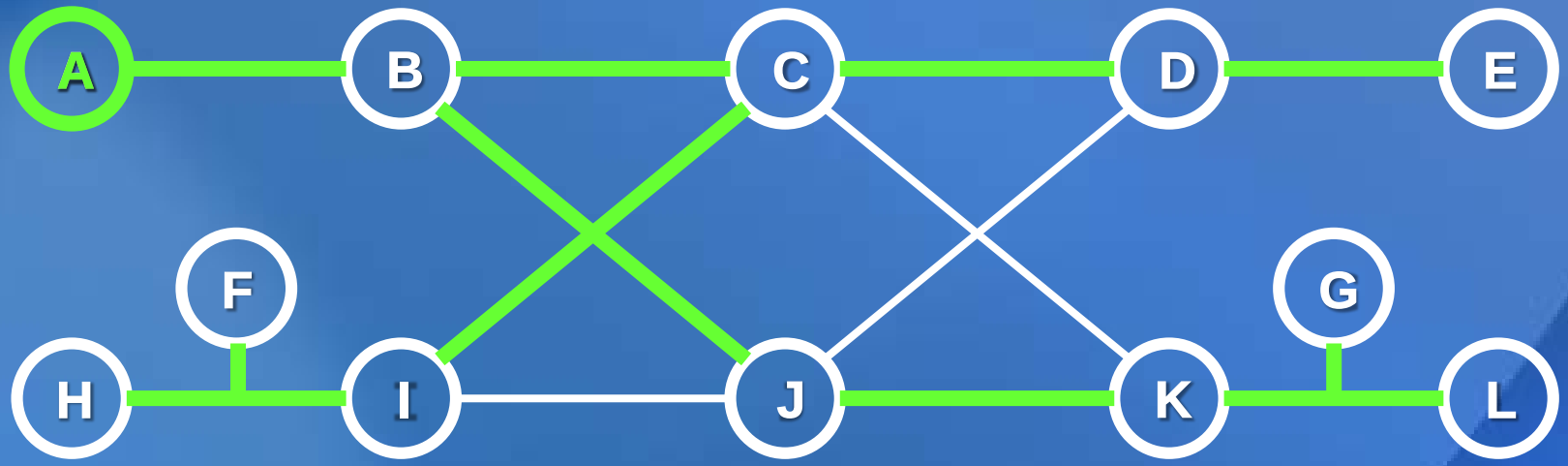


Find forwarding table for node C

dest	A	B	C	D	E	F	G	H	I	J	K	L
output	L1	L1	-	L2	L2	L3	L4	L3	L3	L4	L4	L4

Routing

Find best path from node A to every other node



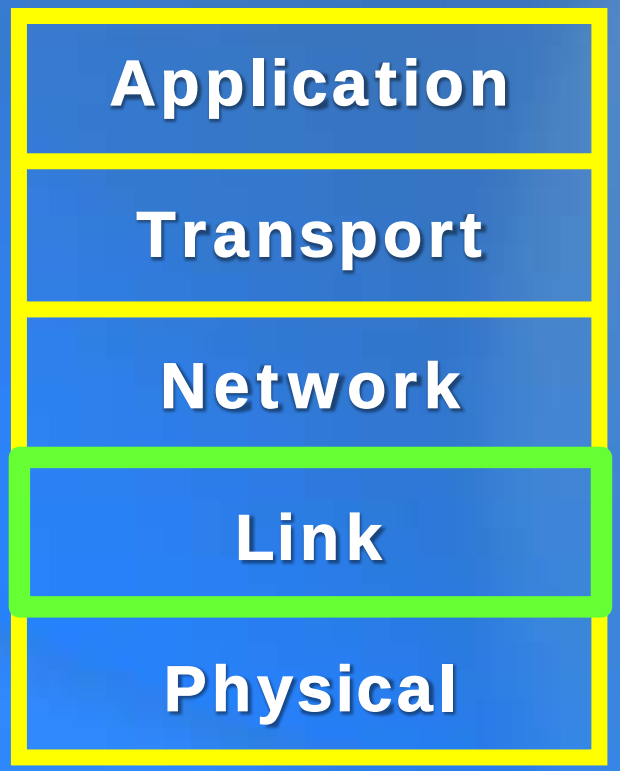
Distance Vector Algorithm

- Decentralized
- Iterative computation via message passing between nearest neighbors

Link State Algorithm

- Global
- All nodes have estimate of network topology
- Message flooding

Internet protocol stack



Link layer

- handles data transfer from one node to a physically adjacent node
- e.g. 802.11 (WiFi)

Services

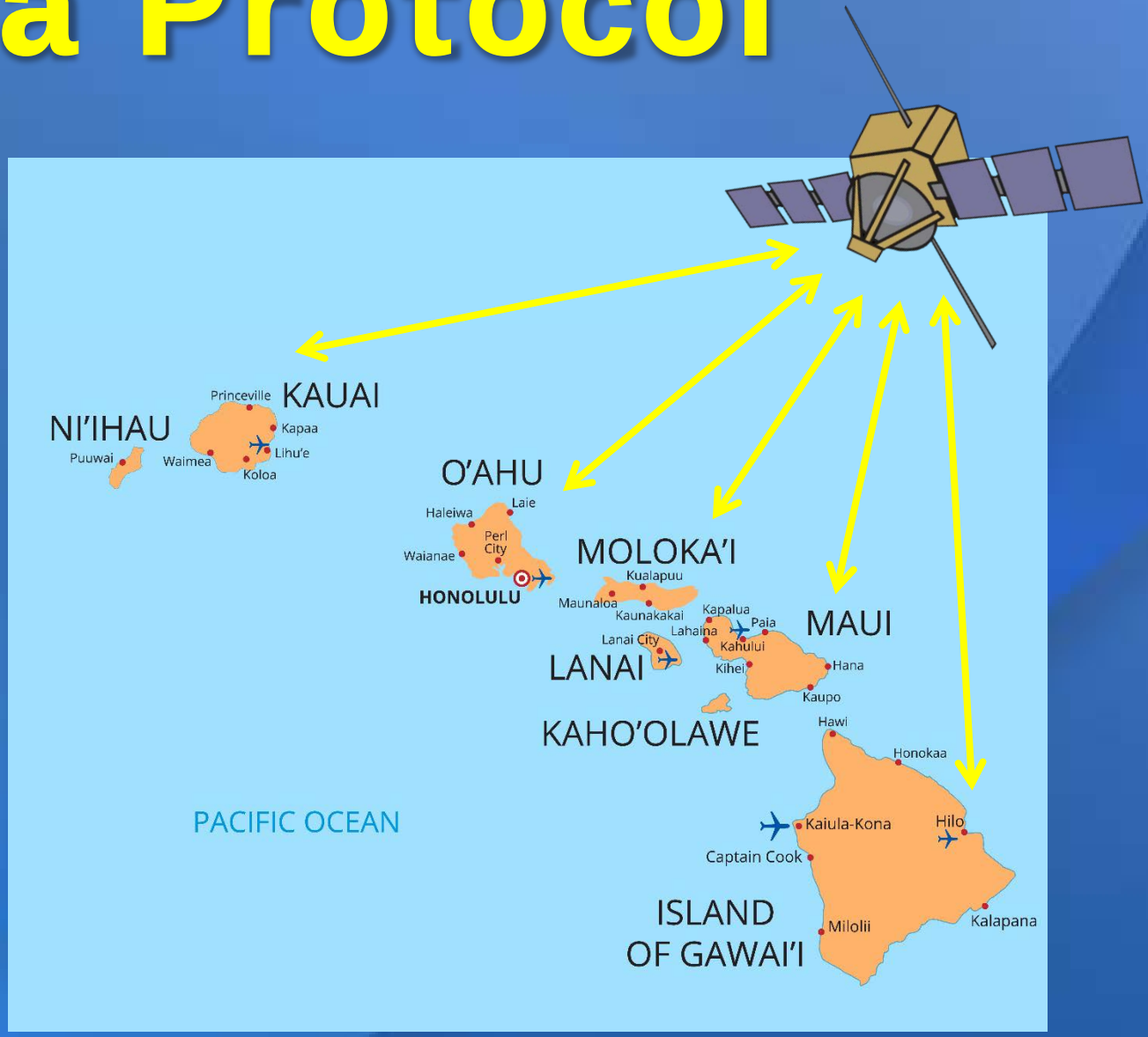
- framing
- error detection/correction
- flow control
- media access control (MAC)

The Aloha Protocol

Simple example of a randomized contention protocol.

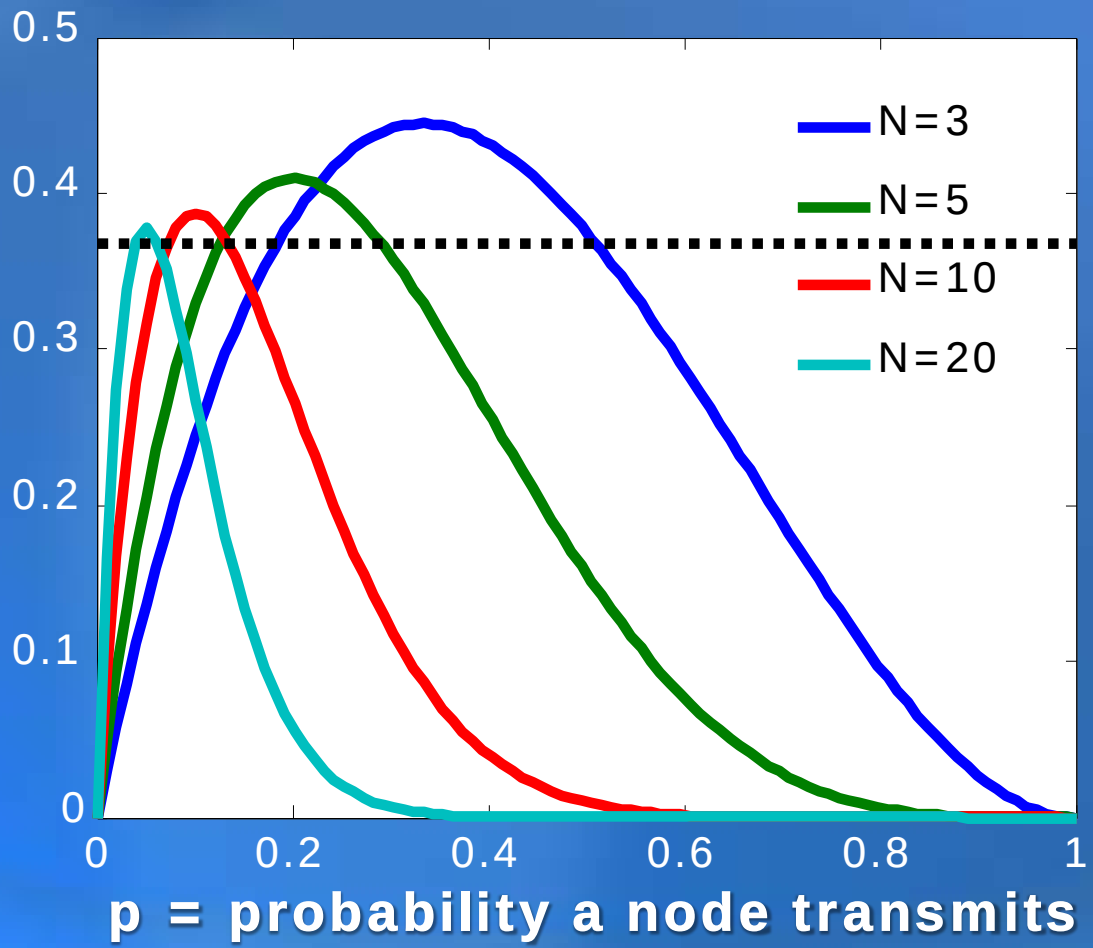
Each node executes

- **If have packet, then transmit.**
- **If a collision is detected, each node waits a random amount of time before re-transmitting the packet.**
  - **These nodes are said to be backlogged.**



Efficiency of Slotted Aloha

Efficiency:
The fraction of time slots with a successful transmission

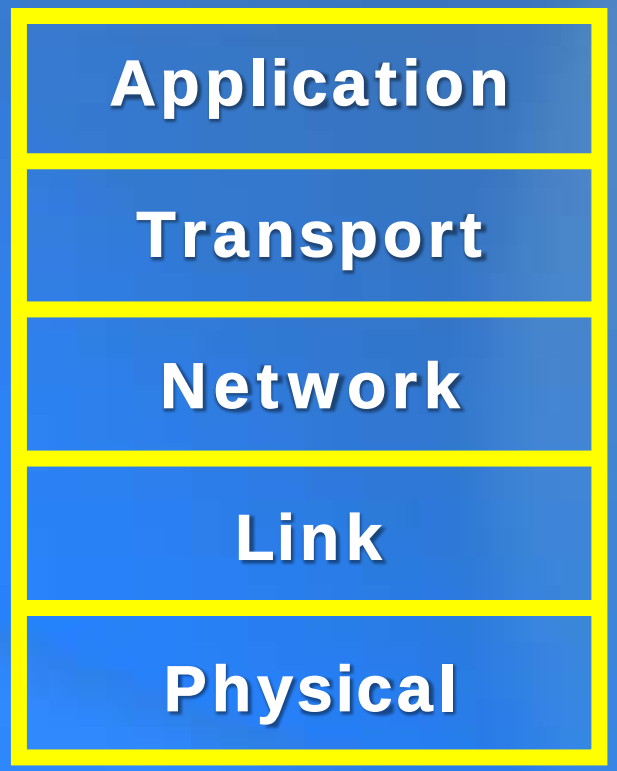


N = # of nodes

For max efficiency, p = 1/N

As N → ∞, efficiency → 37%

Internet protocol stack



- Application layer runs applications, e.g. email, web browser, messaging
- Transport layer provides for logical communication between applications
- Network layer delivers packets from source to destination over a network
- Link layer handles data transfer from between adjacent nodes
- Physical layer deals with properties of medium (e.g. wired/wireless)