

Introduction to Networking

Zane Ma

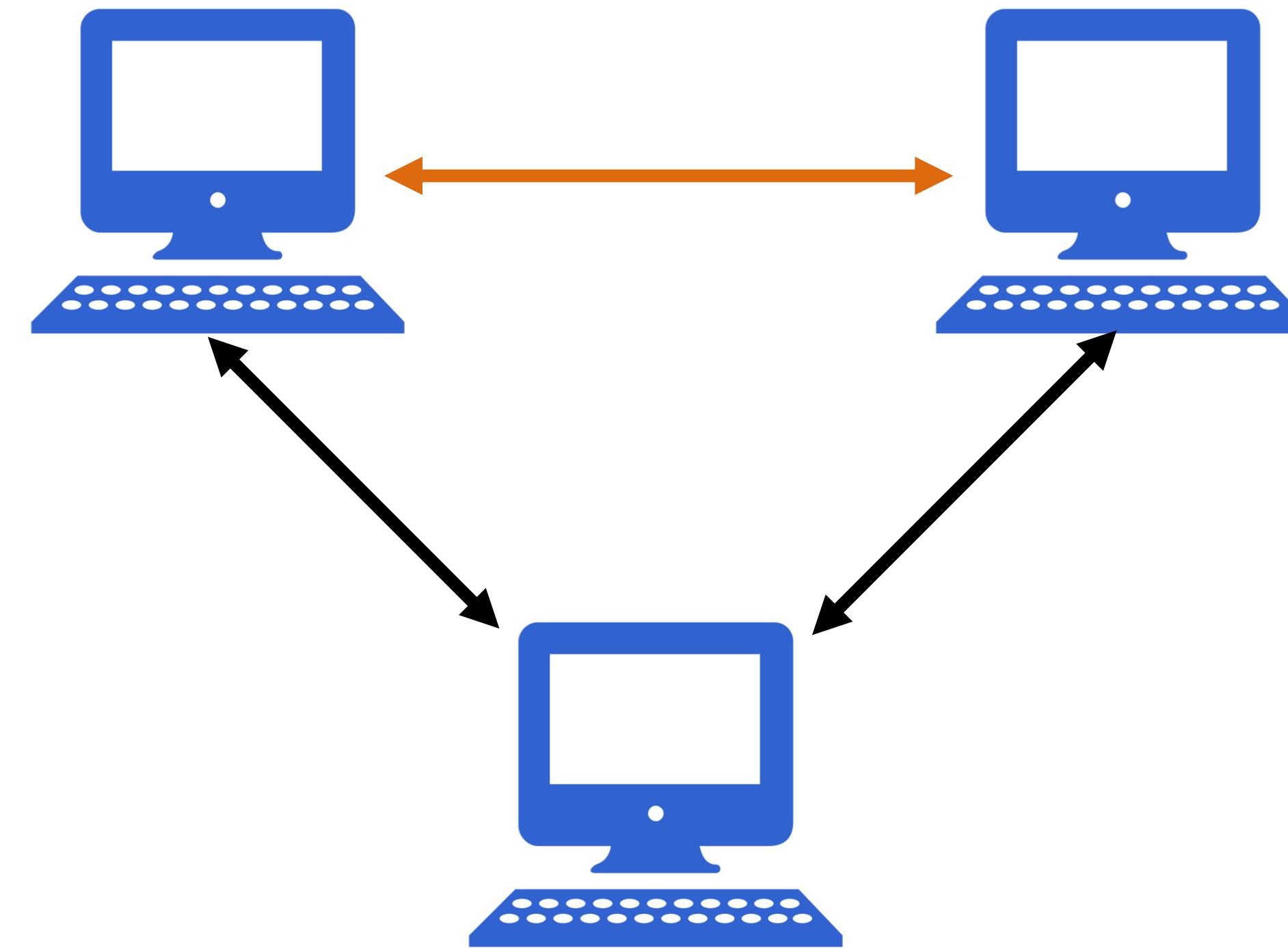
University of Illinois

CS 461 / ECE 422 - Spring 2018



What is Networking?

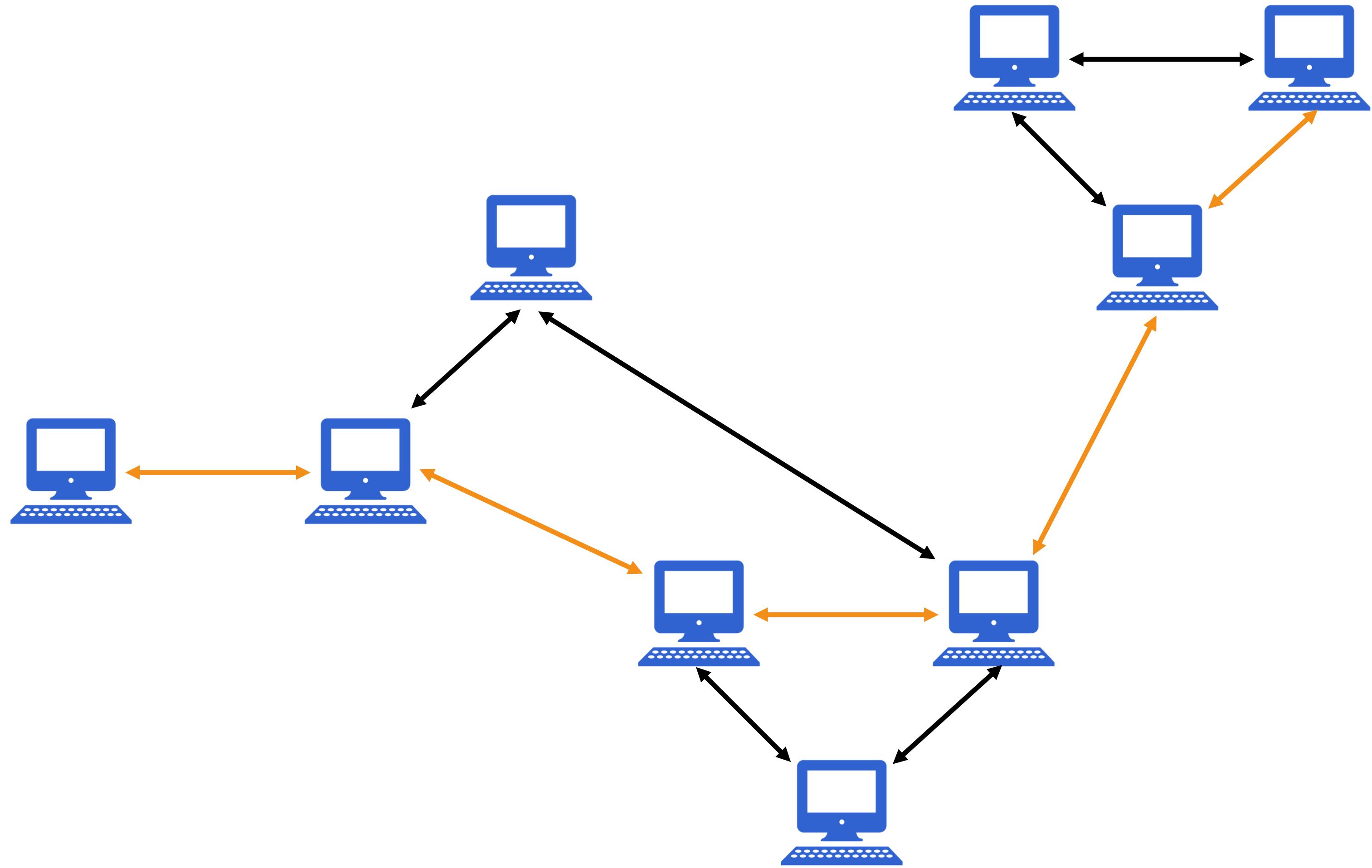
1950s - Simple networks



What is Networking?

1950s - Simple networks

1960s & 70s - Internet

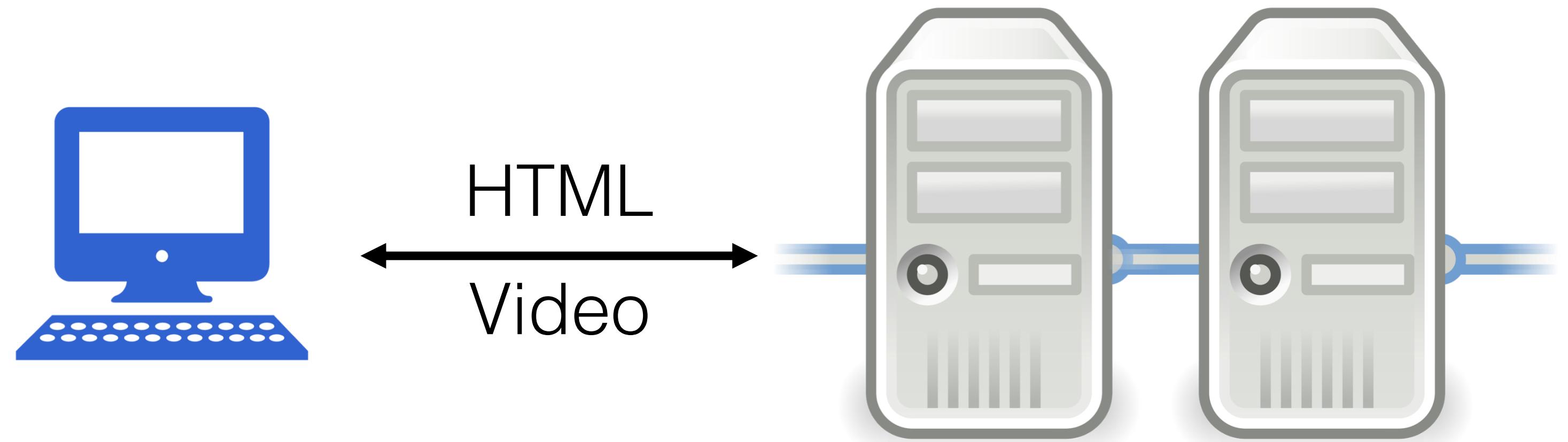


What is Networking?

1950s - Simple networks

1960s & 70s - Internet

1980s & 90s - Web



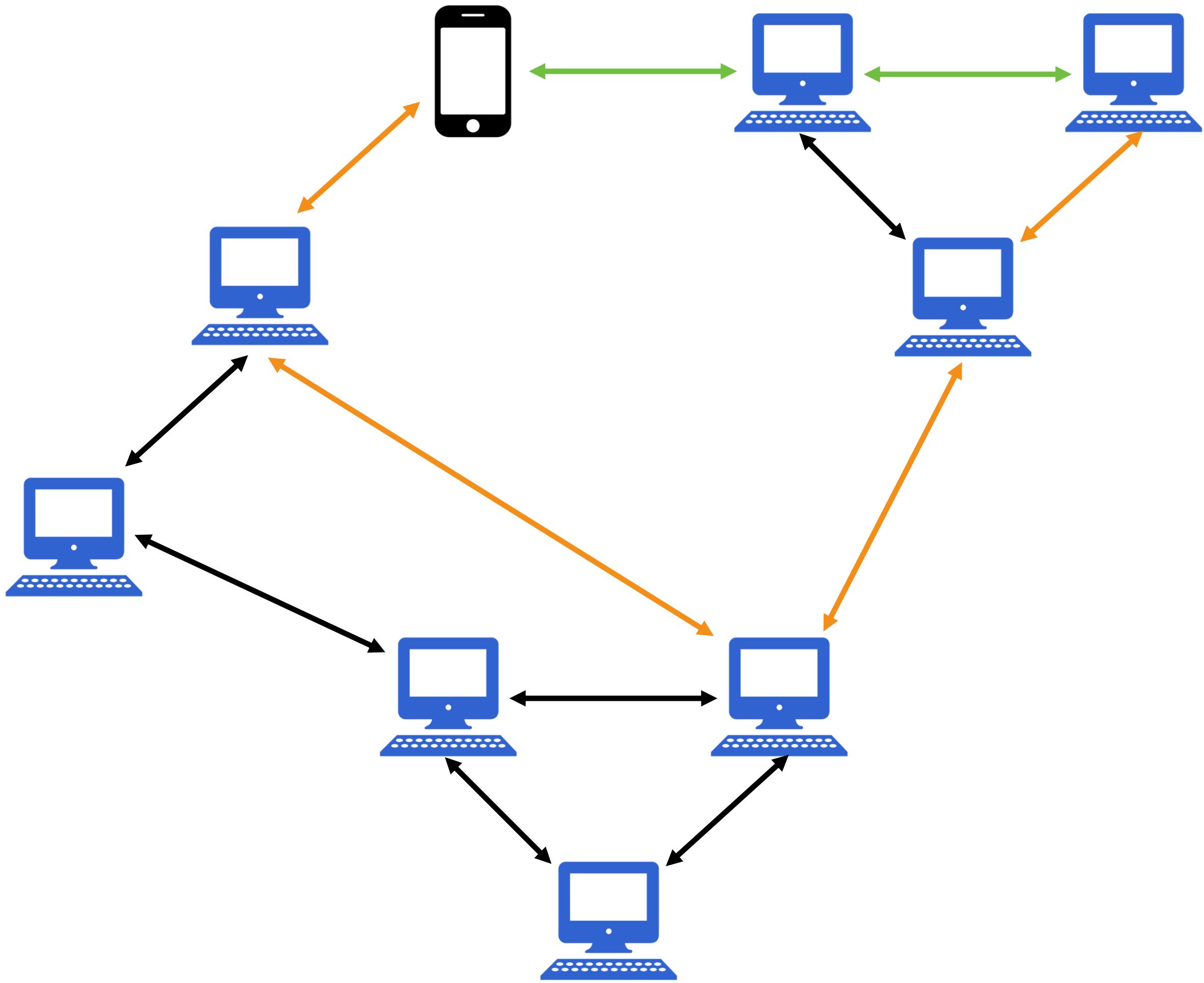
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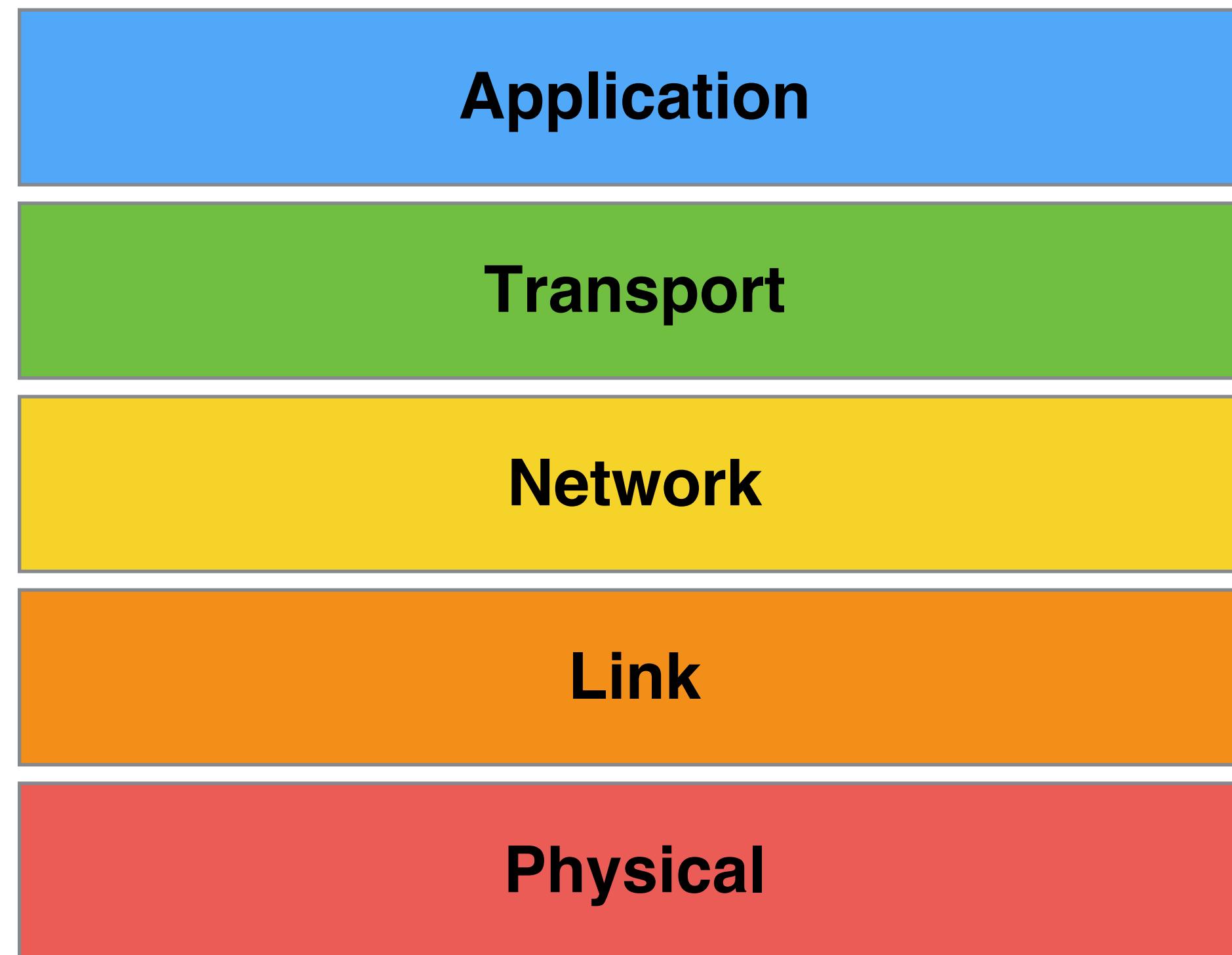
2000s - Mobile



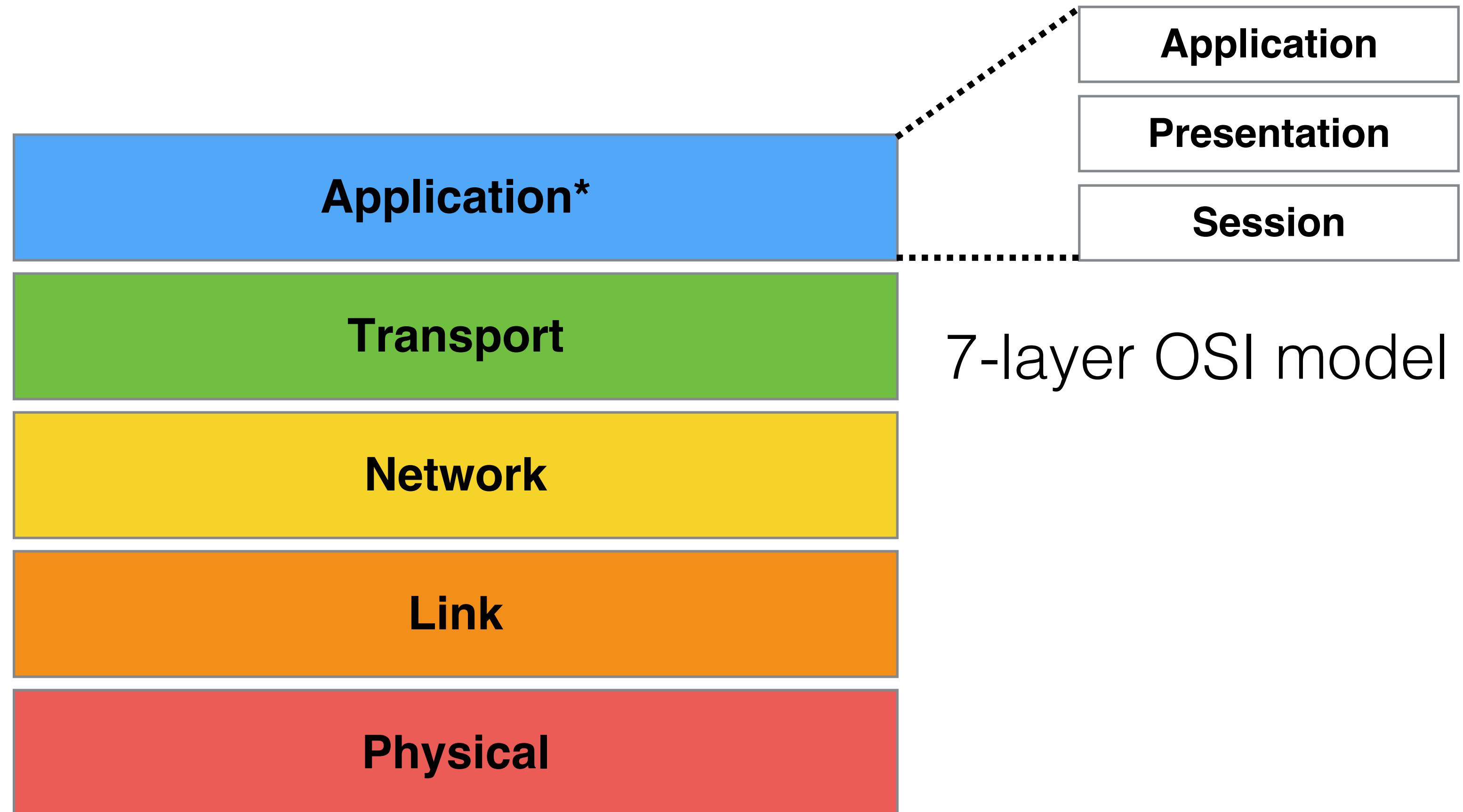
How Does Networking Work?



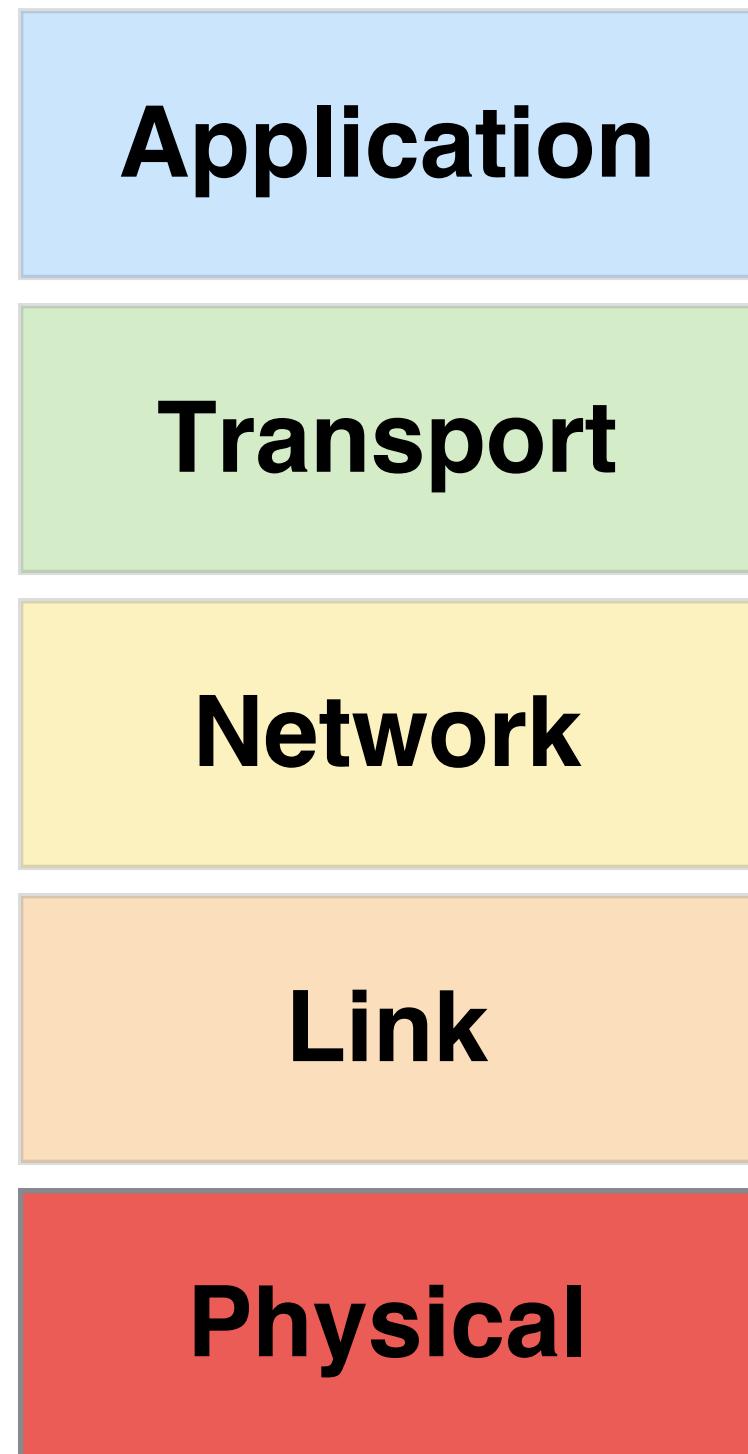
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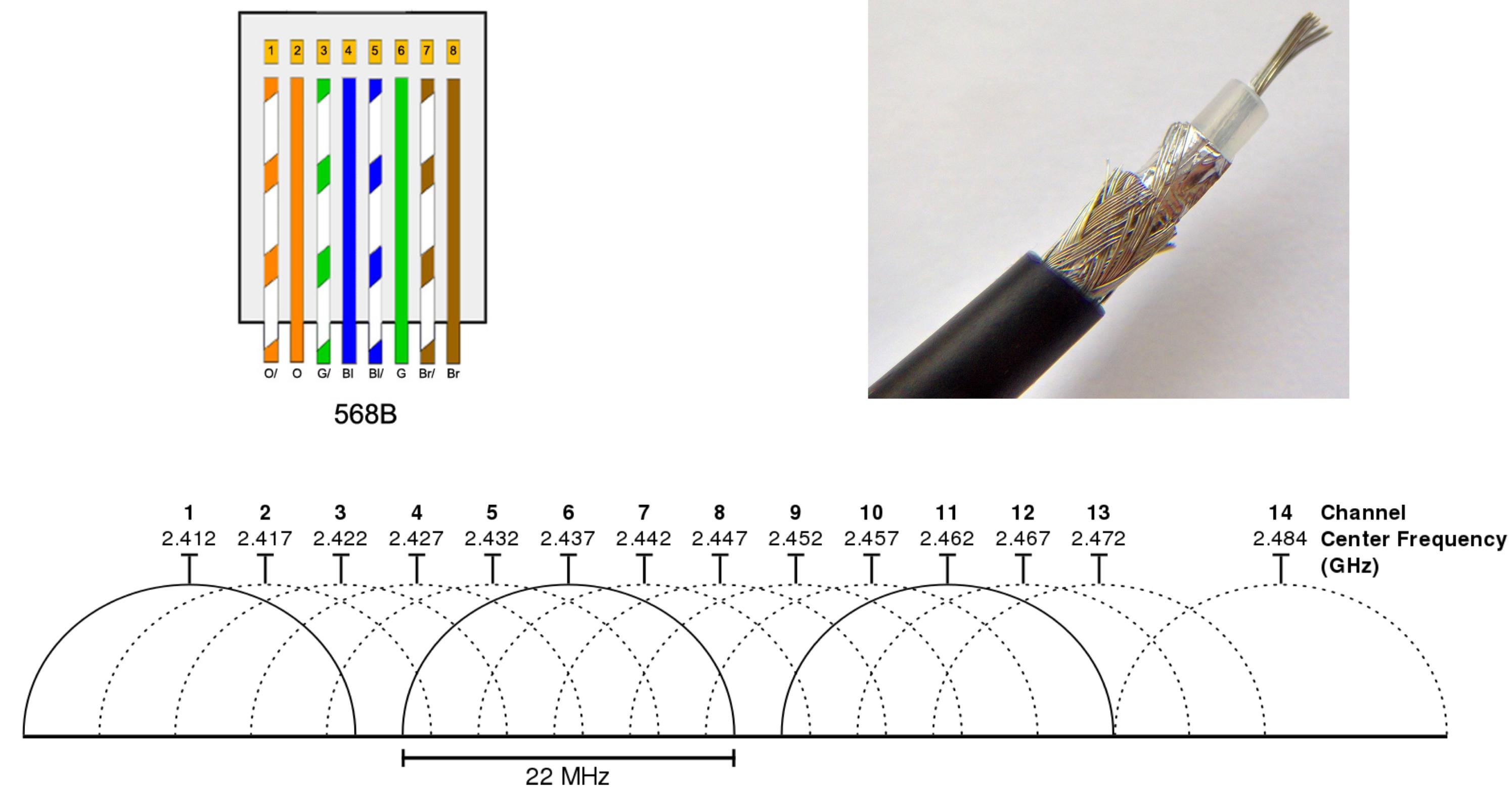
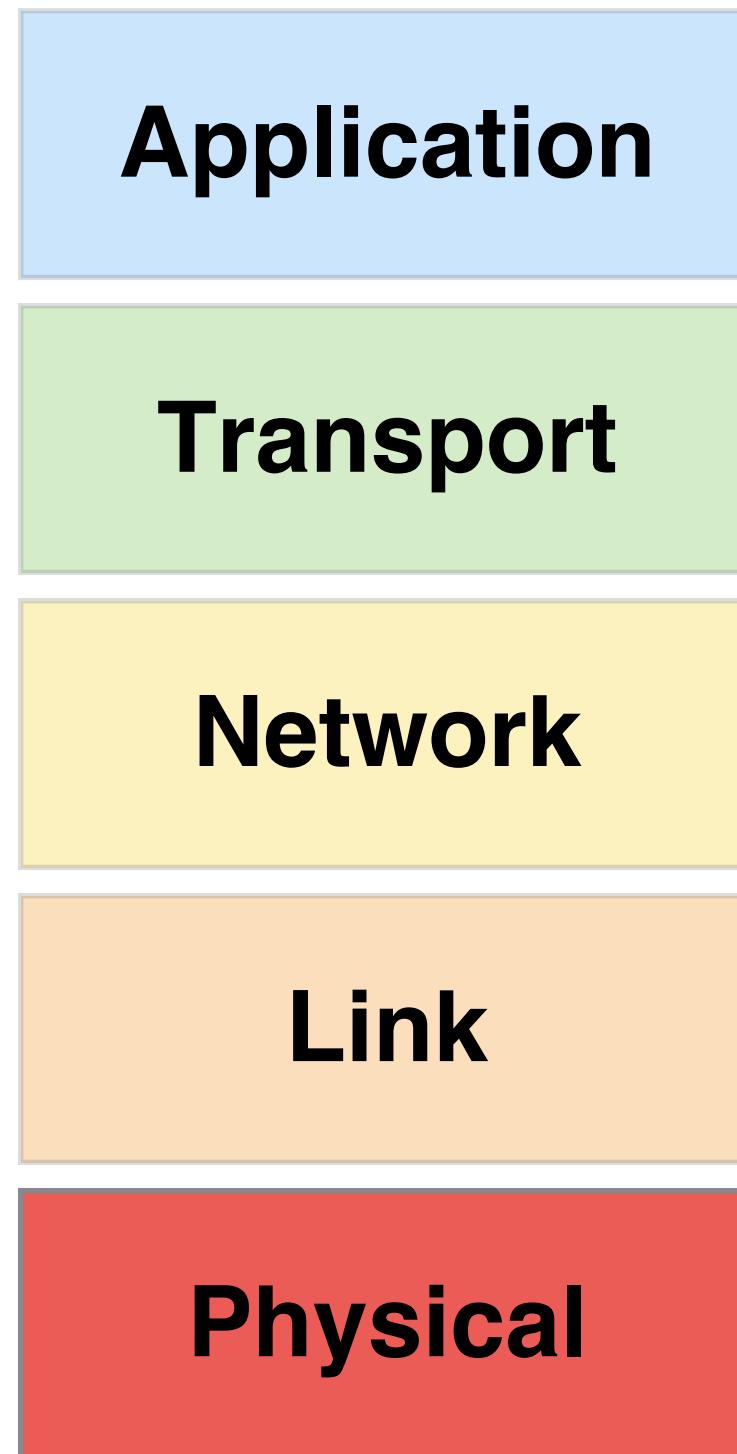
How Does Networking Work?



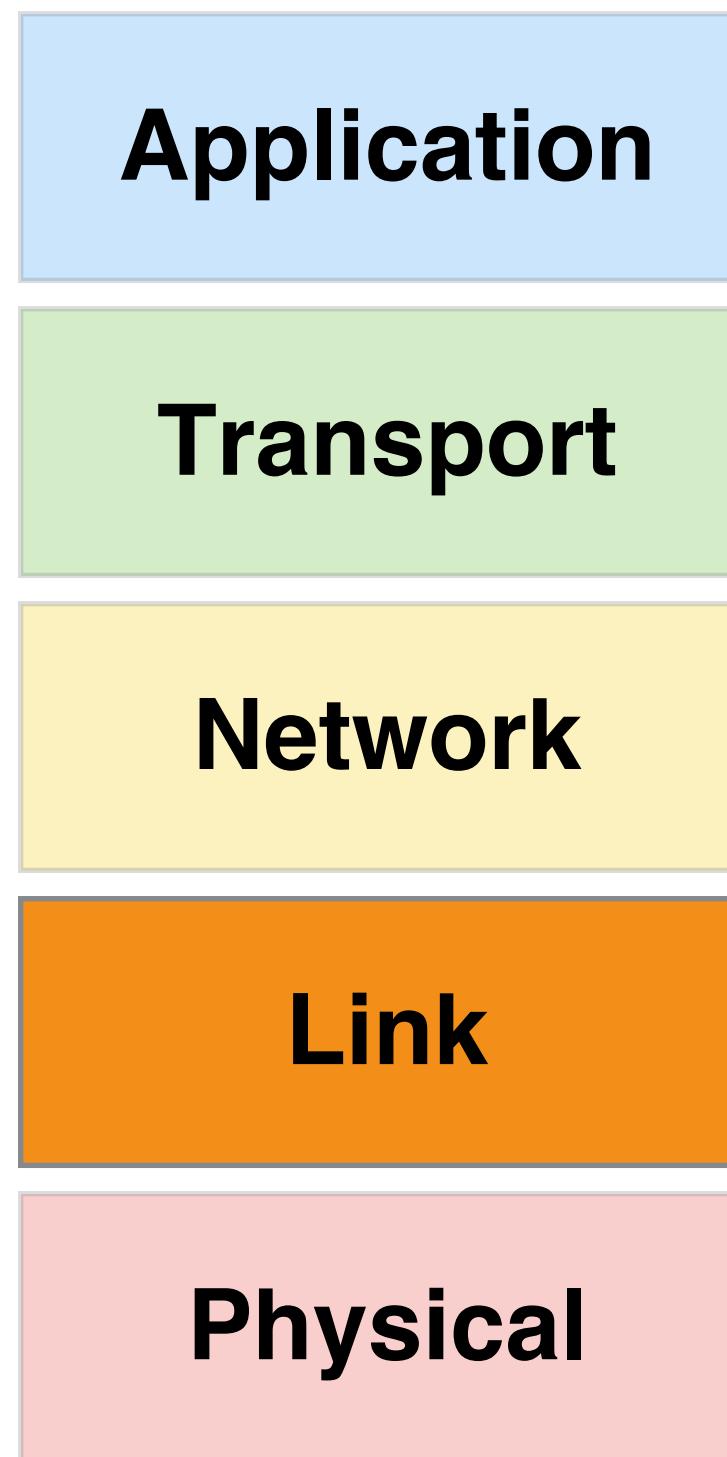
Physical Layer



Physical Layer



Link Layer

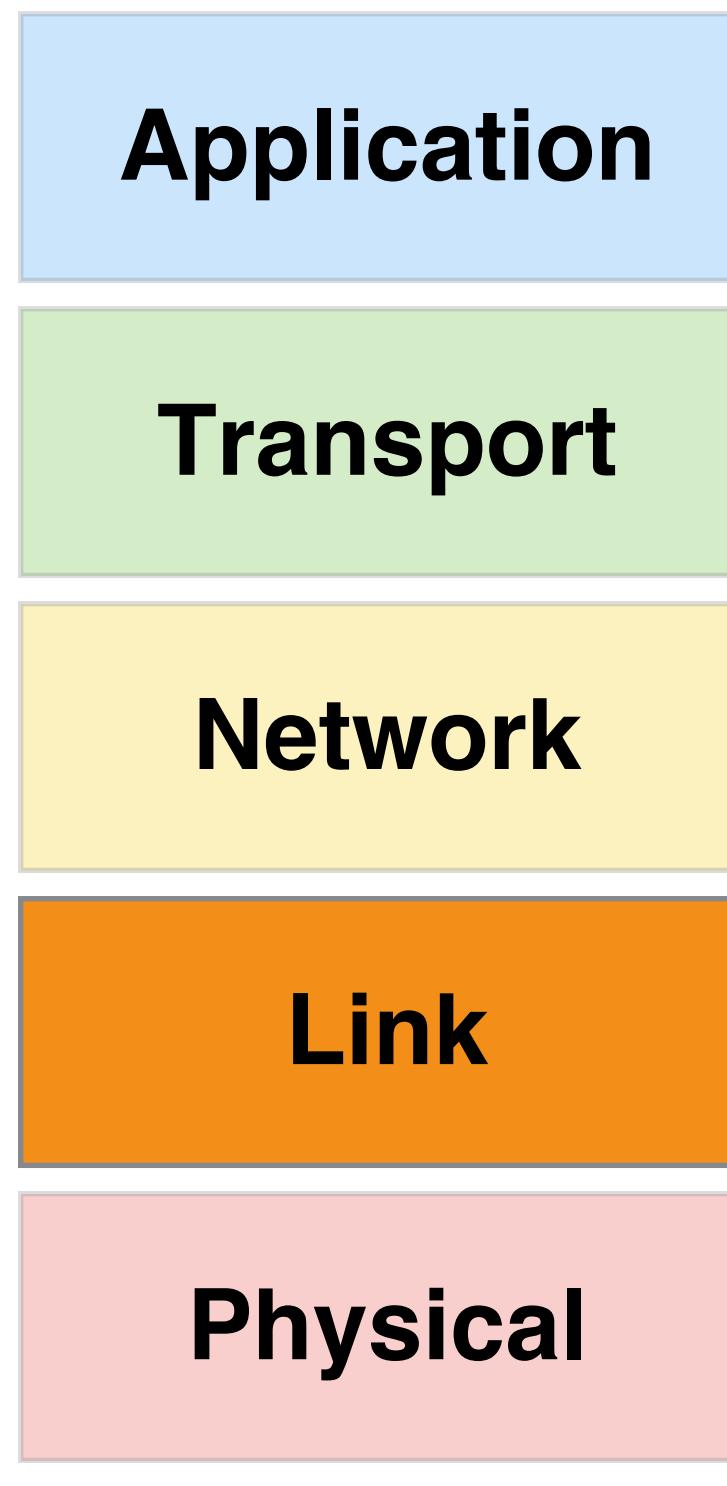


Physically connected node-to-node communication

MAC Address: unique ID for network interface controller



Link Layer



Physically connected node-to-node communication

MAC Address: unique ID for network interface controller

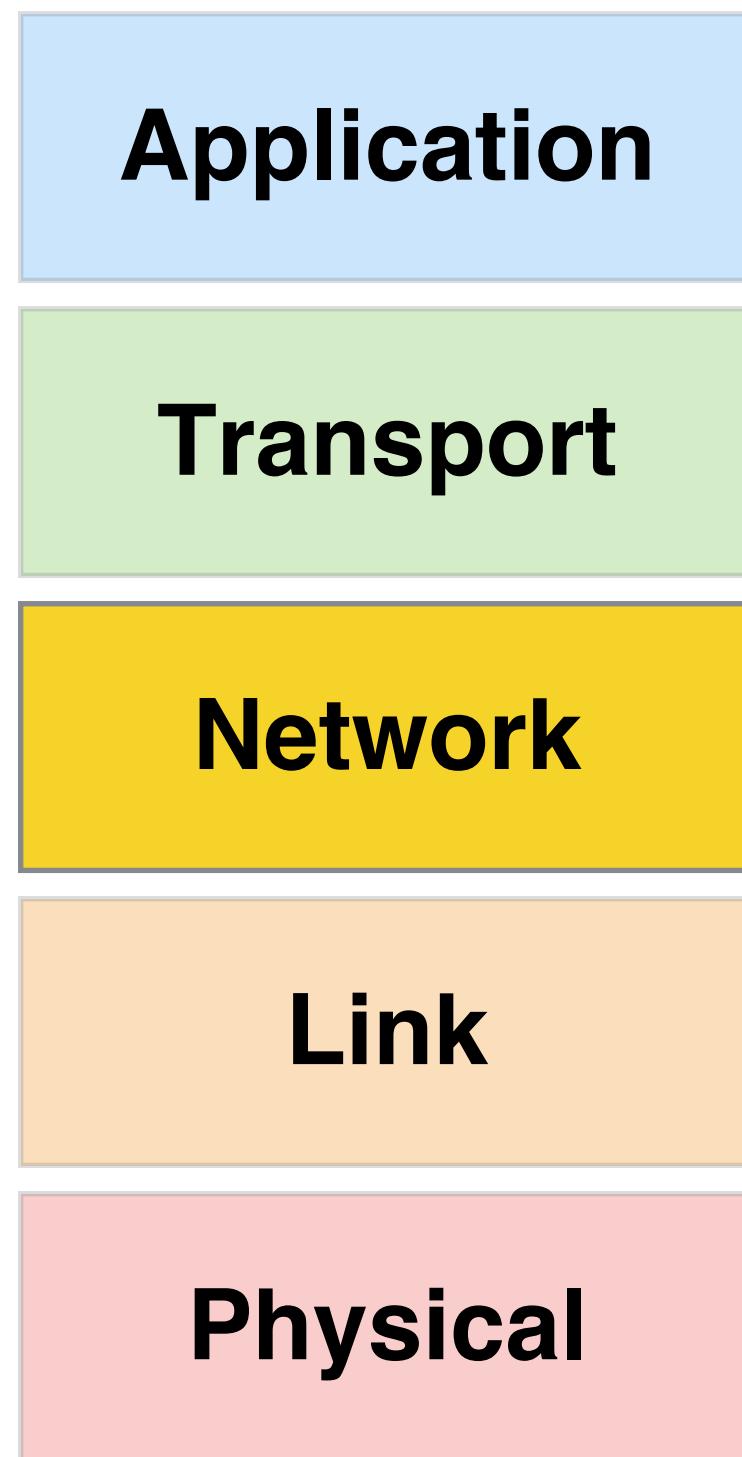
WiFi (802.11)

Ethernet

Preamble	Start of frame delimiter	MAC destination	MAC source	802.1Q tag (optional)	Ethertype (Ethernet II) or length (IEEE 802.3)	Payload	Frame check sequence (32-bit CRC)	Interpacket gap
7 octets	1 octet	6 octets	6 octets	(4 octets)	2 octets	46-1500 octets	4 octets	12 octets



Network Layer

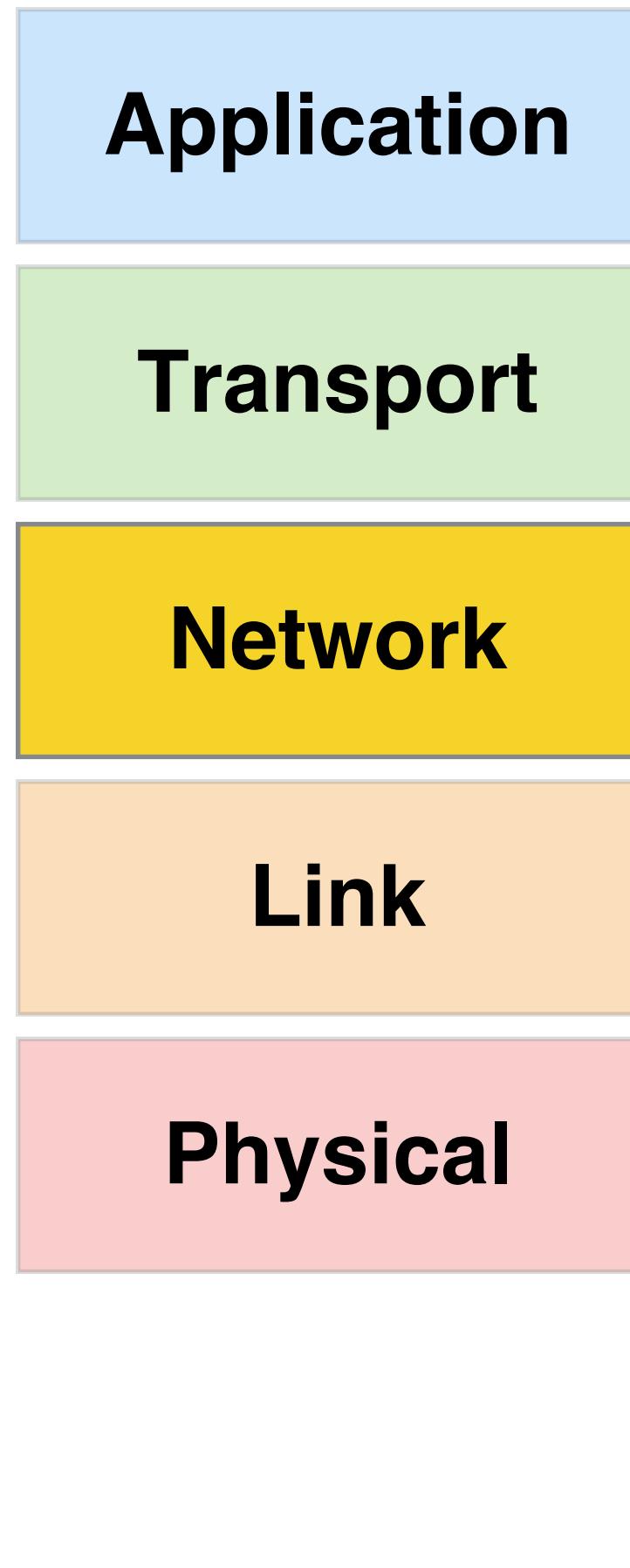


Indirectly connected nodes

IP Address: unique ID for network nodes



Network Layer



Indirectly connected nodes

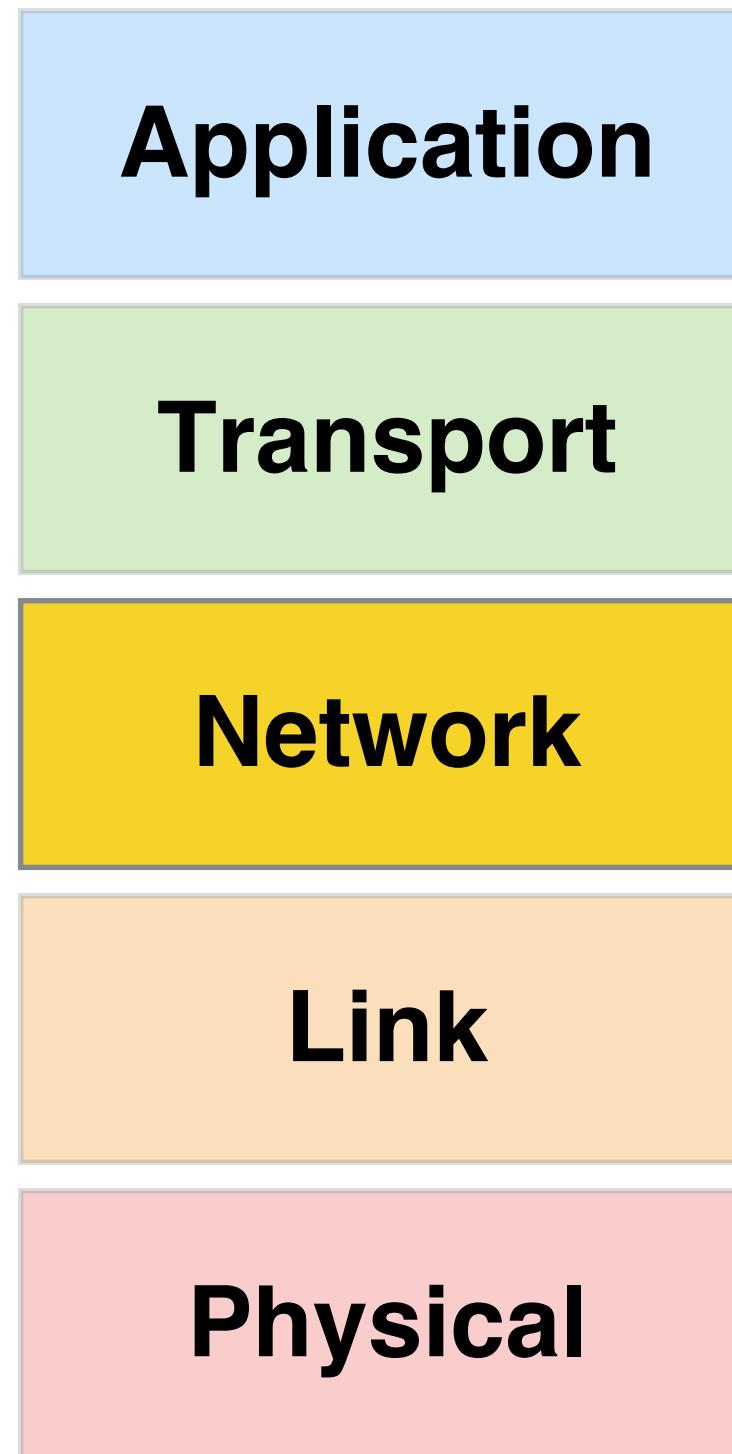
IP Address: unique ID for network nodes

IPv4 Header Format

Offsets	Octet	0								1								2								3																																								
Octet	Bit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31																																	
0	0	Version				IHL				DSCP				ECN				Total Length																																																
4	32	Identification																Flags				Fragment Offset																																												
8	64	Time To Live								Protocol								Header Checksum																																																
12	96	Source IP Address																																																																
16	128	Destination IP Address																																																																
20	160																																																																	
24	192																																																																	
28	224	Options (if IHL > 5)																																																																
32	256																																																																	
Data Payload																																																																		



Network Layer



How does routing work?

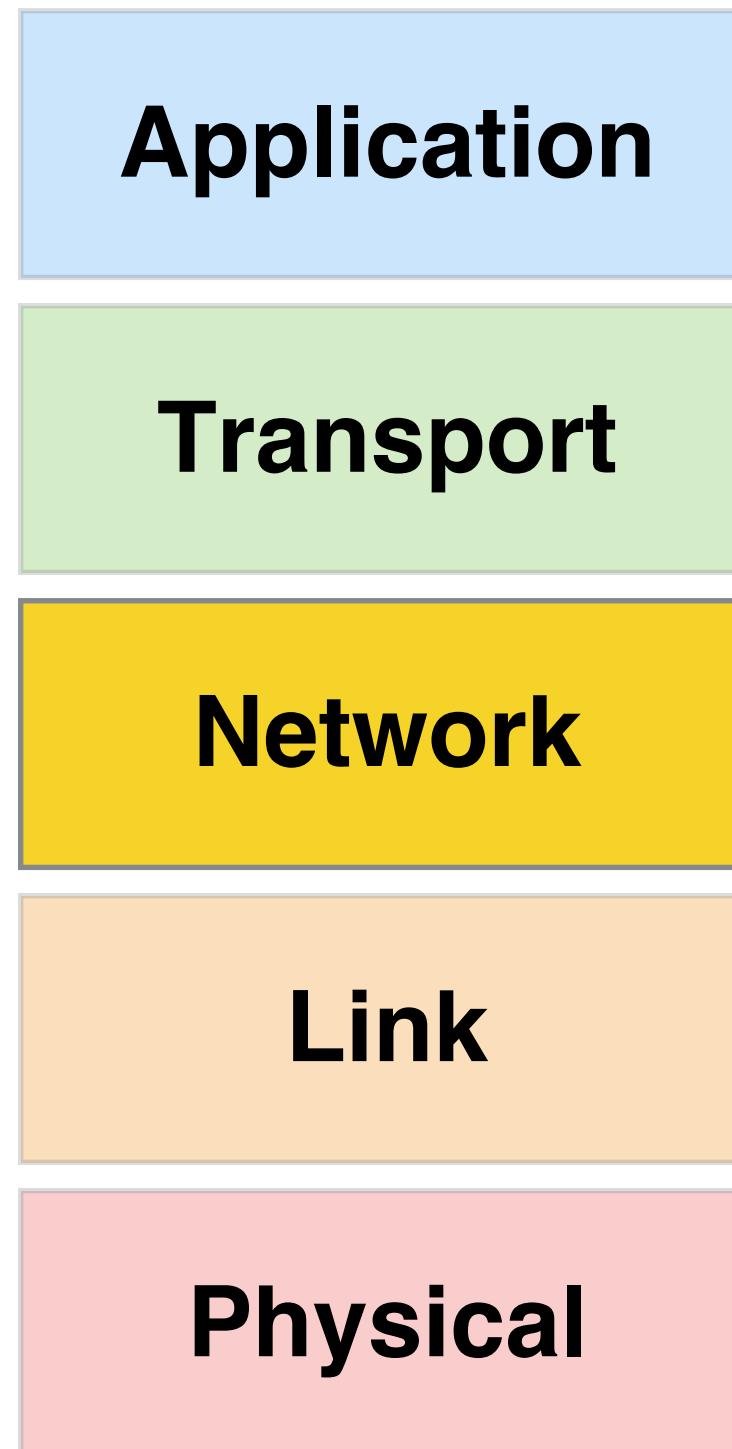
BGP - Border Gateway Protocol

Protocol to announce IP reachability

Routing table: IP prefix → network interface mapping



Network Layer



How does routing work?

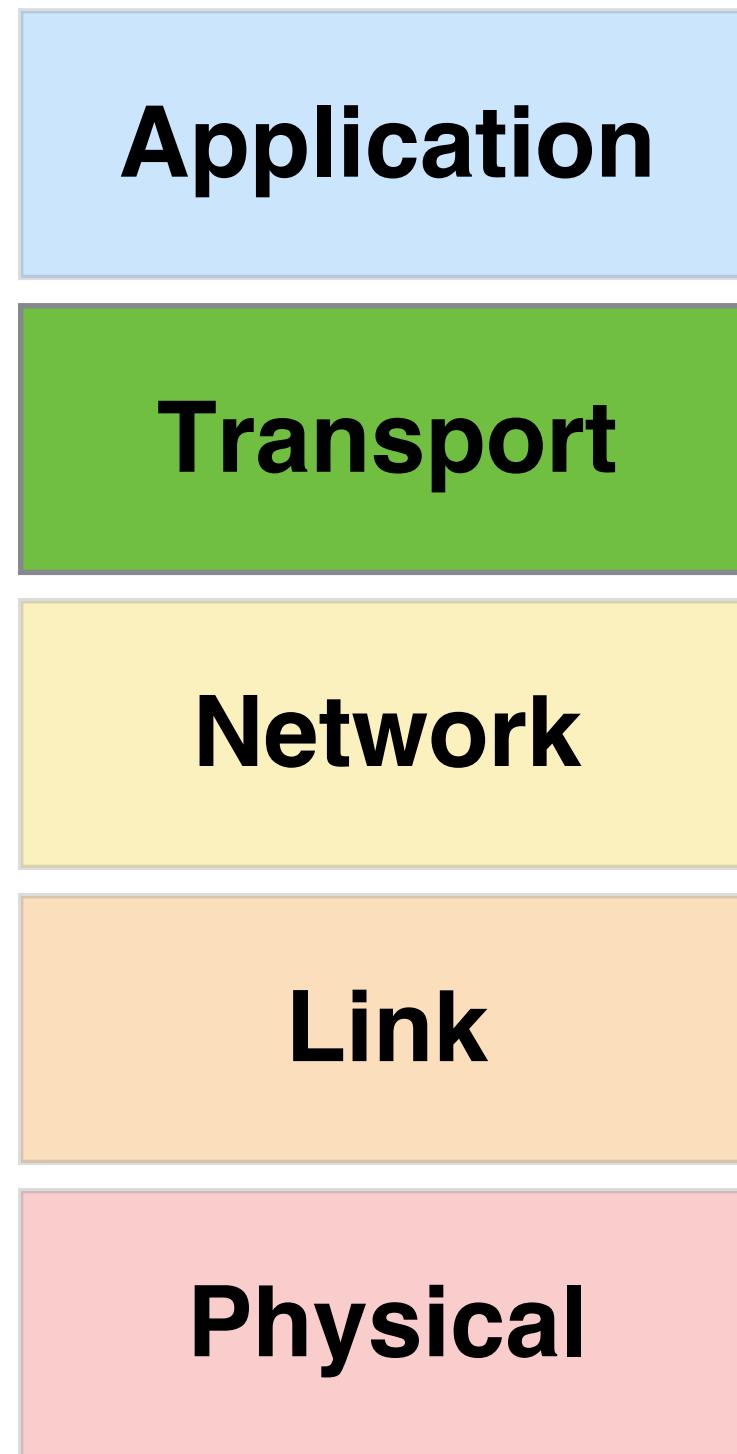
BGP - Border Gateway Protocol

Protocol to announce IP reachability

Routing table: IP prefix → network interface mapping



Transport Layer



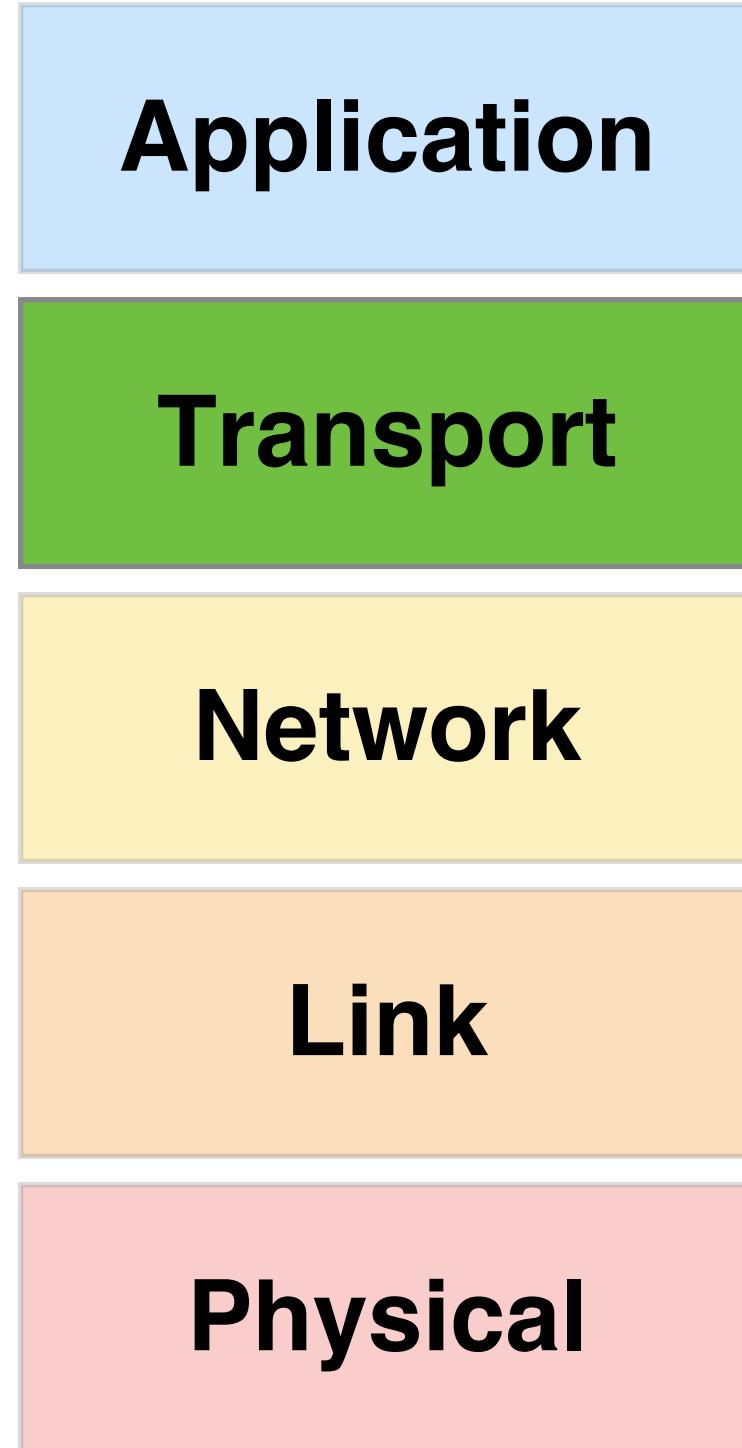
Network layer: communication between hosts

Transport: communication between processes

Can also be used for reliability, flow control, multiplexing, connection-oriented communication



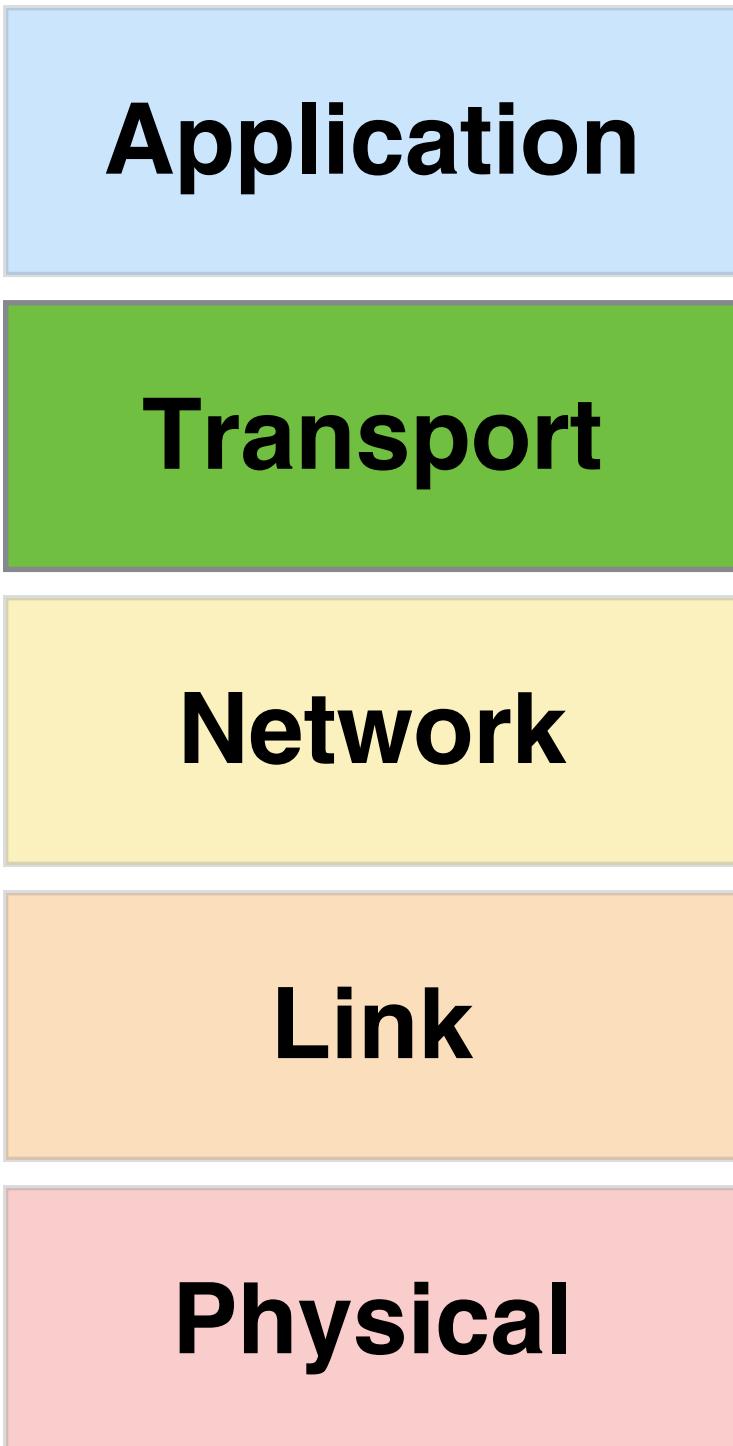
Transport Layer



		UDP Header																															
Offsets	Octet	0								1								2								3							
Octet	Bit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
0	0	Source port																Destination port															
4	32	Length																Checksum															



Transport Layer

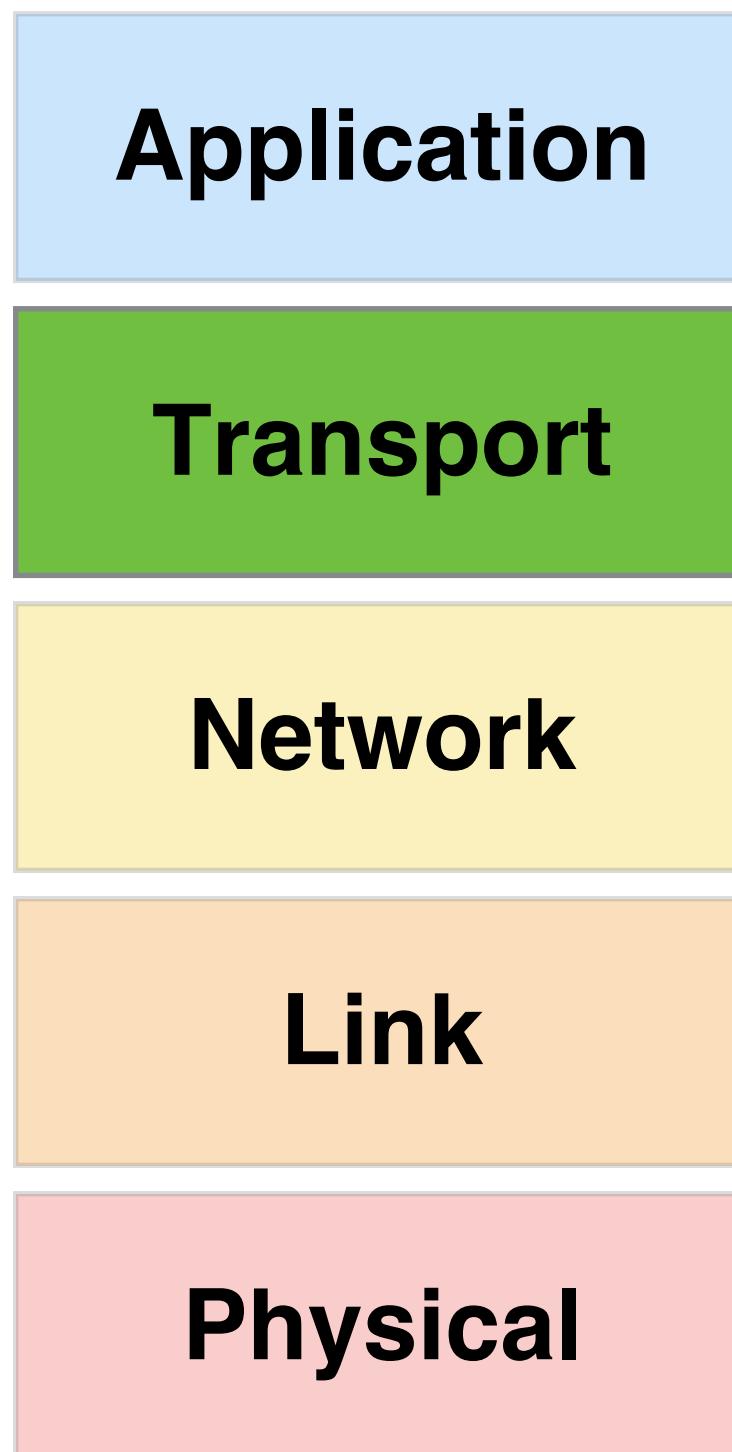


UDP Header																																	
Offsets	Octet	0								1								2								3							
Octet	Bit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
0	0	Source port																Destination port															
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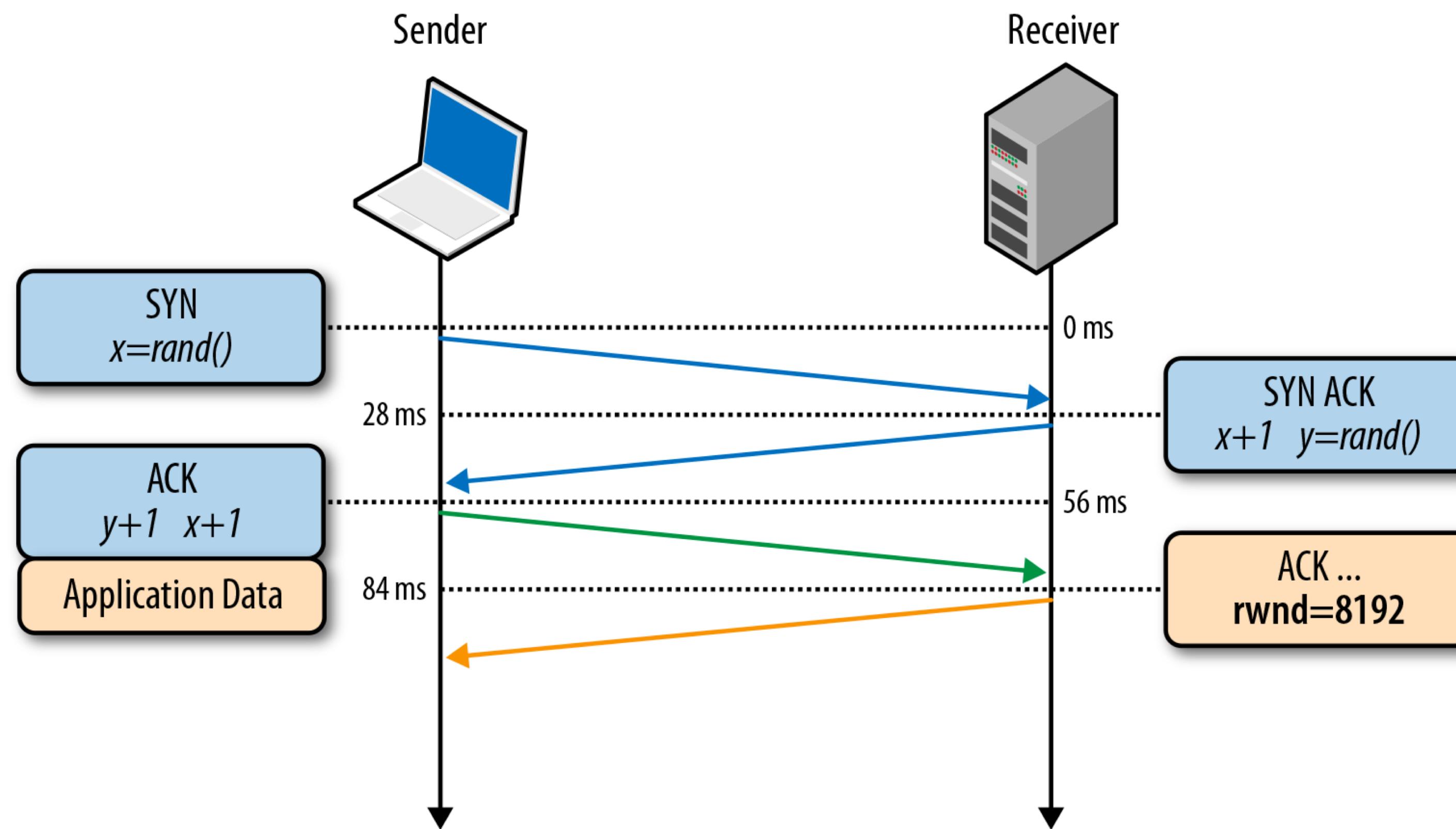
TCP Header																																																					
Offsets	Octet	0								1								2								3																											
Octet	Bit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31																				
0	0	Source port																Destination port																																			
4	32	Sequence number																Acknowledgment number (if ACK set)																																			
8	64	Data offset																Reserved																																			
12	96	N S R R				C W C E				E C R G				U R C K				A S S H				P S S T				R Y Y N				S I I N																							
16	128	Checksum																Window Size																																			
20	160	Options (if <i>data offset</i> > 5. Padded at the end with "0" bytes if necessary.)																																																			
...																																																			



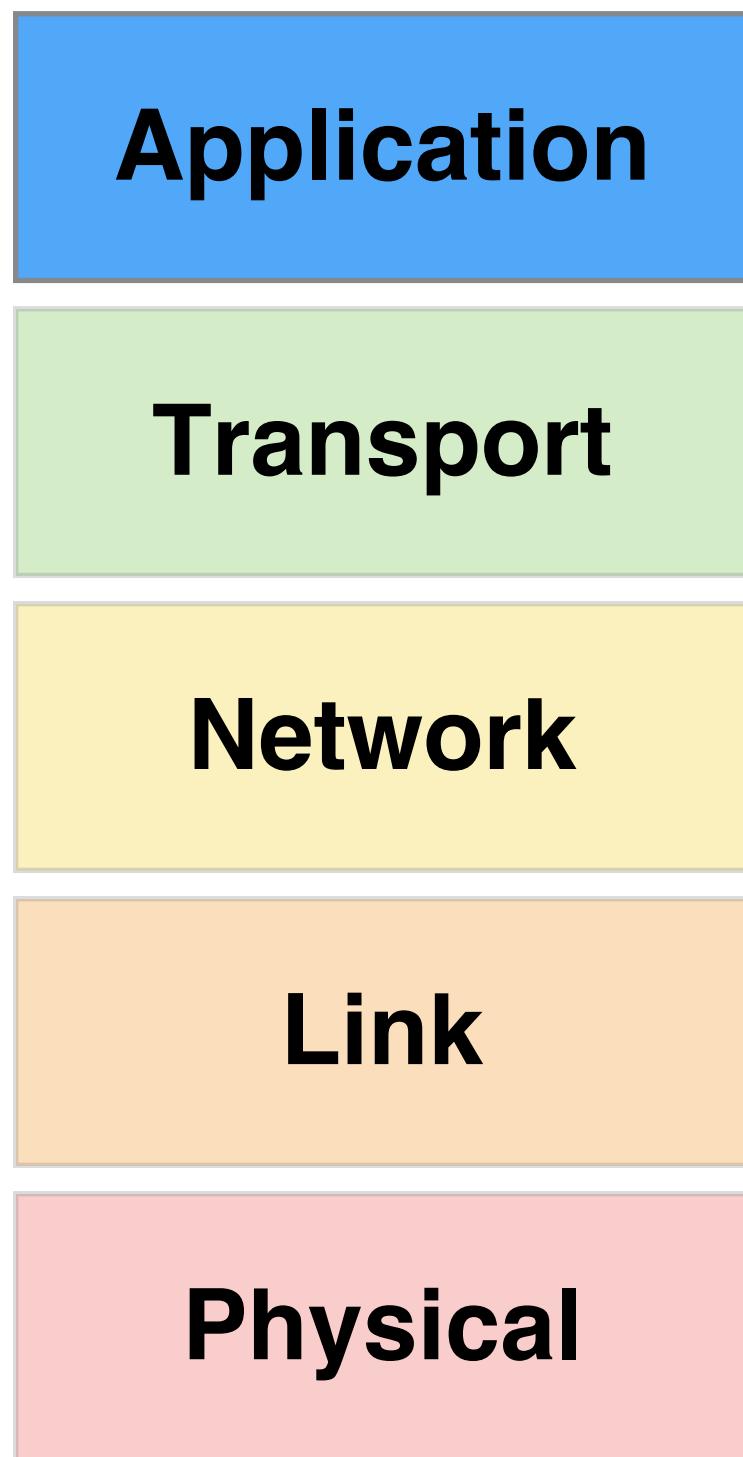
Transport Layer



TCP: Three-way handshake



Application Layer

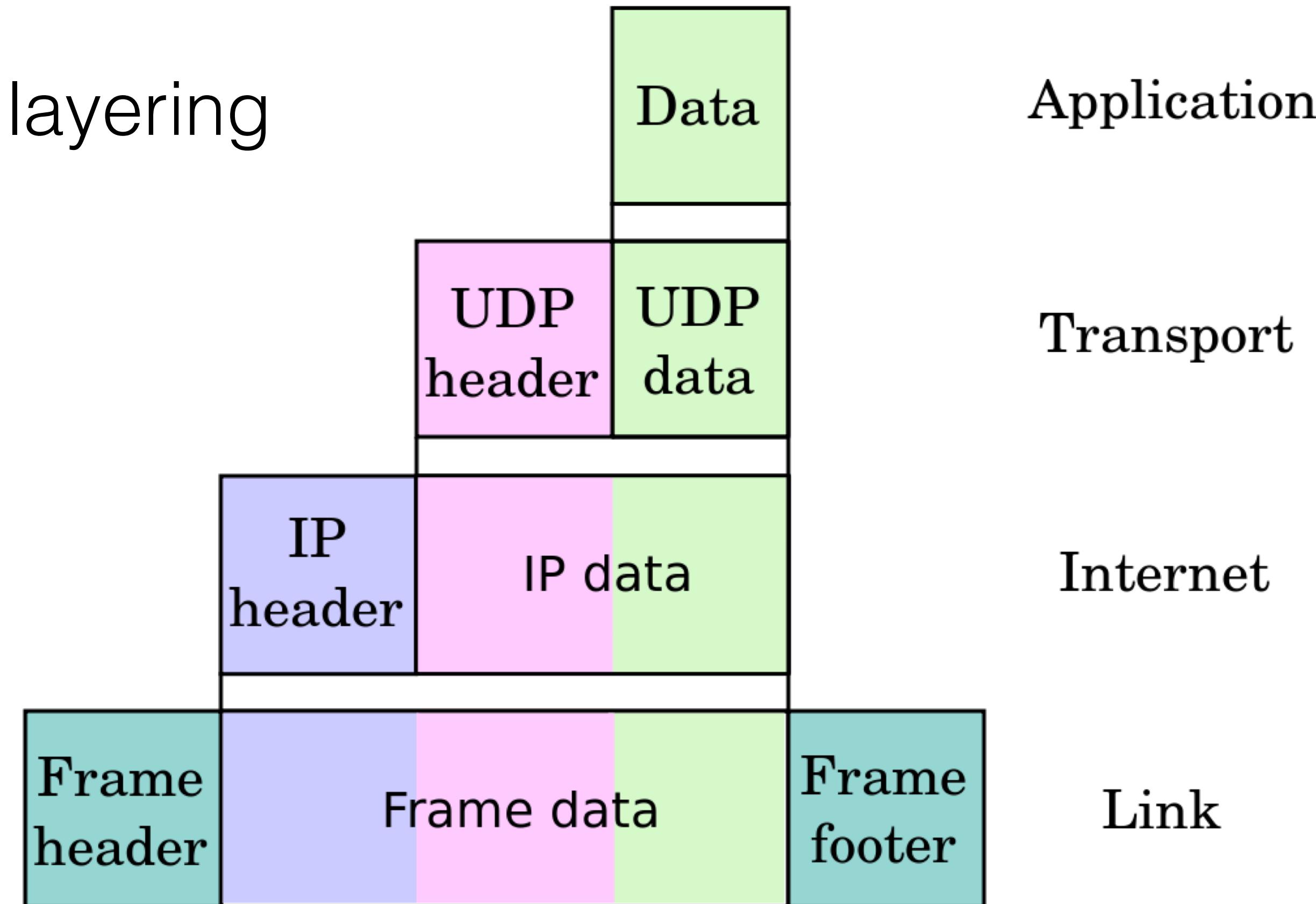


Anything and everything!



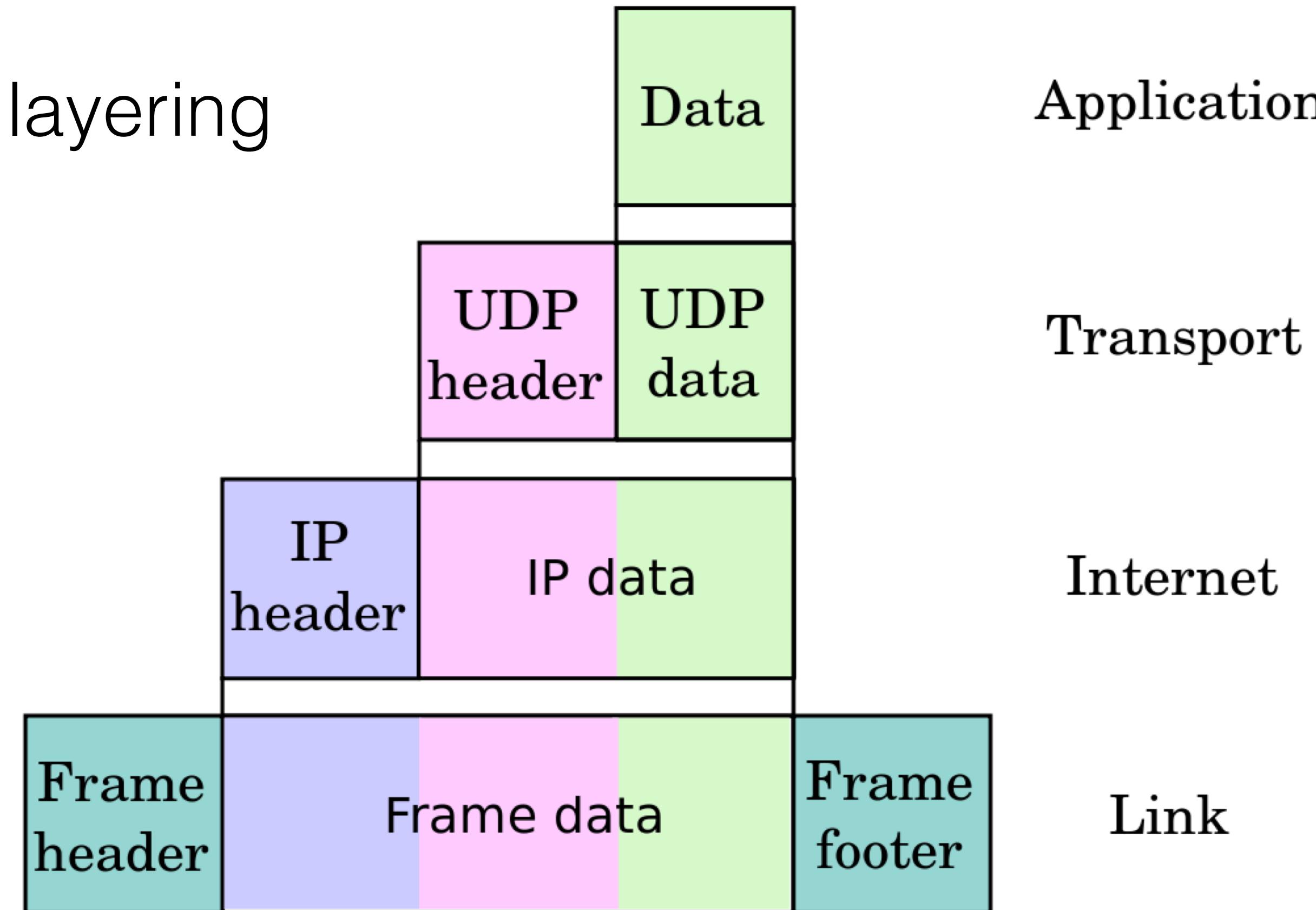
Encapsulation

Network packet layering



Encapsulation

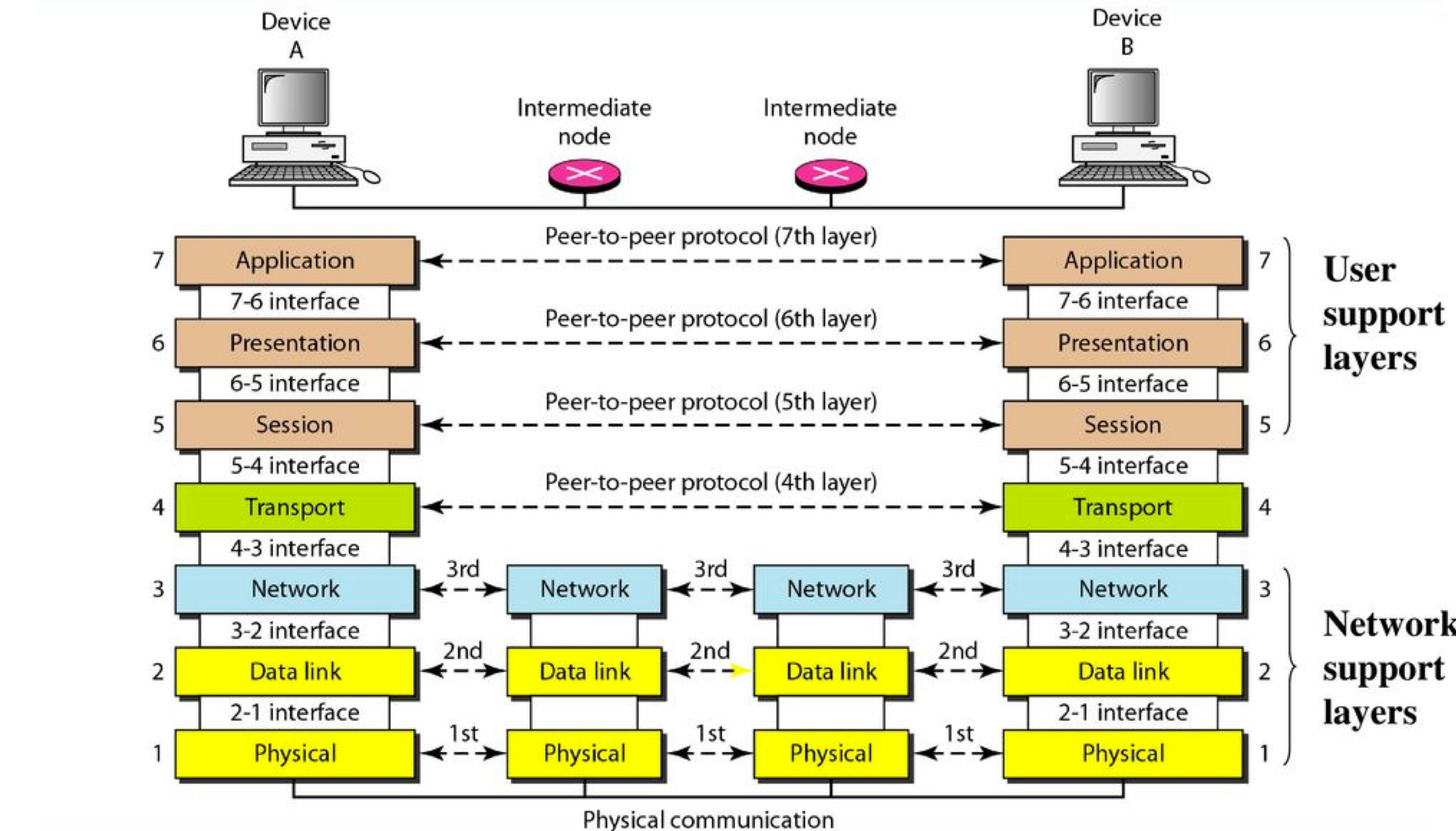
Network packet layering



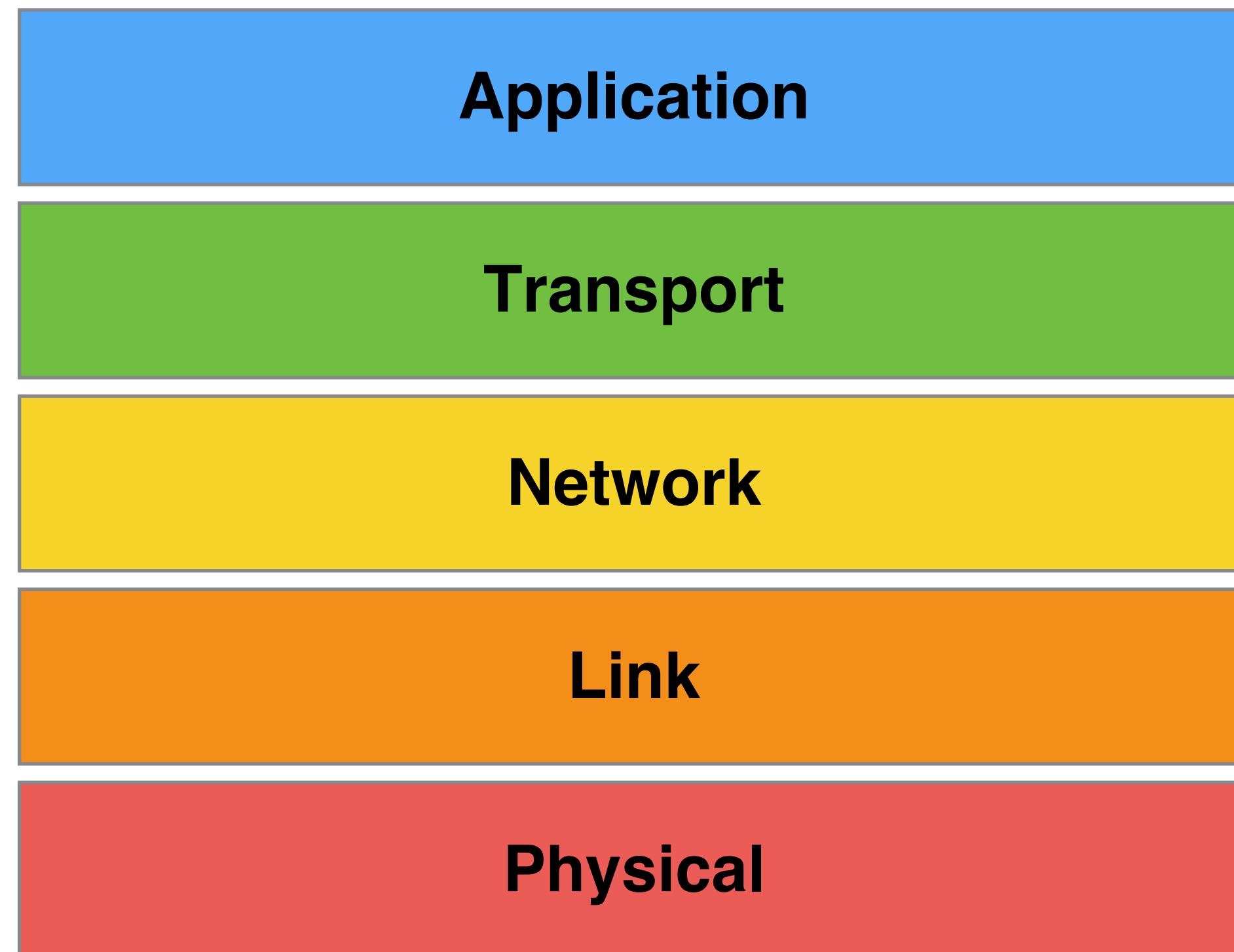
Counterintuitive: higher layers are more deeply nested



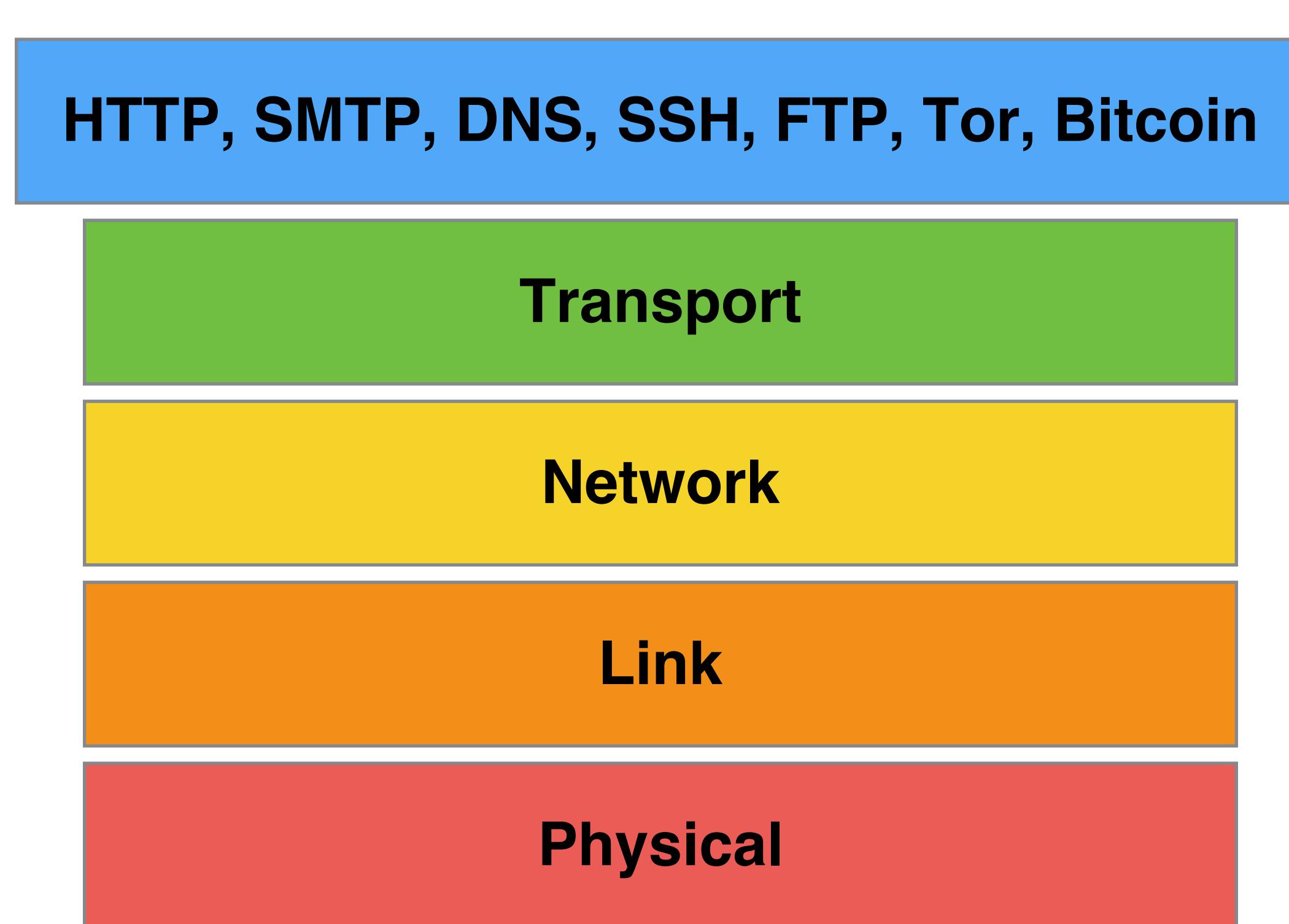
Encapsulation



Narrow Waist



Narrow Waist



Narrow Waist

HTTP, SMTP, DNS, SSH, FTP, Tor, Bitcoin

TCP, UDP, MPTCP

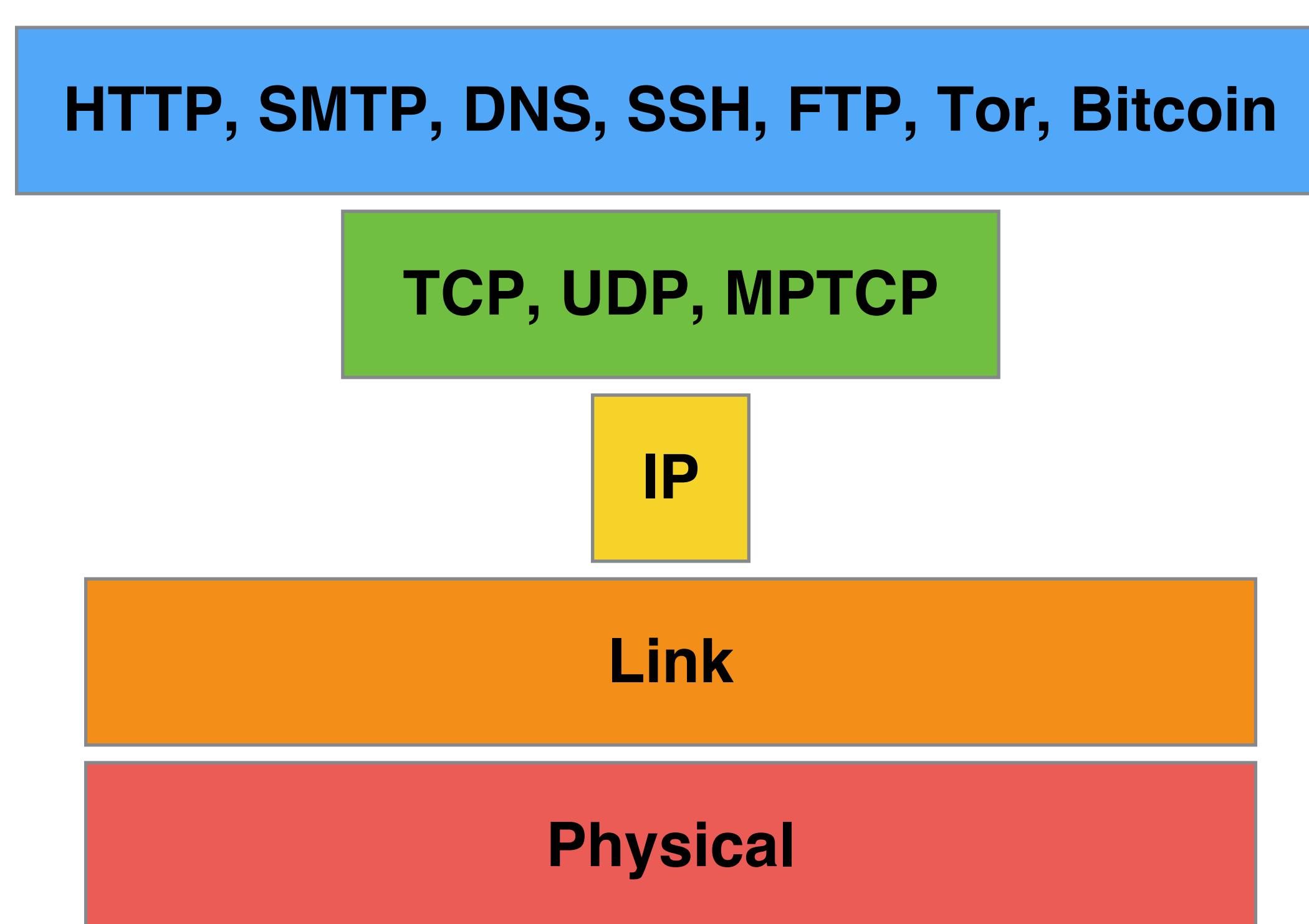
Network

Link

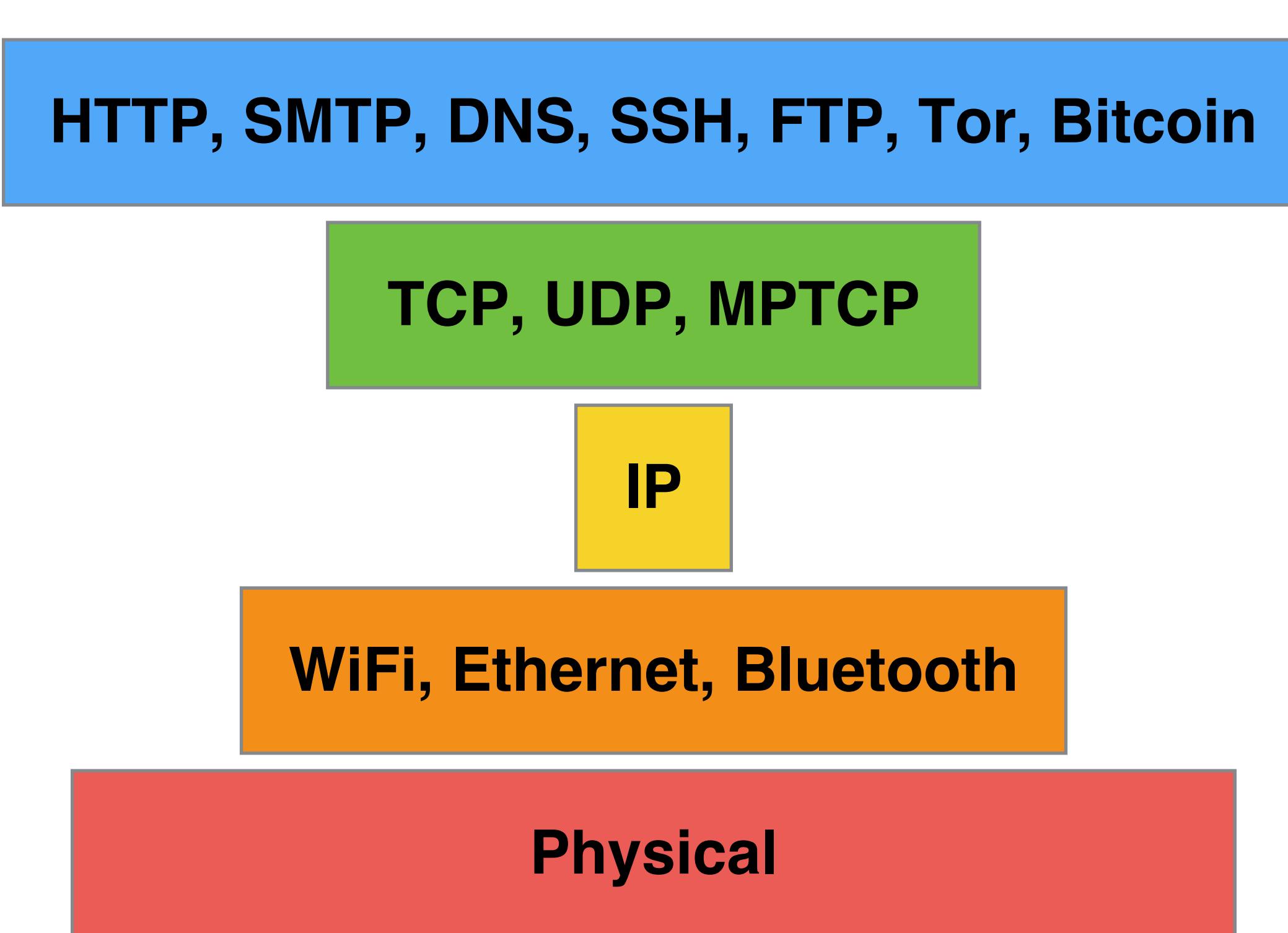
Physical



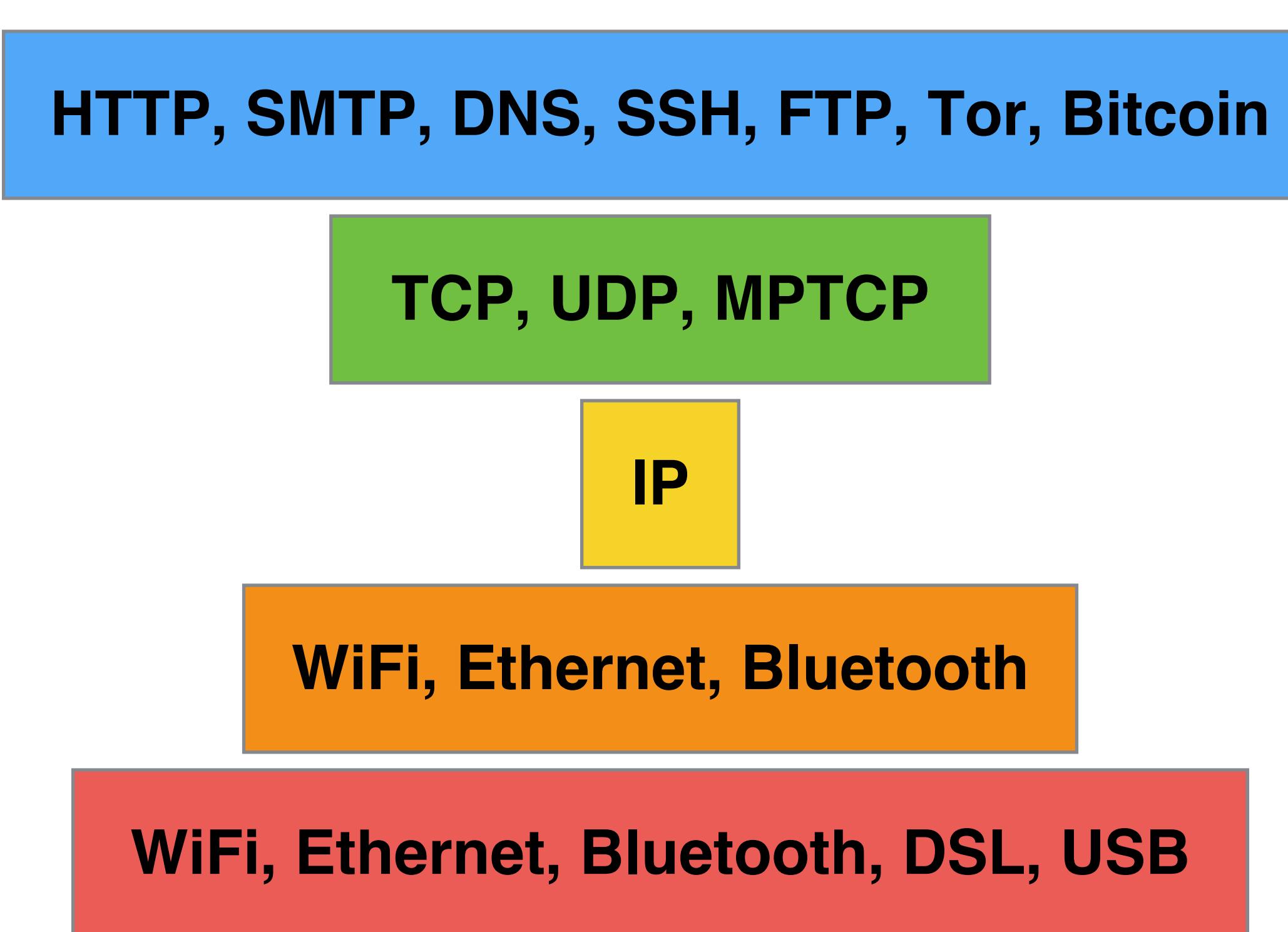
Narrow Waist



Narrow Waist



Narrow Waist



WireShark

When in doubt (or not in doubt), use WireShark.

