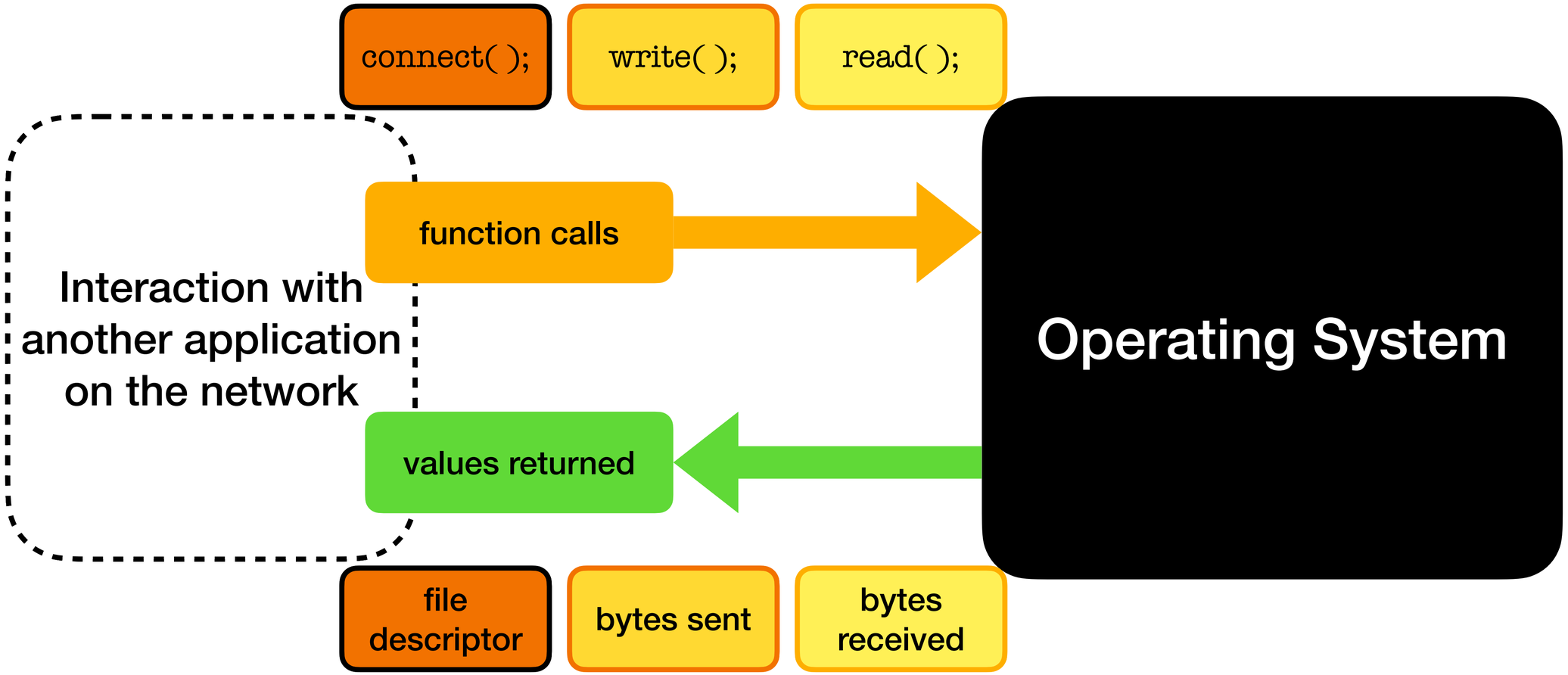
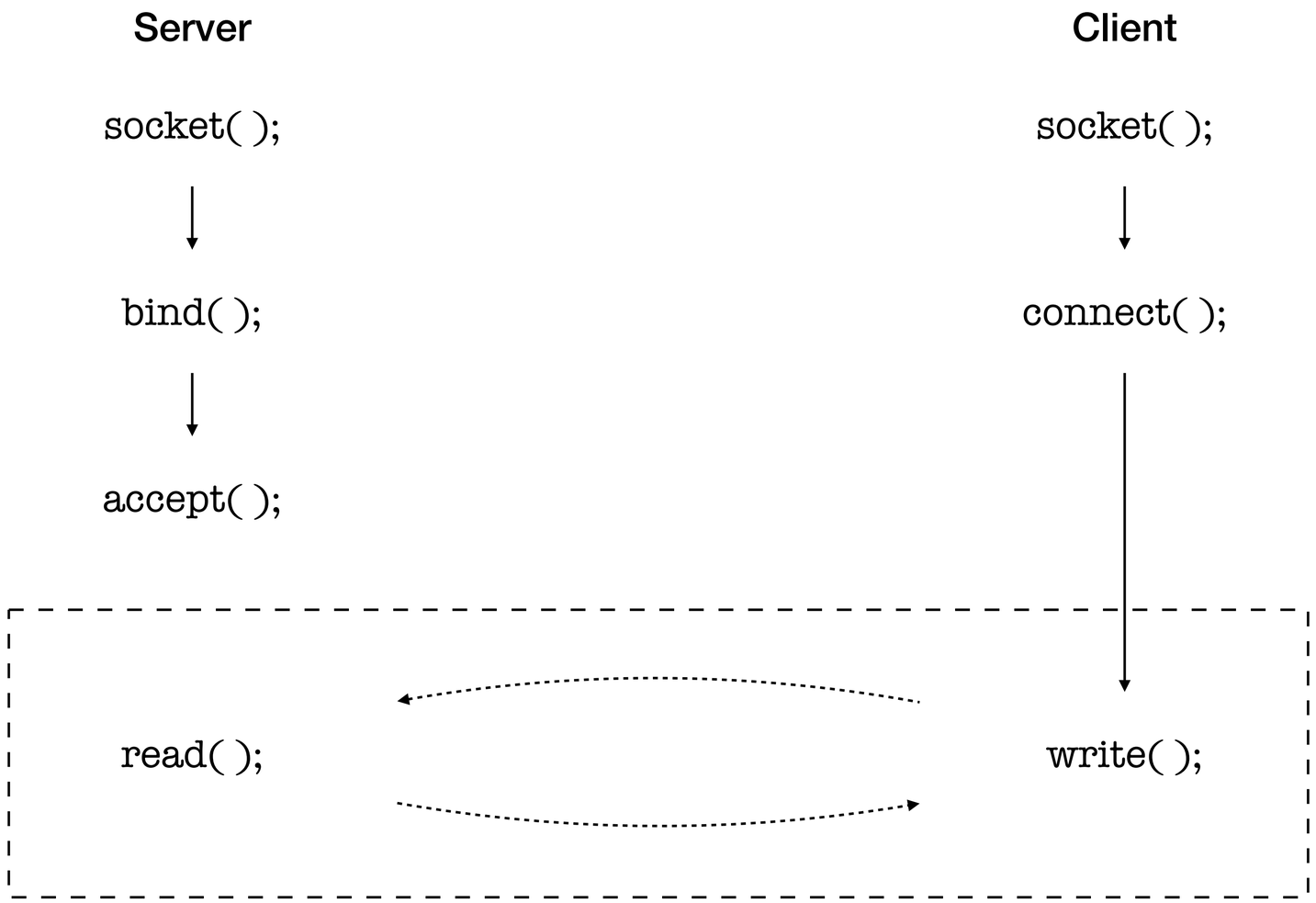
Networked Systems

Outline

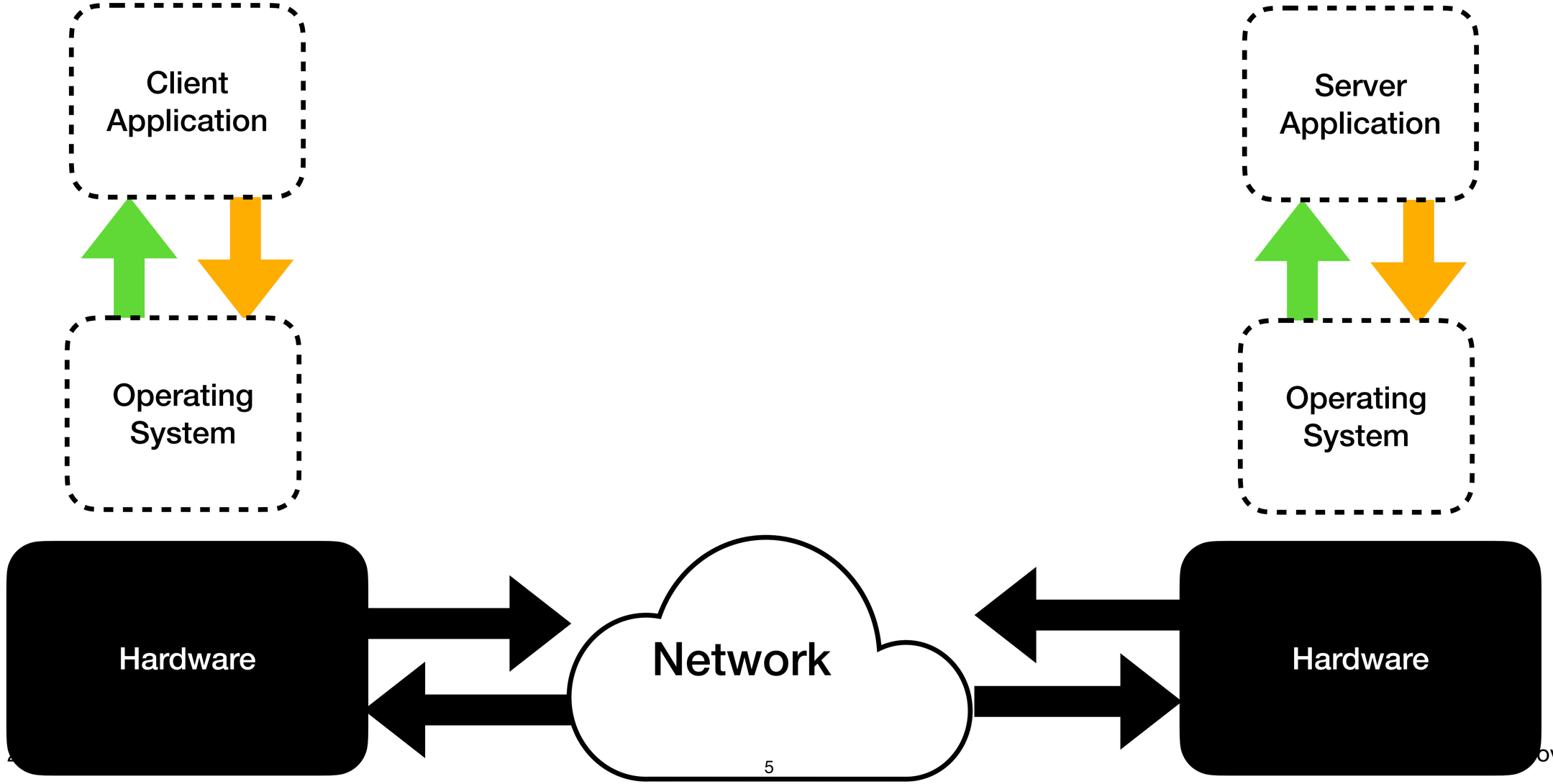
- Networked Systems
- Components of a Networked System
- Protocols for Networking


connect( );
write( );
read( );
Interaction with another application on the network
function calls
values returned
Operating System
file descriptor
bytes sent
bytes received

Client/Server Networked System



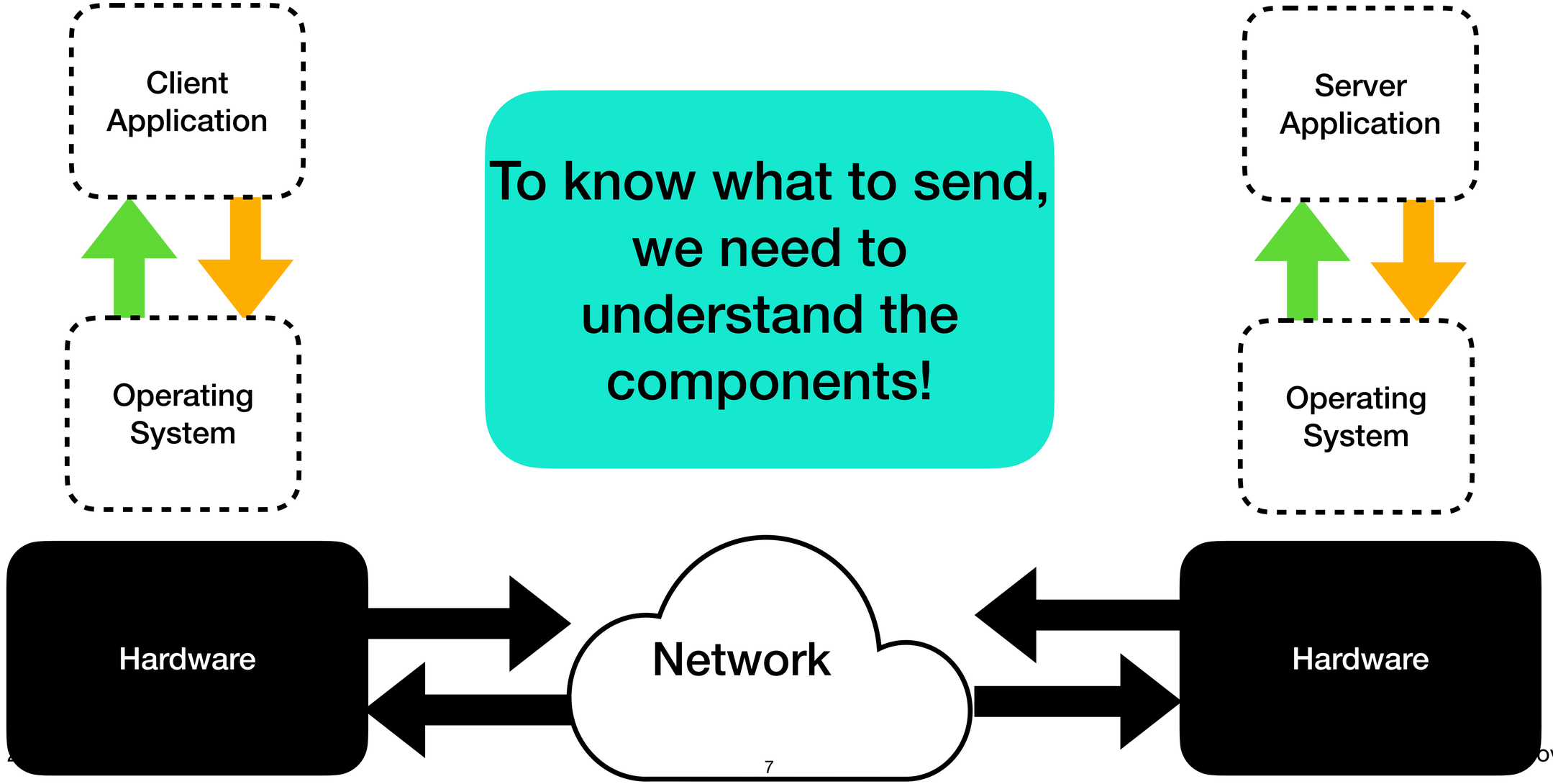
Client/Server Networked System



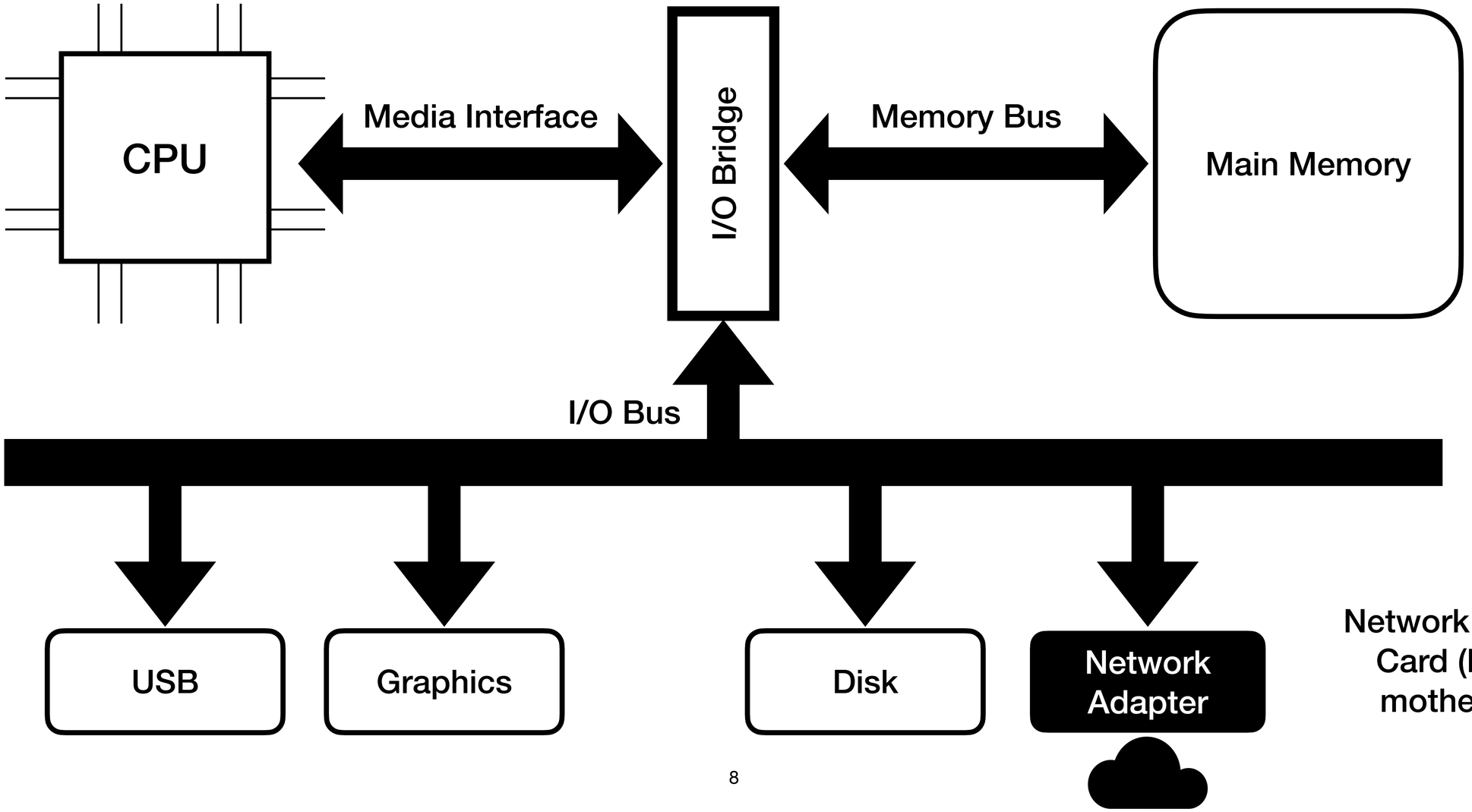
Chat with your neighbor!

What are some examples of networked systems?

What is what in your networked system?

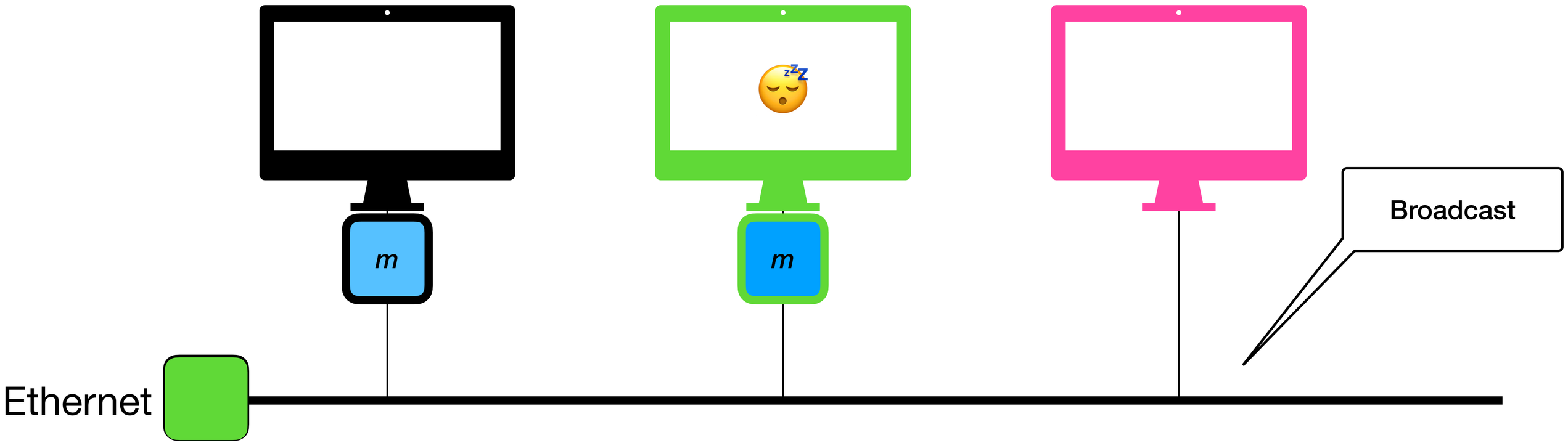


Networking Architecture



Network Interface Card (NIC) on motherboard

Wired Network Example



Wired Network Example

- Small networked systems can use wires (i.e., ethernet) to be linked together
- To communicate, they:
  - Try to listen for traffic from others
  - If quiet, try to acquire “ownership” of wire
  - Broadcast message to other members of the networked system
- In case of collision: stop, sleep, retry

Sometimes referred to as a local area network (LAN)

Chat with your neighbor!

What are some advantages and disadvantages of wired networks?

Wired Network Summary

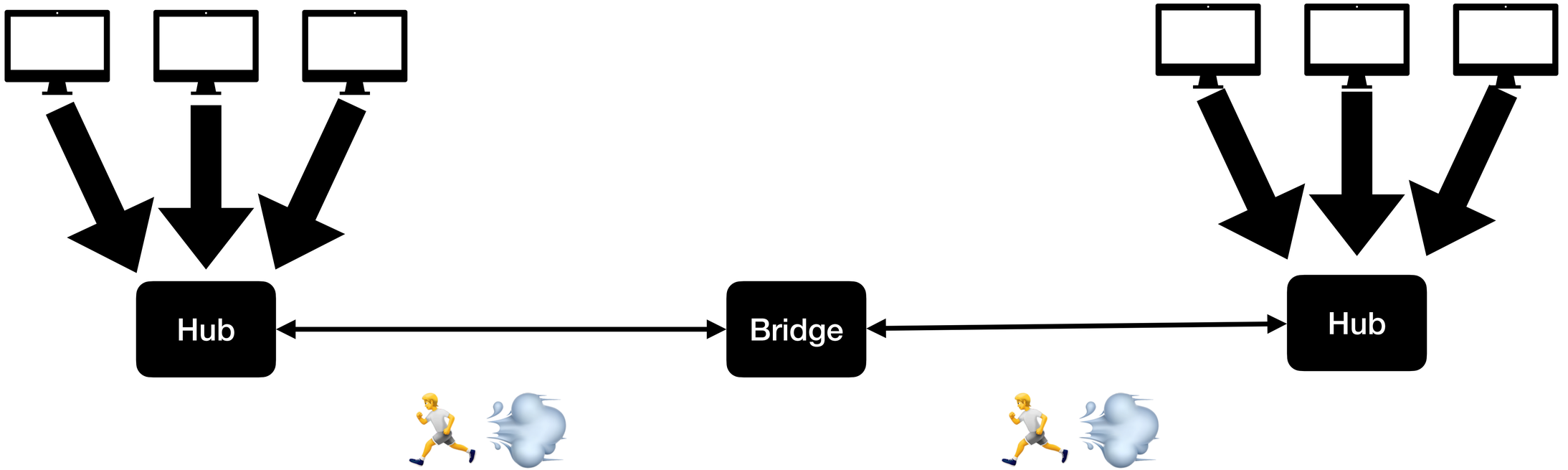
Completely decentralized!

Inexpensive!

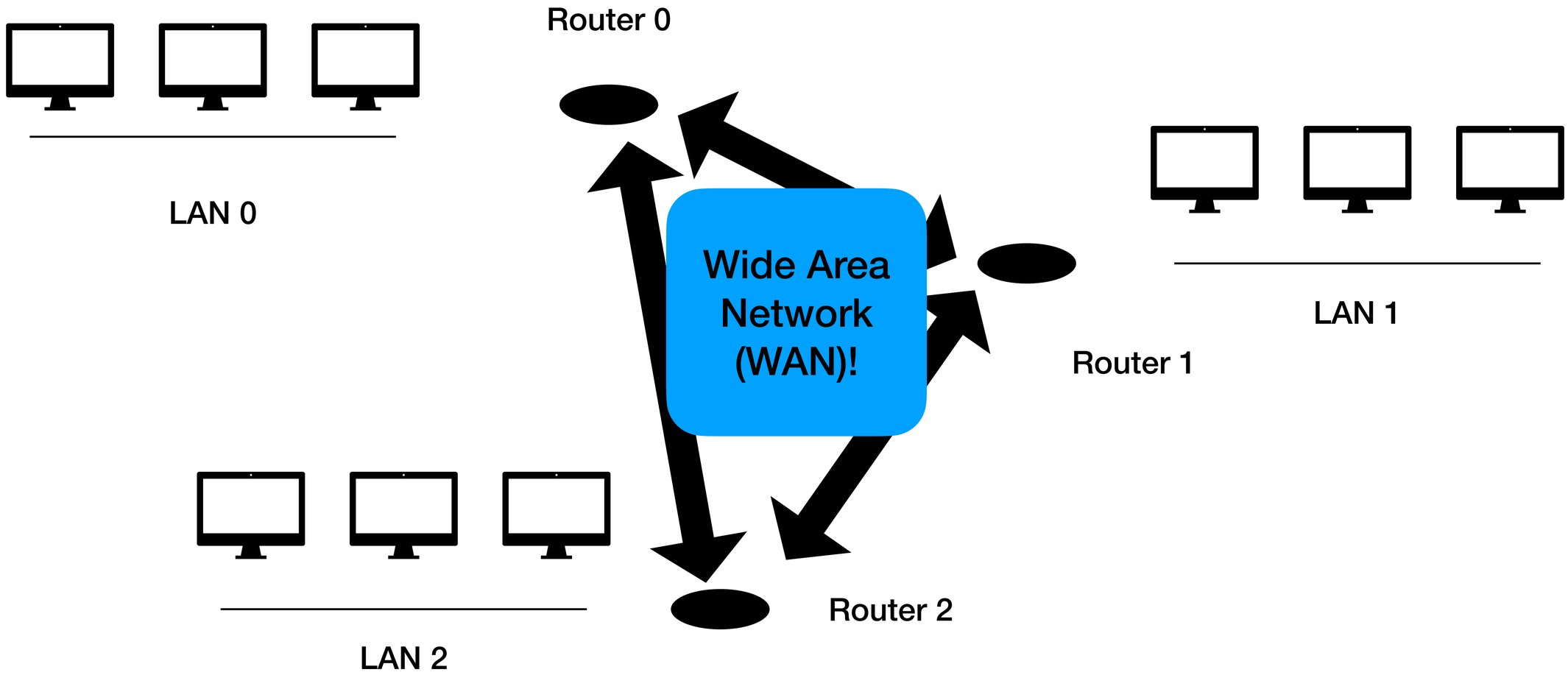
Everyone can see all of the data…

Does not scale well!

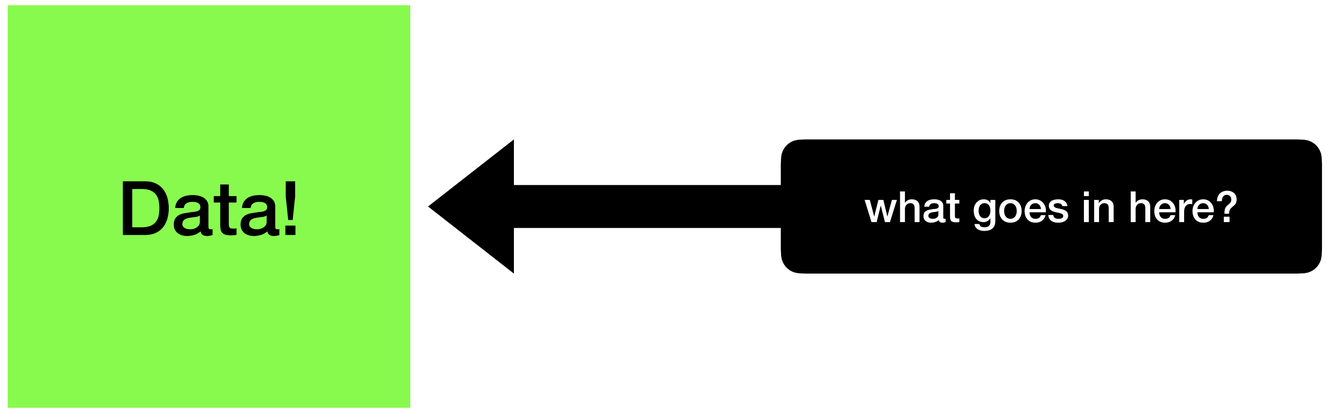
Internetwork Example 1



Internetwork Example 2



Data Encapsulation Layers



Application Layer

- In order to make some request, clients and servers need to agree on a *protocol* to make requests and responses
- Examples:
  - HTTP: HyperText Transport Protocol
  - SSH: Secure SHell
  - SMTP (email): Simple Mail Transport Protocol
  - …

Application Layer, HTTP

- Typical client request types
  - GET: request data from the source
  - POST: send some data to a server to change the state
- Typical server responses
  - Status line
  - HTTP headers summarizing the data
  - Requested data (optional)

HTTP Example!

```
Sams-MacBook-Pro-92:Brown samthomas$ telnet google.com 80
Trying 2607:f8b0:4006:820::200e...
Connected to google.com.
Escape character is '^]'.
GET / HTTP/1.1
Host: google.com
```

Chat with your neighbor!

Suppose you want to upload a file to Google Drive. Describe the client/server request/response!

Data Encapsulation Layers

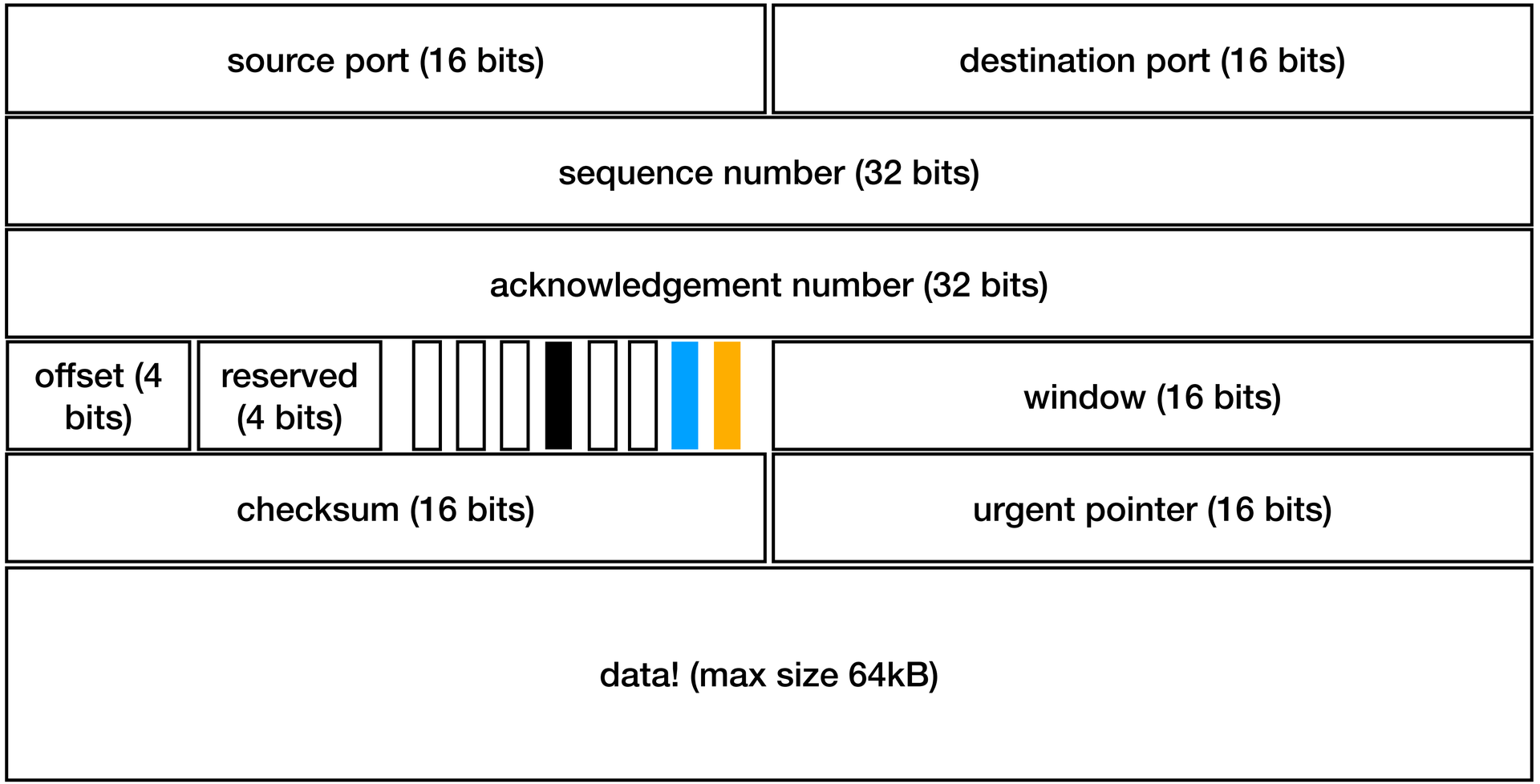
Transport Layer

- Application requests are broken up into *packets* that get sent over the network
- Examples:
  - UDP: User Datagram Protocol
  - TCP: Transmission Control Protocol

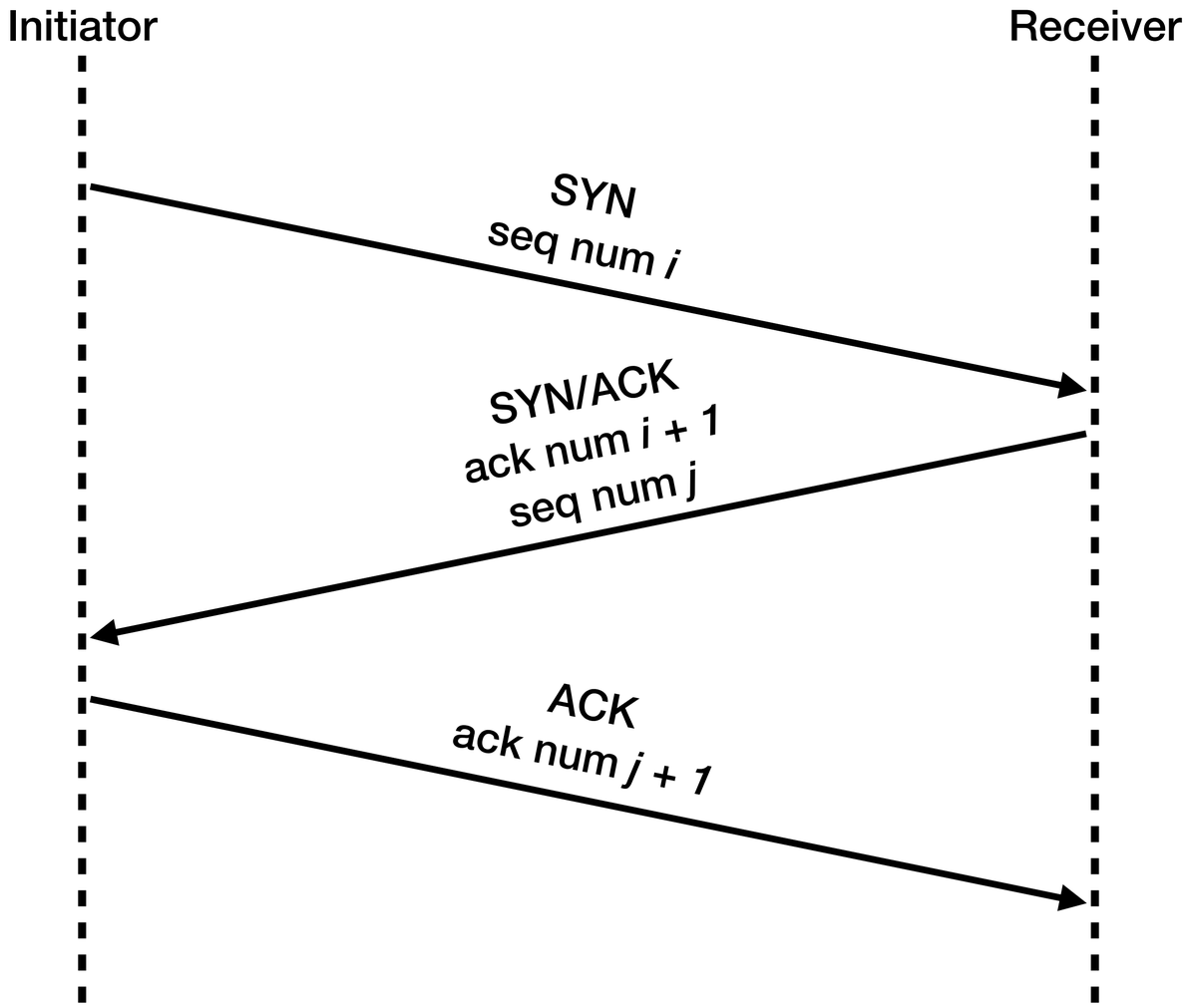
Transport Layer, UDP

source port (16 bits)	destination port (16 bits)
data length (16 bits)	checksum (16 bits)
data! (max size 64kB)	

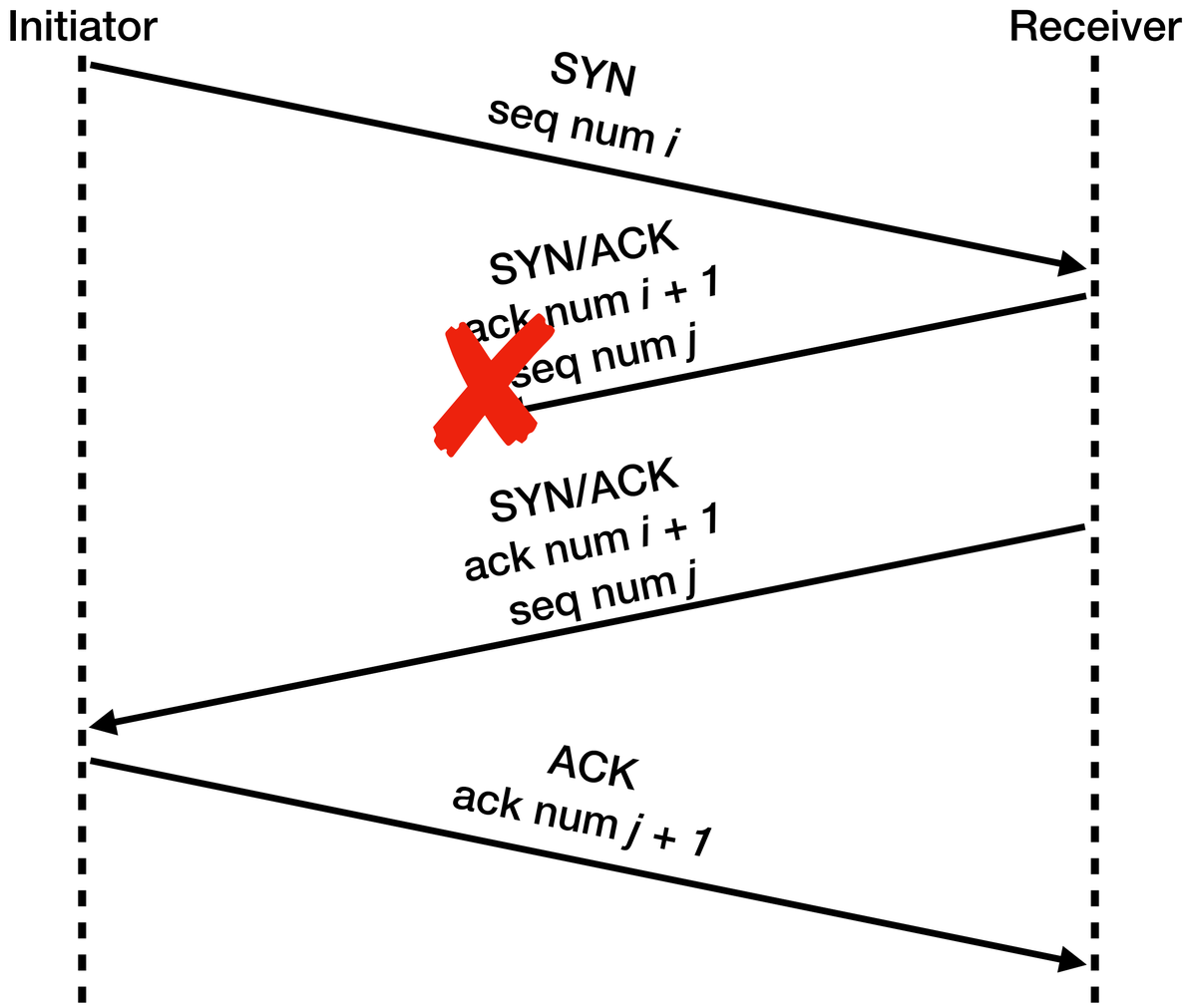
Transport Layer, TCP



Transport Layer, TCP



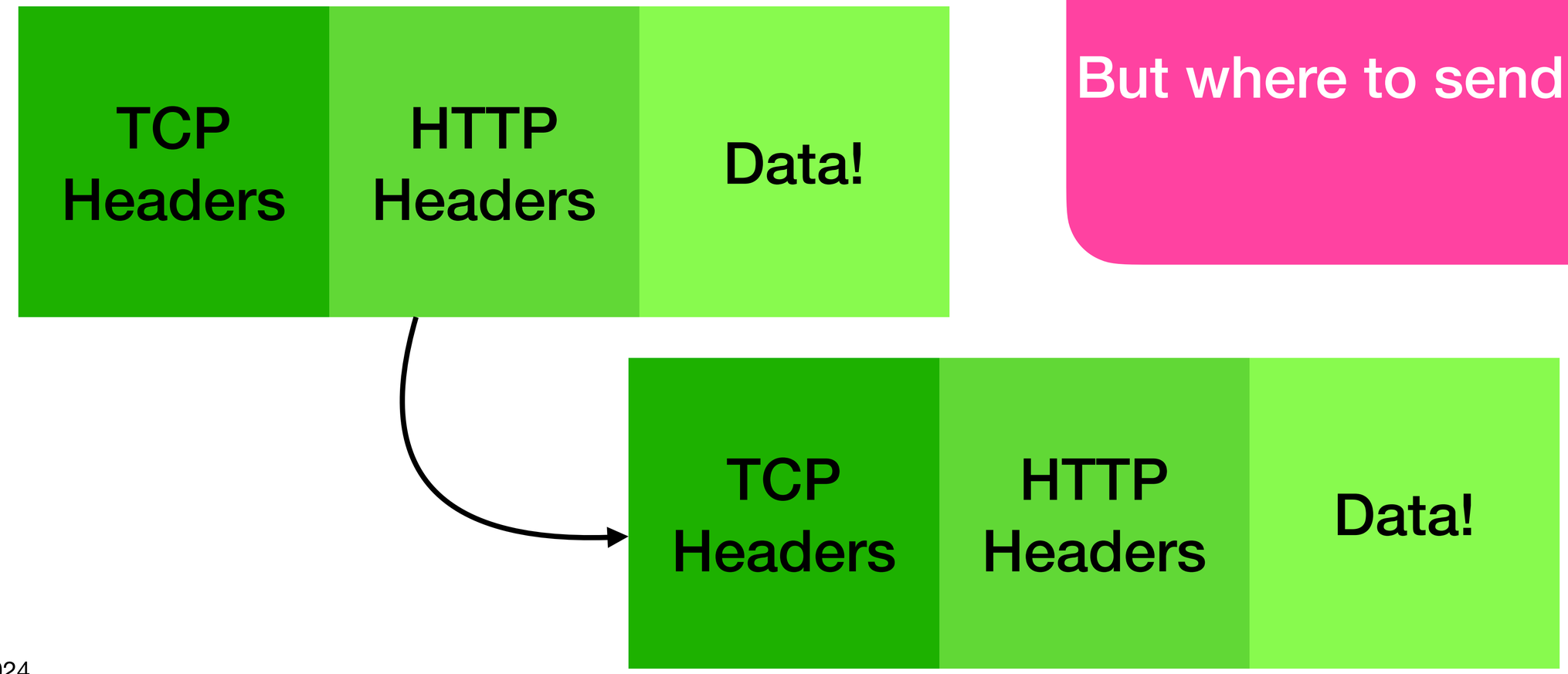
Transport Layer, TCP



Transport Layer

- Allows application layer requests/responses to be broken up into packets
- UDP: simple, doesn’t handle unreliability well
- TCP: longer exchanges between sender/receiver, more reliable

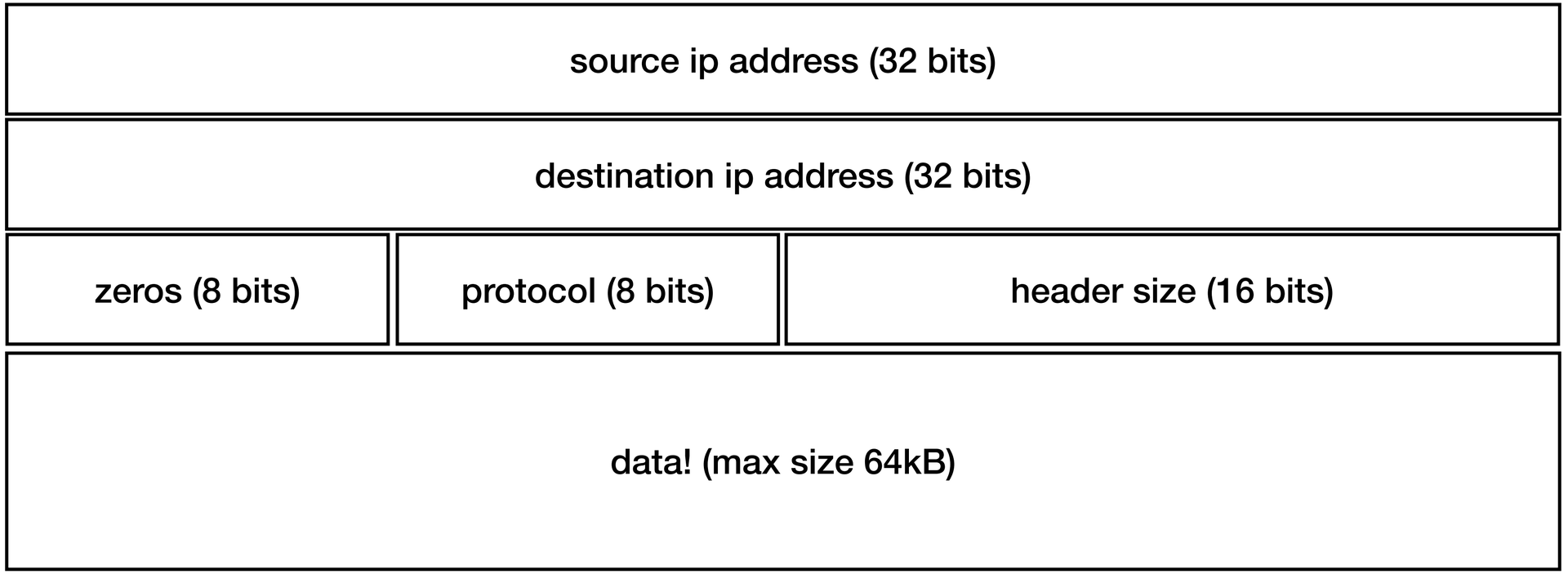
Data Encapsulation Layers



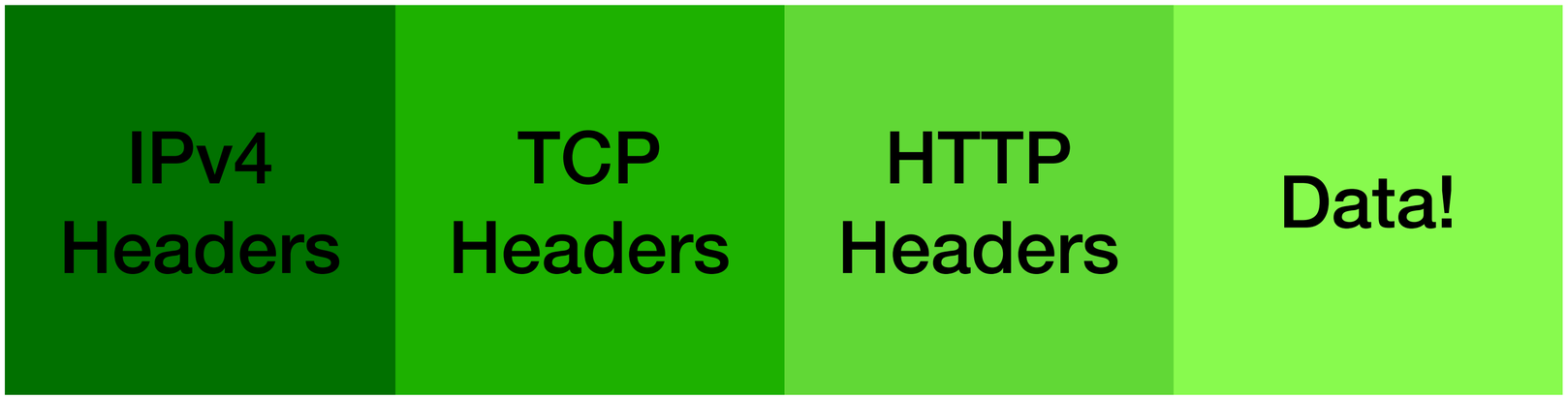
Internet Layer

- Tells transport layer where to send the packet!
- For outgoing packets, select the next-hop host and transmit transmit it!
- For incoming packets, capture the packet and pass the payload to the transport layer if we are the destination
- Examples:
  - IPv4
  - IPv6

Network Layer, IPv4



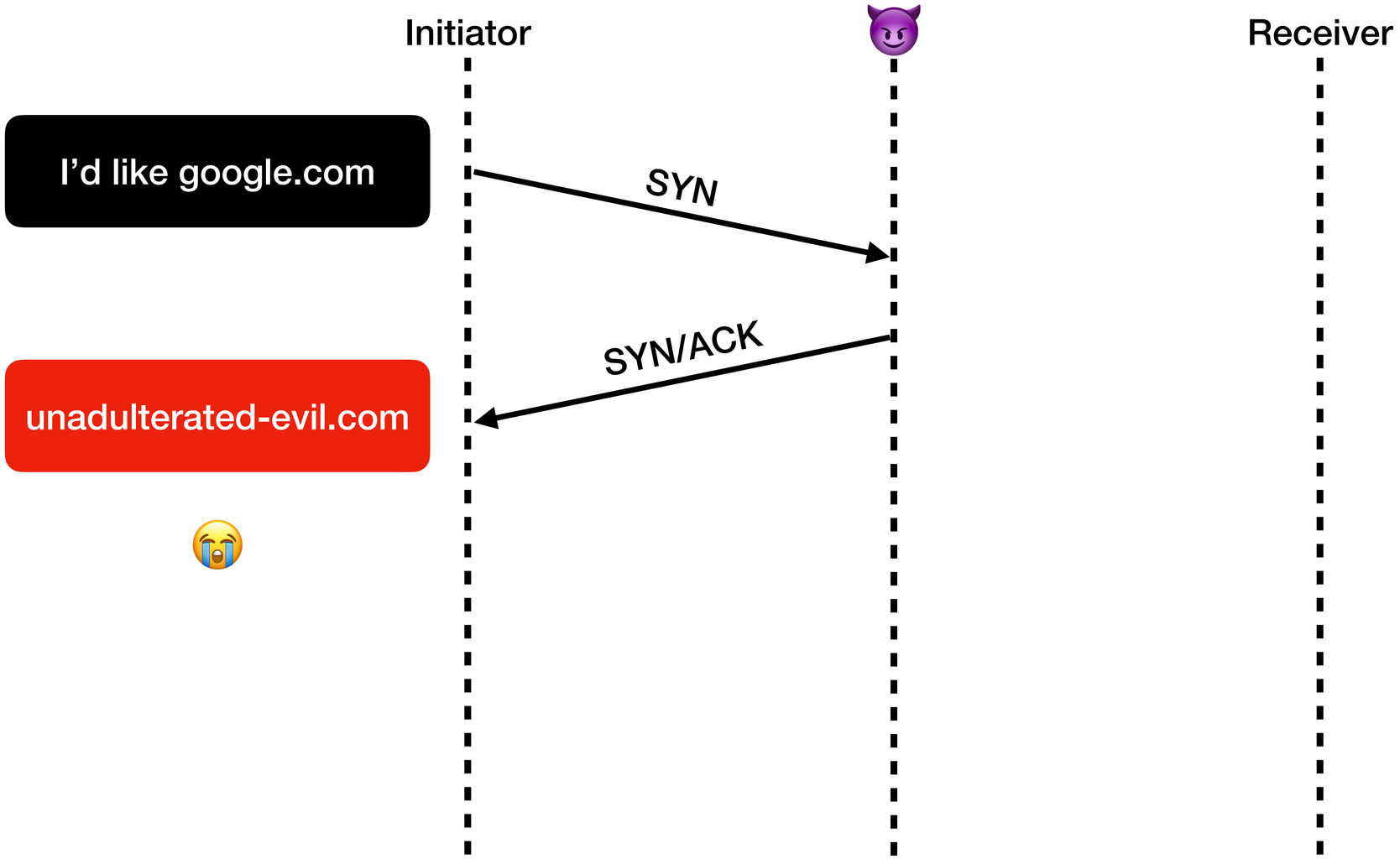
Data Encapsulation Layers



Chat with your neighbor!

Summarize the conversation about data encapsulation. Why do we encapsulate data that we send on the network?

Uh oh…


Initiator
Receiver
I'd like google.com
SYN
SYN/ACK
unadulterated-evil.com
😭

The Case for HTTPS

- All HTTP packets are encrypted using TLS (Transport Layer Security)
- In order to encrypt/decrypt a packet, the server provides a *certificate* to a certificate authority
- For more, here's a great video of how the protocol works!
  - https://www.youtube.com/watch?v=YEBfamv-_do