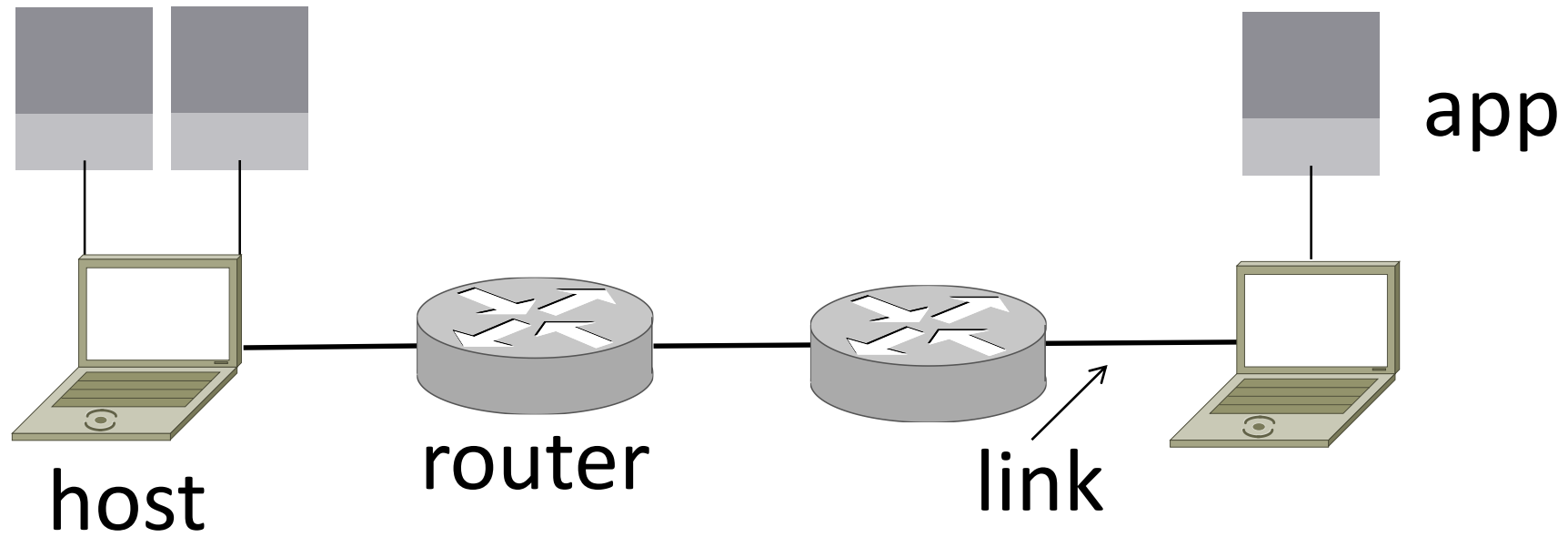


Network Components

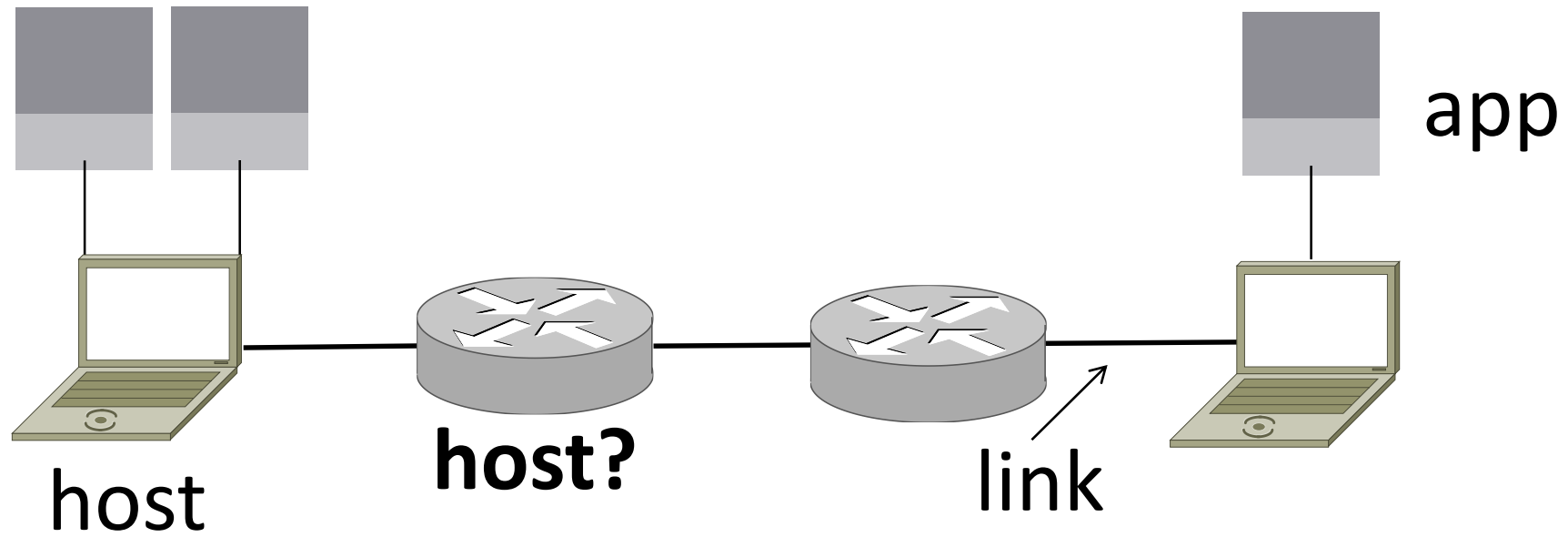
Component Names

Component	Function	Example
<u>Application</u> , or app, user	Uses the network	Skype, iTunes, Amazon
<u>Host</u> , or end-system, edge device, node, source, sink	Supports apps	Laptop, mobile, desktop
<u>Router</u> , or switch, node, hub, intermediate system	Relays messages between links	Access point, cable/DSL modem
<u>Link</u> , or channel	Connects nodes	Wires, wireless

Parts of a Network

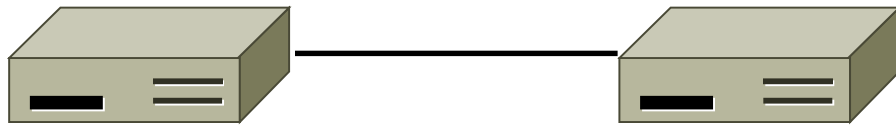


Parts of a Network

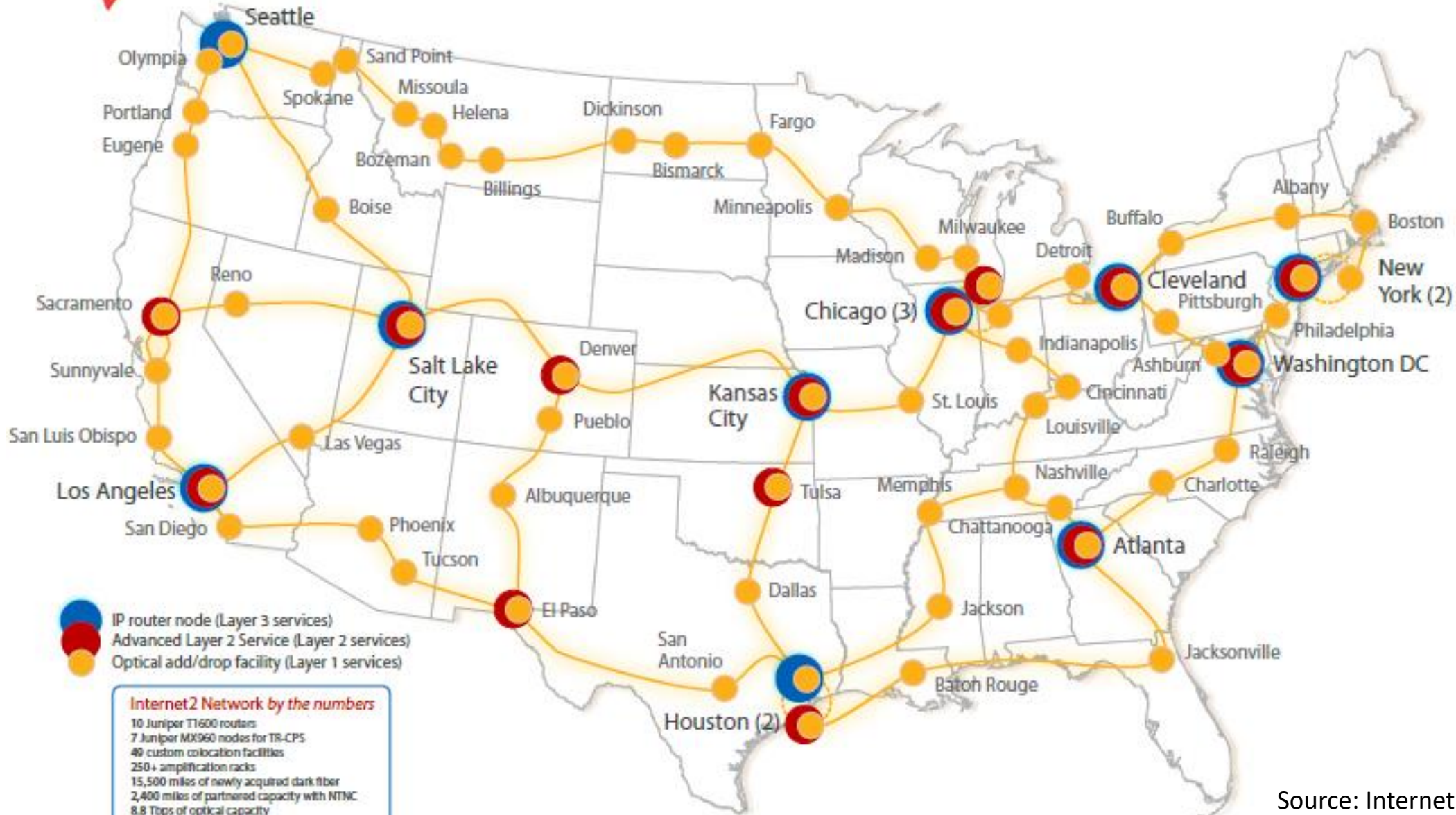


A Small Network

- Connect a couple of computers



- Next, a large network ...



- IP router node (Layer 3 services)
- Advanced Layer 2 Service (Layer 2 services)
- Optical add/drop facility (Layer 1 services)

Internet2 Network by the numbers

- 10 Juniper T1600 routers
- 7 Juniper MX960 nodes for TR-CPS
- 40 custom colocation facilities
- 250+ amplification racks
- 15,500 miles of newly acquired dark fiber
- 2,400 miles of partnered capacity with NTNC
- 8.8 Tbps of optical capacity
- 100 Gbps of IP capacity
- 300+ Ciena ActiveFlex 6500 network elements



IN SUPPORT OF
U.S.UCAN

NETWORK
PARTNERS

ciena

CISCO

INDIANA UNIVERSITY

infinera

JUNIPER
NETWORKS



Example Networks

- WiFi (802.11)
- Enterprise / Ethernet
- ISP (Internet Service Provider)
- Cable / DSL
- Mobile phone / cellular (2G, 3G, 4G)
- Bluetooth
- Telephone
- Satellite ...

Network names by scale

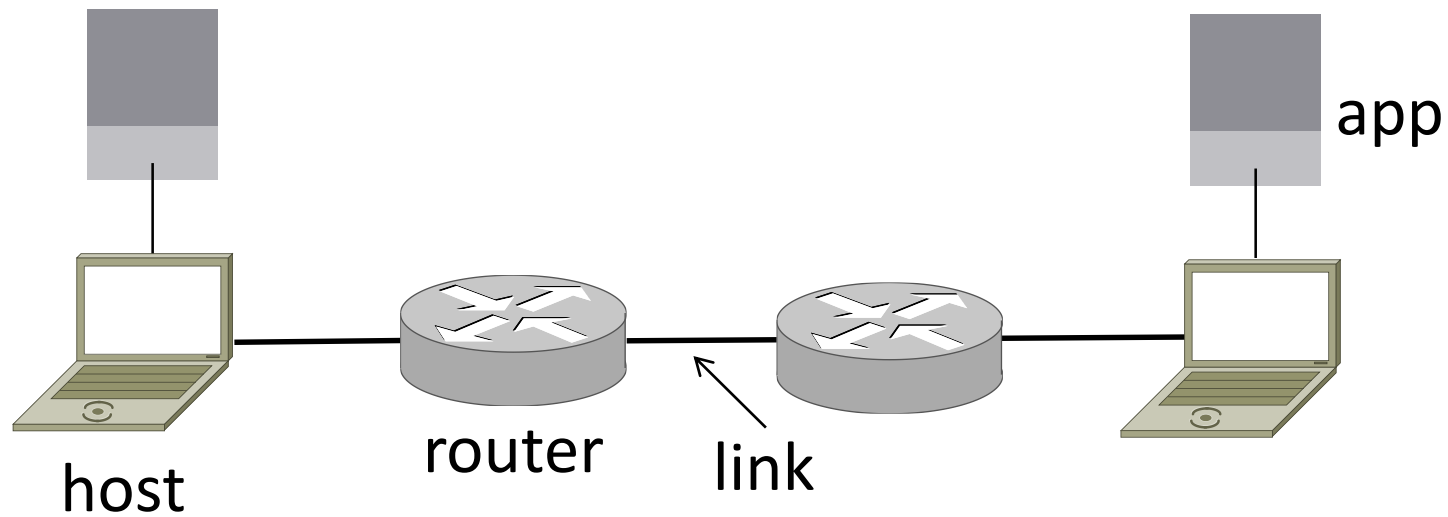
Scale	Type	Example
Vicinity	<u>PAN</u> (Personal Area Network)	Bluetooth (e.g., headset)
Building	<u>LAN</u> (Local Area Network)	WiFi, Ethernet
City	<u>MAN</u> (Metropolitan Area Network)	Cable, DSL
Country	<u>WAN</u> (Wide Area Network)	Large ISP
Planet	The Internet (network of all networks)	The Internet!

Internetworks

- An internetwork, or internet, is what you get when you join networks together
 - Just another network
- The Internet (capital “I”) is the internet we all use

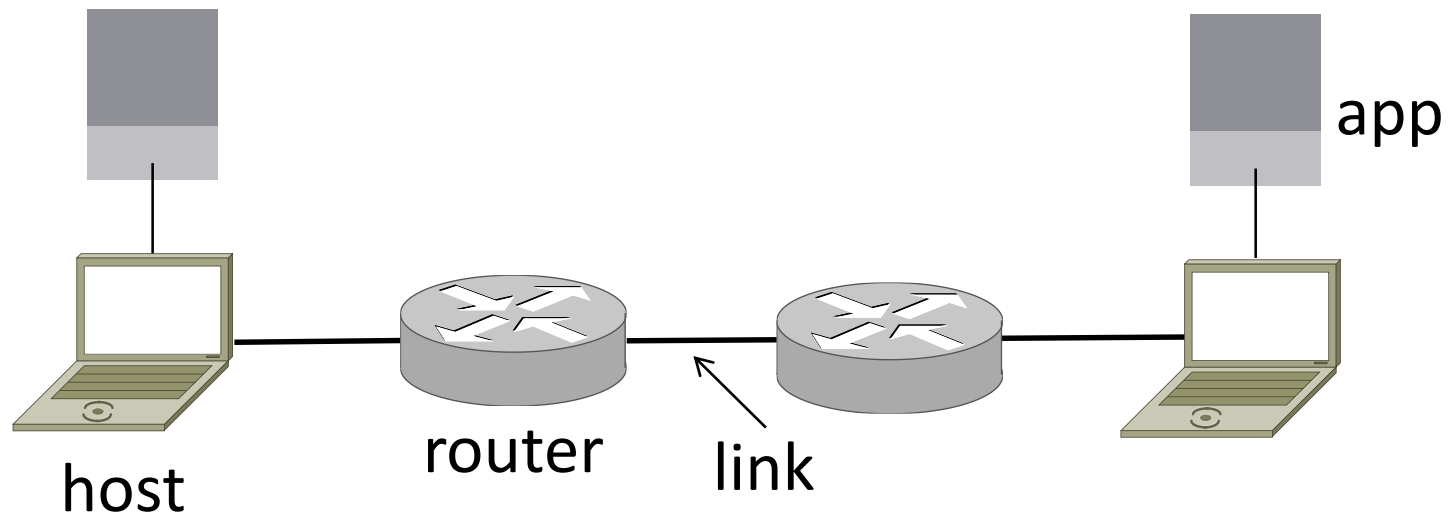
Network Boundaries

- What part is the “network”?



Network Boundaries (2)

- What part represents an “ISP”?



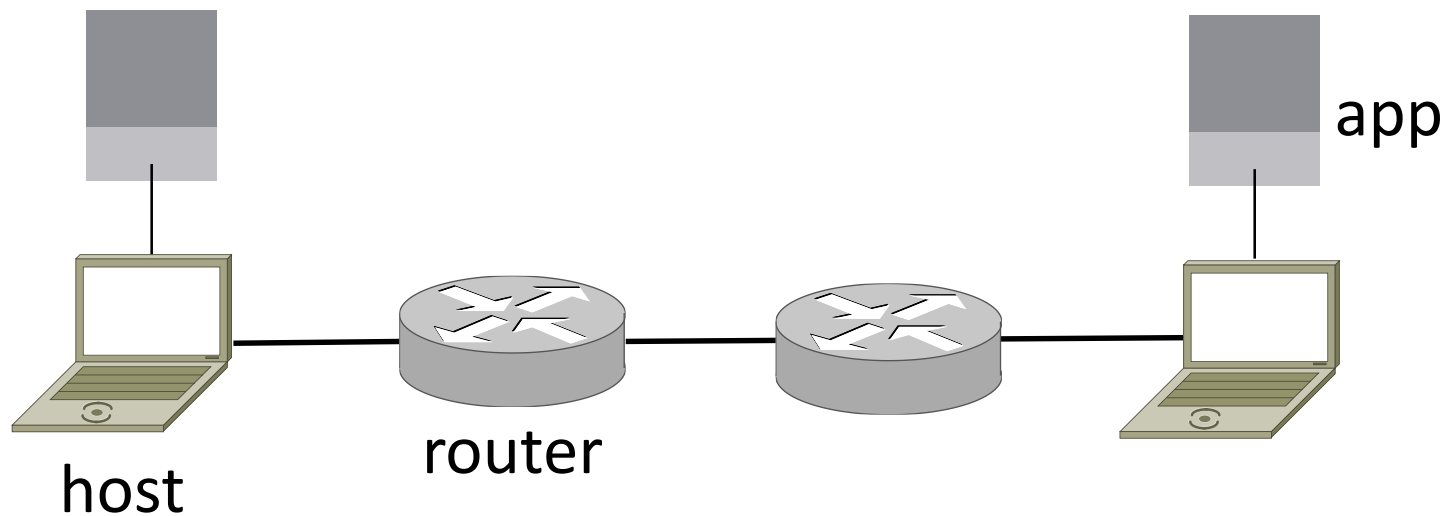
Network Boundaries (3)

- Cloud as a generic network



Key Interfaces

- Between (1) apps and network, and (2) network components



Networks Need Modularity

- The network does much for apps:
 - Make and break connections
 - Find a path through the network
 - Transfers information reliably
 - Transfers arbitrary length information
 - Send as fast as the network allows
 - Shares bandwidth among users
 - Secures information in transit
 - Lets many new hosts be added
 - ...

Networks Need Modularity

- The network does much for apps:

We need a form of modularity, to help manage complexity and support reuse

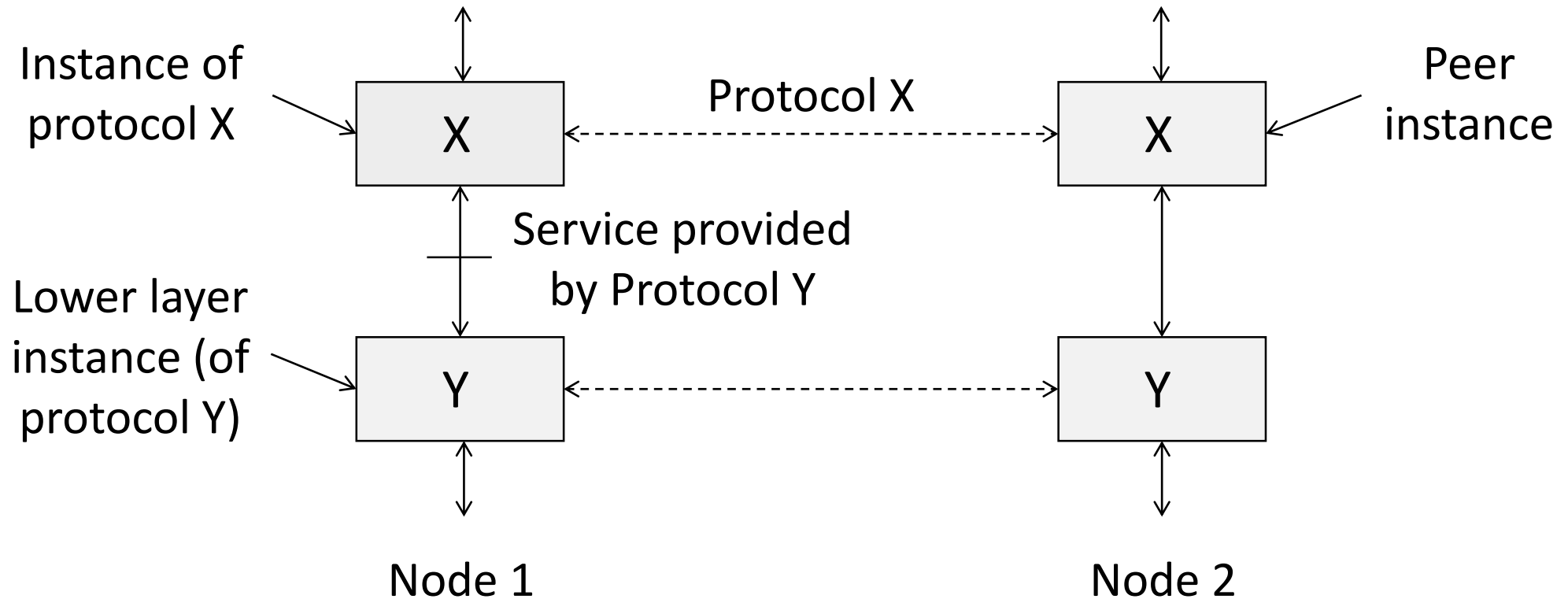
- Secures information in transit
- Lets many new hosts be added
- ...

Protocols and Layers

- Protocols and layering is the main structuring method used to divide up network functionality
 - Each instance of a protocol talks virtually to its peer using the protocol
 - Each instance of a protocol uses only the services of the lower layer

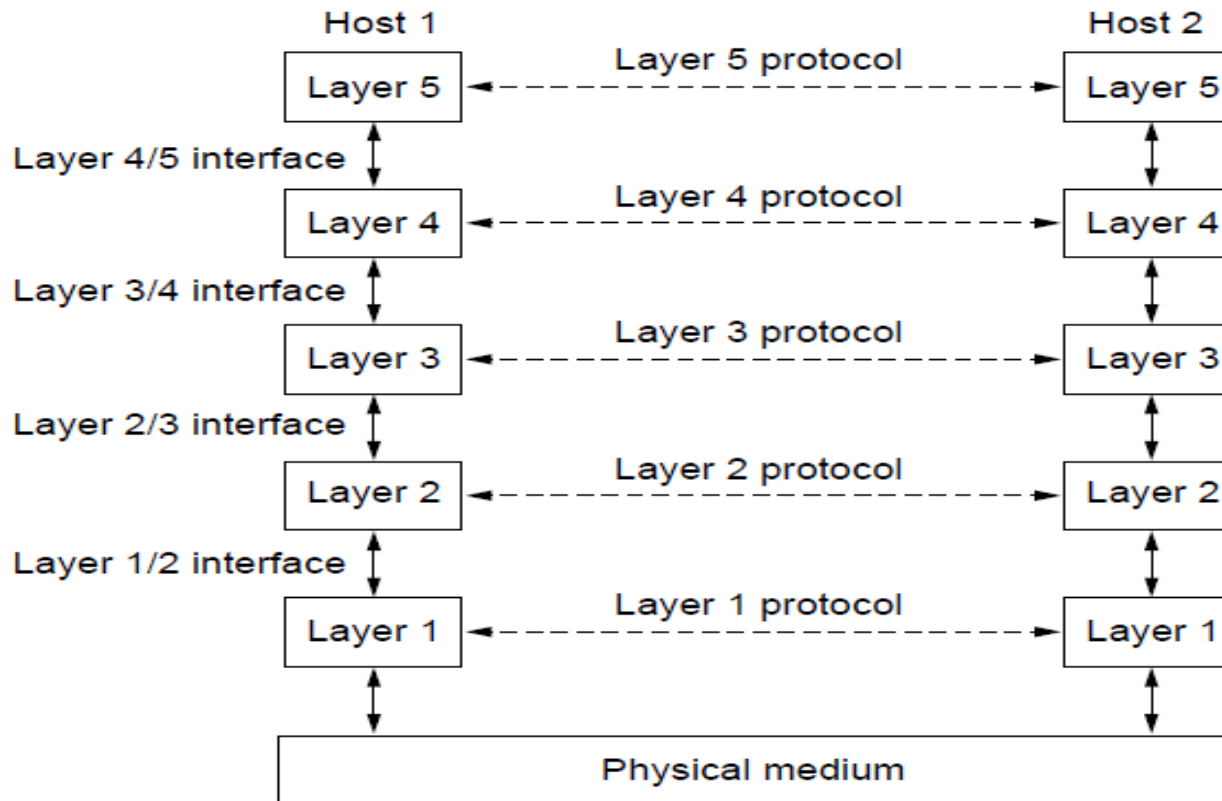
Protocols and Layers (2)

- Protocols are horizontal, layers are vertical



Protocols and Layers (3)

- Set of protocols in use is called a protocol stack

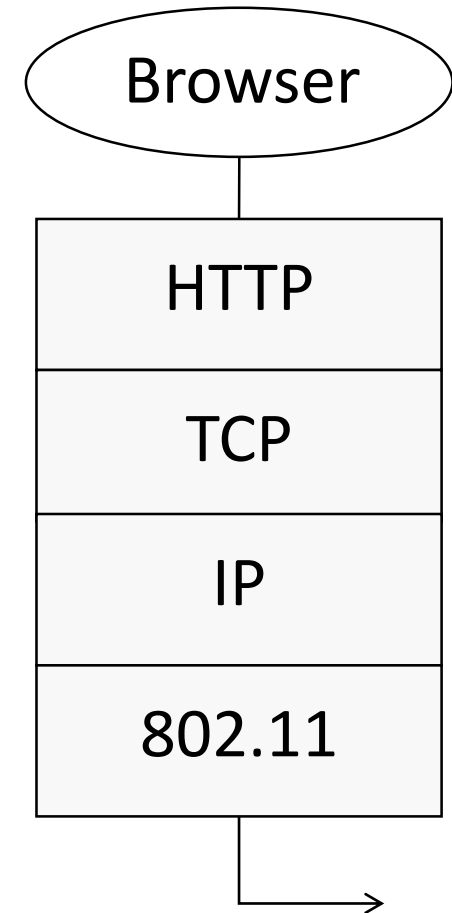


Protocols and Layers (4)

- Protocols you've probably heard of:
 - TCP, IP, 802.11, Ethernet, HTTP, SSL, DNS, ... and many more

Protocols and Layers (5)

- Protocols you've probably heard of:
 - TCP, IP, 802.11, Ethernet, HTTP, SSL, DNS, ... and many more
- An example protocol stack
 - Used by a web browser on a host that is wirelessly connected to the Internet

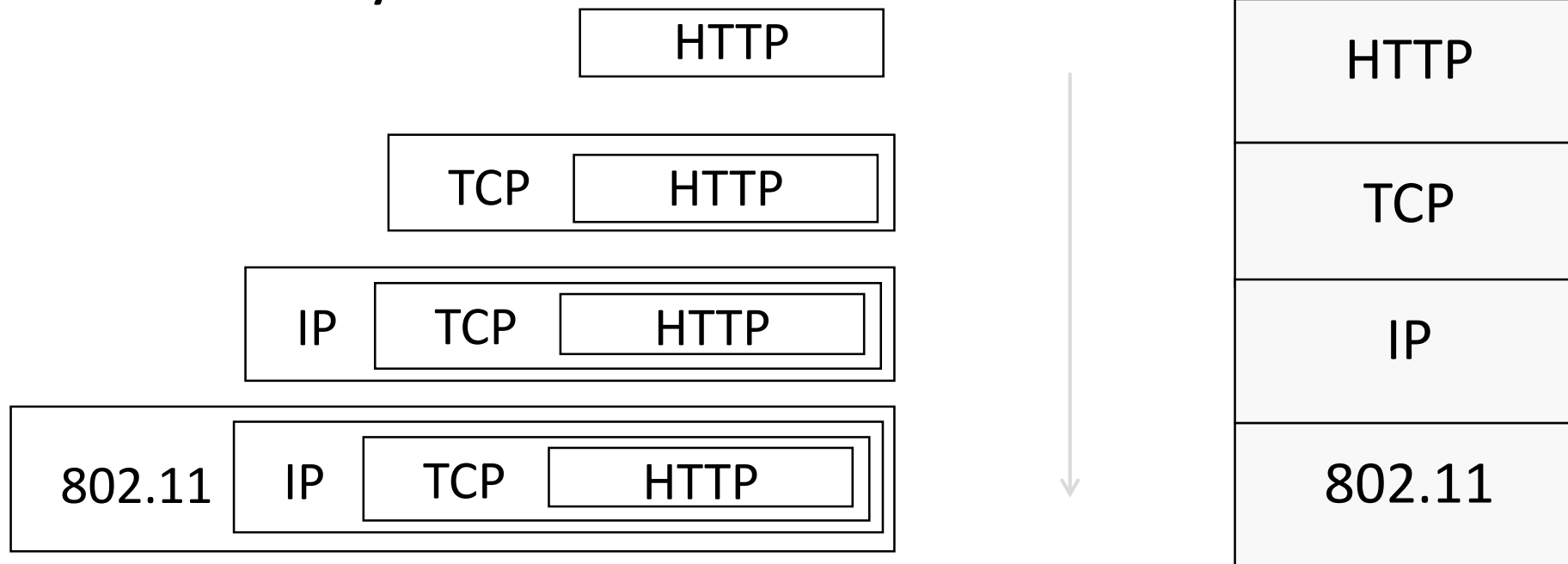


Encapsulation

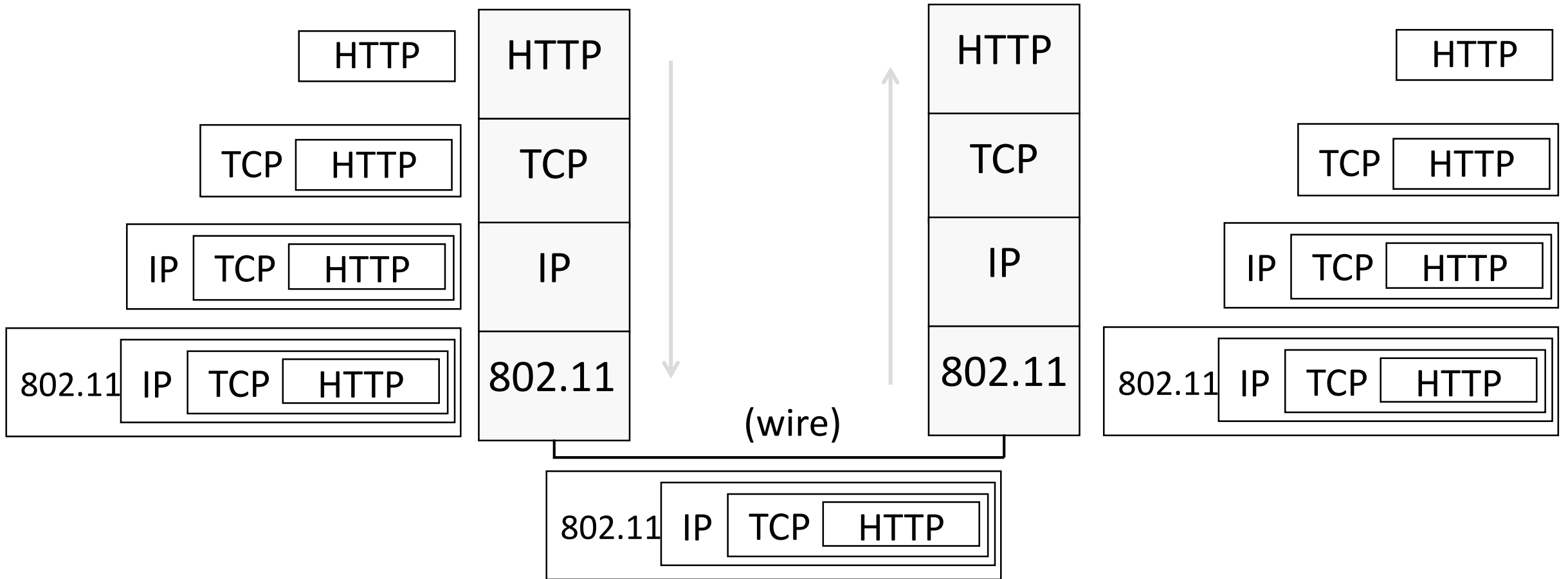
- Encapsulation is the mechanism used to effect protocol layering
 - Lower layer wraps higher layer content, adding its own information to make a new message for delivery
 - Like sending a letter in an envelope; postal service doesn't look inside

Encapsulation (2)

- Message “on the wire” begins to look like an onion
 - Lower layers are outermost

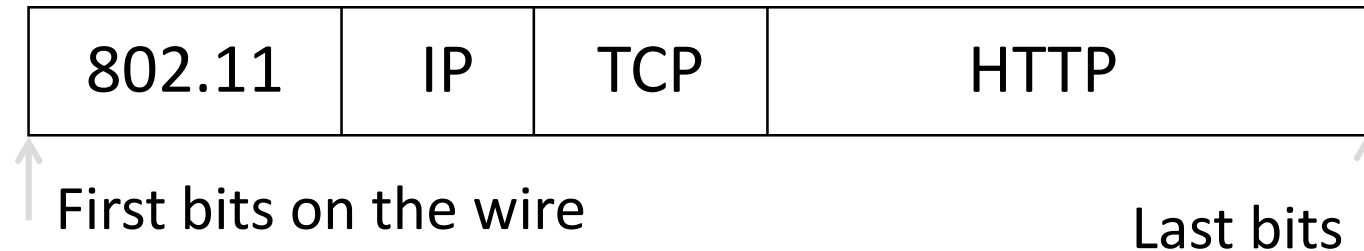


Encapsulation (3)



Encapsulation (4)

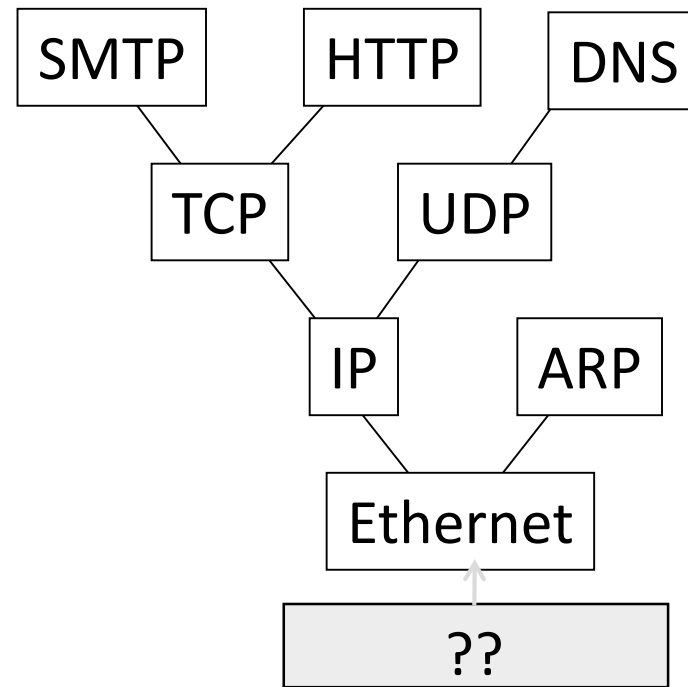
- Normally draw message like this:
 - Each layer adds its own header



- More involved in practice
 - Trailers as well as headers, encrypt/compress contents
 - Segmentation (divide long message) and reassembly

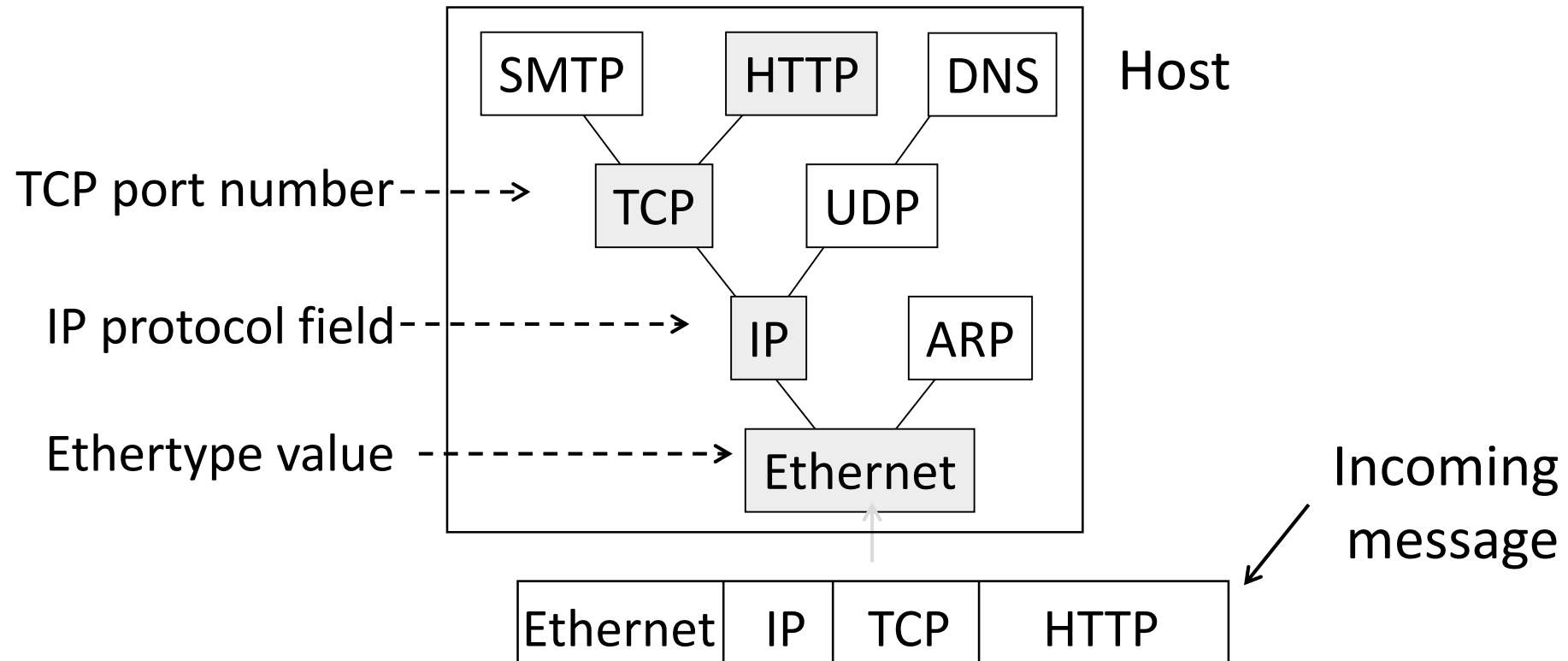
Demultiplexing

- Incoming message must be passed to the protocols that it uses



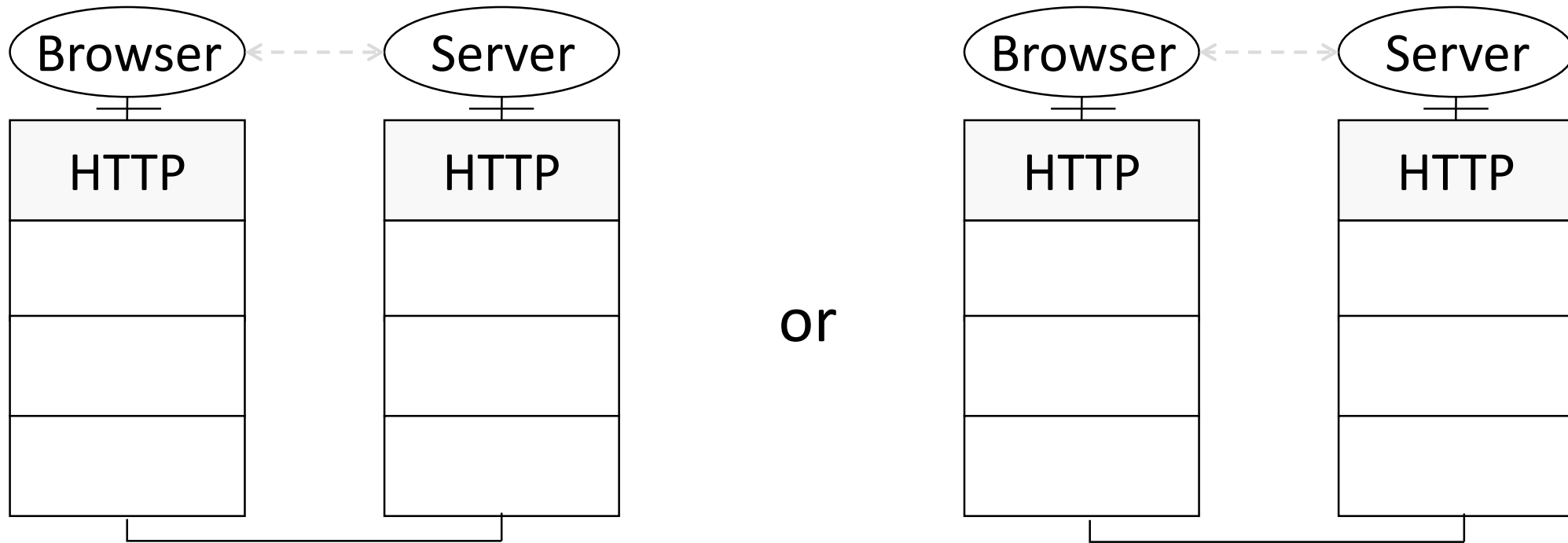
Demultiplexing (2)

- Done with demultiplexing keys in the headers



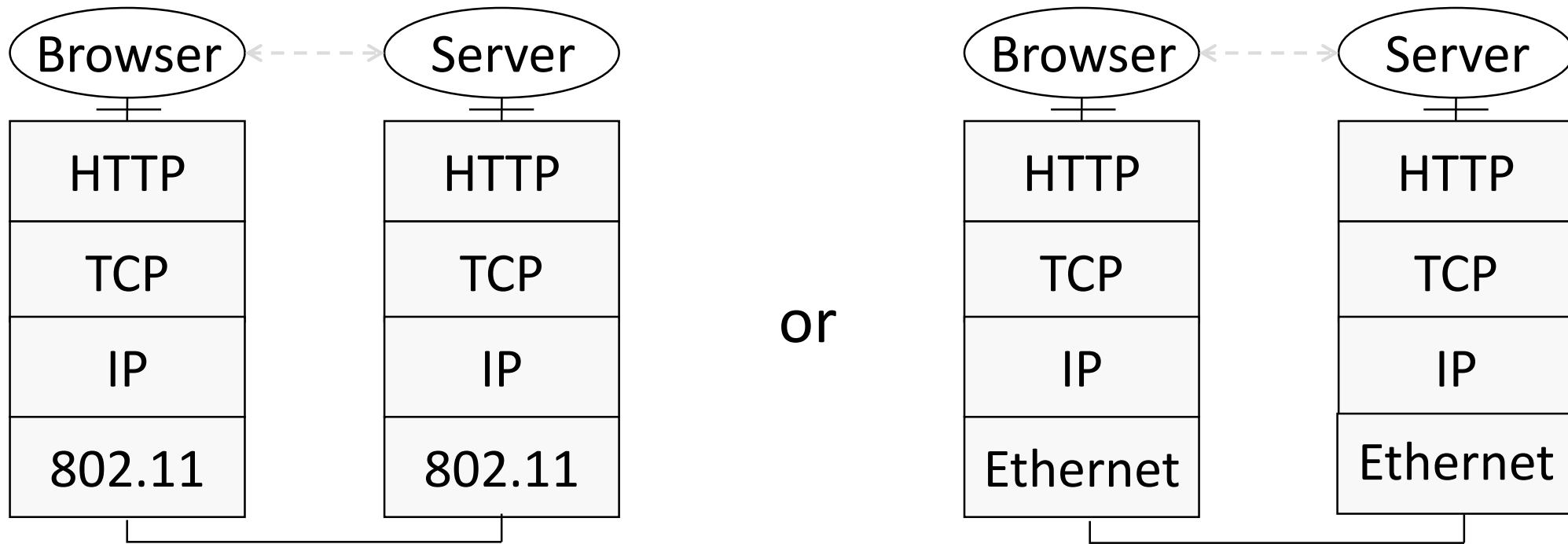
Advantage of Layering

- Information hiding and reuse



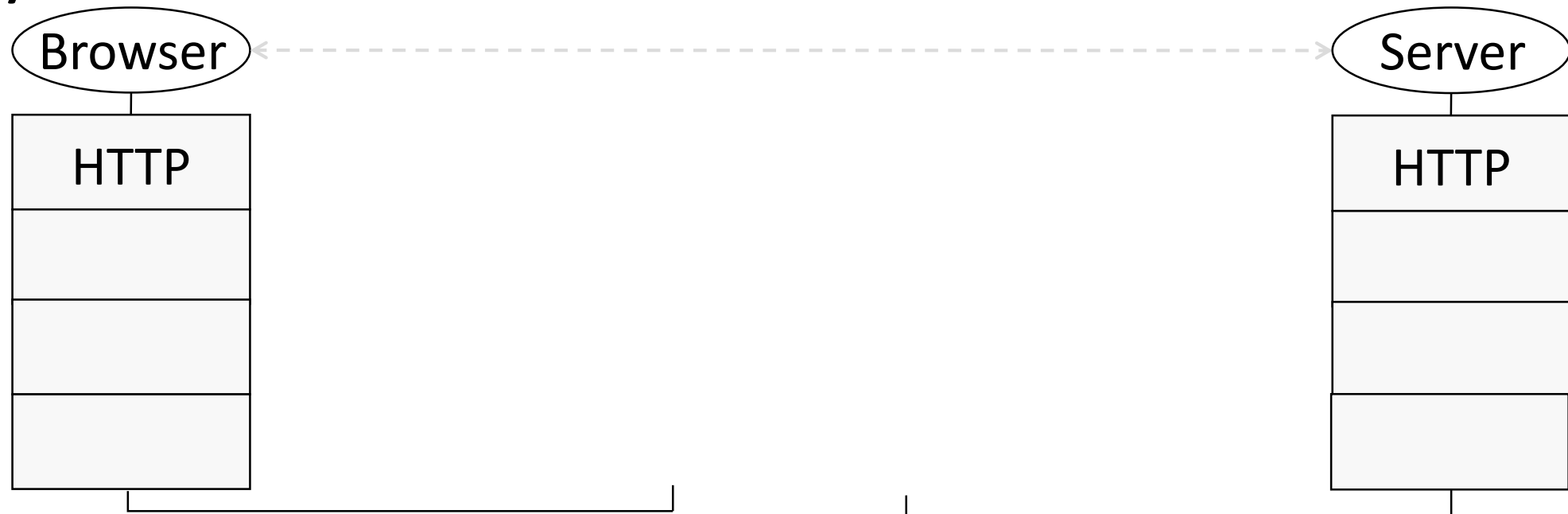
Advantage of Layering (2)

- Information hiding and reuse



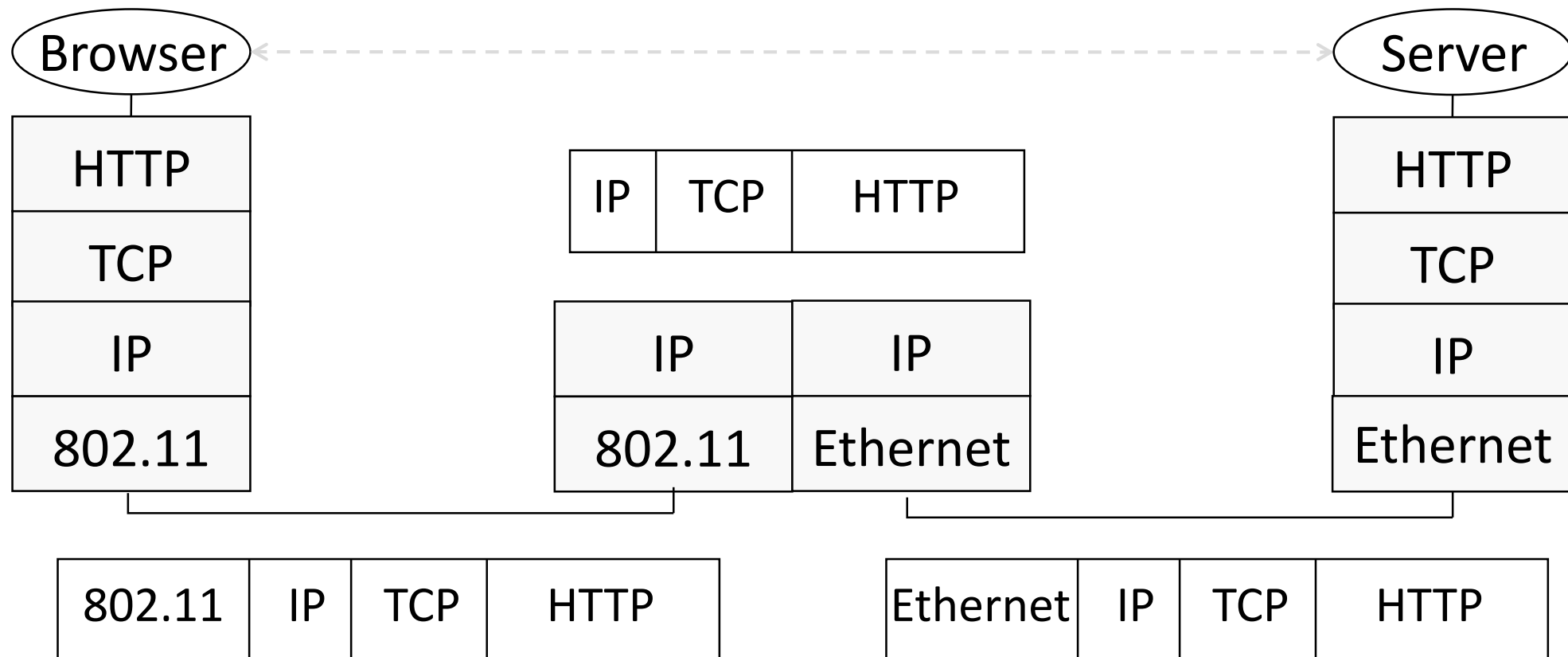
Advantage of Layering (3)

- Using information hiding to connect different systems



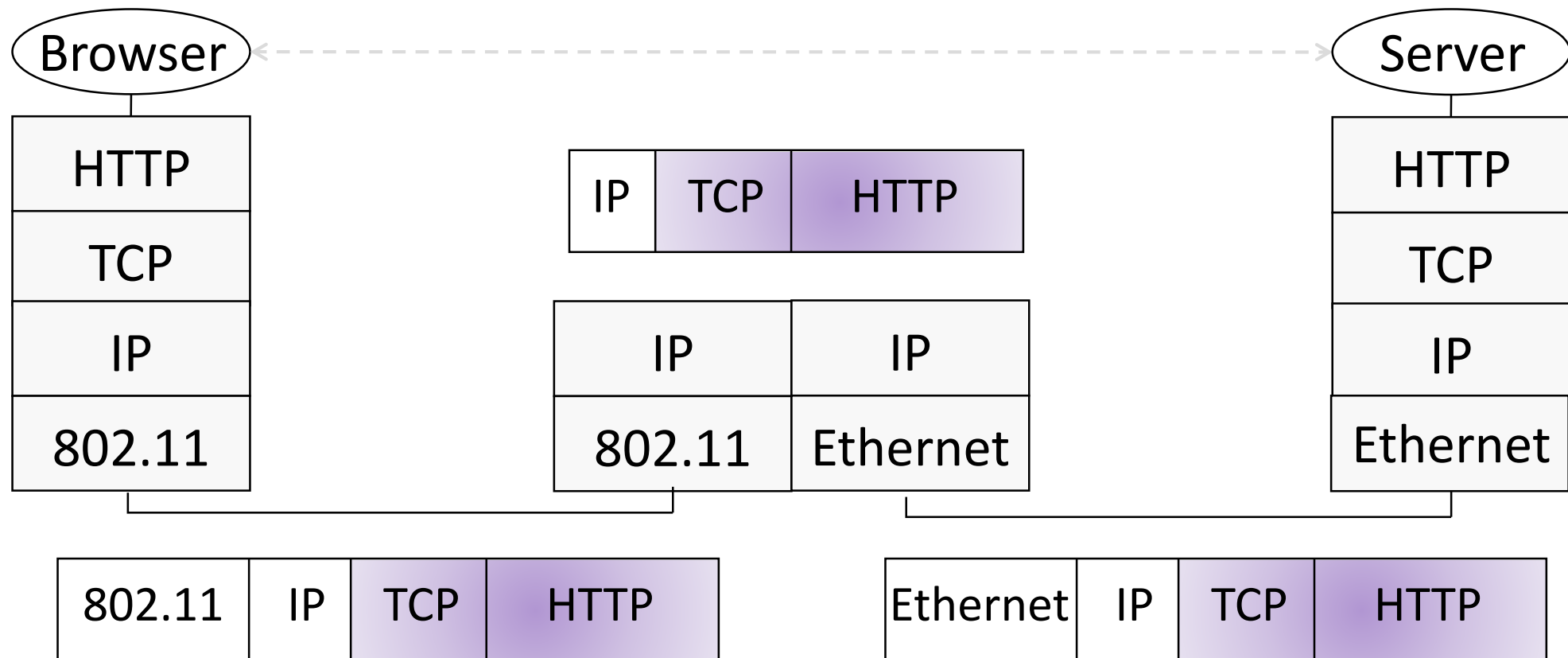
Advantage of Layering (4)

- Information hiding to connect different systems



Advantage of Layering (5)

- Information hiding to connect different systems



Disadvantages of Layering

- ?

Disadvantage of Layering

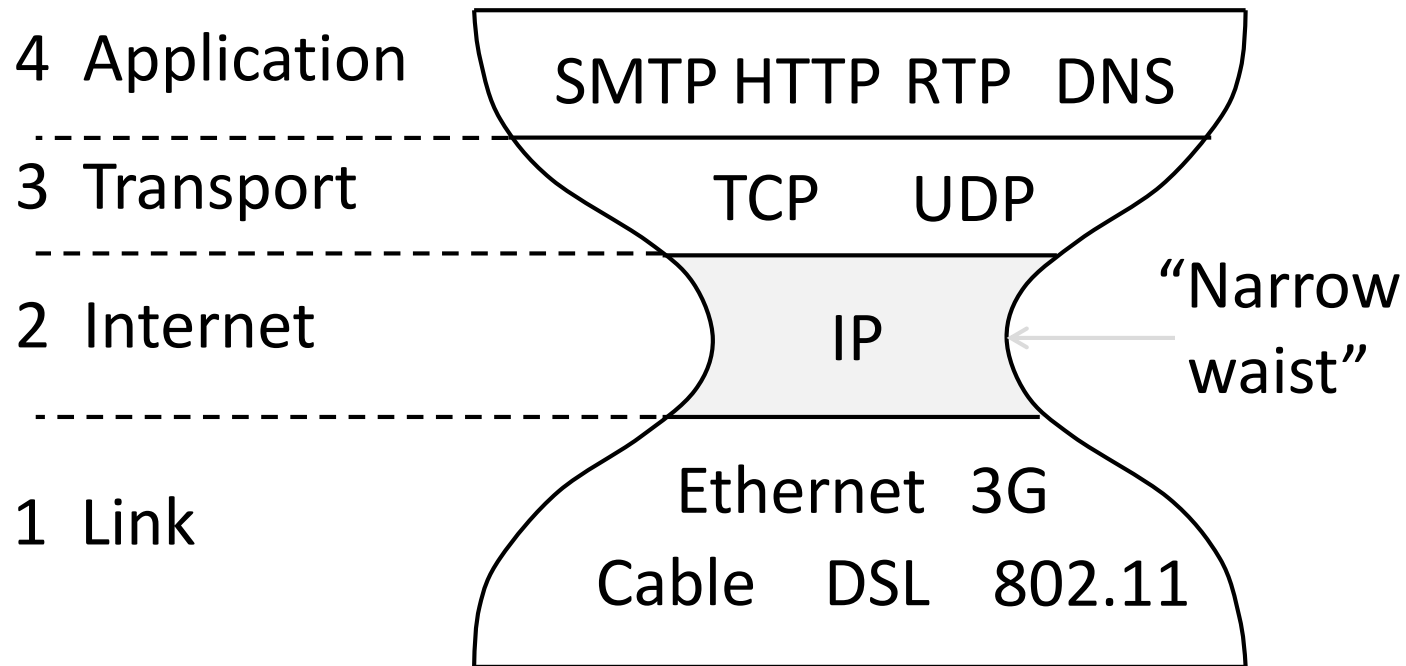
- Adds overhead
 - More problematic with short messages
- Hides information
 - App might care about network properties (e.g., latency, bandwidth, etc)
 - Network may need to know about app priorities (e.g., QoS)

OSI Layers

Layer	Function	Example
Application (7)	Services that are used with end user applications	SMTP,
Presentation (6)	Formats the data so that it can be viewed by the user Encrypt and decrypt	JPG, GIF, HTTPS, SSL, TLS
Session (5)	Establishes/ends connections between two hosts	NetBIOS, PPTP
Transport (4)	Responsible for the transport protocol and error handling	TCP, UDP
Network (3)	Reads the IP address from the packet.	Routers, Layer 3 Switches
Data Link (2)	Reads the MAC address from the data packet	Switches
Physical (1)	Send data on to the physical wire.	Hubs, NICs, Cable

Protocols and Layering

- The real internet protocol stacks:



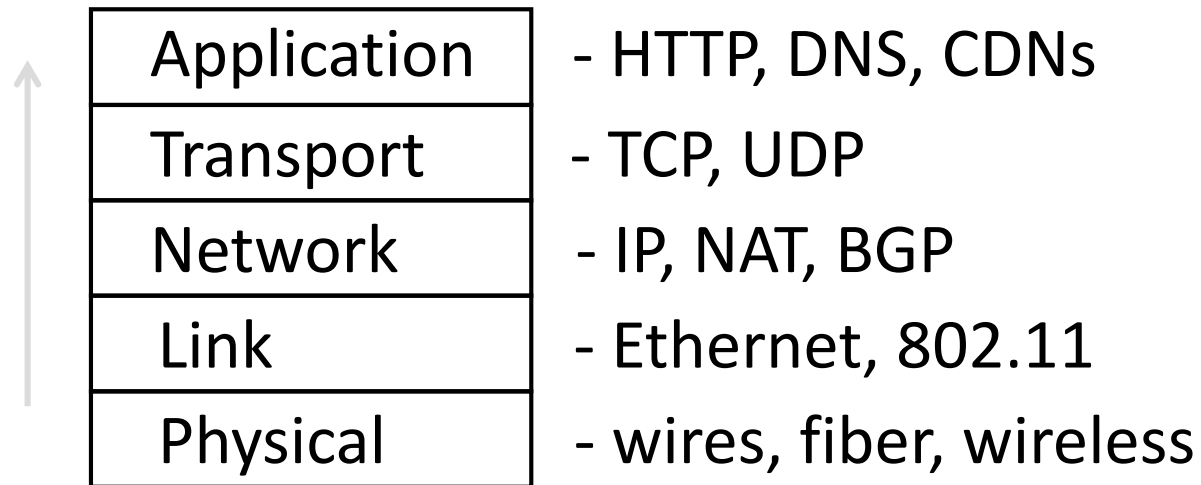
Course Reference Model

- We mostly follow the Internet
 - A little more about the Physical layer, and alternatives

5	Application	– Programs that use network service
4	Transport	– Provides end-to-end data delivery
3	Network	– Send packets over multiple networks
2	Link	– Send frames over one or more links
1	Physical	– Send bits using signals

Lecture Progression

- Bottom-up through the layers:



- Followed by more detail on:
 - Quality of service, Security (VPN, SSL)