1. Introduction: roadmap
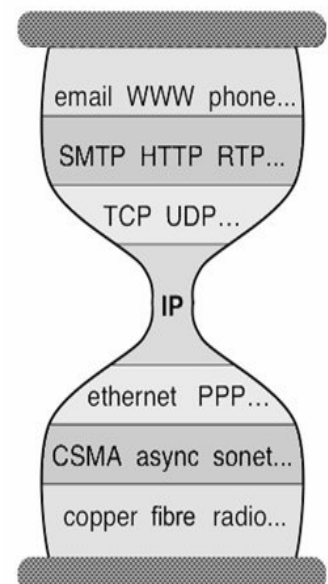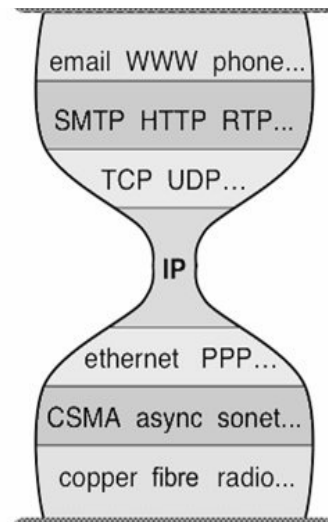
Self study

Internet protocol stack

- ❖ *application:* supporting network applications
  - FTP, SMTP, HTTP, Skype, ..
- ❖ *transport:* process-process data transfer
  - TCP, UDP
- ❖ *network:* routing of datagrams from source to destination
  - IP, routing protocols
- ❖ *link:* data transfer between neighboring network elements
  - Ethernet, 802.11(WiFi), PPP
- ❖ *physical:* bits "on the wire"

email WWW phone...

SMTP HTTP RTP...

TCP UDP...

IP

ethernet PPP...

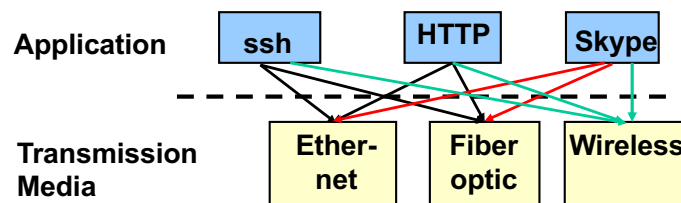CSMA async sonet...

copper fibre radio...

Three Observations

- ❖ Each layer:
  - Depends on layer below
  - Supports layer above
  - Independent of others

- ❖ Multiple versions in layer
  - Interfaces differ somewhat
  - Components pick which lower-level protocol to use

- ❖ But only one IP layer
  - Unifying protocol

email WWW phone...

SMTP HTTP RTP...

TCP UDP...

IP

ethernet PPP...

CSMA async sonet...

copper fibre radio...

An Example: No Layering

Application ssh   HTTP   Skype

Transmission Media   Ether-net   Fiber optic   Wireless

- ❖ No layering: each new application has to be re-implemented for every network technology !

An Example: Benefit of Layering

❖ Introducing an intermediate layer provides a common abstraction for various network technologies

Application   ssh   HTTP   Skype

Transport & Network

Transmission Media   Ethernet   Fiber optic   Wireless
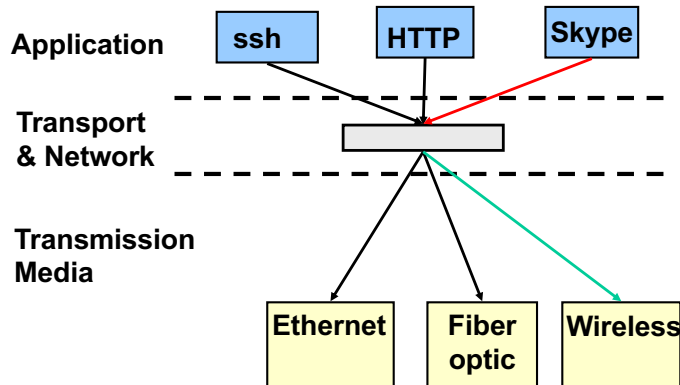
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Is Layering Harmful?

❖ Layer N may duplicate lower-level functionality
  ▪ E.g., error recovery to retransmit lost data
❖ Information hiding may hurt performance
  ▪ E.g., packet loss due to corruption vs. congestion
❖ Headers start to get large
  ▪ E.g., typically, TCP + IP + Ethernet headers add up to 54 bytes
❖ Layer violations when the gains too great to resist
  ▪ E.g., Network Address Translation (NAT – to be covered in Network Layer)
❖ Layer violations when network doesn't trust ends
  ▪ E.g., Firewalls (Security)

6

Distributing Layers Across Network

❖ Layers are simple if only on a single machine
  ▪ Just stack of modules interacting with those above/below

❖ But we need to implement layers across machines
  ▪ Hosts
  ▪ Routers
  ▪ Switches

❖ What gets implemented where?

What Gets Implemented on Host?

❖ Hosts have applications that generate data/messages that are eventually put out on wire

❖ At receiver host bits arrive on wire, must make it up to application
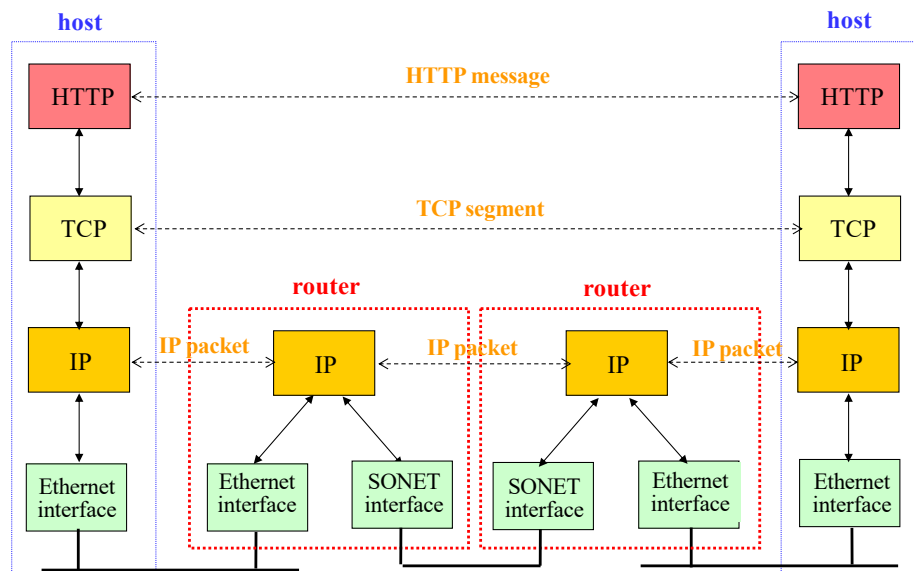
❖ Therefore, all layers must exist at host!

What Gets Implemented on Router?

❖ Bits arrive on wire
  ▪ Physical layer necessary

❖ Packets must be delivered to next-hop
  ▪ datalink layer necessary

❖ Routers participate in global delivery
  ▪ Network layer necessary

❖ Routers don't support reliable delivery
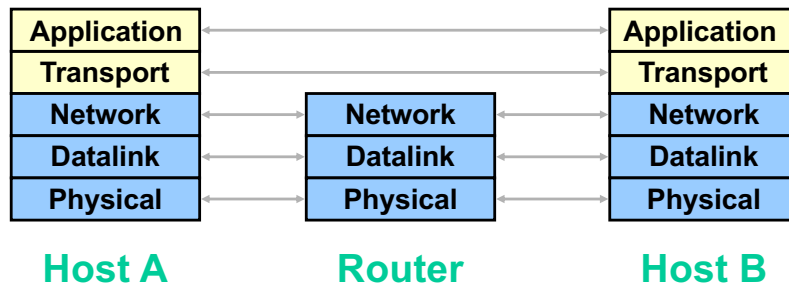 ▪ Transport layer (and above) **_not_** supported
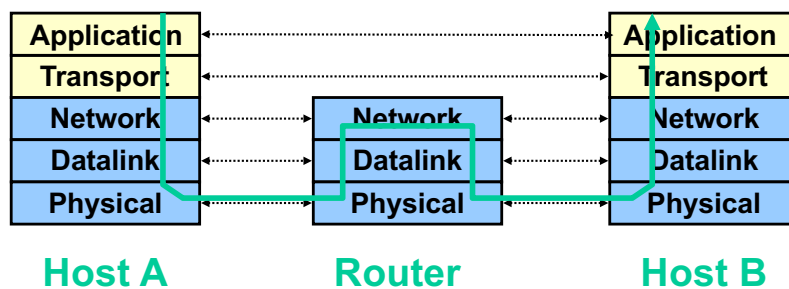
Internet Layered Architecture

Logical Communication

❖ Layers interacts with peer's corresponding layer

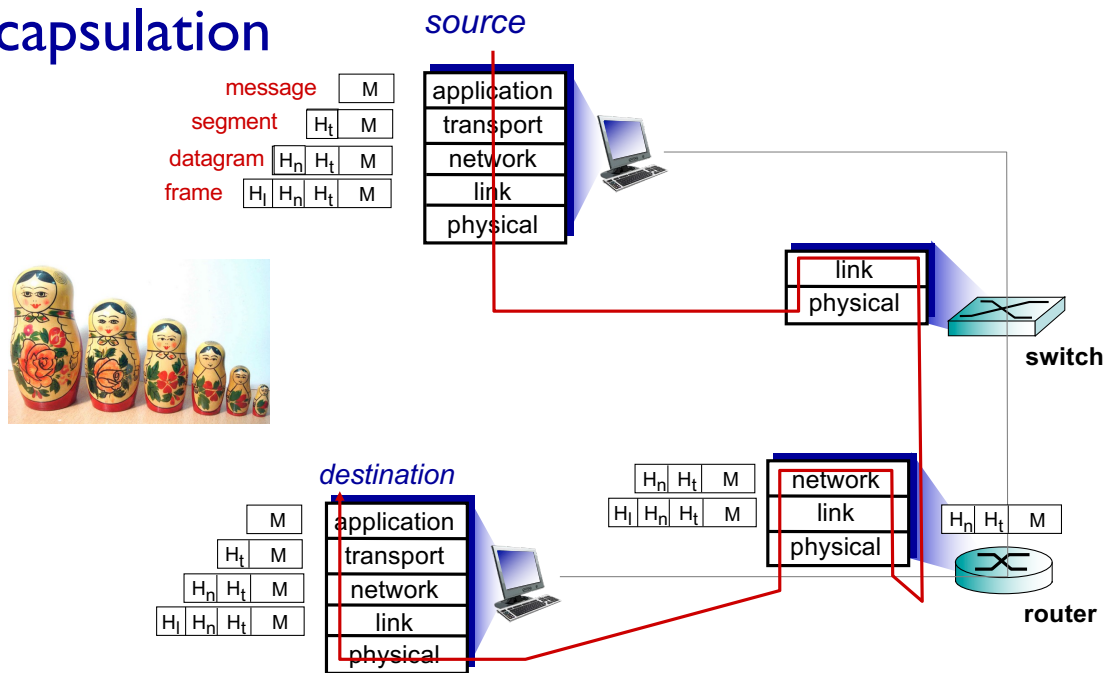| Application		Application
Transport		Transport
Network	Network	Network
Datalink	Datalink	Datalink
Physical	Physical	Physical
Host A	**Router**	**Host B**

Physical Communication

❖ Communication goes down to physical network
❖ Then from network peer to peer
❖ Then up to relevant layer

Application		Application
Transport		Transport
Network	Network	Network
Datalink	Datalink	Datalink
Physical	Physical	Physical
Host A	**Router**	**Host B**

Encapsulation

source

message				M
segment			H_t	M
datagram		H_n	H_t	M
frame	H_l	H_n	H_t	M

application
transport
network
link
physical

link
physical

switch

destination

				M
			H_t	M
		H_n	H_t	M
	H_l	H_n	H_t	M

application
transport
network
link
physical

H_n	H_t	M
H_l	H_n	H_t	M

network
link
physical

H_n	H_t	M

router

Quiz: Layering

What are two benefits of using a layered network model ? (Choose two)

A. It makes it easy to introduce new protocols

B. It speeds up packet delivery

C. It allows us to have many different packet headers

D. It prevents technology in one layer from affecting other layers

E. It creates many acronyms

1. Introduction: roadmap

Self study

We have now completed Chapter 1 from the textbook