

Computer Networks

COL 334/672

Using layering magic to make it work

Tarun Mangla

Sem 1, 2024-25

Recap

- How to send data across distributed networks?
- Requirement 1: Cost-effective resource sharing
 - Uses packet switching
 - Implications on other network services and network equipment design
- Requirement 2: Common network services
 - Where to implement those?
 - End-to-end design principle
- **This class: How does Internet architecture look like?**

How do we go about designing Internet architecture?

Networks are complex, with many “pieces”:

- hosts
- routers
- links of various media
- applications
- hardware, software

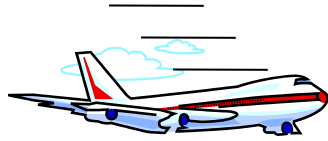
Variety of network services:

- data transmission
- routing
- reliability
- congestion control
- ...

Question: is there any hope of *organizing* structure of network?

- and/or our *discussion* of networks?

Example: organization of air travel



————— *end-to-end transfer of person plus baggage* —————>

ticket (purchase)

baggage (check)

gates (load)

runway takeoff

airplane routing

ticket (complain)

baggage (claim)

gates (unload)

runway landing

airplane routing

airplane routing

How would you *define/discuss* the *system* of airline travel?

- a series of steps, involving many services

Example: organization of air travel



layers: each layer implements some services

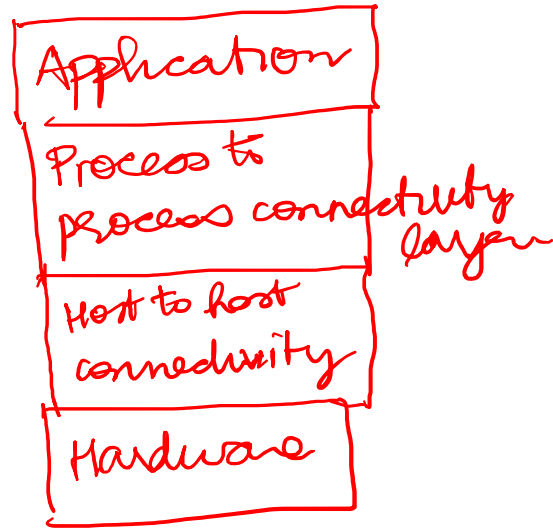
- via its own internal-layer actions
- relying on services provided by layer below

Why layering?

Approach to designing/discussing complex systems:

- explicit structure allows identification, relationship of system's pieces
 - layered reference model for discussion
- modularization eases maintenance, updating of system
 - change in layer's service *implementation*: transparent to rest of system
 - e.g., change in gate procedure doesn't affect rest of system

How can we layer the network?



Layering the network

Services

- Data transmission
- Addressing/Routing
- Reliable delivery
- Congestion control
- In-order delivery
- Encryption
- Authentication

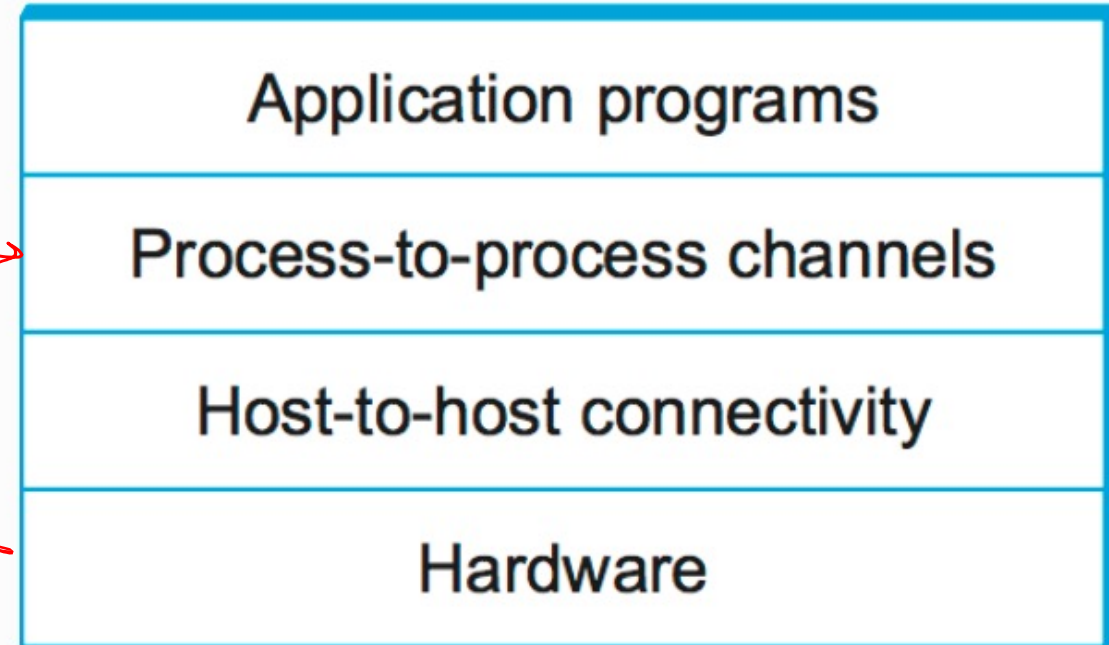
Send, recv

Protocol 1

Reliable

Protocol - 2

Unreliable



Data transmission

How does the Internet reference model look like?

Layered Internet protocol stack

/ IP suite /
Internet Reference Model

- **application:** supporting network applications

- HTTP, IMAP, SMTP, DNS, FTP

- **transport:** process-process data transfer

- TCP, UDP

CC
Reliability

In order

- **network:** routing of datagrams from source to destination → Internet Protocol

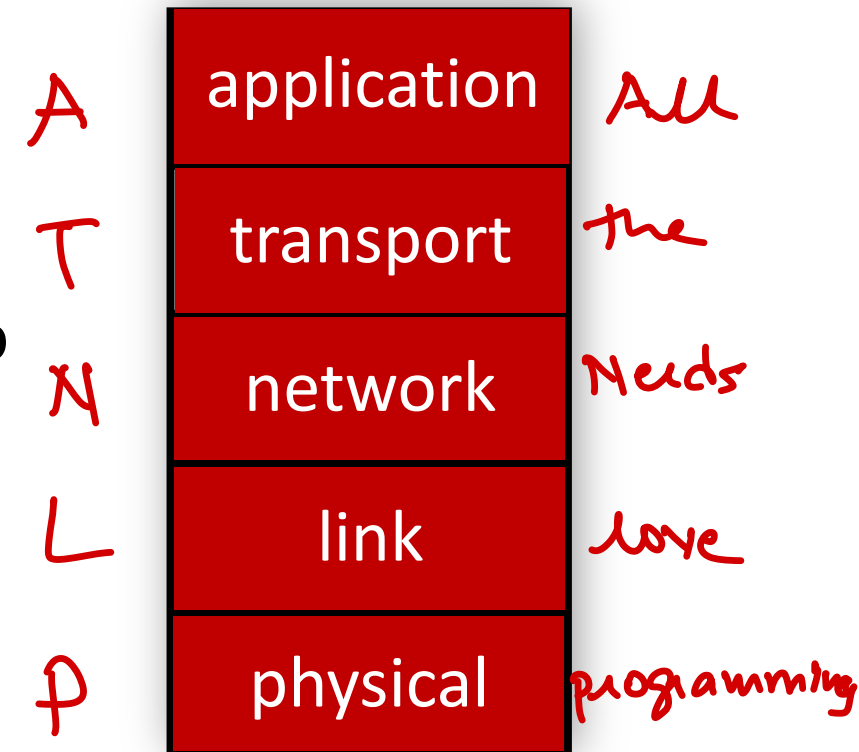
- IP, routing protocols

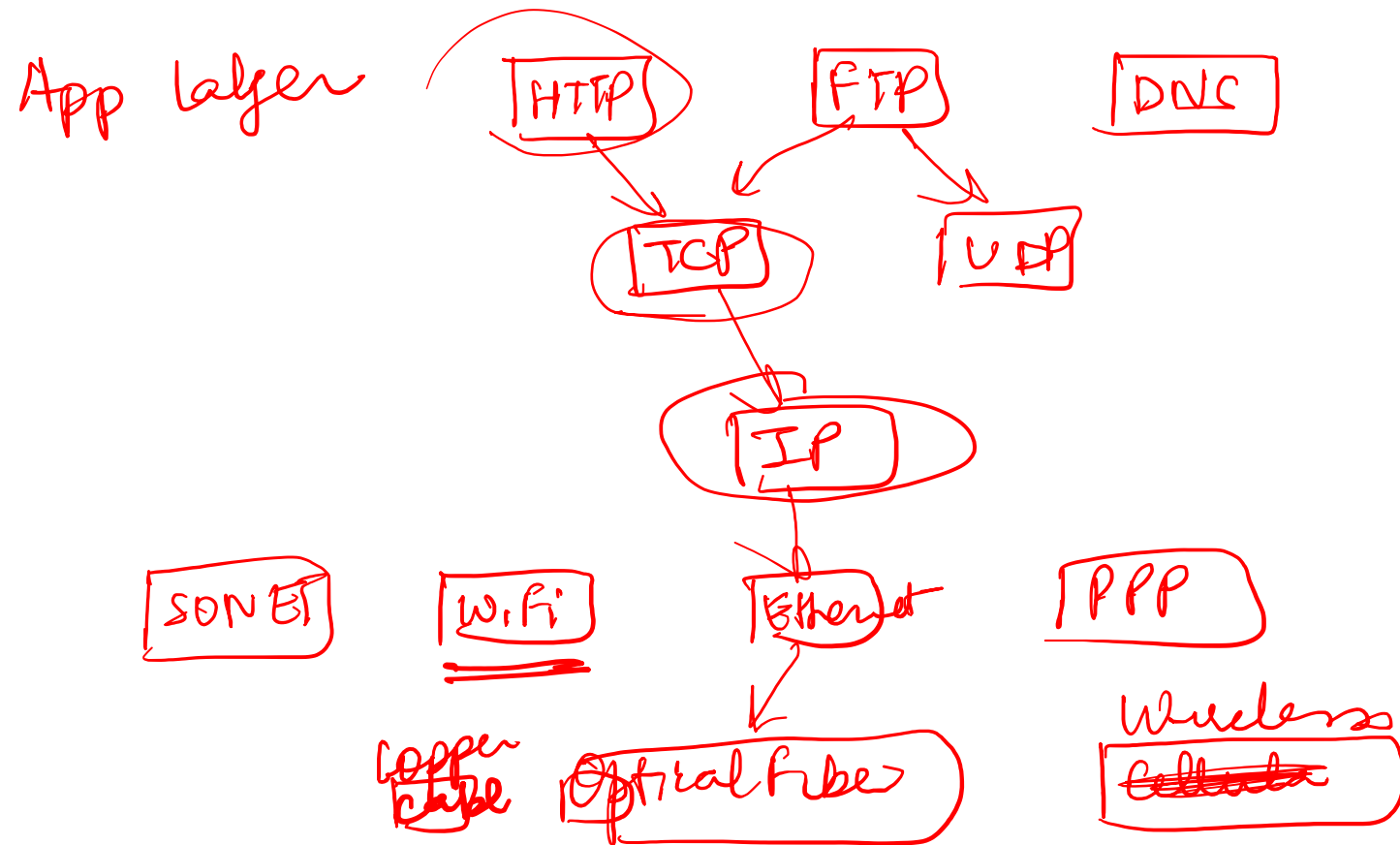
- **link:** data transfer between neighboring network elements

- Ethernet, 802.11 (WiFi), PPP

- **physical:** bits “on the wire”

Optical cable / Copper cable → coax → DSL cable

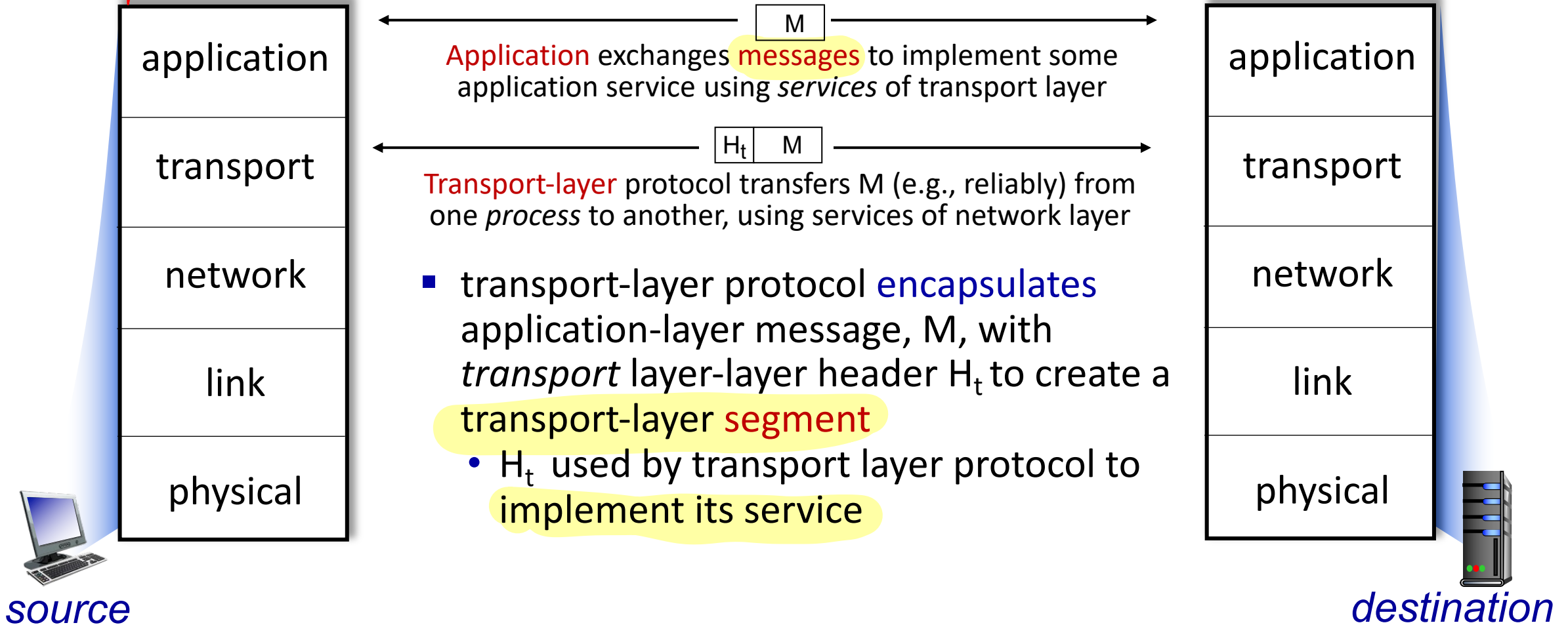




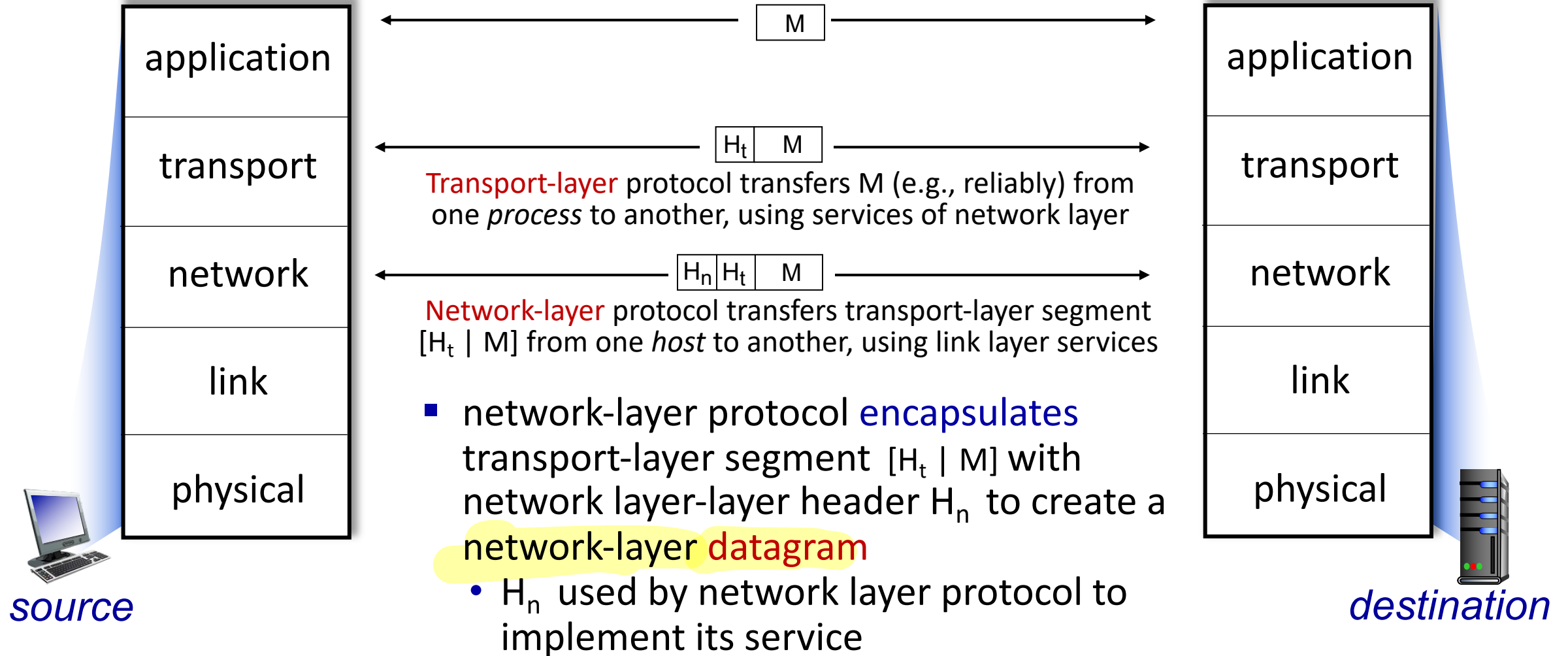
Services, Layering and Encapsulation

Service Interface

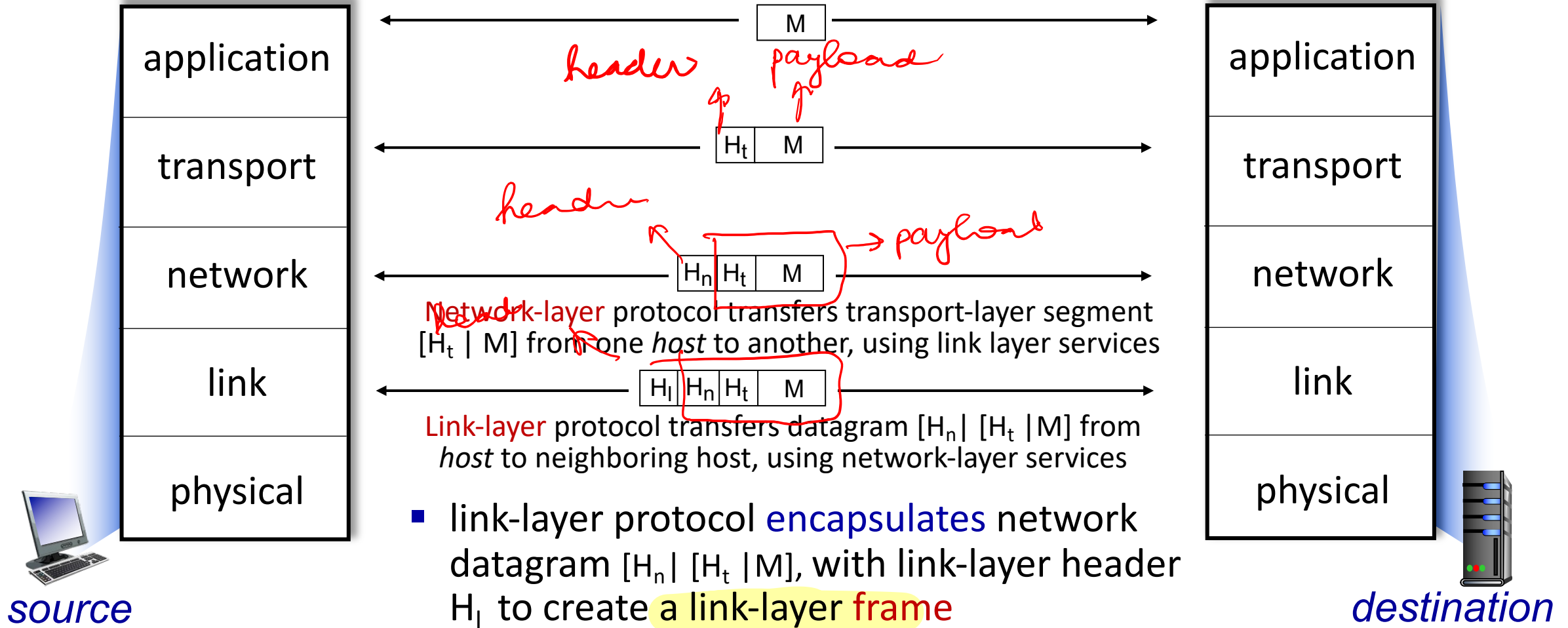
Peer Interface



Services, Layering and Encapsulation

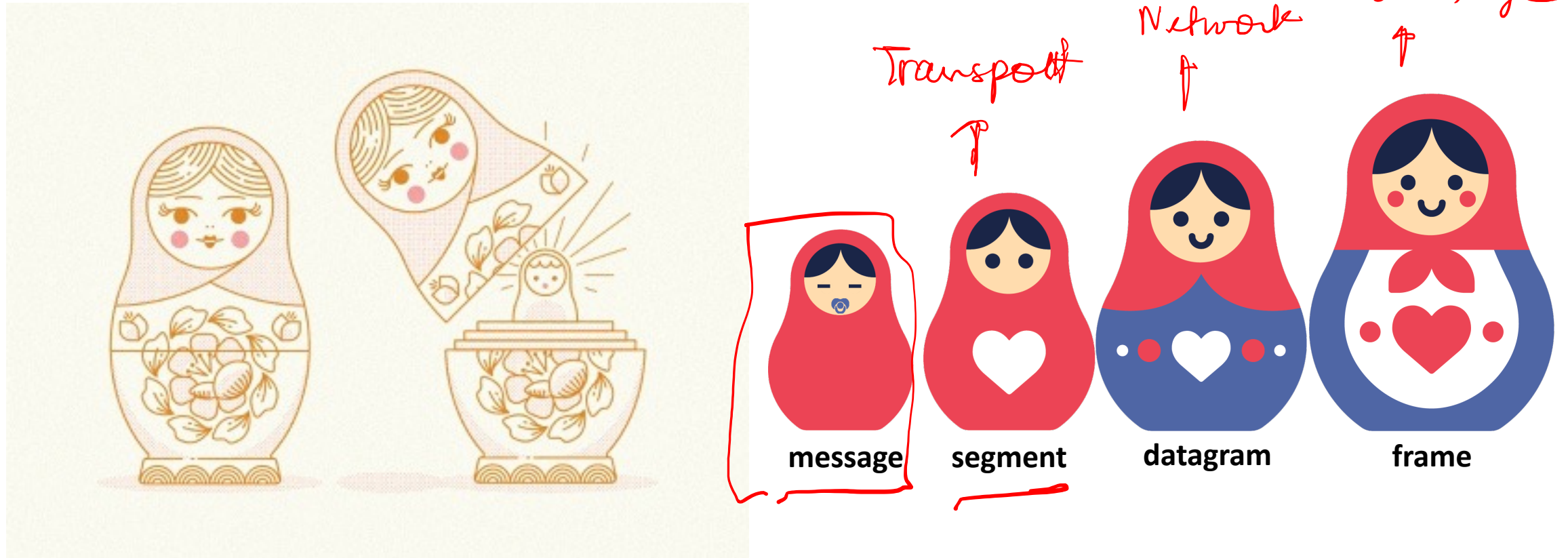


Services, Layering and Encapsulation

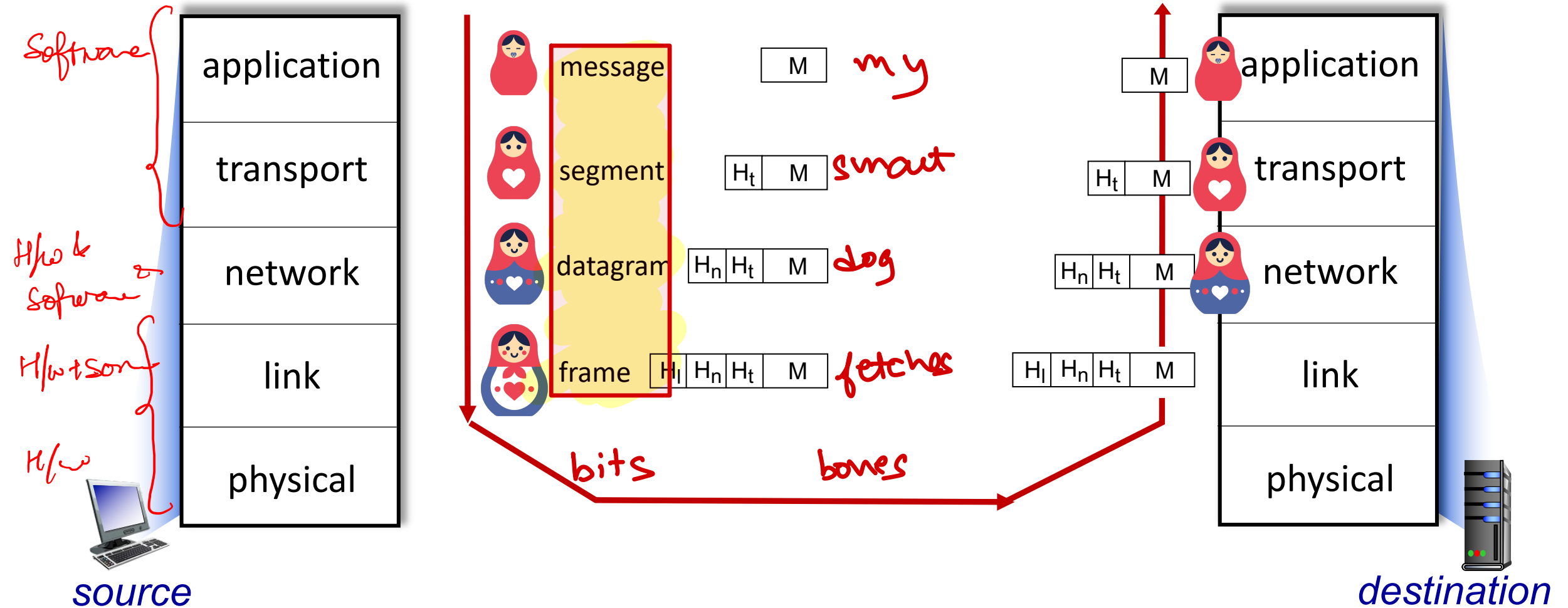


Encapsulation

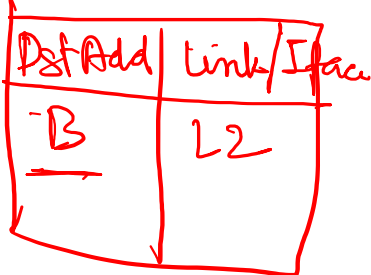
Matryoshka dolls (stacking dolls)



Services, Layering and Encapsulation



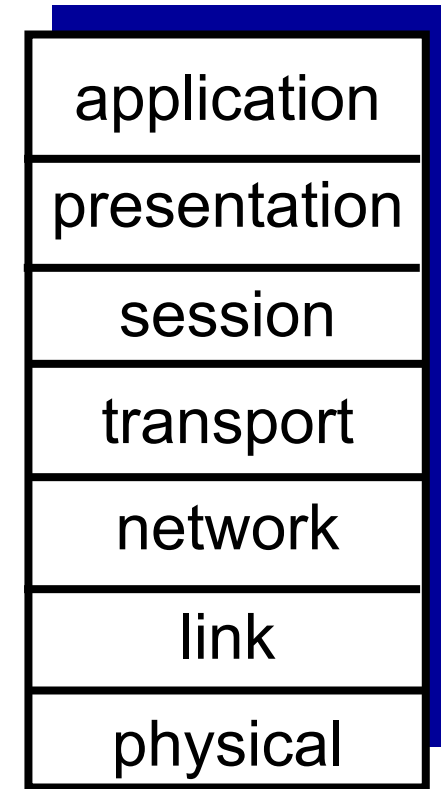
Route tabs



An alternative model: OSI reference model

Two layers not found in Internet protocol stack!

- *presentation*: allow applications to interpret meaning of data, e.g., encryption, compression, machine-specific conventions
- *session*: synchronization, checkpointing, recovery of data exchange
- Internet stack “missing” these layers!
 - these services, *if needed*, must be implemented in application
 - needed?

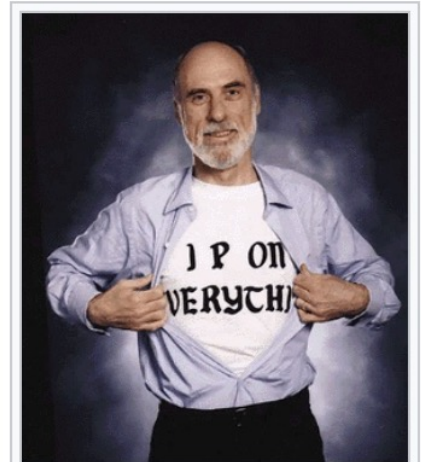


The seven layer OSI/ISO reference model

Protocol Wars

Philosophical and cultural aspects [\[edit \]](#)

Historian Andrew L. Russell wrote that Internet engineers such as Danny Cohen and Jon Postel were accustomed to continual experimentation in a fluid organizational setting through which they developed TCP/IP. They viewed OSI committees as overly bureaucratic and out of touch with existing networks and computers. This alienated the Internet community from the OSI model. A dispute broke out within the Internet community after the [Internet Architecture Board](#) (IAB) proposed replacing the Internet Protocol in the Internet with the [OSI Connectionless Network Protocol](#) (CLNP). In response, Vint Cerf performed a striptease in a [three-piece suit](#) while presenting to the 1992 [Internet Engineering Task Force](#) (IETF) meeting, revealing a T-shirt emblazoned with "IP on Everything". According to Cerf, his intention was to reiterate that a goal of the IAB was to run IP on every underlying transmission medium.^[163] At the same meeting, [David Clark](#) summarized the IETF approach with the famous saying "We reject: kings, presidents, and voting. We believe in: rough consensus and running code."^[163] The [Internet Society](#) (ISOC) was chartered that year.^[164]



Vint Cerf emphasized [🔍] the goal of running "IP on everything", notably with a T-shirt he wore while presenting to the 1992 [IETF](#) meeting.^[163]

Summary

- Layering, a useful construct, to organize Internet architecture

- Internet uses a 5-layered architecture

- Each layer provides services to the layer below

- Encapsulation used for adding layer information

- Next class: How ~~to~~ ^{to} study performance of this system?

