# Computer Networks
# COL 334/672

Using layering magic to make it work

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# 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

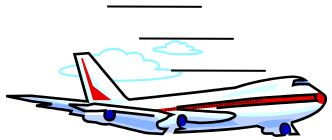
Variety of network services:

- 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

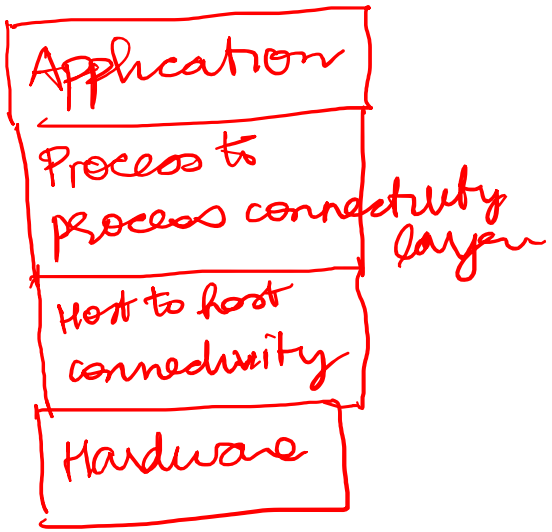
- via its own internal-layer actions
- relying on services provided by layer below

# 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

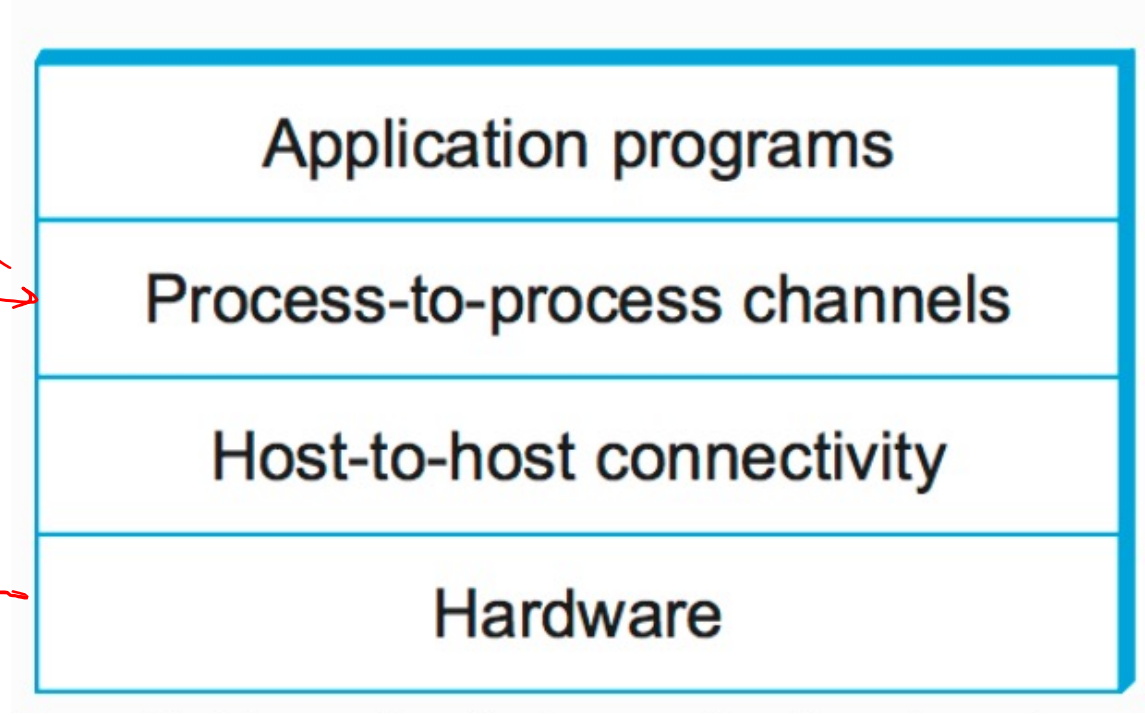
# How can we layer the network?



# Layering the network

**Services**

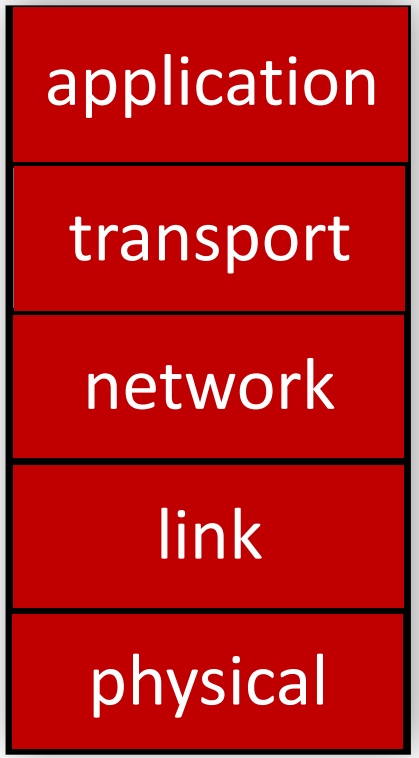
- Data transmission
- Addressing/Routing
- Reliable delivery
- Congestion control
- In-order delivery
- Encryption
- Authentication

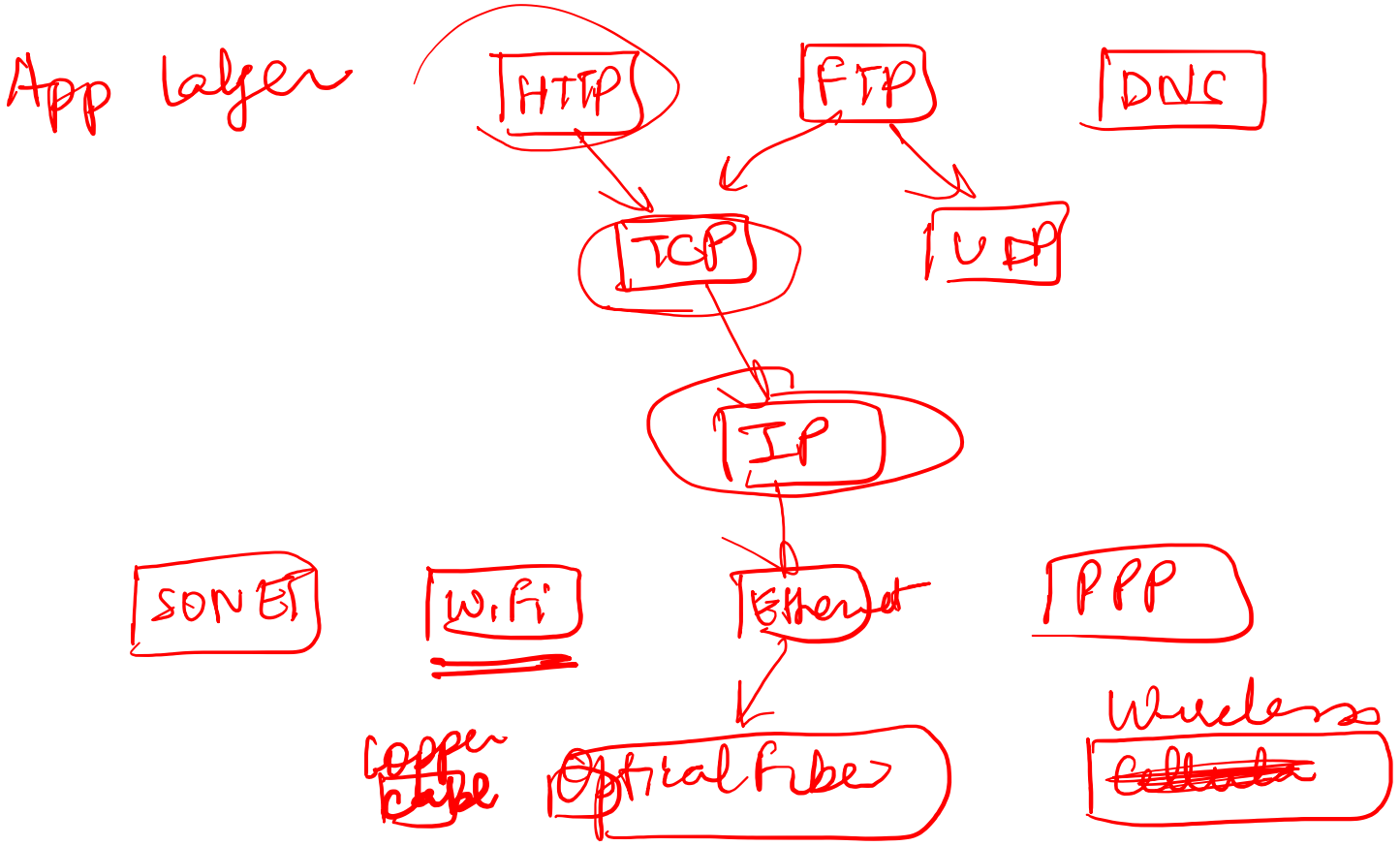



How does the Internet reference model look like?

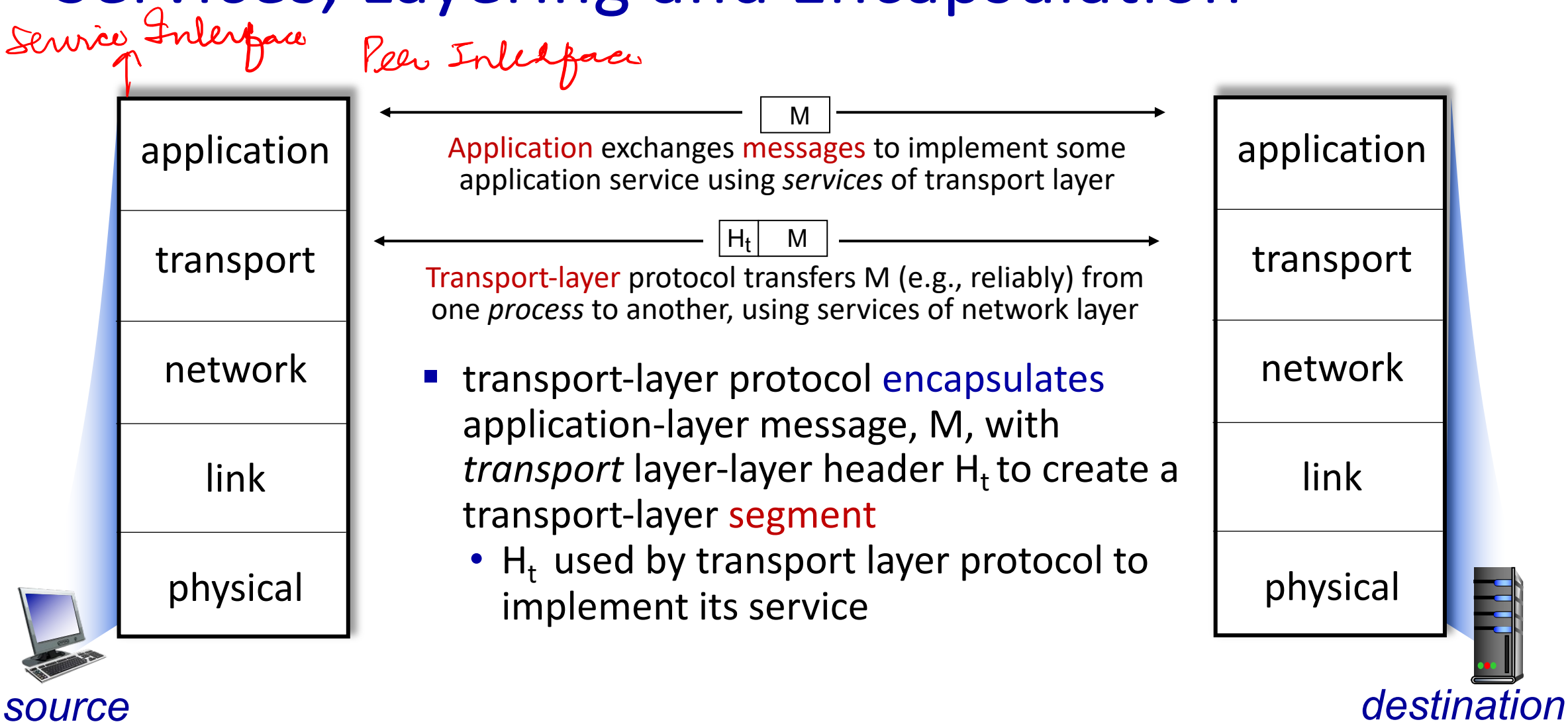
# Layered Internet protocol stack

- *application:* supporting network applications
  - HTTP, IMAP, SMTP, DNS, FTP
- *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"



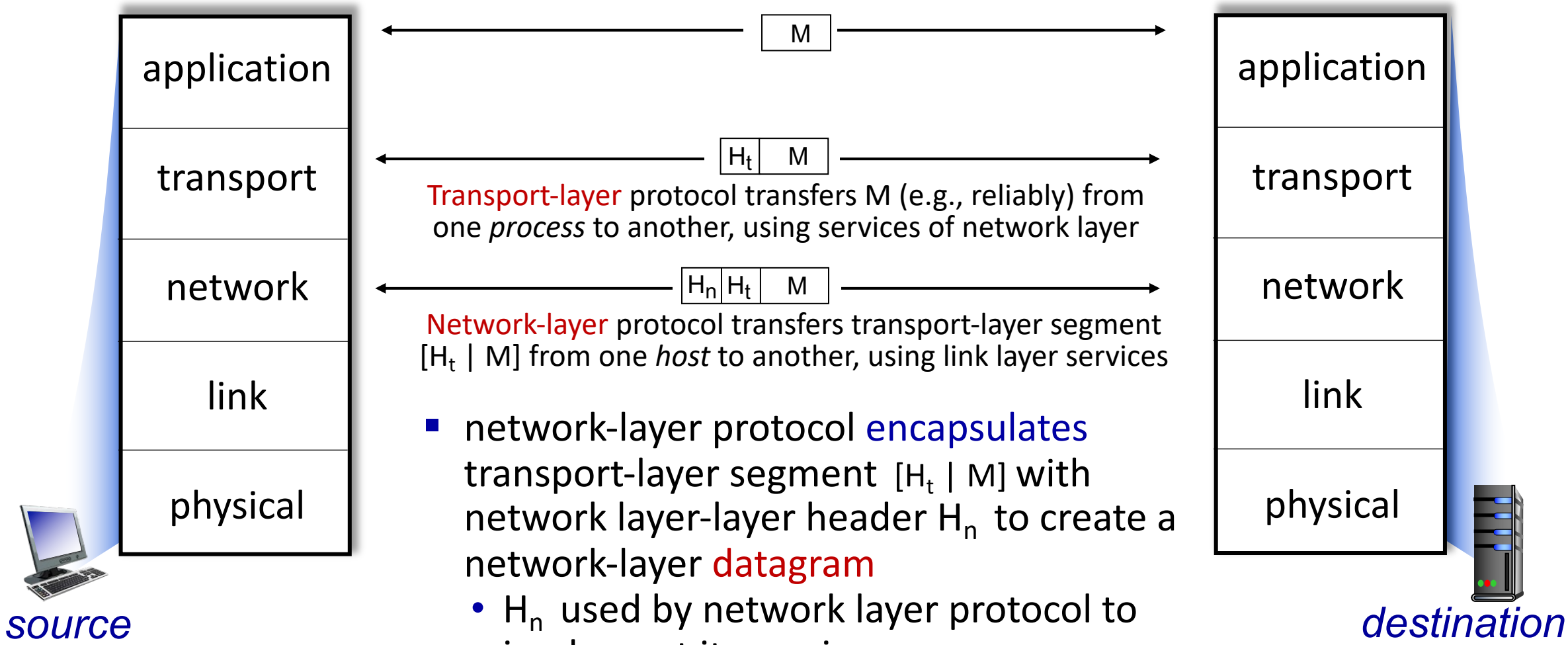

App layer
HTTP
FTP
DNS
TCP
UDP
IP
SONET
Wi-Fi
Ethernet
PPP
copper cable
Optical Fiber
Wireless

# Services, Layering and Encapsulation



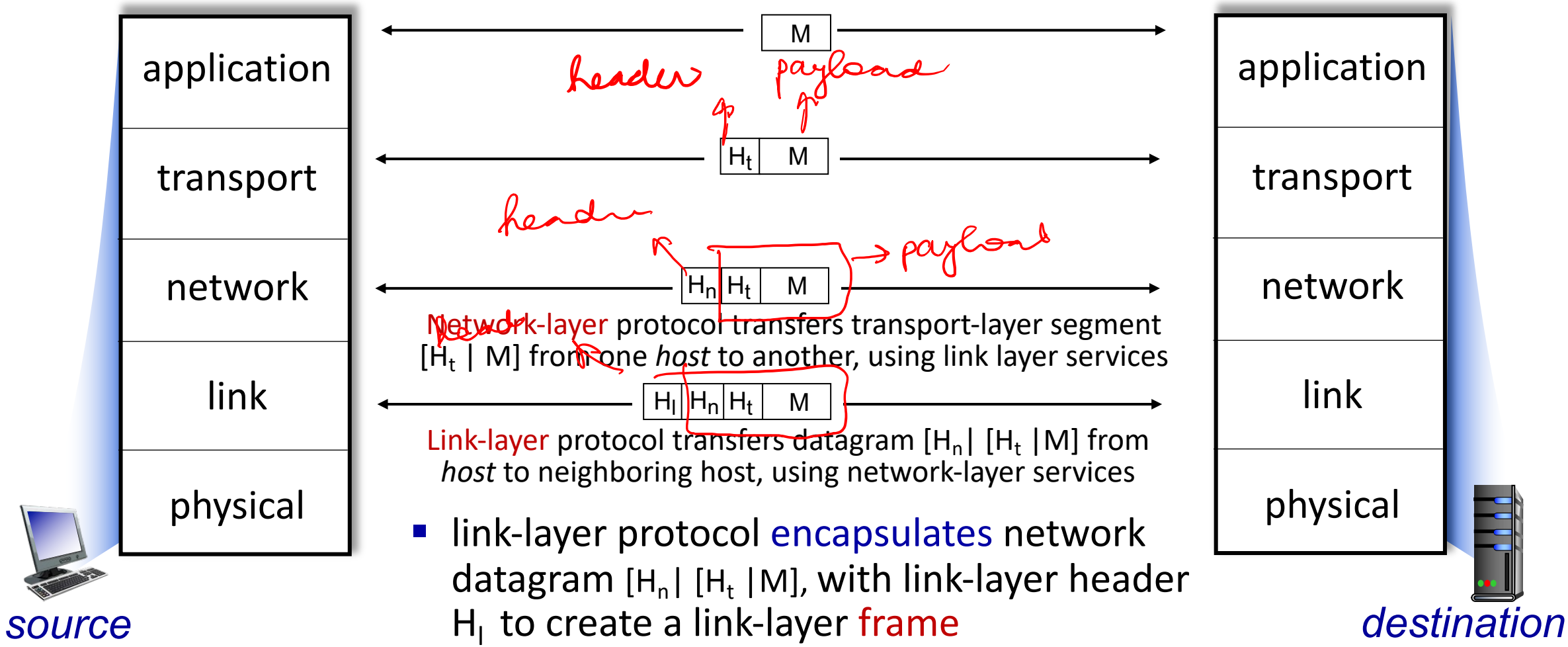

- transport-layer protocol encapsulates application-layer message, M, with *transport* layer-layer header $H_t$ to create a transport-layer segment
  - $H_t$ used by transport layer protocol to implement its service

# Services, Layering and Encapsulation




- network-layer protocol encapsulates transport-layer segment [$H_t$ | M] with network layer-layer header $H_n$ to create a network-layer datagram
  - $H_n$ used by network layer protocol to implement its service

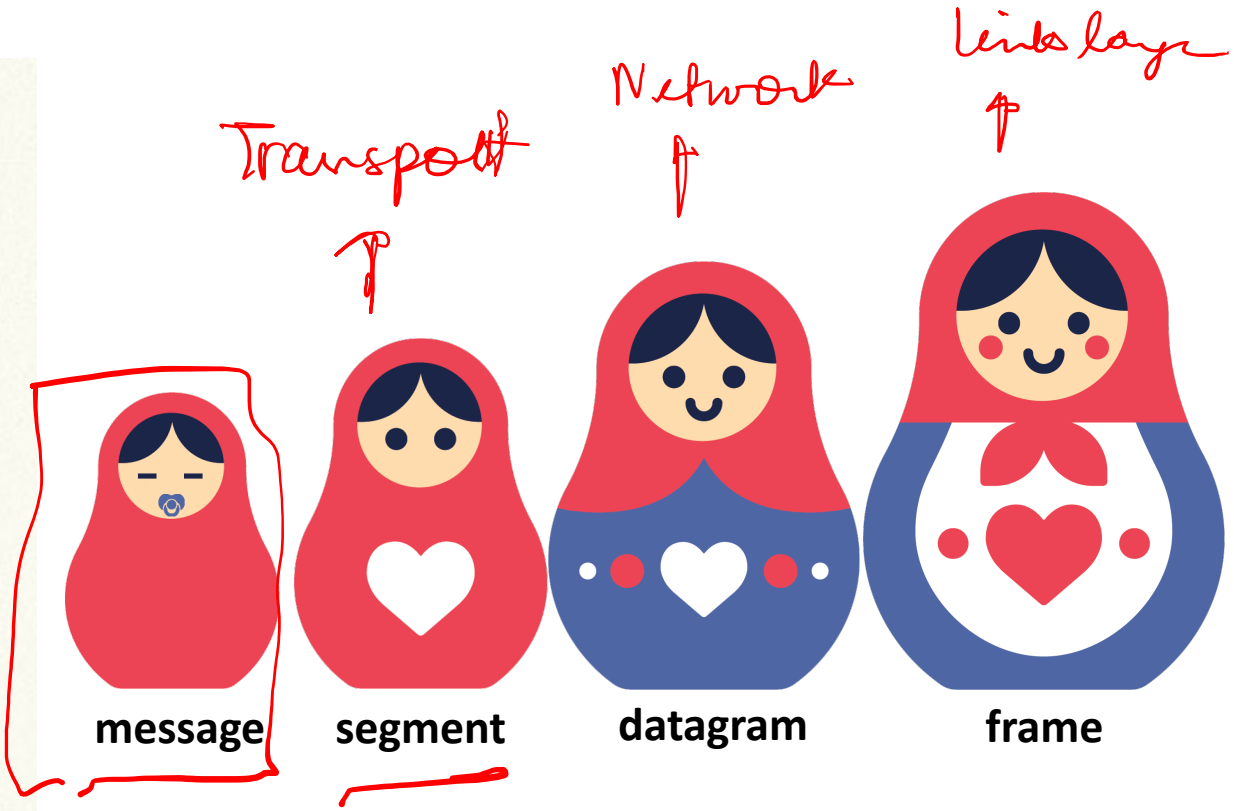
# Services, Layering and Encapsulation




- link-layer protocol encapsulates network datagram $[H_n|\ [H_t\ |M]$, with link-layer header $H_l$ to create a link-layer frame

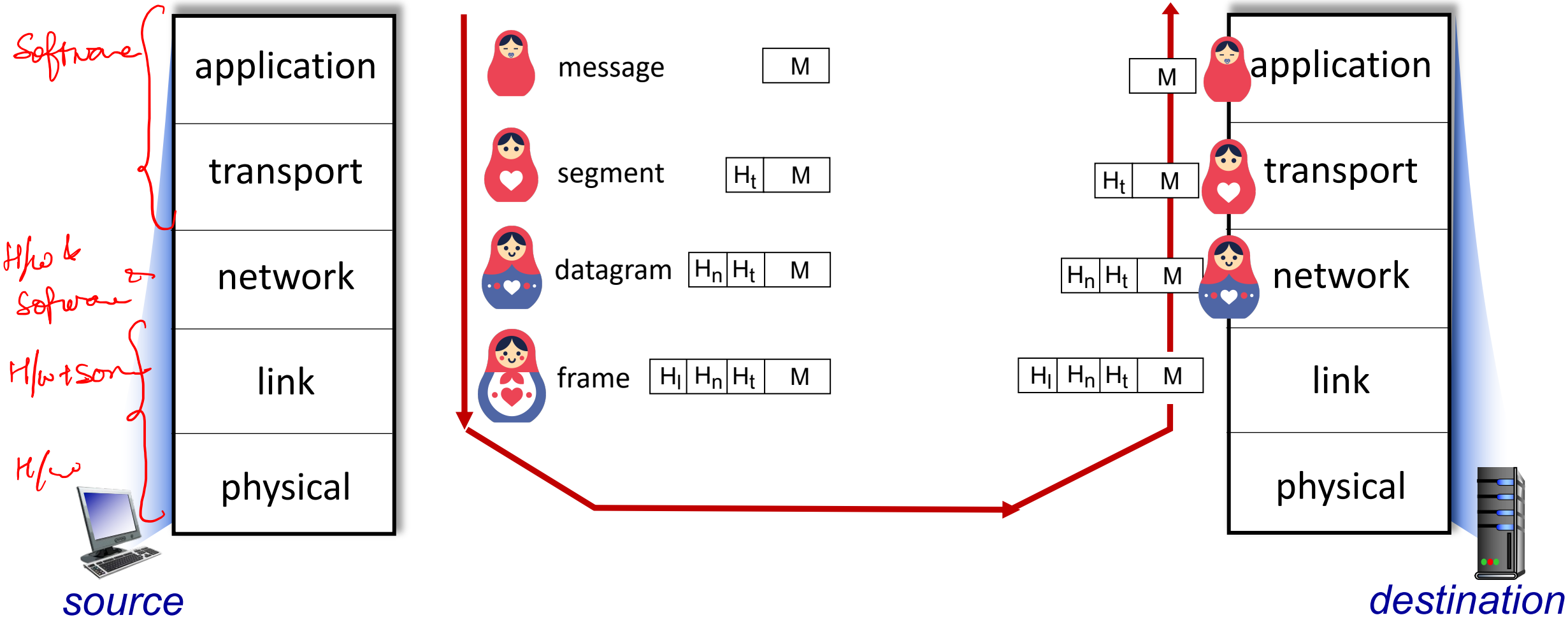
# Encapsulation

*Matryoshka dolls (stacking dolls)*

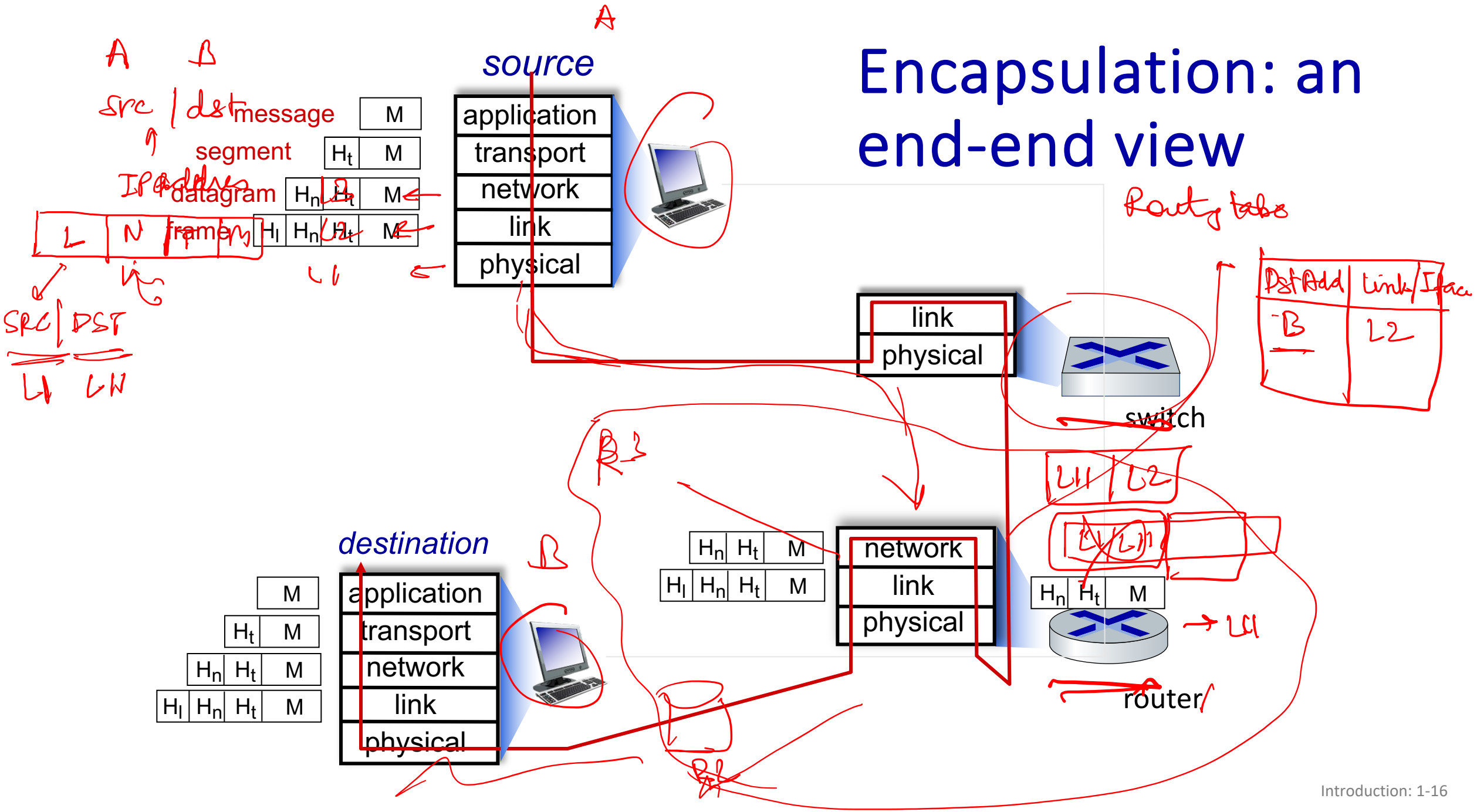



Credit: https://dribbble.com/shots/7182188-Babushka-Boi

# Services, Layering and Encapsulation



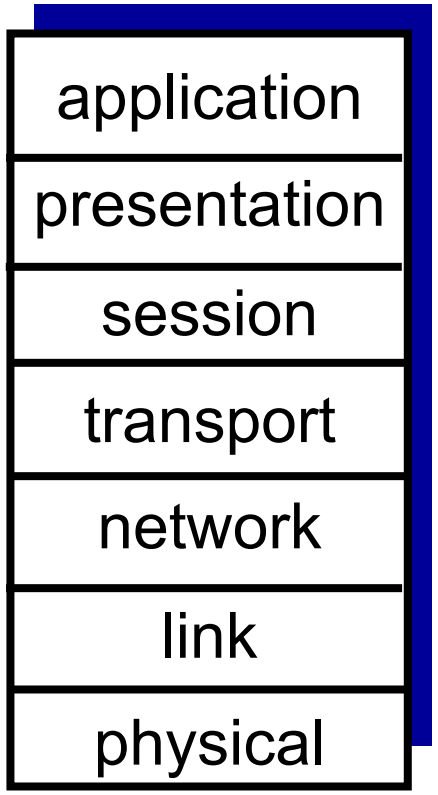
# Encapsulation: an end-end view



# 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?

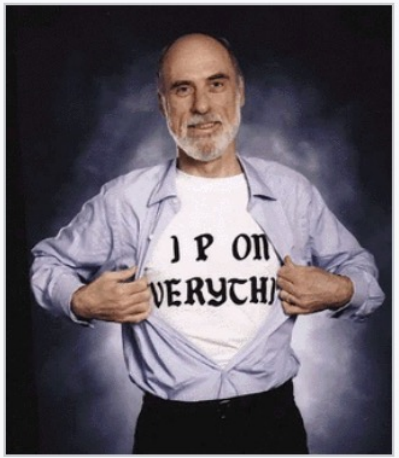



The seven layer OSI/ISO reference model

# 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 do study performance of this system?**