Computer Networks
COL 334/672

Using layering magic to make it work

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Sem 1, 2025-26

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Recap

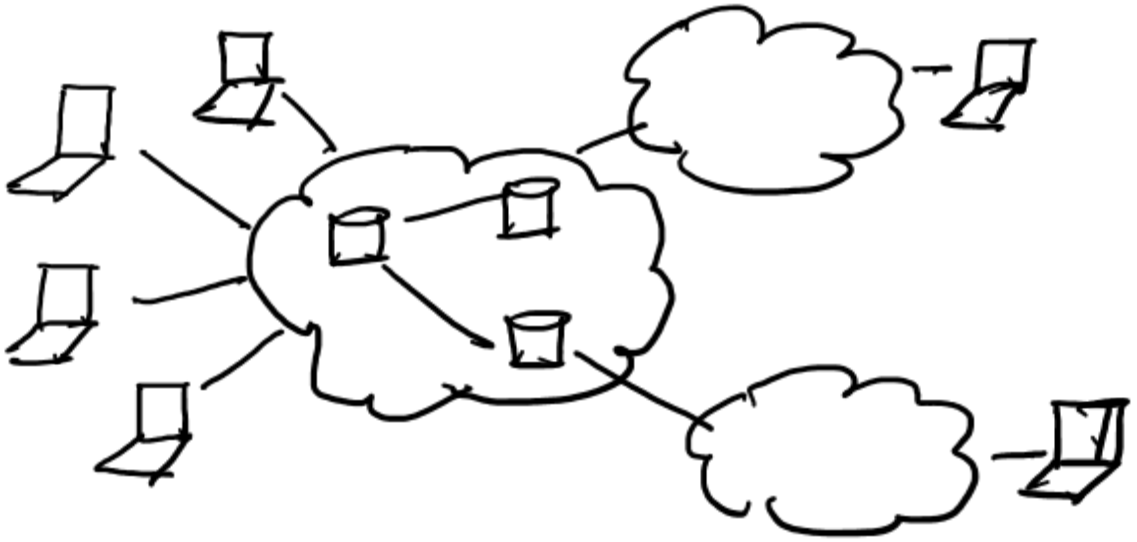
- How to send data across distributed networks?

- 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 To Send Data over Distributed Network?



N/w function

- Encoding (bits to signal)
- Addressing, Routing
- Resource sharing
  - Packet switching

→ Routers will implement

- Reliability → Voice or video call
- In-order delivery
- Congestion control

End host

- …

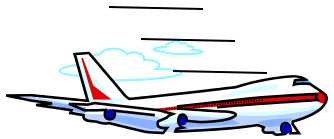
How to implement them?

can we modularise these function!

If yes, how.

Example: organization of air travel

→ layered Architecture



end-to-end transfer of person plus baggage →

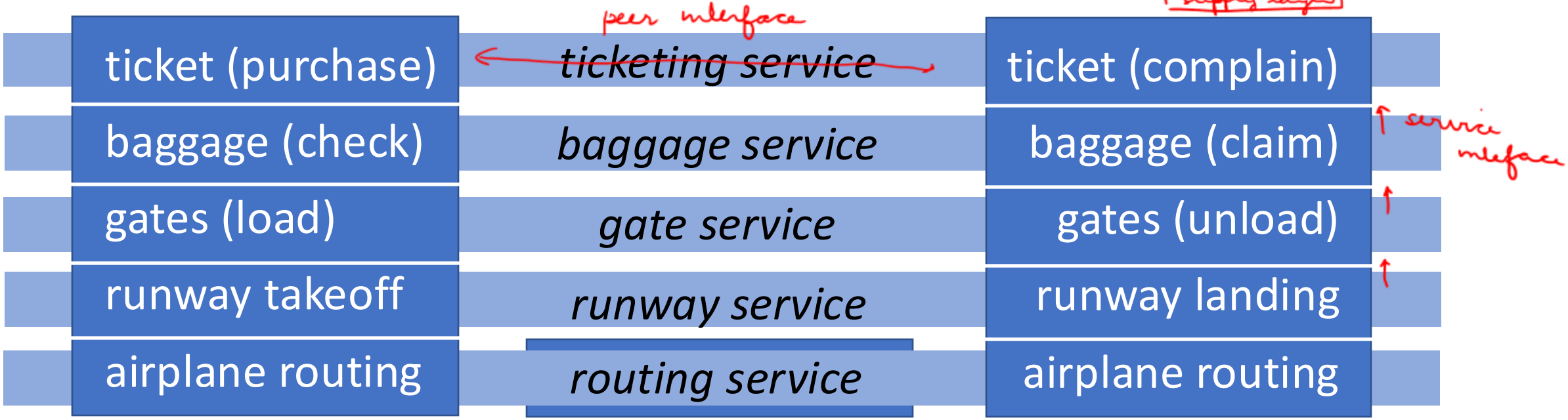
ticket (purchase)	ticket (complain)
baggage (check)	baggage (claim)
gates (load)	gates (unload)
runway takeoff	runway landing
airplane routing	airplane routing

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?

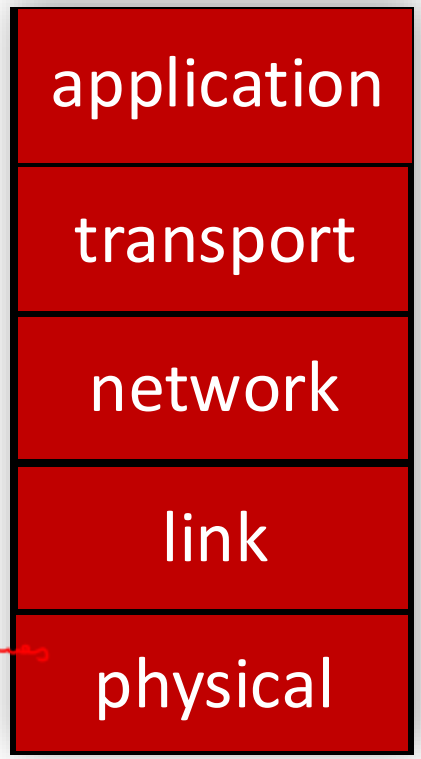
Channel Abstraction

Security, Reliability ..

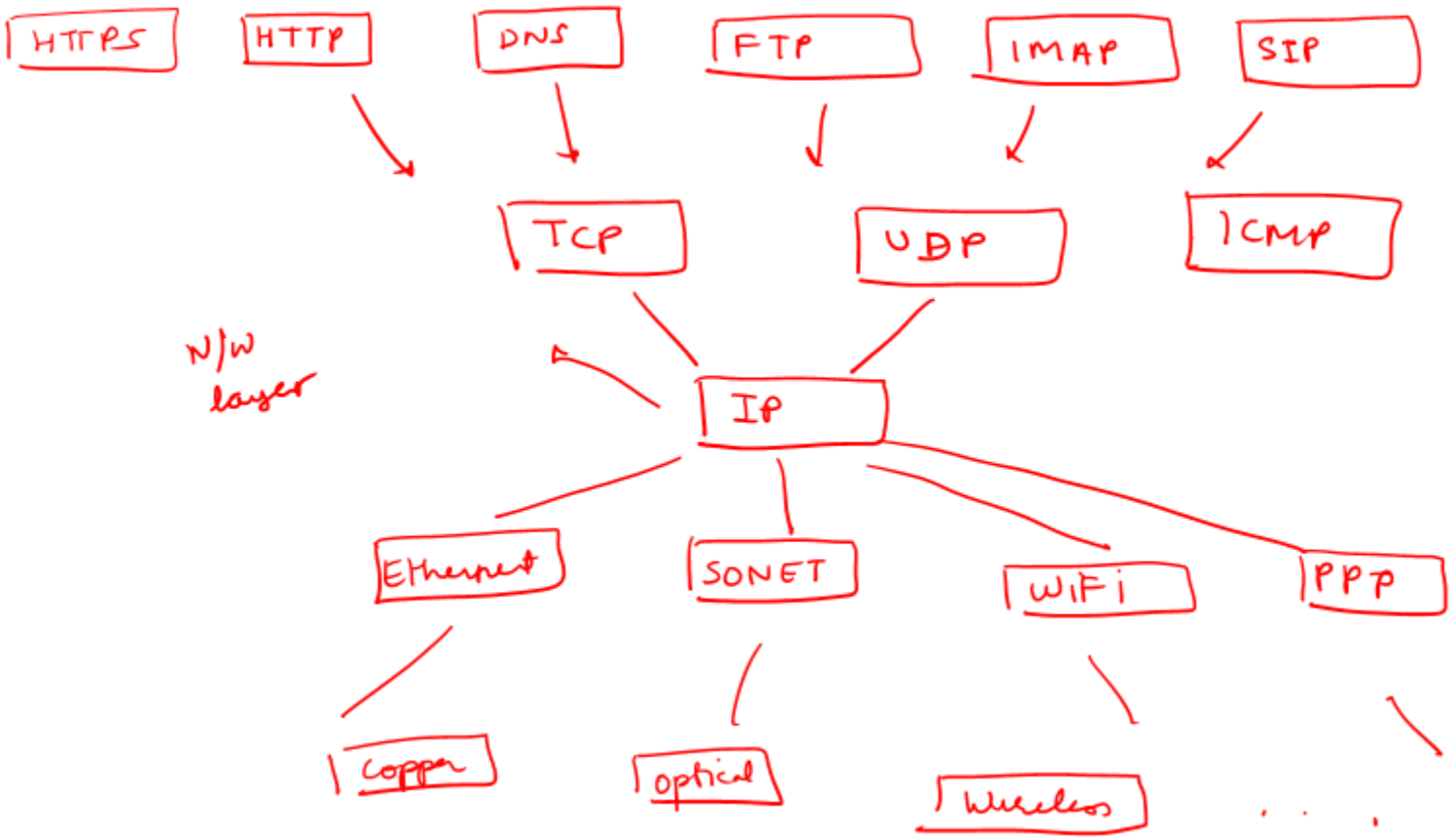
- Application
- Process to process connectivity
- Host to host connectivity
- M2M connectivity b/w physically connected Machines
- Physical layer

Layered Internet protocol stack

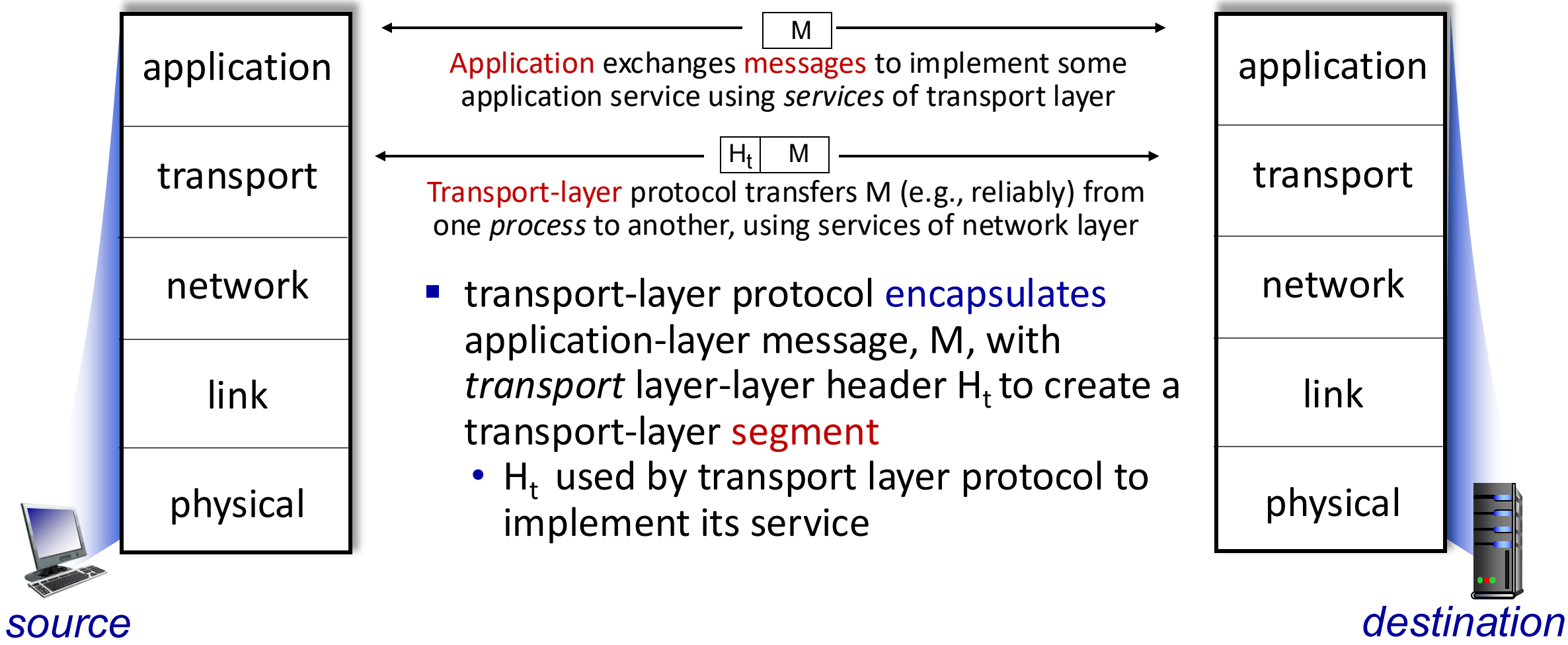
- *application:* supporting network applications
  - HTTP, IMAP, SMTP, DNS, FTP
- *transport:* process-process data transfer
  - TCP, UDP
- *network:* routing of datagrams from source to destination
  - IP, routing protocols
- *link:* data transfer between neighboring network elements
  - Ethernet, 802.11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



Hourglass Model

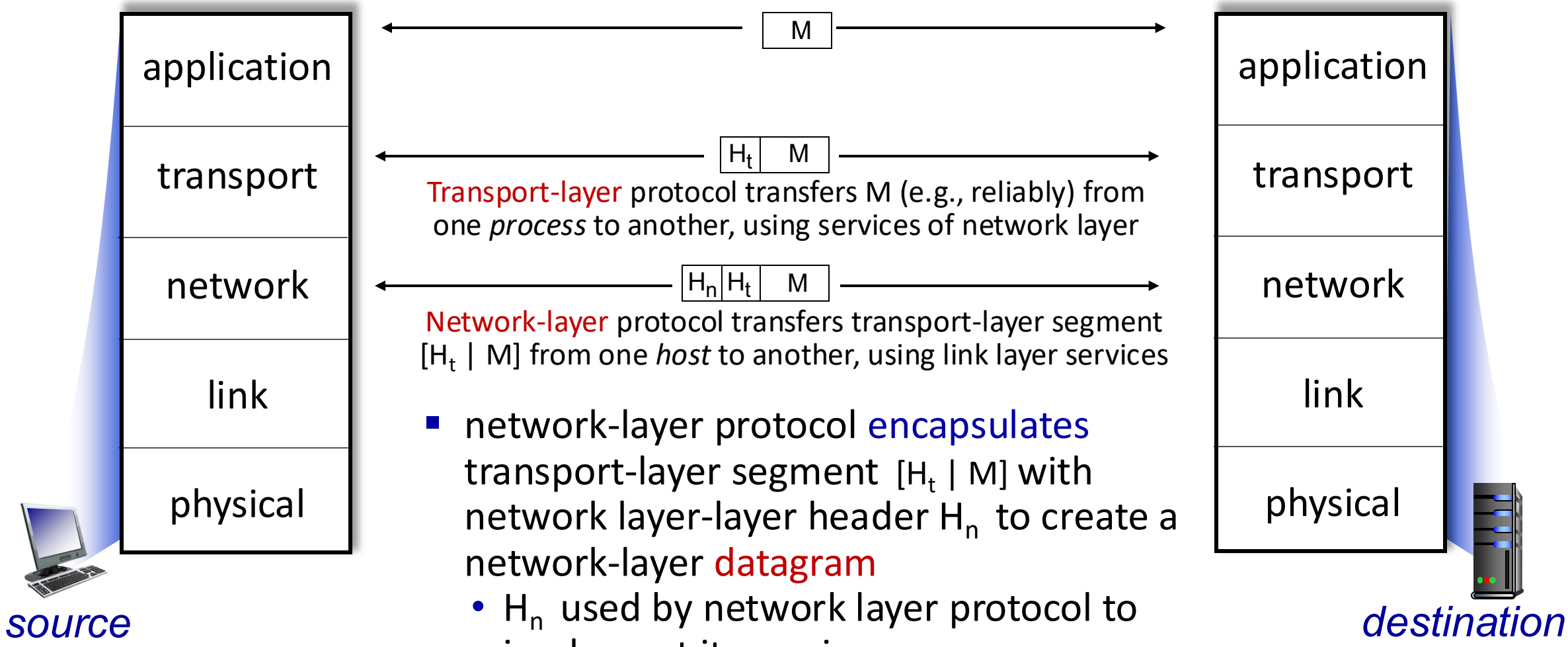


Services, Layering and Encapsulation



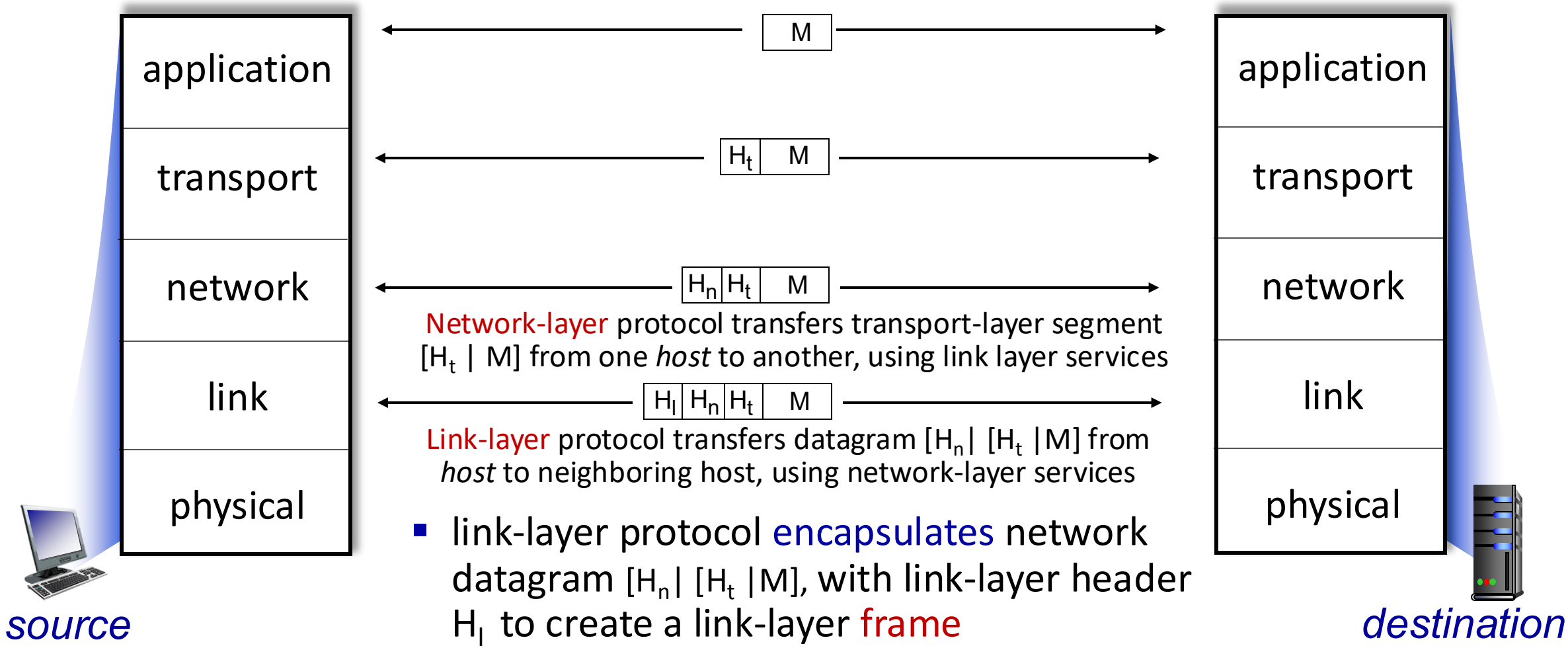
- transport-layer protocol encapsulates application-layer message, M, with *transport* layer-layer header H_t to create a transport-layer segment
  - H_t used by transport layer protocol to implement its service

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

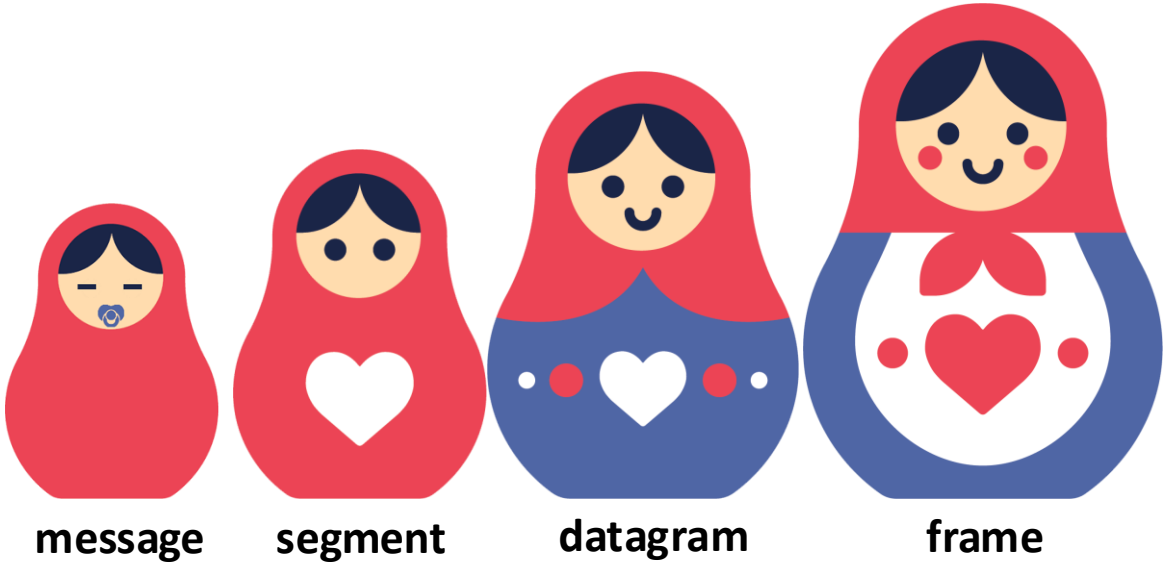
Services, Layering and Encapsulation



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

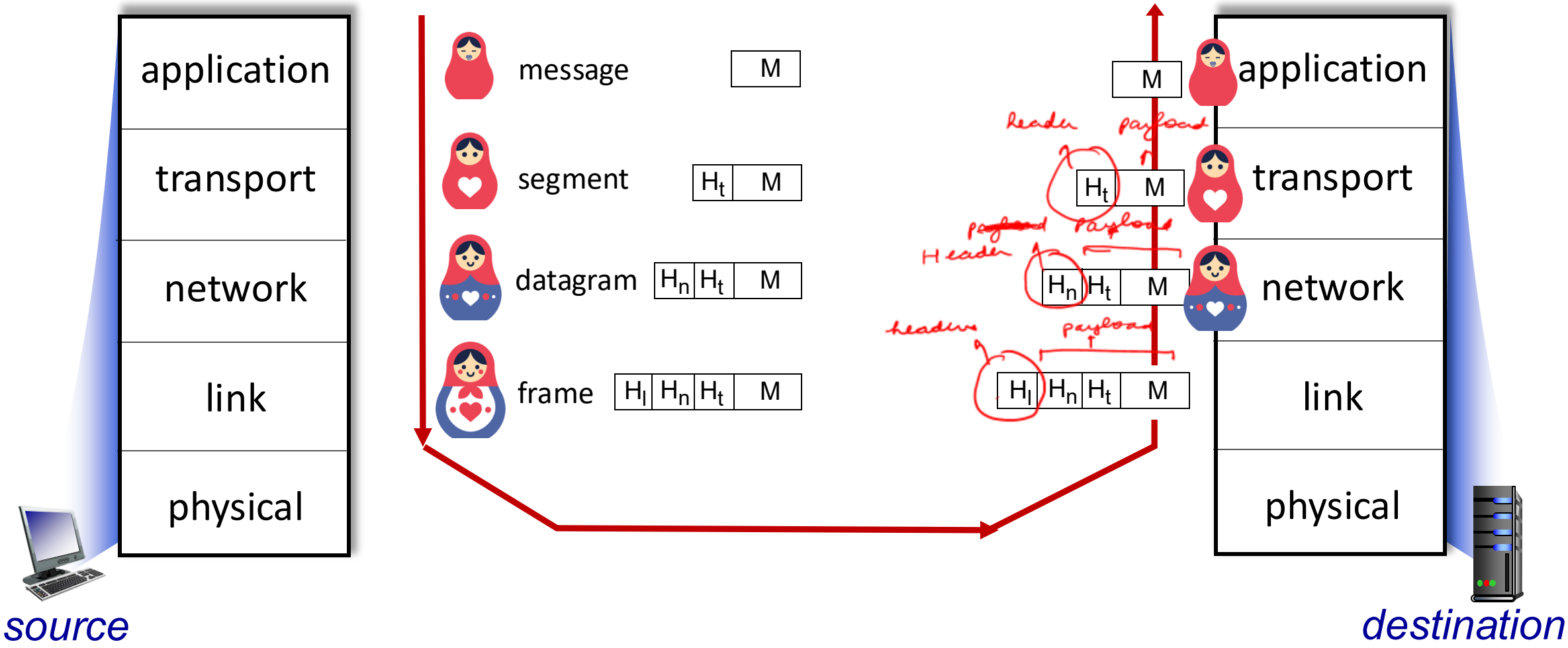
Encapsulation

Matryoshka dolls (stacking dolls)

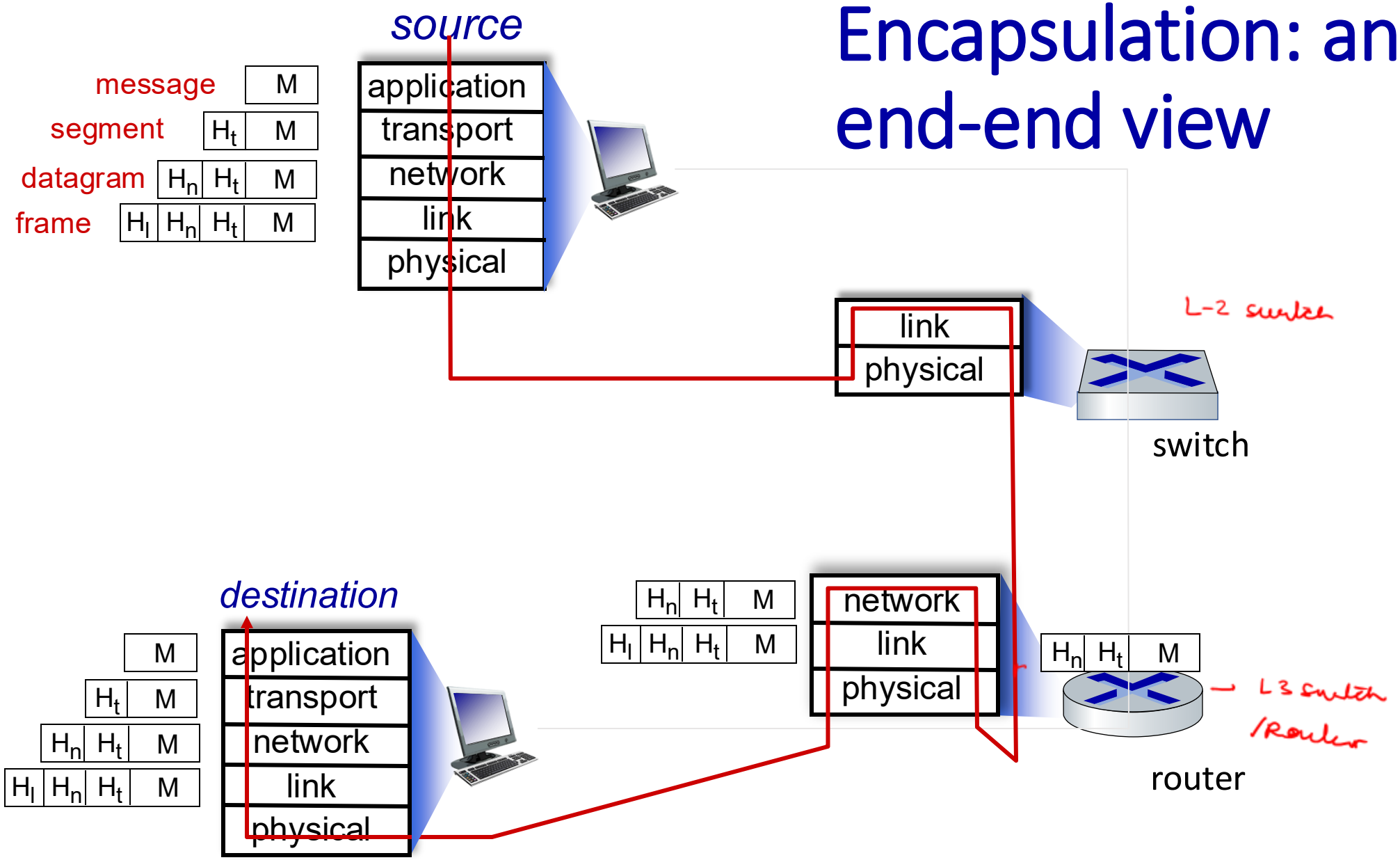


Credit: https://dribbble.com/shots/7182188-Babushka-Boi

Services, Layering and Encapsulation



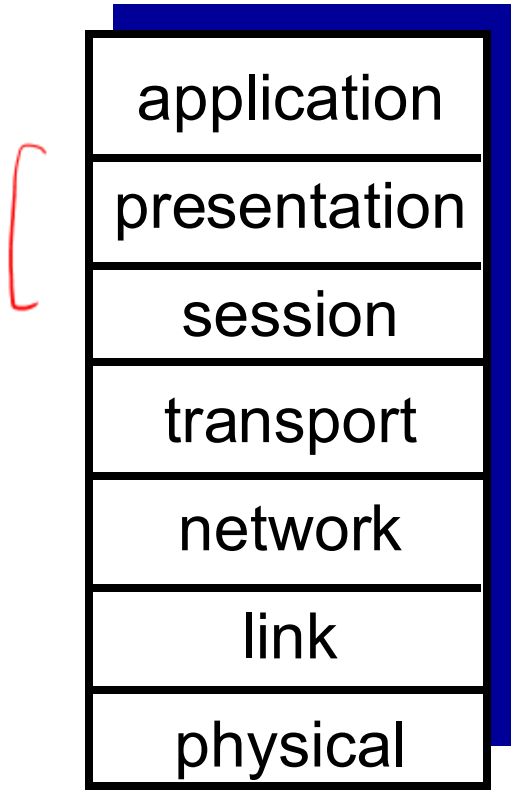
Encapsulation: an end-end view



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?

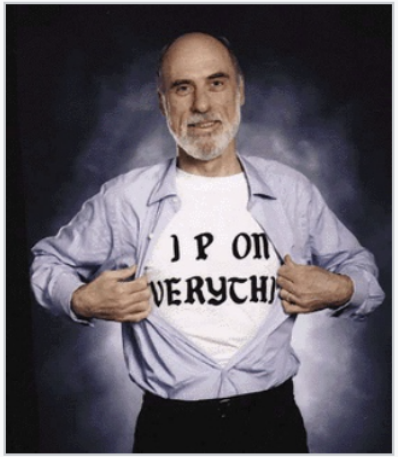


The seven layer OSI/ISO reference model

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 above
- Encapsulation used for adding layer information
- **Next class: How do study performance of this system?**