Internet Technology

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Questions

- What is a network?
- What is a protocol?
- What is the internet?

What is a Network?

What is a Network?

- Way to connect 2 or more entities with an Interconnection or link to carry some items
- Interconnection may happen over be any medium

1. Entities?.....
2. Link? …….
3. Carry?.....

1. Entities?.....
2. Link? …….
3. Carry?.....

1. Entities?.....
2. Link? …….
3. Carry?.....

What is a Network?

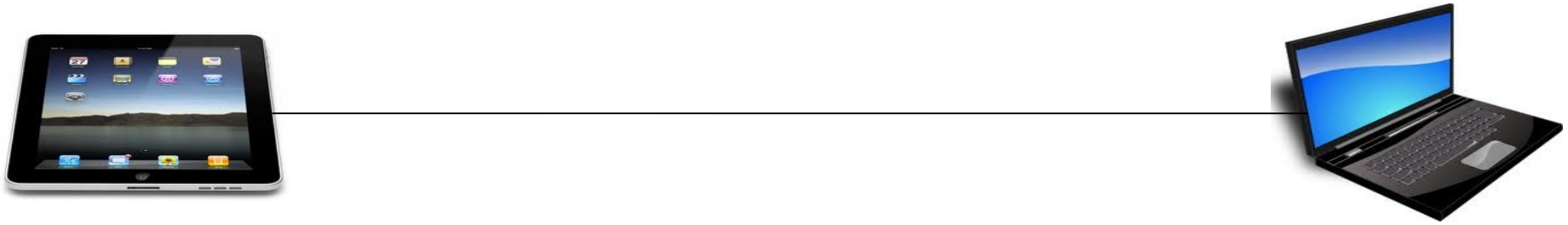
- Road network
  - …
  - …
- Airplane network
  - …
  - …
- Social network
  - …
  - …
- In this class we will learn about design attributes of computer networks and in particular the Internet

What is a Network?

Computer Network?

- Carrier of information between 2 or more computing entities
- Interconnection may be any medium capable of communicating information:
  - copper wire
  - Lasers (optic fiber)
  - Microwave
  - Cable (coax), satellite link
  - Wireless link (cellular, 802.11, bluetooth)
- Examples: Cable, Ethernet, 802.11(WIFI), cellular, satellite

What is a Network?



- Send bits of data in packets or frames
- Need to worry about errors, how to convert bits into signals and vice versa

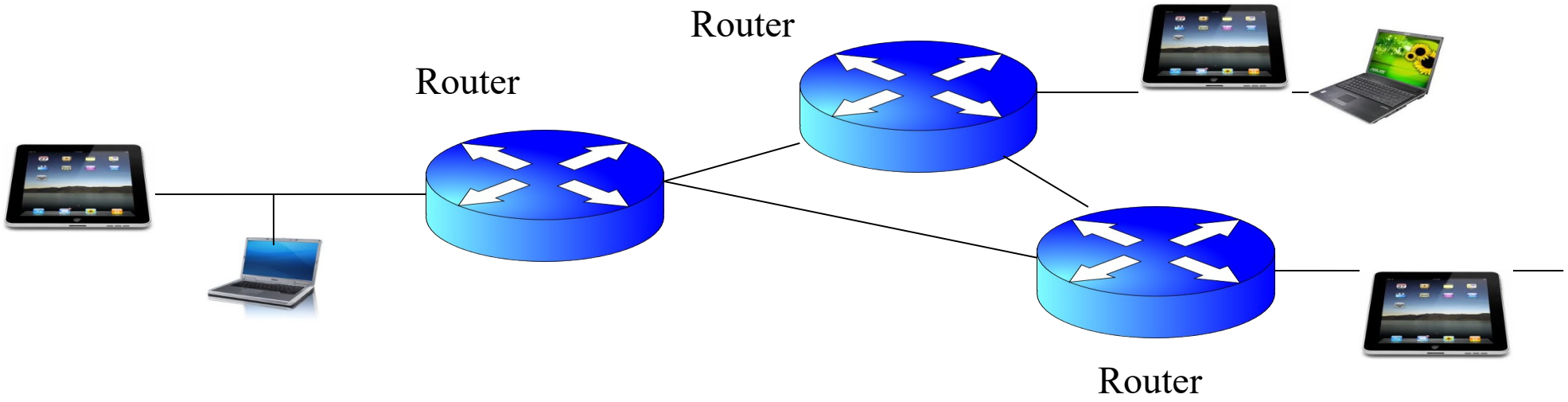
What is a Network?

A single link multiple access network

- Send bits of data in packets or frames
- Need to worry about errors, how to convert bits into signals and vice versa
- In addition, how to differentiate among many receivers
- Every host as a link layer address– MAC address
- Packets or frames will have destination address
- Cant have every computer in the world on the same link!

What is a Network?

A network



- Connect multiple links via routers
- Need to figure out how to route packets from one host to another host

What is a Network?

Components of a network

- Links
  - Communication links for transmission
- Host
  - Computer running applications of end user
- Router
  - Computer for routing packets from input line to another output line
- Gateway
  - A device directly connected to two or more possibly different networks (serves as an access point), provides access
- Network
  - A group of hosts, links, routers capable of sending packets among the members of the network

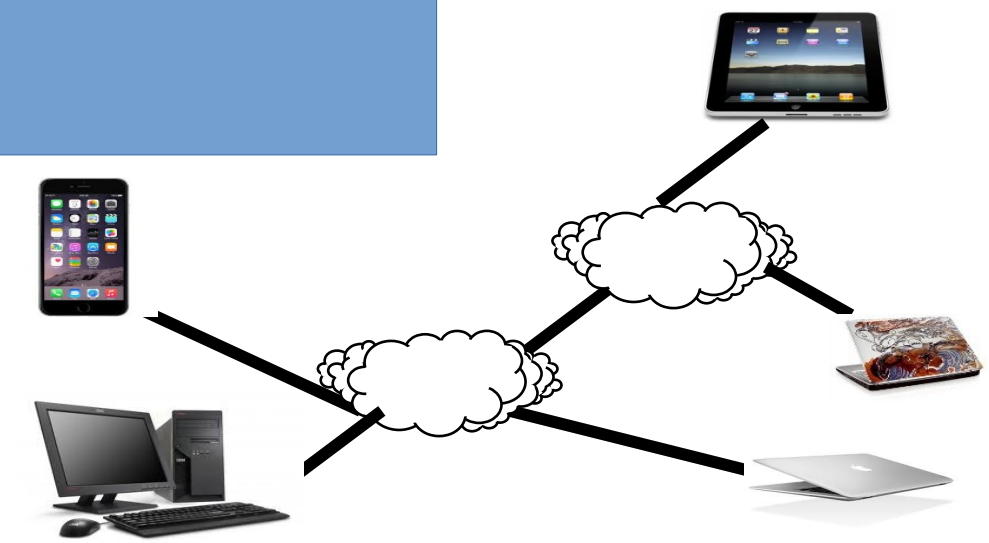
What is a Network?

Why Networks?

- Availability of Resources
  - Resources become available regardless of the user's physical location
- Load Sharing
  - Jobs processed on least loaded machine
  - High Reliability
  - Alternative source of supply (multiple copies)
- Human-to-Human Communication
  - e.g., Messaging, Posts,Telephone (Voice-over IP)

- What is the Internet?

What is the Internet?

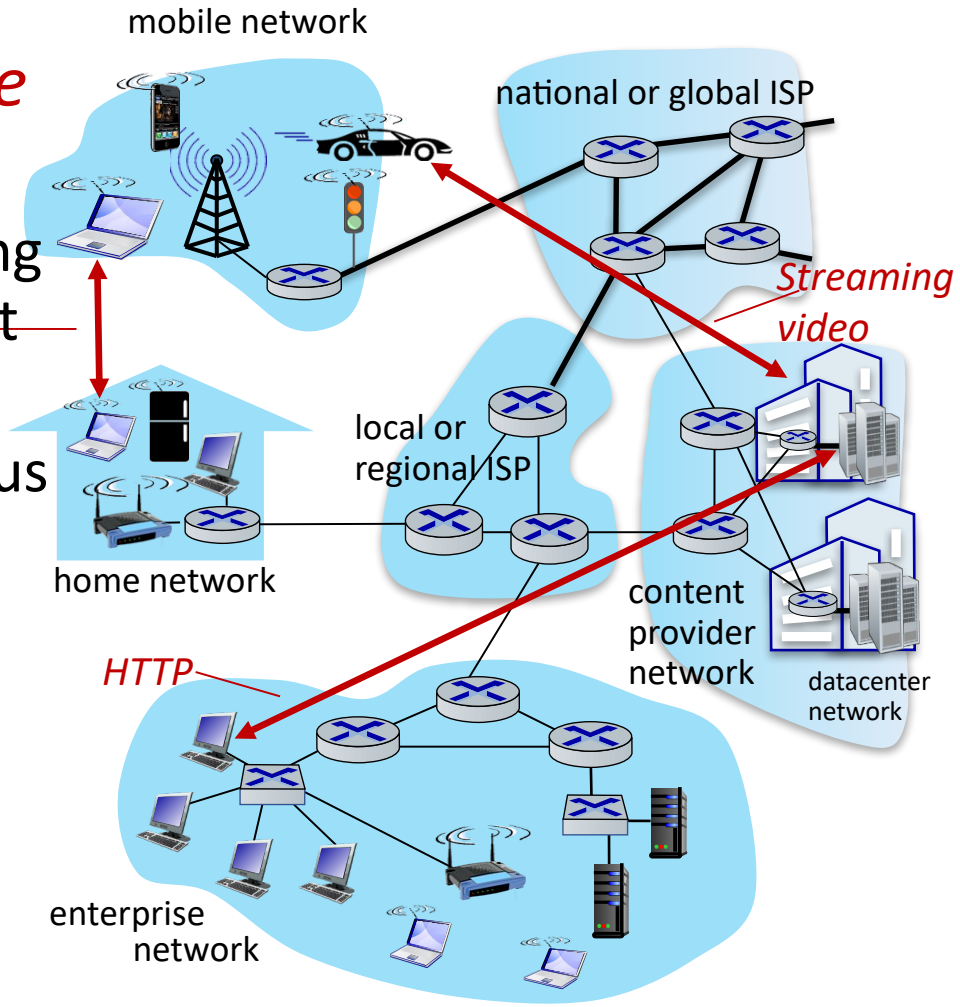


- What is an internet?
  - Network of networks
- What is *the* Internet?
  - A global internet based on the IP protocol
  - Network to network – adopt a common language
- To what does “Internet technology” refer?
  - Architecture, protocols and services

What is the Internet?

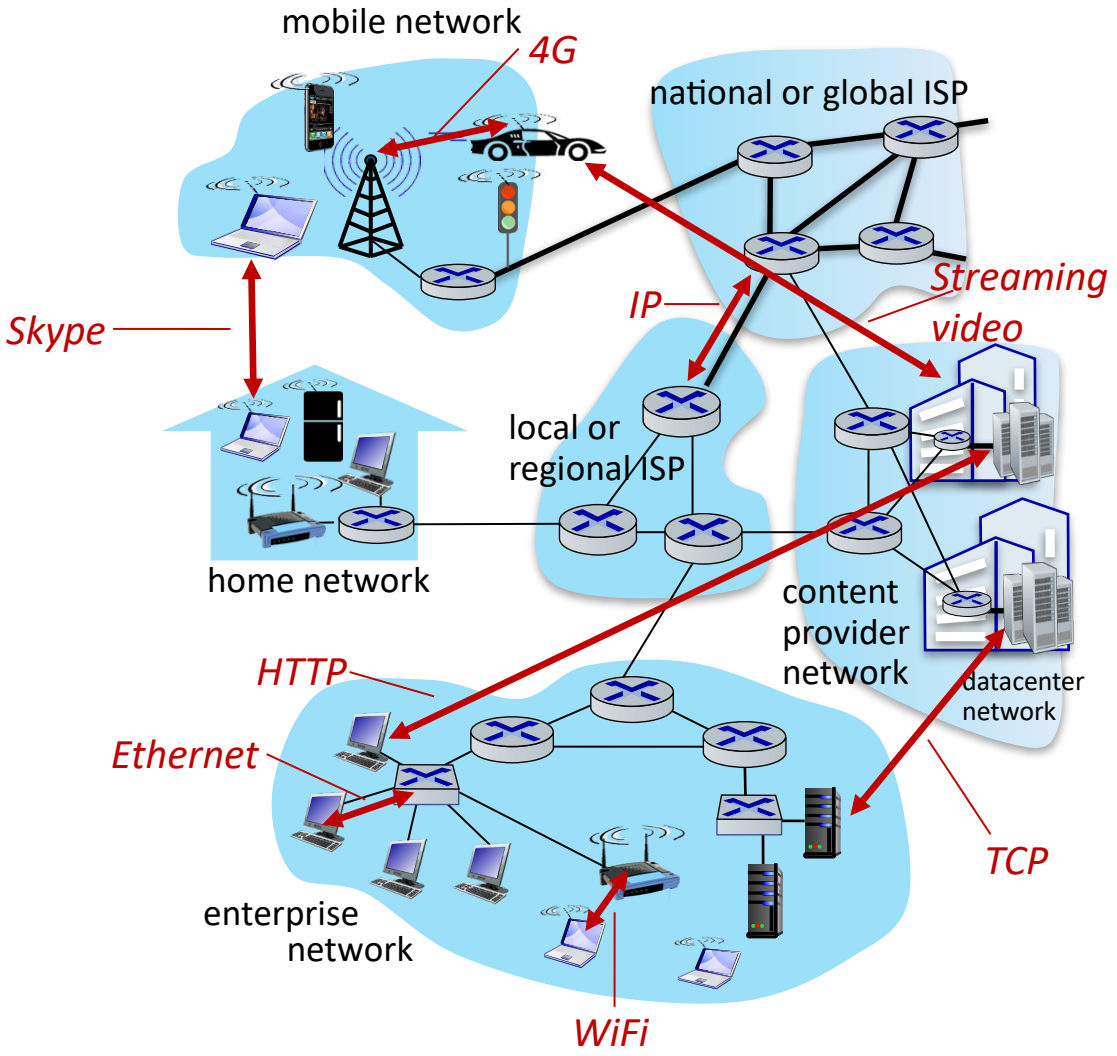
- *Infrastructure* that provides services to applications:
  - Web, streaming video, multimedia teleconferencing, email, games, e-commerce, social media, inter-connected appliances, …

- provides *programming interface* to distributed applications:
  - "hooks" allowing sending/receiving apps to "connect" to, use Internet transport service
  - provides service options, analogous to postal service



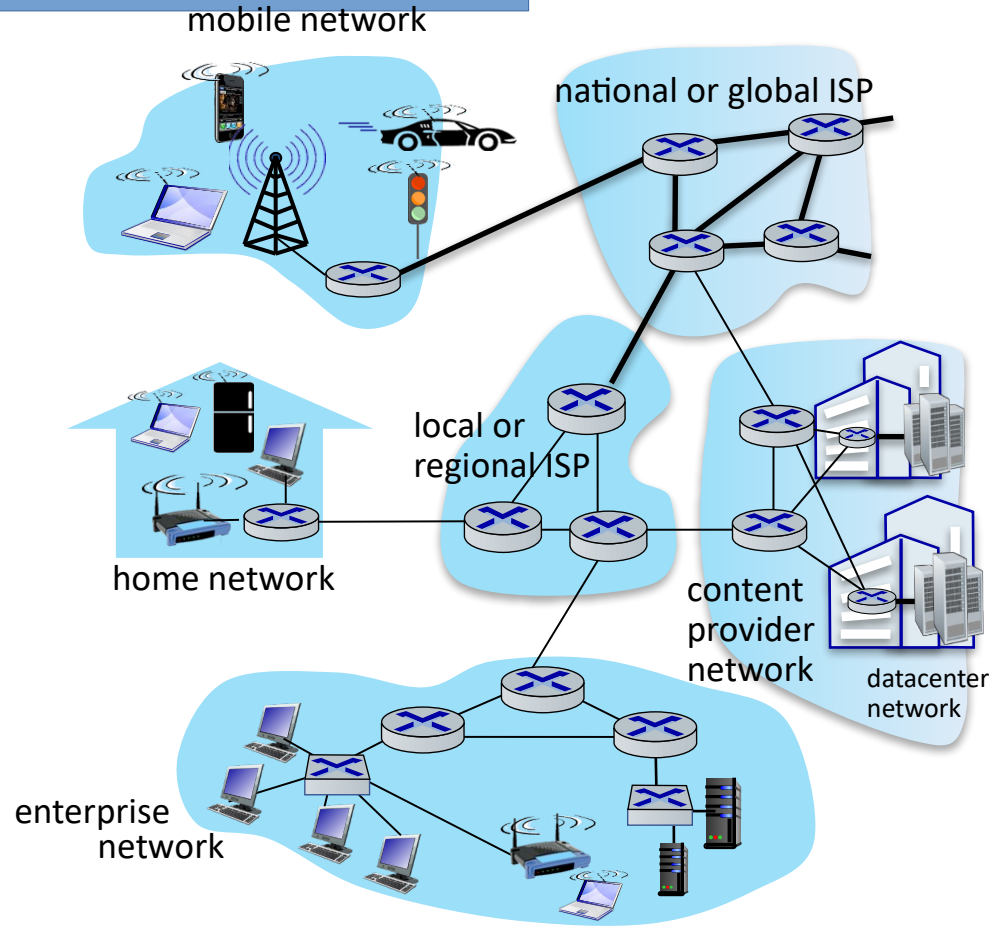
What is the Internet?

- *Internet:* "network of networks"
  - Interconnected ISPs
- *protocols* are *everywhere*
  - control sending, receiving of messages
  - e.g., HTTP (Web), streaming video, Skype, TCP, IP, WiFi, 4/5G, Ethernet
- *Internet standards*
  - RFC: Request for Comments
  - IETF: Internet Engineering Task Force



What is the Internet?

- hosts connect to Internet via access Internet Service Providers (ISPs)
- access ISPs in turn must be interconnected
  - so that *any* two hosts *(anywhere!)* can send packets to each other
- resulting network of networks is very complex
  - evolution driven by economics, national policies

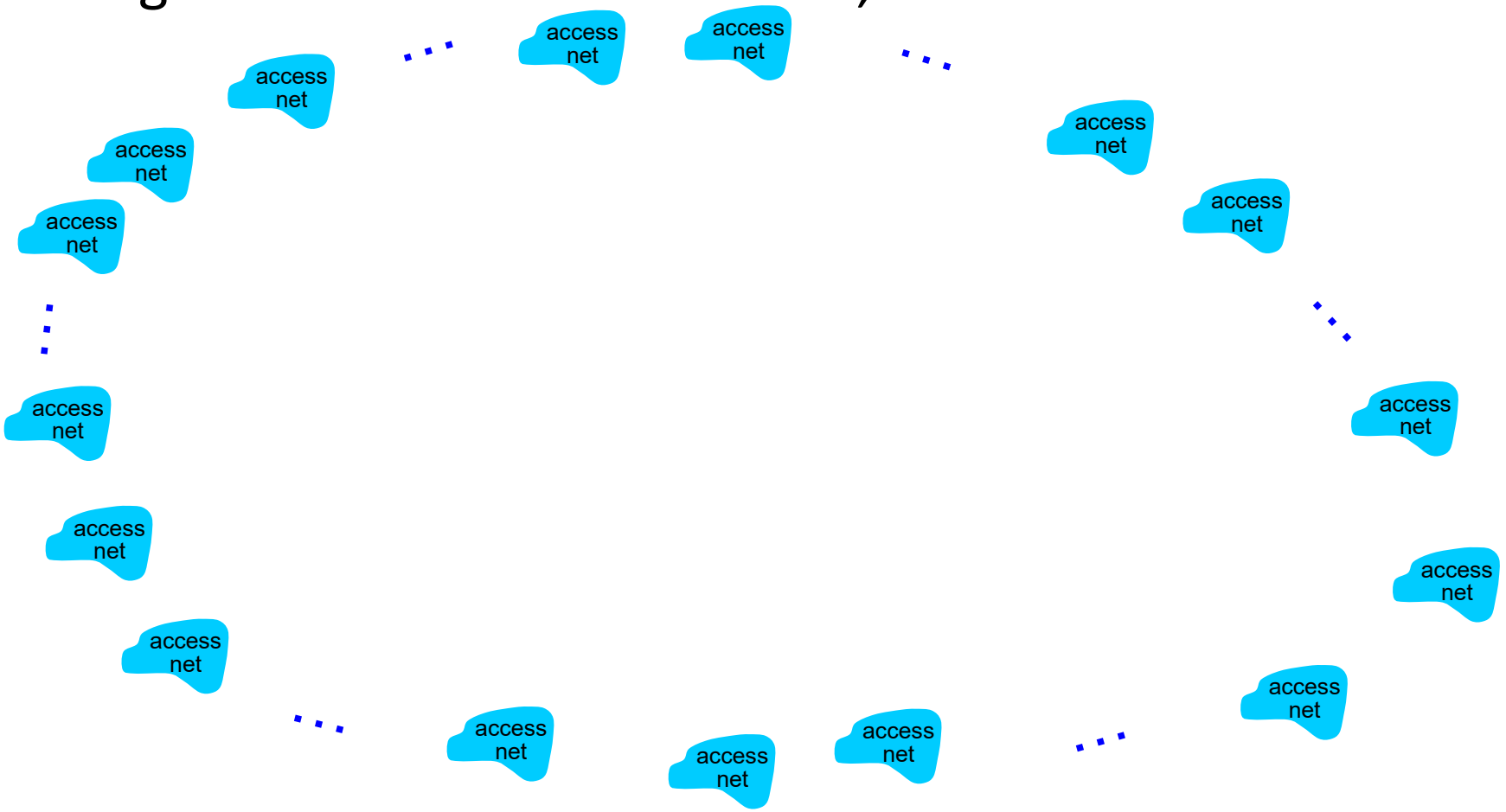


Let's take a stepwise approach to describe current Internet structure

How to build the internet?

What is the Internet?

Question: given *millions* of access ISPs, how to connect them together?



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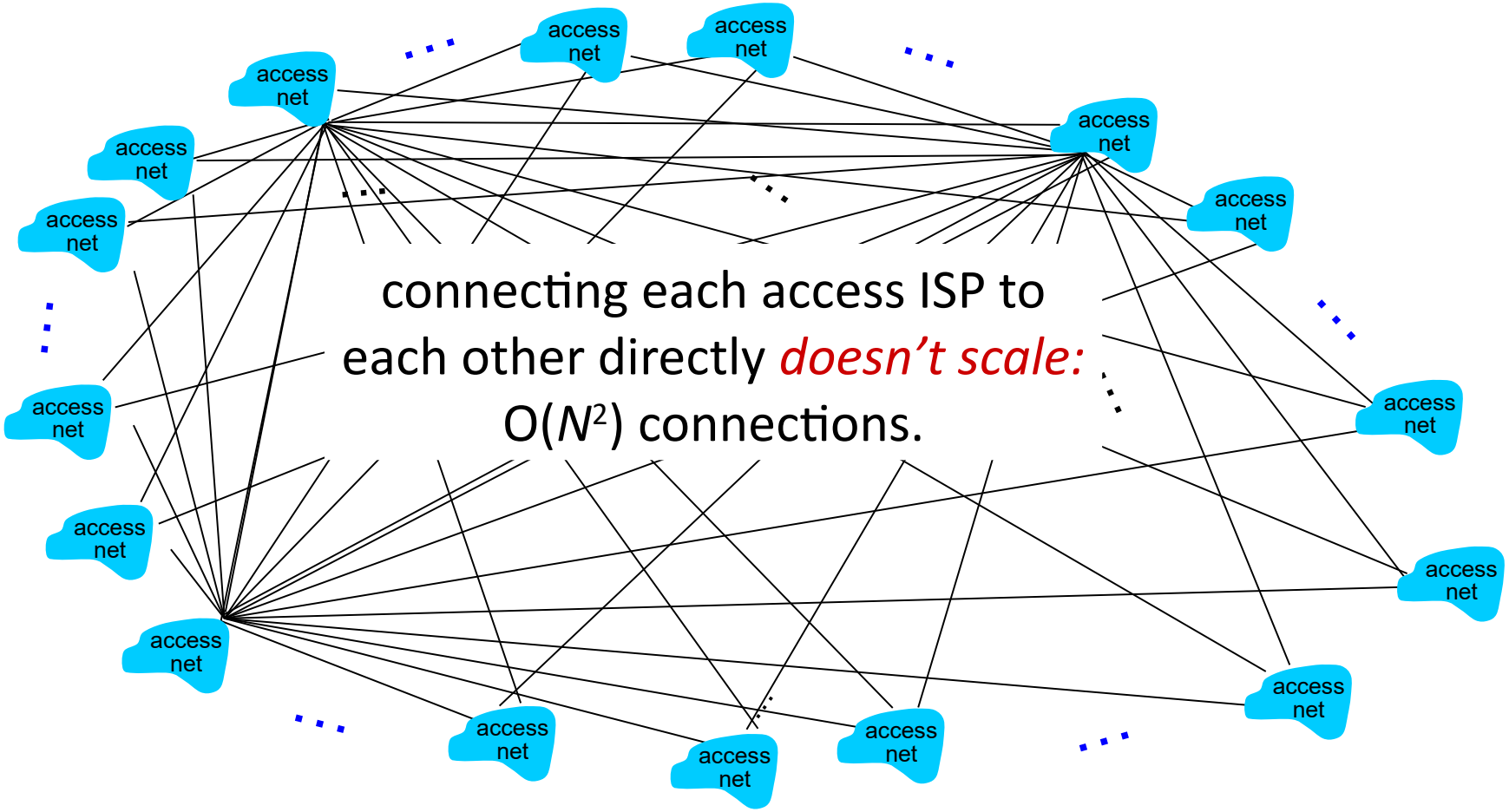
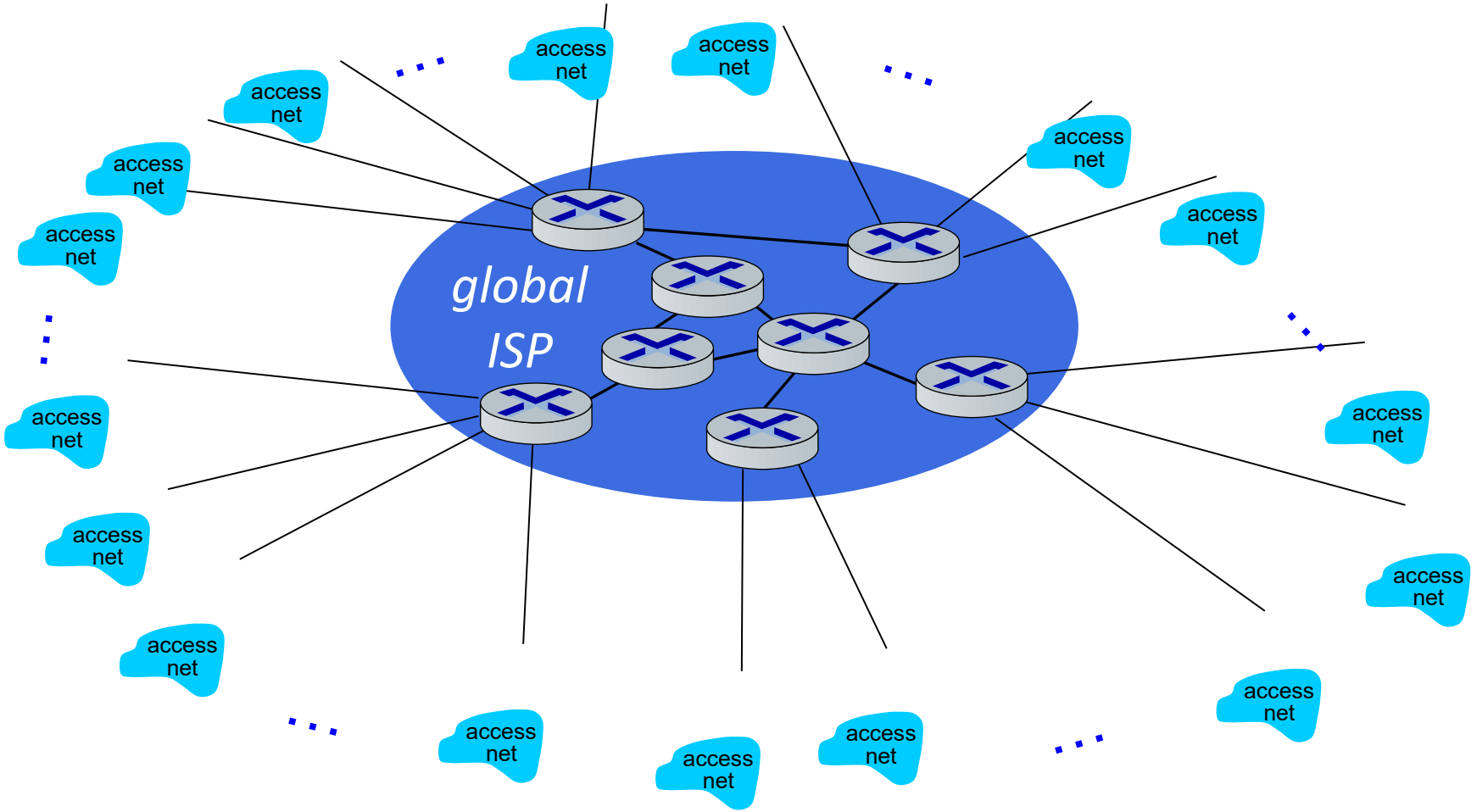


• What is the Internet?

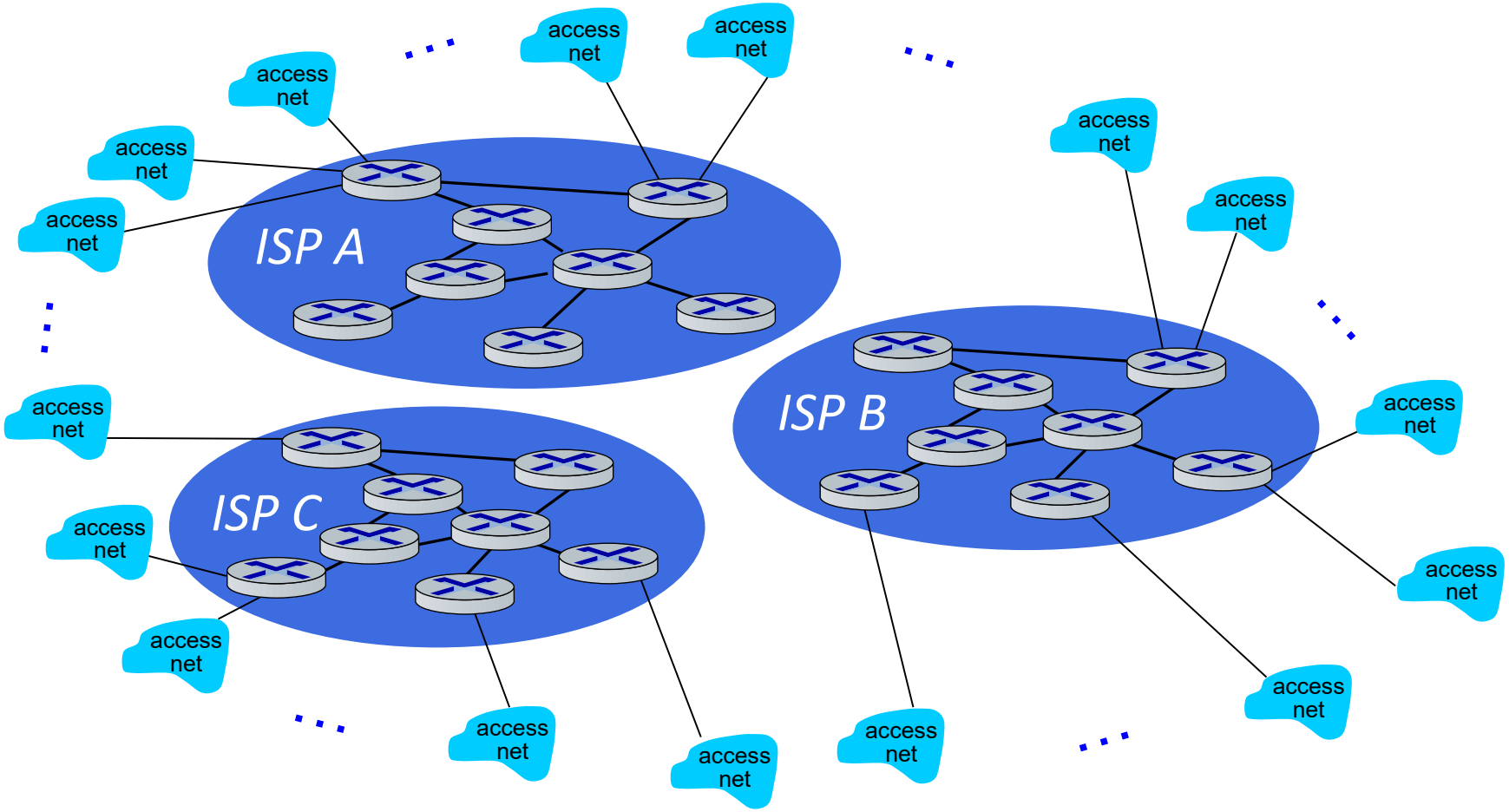
Option: connect each access ISP to one global transit ISP?

Customer and provider ISPs have economic agreement.



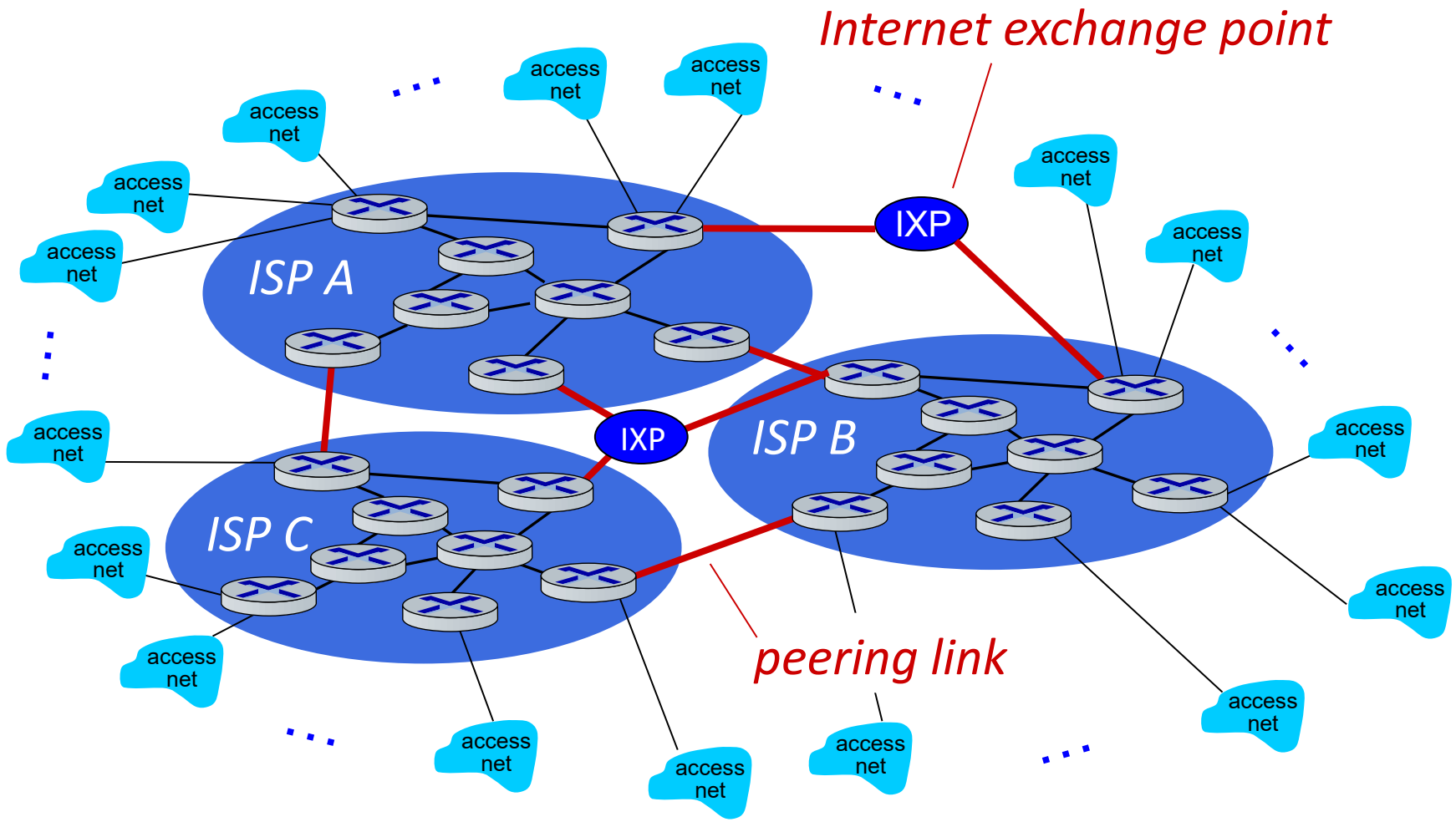
• What is the Internet?

But if one global ISP is viable business, there will be competitors ….



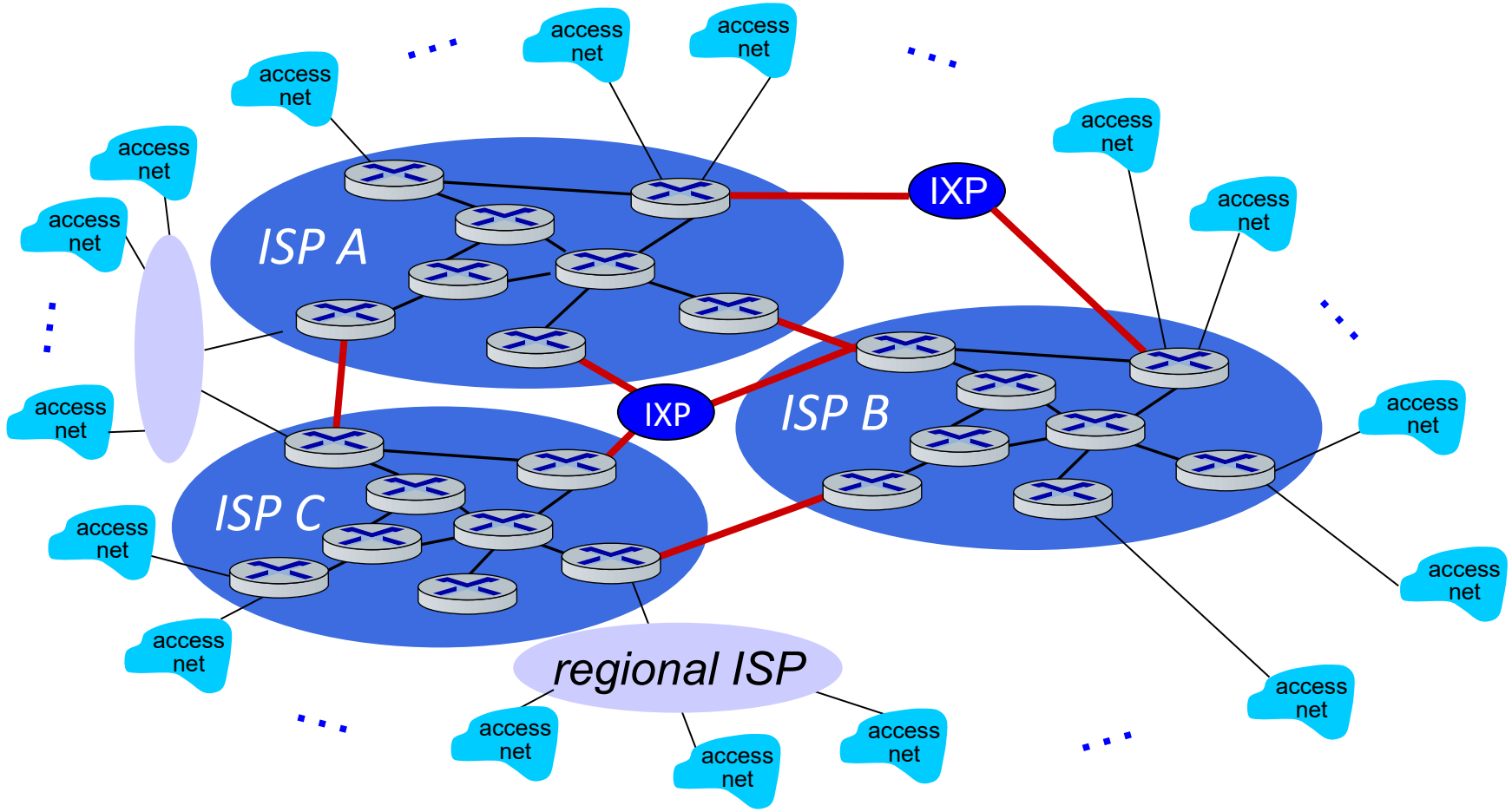
What is the Internet?

But if one global ISP is viable business, there will be competitors …. who will want to be connected



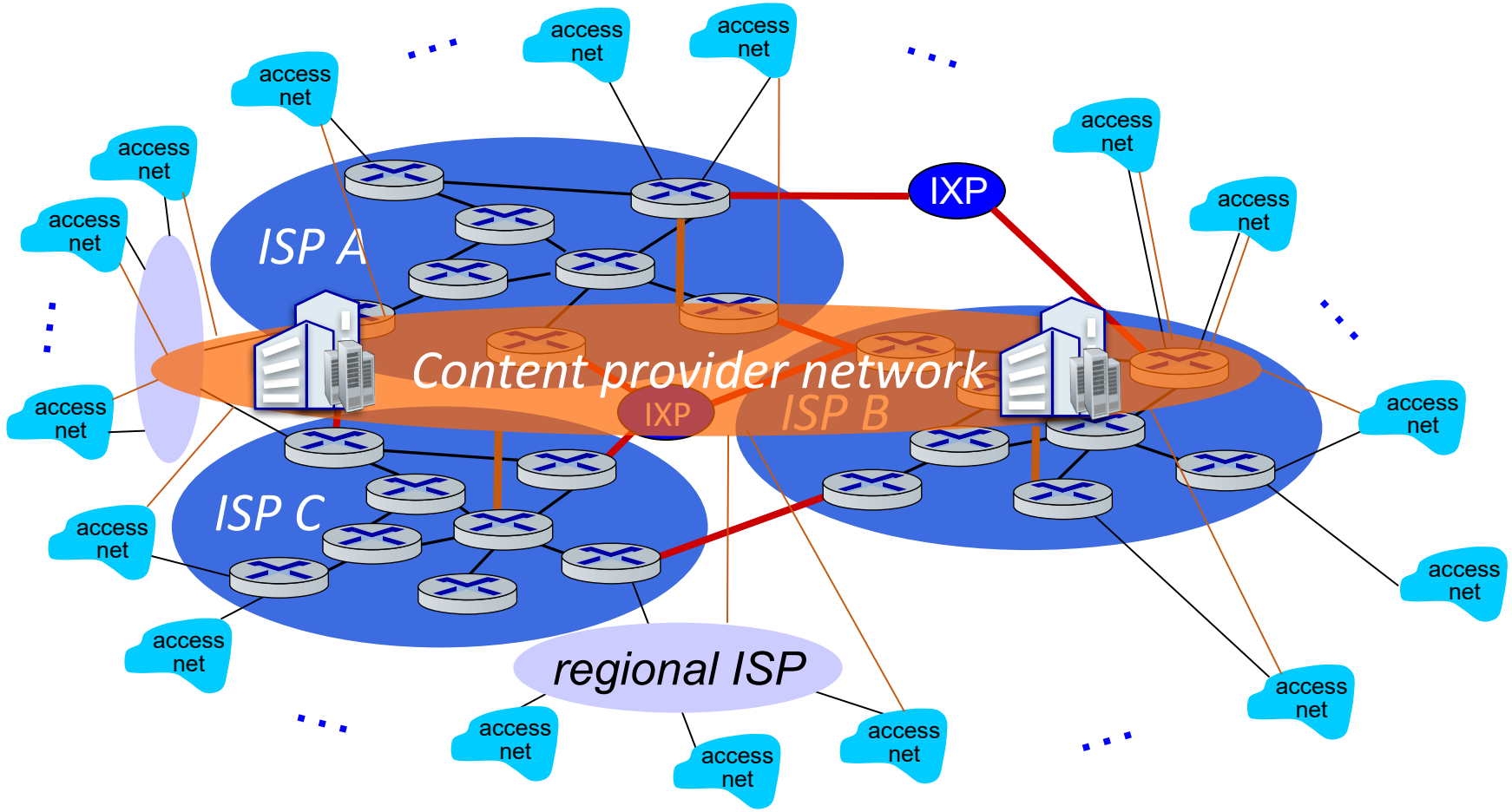
• What is the Internet?

… and regional networks may arise to connect access nets to ISPs

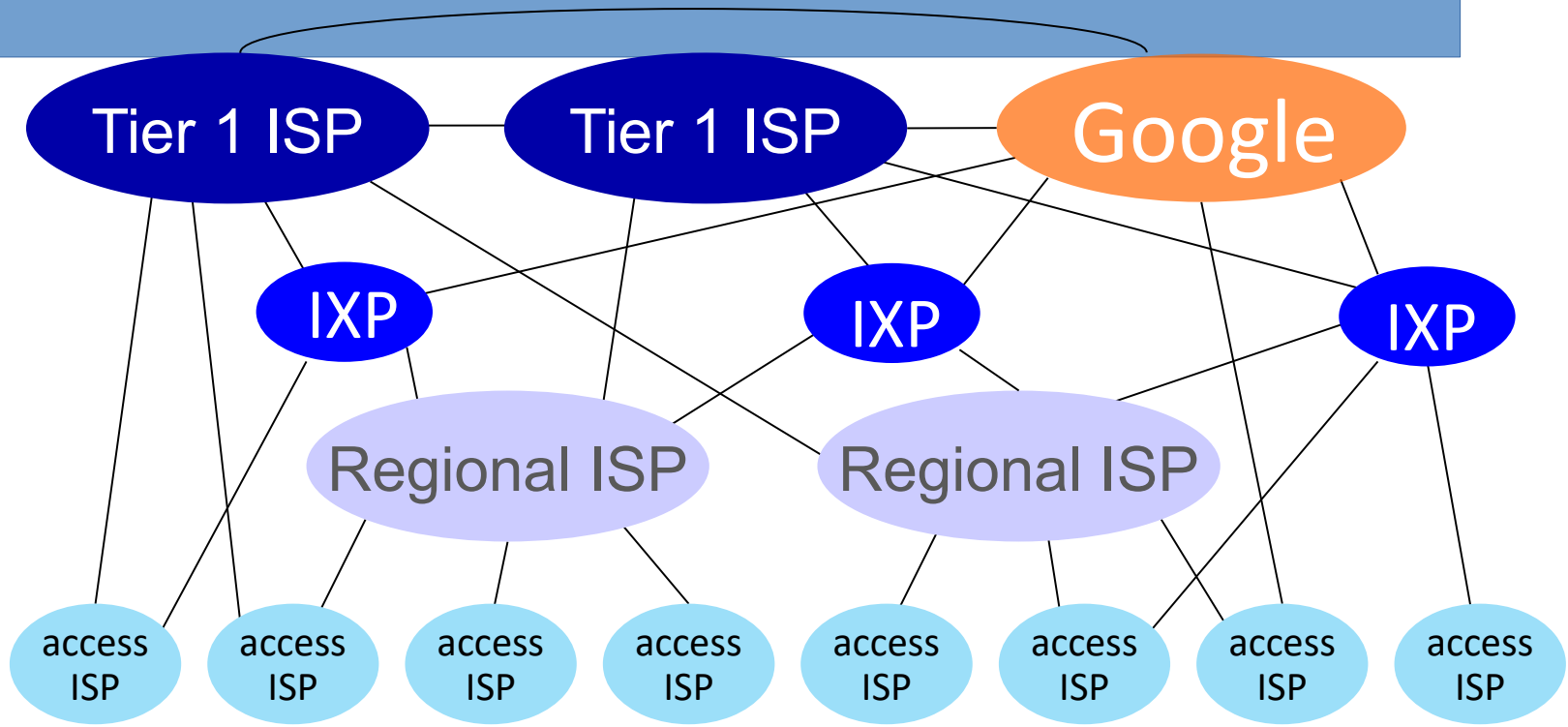


• What is the Internet?

… and content provider networks (e.g., Google, Microsoft, Akamai) may run their own network, to bring services, content close to end users



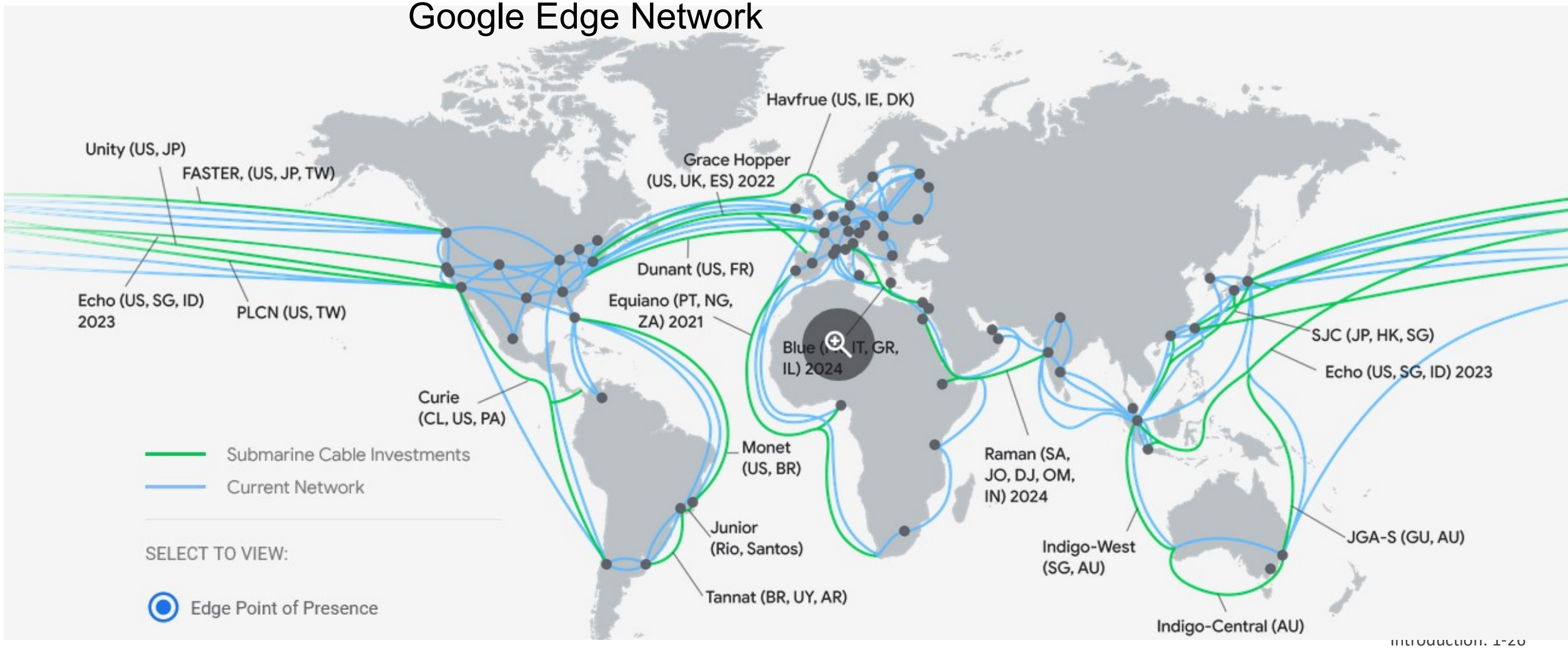
What is the Internet?



At "center": small # of well-connected large networks

- "tier-1" commercial ISPs (e.g., Level 3, Sprint, AT&T, NTT), national & international coverage
- content provider networks (e.g., Google, Facebook): private network that connects its data centers to Internet, often bypassing tier-1, regional ISPs

• What is the Internet?



What is the Internet?

- Local area networks
  - Privately owned, within building
  - High speed, broadcast, Ethernet, WIFI, blue tooth
    - 2 to 100 Mbps
- Wide area networks
  - Spans a large area
  - Point-to-point, high speed fiber or trunk lines
    - Long delays but very high speed links
    - Several Gbps

What is the Internet?

- Wireless networks
  - Hosts connected by infrared or radio links
  - Local area and wide area
  - Satellite networks

- What is a Protocol?

What is a Protocol?

- Building blocks of a network architecture
- Each protocol object has two different interfaces
  - *service interface*: operations on this protocol
  - *peer-to-peer interface*: messages exchanged with peer
- Term “protocol” refers to both the specification and implementation of the module

What is a Protocol?

Human protocols:

- "what's the time?"
- "I have a question"
- introductions

Rules for:

… specific messages sent

… specific actions taken when message received, or other events

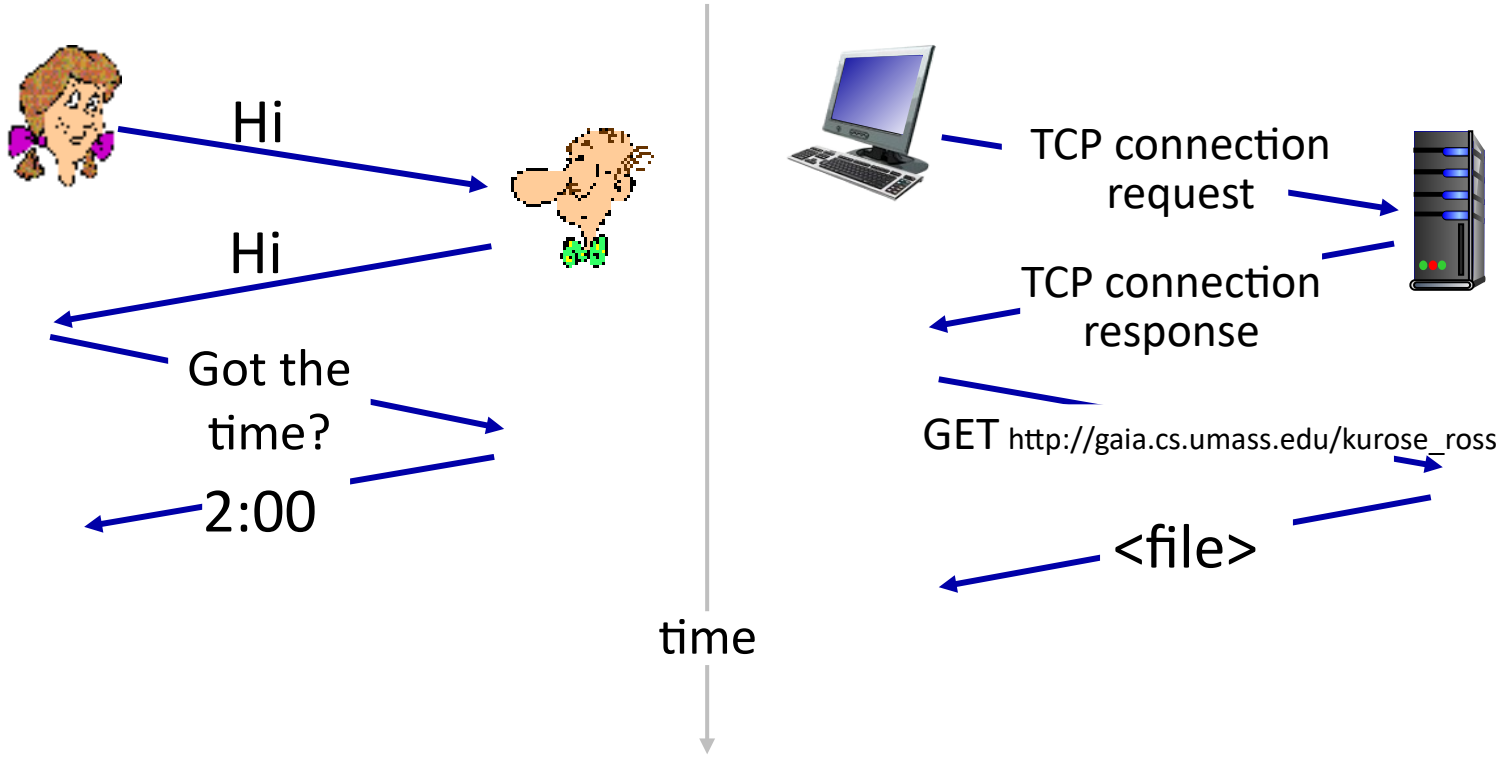
Network protocols:

- computers (devices) rather than humans
- all communication activity in Internet governed by protocols

Protocols define the format, order of messages sent and received among network entities, and actions taken on message transmission, receipt

What is a Protocol?

A human protocol and a computer network protocol:



Q: other human protocols?

- Syllabus and Course Overveiw

- Layered Internet

• Layered Internet

Networks are complex, with many "pieces":

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

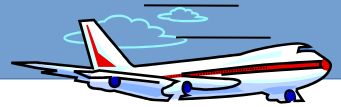
Question: is there any hope of *organizing* structure of network?

- and/or our *discussion* of networks?

Layered Internet

- Network communication is very complex
- Testing and maintenance is simplified
- Easy to replace a single layer with a different version

• Layered Internet



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

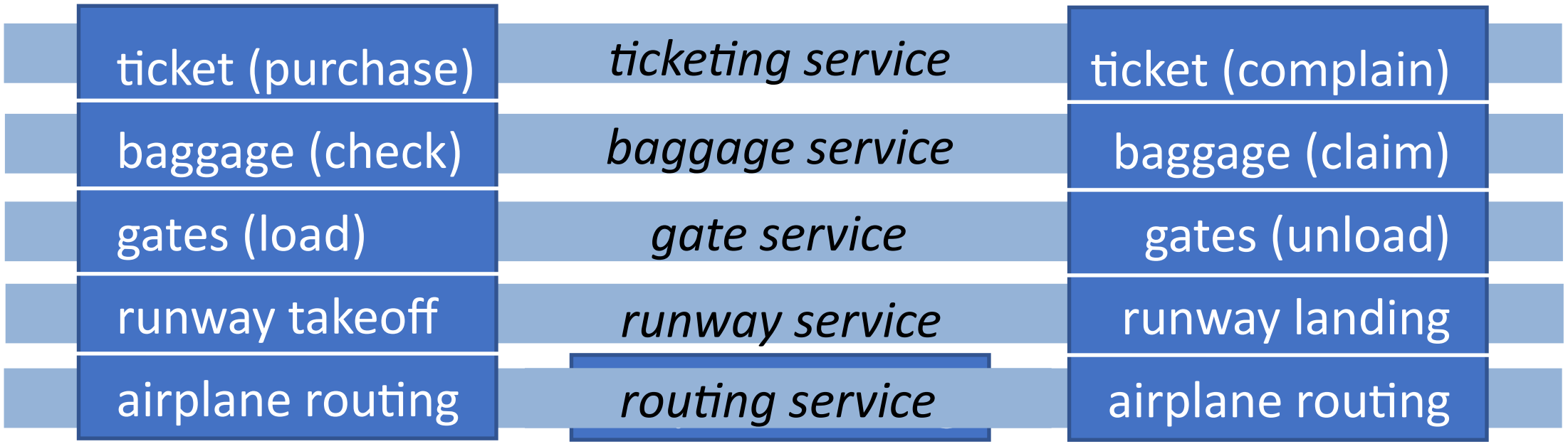
airplane routing

airplane routing

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

- a series of steps, involving many services

• Layered Internet



layers: each layer implements a service

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

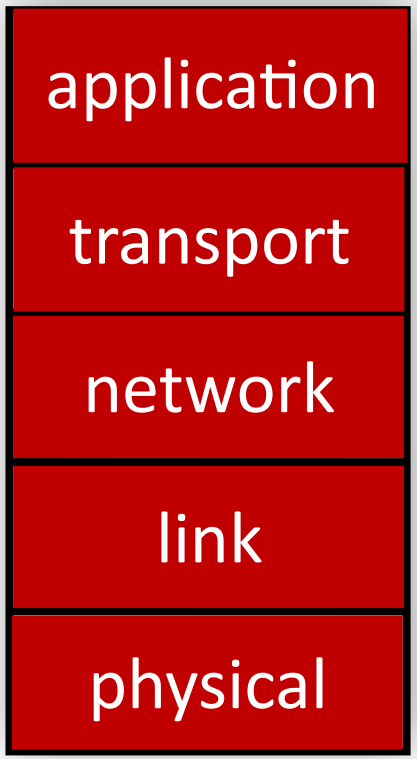
• Layered Internet

Approach to designing/discussing complex systems:

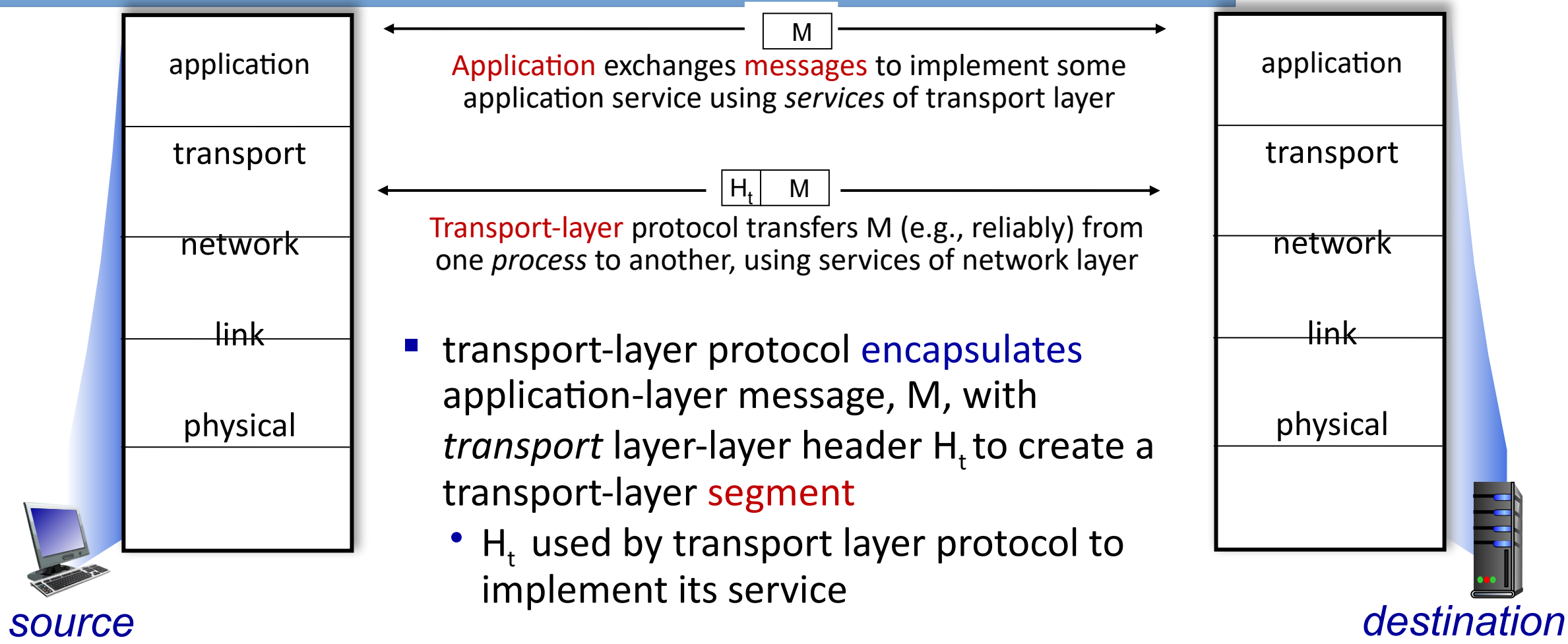
- explicit structure allows identification, relationship of system's pieces
  - layered *reference model* for discussion
- modularization eases maintenance, updating of system
  - change in layer's service *implementation*: transparent to rest of system
  - e.g., change in gate procedure doesn't affect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

Layered Internet

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

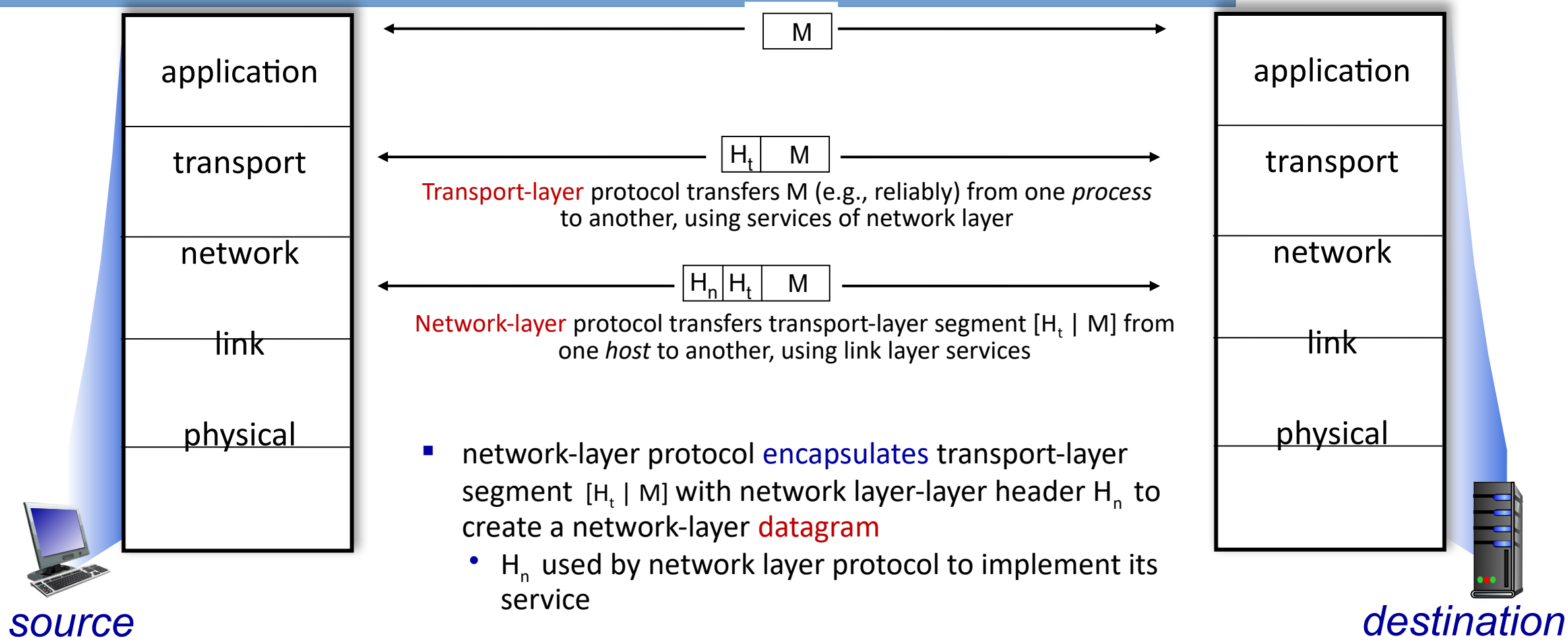


• Layered Internet



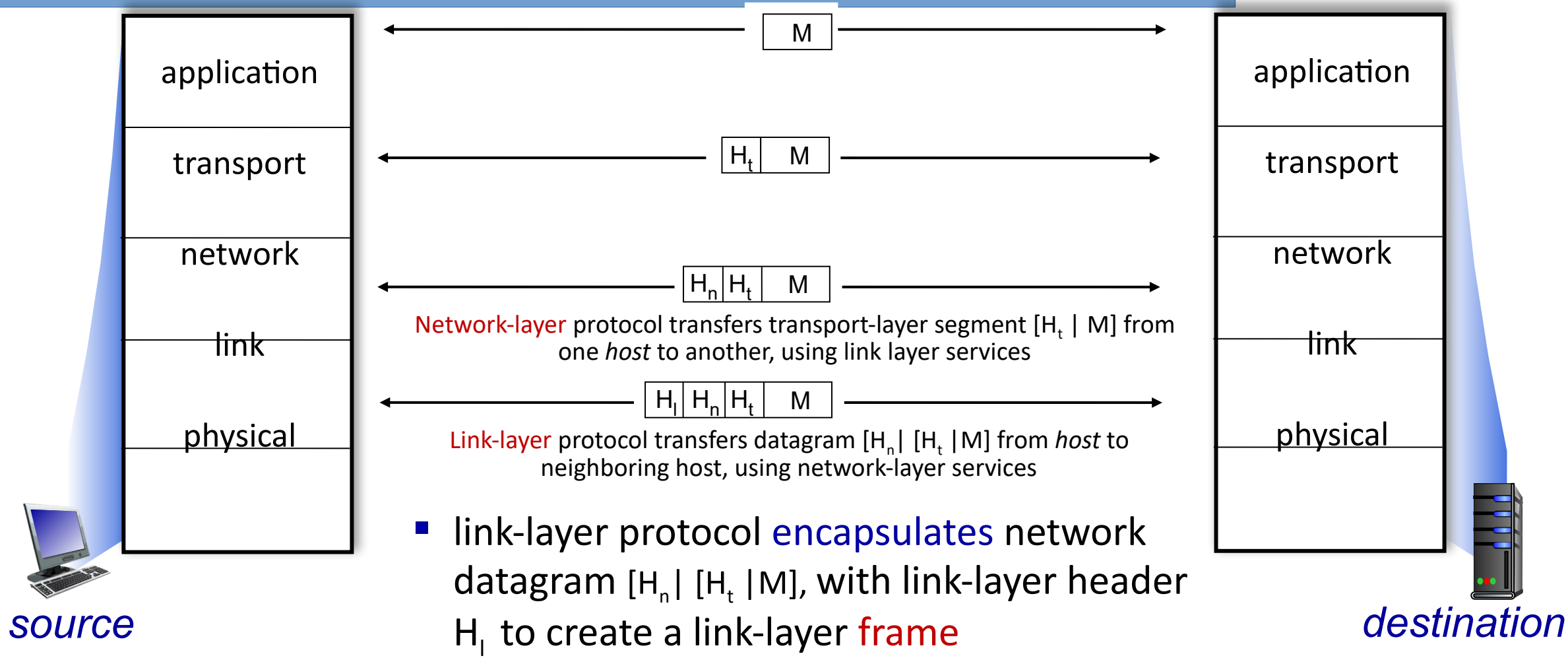
- transport-layer protocol encapsulates application-layer message, M, with *transport* layer-layer header H_t to create a transport-layer segment
  - H_t used by transport layer protocol to implement its service

• Layered Internet



- 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

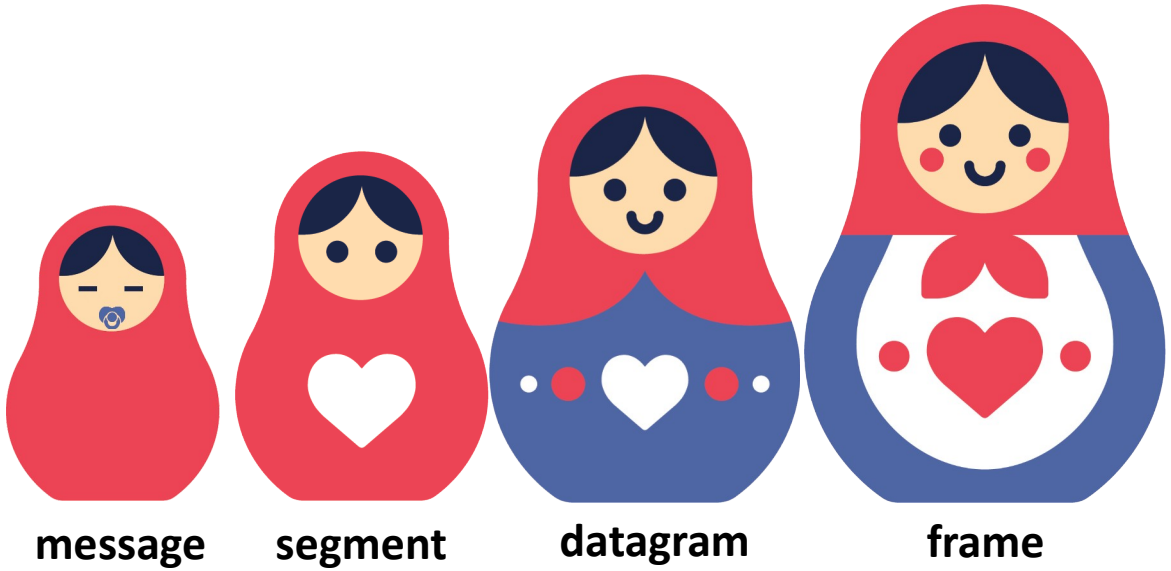
• Layered Internet



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

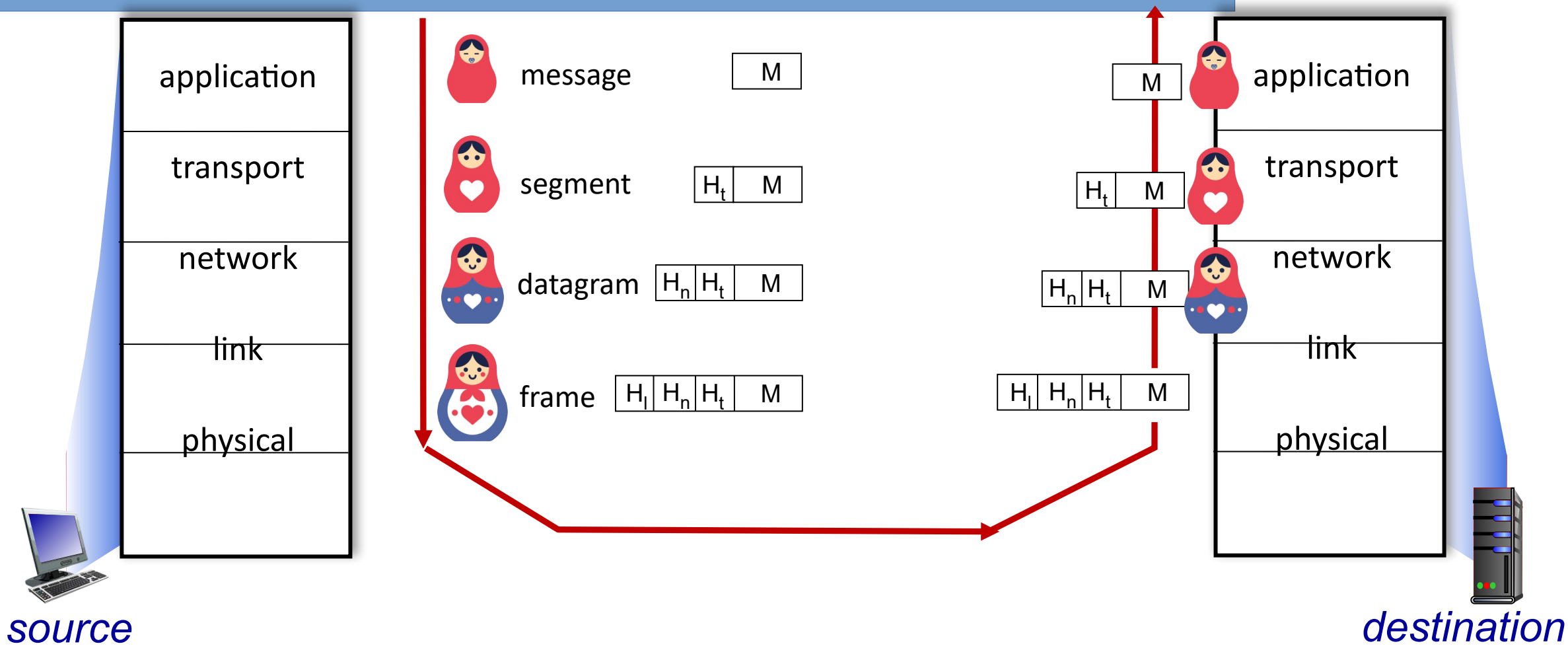
• Layered Internet

Matryoshka dolls (stacking dolls)



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

• Layered Internet



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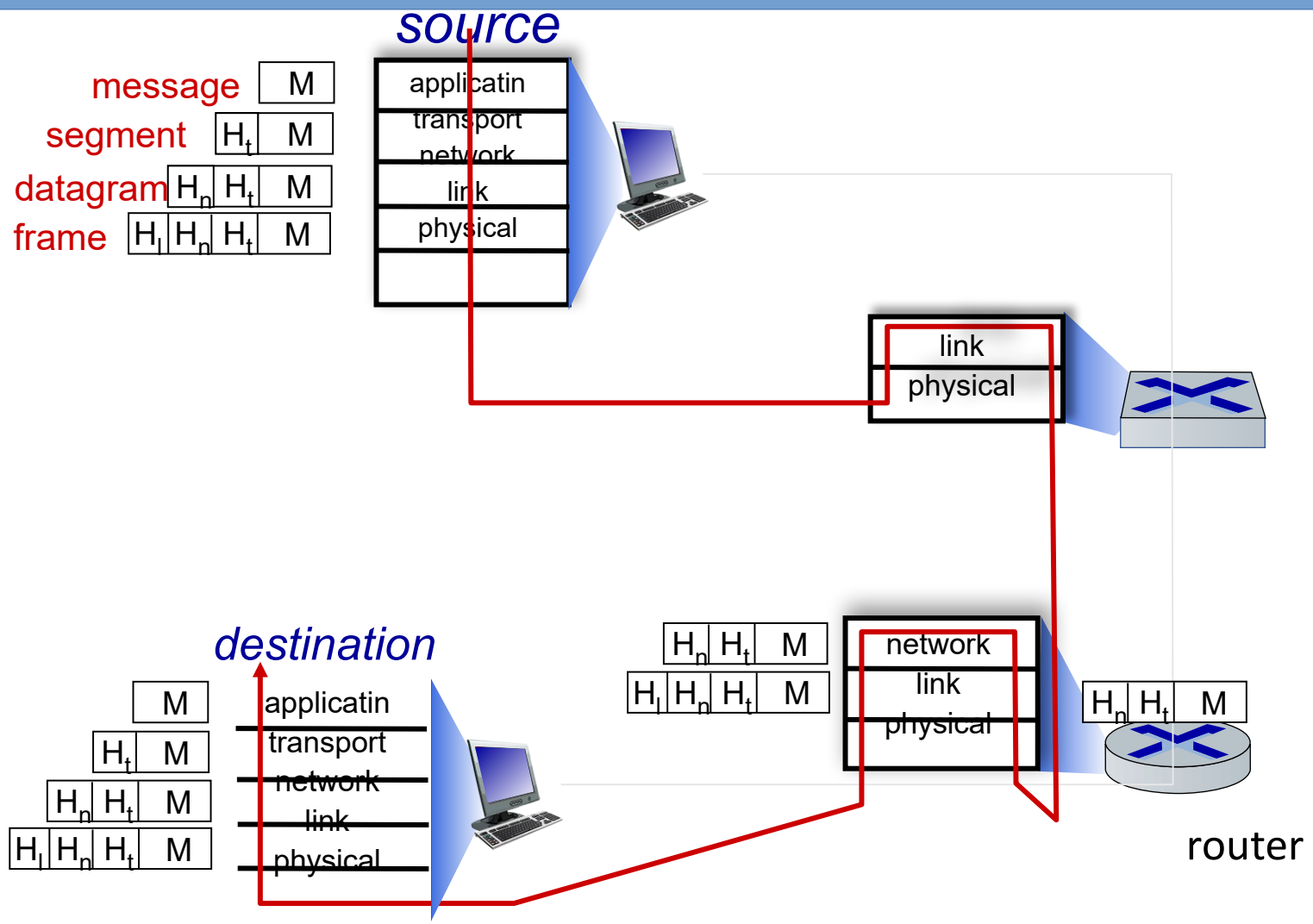

Network Performance

- What is throughput?
- Transmission Delay
- Propagation Delay
- Queuing Delay

Network Performance

- **Packet length**: size of a packet (units = bits or bytes)
- **Channel speed or bandwidth**: How fast the channel can transmit bits (units = bits/second or Bytes/second or packets/second)
- **Packet transmission time**: amount of time to transmit an entire packet (units = seconds)
- **Propagation delay**: Delay imposed by the properties of the link. Depends on the link's distance (units = seconds)
- Total transfer time =propagation delay + packet transmission time

Network Performance

- **Bits** are the units used to describe an amount of data in a network
  - 1 kilobit (Kbit) = 1×10^3 bits = 1,000 bits
  - 1 megabit (Mbit) = 1×10^6 bits = 1,000,000 bits
  - 1 gigabit (Gbit) = 1×10^9 bits = 1,000,000,000 bits
- **Seconds** are the units used to measure time
  - 1 millisecond (msec) = 1×10^{-3} seconds = 0.001 seconds
  - 1 microsecond (μsec) = 1×10^{-6} seconds = 0.000001 seconds
  - 1 nanosecond (nsec) = 1×10^{-9} seconds = 0.000000001 seconds
- **Bits per second** are the units used to measure channel capacity/bandwidth and throughput
  - bit per second (bps)
  - kilobits per second (Kbps)
  - megabits per second (Mbps)
- Bytes (8 bits a byte) Mega bytes, Giga bytes, Tera bytes, Peta Bytes, Exa bytes