Lecture 01-2:
What is Internet anyway

CS 326E Elements of Networking

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The title of the slide is inspired by the following video

Goals

Upon completing this lesson, you will be able to

- Answer the question "What is Internet, anyway" with a bit more details on its components and its architecture
- Understand protocols and layering in network communication
- Describe how the protocol stack operates
- Learn basic concepts and terminologies in networks

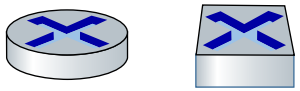
Outline

1. Goals
2. What is Internet: Components and Architecture
3. Internet communication: Protocols and Layers

The Internet: a "nuts and bolts" view

Billions of connected computing devices:

- hosts = end systems
- runs network apps at Internet's "edge"



Routers and switches:

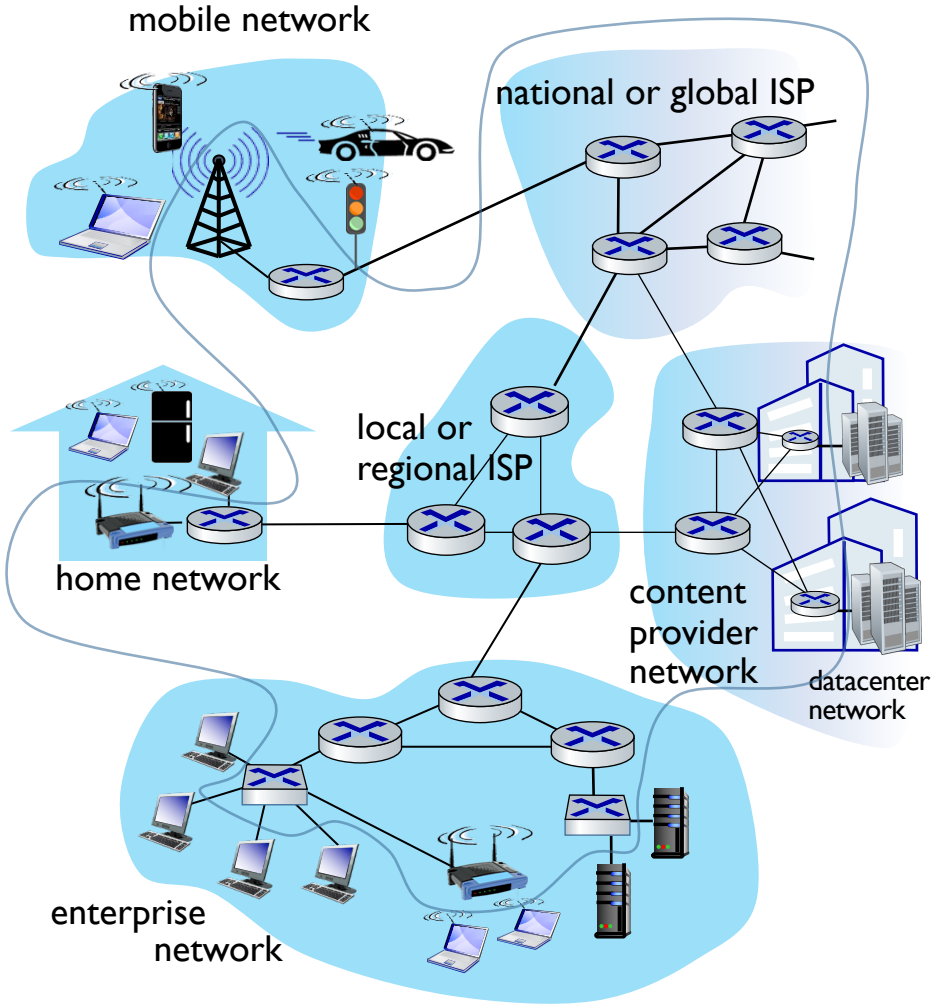
- forwards packets

Communication links

- fiber, copper, radio, satellite
- transmission rate: bandwidth

Networks

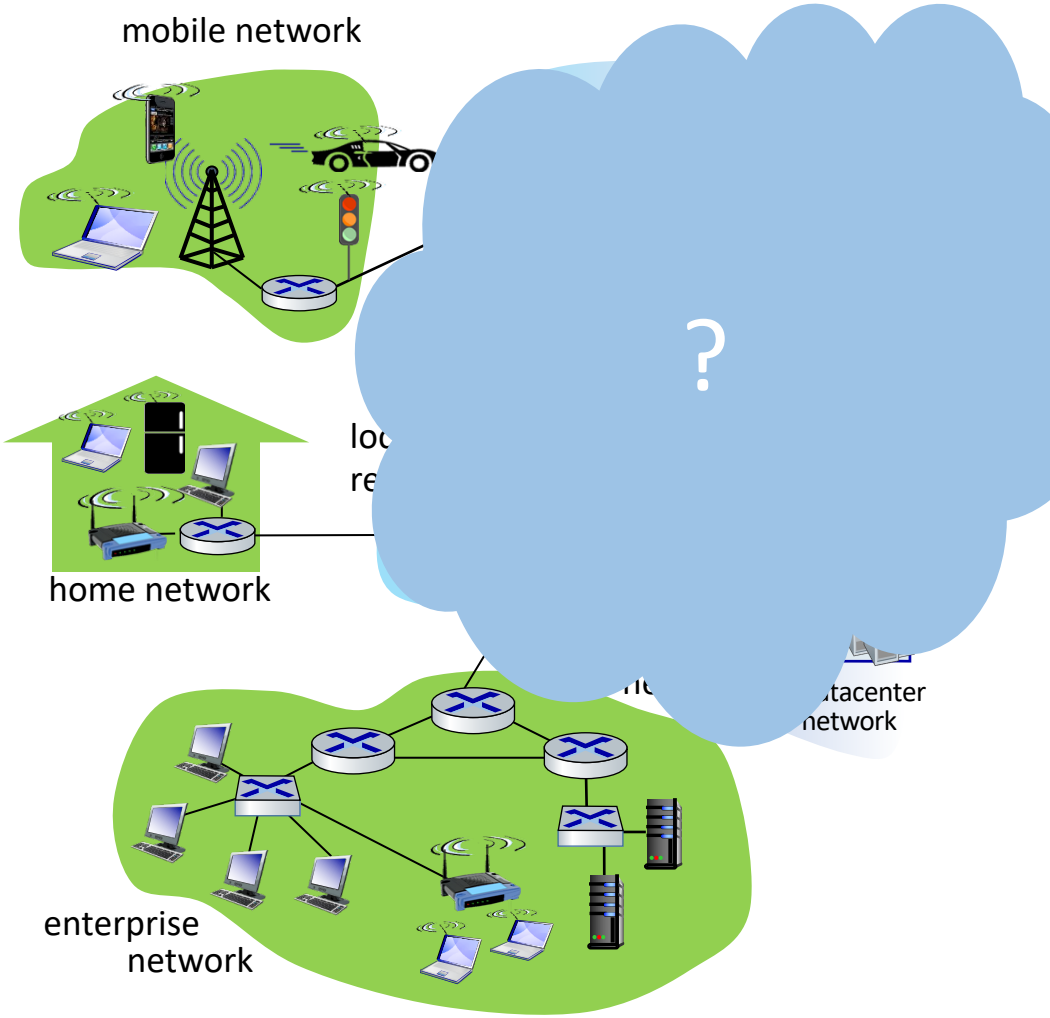
- collection of devices, routers, links: managed by an organization



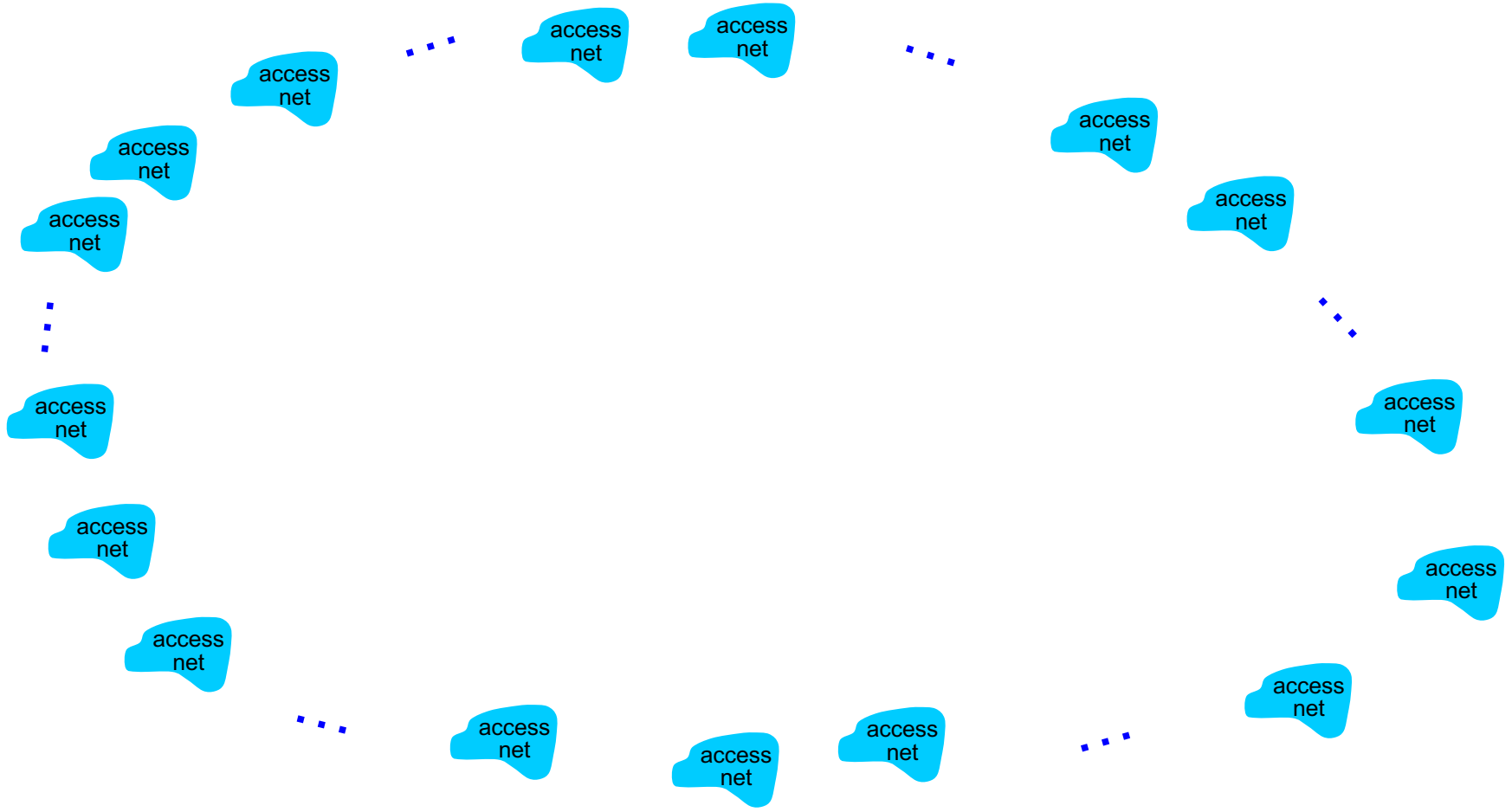
Let's start with an access network

- Access network – the network that physically connects an end host to its first router
  - Types: home, enterprise, mobile network
- Hosts connect to Internet via access Internet Service Providers (ISPs)

How to connect these access networks?



Given millions of access ISPs how to connect them together?



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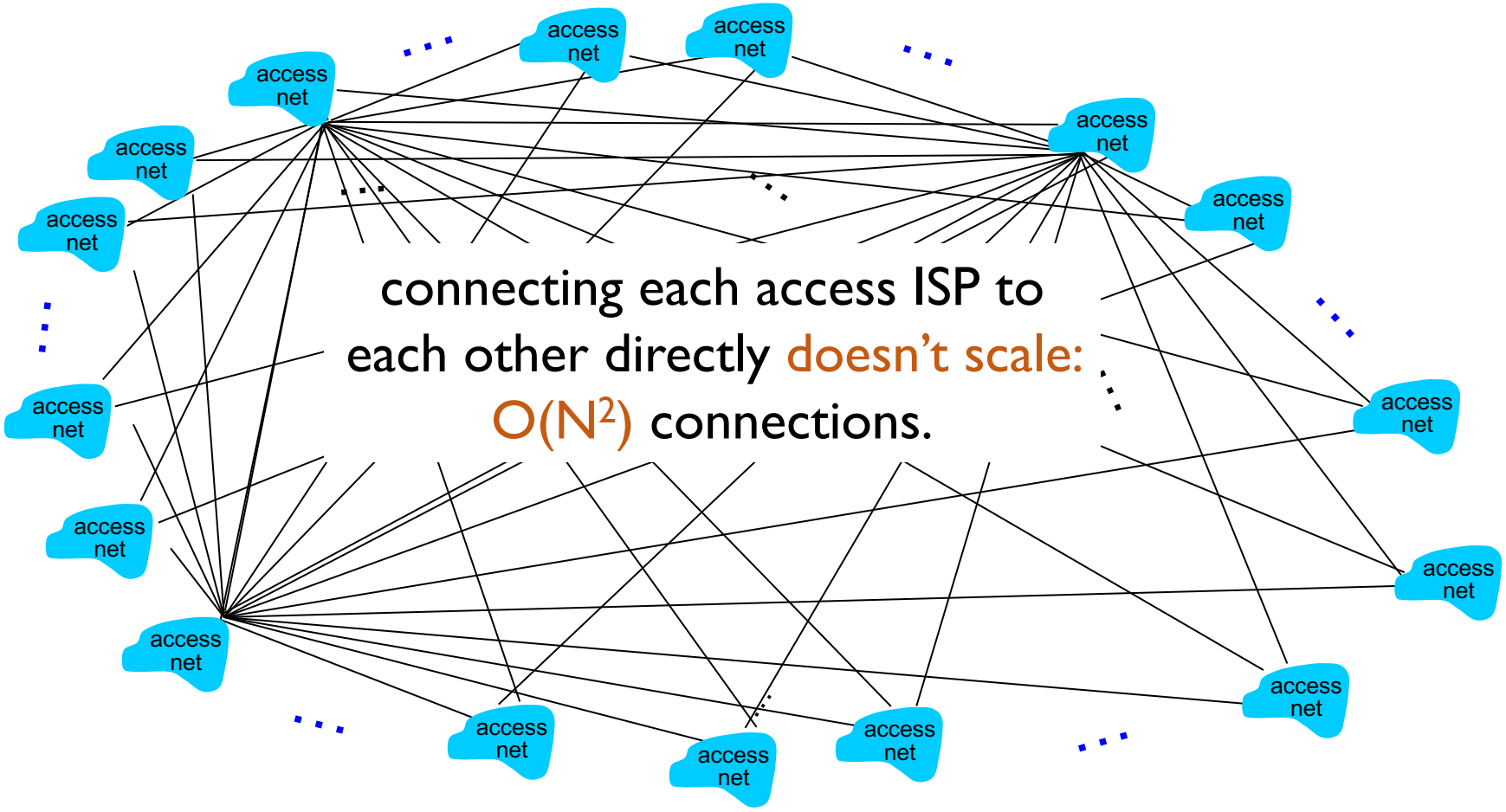
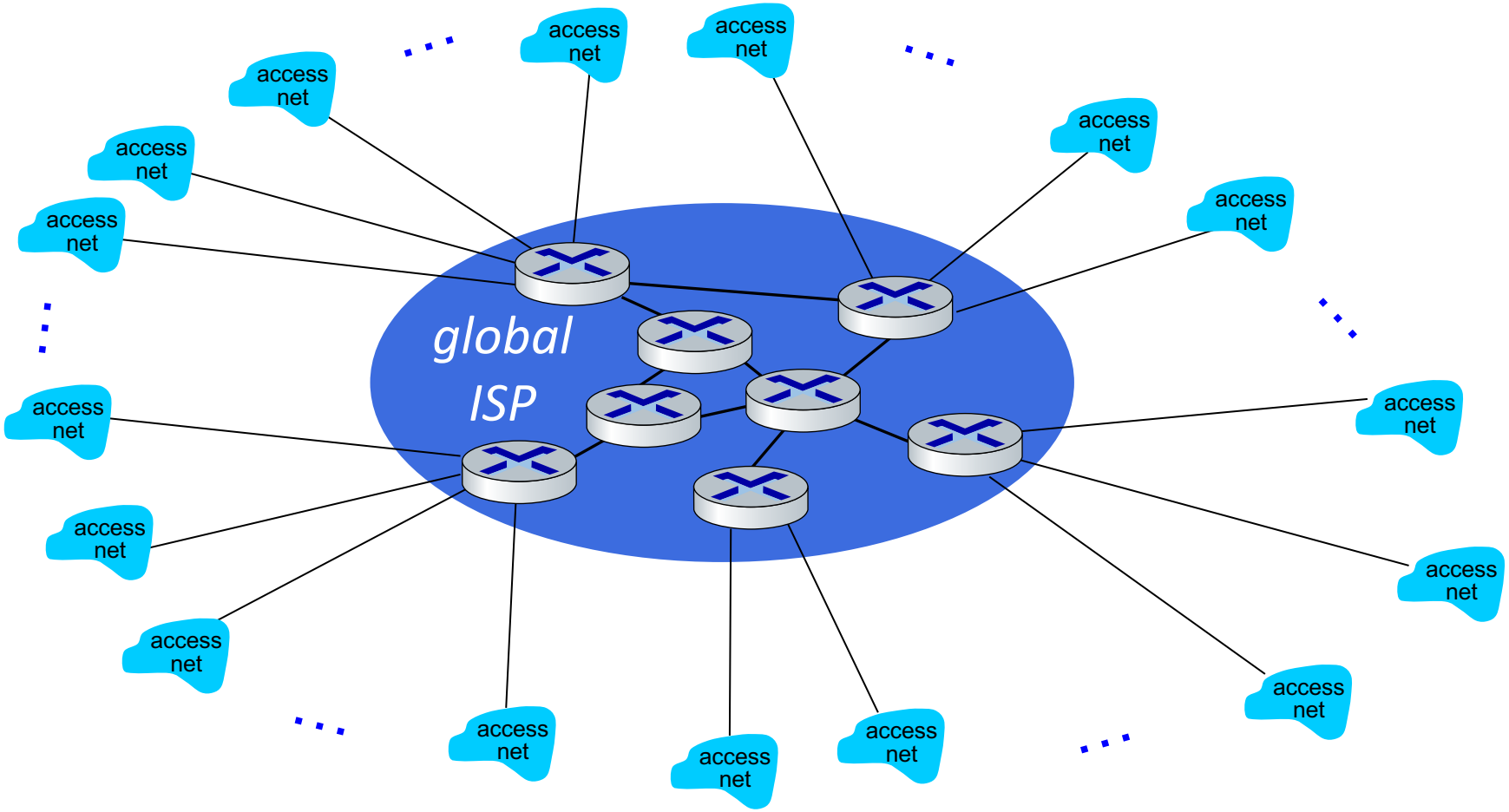
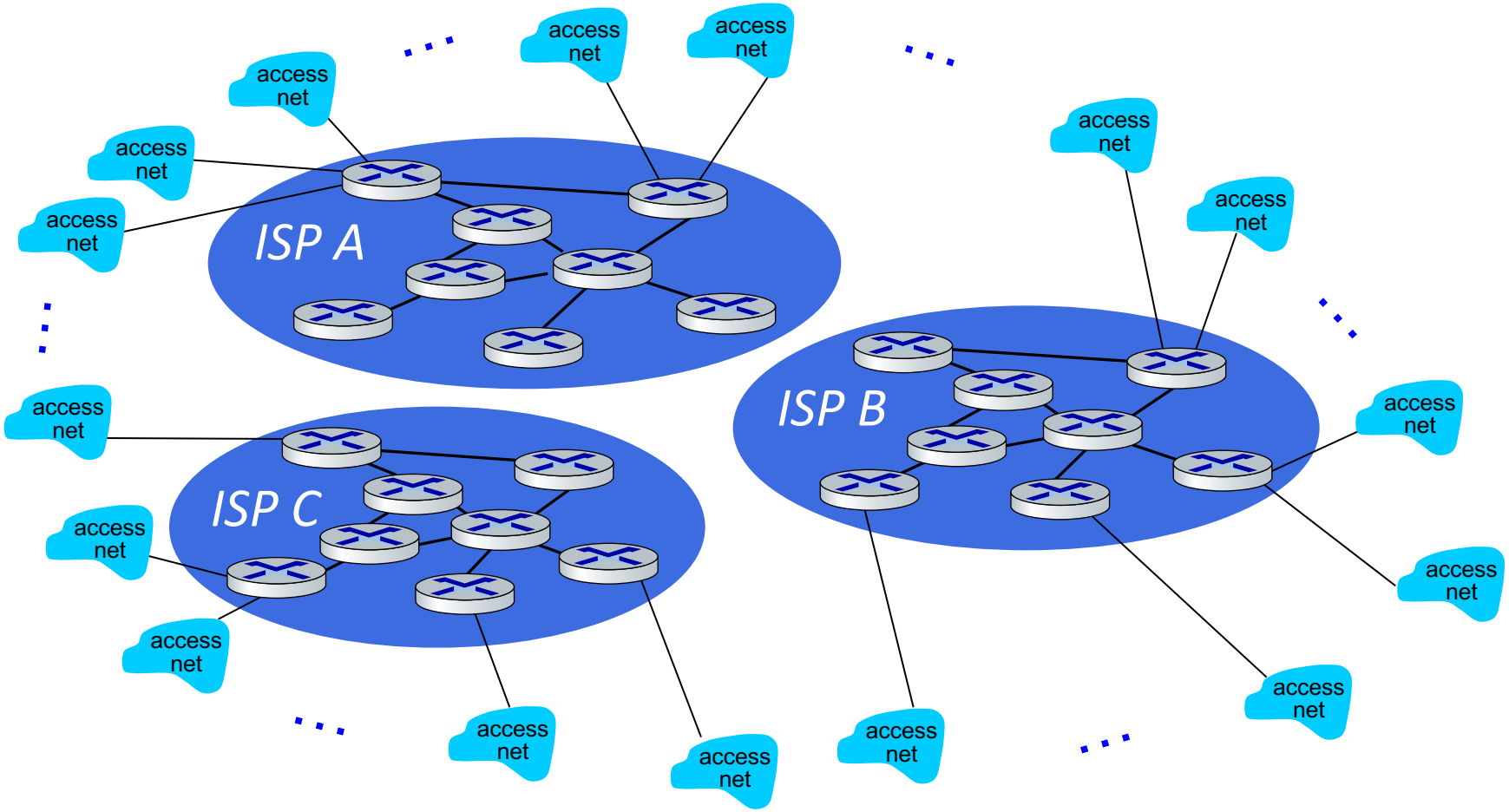


Option: Connect each access ISP to one global transit ISP

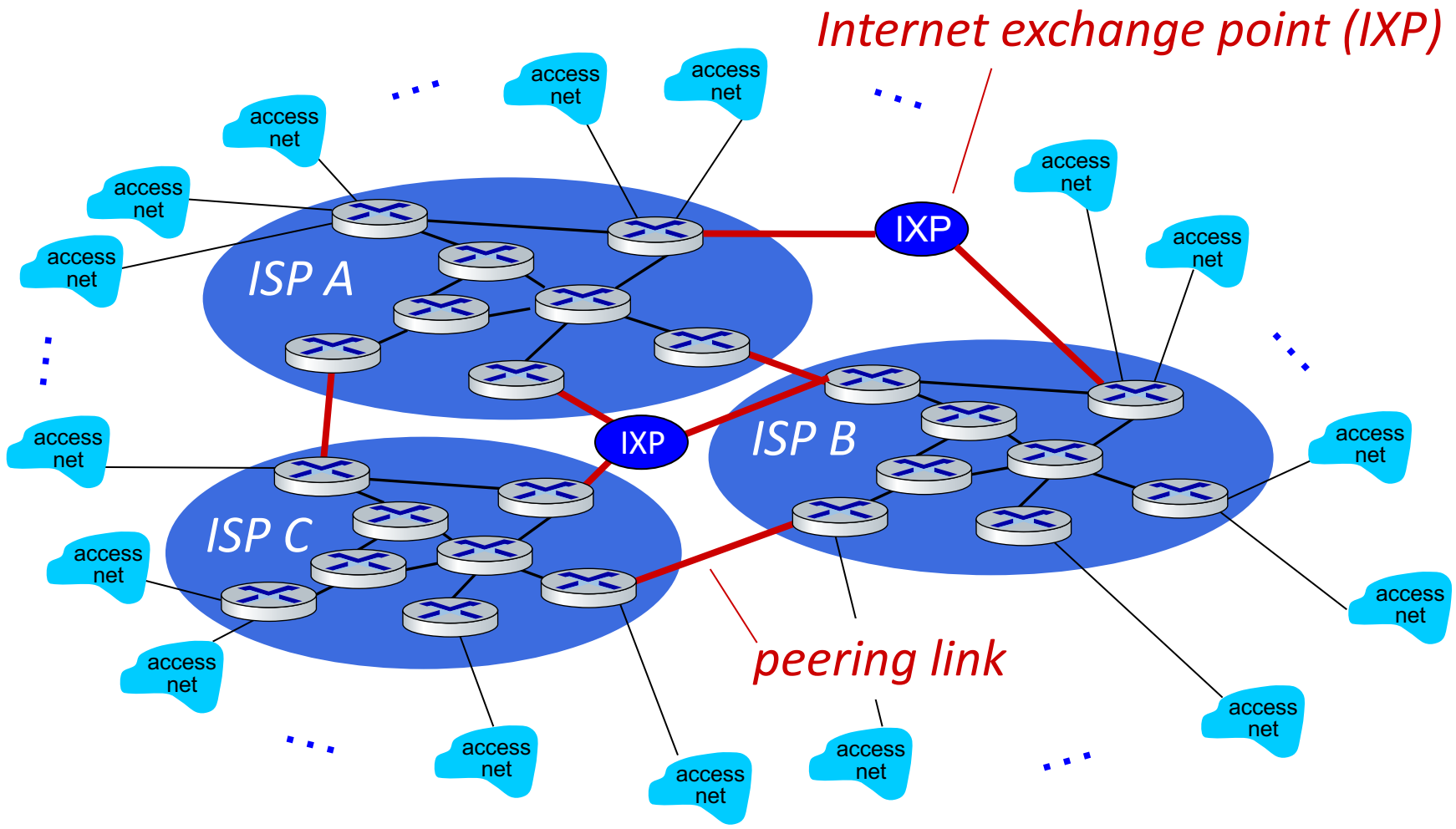
Customer and provider ISPs have economic agreement.



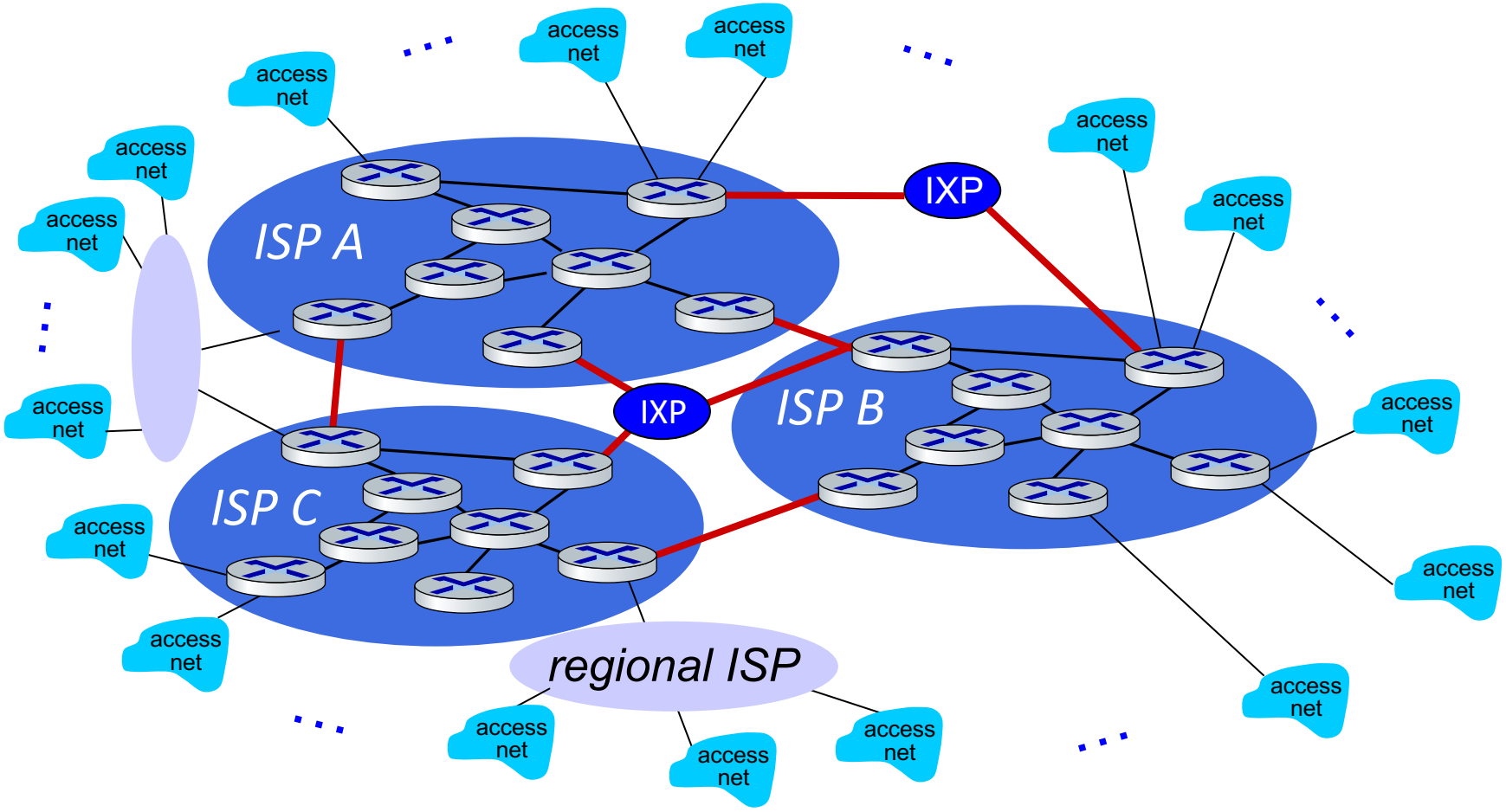
But if one global ISP is viable business, competitors will rise



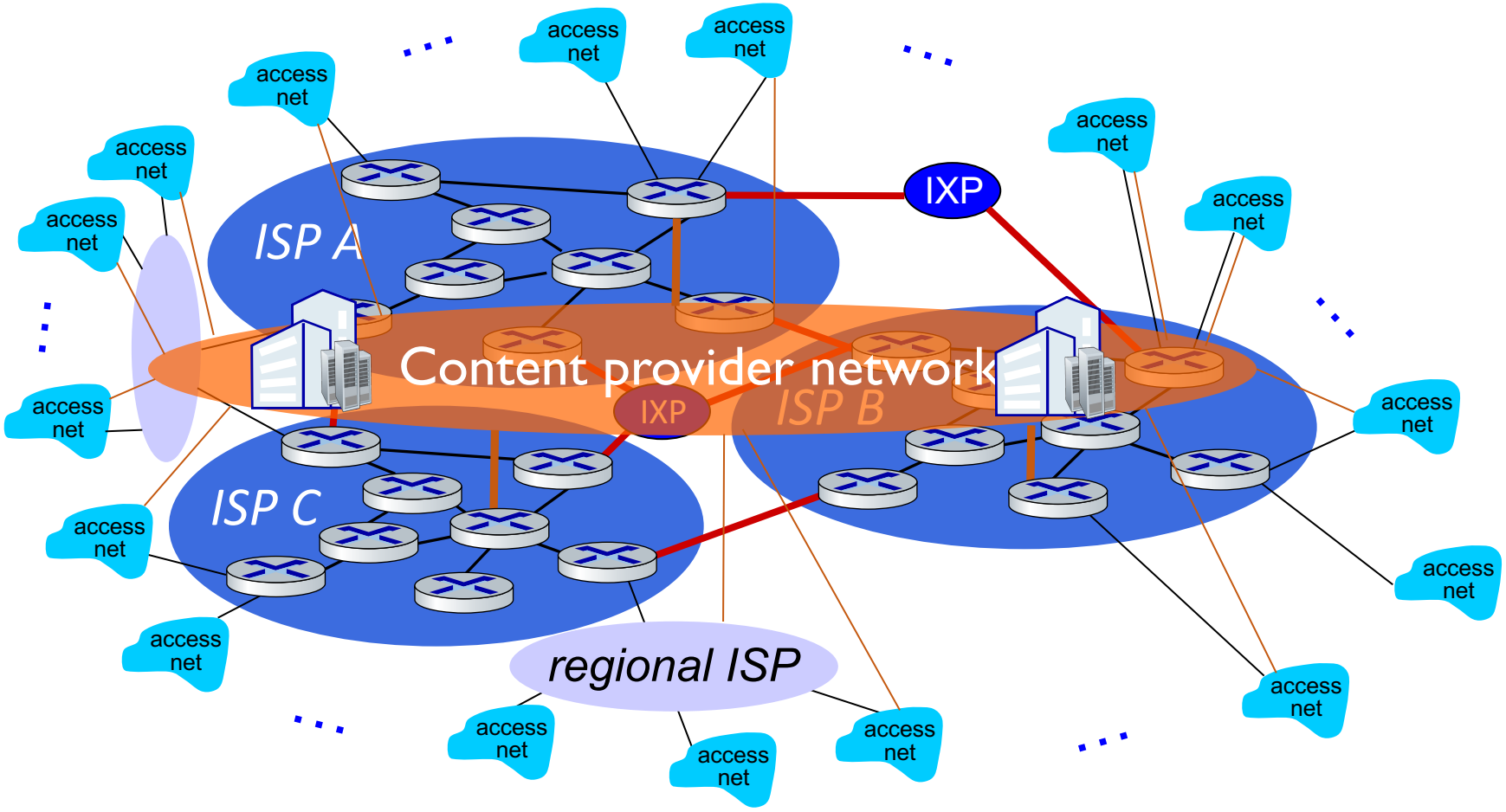
IXP is the physical infrastructure through which ISPs exchange Internet traffic



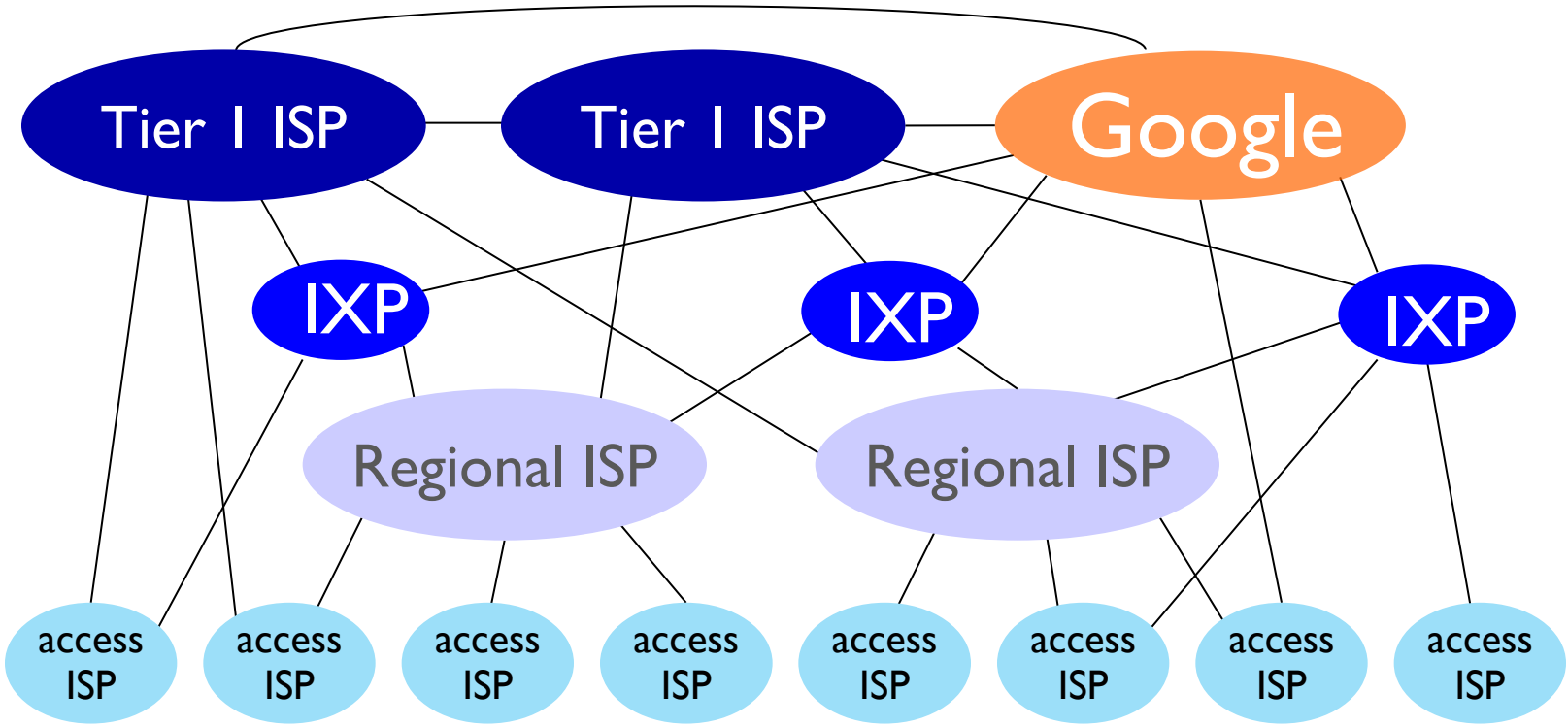
And regional networks may arise to connect access networks to ISPs



Also, content providers may run their own network to bring services and content close to end users



Internet structure: a "network of networks"



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

Now that we are connected,
how can we communicate over these networks?

Outline

1. Goals
2. What is Internet: the Components and the Architecture
3. Two basic building blocks of Internet communication

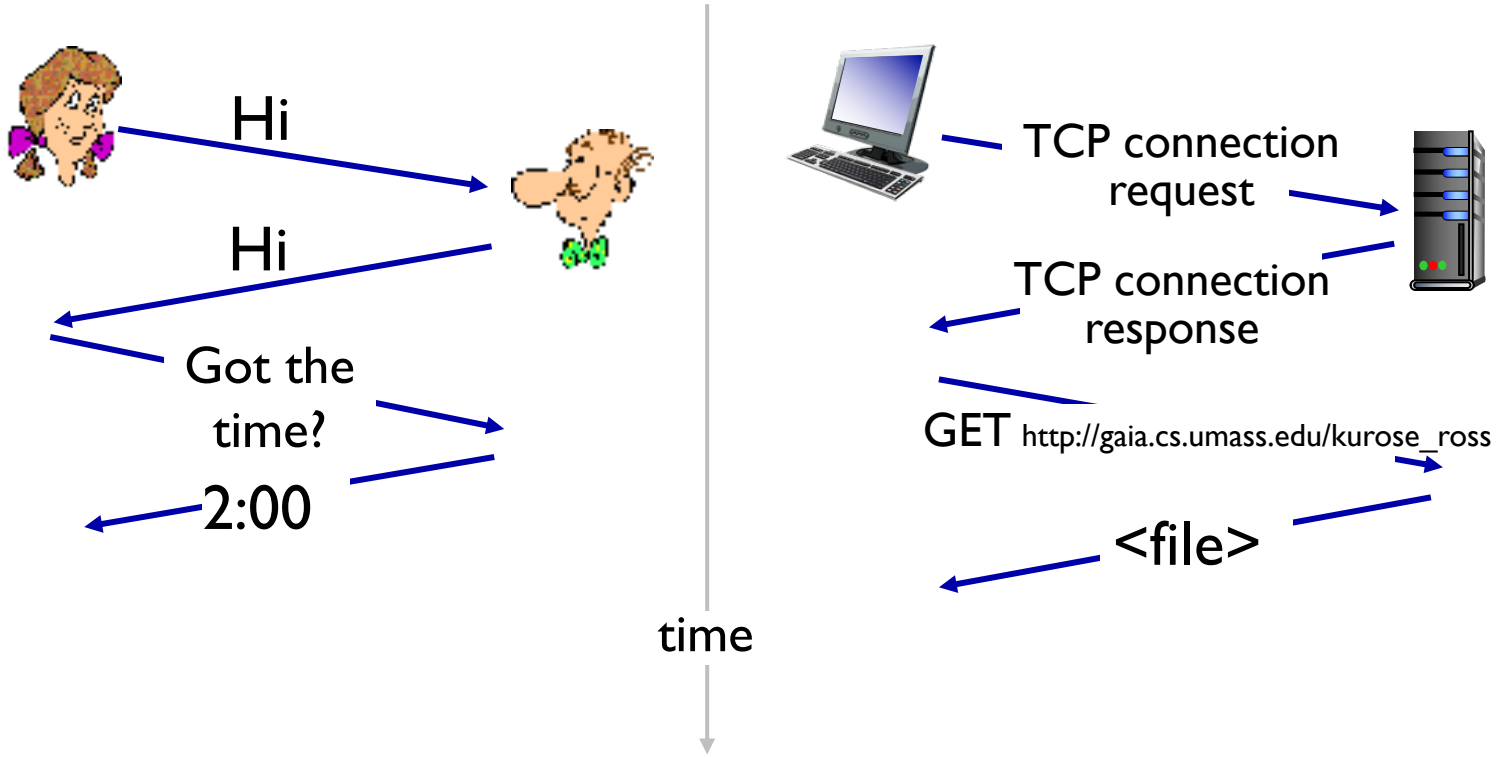
Now two entities are connected via physical medium
What should happen next?

What would be the basic building blocks in network communication?

Protocols and layering are the basic building blocks in network communication

Why protocol?

Need to agree on who/when/how/what we will communicate

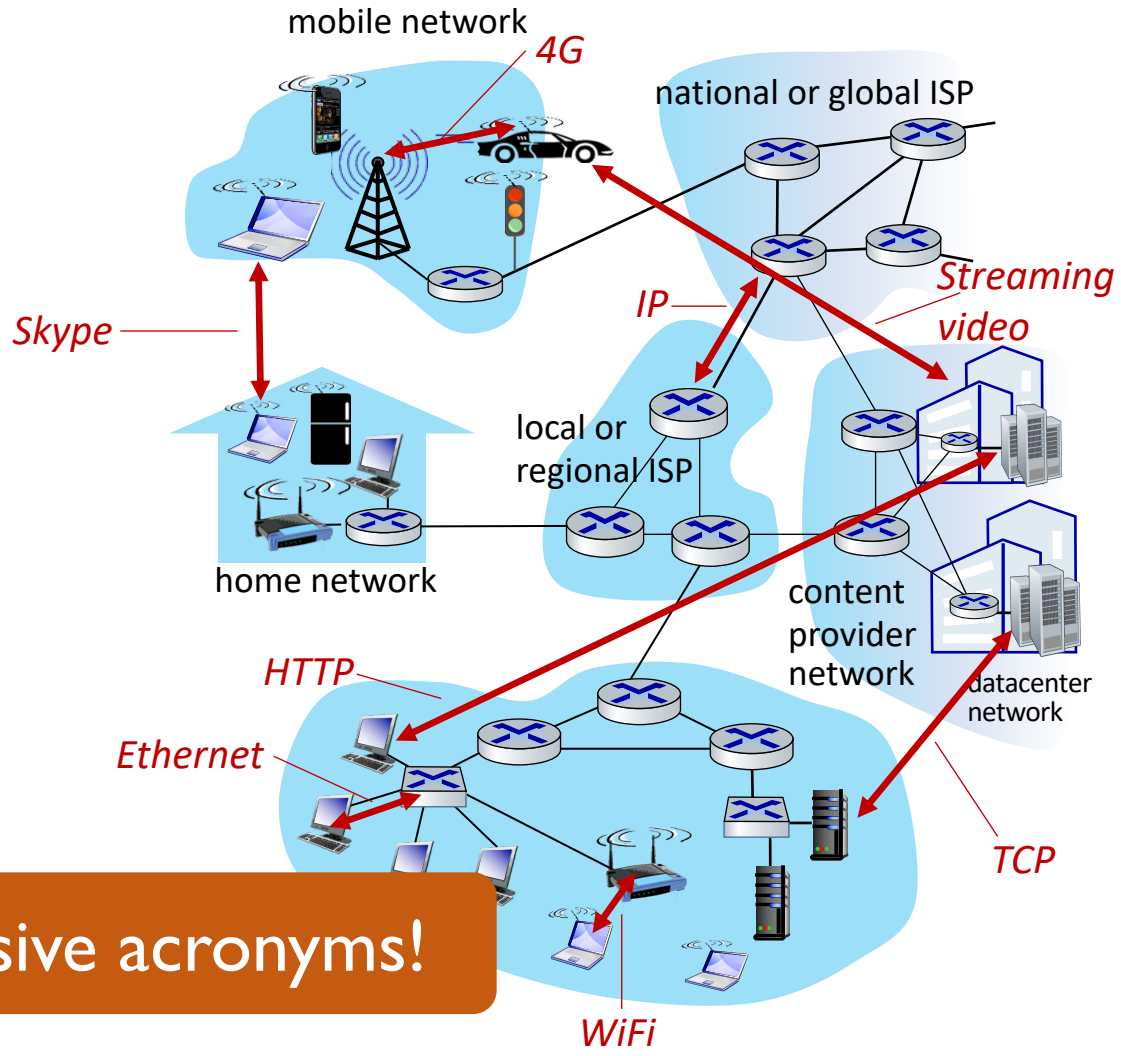


A human protocol vs computer network protocol

Protocols specifies how messages should be sent and received among network entities

HTTP, TCP, IP, ARP, DHCP, DNS, FTP, ICMP, IGMP, IMAP, LDAP, POP3, NTP, MAC, BGP, IRP, PTP, SNMP, SSH, TLS, SIP, RTSP, XMPP, etc..

Protocols follow Internet standards maintained by Internet Engineering Task Force (IETF)

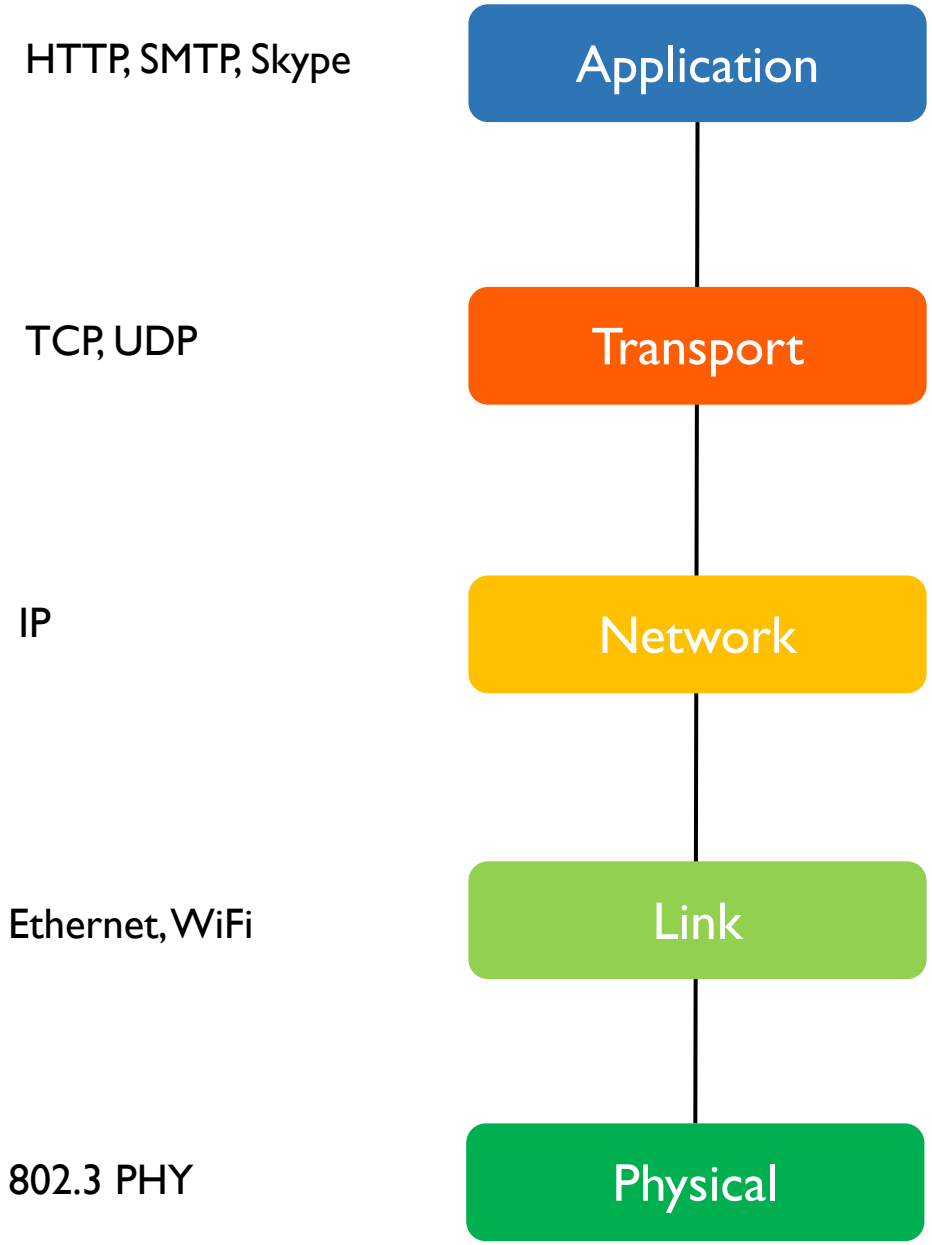


Welcome to the world of excessive acronyms!

Why layering?

What are the layers?

Layers in Internet Protocol Stack

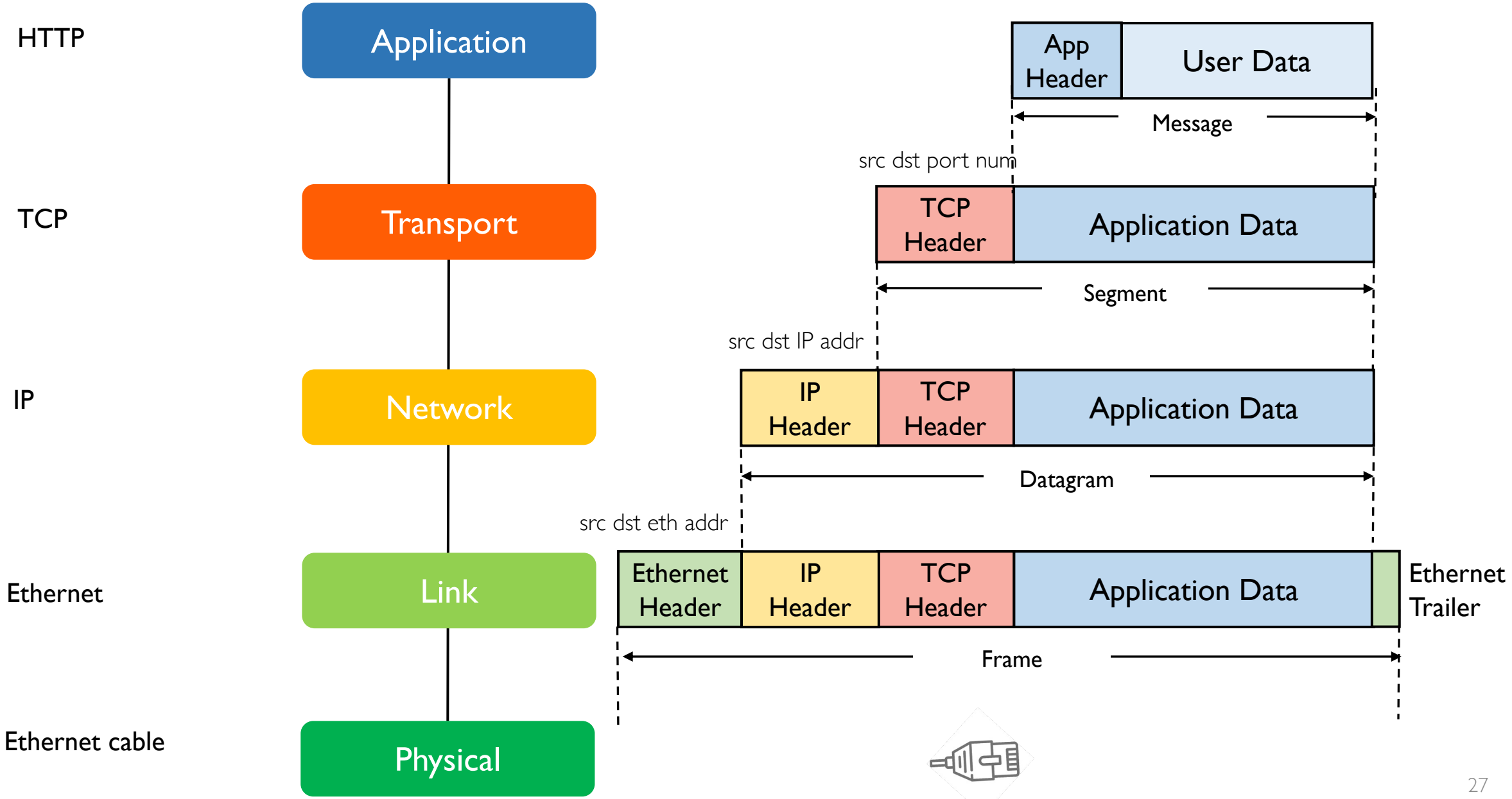


Need to solve various interesting problems

- How to share the same link between multiple users?
- How to do node discovery?
- How to determine the number of hops and routes to take?
- How to ensure the data is indeed received
- How to ensure multiple messages would be delivered in order?
- What if everybody is just sending too much?
- How to ensure the communication is safe?
- How to ensure "Bob" is really "Bob"?
- …

Assign each problem to an appropriate layer
where the layer only care about the problems assigned

Example Protocols	Layers	Responsible for
FTP, HTTP, SMTP	Application	application specific needs
TCP, UDP	Transport	process to process data transfer
IP	Network	host to host data transfer across different network
Ethernet, WiFi	Link	data transfer between physically adjacent nodes
802.3 PHY	Physical	bit-by-bit or symbol-by-symbol delivery


HTTP
Application
App Header
User Data
Message
src dst port num
TCP
Transport
TCP Header
Application Data
Segment
src dst IP addr
IP
Network
IP Header
TCP Header
Application Data
Datagram
src dst eth addr
Ethernet
Link
Ethernet Header
IP Header
TCP Header
Application Data
Ethernet Trailer
Frame
Ethernet cable
Physical

Pros and cons of layering

+ Provides abstraction and encapsulation
+ Changes are one layer do not affect other layers
+ Flexible: Supports heterogenous links and hosts (mix-n-match!)

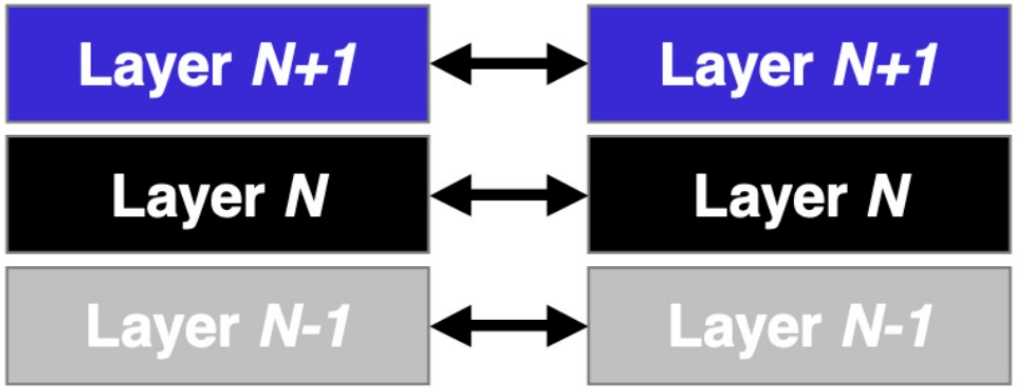
- Overhead: every layer adds info to the payload
- Limited visibility
  - When having poor performance: hard to know what was the real cause
  - Layer2 is doing hard work to ensure next hop delivery but the packet was a UDP packet (waste of effort)
- Redundancy in error handling

True/False

- A protocol always consider two communicating parties
- The two communicating parties can be from different layers

Note:
Protocols are horizontal and layers are vertical

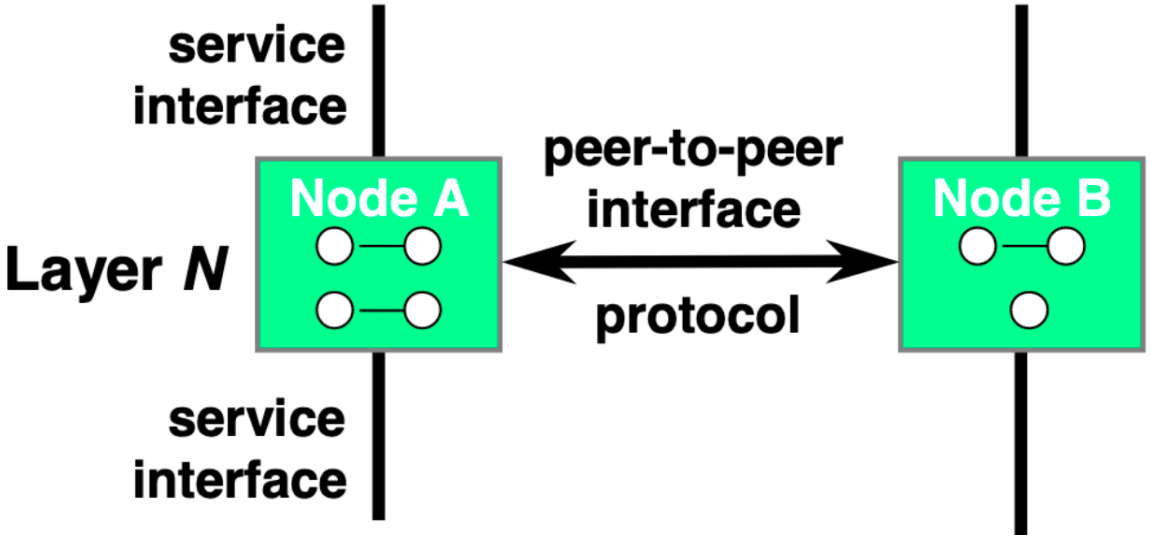
Protocols provides ways for peers to communicate horizontally



Layer N ONLY interact with peers in the same layer N via protocol

Each layer provides service to their upper layer

Layer N provides services to layer N+1

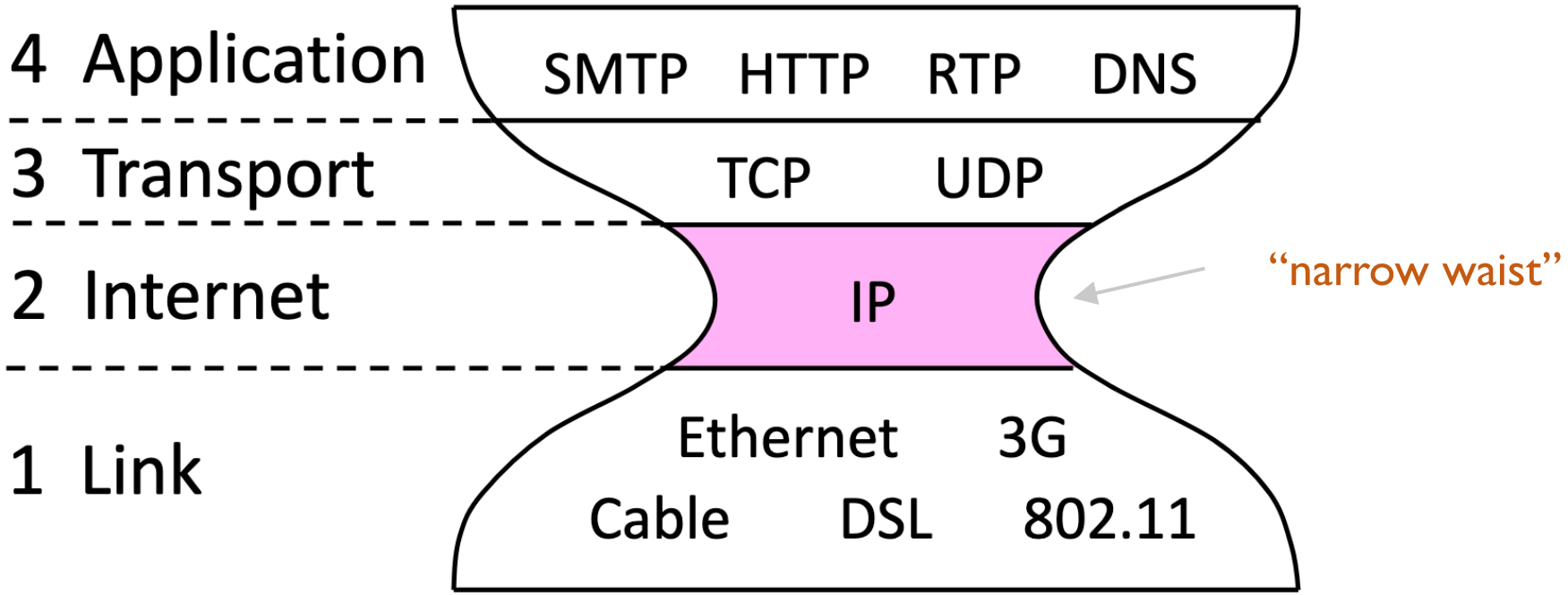


Layer N is serviced by layer N-1

Some more concepts and terms..

Hourglass: IP is the "narrow waist" of the Internet

- Supports many different apps above and links below

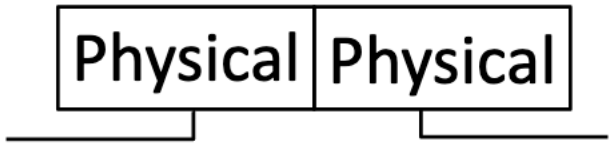


"Protocol stack" refers to a set of protocols in use

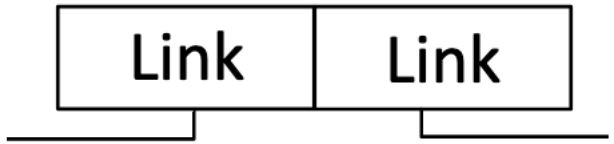
HTTP
TCP
IP
802.11

Repeater vs switch vs router vs proxy

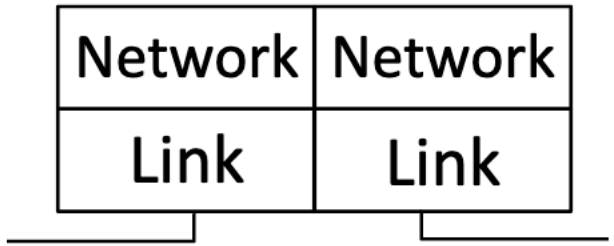
Repeater (hub)

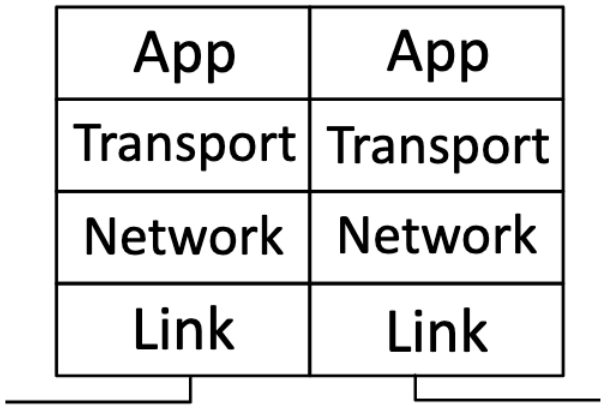


Switch (bridge)



Router





Proxy

But they all look like this! ☺

Acknowledgements

Slides are made based on

- James Kurose's slides