

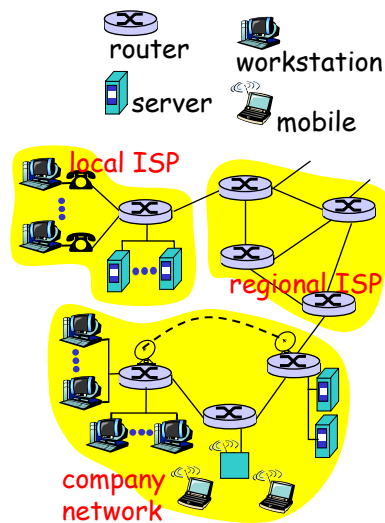
# Internet Routing

## Review of Networking Principles

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### What's the Internet: "nuts and bolts" view

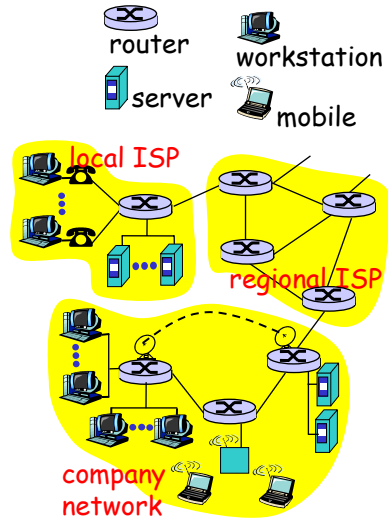
- Millions of connected computing devices: *hosts, end-systems*
  - PC's workstations, servers
  - PDA's, phones, toasters running *network apps*
- *Communication links*
  - Fiber, copper, radio, satellite
- *Routers*: forward packets (chunks) of data through network



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## What's the Internet: "nuts and bolts" view

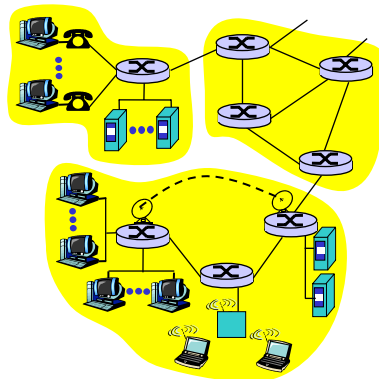
- **Protocols:** control sending, receiving of messages
  - E.g., TCP, IP, HTTP, FTP, PPP
- **Internet: "network of networks"**
  - Loosely hierarchical
  - Public Internet versus private intranet



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## What's the Internet: a service view

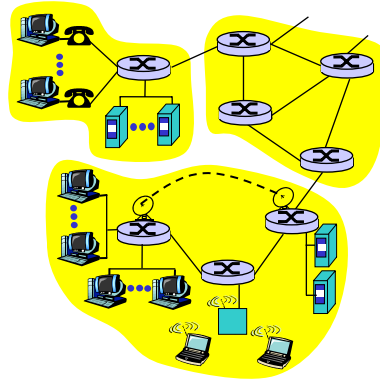
- **Communication infrastructure** enables distributed applications:
  - WWW, email, games, e-commerce, database, voting,
  - More?
- **Communication services provided:**
  - Connectionless
  - Connection-oriented



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## A closer look at network structure

- ❑ **Network edge:**
  - Applications
  - Hosts
- ❑ **Network core:**
  - Routers
  - Network of networks



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## Principles of the Internet

- ❑ Edge vs. core (end-systems vs. routers)
  - Dumb network
  - Intelligence at the end-systems
- ❑ Different communication paradigms
  - Connection oriented vs. connection less
  - Packet vs. circuit switching
- ❑ Layered System
- ❑ Network of collaborating networks

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## Network edge: Connection-oriented service

**Goal:** data transfer between end sys.

- **Handshaking:** setup (prepare for) data transfer ahead of time
  - Hello, hello back human protocol
  - **Set up "state"** in two communicating hosts
- **TCP – Transmission Control Protocol**
  - Internet's connection-oriented service

**TCP service** [RFC 793]

- **Reliable, in-order** byte-stream data transfer
  - Loss: acknowledgements and retransmissions
- **Flow control:**
  - Sender won't overwhelm receiver
- **Congestion control:**
  - Senders "slow down sending rate" when network congested

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## Network edge: connectionless service

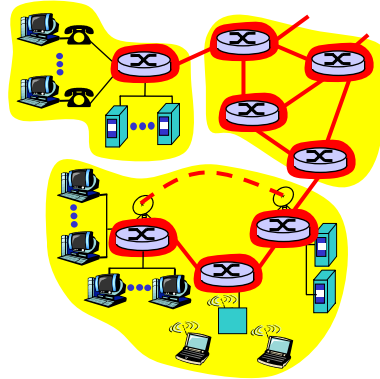
**Goal:** Data transfer between end systems

- Same as before!
- **UDP – User Datagram Protocol [RFC 768]:** Internet's connectionless service
  - Unreliable data transfer
  - No flow control
  - No congestion control

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## The network core

- Mesh of interconnected routers
- **The fundamental question:** How is data transferred through net?
  - **Circuit switching:** Dedicated circuit per call: telephone net
  - **Packet switching:** Data sent through net in discrete "chunks"



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## Routing

- **Goal**
  - Move pkts among routers from src to dst
- **Datagram network**
  - *Destination address* determines next hop
  - Routes may change during session
- **Virtual circuit network**
  - Each packet carries tag (virtual circuit ID), tag determines next hop
  - Fixed path determined at *call setup time*, remains fixed through call
  - Routers maintain per-call state

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## Protocol "Layers"

### Networks are complex!

- Many "pieces":
  - Hosts
  - Routers
  - Links of various media
  - Applications
  - Protocols
  - Hardware, software

### Question:

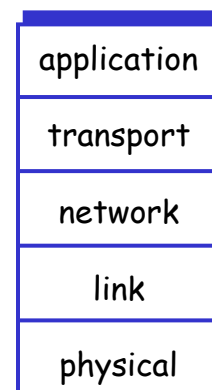
Is there any hope of  
*organizing* structure of  
network?

Or at least in our  
discussion of networks?

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## Internet protocol stack

- **Application:** supporting network applications
- **Transport:** host-host data transfer
- **Network:** uniform format of packets, routing of datagrams from source to destination
- **Link:** data transfer between neighboring network elements
- **Physical:** bits "on the wire"

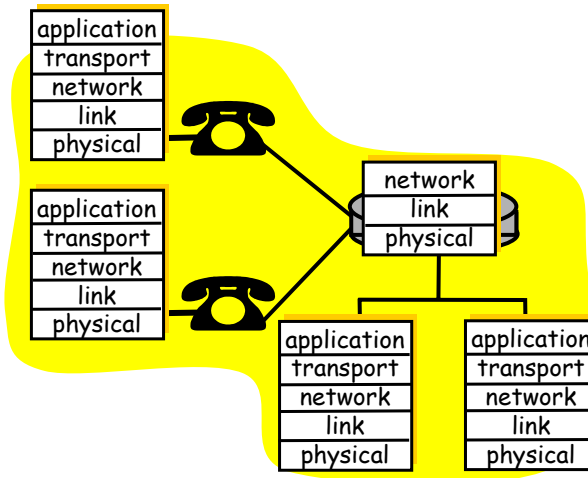


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## Layering: Logical communication

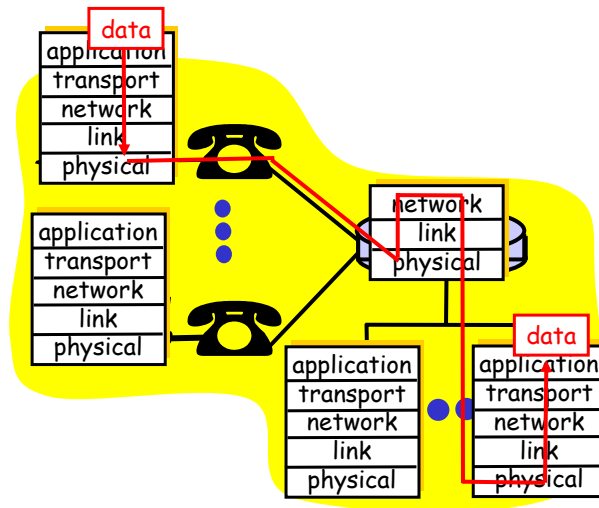
Each layer:

- Distributed
- "Entities" implement layer functions at each node
- Entities perform actions, exchange messages with peers



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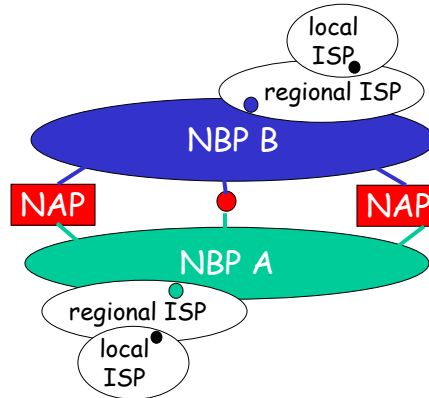
## Layering: Physical communication



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## Internet structure: Network of networks

- Roughly hierarchical
- **National/international backbone providers (NBPs)**
  - E.g., BBN/GTE, Sprint, AT&T, IBM, UUNet
  - Interconnect (peer) with each other privately, or at public Network Access Point (NAPs)
- **Regional ISPs**
  - Connect into NBPs
- **Local ISP, company**
  - Connect into regional ISPs



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