CPSC156a: The Internet
Co-Evolution of Technology and Society

Lecture 3: September 11, 2003

Internet Basics, continued

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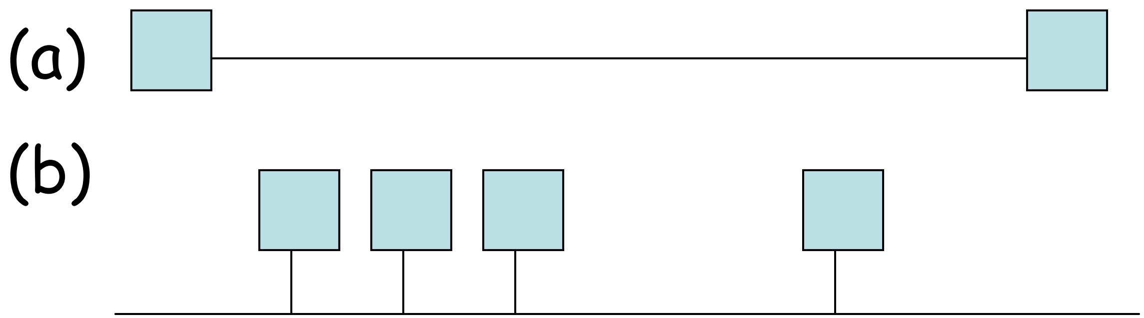
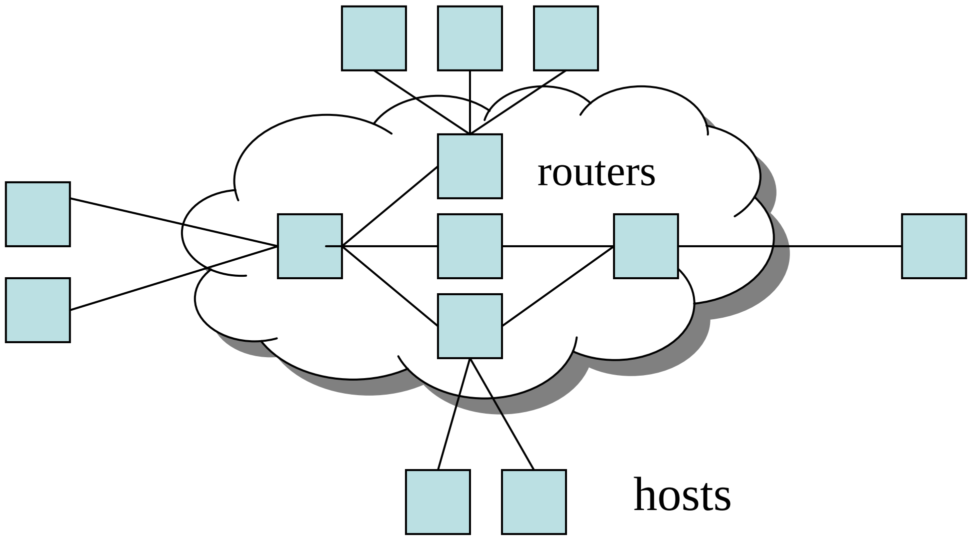
Directly Connected Machines



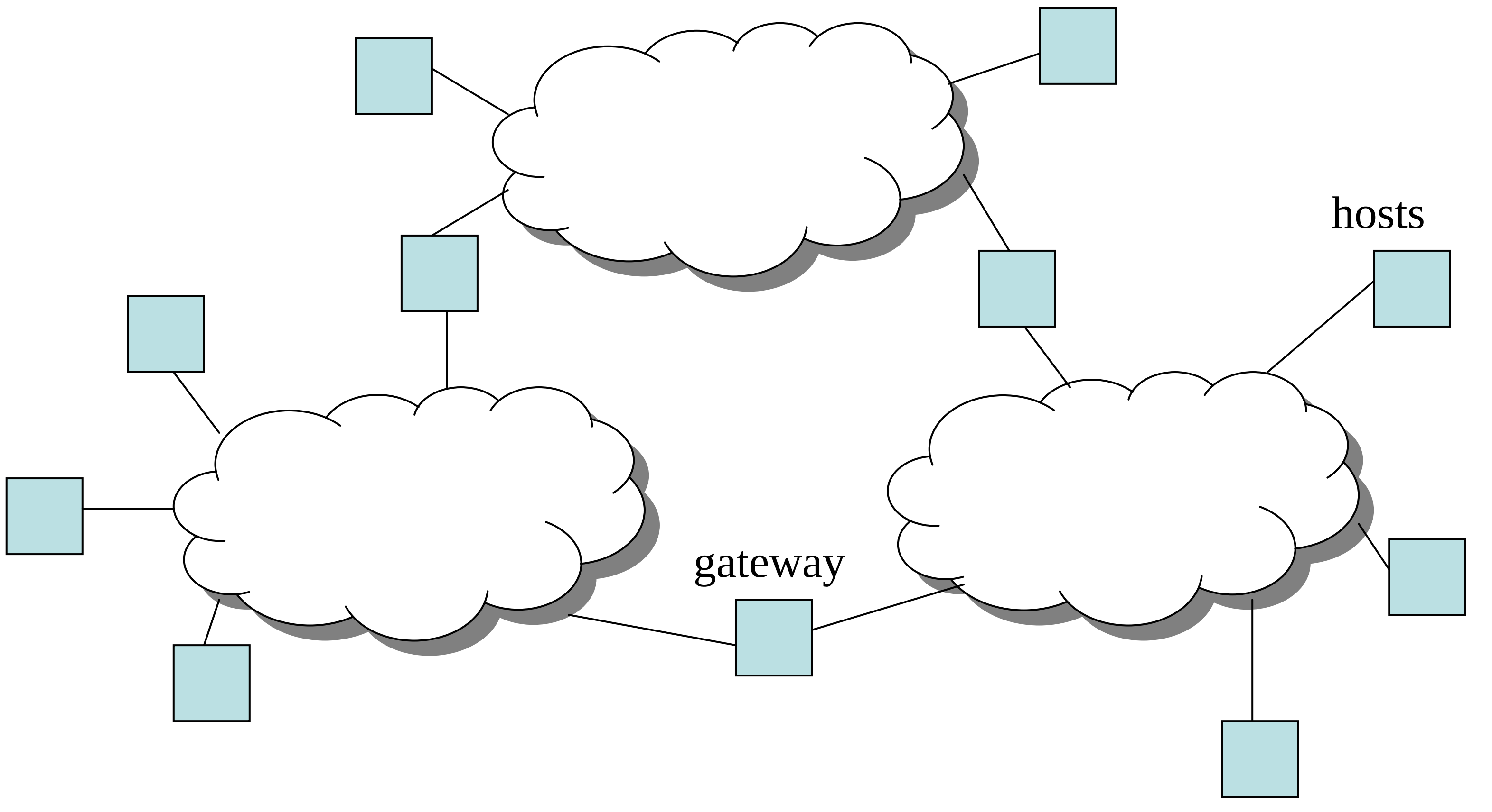
- (a) Point-to-point: *e.g.,* ATM
- (b) Multiple-access: *e.g.,* Ethernet
- Can't build a network by requiring *all* nodes to be directly connected to each other; need scalability with respect to the number of wires or the number of nodes that can attach to a shared medium

Switched Network



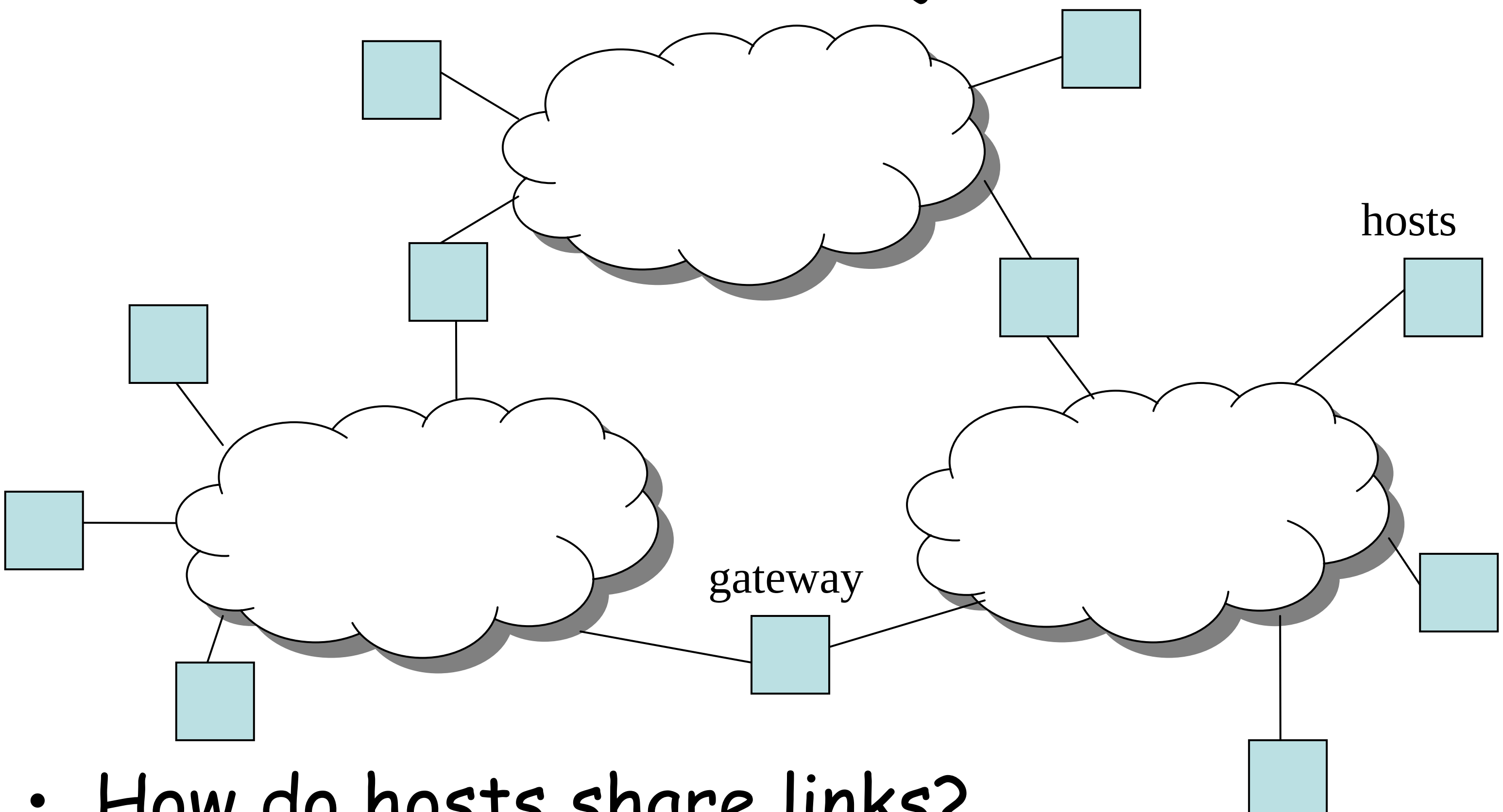
- Circuit switching *vs*. packet routing
- Hosts *vs*. “the network,” which is made of routers
- Nice property: scalable aggregate throughput

Interconnection of Networks



Recursively build larger networks

Some Hard Questions

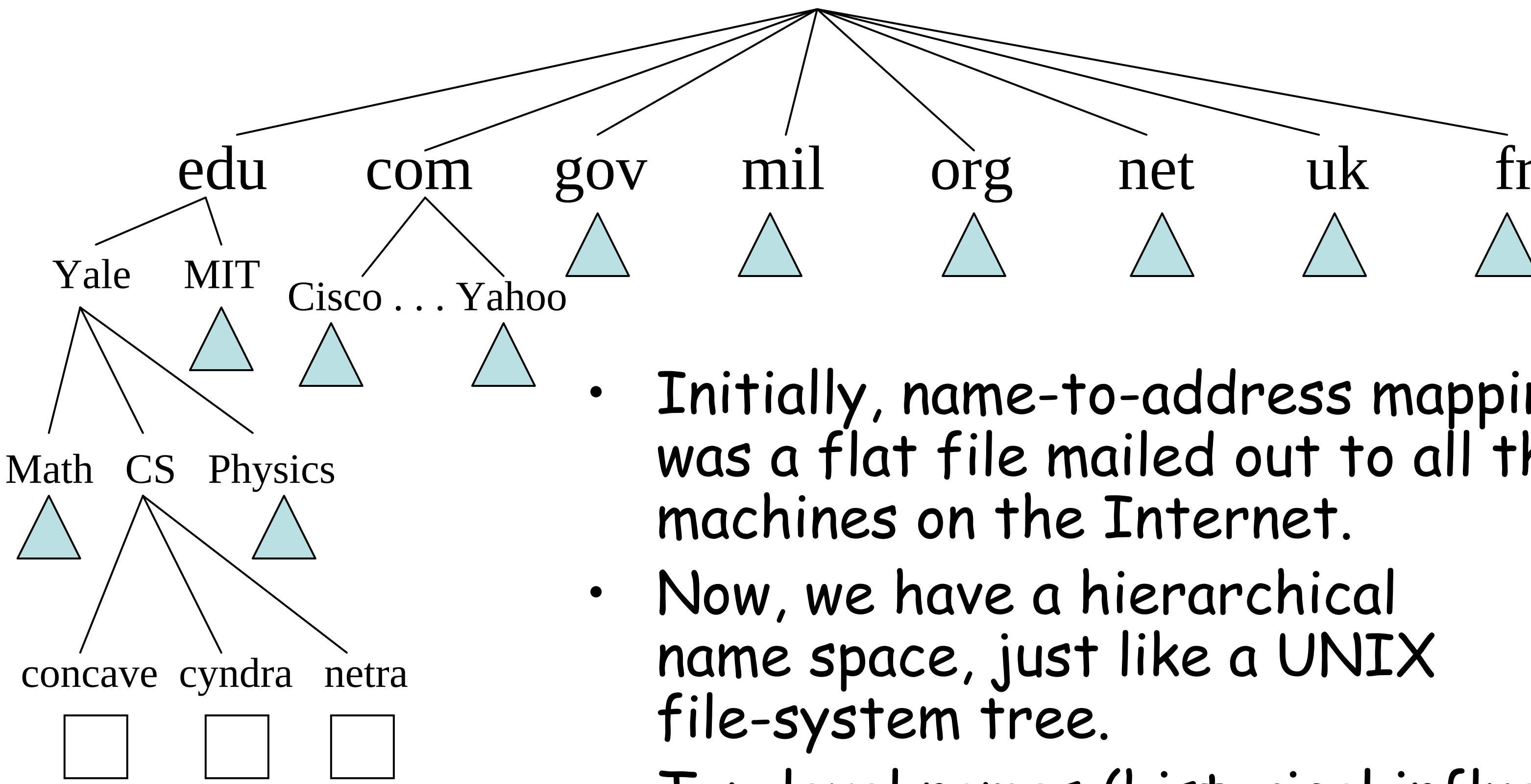


- How do hosts share links?
- How do you name and address hosts?
- Routing: Given a destination address, how do you get to it?

IP Addresses and Host Names

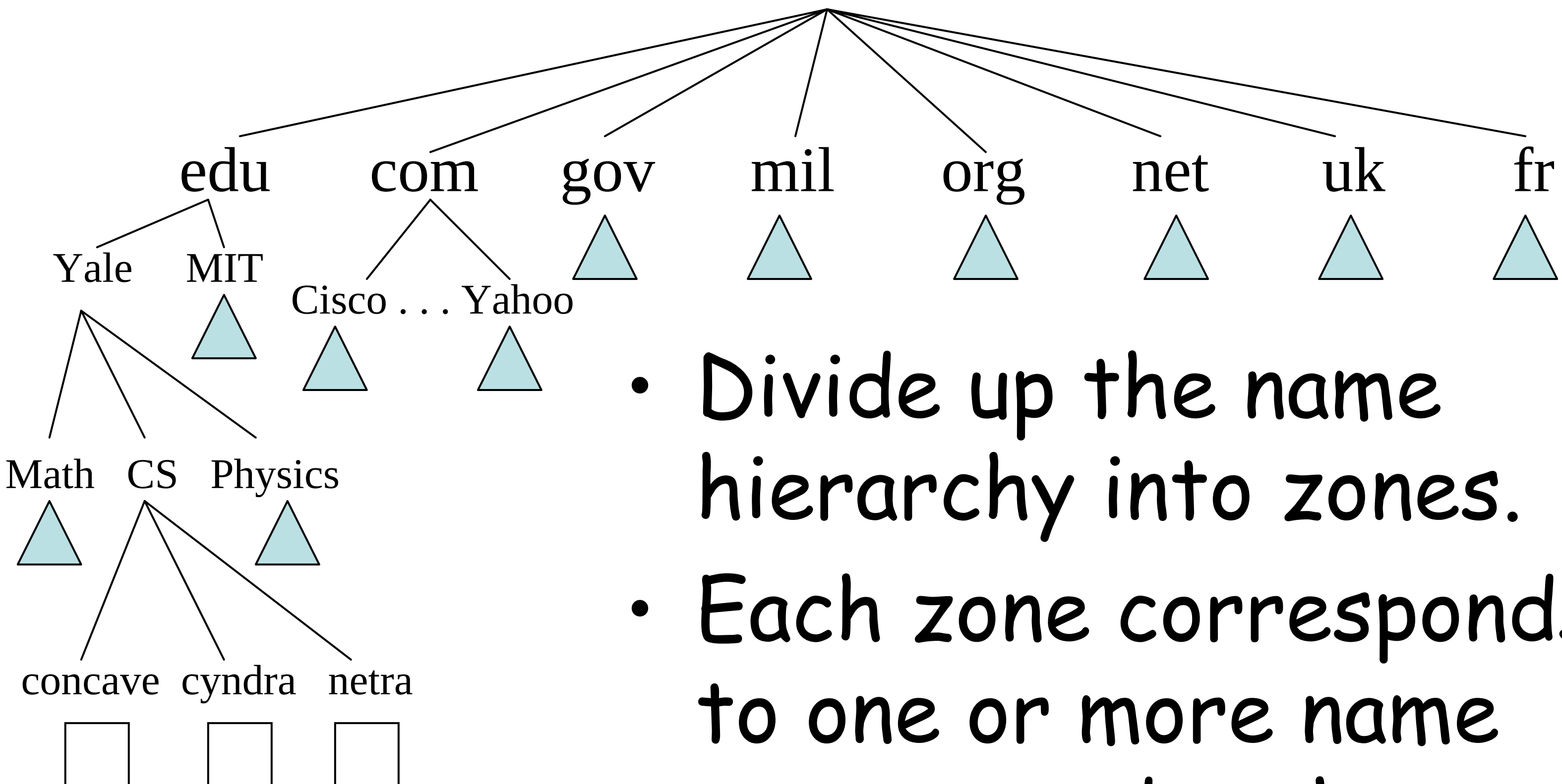
- Each machine is addressed by an integer, its **<u>IP address</u>**, written down in a “dot notation” for “ease” of reading, such as **`128.36.229.231`**
- IP addresses are the universal IDs that are used to name everything.
- For convenience, each host also has a human-friendly host name. For example, **`128.36.229.231`** is **`concave.cs.yale.edu.`**
- Question: How do you translate names into IP addresses?

Domain Hierarchy



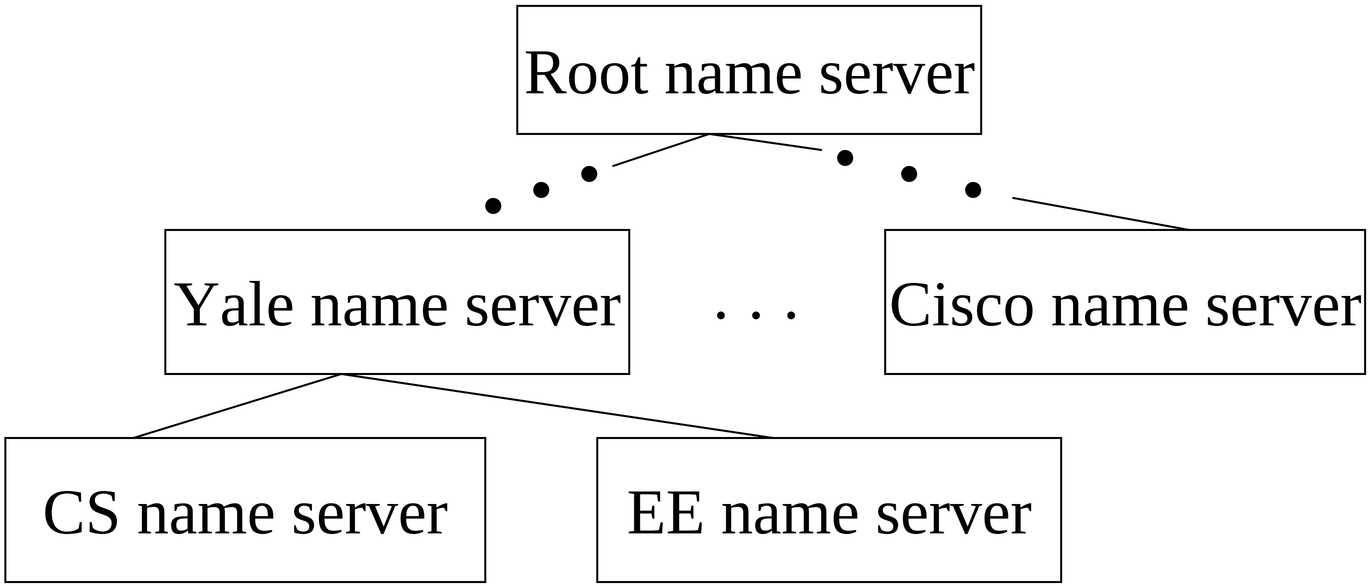
- Initially, name-to-address mapping was a flat file mailed out to all the machines on the Internet.
- Now, we have a hierarchical name space, just like a UNIX file-system tree.
- Top-level names (historical influence): heavily US-centric, government-centric, and military-centric view of the world

DNS Zones and Name Servers



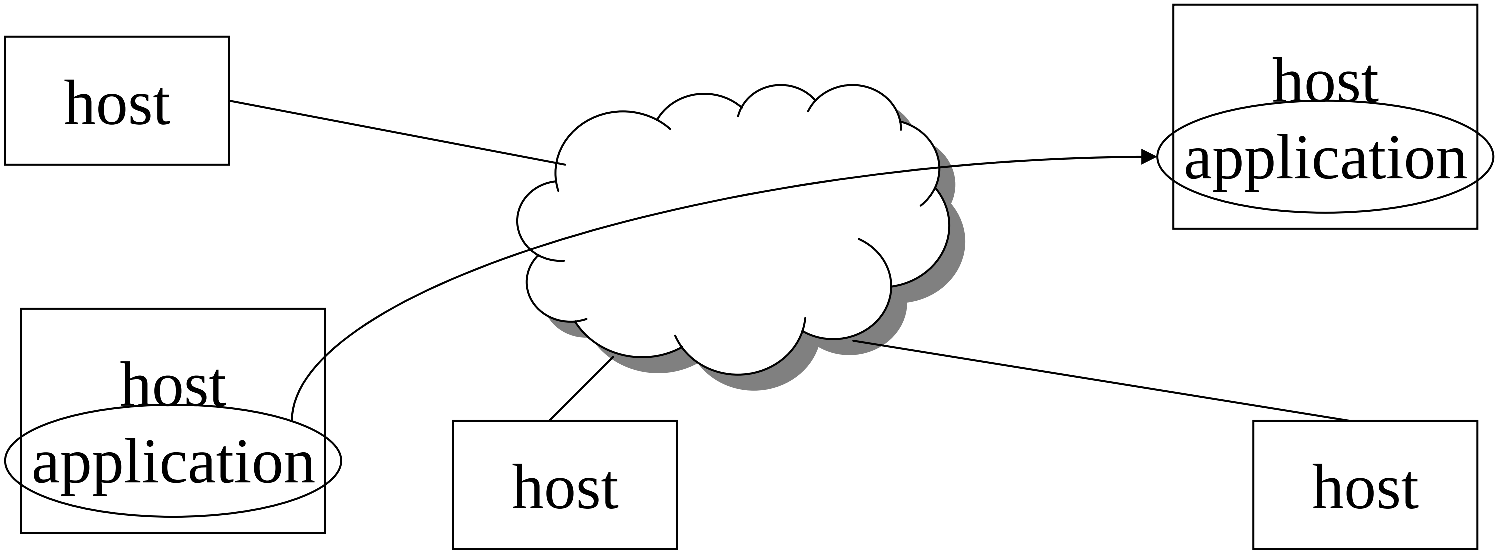
- Divide up the name hierarchy into zones.
- Each zone corresponds to one or more name servers under the same administrative control.

Hierarchy of Name Servers



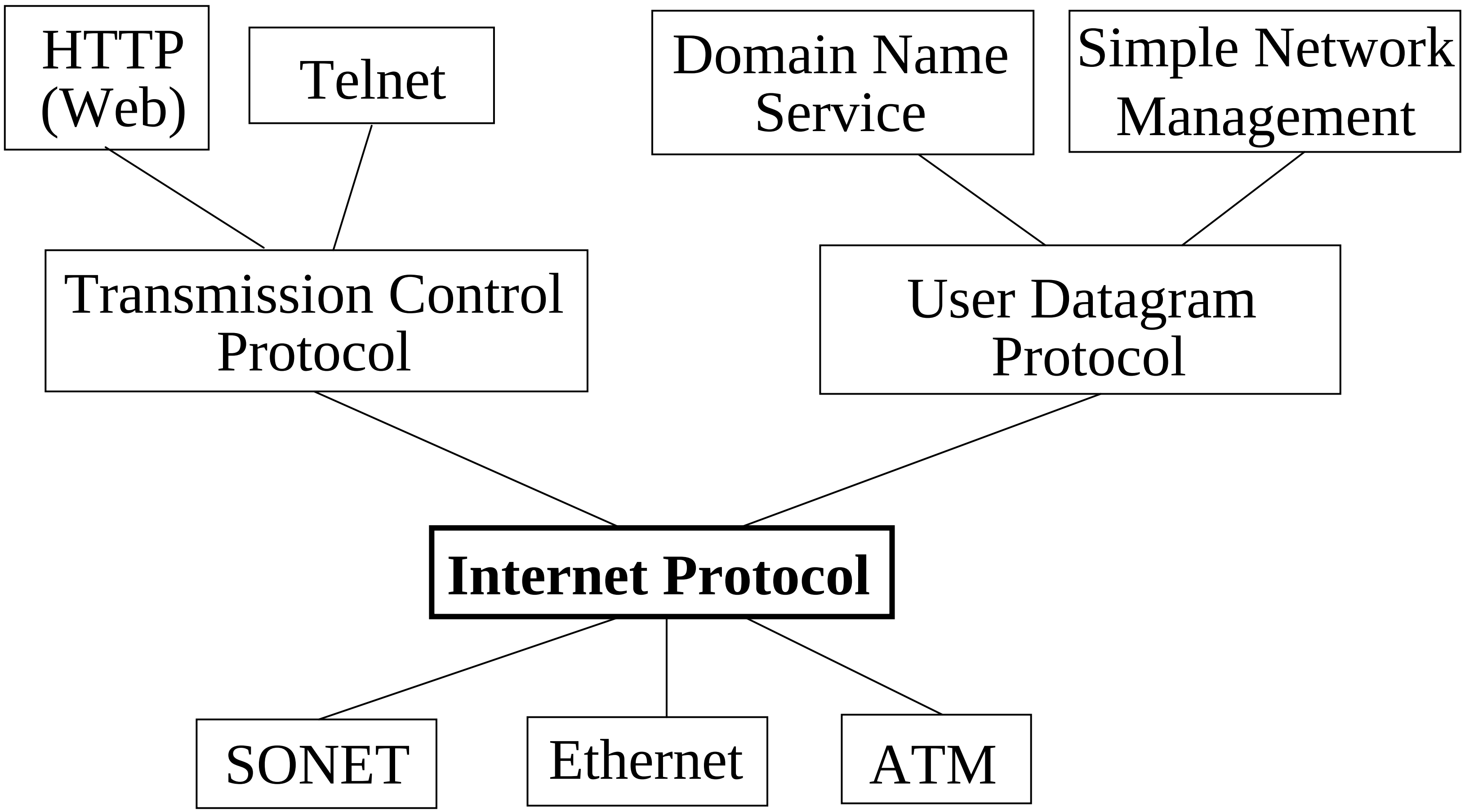
- Clients send queries to name servers.
- Name servers reply with answers or forward requests to other name servers.
- Most name servers perform "lookup caching."

Application-Level Abstraction



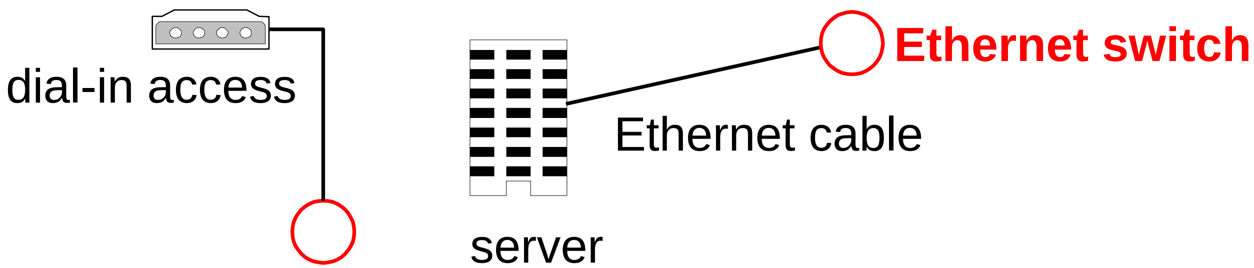
- What you have: hop-to-hop links, multiple routes, packets, can be potentially lost, can be potentially delivered out-of-order
- What you may want: application-to-application (end-to-end) channel, communication stream, reliable, in-order delivery

Basic Architectural Principle: Layering



The Physical Layer

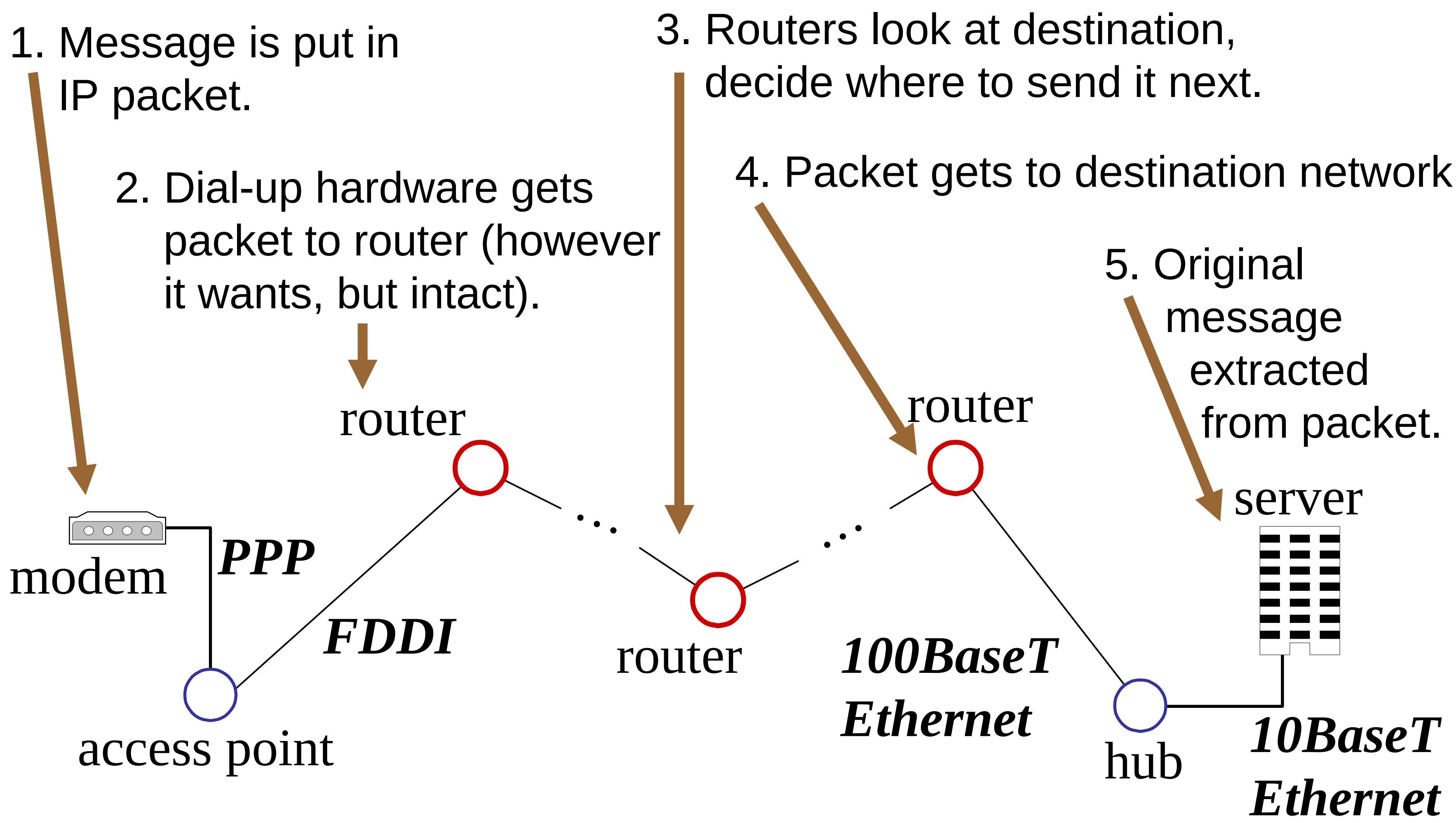
- A network spans different hardware.



- Physical components can work however they want, as long as the **interface between them is consistent**.
- Then, different hardware can be connected.

The Role of the IP Layer

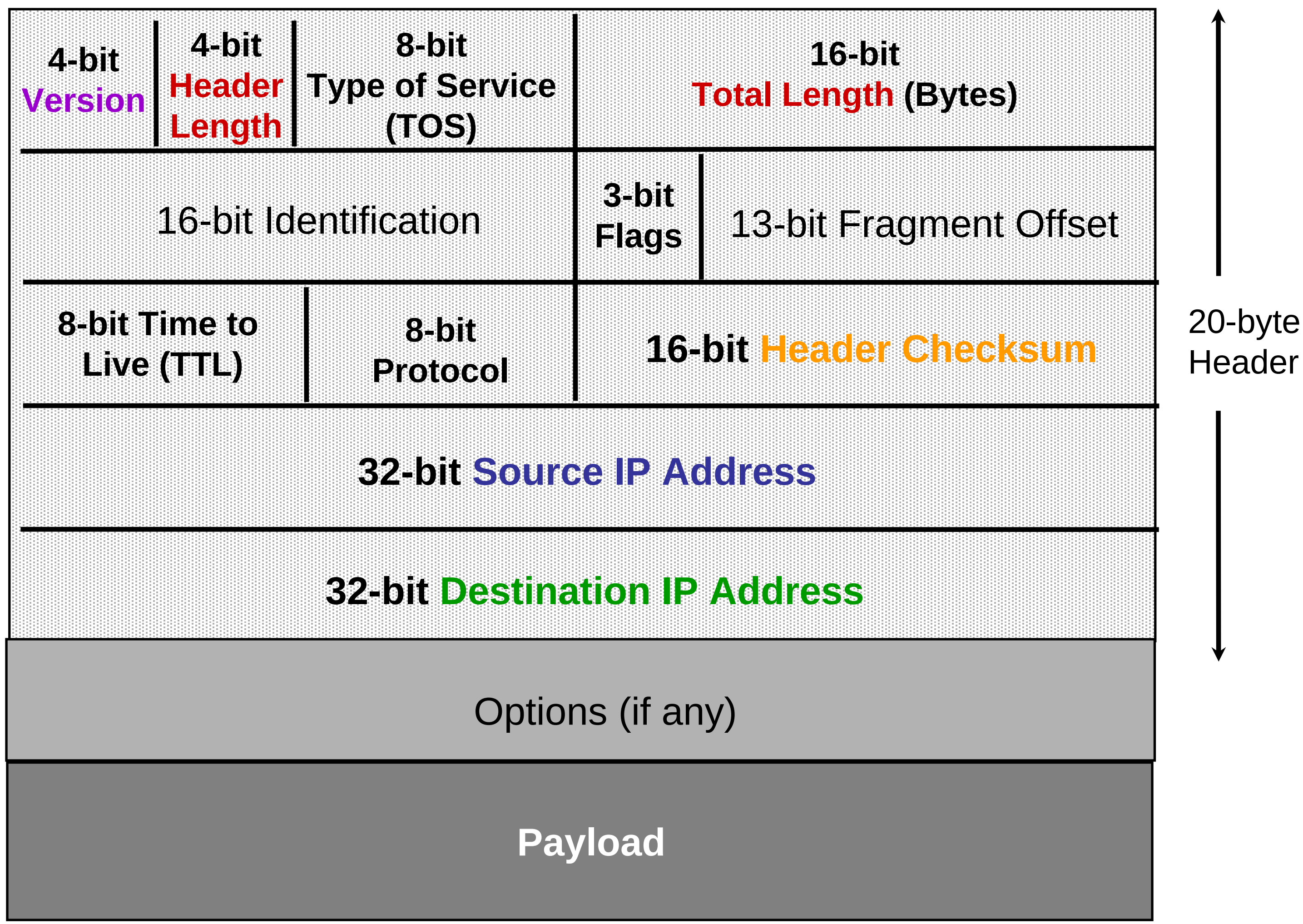
- **Internet Protocol (IP):** gives a standard way to "package" messages across different hardware types.



IP Connectionless Paradigm

- No error detection or correction for packet data
  - Higher-level protocol can provide error checking
- Successive packets may not follow the same path
  - Not a problem as long as packets reach the destination
- Packets can be delivered out-of-order
  - Receiver can put packets back in order (if necessary)
- Packets may be lost or arbitrarily delayed
  - Sender can send the packets again (if desired)
- No network congestion control (beyond “drop”)
  - Send can slow down in response to loss or delay

IP Packet Structure



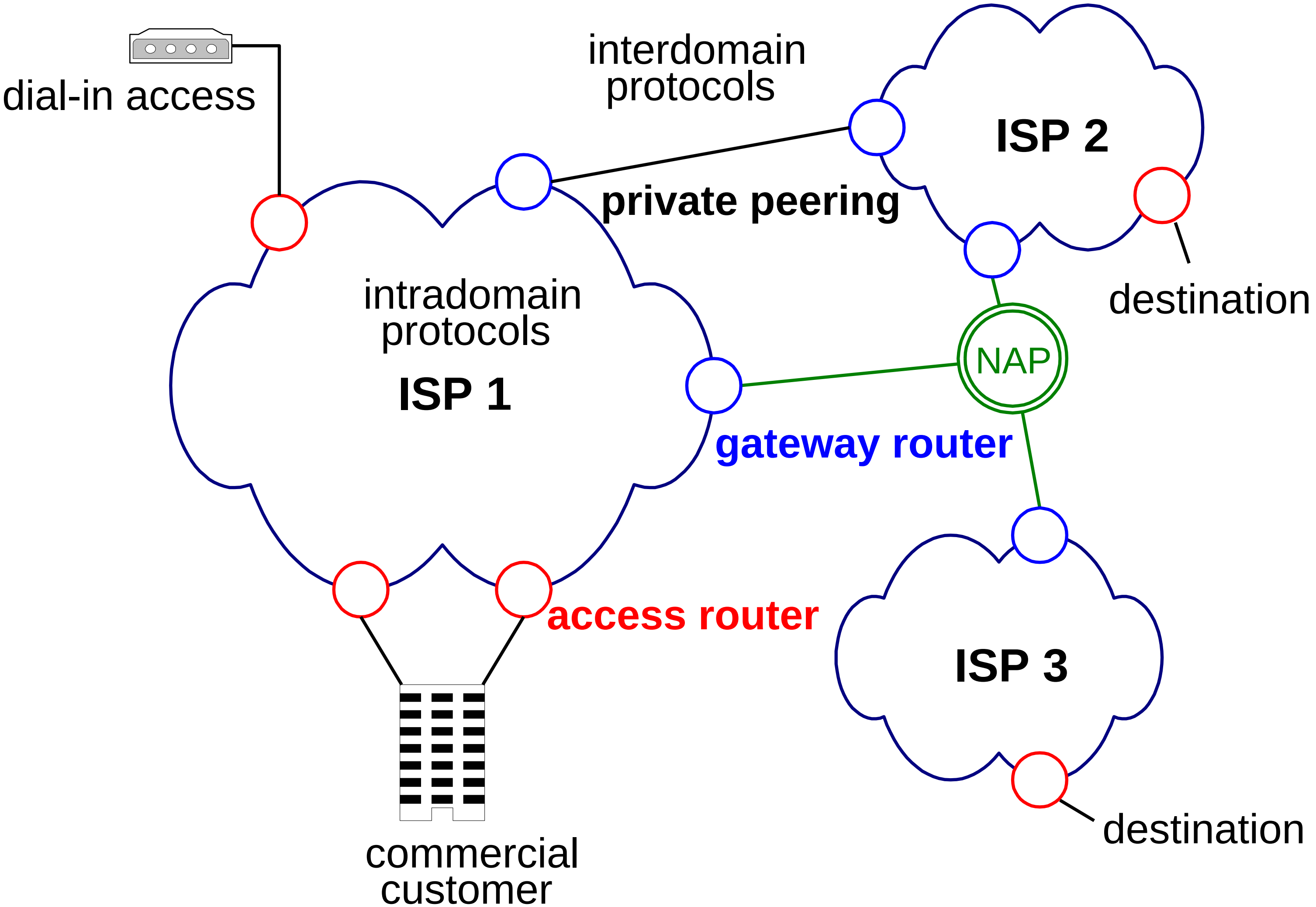
Main IP Header Fields

- **Version number** (e.g., version 4, version 6)
- **Header length** (number of 4-byte words)
- **Header checksum** (error check on header)
- **Source** and **destination** IP addresses
- Upper-level protocol (e.g., TCP, UDP)
- **Length** in bytes (up to 65,535 bytes)
- IP options (security, routing, timestamping, etc.)
- TTL (prevents messages from looping around forever; packets "die" if they "get lost")

Getting from A to B: Summary

- Need IP addresses for:
  - Self (to use as source address)
  - DNS Server (to map names to addresses)
  - Default router to reach other hosts (e.g., gateway)
- Use DNS to get destination address
- Pass message through TCP/IP handler
- Send it off! **Routers** will do the work:
  - Physically connecting different networks
  - Deciding where to next send packets

Internet Architecture



Discussion Point

- Dial-up, intermittent access
  - Low-bandwidth, slow
  - Dynamic IP addressing more private?
- Cable, always-on access
  - High-bandwidth, fast
  - Static IP addressing less private?

Other examples of similar tradeoffs?