What computers talk about and how.
(Networking & the Internet.)

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Brief history

- Local area networks & university networks

- Military communication networks
  - ARPANET ['68] (a.k.a. DARPANET), etc.

- Early 1980s: US government decides on new way to connect various networks: the "Internet"

- 1989: World Wide Web; html, browsers

- 1998: Responsibility for Internet naming system handed over to private non-profit corporation ICANN.

Modern Internet

- Collection of computers (including devices, servers, etc.) connected by wires, optical cables, wireless, etc.

- To join, need:
  - Device capable of "speaking the right protocol" (TCP/IP)
  - IP "address" given by an Internet provider
  - Connection to provider's servers (via modem, DSL, wireless, etc.)

Rest of Internet

at&t
Worldnet

Your PC
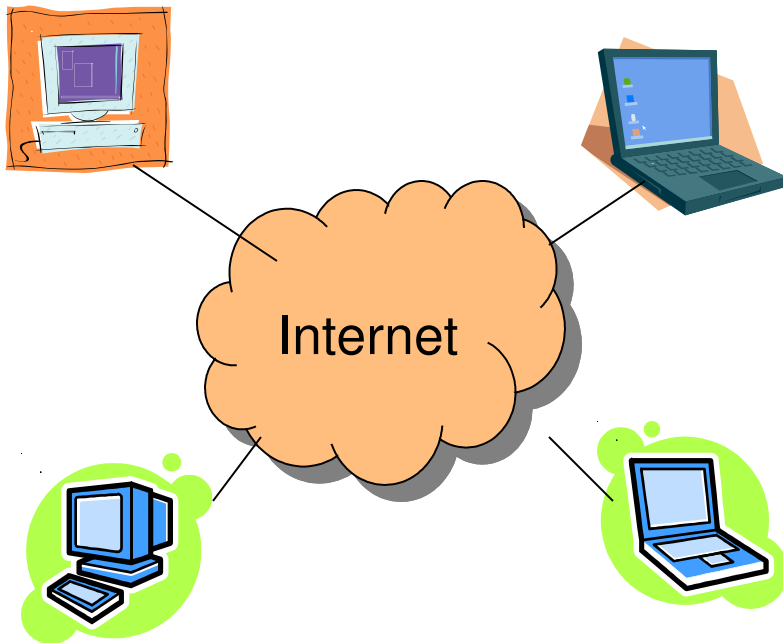IP Address: 128.156.16.201
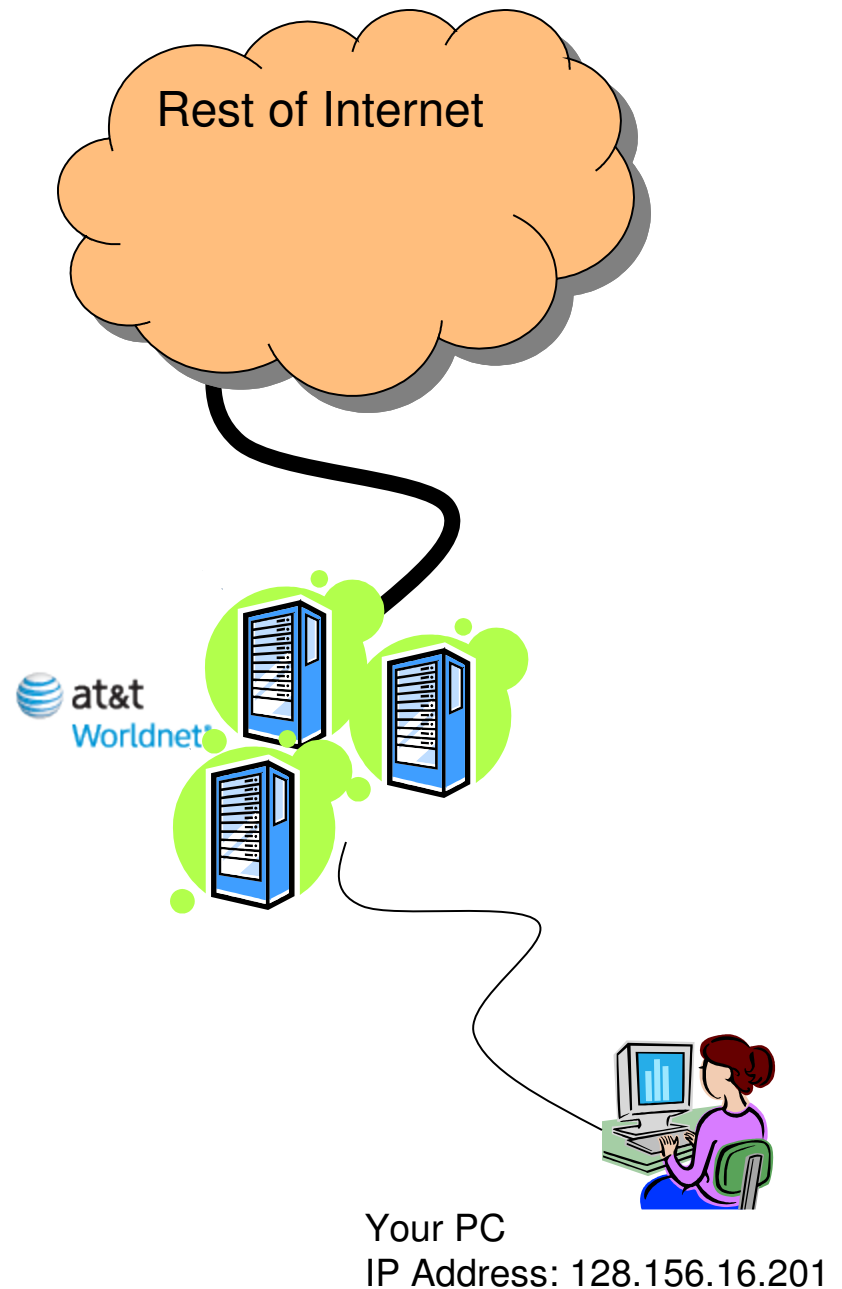
Today: A Peek Underneath the 'Net

Why?

- Dominant technological artifact of second half of 20th century

- Interesting example of design of a large, heterogeneous system (decentralized, yet fairly robust).

Caveat: Internet ≠ W W W

- Internet: network connecting computers, devices, etc.

Internet

- WWW: hyperlinked content (webpages) stored on servers; requested and served using http protocol

- Built *on top of* the internet

One box does it all.
- NETWORK DRIVE
- INTERNET ROUTER
- PRINTER SHARING
- WEB SERVER

320 GB
SQ101-N

SQUARE ONE
Personal Internet Server

NETWORK DRIVE
Back up and share files over the network.

INTERNET ROUTER
Share your internet connection.

PRINTER SHARING
Print from any PC on the network.

WEB SERVER
Run your own blog or Web site, 24/7.
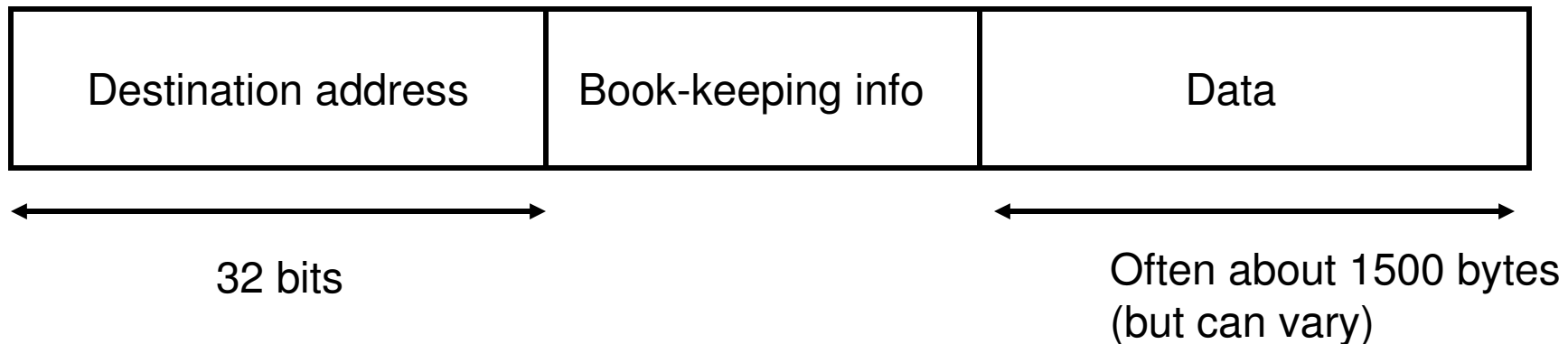
Theme 1:

Building reliability on top of unreliable protocols

The (shaky) foundation of the Internet: TCP/IP Protocol

- All transmissions broken up into packets

A Packet:

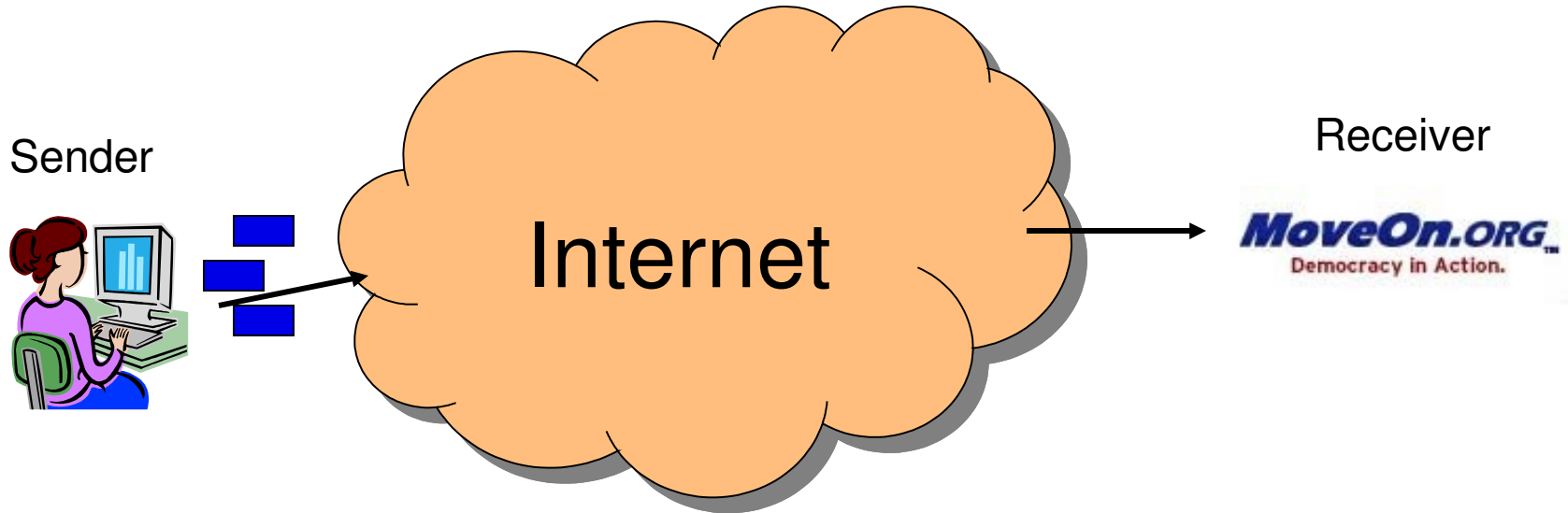| Destination address	Book-keeping info	Data

32 bits

Often about 1500 bytes (but can vary)

Hopping along

- Internet is actually a bunch of connected computers called *routers*
- Packets hop from router to router until they reach destination

Internet

See, for example: http://network-tools.com
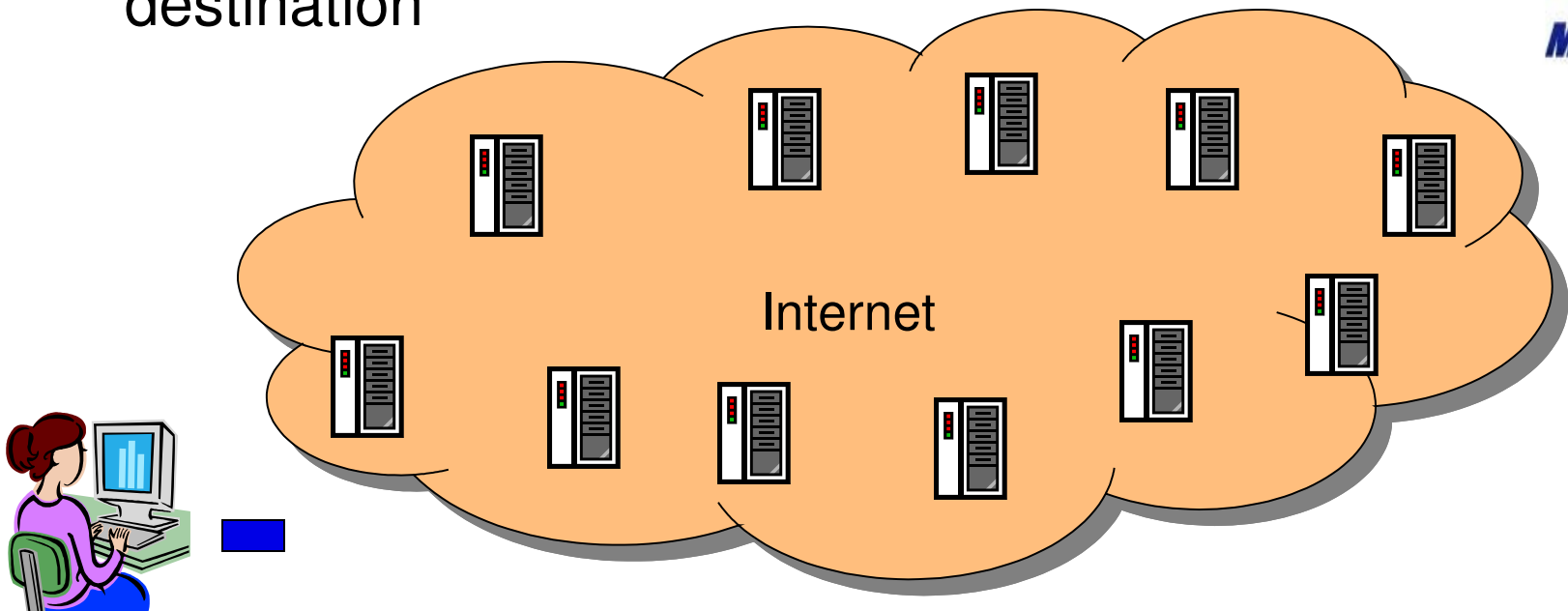
"Best effort transmission"

Sender

Receiver

Internet

MoveOn.ORG™
Democracy in Action.

- Packet not guaranteed to arrive in a timely fashion (or ever!)
- If many packets sent, may arrive out of order

Discussion

- Is there some unreliable communications device you use everyday?

- How do you cope with the cellphone's unreliability?

Some mechanisms

- Retransmission ("Could you say that again?")

- Timeout ("Let me hang up and try redialing?")

- Acknowledgements ("Finally understood you. Go on.")
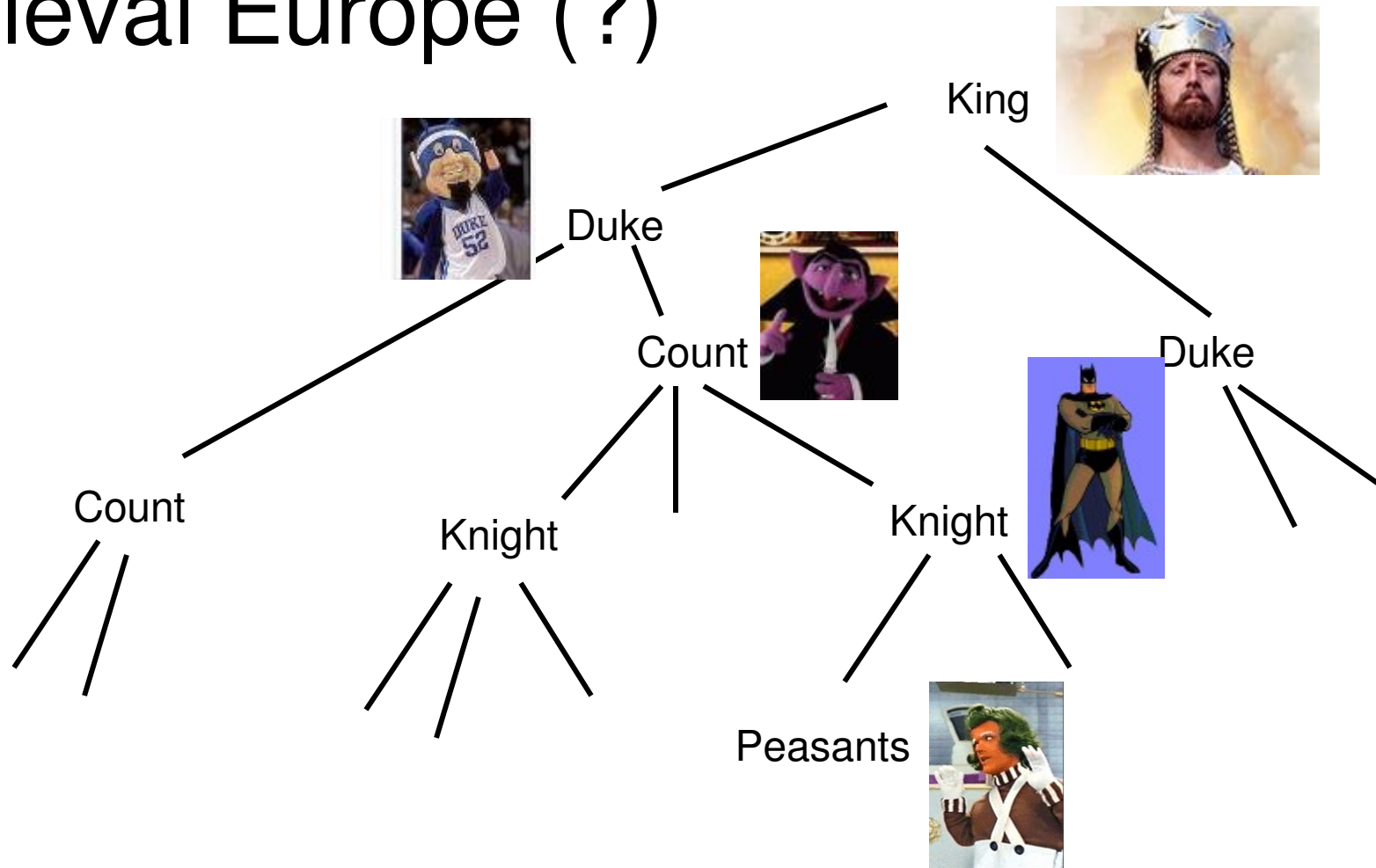

"Can you hear me now? Good."

(In TCP/IP: if sequence of packets, number them and sort at receiver end.)

Theme 2:

Decentralized control

Political and Military Setup in Medieval Europe (?)

King

Duke

Count

Duke

Count

Knight

Knight

Peasants

- What is a suitable postal system for this "army"?

- How should a peasant in one town send mail to a peasant in another town?

- What happens if a knight leaves the army?

First example of decentralization: Physical network
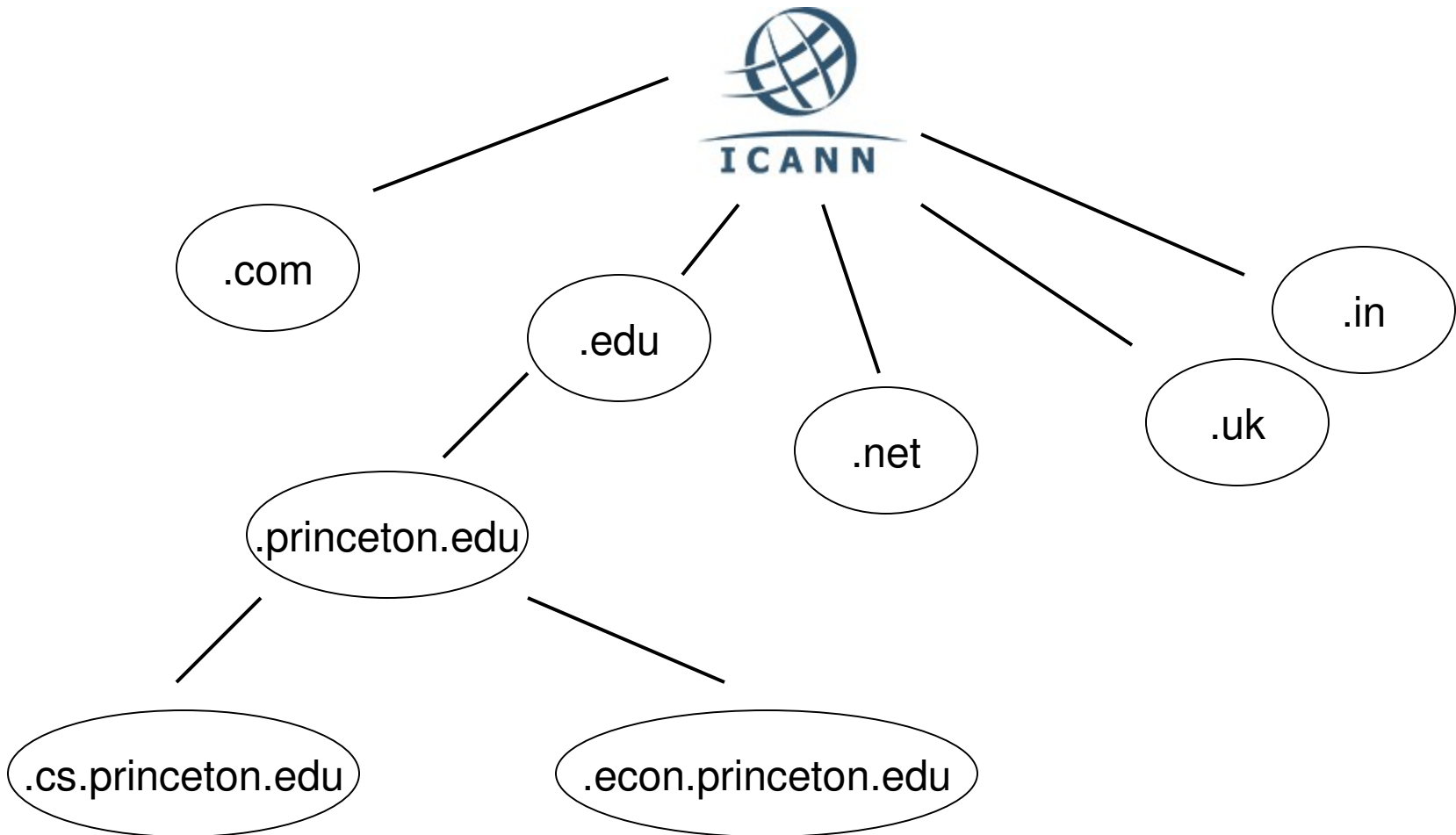
- 12 major providers

- Many local providers

Sprint

at&t Worldnet

USLEC

Patriot Media
A Simmons Company

Princeton homes & businesses

Princeton Schools

McCarter

# The Second Decentralization: Domain Name System
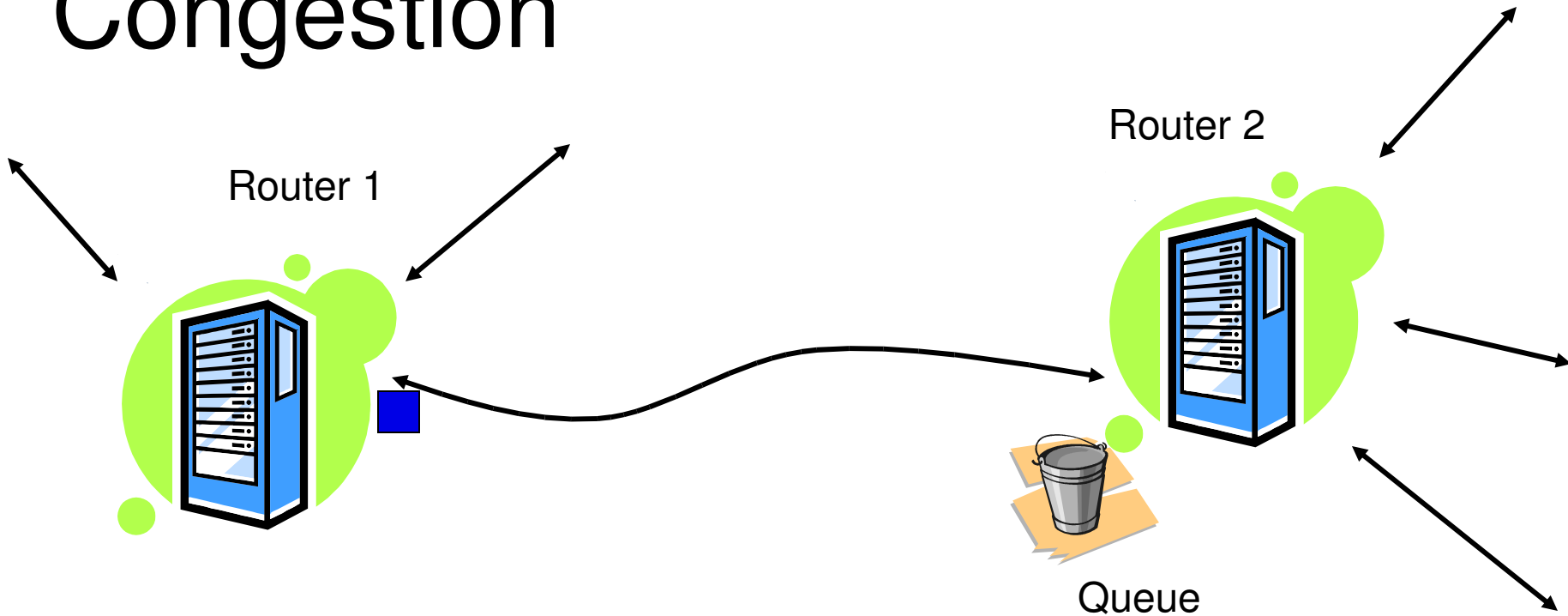
What happens when you type a URL?

- Address translated by asking appropriate DNS server up/down the DNS hierarchy
  - www.nytimes.com → query to .com server
    →199.239.136.200

- Physical routing of packets up/down the physical network hierarchy based upon address

- Other stuff

Theme 3.

Dependence upon the kindness of strangers

Congestion

Router 1

Router 2
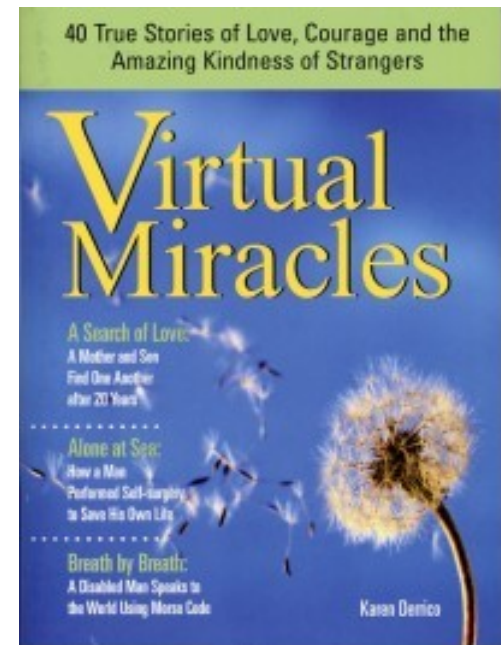
Queue

- Queue full → packets are dropped

How does a good netizen respond to congestion?

- Packets getting dropped?
  $\rightarrow$ Halve the transmission rate

- All packets getting through?
  $\rightarrow$ Increase transmission rate a little.

- **Done in all TCP/IP software**
  But, no enforcement mechanism!
  (Allows "cheating", as well as VoIP Telephony, Streaming media, etc.)

What's in the future?

- 128-bit instead of 32-bit addresses.
  - Can send email to your toaster. (Especially if it lives in Asia)

- Mechanisms for pricing, security, quality of service, etc.
  - NSF's GENI initiative