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

COS 116, Spring 2011

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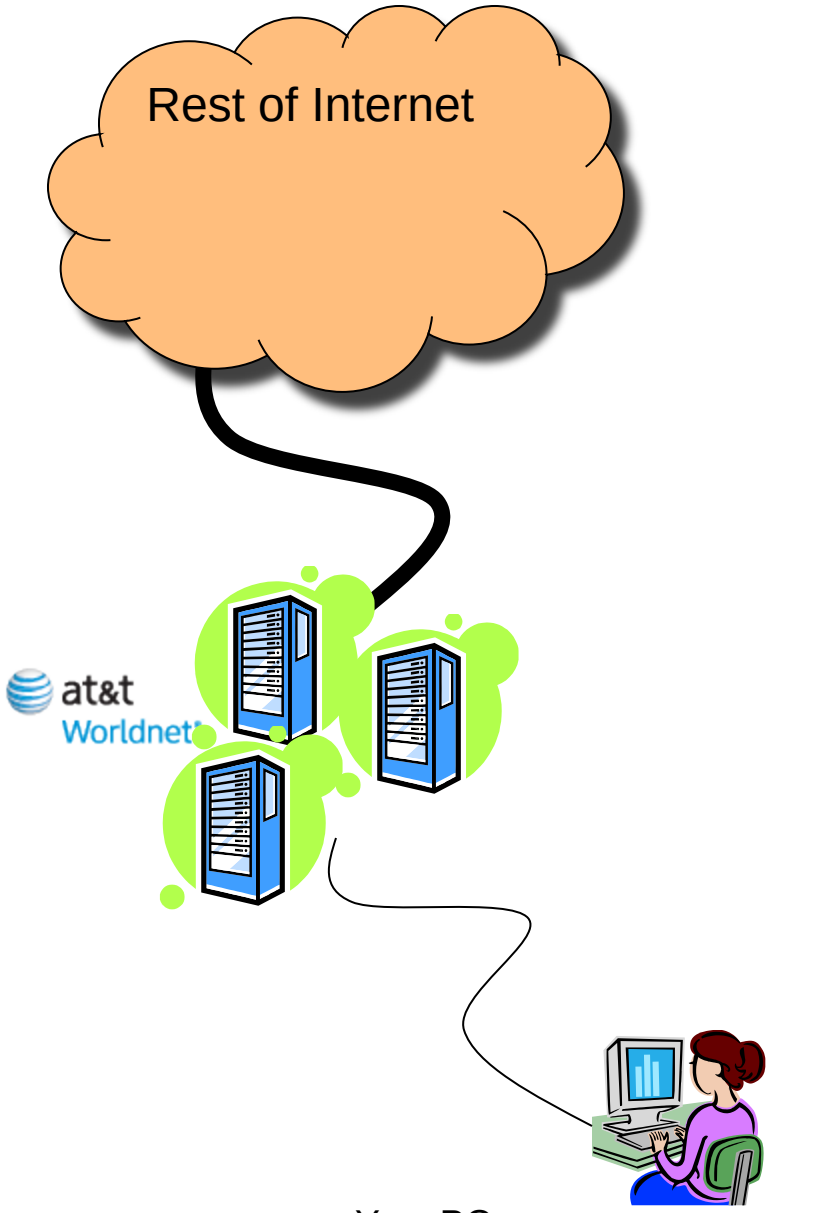
Brief history

- 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: 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.)



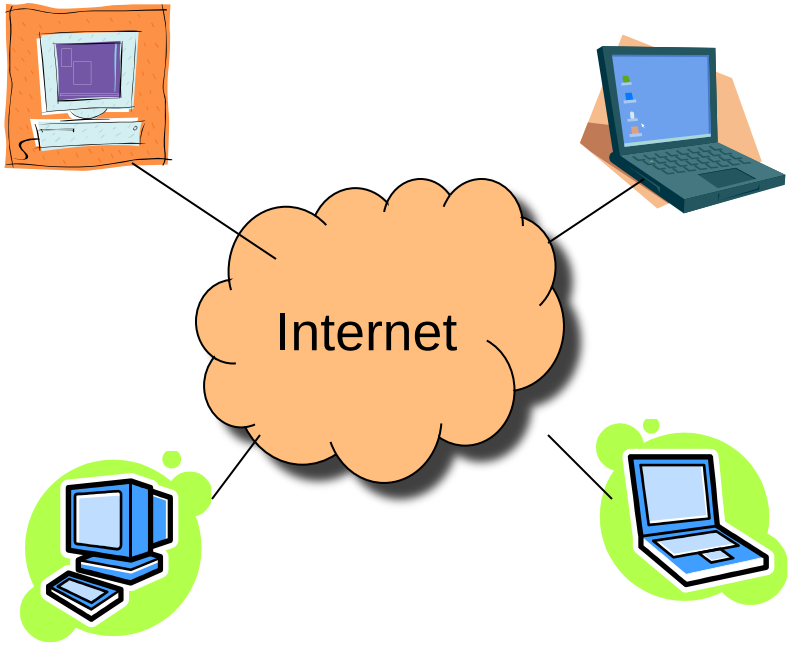
Today: A Peek Underneath the ‘Net

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.



- WWW: hyperlinked content (webpages) stored on servers; requested and served using http protocol
- Built *on top of* the internet

Theme 0: Networks have many layers, with well-specified interfaces.

Example: Social network of friends who email/IM each other via facebook.

Assumes availability of the internet.

Which in turn assumes availability of underlying fiber optics networks, cellphone towers, satellites etc.

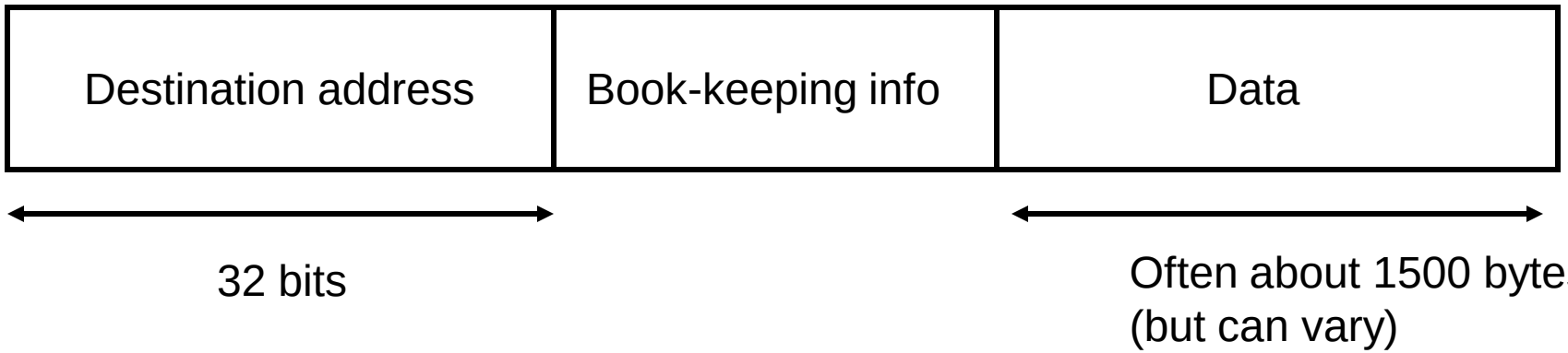
Theme 1:

Building reliability
on top of
unreliable
protocols

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

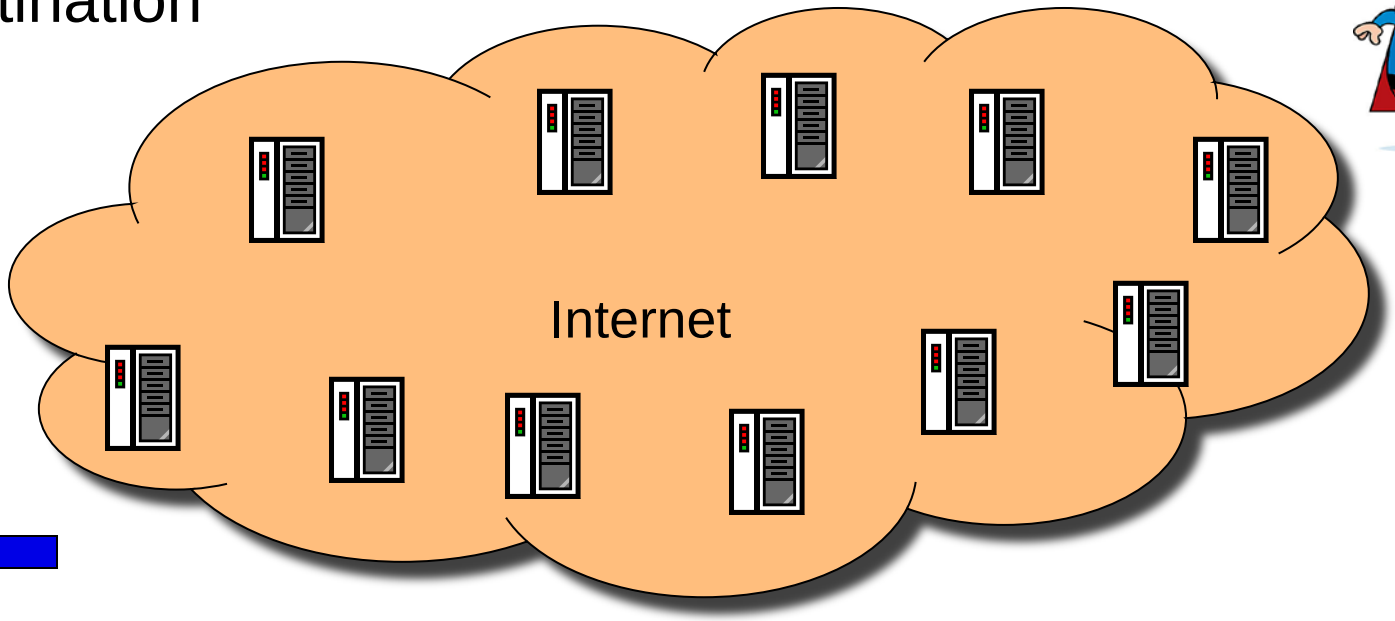
- All transmissions broken up into packets

A Packet:



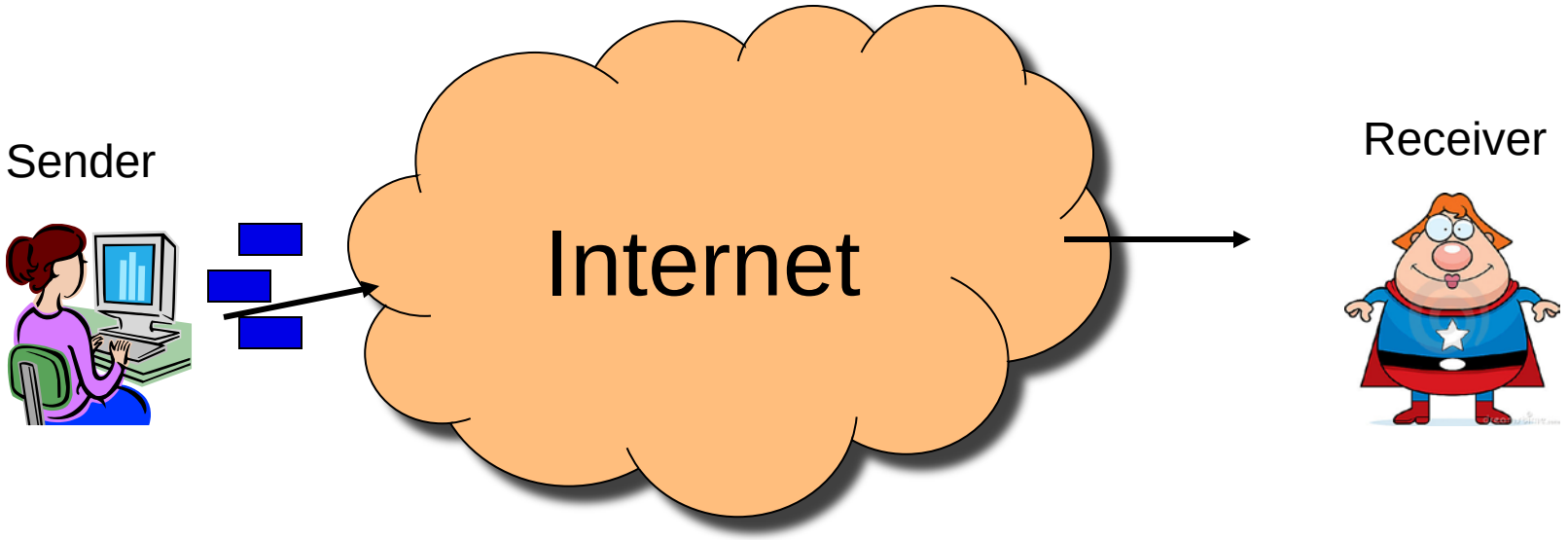
Hopping along

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



See, for example: http://network-tools.com

“Best effort transmission”



- Packet not guaranteed to arrive quickly (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

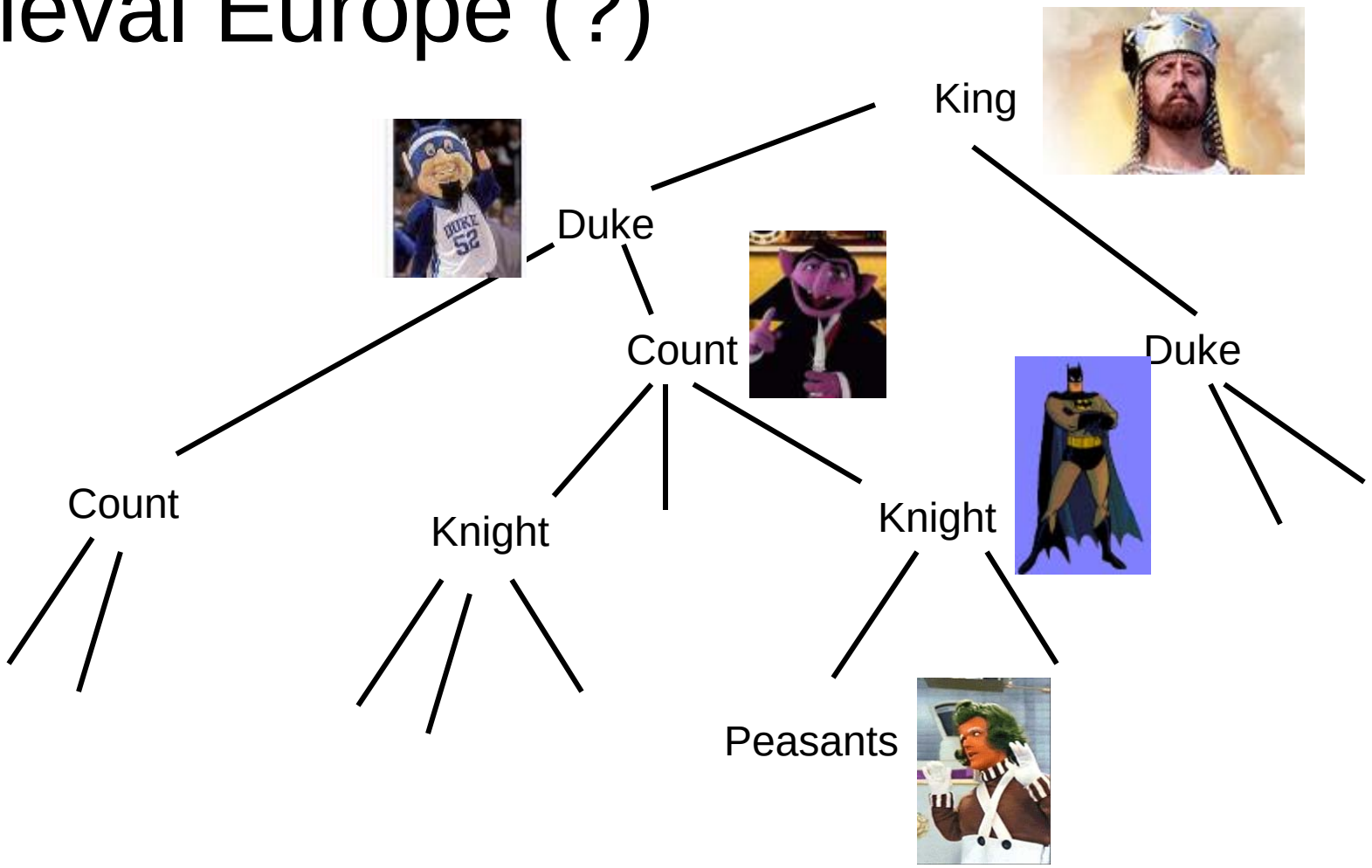
- Retransmission (“Could you say that again?”)
- Timeout (“Let me hang up and try redialing?”)
- Acknowledgements (“Finally understood you. Go on.”)

(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 (?)



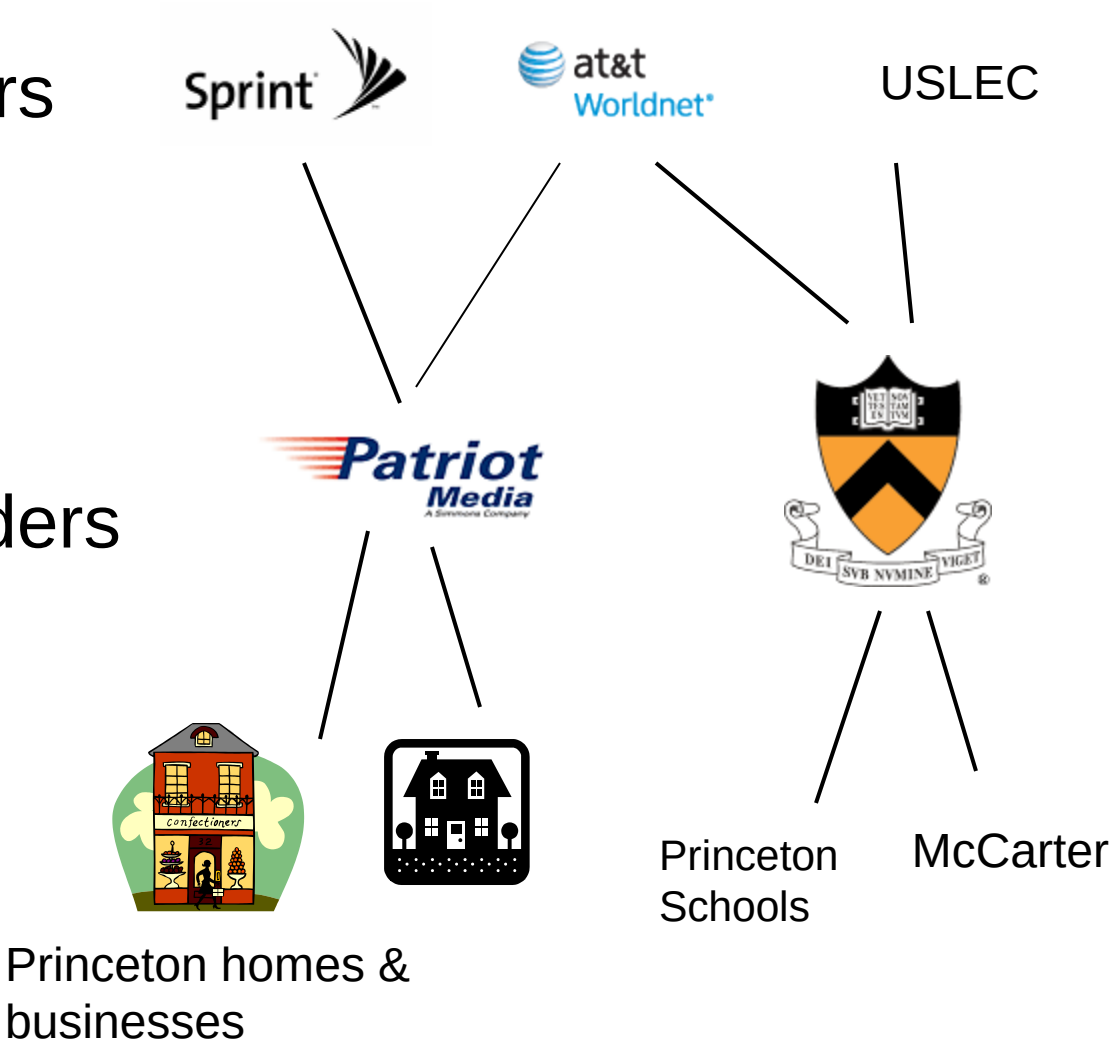
- What is a suitable postal system for this “army”?

Discussion Time

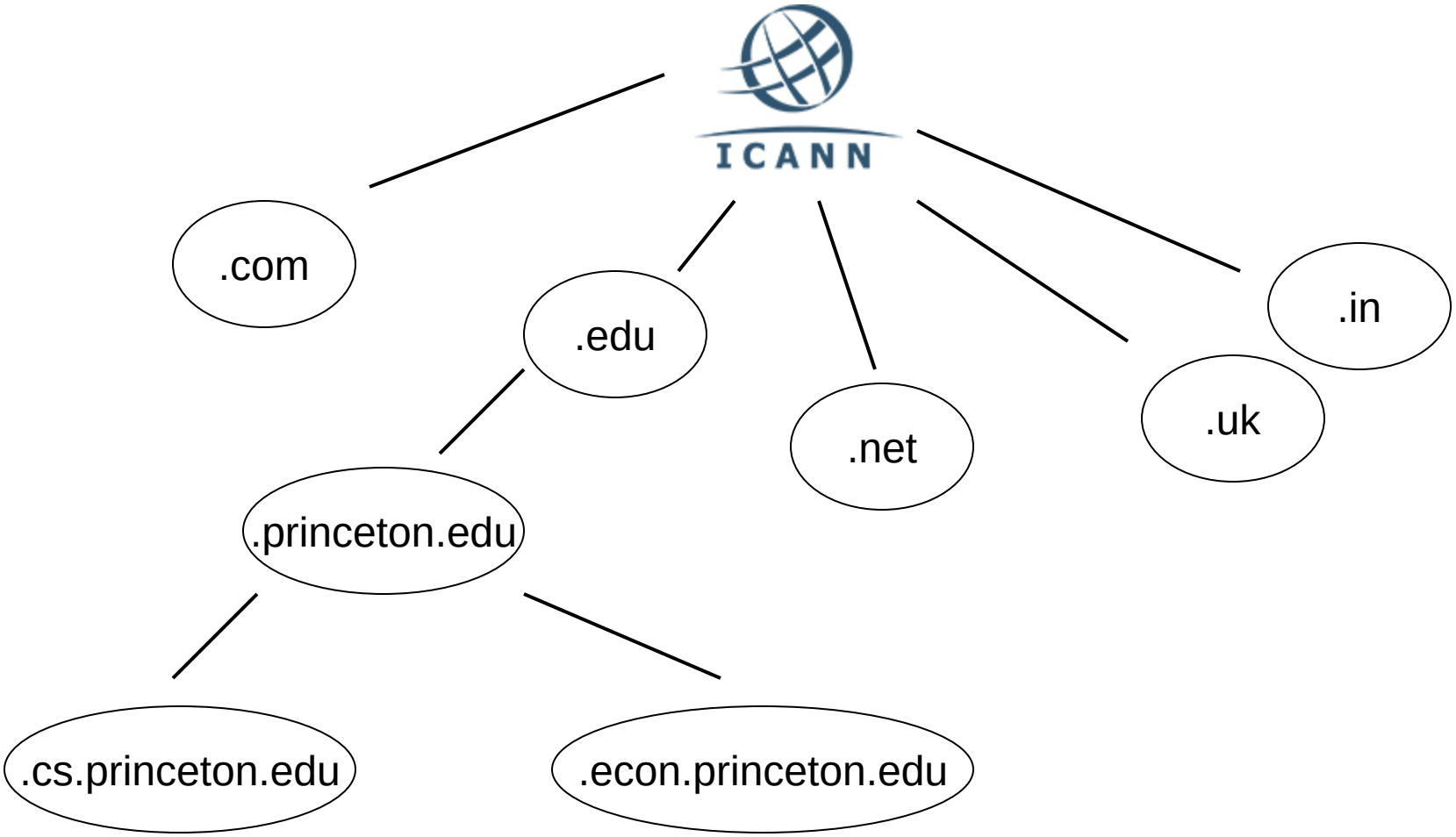
- How should a peasant in one town send mail to a peasant in another town?
- What happens if a knight leaves the army?
- What happens if this peasant joins the network?

First example of decentralization: Physical network

- 12 major providers
- Many local providers



The Second Decentralization: Domain Name System

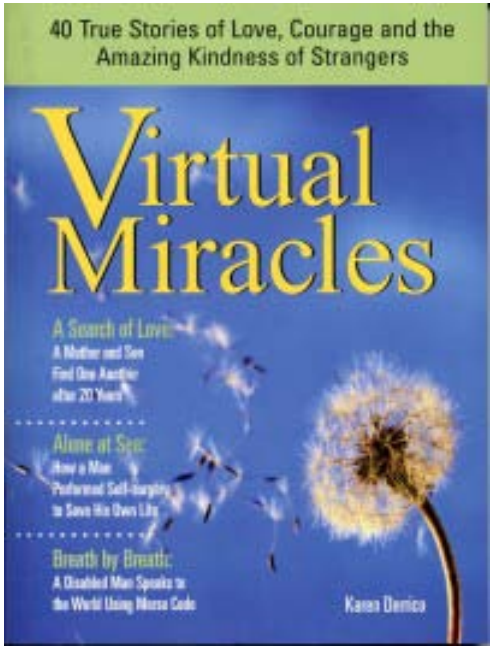


What happens when you type URL?

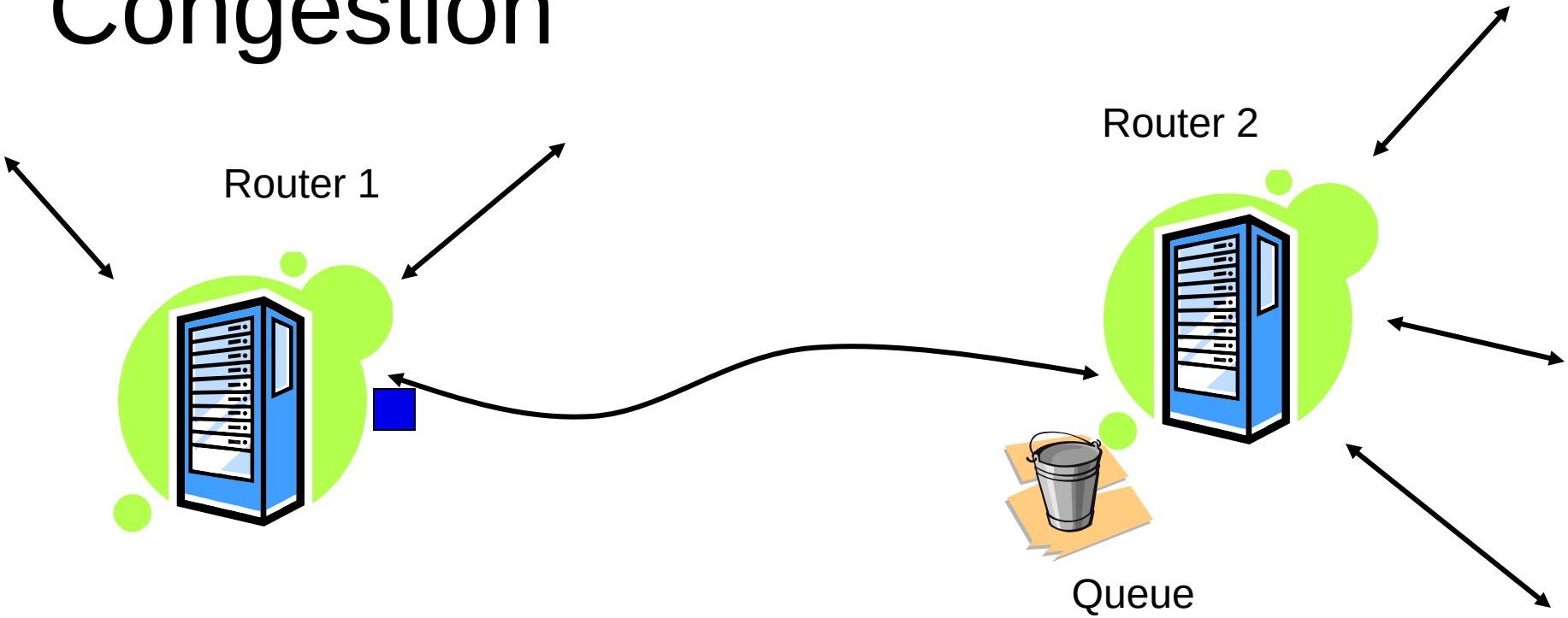
- Address translated by asking appropriate DNS server up/down the DNS hierarchy
  - www.nytimes.com → query to .com server
    →199.239.136.200
- Physical routing of packets up/down the physical network hierarchy based upon address
- Other stuff

Theme 3.

Dependence upon the kindness of strangers



Congestion



- 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 (IPv6).
  - Can send email to your toaster.
    (Especially if it lives in Asia)

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

Important battleground: Net Neutrality:

Forbid restrictions by internet providers and govts on content, sites, platforms, equipments, modes of communication.