Preliminaries

Networking is complicated

- Enormous body of knowledge
- Years of training
- Specialization in
  - Hardware
  - Algorithms
  - Applications
  - Administration
  - Protocols
  - Encryption
  - Security
  - Wireless
  - Etc.

Why is networking so complex?

- Variety of hardware
- Variety of software
- Variety of protocols / standards
- Terminology can be confusing
  - [Acronyms](#)
  - Industry re-defines or changes terminology from academia
  - New [terms](#) invented continuously
- Wireless / mobility issues add even more complexity

Why is networking so complex?

- There are <u>many</u> standards that have to be able to communicate with each other

- Outside the most isolated local-area network, every communication must include information about which standards are being used.

Handling the complexity

- Concentrate on abstractions / concepts to unravel complexity
- Use a few example technologies to illustrate the concepts
- Use some hands-on lab experience to reinforce the concepts.

Networks and the Internet

- *Network*: system for connecting computers using a <u>single transmission technology</u>
- *Internet*: <u>set of networks</u> connected by <u>routers</u> that are configured to communicate among a <u>variety of network transmission technologies</u>
  - A network of networks

The Internet

PC

server

wireless
laptop

smartphone

wireless
links

_____ wired
links

router

❖ *Millions of connected computing devices:*
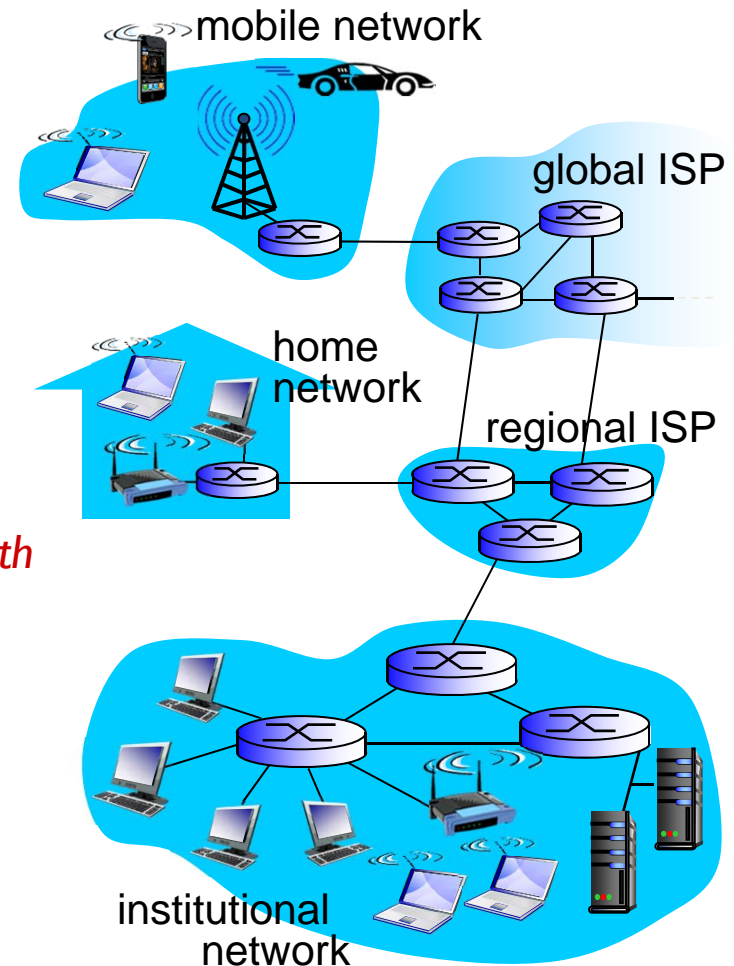- *hosts* = end systems
- running *network apps*
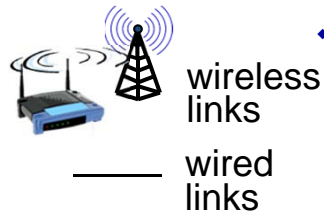
❖ *Communication links:*
- fiber, copper, radio, satellite
- transmission rate = *bandwidth*

❖ *Packet switches:* forward packets (chunks of data)
- *routers* and *switches*

mobile network

global ISP

home
network

regional ISP

institutional
network

Networks and the Internet

We will analyze networks and the Internet in terms of

- Transmission technologies
  - Data transmission - media, data encoding
  - Packet transmission - data exchange over a network
- Communication protocols – reliable transmission
- Internetworking - universal service over a network of networks
- Internet applications - programs that use the Internet

In the real world …

- Networks are an important part of everyday activities
  - Business
  - Home
  - Government
  - Education
- Globally, the Internet is growing exponentially
  - Started out as a research project with a few dozen university sites
    - Support came from military
  - Today, billions of computers and millions of networks world-wide

Growth of the internet

- *Ethernet* made <u>local networking</u> possible
  - *Ethernet* is a networking standard
  - Several other standards exist
- *TCP/IP* protocol made <u>internetworking</u> possible
  - Transmission Control Protocol / Internet Protocol

Growth of the internet

- Fundamental changes from centralized to distributed computing
- Incorporated features for reliability, robustness, and scalability
  - Multiple links
  - Distributed routing / messaging
- Exponential growth

Counting Internet Hosts

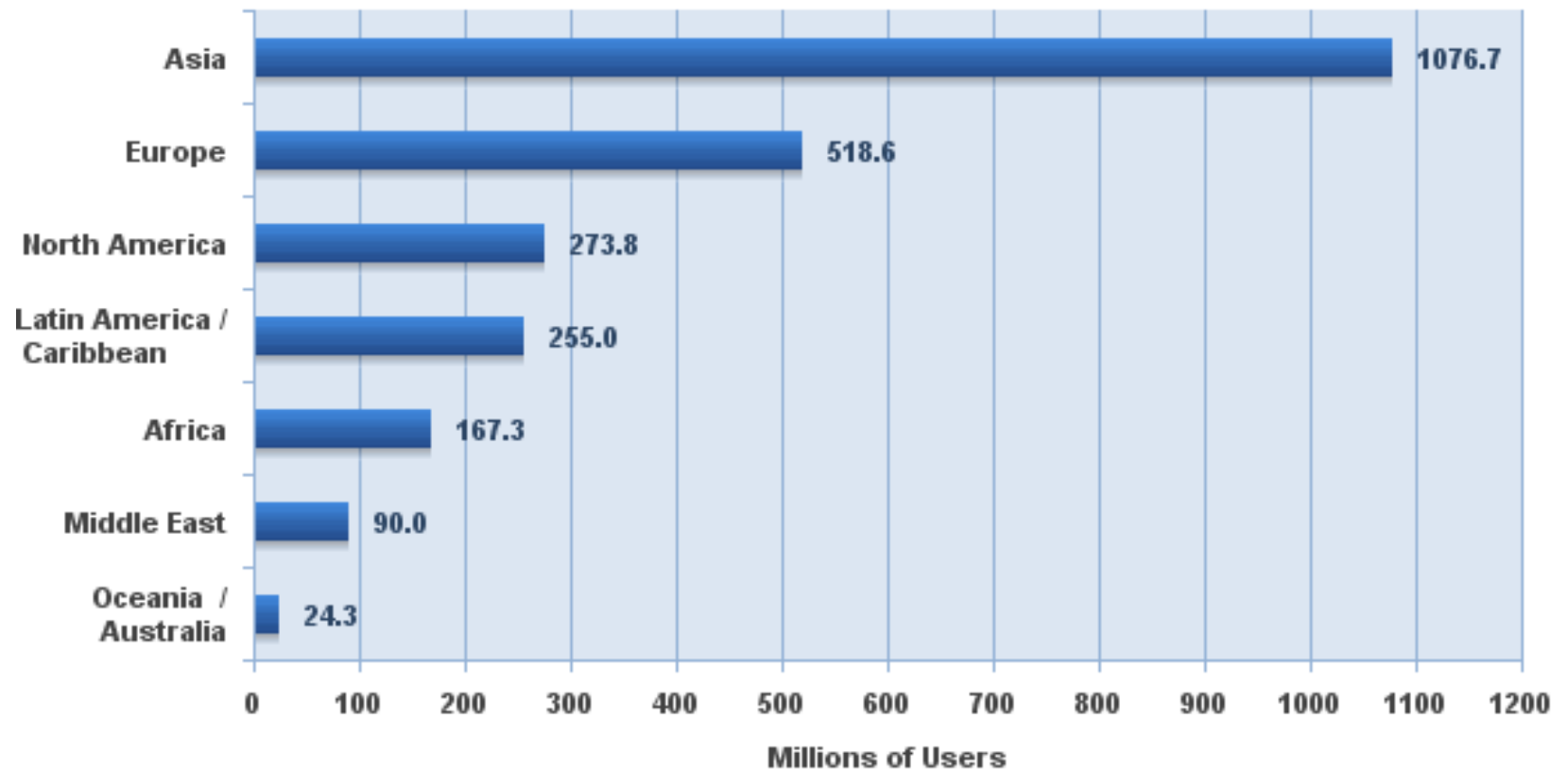|		
Aug 1981	213	
...		
Feb 1986	2,308	Source: Internet World Stats
...		
Jan 1991	376,000	
...		
Sep 2000	360,985,492	Percent of Earth's population
...		
Sep 2006	~1,093,000,000	16.7 %
Sep 2008	~1,572,000,000	23.5 %
Sep 2010	1,966,514,816	28.7 %
Sep 2012	**2,405,510,175**	**34.3 %**

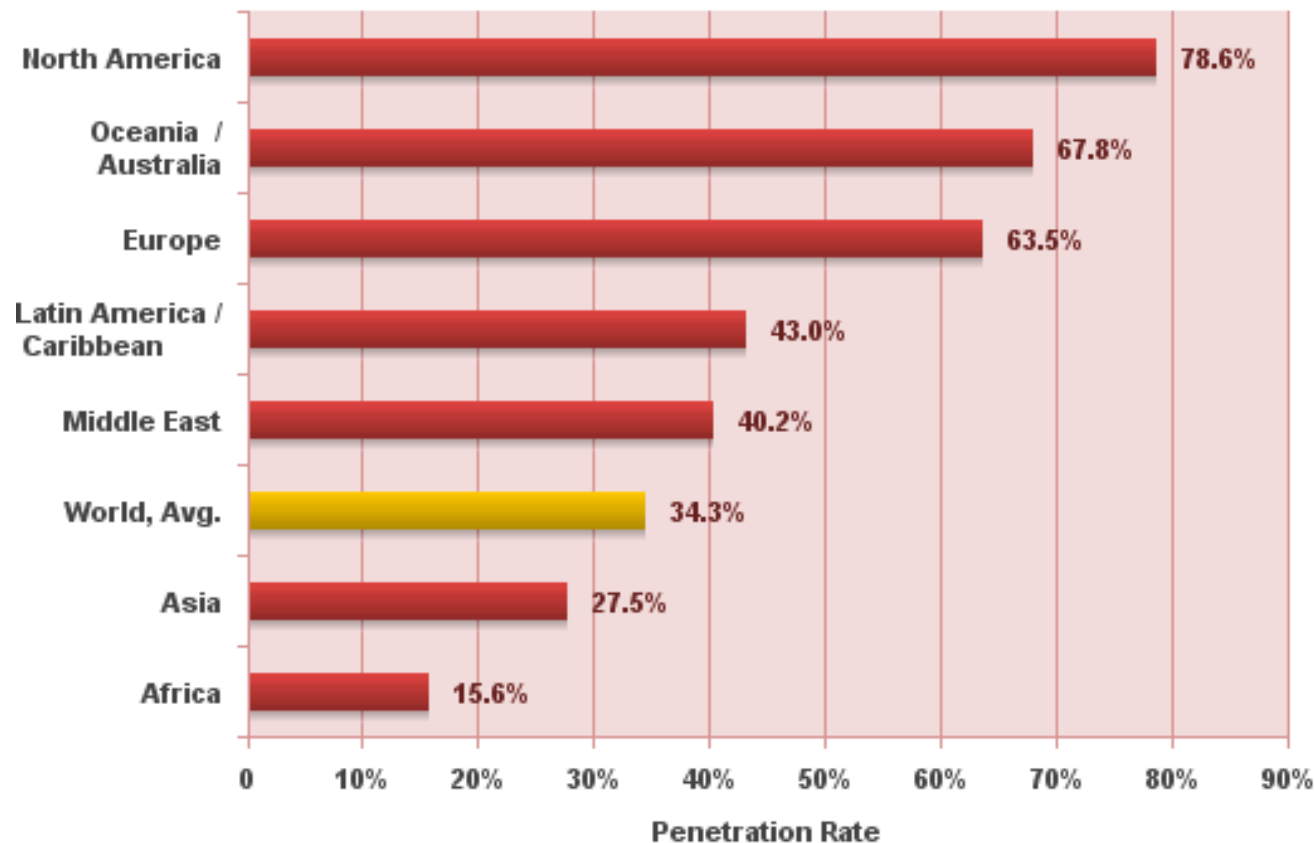Internet Users in the World by Geographic Regions - 2012

Source: Internet World Stats - www.internetworldstats.com/stats.htm
Estimated Internet users are 2,405,510,175 on June 30, 2012
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World Internet Penetration Rates
by Geographic Regions - 2012

Region	Penetration Rate
North America	78.6%
Oceania / Australia	67.8%
Europe	63.5%
Latin America / Caribbean	43.0%
Middle East	40.2%
World, Avg.	34.3%
Asia	27.5%
Africa	15.6%

Penetration Rate

Source: Internet World Stats - www.internetworldststs.com/stats.htm
Penetration Rates are based on a world population of 7,012,519,841
and 2,405,510,175 estimated Internet users on June 30, 2012.
Copyright © 2012, Miniwatts Marketing Group

Economic impact

- Phenomenal industry growth around:
    - Computer hardware / software
    - Networking hardware / software
    - Network management / security
- Companies must integrate planning, implementation, management and upgrades

- Job creation

Network standards

- Research started in 1967 to develop an Interface Message Processor (*IMP*)
- Group started a repository for comments by other researchers … Request for Comments (*RFC*) - 1969
  - http://www.rfc-editor.org grew from this. It is **the place** to find all of the latest adopted standards for networking.
  - First "open-source" community
- Internet Engineering Task Force (IETF)
  - http://www.ietf.org
  - Non-profit organization, produces technical documents that influence the way people design, use, and manage the Internet.

Preliminaries: **Metrics** (measurements)

- Speed (distance/time) is measured in electronic units:
  - K = 10^3, M = 10^6, G = 10^9, etc.
  - E.G., network speed of 8 Mbps means 8,000,000 bits per second

- Size in bits, Bytes is measured in binary units
  - Commonly used: K = 2^{10}, M = 2^{20}, G = 2^{30}, etc.
  - In this course, use: Ki = 2^{10}, Mi = 2^{20}, Gi = 2^{30}
  - E.G., disk size of 200 GiB means

    200 x 2^{30} Bytes = 214,748,364,800 Bytes

    = 1,717,986,918,400 bits

- Bytes and bits (abbreviations)
  - Use lower-case **b** for bits
  - Use upper-case **B** for Bytes
  - Example: 1 Mi**b** = 128 Ki**B**

Etymology

- Common variable names in RFC
  - foo
  - bar
  - foobar

- http://www.faqs.org/rfcs/rfc3092.html

- Definitions:
  - network, internet
- Networking complexity
- Growth of the Internet
  - Economic impacts
- RFC and IETF (networking standards)
- Metrics (speed and size)