

# The Internet

*History & Current Applications*

# Connecting computers to other computers

- Share data
- Join computing forces
- Ensure resiliency

# Types of Communication

- *Synchronous*:
  - sender and receiver active at the same time (e.g. phone call)
- *Asynchronous*:
  - receiver active sometime after sender has sent a message (e.g., postcard)
- *Broadcast*:
  - one sender, many receivers (e.g. TV)
- *Multi-cast*:
  - one sender, many receivers, but not everyone is a receiver (e.g. Magazine subscription)
- *Point-to-point*:
  - one sender communicating with one specific receiver (Uni-cast)

# Internet history

- Computers connected in (local) network
- Connecting networks, networks of networks, interconnected networks, *internet*
- Examples of early networks of networks
  - ARPANET, Mark I, CYCLADES, Telenet

# Packet switching

- Divide messages into packets
- Per-packet routing
  - Packets store destination address, message id, and index within message
- Store and forward networking
  - Servers receive packets
  - Store them temporarily
  - Forward them to other servers

# Packet switching

- Divide messages into packets
- Per-packet routing
- Store and forward networking
- Better than circuit switching (telephony)
  - Circuit switching implies rigid routing
  - Packet switching: better bandwidth utilization and response times on resource-limited networks
- Better than message switching
  - Message switching: routing entire messages
  - Failure requires resending entire message

# Early years

- Transmission Control Protocol / Internet Protocol
  - 1982
  - Internet : world-wide web of fully interconnected TCP/IP networks
- ARPANET (military) and NSFNET (National Science Foundation)
  - 1980's
  - Access to supercomputers

"We set up a telephone connection between us and the guys at SRI ...", Kleinrock ...  
said in an interview: "We typed the L and we asked on the phone,

"Do you see the L?"

"Yes, we see the L," came the response.

We typed the O, and we asked, "Do you see the O."

"Yes, we see the O."

Then we typed the G, and the system crashed ...

Yet a revolution had begun" ....<sup>[10]</sup>

"Roads and Crossroads of Internet History" by Gregory Gromov. 1995



# Commercial traffic

- Internet Service Providers (ISPs) emerge in late 80's and 90's
- ARPANET and NSFNET decommissioned

# Explosive growth of the internet

- In 1993, Internet carried 1% of information flowing through 2-way telecommunication
- By 2000, 51%
- By 2007, 97%

# Web Addressing (IPv4)

- Everything connected to the internet gets a web address.
- In IPv4 (Internet Protocol version 4), address is a 4-byte number, such as 128.10.10.250, or 128.10.10.41.
- Example:

25.13.109.72



25.13.109.73



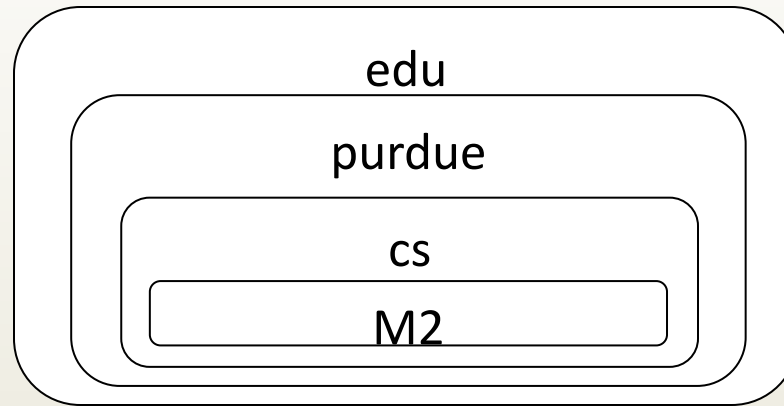
25.13.109.74



25.13.109.75



# Web Addressing (IPv4)

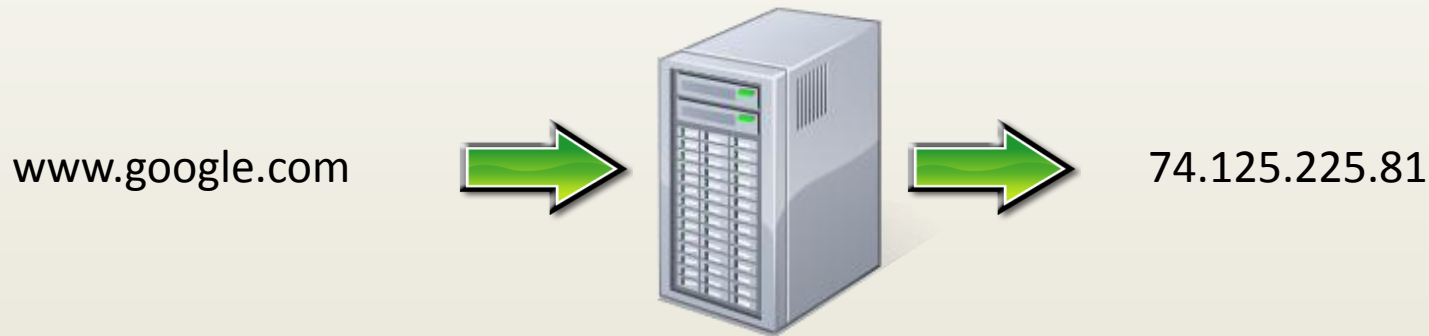


## Example: m2.cs.purdue.edu

- **M2**
  - the computer name
- **cs**
  - a member of the **cs** domain, which has many computers
- **purdue**
  - a member of the **purdue** domain, which has many departments
- **edu**
  - A member of the **edu** domain, which has many schools

# Web Addressing (IPv4), cont.

- DNS servers are computers that translate textual addresses to IP addresses.



- However, a 4-byte address structure is no longer sufficient. The world has run out of IP addresses. IPv6, gradually deployed in parallel, uses 16-byte addresses, such as 2531:0db8:85a3:0000:0000:8a2e:0370:7334

# iClicker question

- How many internet addresses can be defined with 4 bytes?
  - A.  $4 \times 8$
  - B.  $8 \times 8 \times 8 \times 8$
  - C.  $256 \times 256 \times 256 \times 256$
  - D.  $2^4$
  - E. None of the above

# Internet applications

- Information repository
- Telecommunication
- Health care
- Education
- Commerce
- Stock exchange trading
- Gaming
- Social networking

# Internet—information repository

- Server side
  - Web pages stored on web servers
  - Web pages are defined using specialized languages
    - e.g. HTML (Hyper Text Markup Language)
    - Content (e.g. text, images, audio sequences, videos) + hyperlinks (links to other webpages)
  - Connected web pages form a graph
    - 1 trillion (1,000,000,000,000, or one million millions) web pages by 2008



# Internet—information repository

- Client side
  - Web browser—a software application
  - Allows displaying content, including multimedia
  - Extendable through plugins
  - Allows following hyperlinks on webpages to navigate or surf the web



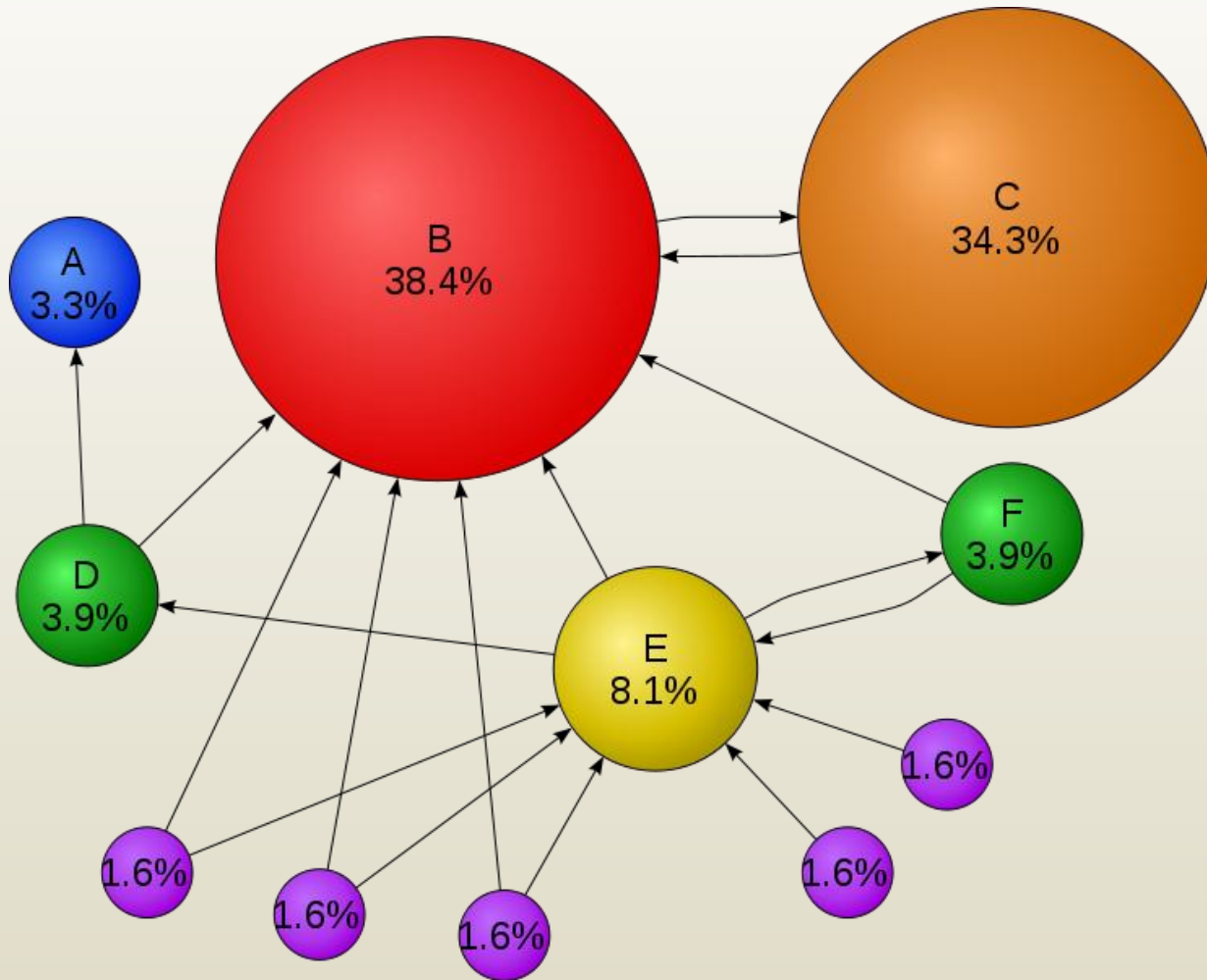
# Search engines

- With a web browser you can only go to known web addresses
- Search engines allow finding addresses of web pages that might have the content needed
- How to find web pages in a graph with 1 trillion nodes?

# Page rank algorithm

- Named after Larry Page, used by Google
- A link analysis algorithm
- Assigns weights to each web page to measure its relative importance
- Page receives higher weight when
  - Many pages link to it
  - A page with a high weight points to it

# Page Rank Algorithm example



Source: Wikimedia Commons

# Internet—information repository

- So far we have the following ingredients
  - Web page—*encodes content*
  - Web server—*stores content and sends it when requested*
  - Web browsers—*allow users to go to web addresses*
  - Search engines—*allow users to find information on the web*
- Who provides the content?

# Wikipedia

- Multilingual, web-based, free-content encyclopedia
- Openly editable model
  - Written collaboratively by largely anonymous internet volunteers
  - Results in information of remarkably good quality
- 4 million articles in English



# Internet for telecommunication

- Email, chat, blog
  - Text, images, and videos, asynchronously
- Voice and video synchronously
  - Voice over IP, video over IP
  - New protocols developed for live streaming
  - Requires (residential) broadband



# Healthcare

- Provides medical knowledge
  - used by physicians *and* patients
- Remote surgery
  - 2001 Operation Lindbergh, cholecystectomy surgeon in NY and patient in Strasbourg, France





# Education

- Knowledge repository
  - Is Wikipedia an acceptable reference?
- Online learning
  - Synchronous: remote student attend lecture in real time
  - Asynchronous: students access prerecorded lectures
  - This course has an online section
  - Benefits: scheduling flexibility, reaching remote students, guest lectures by remote instructors

# iClicker Question

In the distance learning system described, remote students are displayed in a virtual extension of the physical classroom (see photo). Should a remote student always be assigned to the same seat? Should nearby students be able to talk to teach other privately?



- A. Yes, they'll become friends and work together, improving learning outcomes.
- B. No, they'll talk to each other and not pay attention to class.
- C. Yes, but remote students should choose where to sit.
- D. A and C.
- E. No, that's why they take the remote course to begin with.



Distance education system (*top*), and photographs of the back-wall screen showing remote students integrated into a virtual extension of the classroom (*bottom*).

# Commerce

- Online stores
  - Lower costs: no physical stores, no state sales taxes\*
  - Early on only some products were bought online (e.g. books, music), not anymore
  - Cyber Monday—Monday following Thanksgiving
- Online auctions
  - System of seller rating by costumers
  - Online bidding over days
  - Anyone can own a “store”
  - eBay



# Stock Exchange Trading

- Anyone can trade securities from anywhere
- Computer simply executes trade
- Computer decides which trades to make according to sophisticated algorithms
- High frequency trading
  - Investment position held only for very brief periods of time, from seconds to hours
  - Might have contributed to the 2010 Flash Crash

# Dow Jones Flash Crash of May 6 2010



- At 2:42pm the Dow Jones starting falling rapidly
- Dropped more than 600 points in 5 minutes
- Biggest intra-day decline, second largest point swing
- Losses recovered within minutes

# Gaming

- MMORPG (Massively Multiplayer Online Role-Playing Game)
- Second Life
  - Players interact with each other through avatars
  - Avatar (here): An electronic image that represents and is manipulated by a player of a computer game (M-Webster)
  - 80,000 players online at the same time
- Half-life, World of Warcraft



# Social networking



- Facebook
  - 1 trillion page views in June 2011
  - 1b users soon
  - Filed for Initial Public Offering on Feb 1, 2012

Total active users<sup>[N 1]</sup>

Date	Users (in millions)	Days later	Monthly growth <sup>[N 2]</sup>
August 26, 2008	100 <sup>[30]</sup>	1,665	178.38%
April 8, 2009	200 <sup>[31]</sup>	225	13.33%
September 15, 2009	300 <sup>[32]</sup>	160	9.38%
February 5, 2010	400 <sup>[33]</sup>	143	6.99%
July 21, 2010	500 <sup>[34]</sup>	166	4.52%
January 5, 2011	600 <sup>[35][N 3]</sup>	168	3.57%
May 30, 2011	700 <sup>[36]</sup>	145	3.45%
September 22, 2011	800 <sup>[37]</sup>	115	3.73%



# Social networking

- Facebook
- Twitter
- What is the innovation?
  - Everyone can create their own webpage trivially (no HTML, no Java, no Flash programming required)
  - Exponential growth through friends of friends
  - Deployed on all devices, including smartphones

