CS 352
Internet Technology

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About us: Management

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  - Office hours: CoRE 312, Thursdays 10 am -- noon or by appointment
  - Class: Wed 10.20 – 11.40 AM and Fri 3.20 – 4.40 PM TIL 232
- Recitation section 5: Bala Murali Komanduri bk455@scarletmail.rutgers.edu
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  - Thursday 8.55 – 9.50 AM LSH-B115
- Course info
  - http://www.cs.rutgers.edu/~sn624/352-S19/
- Piazza: accessible from class Sakai site

Class etiquette

- Cell phones in off position
- No FB status updates, texting, selfies in class
- If you need to surf while in class (I prefer you do not), do not disturb your neighbors
- Stop me anytime to ask questions
- Try to learn as much as you can in class

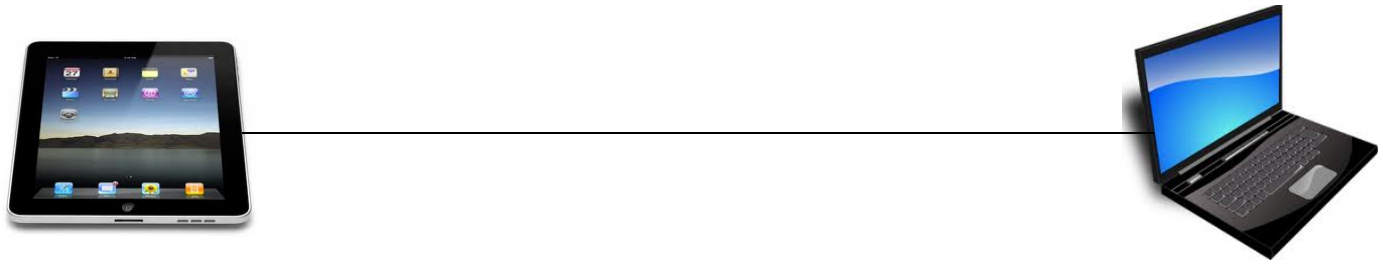
What is a Network?

- Carrier of information between 2 or more entities

- Interconnection may be any medium capable of communicating information:
  - copper wire
  - Lasers (optic fibre)
  - Microwave
  - Cable (coax)
  - satellite link
  - Wireless link (cellular, 802.11, bluetooth)

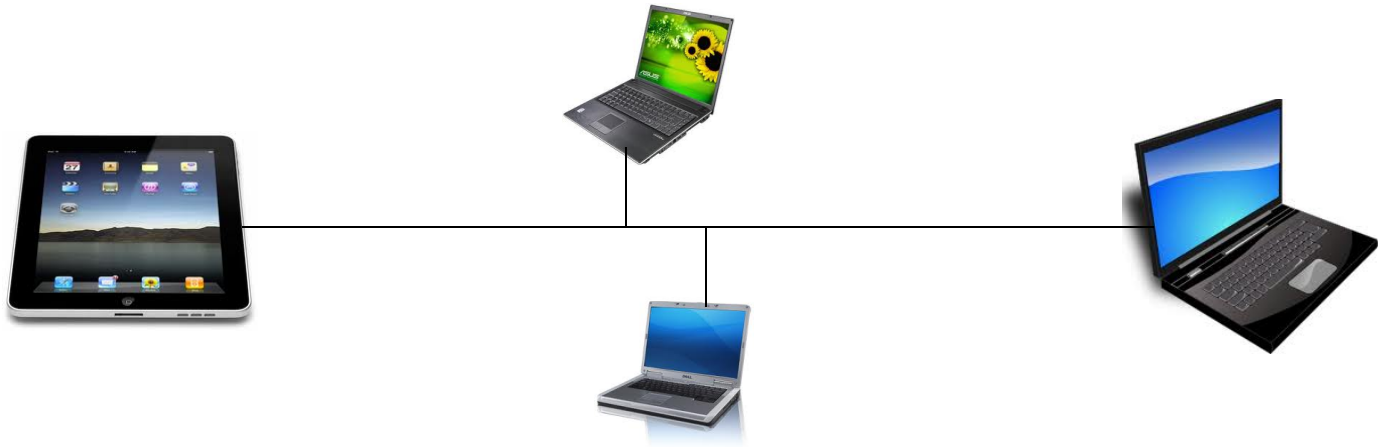
- Examples: Ethernet, 802.11(WIFI), cable modem, cellular

A single link network



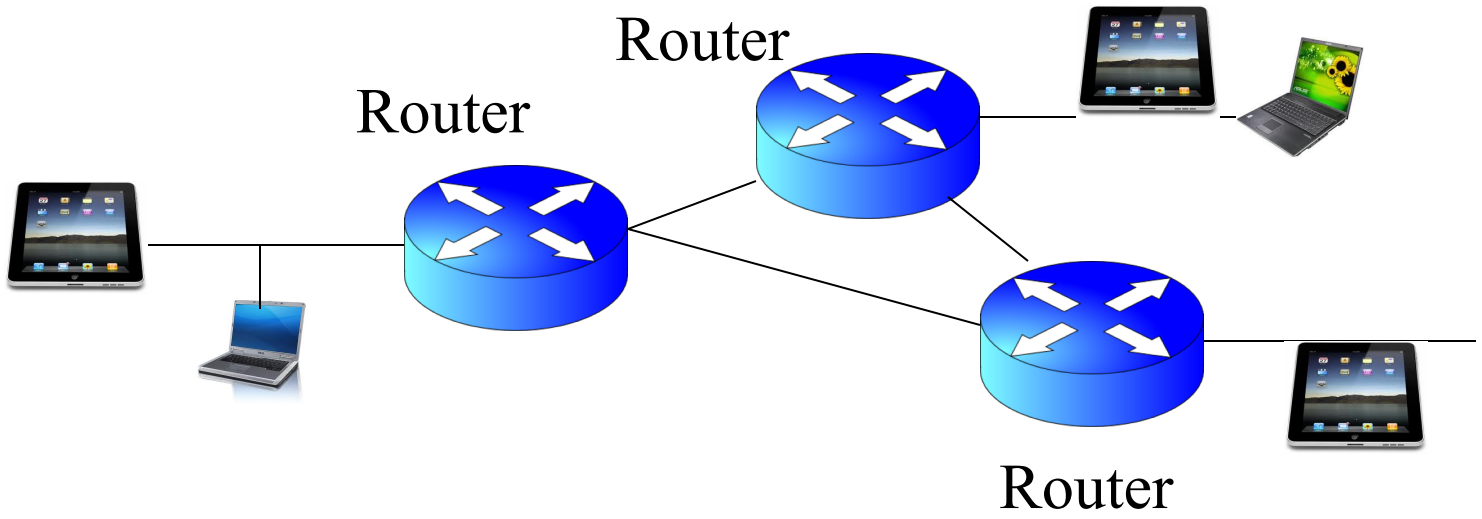
- Send bits of data in packets or frames
- Need to worry about errors, how to convert bits into signals and vice versa

A single link multiple access network



- Send bits of data in packets or frames
- Need to worry about errors, how to convert bits into signals and vice versa
- In addition, how to differentiate among many receivers?
- Every host as a link layer address: MAC address
- Packets or frames will have destination address
- However, can’t have every computer in the world on the same link!

A multi-link network



- Connect multiple links via routers
- Need to figure out how to route packets from one host to another host

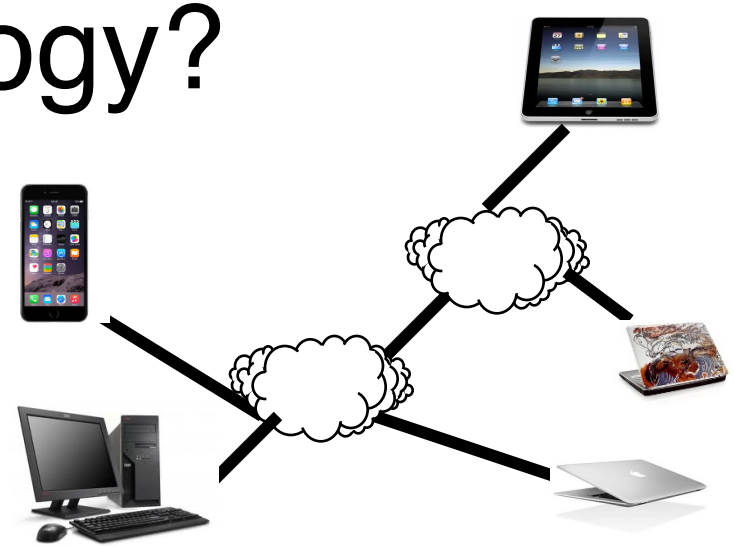
Components of a network

- Link
  - Communication links for transmission
- Host
  - Computer running applications of end user
- Router
  - Computer for routing packets from input line to another output line
- Gateway
  - A device directly connected to two or more possibly different networks (serves as an access point), provides access
- Network
  - A group of hosts, links, routers capable of sending packets among its members

Why are networks useful?

- Availability of resources
  - Resources become available regardless of user location
- Performance and load sharing
  - Ex: Move work to the least loaded machine
- High reliability
  - Alternative sources for the same data (multiple copies)
- Human-to-human communication!
  - Ex: telephone (voice over IP), text messaging

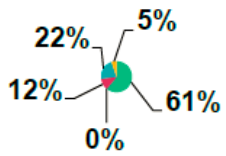
What is Internet Technology?



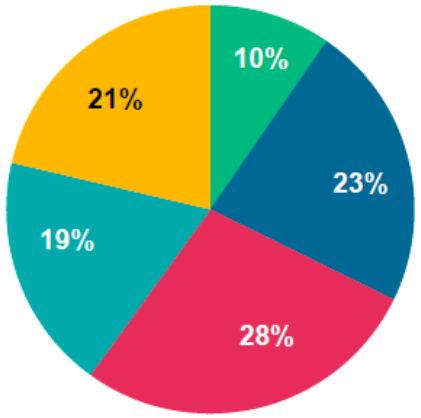
- What is an internet?
  - Network of networks
- What is *the* Internet?
  - A global internet based on the IP protocol
  - Network to network – adopt a common language
- What does “Internet technology” refer to?
  - Architecture, protocols, and services

Internet growth

1995
35MM+ Internet Users
0.6% Population Penetration



2014
2.8B Internet Users
39% Population Penetration

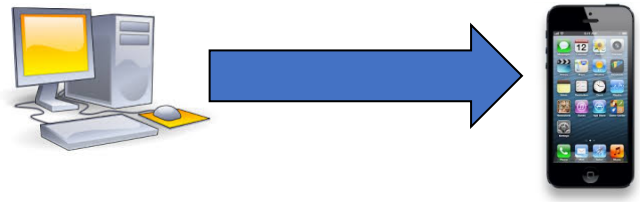


USA China Asia (ex. China) Europe Rest of World

2018:
3.6B users

Mobile Phones: in 1995 80 M, now 5 B

Evolution of Internet Applications

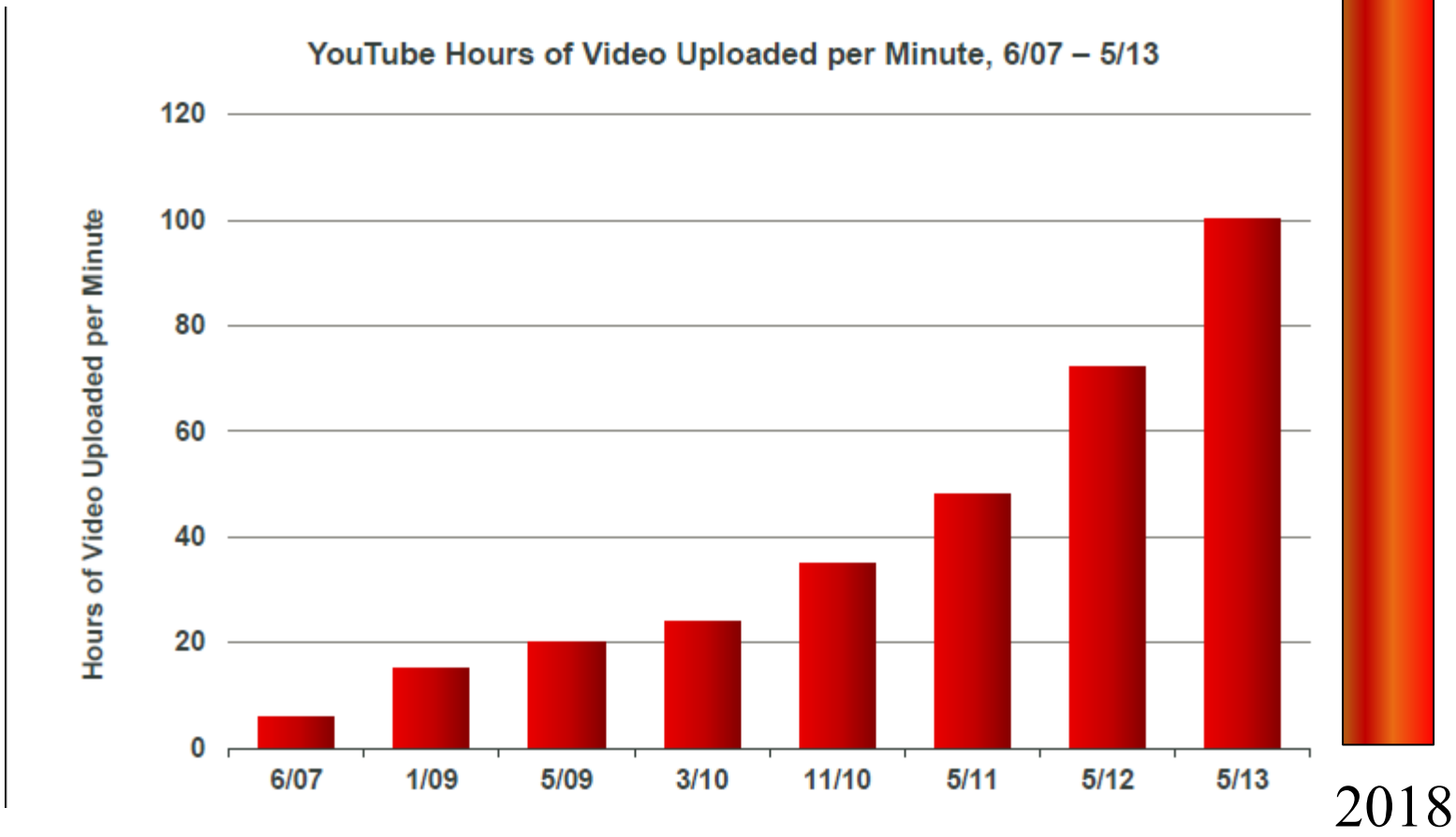


1992	1996	2000	2004	2008	2010-now
ftp web	chat Games IM Yahoo!	news Blog Search amazon	Music itunes Games search Google	Wikipedia Craiglist Youtube	UBER airbnb NETFLIX Spotify

Web evolution

- Web 1.0
  - Read-only web
  - Content ➔ Users
  - Yahoo, google, daily targum
- Web 2.0
  - Read-write web
  - Content ➔Users and Users ➔ Content
  - Blog, wikipedia, facebook, twitter, youtube
- Web 3.0
  - Contextual web
  - Personalized, location dependent
  - Apps on your phone get organized (ex: weather, maps); Google NOW
- Web 4.0
  - Devices will be connected as first class objects: refrigerator, car, fitbit, thermostat, …
  - Prediction-Machine learning

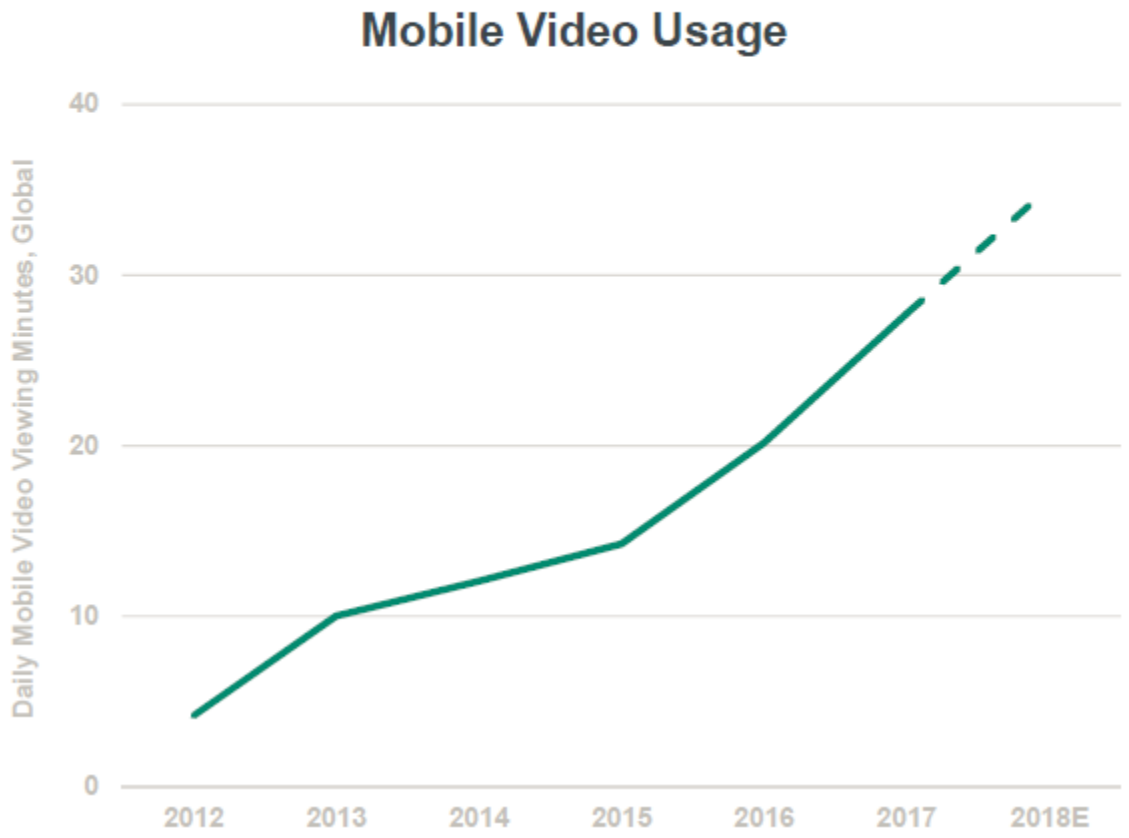
Content is exploding



HD quality video: 2G to 4G / hour

Source: Mary Meeker Internet trends Presentation

Video =
Mobile Adoption Climbing...

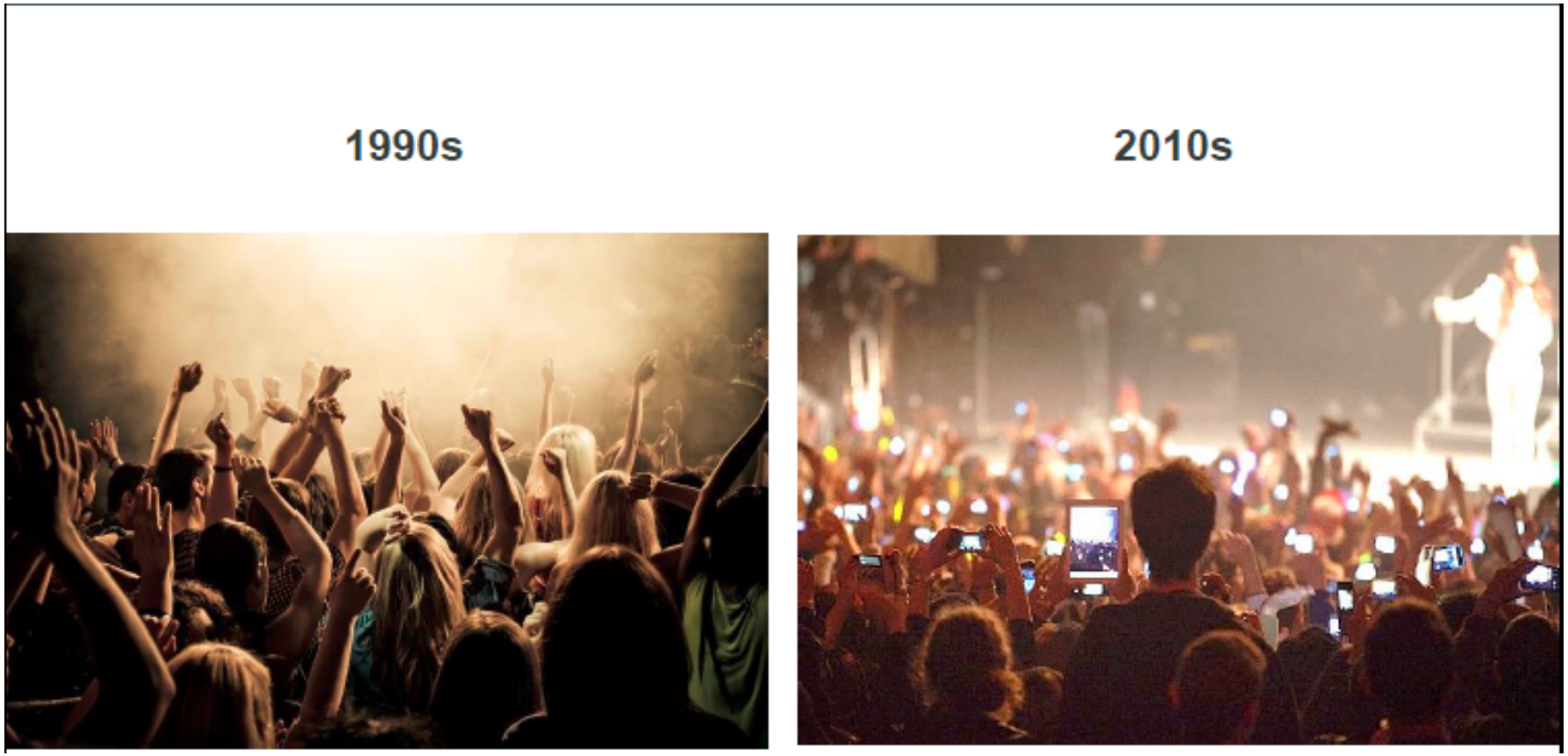


1.8 B youtube users

Transforming the economy

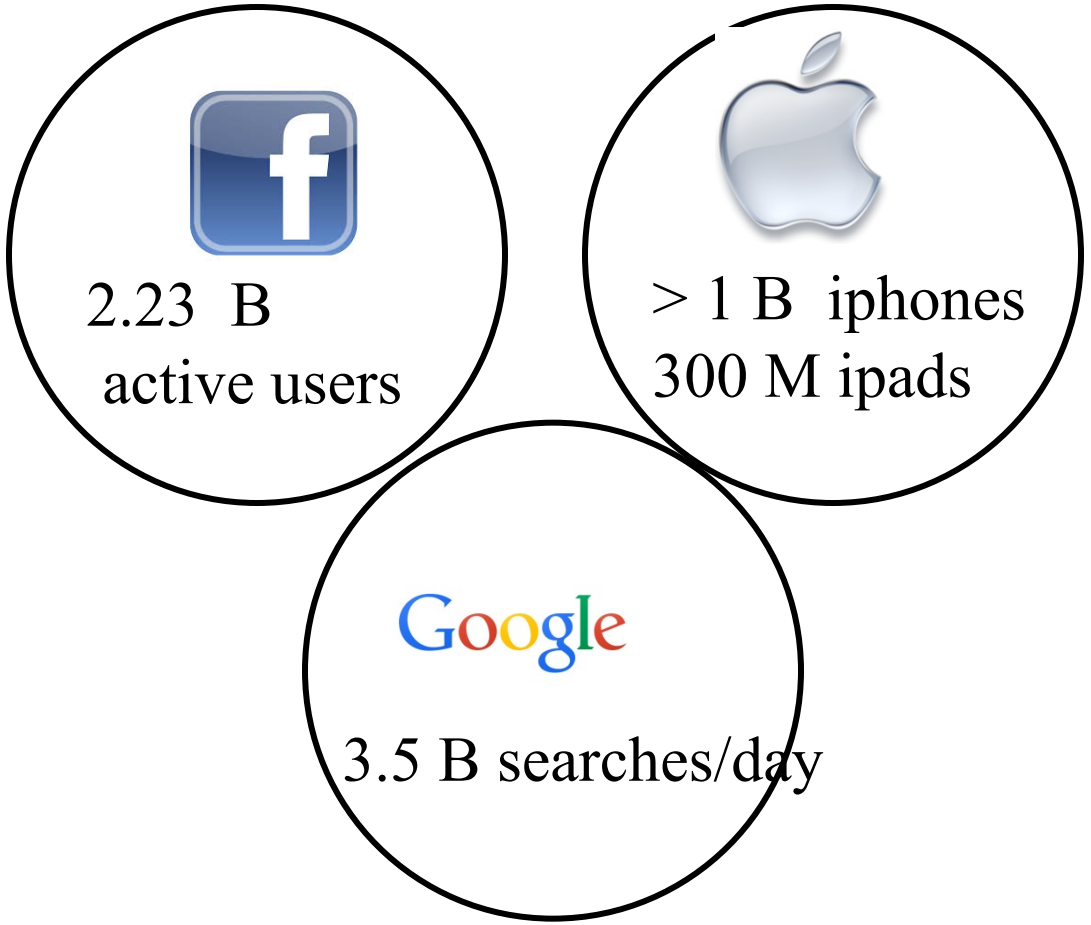
- Mobile payment
  - Venmo, square, paytm
- Shared resource platforms
  - Uber, Airbnb, WeWork

Just dancing and listening, to video, tweets, selfies, and share



Source: Mary Meeker Internet trends Presentation

Scale of Web apps



Impact of the Internet on People

- Access to remote information
  - HW assignments from my server
  - Stock quotes from financial web site
  - News, wikipedia, google
- Person to person and group communication
  - email, whatsapp, blogs, fb, twitter, instagram, snapchat
- Interactive entertainment
  - video clips (youtube), movies (netflix), music (itunes, spotify), games
- Online commerce
  - Amazon, Ebay, hotels

Impact of the Internet on Society

- The good
  - Access to information, services, e-commerce, productivity
- The bad
  - Gossip, distraction, Internet addiction, chat room
- The ugly
  - Phishing, fraud, trolling, cyberbullying
- The Internet is a mirror of society

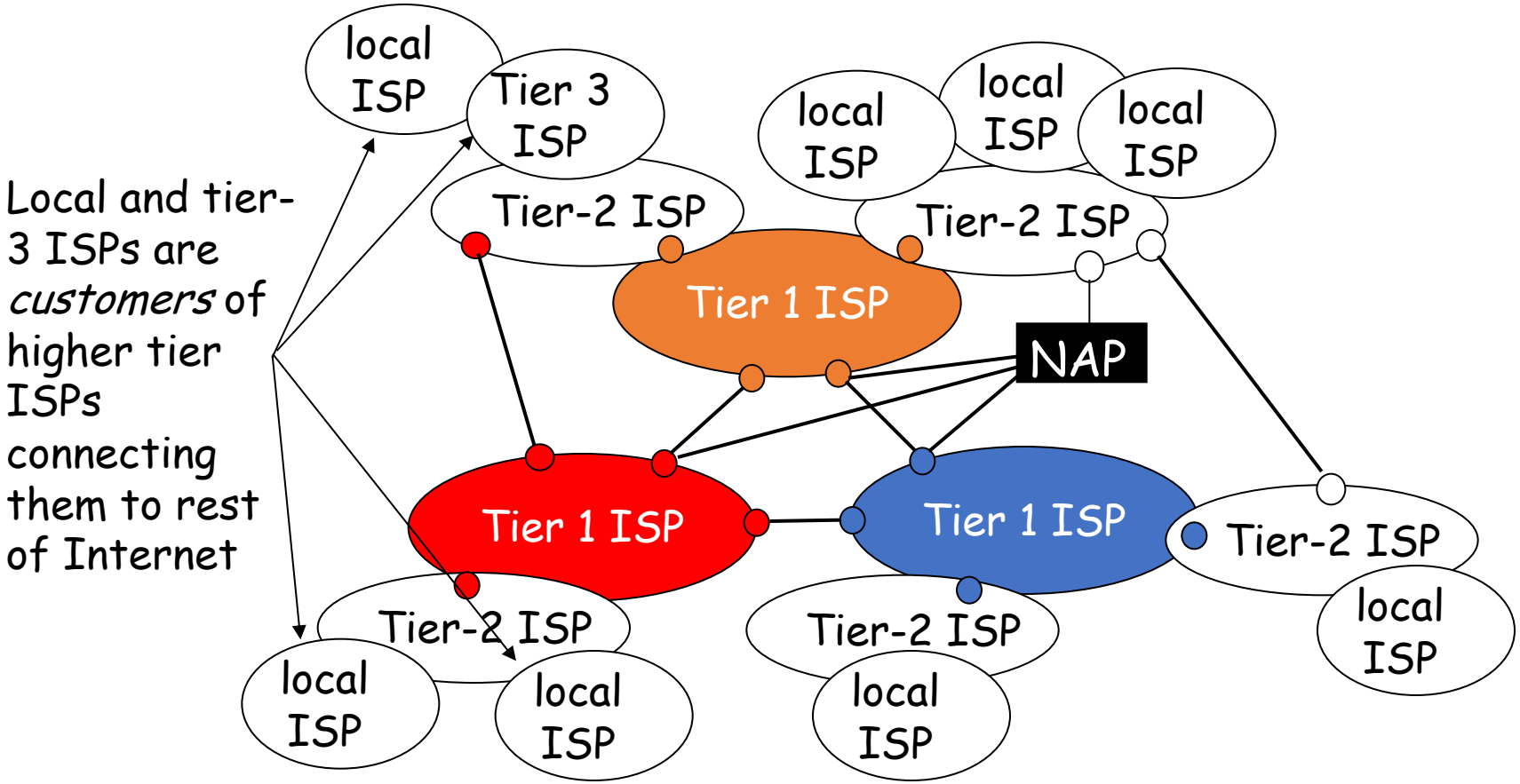
Internet Players

- Users of applications
    - Everyone (mom and pop, kids) to get something done
- Network Designers
    - Protocol design and implementation
    - Performance, cost, scale
- Internet Service Providers
    - Administrators and ISPs (AT&T)
    - Management, revenue, deployment
- Market/businesses on the Internet
    - Consumer to consumer (ebay), Business to consumer (amazon, netflix), Business to business (alibaba, importers.com,21food.com), Consumer to business (hotjobs, monster), Govt to C, Govt to B, etc.

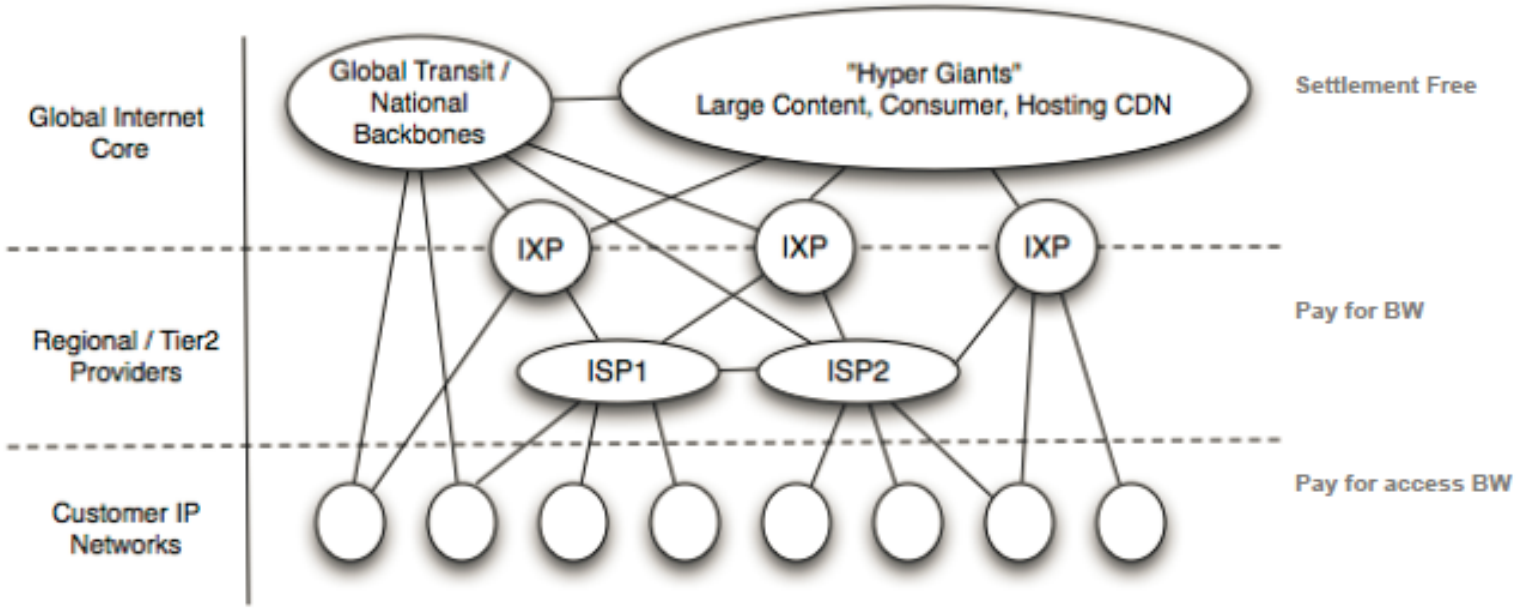
Internet service providers (ISPs)

- Local ISPs: Tier 3 (cablevision)
- Regional ISPs: Tier2 (internap)
- Global ISPs: Tier 1 (Verizon, Sprint, AT&T, level 3, century link, Deutsche Telekom, NTT) provide access to the entire internet; connect ISP to other ISPs
- Peering ISPs
  - Have a mutual relationship about forwarding traffic of each others customers (no $ involved)
- Transit ISPs
  - Provides access to all reachable customers ($$ involved)

Core Networks: ISP Tiers



ISPs connected via Exchanges



- Flatter Internet
- Business models among, content provider, transit providers, and customers
- Net Neutrality

Internet Inter-domain traffic By Labovitz et.al, SIGCOMM 2010

Types of Networks in an Internet

- Local area networks (LAN)
  - Privately owned, within building
  - High speed, broadcast, Ethernet
    - 2 to 100 Mbps
- Wide area networks (WAN)
  - Spans a large area
  - Point-to-point, high speed fiber lines
    - Long delays but very high speed links
    - Several Gbps

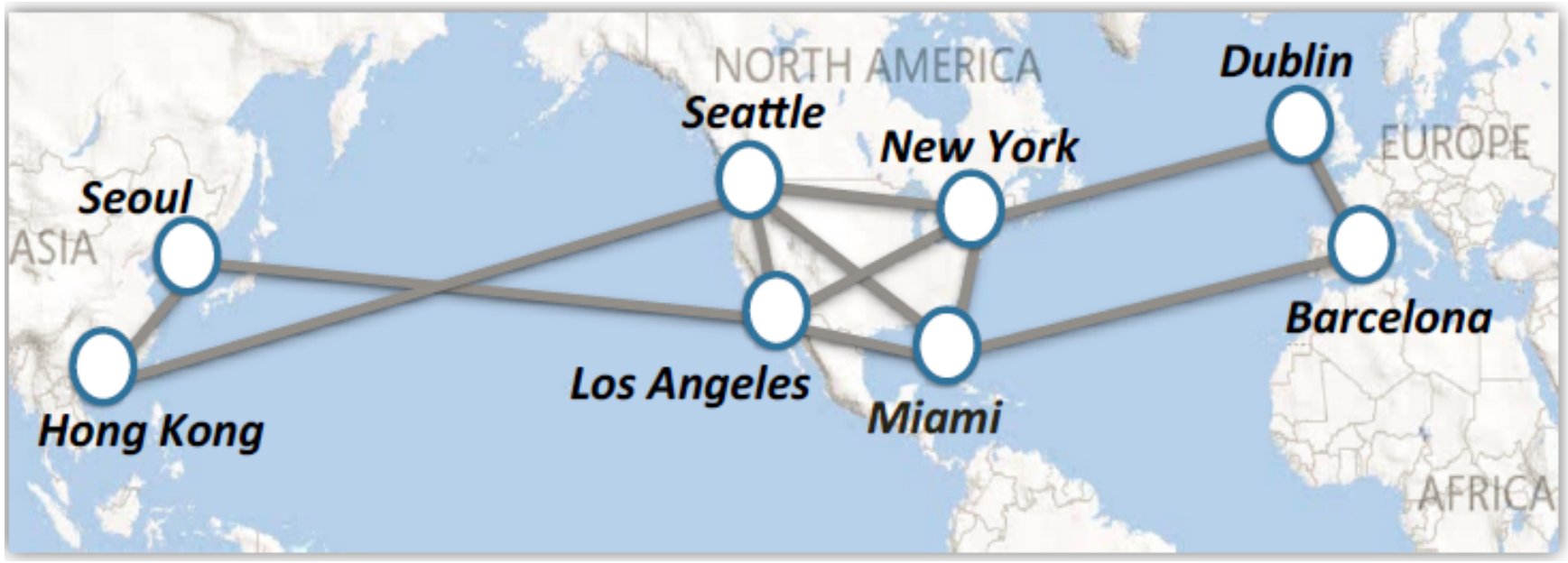
Types of Networks *(cont'd)*

- Wireless networks
  - Hosts connected by radio or infrared links
  - Local area and wide area
  - Satellite networks

Google WAN

Figure 1: B4 worldwide deployment (2011).

Microsoft WAN



Historical perspective

- Late 1960's: ARPAnet (4 nodes)
- Early 1970's: Aloha net, ethernet, multiple access problem
- Mid-to-late 1970's: TCP/IP, 4.2BSD
- 1980's to early 1990's: early internet growth, e-mail & file transfer dominant, NSFNET
- Mid 1990s: NSFnet handed over to commercial service providers, WWW explodes
- Late 90s, business models using the internet; dot-com boom and bust
- Early to mid 2000s, Web 2.0, Facebook, google, Wikipedia
- Future: "Embedded networks", 5 to 10 billion devices waiting to be networked, media convergence, ubiquitous RFID tags

Course Goals

- Understand the basic design principles of computer networks
- Understand how the Internet works
  - Services, protocols, and architectures
- Text: “Computer networking, a top-down approach,” by James Kurose and Keith Ross

Course Assessments

- Sakai quizzes (15%)
  - 6 of them, can drop lowest grade
- 2 Mid-terms (15% each)
  - No electronic devices, notes, or cheat sheets allowed
- Final (25%)
  - You must notify me at least 2 weeks before the final if you need to take the makeup!
- Project (30%)
  - Part 1 (10%)
  - Part 2 (10%)
  - Part 3 (10%)
- You may not dispute a grade before 24 hours or after 7 days of receiving it

Programming assignments

- Single long project
  - Broken into three parts
- Can work in a group of 2
- Both program and write-up required
- Background needed to get started:
  - C or Python (211, 214 level)
    - Comfortable using data structures (dictionaries, vectors, trees)
  - Unix (login, permissions, gcc)

Programming assignments

- Each phase of the code feeds into the next phase
- Make improvements for next phase of the assignment
- Hand-in via sakai
  - Failure to meet the deadline will result in a zero for all team members. No exceptions.
- You must turn in all projects to pass this course

Academic integrity

- No cheating on projects and exams
  - Run code similarity detectors on the projects & code review
  - Scrutinize exams for copying
- Department academic integrity policy
  - https://www.cs.rutgers.edu/academic-integrity/introduction
  - Please read and acknowledge your awareness of this policy