

Introduction to Computer Networking: Trends and Issues



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These slides are available on-line at:

<http://www.cse.wustl.edu/~jain/talks/cs13110.htm>



1. Recent Networking Developments
2. Wireless Networking Trends
3. Wireless Networking Challenges
4. Recent Wireless Technologies
5. Networking Courses at WUSTL

Goal: To get you interested in Computer networking, wireless, and network security research

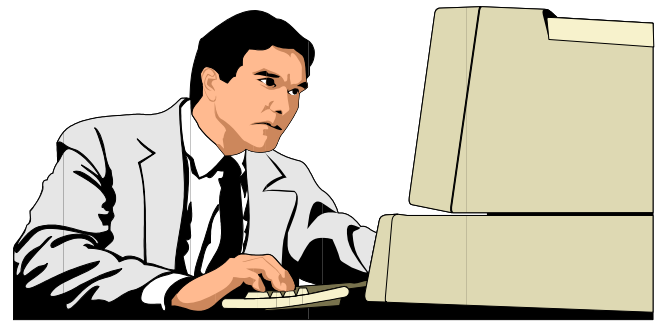
Why Study Computer Networking?

- ❑ Networking is the “plumbing” of computing
- ❑ Almost all areas of computing are network-based.
 - Distributed computing
 - Distributed databases
 - Distributed storage
- ❑ Fast growing field
- ❑ Job Opportunities: Google, Facebook, eBay, Microsoft, Cisco, HP, Intel, ...



Stone Age to Networking Age

- ❑ Stone, iron, ..., automotive, electricity, telephone, jet plane, ..., networks caused a fundamental change in our life style



- ❑ No need to get out for
 - Office
 - Shopping
 - Entertainment
 - Education

- ❑ Virtual reality will satisfy your needs for
 - ❑ Games
 - ❑ Tourism
 - ❑ Sex

Current Issues in Networking

1. Network Security
2. Mobile Networking
3. Wireless Networking
4. Energy Efficient Networking
5. Multimedia Networking
6. Datacenter Networking
7. Internet Routing

Note: These topics are based on current activity in industry groups like IETF, IRTF, IEEE

1. Network Security

- ❑ No authentication:
 - DNS attack: All YouTube traffic went to a black hole in Pakistan
- ❑ Phishing: Enter personal information on fake websites
- ❑ Spam
- ❑ Cyber warfare
- ❑ CSE 571: Network Security



SPAM

- ❑ Averages 78% of all emails sent
- ❑ 81% of spam is about pharmaceutical drugs
- ❑ Cost businesses \$100 Billion in 2007
- ❑ CAN-SPAM act of 2003
- ❑ Sent through Botnets of infected computers



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"Wow! I've got one from some" www.CartoonStock.com

Ref: http://en.wikipedia.org/wiki/Email_spam

Cyber Warfare

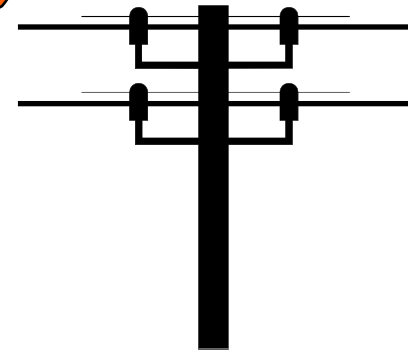
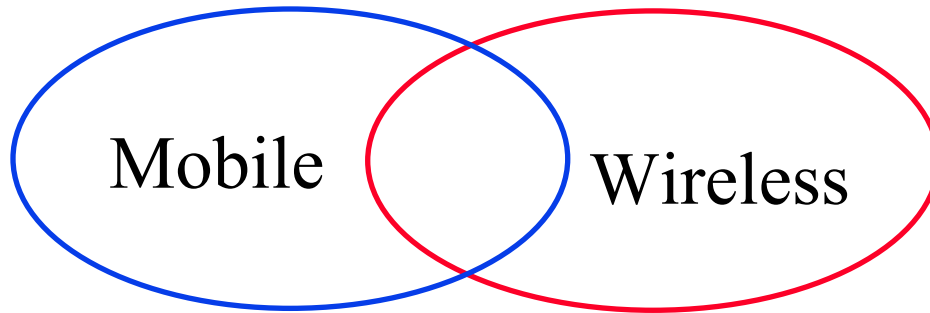
- ❑ Nation States are penetrating other nations computers
- ❑ In 2009, US set up a cyber command
- ❑ UK, China, Russia, Israel, North Korea have similar centers
- ❑ Targets: Telecommunications, Transportations, Power Grid
- ❑ Pentagon spent more than \$100 million in first half of 2009 in repairing damages from cyber attacks.



Ref: http://en.wikipedia.org/wiki/Cyber_war

2. Mobile Networking

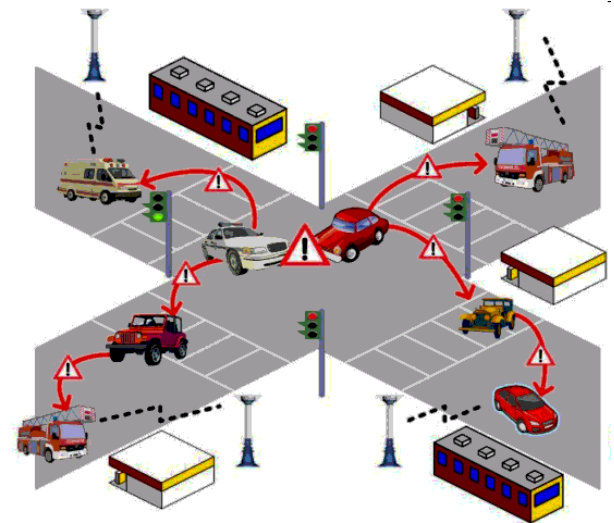
- ❑ Smart Phones (iPhone, Blackberry, Android Phones), Net books, Laptops \Rightarrow Mobile computers



- ❑ Mobile vs Stationary
- ❑ Wireless vs Wired
- ❑ Wireless \Rightarrow Media sharing issues
- ❑ Mobile \Rightarrow Location, addressing, Handoff
Address changes when connected at a different point

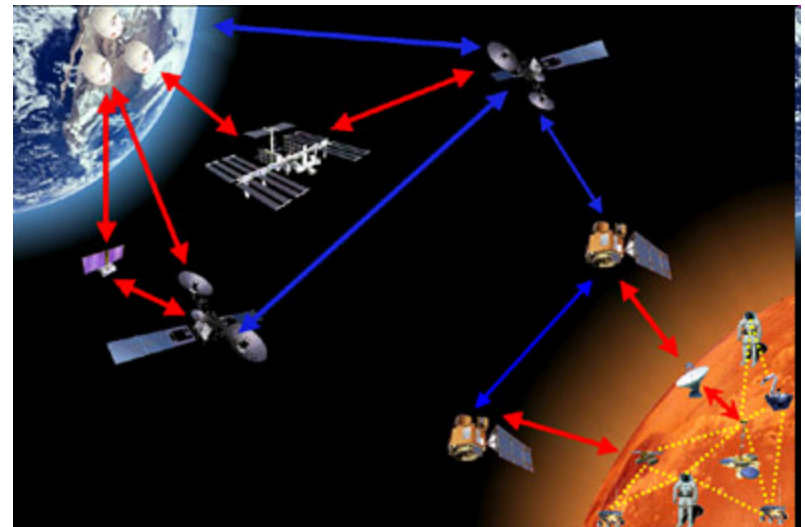
3. Wireless Networking

1. Wireless (WiFi) is ubiquitous (Intel Centrino)
2. More Cell phones than POTS.
Ratio projected to be 4-to-1 by 2012.
3. Wiring more expensive than equipment
⇒ Wireless Access
4. New Developments:
 - 4G: 1Gbps Metropolitan Area Networks (LTE-Advanced, WiMAX V2)
 - Vehicular Networking (802.11p)
 - Ad-hoc Wireless Networks
 - TV Band (700 MHz) networking
 - Audio/Video over Wi-Fi (802.11aa)



4. Energy Efficient Networking

- ❑ Original Internet design assumed all hosts are up all the time
- ❑ You cannot turn off your routers
- ❑ Computer Industry produces as much green house gases as the airlines industry
- ❑ One small computer server = one SUV with 15 miles/gallon
- ❑ Need to design protocols that allow nodes to be off
- ❑ Energy Efficient Ethernet:
 - Turns off most of circuits until a bit arrives
- ❑ Delay-Tolerant Networking:
Routers store data if the next hop is down



5. Multimedia Networking

□ Trends:

- Audio/Video over networks
- Entertainment on cellular phones
- Home Entertainment
- Movies on Demand
- YouTube

□ Issues:

- Timing and synchronization
- Peer to peer streaming
- Stream reservation
- Media caching



6. Datacenter Networking

❑ Cloud Computing:

- Applications through Internet (Google Docs)
- Computing through Internet (Amazon EC3)
- Storage and backup through Internet



❑ Issues:

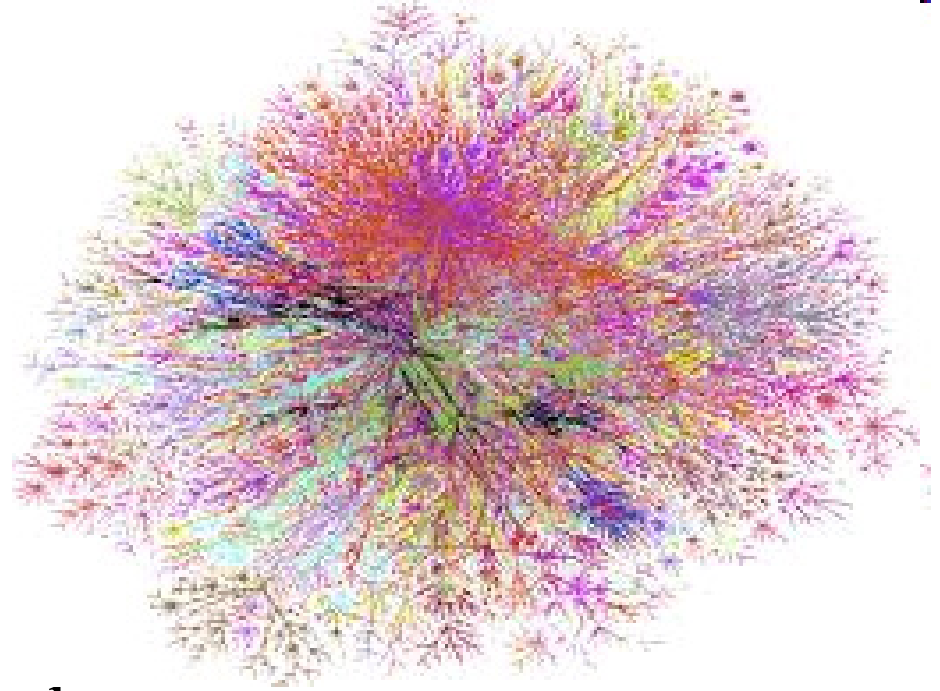
- Inter-Cloud Provider Networking: High-speed links on demand
- Policy, Security, QoS issues (Multi-organizational ownership)

❑ Data Center Networking: Ethernet optimized for data centers

- Congestion control at Multi-Gigabit Speeds
- Micro-seconds transaction delays

7. Internet Routing

- ❑ Billions of nodes
- ❑ Large numbers of ISPs
⇒ Scalability Issues
- ❑ Performance:
Multipath routing
- ❑ Privacy issues
⇒ Virtual overlay networks

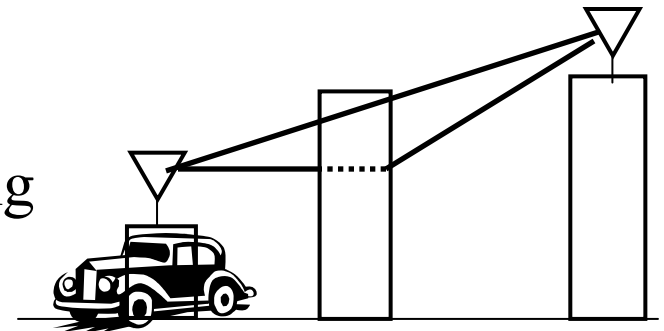


Wireless Networking

Impact of Wireless on Networking:

1. Not tied to walls/infrastructure
⇒ Ad-hoc networking
2. Error-prone ⇒ Traffic Management
3. Frequent Disconnections
⇒ Resource Management
Quality of Service for multimedia
4. Battery operated
⇒ Media access and networking while sleep
⇒ Time synchronization
5. Broadcast ⇒ Security

CSE574: Wireless and Mobile Networking

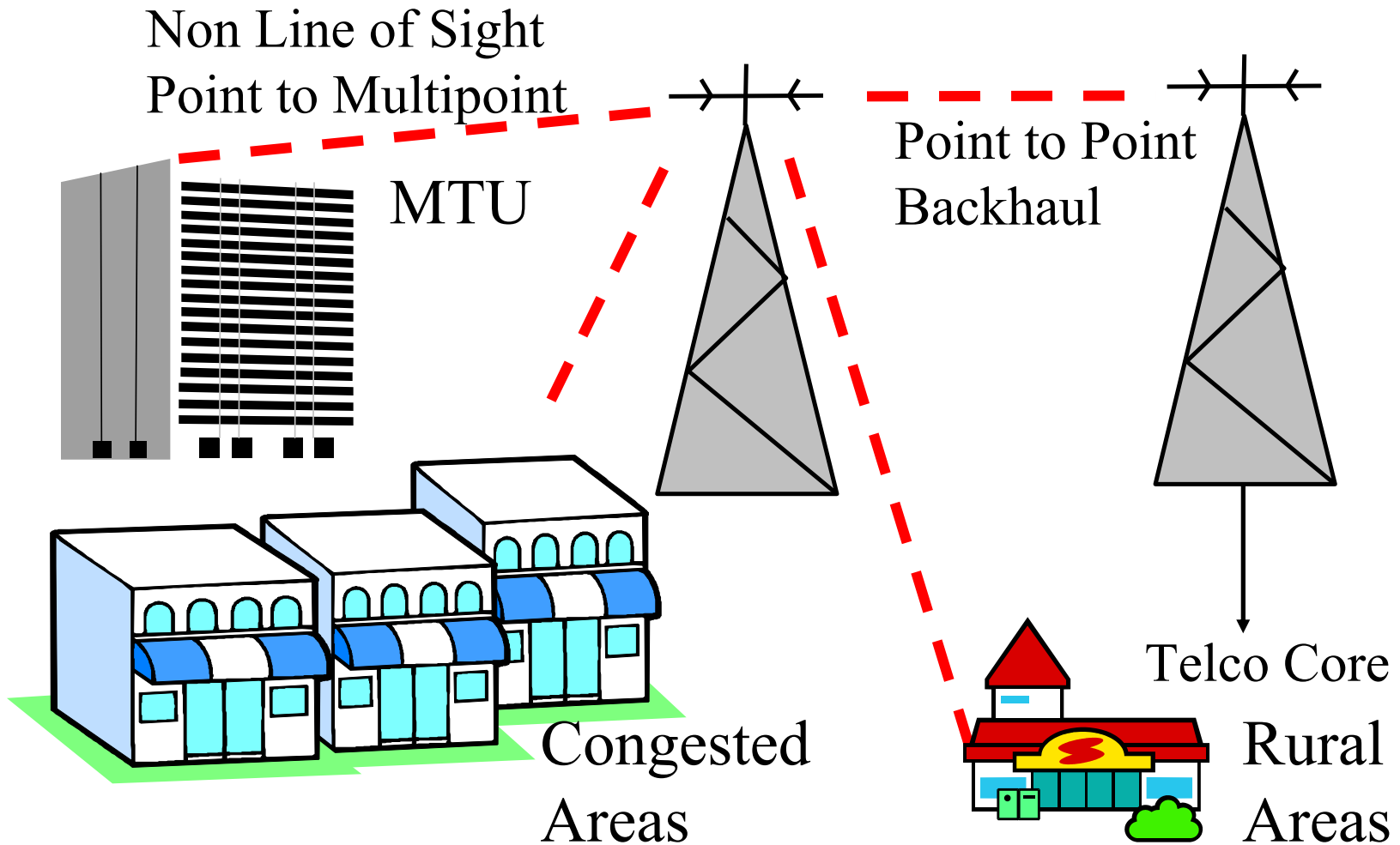


Cantenna



- ❑ 13,000 Free WiFi access nodes and growing
- ❑ 12db to 12db can-to-can shot can carry an 11Mbps link well over ten miles
- ❑ Ref: <http://www.netscum.com/~clapp/wireless.html>

Metropolitan High-Speed Wireless: WiMAX



IEEE 802.16 (WiMAX): Key Features

- ❑ WiMAX = Wireless Interoperability for Microwave Access ⇒ Industry group for interoperability
- ❑ Up to 50 km or Up to 70 Mbps.
- ❑ Data rate vs Distance trade off w adaptive modulation.
⇒ High rate near the tower.
Lower as distance increases
- ❑ Offers non-line of site (NLOS) operation
- ❑ Hundreds of simultaneous sessions per channel
- ❑ Allows mobility
- ❑ Robust Security

Status of WiMAX

- ❑ WiBro service started in Korea in June 2006.
- ❑ Service available in Bangalore, India since 2007.
- ❑ Sprint-Nextel in 2.3/2.5 GHz with equipment supplied by Intel, Motorola, Samsung, Nokia, and LG.
Initial deployment in Washington DC and Chicago (Sept 2008)
- ❑ 592 WiMAX networks in 148 countries (October 2010)
- ❑ New WiMAX V2 standard with higher was approved last year.
- ❑ Most of the ideas have been incorporated in a new technology called “Long Term Evolution (LTE)” that is more compatible with current cellular networks ⇒ Most cellular providers planning to go with LTE

Sample WiMAX Subscriber Stations



Alvarion



Airspan



Axxcelera



Siemens



Aperto



Redline



SR Telecom

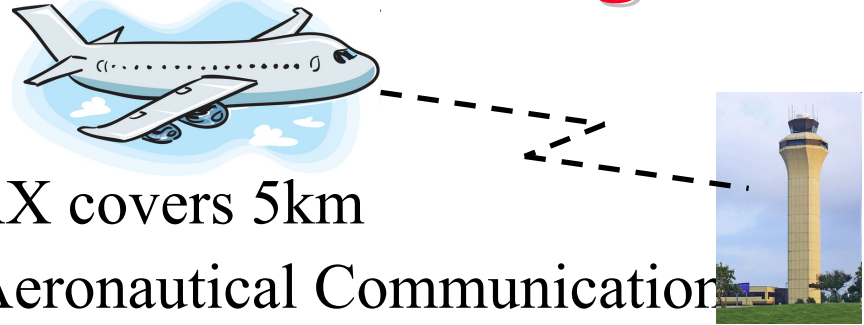


Telsima

Cavemen of 2050



Aeronautical Datalinks: Challenges



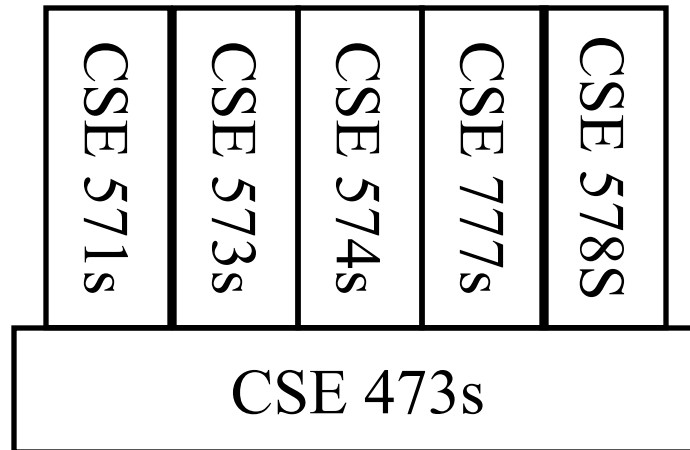
- ❑ Very long distances:
 - Wi-Fi covers 100m. WiMAX covers 5km
 - L-DACS (L-Band Digital Aeronautical Communication System) needs to cover 200 nautical miles (360 km)
 - ❑ Limited Power \Rightarrow High bit error rate or very low data rate \Rightarrow Low Spectral efficiency (2 bps/Hz is a challenge)
 - ❑ Long turn-around times \Rightarrow Large guard times (360km = 1.2 ms one-way at speed of light)
- ❑ Very High Mobility:
 - Wi-fi isn't designed for mobility (200m at 60km/hr = 12s between handovers)
 - WiMAX is designed for 60 km/hr
 - L-DACS needs to cover 600 nm/hr (1080 km/hr)

Next Generation Internet: Internet 3.0

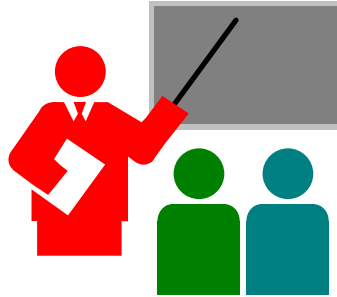
- ❑ Internet 1.0: Before Commercialization
 - First twenty years (1969-1989)
 - No Security, Optimal routing
- ❑ Internet 2.0: After Commercialization
 - 1989-2009
 - Security, Policy based routing: ISP
- ❑ Internet 3.0:
 - The next 20 years
 - How would you design the networks, if you were to design it today
 - All leading universities all over the world are working on a clean slate design
 - Internet 3.0 is the name of our clean-slate research program

Networking Courses at WUSTL

- ❑ CSE 473s: Introduction to Computer Networks
- ❑ CSE 571S: Network Security
- ❑ CSE 573s: Protocols for Computer Networks
- ❑ CSE 574s: Wireless and Mobile Networking
- ❑ CSE 578S: Multimedia Computing and Networking
- ❑ CSE 777s: Research Seminar in Networking



Overall Summary



1. Computer networking is the backbone of all computing
⇒ Cyber age
2. Key Issues: Security, Mobility, Energy, datacenters
3. Wireless is the major source of carrier revenue
⇒ Significant growth in Wireless networking
Working on gigabit wireless technologies
4. WUSTL has a leading research group on Computer Networking

References

- ❑ Audio/Video recordings and podcasts of several networking classes are available:
 - CSE 473: Introduction to Computer Networks, <http://www.cse.wustl.edu/~jain/cse473-10/index.html>
 - CSE 571S: Network Security, <http://www.cse.wustl.edu/~jain/cse571-09/index.html>
 - CSE 574S: Wireless Networks, <http://www.cse.wustl.edu/~jain/cse574-10/index.html>