

Wireless Networking: Trends and Issues



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These slides are available on-line at:

http://www.cse.wustl.edu/~jain/talks/cs131_08.htm

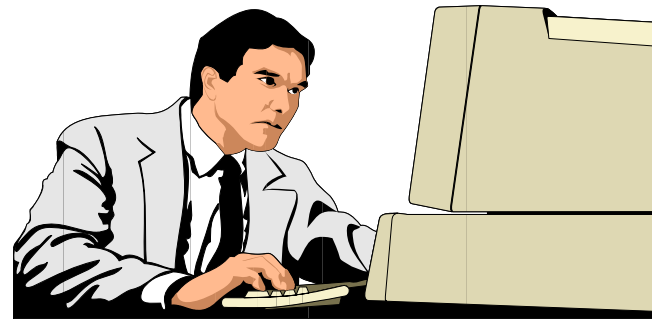


1. Recent Networking Developments
2. Wireless Networking Trends
3. Wireless Networking Challenges
4. Recent Wireless Technologies
5. Networking Courses at WUSTL

Goal: To get you interested in wireless networking research

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

Recent Networking Developments

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. Smart Cell phones w PDA, email, video, images
⇒ Mobility

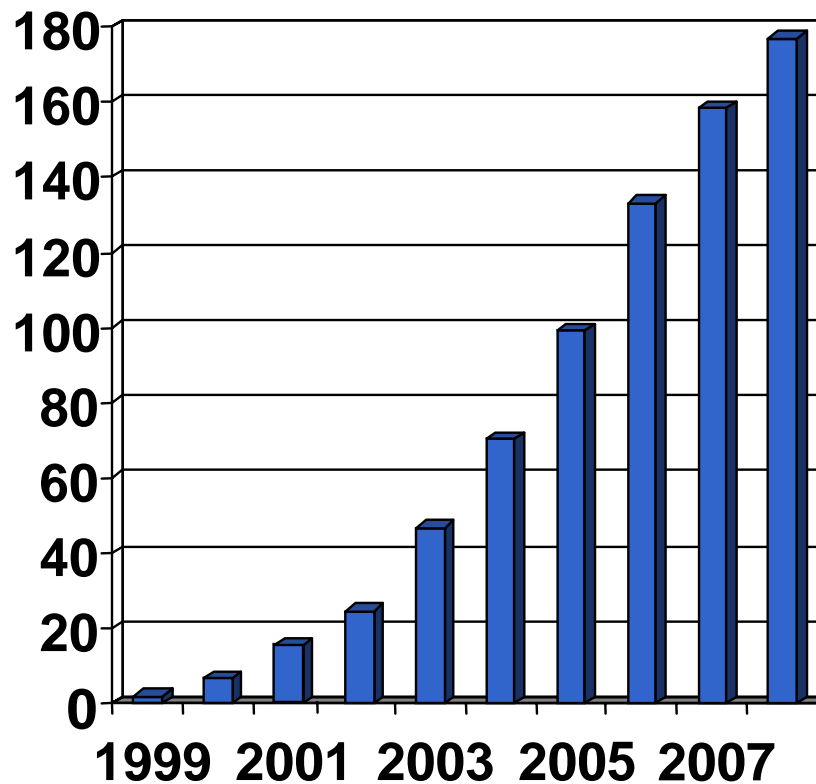
Telecom Revenue

| | Revenue in Billions | | | | | | Annual Growth |
|------------------------|---------------------|-------|-------|-------|-------|-------|---------------|
| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | |
| Video | 0.2 | 0.3 | .05 | 1.0 | 1.6 | 2.5 | 65.7% |
| Consumer Broadband | 2.8 | 3.5 | 4.0 | 4.2 | 4.6 | 4.8 | 11.4% |
| Consumer long distance | 20.7 | 18.2 | 16.0 | 13.6 | 11.3 | 9.2 | -15.0% |
| Business local | 26.3 | 26.7 | 26.4 | 26.1 | 25.8 | 25.5 | -0.6% |
| Business long distance | 26.1 | 24.5 | 23.0 | 21.3 | 19.7 | 18.2 | -7.0% |
| Business data | 44.8 | 45.6 | 46.6 | 47.1 | 46.8 | 45.4 | 0.3% |
| Consumer local | 46.9 | 42.2 | 39.0 | 36.2 | 34.0 | 32.3 | -7.25% |
| Wireless | 91.5 | 108.7 | 119.2 | 132.8 | 144.5 | 153.6 | 10.9% |
| Total | 260.7 | 271.5 | 277.0 | 285.0 | 291.3 | 294.9 | 2.5% |

- ❑ 48% revenues are from wireless.
- ❑ 26% of revenue from data (vs. voice)
- ❑ Source: Instat/MDR (Business Week, Feb 28, 2005)

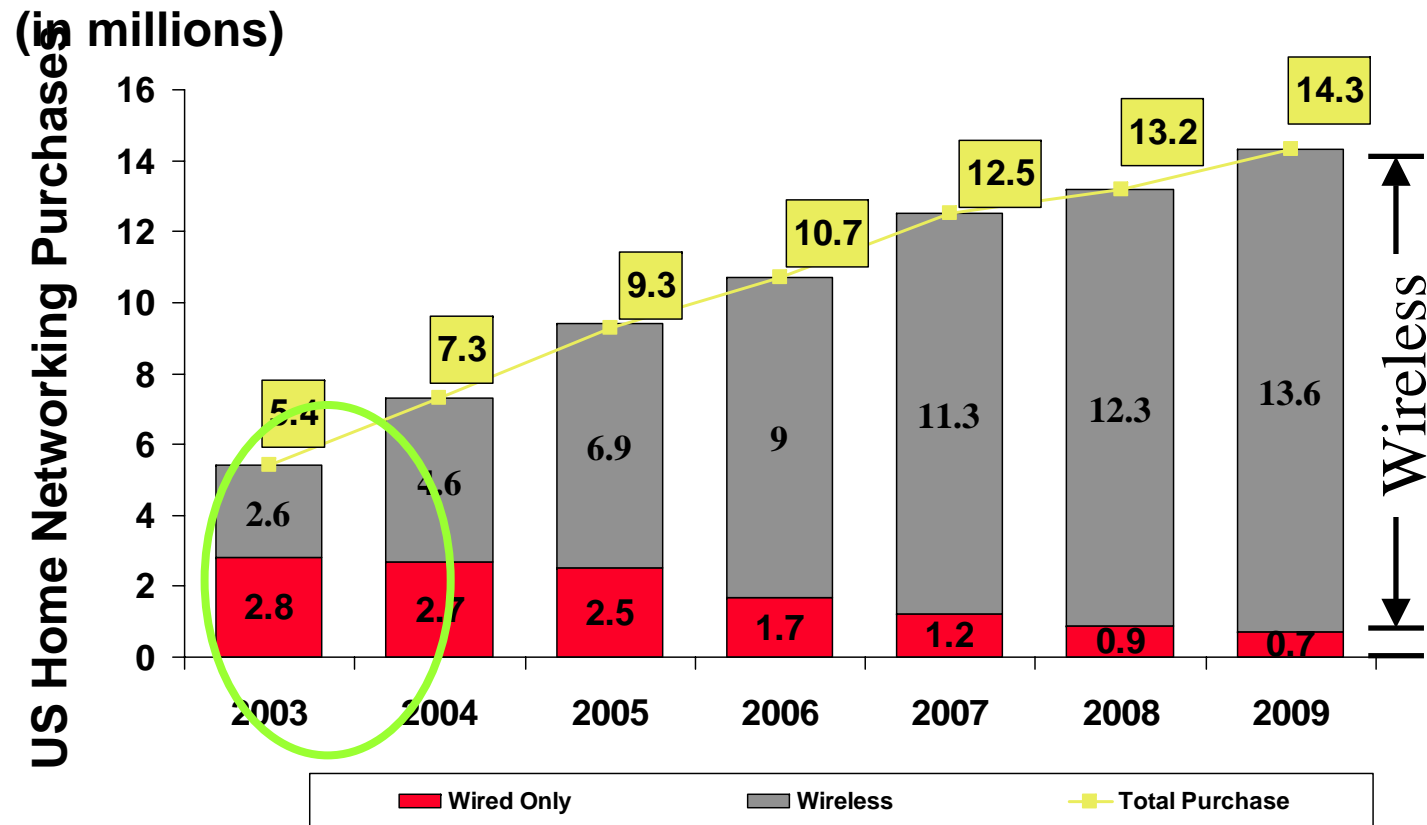
Wireless Data Connections

North American Wireless Data Connections (Millions)



Source: Gartner, "U.S. Wireless Data Market Update, 2004"

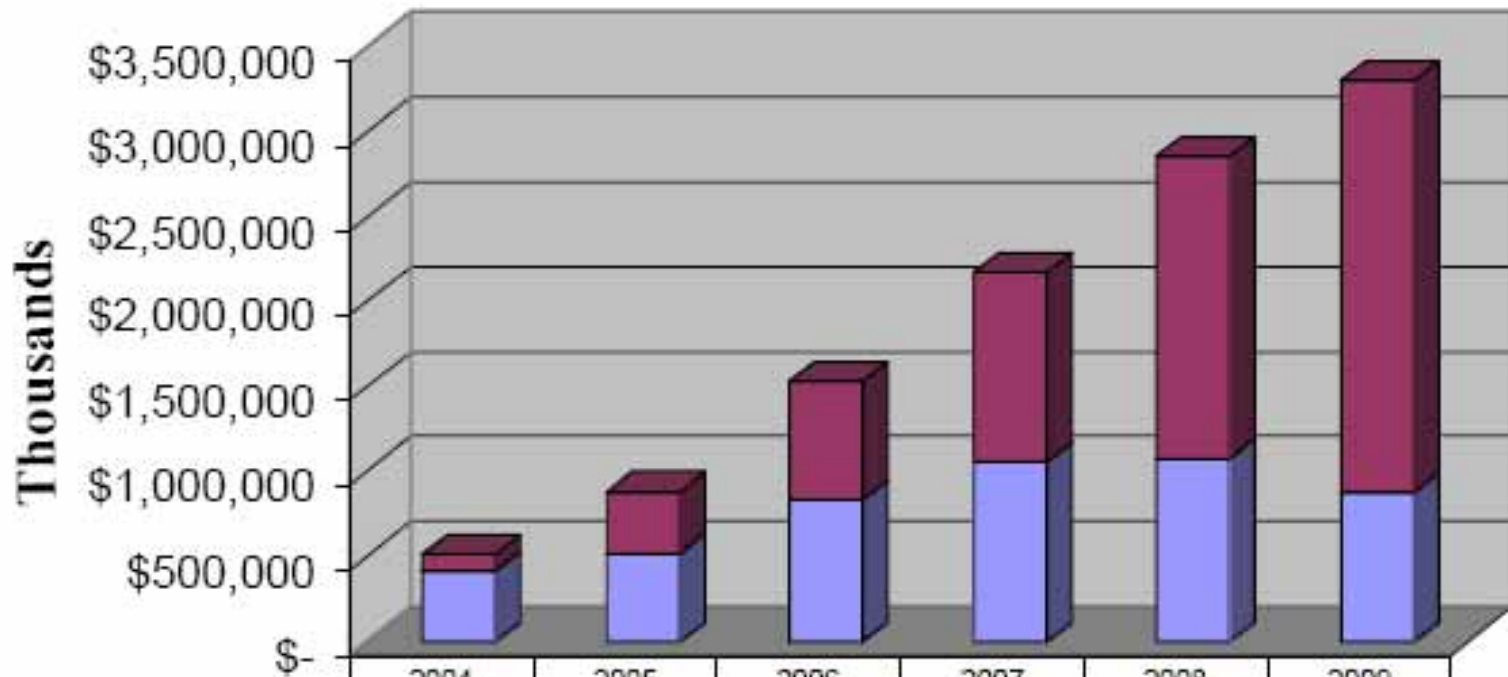
Home Networking Equipment Trends



Source: JupiterResearch Home Networking Model, 8/04 (US Only)

- Wireless outsold wired home networking gear for the first time in 2004

Personal Broadband: Fixed vs. Mobile

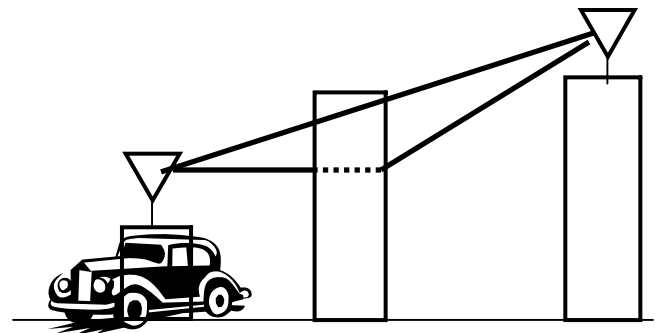


| | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|--------------------------------------|-----------|-----------|-----------|-------------|-------------|-------------|
| ■ Portable/Mobile wireless equipment | \$100,655 | \$358,184 | \$699,616 | \$1,118,670 | \$1,776,591 | \$2,415,165 |
| ■ Fixed wireless equipment | \$414,125 | \$519,620 | \$829,612 | \$1,051,557 | \$1,072,812 | \$878,090 |

Source: Skylight Research

Wireless Networking Challenges

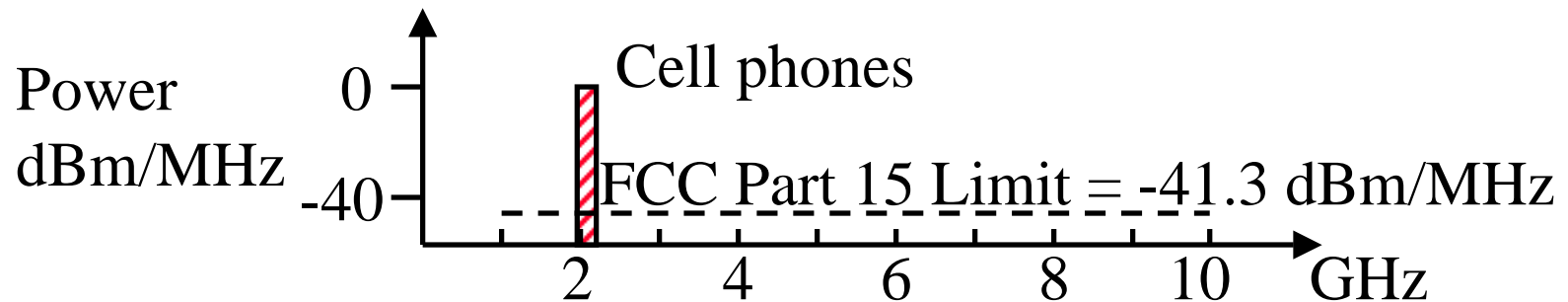
1. Propagation Issues: Shadows, Multipath
2. Interference \Rightarrow High loss rate, Variable Channel
 \Rightarrow Retransmissions and Cross-layer optimizations
3. Transmitters and receivers moving at high speed
 \Rightarrow Doppler Shift
4. Low power transmission \Rightarrow Limited reach
100mW in WiFi base station vs. 100 kW TV tower
5. Unlicensed spectrum \Rightarrow Media Access Control
6. Limited spectrum \Rightarrow Limited data rate
Original WiFi (1997) was 2 Mbps.
New standards allow up to 200 Mbps
7. No physical boundary \Rightarrow Security
8. Mobility \Rightarrow Seamless handover



Recent Wireless Technologies

- ❑ Ultra wide-band (UWB)
- ❑ Multiple-input Multiple-Output (MIMO)
- ❑ High-Speed Metro Wireless

Ultra-Wideband (UWB)



- ❑ US Federal Communications Commission (FCC) rules restrict the maximum noise generated by a wireless equipment
- ❑ UWB uses signals below the allowed noise level but uses 500 MHz to 10 GHz of frequency spectrum \Rightarrow Ultra-wide band
- ❑ FCC approved UWB operation in 2002
 - Between 3.1GHz and 10.6GHz
 - More than 500 MHz bandwidth
- ❑ High-speed over short distances \Rightarrow Wireless USB

Advantages of UWB

- ❑ Shares spectrum with other applications
- ❑ Large bandwidth
- ❑ Low probability of intercept and detection
- ❑ Resistance to jamming
- ❑ Superior penetration properties at low frequency spectrum
- ❑ Simple transceiver architecture. All digital. Low cost
- ❑ Very low energy consumption: Good Watts/Mbps
- ❑ Line of sight not required. Passes through walls.
- ❑ Sub-centimeter resolution allows precise motion detection.
Track high-value assets

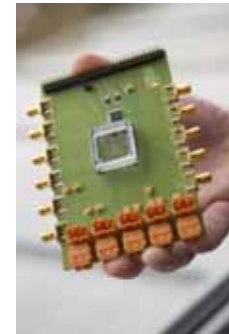
UWB Products (Cont)



Belkin
Wireless USB



Toshiba UWB
Docking Station



IMEC
UWB Chip



Cell phone with
Infineon UWB

Washington University in St. Louis



LeCroy UWB
Protocol Analyzer

CSE131



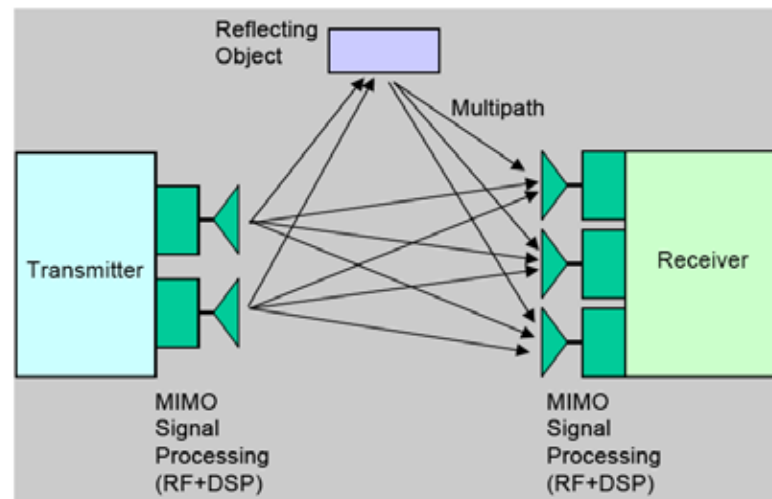
Haier's UWB-based
HDTV Media Server

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2. MIMO



- ❑ Multiple Input Multiple Output
- ❑ Simultaneous reception or transmission of multiple streams



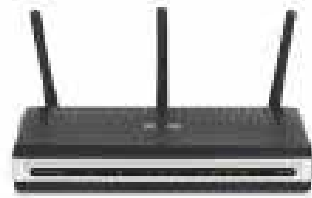
2x3

802.11n High-Throughput WiFi

- ❑ Uses multiple input multiple output antenna (MIMO)
- ❑ Data rate and range are enhanced by using spatial multiplexing (N antenna pairs) plus antenna diversity
- ❑ Up to 200 Mbps
- ❑ Linksys, Belkin, D-Link, Netgear have pre-11 wireless routers



Belkin



D-Link



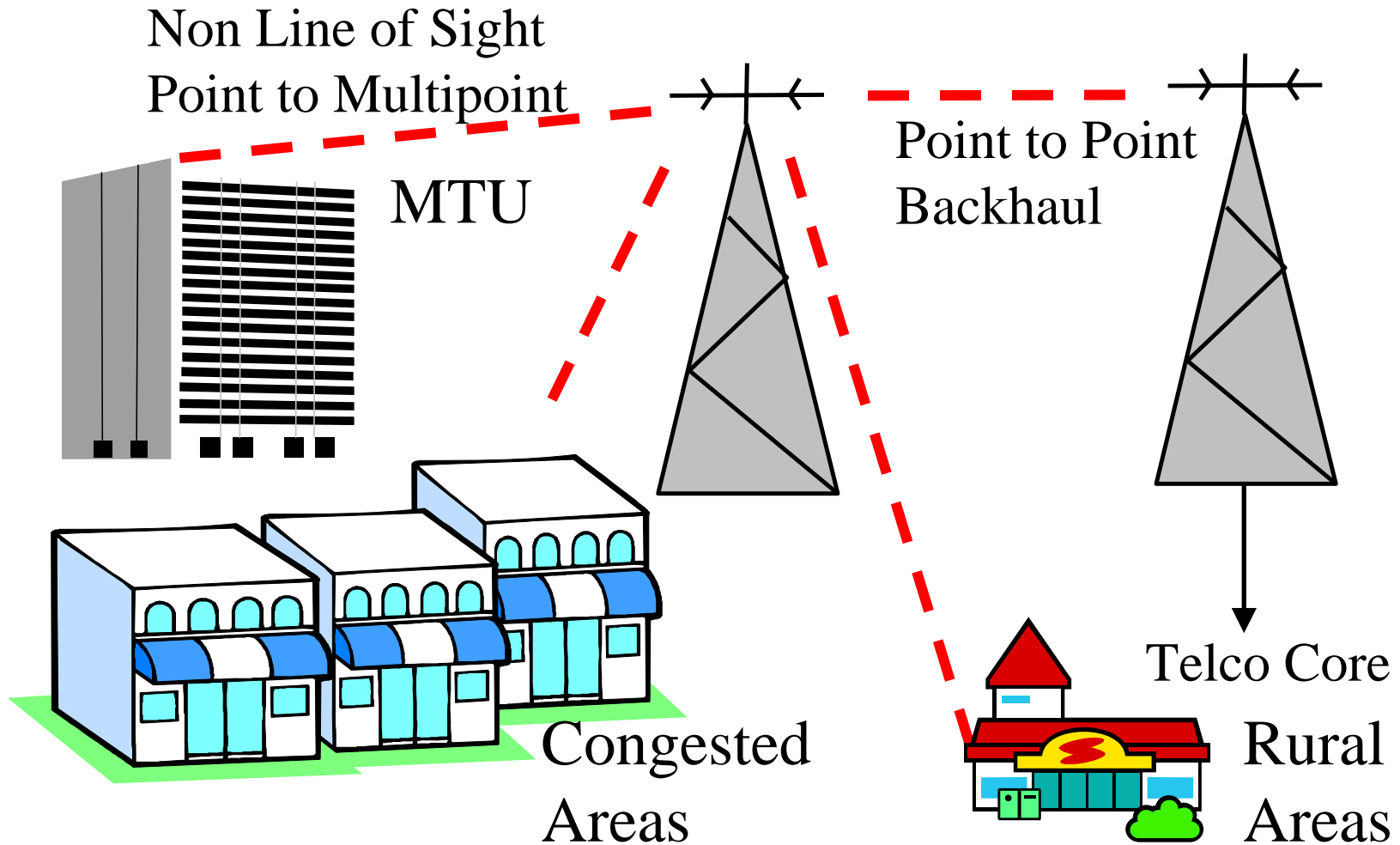
Linksys

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.netcum.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)
- ❑ More than 200 operators have announced plans for WiMAX
- ❑ About half are already trialing or have launched pre-WiMAX
- ❑ Two dozen networks in trial or deployed in APAC
- ❑ Intel has developed a multi-band WiMAX/WiFi chipset
In laptops before the end of this year

Sample WiMAX Subscriber Stations



Alvarion



Airspan



Axxcelera



Siemens



Aperto



Redline



SR Telecom



Telsima

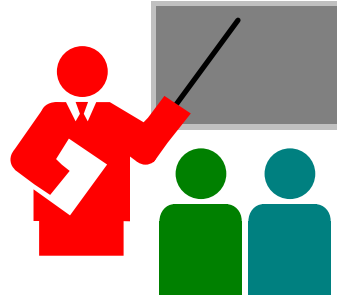
Cavemen of 2050



Networking Courses at WUSTL

1. CSE 473: Introduction To Computer Networks
2. CSE 471T: Communications Theory And Systems
3. CSE 521S: Wireless Sensor Networks
4. CSE 570A: Reinventing The Internet
5. CSE 571S: Network Security
6. CSE 572S: Signaling And Control In Communication Networks
7. CSE 573S: Protocols For Computer Networks
8. **CSE 574S: Advanced Topics In Networking (Wireless Networks)**
9. CSE 577M: Design And Analysis Of Switching Systems
10. CSE 578A: Multimedia Computing And Networking
11. CSE 7703: Research Seminar On Networking

Overall Summary



1. Wireless is the major source of carrier revenue
⇒ Significant growth in Wireless networking
2. UWB uses a wide spectrum by keeping the signal level below the allowed noise floor
3. MIMO uses multiple antennas for high throughput
Used in high-throughput WiFi
4. WiMAX with metro-wide wireless access is here
5. Working on gigabit wireless technologies

References

- ❑ Audio/Video recordings and podcasts of several networking classes are available:
 - CSE 473: Introduction to Computer Networks,
<http://www.cse.wustl.edu/~jain/cse473-05/index.html>
 - CSE 571S: Network Security,
<http://www.cse.wustl.edu/~jain/cse571-07/index.html>
 - CSE 574S: Wireless Networks,
<http://www.cse.wustl.edu/~jain/cse574-08/index.html>