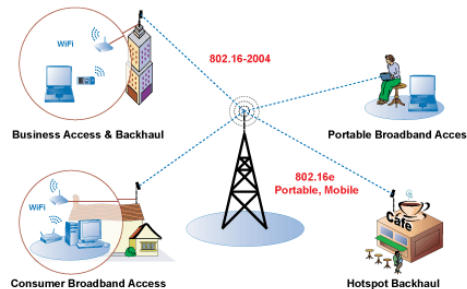


Wireless Networking: Issues and Trends



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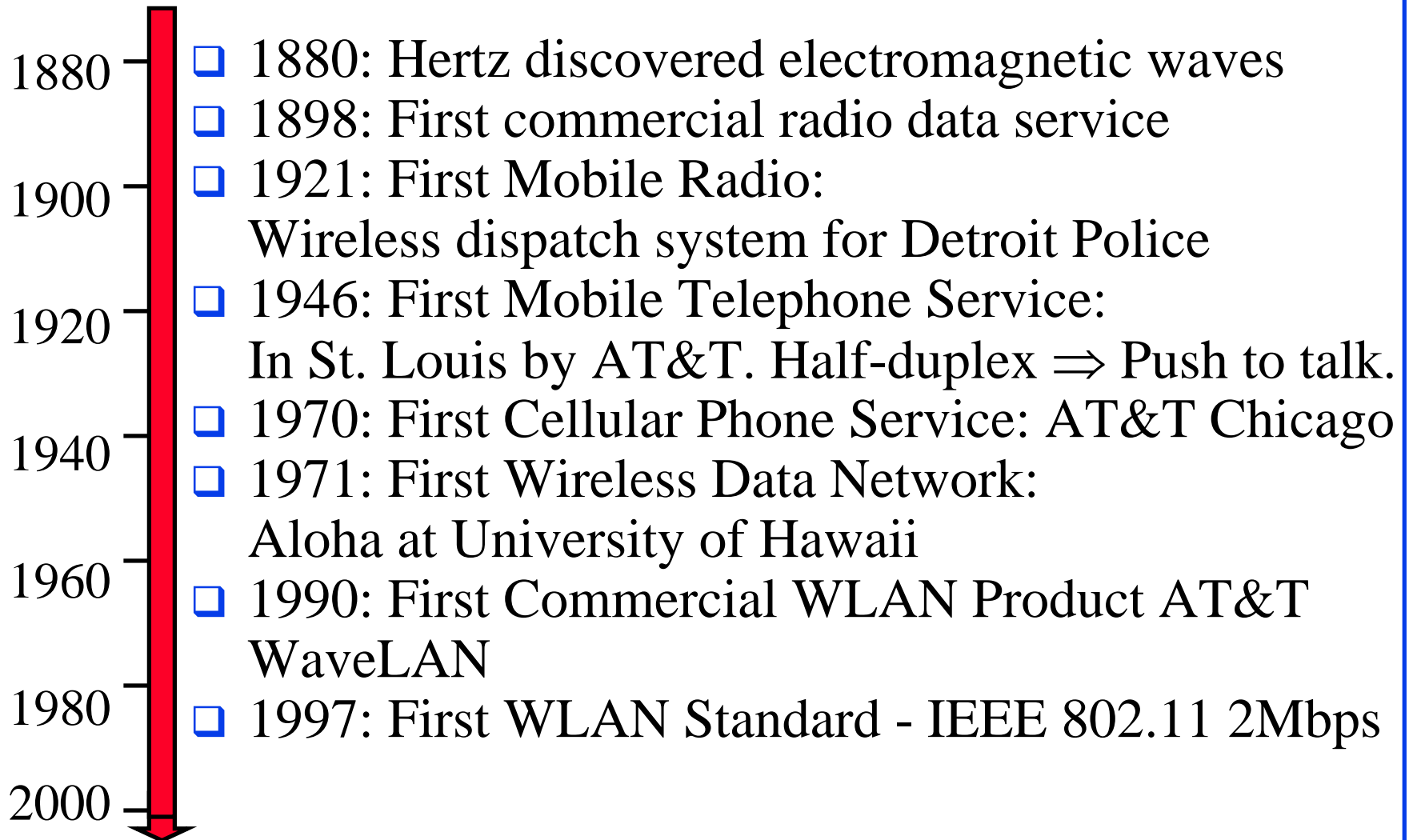
Audio/Video recordings of this lecture are available at:

<http://www.cse.wustl.edu/~jain/cse574-10/>

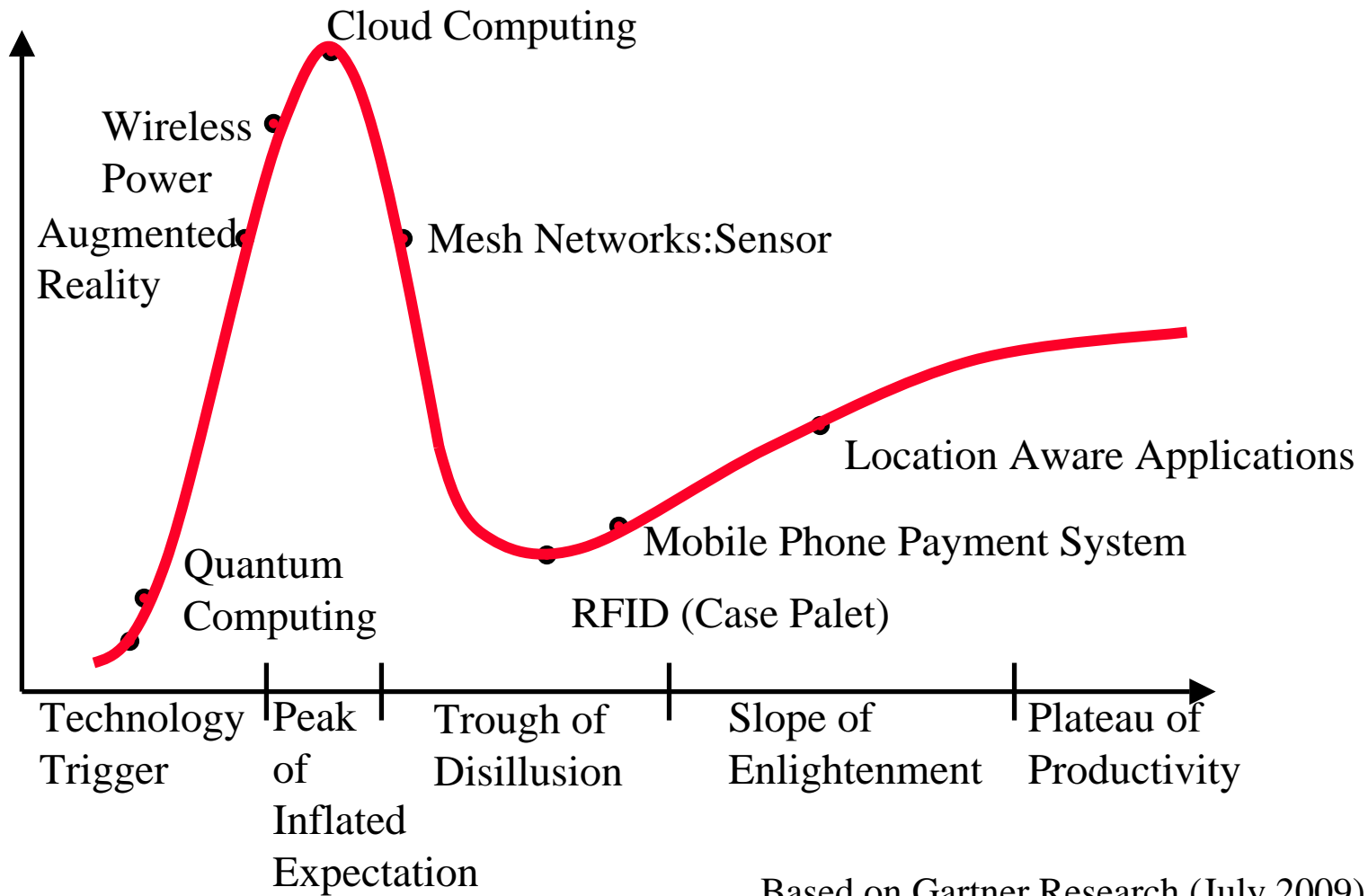


- ❑ Hype Cycles of Technologies
- ❑ Wireless Equipment/Revenue Trends
 - Global Broadband Wireless Equipment
 - Broadband Market by Regions
 - Fixed vs. Mobile
 - Voice vs. Data
- ❑ Wireless and Mobile Trends

Wireless: History

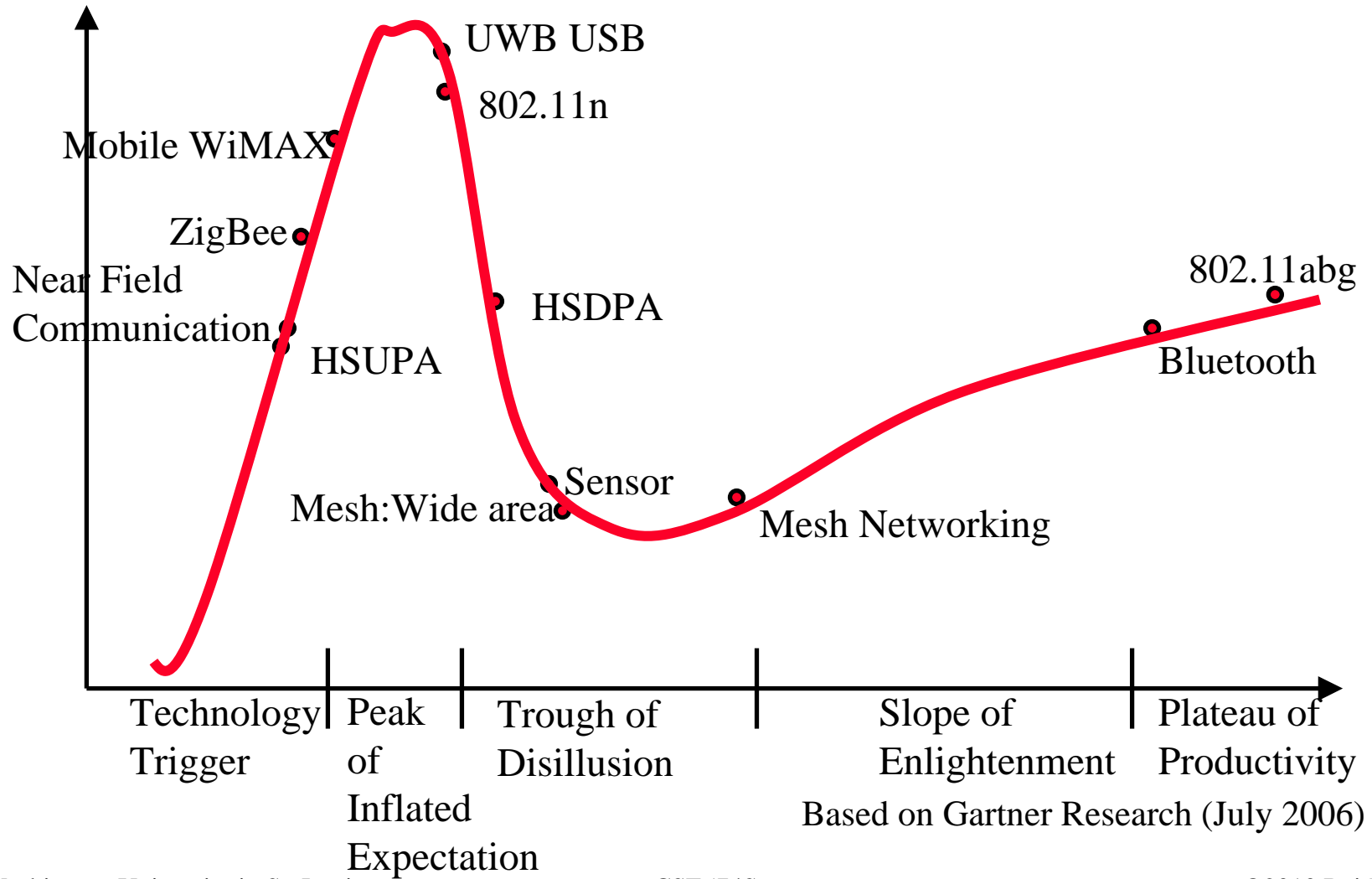


Technology Hype Cycle 2009



Based on Gartner Research (July 2009)

Wireless Networking Hype Cycle 2006

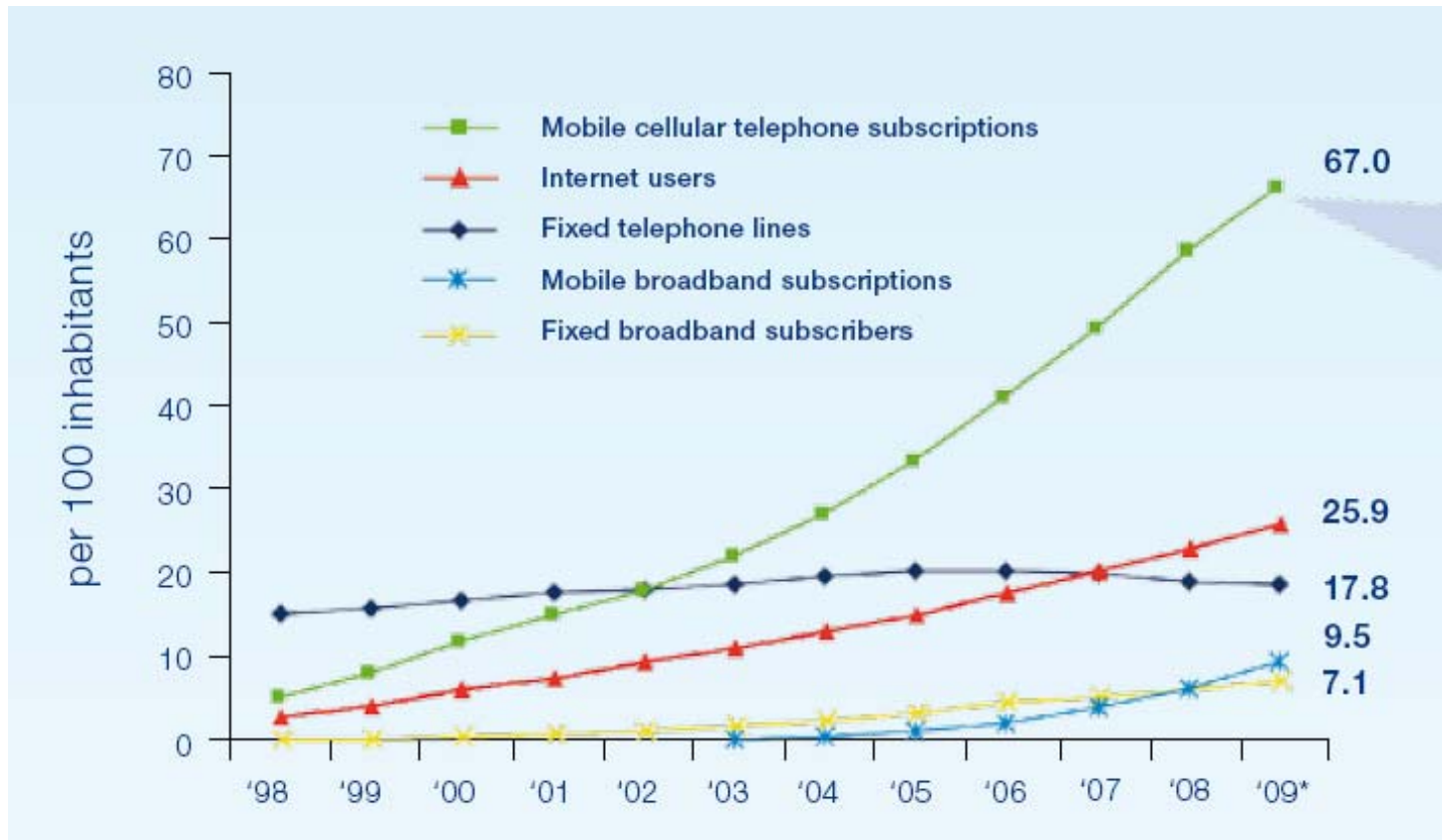


Telecom Revenue

	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)

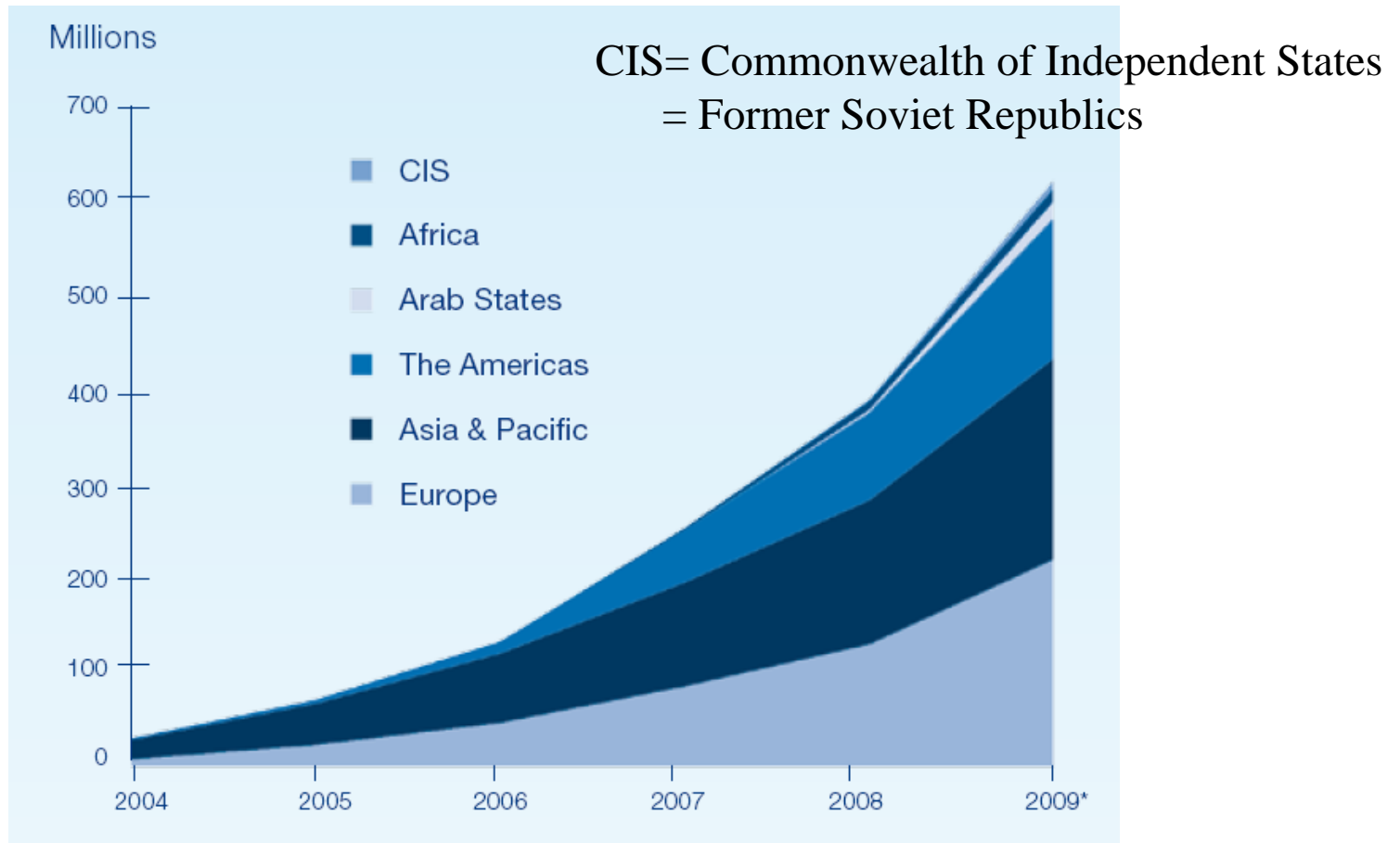
Communication Technology Growth



[Source: ITU 2009]

- ❑ Mobile cellular is most rapidly adopted technology in history
- ❑ A quarter of world population was using Internet in 2009

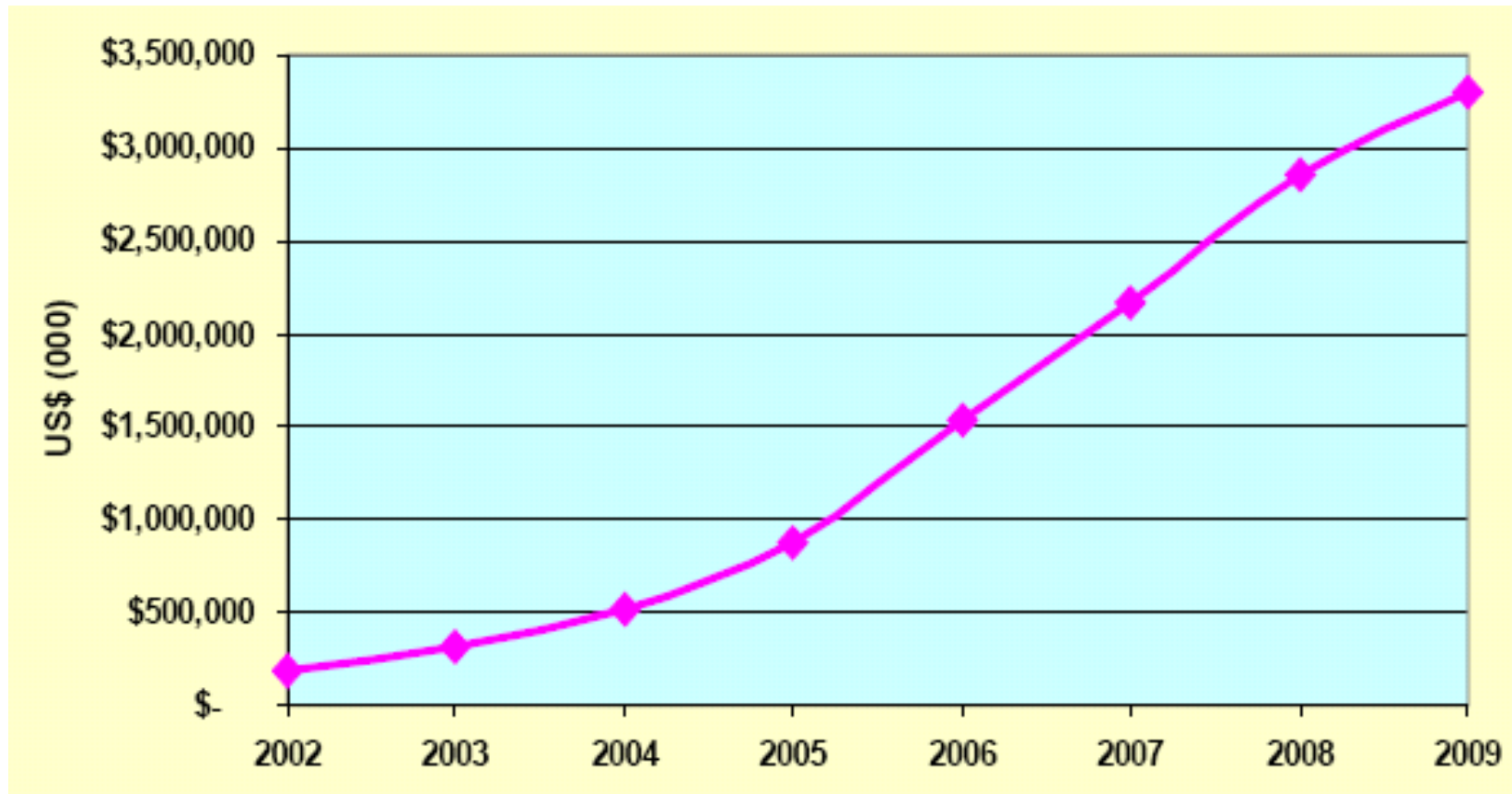
Mobile Broadband By Regions



[Source: ITU 2009]

- Most action in Europe, Asia & Pacific (Japan+Korea 70%) and America's (USA 83%).

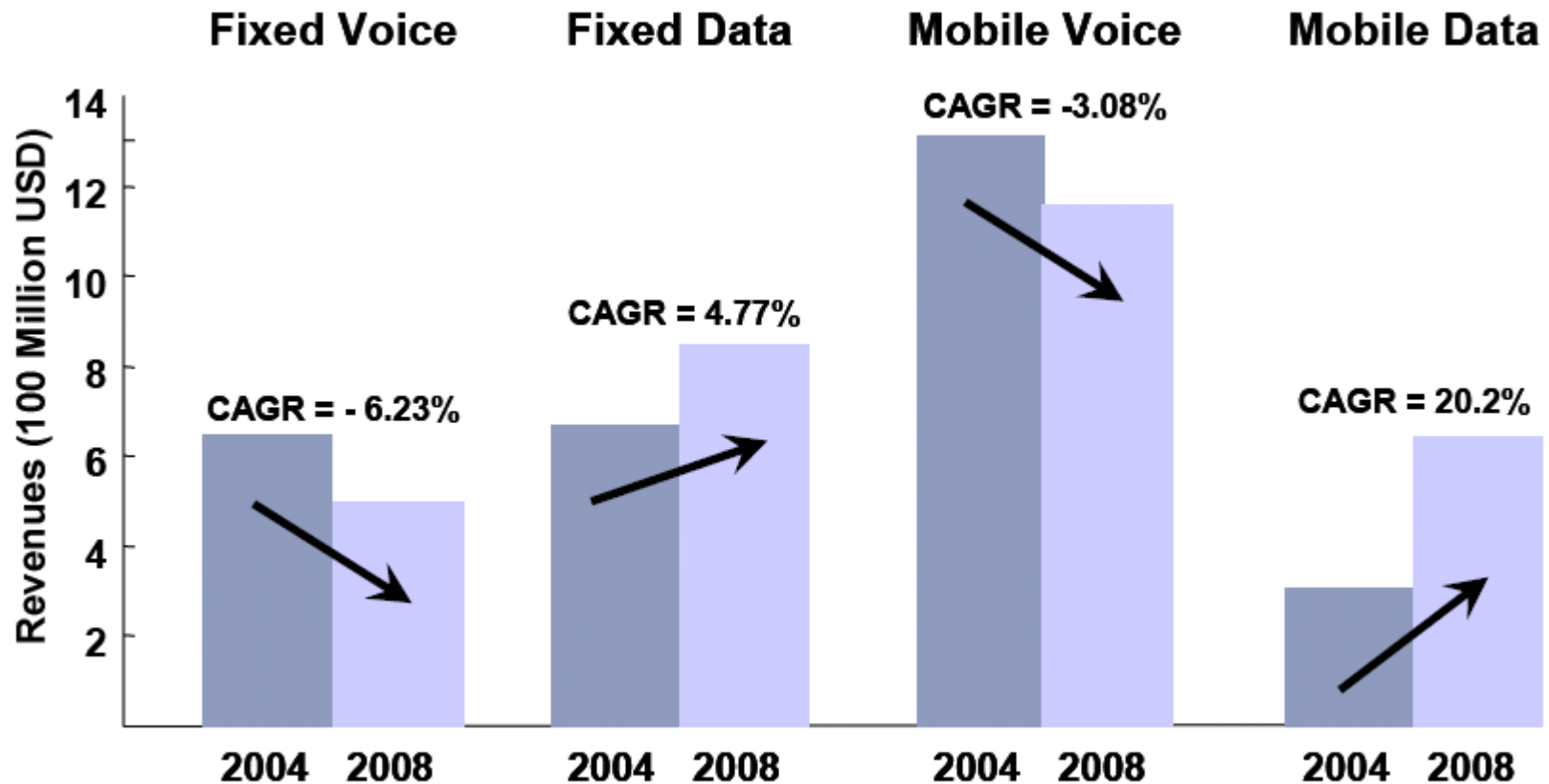
Global Broadband Wireless Equipment



□ 0-10 GHz, Base stations+Subscriber stations

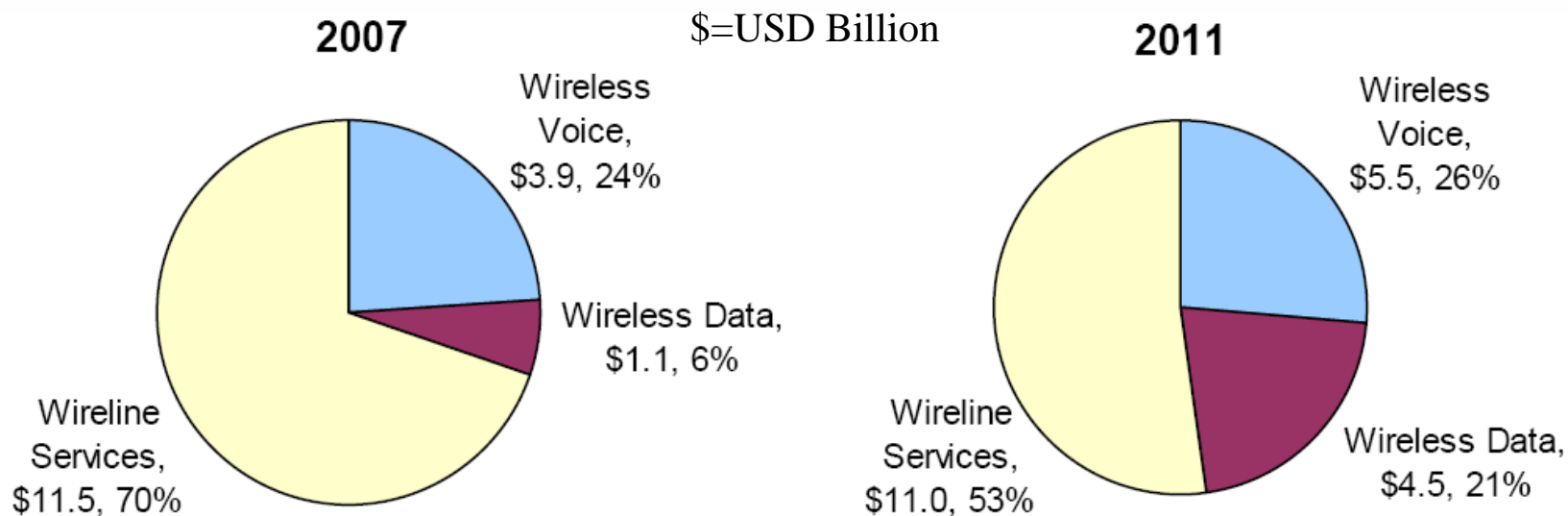
Source: Skylight Research

Voice and Data Revenues (Korea)



Source: KISDI 2004

US Government Spending



Source: In-Stat, 9/07

Conclusions:

1. Wireline is declining
2. Wireless is increasing
3. Wireless data is increasing more than wireless voice

IEEE Communications Society Digital Library: Top 10 Downloads:

1. Information theory of wideband communications
2. Application-oriented network metrology: Metrics and active measurement tools
3. Channel estimation for wireless OFDM systems
4. Using game theory to analyze wireless ad hoc networks
5. Routing in intermittently connected mobile ad hoc networks and delay tolerant networks: Overview and challenges
6. A survey and comparison of peer-to-peer overlay network schemes
7. Broadband wireless access with WiMax/802.16: Current performance benchmarks and future potential
8. A survey of topologies and performance measures for large-scale networks
9. Call admission control in wireless networks: A comprehensive survey
10. A survey of security issues in mobile ad hoc and sensor networks

Observation: 7 out of 10 top downloads are on wireless. [January 2009]

Ref: <http://dl.comsoc.org/comsocdl/>

Wireless and Mobile Networking Trends

1. Mobile Data Traffic Explosion
2. High-Speed Metropolitan Area Networks
3. Femtocells
4. Green Mobile Networking
5. Mobile Apps
6. Mobile Computing
7. Mobile Cloud Computing
8. Mobile-Based Augmented Reality
9. Near Field Communication \Rightarrow Mobile Commerce

Ref: Juniper Research 2010

Mobile Data Traffic Explosion

- ❑ 33.8 million iPhones
- ❑ 3G Networks can't cope
⇒ Need 4G (LTE or WiMAX)

High-Speed Metropolitan Area Networks

- ❑ 3G provides 192kbps to 512 kbps per user (3.6 Mbps Max)
- ❑ WiMAX is here (3 to 6 Mbps)
 - Clearwire selling WiMAX in 24 Markets (Nov 09)
 - DSL rates on Wireless
- ❑ Long-term Evolution (LTE) is coming.
 - Verizon to launch LTE in 30 markets in 2010.
 - ATT in 2011.
- ❑ 802.16e standardized by IEEE
- ❑ LTE Advanced in works.

WiMAX in USA

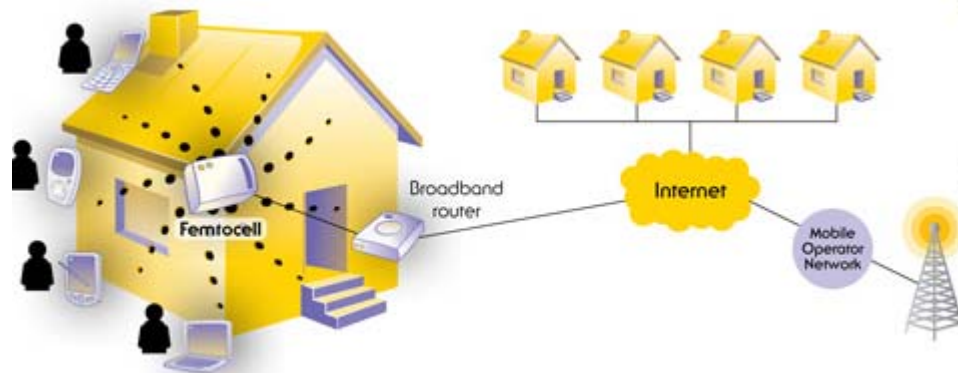


24 Markets (Nov 2009)

Source: Clearwire.com

Femtocells

- ❑ A little cellular tower inside a home
- ❑ Allows cell phones to work better inside homes (and offices)
- ❑ Uses the same frequencies as outside towers and cell phones handoff from outside to inside and vice versa
- ❑ May use DSL connection for high-speed data transfer



Ref: <http://en.wikipedia.org/wiki/Femtocell>

Green Mobile Networking

- ❑ Better Batteries - Fast recharge, longer life
- ❑ Energy savings modes
- ❑ Recyclable handsets (made from recycled materials)
- ❑ Recycling of Handsets
- ❑ Reduced Power consumption at Base Stations
- ❑ Renewable Energy for base stations

Mobile Apps

- ❑ 2 Billion Apps in 15 months.
- ❑ 30 Apps stores
- ❑ Mobile presence critical - Apps for Facebook, New York Times, ...

Mobile Computing

- ❑ Most iPhone users read email, news, Internet tasks on iPhone.
- ❑ In 2008, netbooks outsold desktop computers.
- ❑ New netbooks similar to iPhone. 3G connectivity.
- ❑ Apple Tablet to be announced (Jan 2010).
- ❑ Solid-state storage drives (SSDs)
- ❑ Hybrid drives: Hard drives with SSD cache (cost effective and fast)
- ❑ Next generation of phones/computers will have better keyboarding experience

Mobile Cloud Computing

- ❑ Thin clients on mobile. Processing/storage in remote servers.
- ❑ All computing on browser
- ❑ Android: Mobile operating system. Open source code. Java based applications.

Mobile-Based Augmented Reality

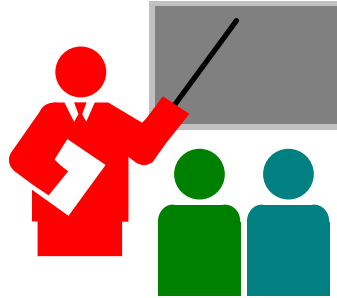
- ❑ Combine Real + Virtual in real time
- ❑ Real = Location, Photo,
- ❑ Virtual = What's inside, near by,
- ❑ iPhone Apps:
 - Sky gazer
 - Photo applications
 - WiFi Finders

Near Field Communication

- ❑ Phones with Near Field Communications Technology (NFC) for payments
- ❑ Active RFID
- ❑ Nokia 6131 Phone with NFC



Summary: Wireless Trends



- ❑ Wireless is the major source of carrier revenue
⇒ Significant growth in Wireless networking
- ❑ Growth also in home and enterprise market
- ❑ Moving from fixed to mobile wireless
- ❑ Moving from voice to data

References

- ❑ Juniper Research, "**Top Ten Wireless Predictions 2010,**"
<http://www.juniperresearch.com/toptenwirelesspredictions2010.php>
- ❑ Jackie Fenn, "**Inside the Hype Cycle: What's Hot and What's Not in 2009,**"
http://my.gartner.com/it/content/1101800/1101817/august12_hype_cycle_final_jfenn.pdf
- ❑ Gartner Research, "**Hype Cycle for Wireless Networking 2006,**"
http://www85.homepage.villanova.edu/timothy.ay/DIT2160/AltBackbone/hype_cycle_for_wireless_netw_140974.pdf
- ❑ Brian Nadel, "**Mobile tech 2010: Five trends that will change our lives,**"
<http://www.computerworld.com/s/article/9127152>
- ❑ In-Stat, "**Wireless Trends and Expenditures: US Government,**"
<http://www.corp.att.com/stateandlocal/docs/wirelessgov.pdf>, October 12, 2007.
- ❑ ITU, "**The World in 2009: ICT Facts and Figures,**"
http://www.itu.int/net/TELECOM/World/2009/newsroom/pdf/stats_ict200910.pdf, 8 pp.

References (Cont)

- ❑ Institute for Prospective Technological Studies (IPTS), "**Mapping European Wireless Trends and Drivers**," <http://ftp.jrc.es/EURdoc/22250-ExeSumm.pdf>, May 2006.
- ❑ Maravedis, "**WiMAX and Broadband Wireless (Sub-11Ghz) Worldwide Market Trends 2008-2014**," http://www.maravedis-bwa.com/Brochure_2005_April_MarketReportWiMAX.pdf, February 2008, 20 pp.
- ❑ VisionMobile Research, "**Mobile Megatrends 2010**," <http://www.visionmobile.com/rsc/researchreports/Megatrends-2010-VisionMobile-%28Rutberg-version%29.pdf>, September 2007, 47 pp.
- ❑ United Nations Foundation, "**Wireless Technology for Social Change: Trends in Mobile Use by NGOs**," http://mobileactive.org/files/MobilizingSocialChange_full.pdf, 2008, 60 pp.
- ❑ Richard Traherne, "**Wireless Trends in Healthcare**," <http://www.cambridgeconsultants.com/downloads/library/WBU-P-023v2.0.pdf>

HTML – An Intro

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HTML Intro (2)

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Voice over IP">

<META NAME="Description" CONTENT="Lectures and
reports on recent advances in networking ">

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<H2>Issue 1: High Speed</H2>

HTML Intro (3)

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Project Homework 2

- ❑ Prepare your personal web page. Must include your photograph
- ❑ Use meta-HTML commands in the header to indicate title, keywords, description, etc
- ❑ Must use at least all the commands listed in “HTML Intro” slides. Use others as appropriate.
- ❑ Use only a text editor
- ❑ Submit a link to the page via email to jain@cse.wustl.edu with a subject field of: CSE 574S Homework 2
- ❑ Validate your page on:
 - W3C Markup Validation Service, <http://validator.w3.org/>
 - HTML code check by Net Mechanic, <http://www.netmechanic.com/toolbox/html-code.htm>
 - CSE HTML Validator , <http://www.htmlvalidator.com/>