EE 577: Wireless and Personal Communications

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Lecture 1: Introduction

Common Applications of Wireless Systems

- AM/FM Radio Broadcast
- VHF and UHF TV Broadcast
- Cordless Phones (e.g., DECT)
- Cellular phones (GSM, cdmaOne, UMTS, etc)
- Broadband Wireless Access
- Wireless LANs
- Wireless Personal Area Networks (WPAN) (e.g., Bluetooth, Zigbee, etc.)
- Wireless sensor networks (WSN)
- Satellite, GPS, Paging, …, etc.

Cordless vs. Cellular

- Cordless
  - Small cell size and low or no mobility
  - Very low handset power
  - Handset and base station have low complexity
- Cellular
  - Large cell size and supports high mobility
  - higher handset power
  - Base station is complex

Examples of Wireless vs. Mobile

Wireless	Mobile	
✗	✗	stationary computer
✓	✗	wireless LANs
✓	✓	Cellular phone

Infrastructure vs. Ad Hoc

- Infrastructure
  - Base station exists
  - Organized in cell-based topology
  - Simplified link and routing protocols
- Ad Hoc
  - No base station exists
  - Self-organized following protocols
  - Involved link and routing protocols

Wireless Networks vs. Fixed Networks

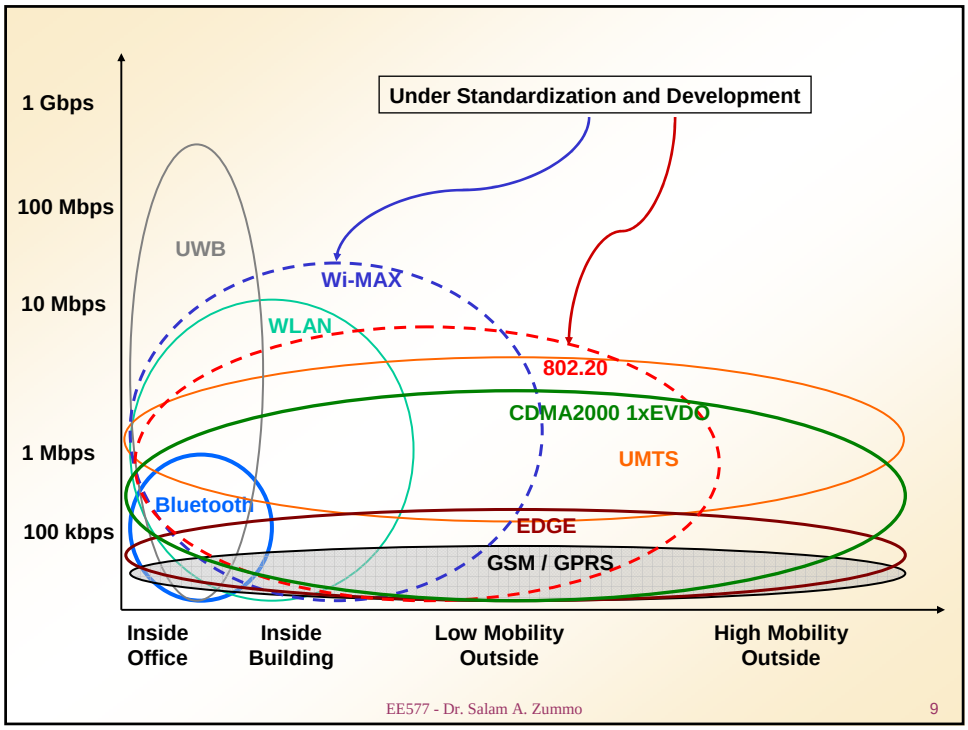
- Signal Propagation:
  - Higher loss rates and delays
  - Interference
  - multipath fading
  - higher timing jitter
- Spectrum Issues
  - limited resources ➔Restrictive regulations of frequencies
  - Shared medium ➔ Multiple Access Techniques
- Security Issues
- Power Issues
- Mobility Issues

Challenges in Wireless Communications

- Limited bandwidth
- Different and harsh propagation environments (multipath fading)
- Interference
- Security threat
- Limited mobile set power
- others

Wireless Systems Standards

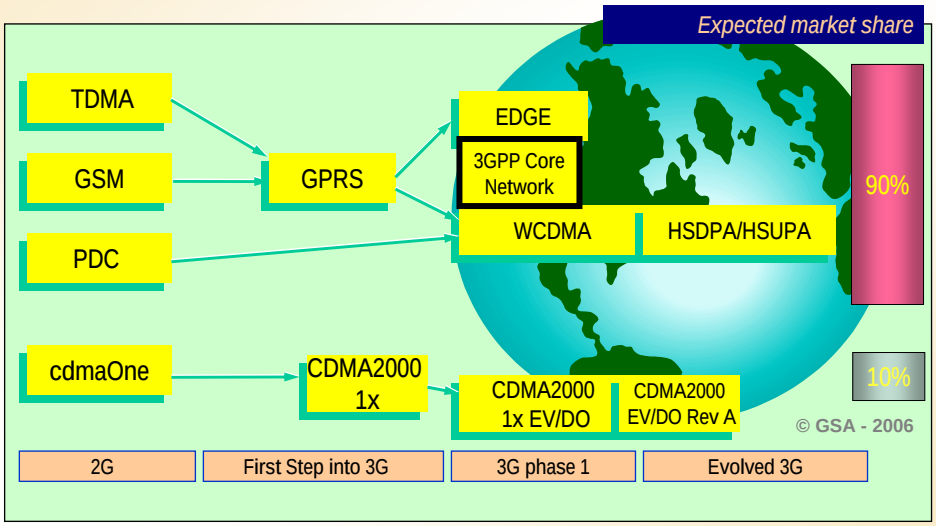
- Different requirements (rate, range, mobility, …)
- Different applications (voice, data, integrated)
- Different Generations (Technology).
- Different Parts of the World.
- Different Companies.



Existing Wireless Systems

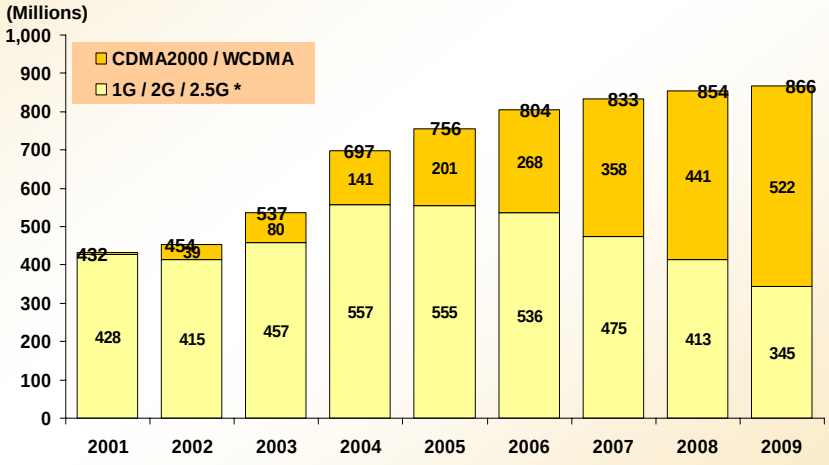
- 3G Cellular (WCDMA)
  - Frequency Division Duplex (FDD): Paired spectrum
  - Time Division Duplex (TDD): Allows "asymmetric" traffic (adjust time slots in uplink and downlink)
  - Lately: HSDPA and HSUPA
- 3G Cellular (CDMA2000, 1x, 3x, 1xEV-DO, 1xEV-DV)
- Wi Fi
  - 802.11, 802.11b and 802.11g
  - Unlicensed frquency band
- WiMAX
  - 802.16d (fixed); 802.16e ("nomadic")
  - 2-6 GHz band; 1.5 – 20 Mbps symmetrical BW

3G Evolution

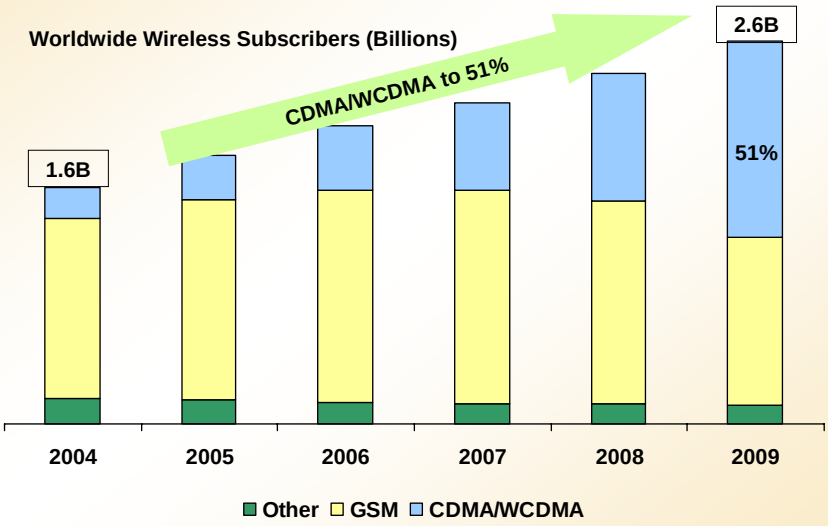


Global Wireless Handset Shipments

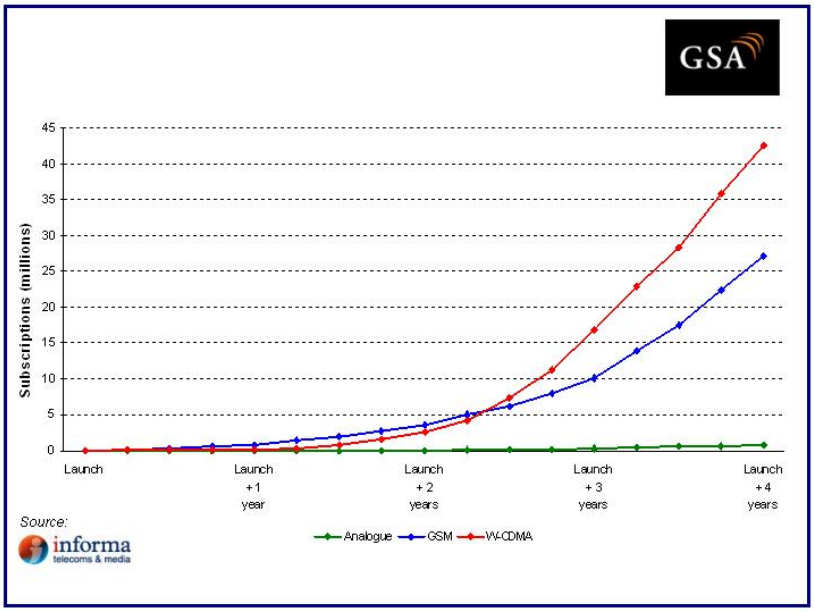
3G (CDMA2000 and WCDMA) will make up 60% of total shipments by 2009



CDMA/WCDMA Becomes the Dominant Wireless Technology



WCDMA Growth Outperforming GSM



3G Data Speeds

	Peak Network Speed	Peak Device Speed	Average PC Browser Speed (loaded network)	Average Streaming Media Speed (loaded network)
GPRS	115 kbps	53 kbps	**20-30 kbps**	10-20 kbps
EDGE	470 kbps	237 kbps	**80-130 kbps**	20-40 kbps
WCDMA	2 Mbps	2 Mbps	**200-300 kbps**	up to 384 kbps
1xRTT	153 kbps	153 kbps	**40-60 kbps**	~64 kbps
1xEV-DO	2.4 Mbps	2.4 Mbps	**120-300 kbps**	50-100 kbps

Source: AT&T Wireless, Mar 2002

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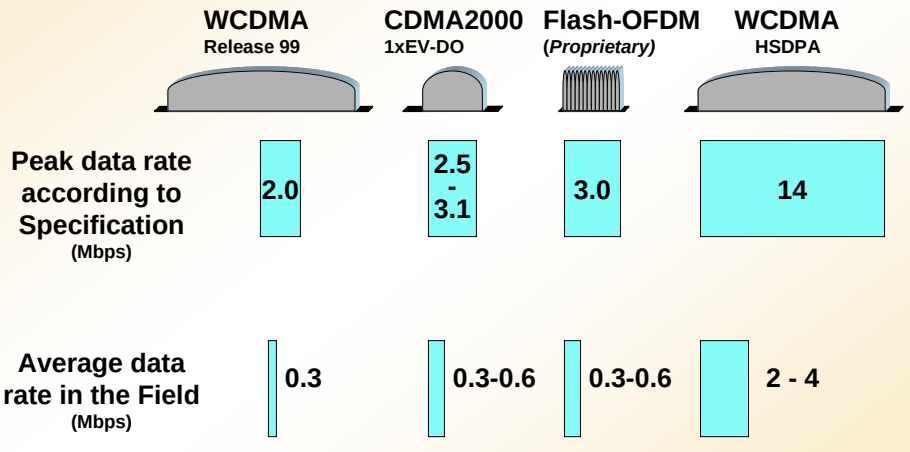
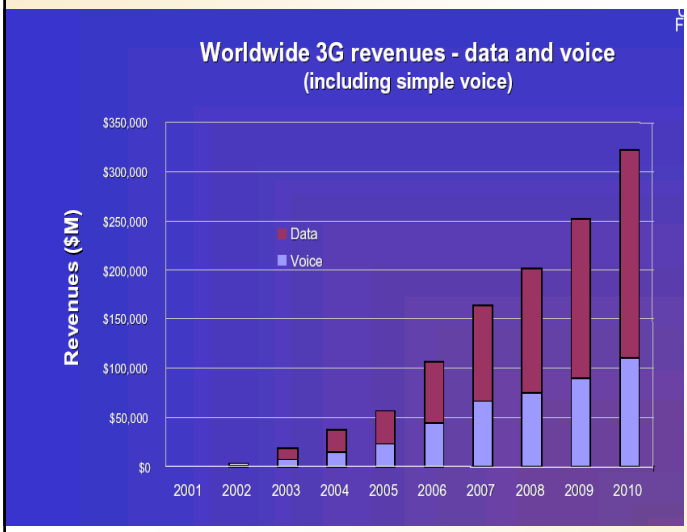
User Data Rates

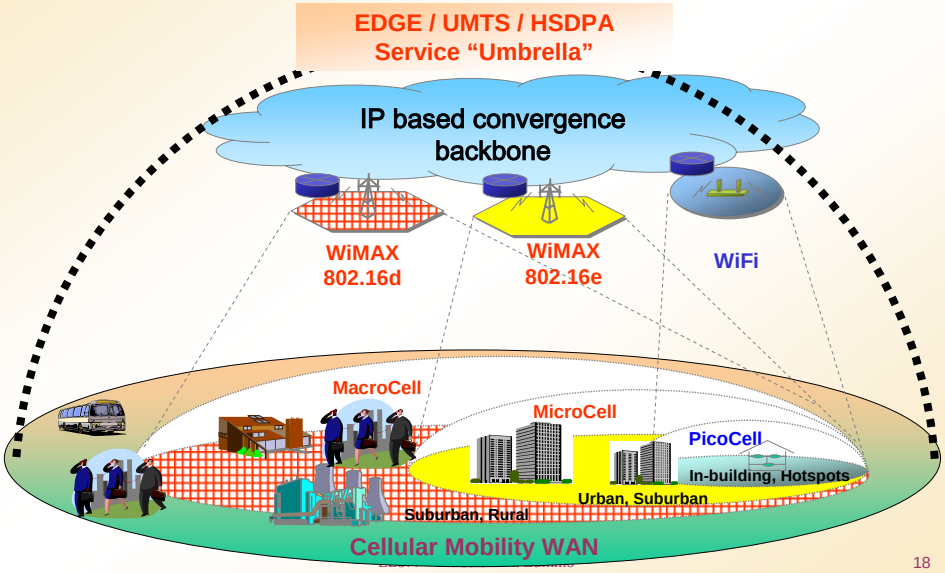


3G+ Systems



- Based on existing 3G spectrum (not new spectrum).
- By 2010, 66% of the revenues will come from data services
- UMTS - Release 99/4 systems alone will not be capable to meet these demands.
- Ultra high speed packet data service (10.8 Mbps)
- All-IP Core Network.

A converged 3G+, WiMAX and WiFi wireless network on a common IMS backbone will provide the lowest cost technology with the widest range of functionality



Course Topics

- The Cellular Concept (Chapter 3)
- Mobile Radio Propagation (Chapter 4, 5)
- Multiple Access Techniques (Chapter 9)
- Systems and Standards (Chapter 11 and external material).
- Wireless-related issues in
  - Modulation
  - Equalization
  - Channel Coding
  - Speech Coding

Notes About Your Textbook

- Written by one of the pioneers of the field.
- Good reference to published material.
- Many examples, though some are trivial.
- Mis-organization: overlap and repetition
- Variable re-use!

Grading Policy

- Homework : 20%
- Midterm Exam: 25%
- Presentation : 10%
- Term Project : 15%
- Final Exam : 30%

Mobile Telephone Service (MTS)

- Introduced in 1946 in USA
- Based on FM technology
- Each voice channel of 3 KHz used 120 KHz of spectrum
- Only half duplex service was available.

Improved Mobile Telephone Service (IMTS)

- Introduced in the mid 1960's in USA
- It allowed for full duplex transmission
- The FM channel bandwidth was reduced to 25- 30KHz

First Generation Cellular Systems

- AMPS in USA
- NMT and TACS in Europe
- NTT in Japan

Features:

- FM modulation
- FDMA/FDD
- Frequency reuse
- Handoff

Advanced Mobile Phone System (AMPS)

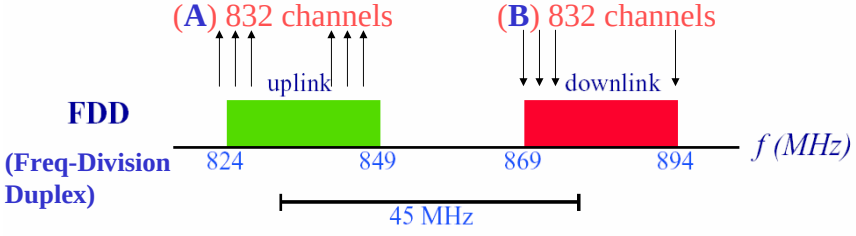
- Developed by AT&T in late 1970's
- Uses FM (30 KHz channels)
- Forward link: 870-890 MHz
- Reverse link: 825-845 MHz
- Similar systems are NMT, TACS (Europe) and NTT (Japan)

AMPS: physical layer

AMPS uses FDMA to separate the channels.

Radio bands

- 832 duplex (paired) channels
- A/B separation: 416 channels each
- channel spacing 30 kHz



AMPS

Channel multiplexing	**FDMA**
Uplink	**824-849 MHz-832 channels**
Downlink	**869-894 MHz-832 channels**
Channel Bandwidth	**30 kHz**
FDD separation	**45 MHz**
Modulation	**FM (traffic, voice); FSK (control)**
Channels	**Control, Paging, Access, Data**

Second Generation Cellular Systems

- GSM:
  - GSM 900
  - GSM 1800 (Europe, similar to GSM)
  - GSM 1900 (USA)
- Digital AMPS (TDMA): IS-54 (USA)
- CDMA: cdmaOne (IS-95) (USA and others)
- PDC in Japan (TDMA)

US Digital Cellular

Conceptually, it works like AMPS

- Standard: USDC = D-AMPS = IS-54 = IS-136 (EIA/TIA)
- TDMA/AMPS dual-mode terminals
- Split each AMPS FDMA channel into six TDMA channels
- Reuse of AMPS analog control channels: IS-54
- New digital control channels: IS-136

D-AMPS; IS-54; IS-136

Channel multiplexing	FDM+6 TDM slots
Uplink (initially) (later)	824-849 MHz; 832 channels 1850-1910 MHz
Downlink (initially) (later)	869-894 MHz; 832 channels 1930-1990 MHz
Channel Bandwidth	30 kHz
FDD separation	45 MHz
Modulation	FM (traffic, voice); FSK (control) PCM
Channels	Control, Paging, Access, Data
Channel Rate	48.6 kbps
Voice compression	56 kbps to 8 kbps; PCM
TDM frames	25 frames, 40 msec each
Time slots	6 slots, 6.67 msec each; (25x6=150)

GSM (Group Special Mobile) (Global System for Mobile)

- Pan-European Cellular Standard: **2G; Digital**
- **FDD:**
  - **890-915 MHz Uplink**
  - **935-960 MHz Downlink**
- 124 frequency carriers; 8 channels per carrier
- **Carrier spacing**: 200 KHz, (Narrowband TDM)
- **Modulation**: PSK
- Slow FHSS modulation **(217.6 hops/s)** to overcome multipath fading.

Global System for Mobile (GSM)

- TDMA based
- Deployed in 1992
- The World's most popular standard
- **Primary (P-GSM 900):** 124 channels
  - 890-915 MHz (up-link)
  - 935-960 MHz (down-link)
- **Extension (E-GSM 900):** 50 more channels
  - 880-890 MHz (up-link)
  - 925-935 MHz (down-link)

GSM

Channel multiplexing	**FDM+8 TDM slots**
Uplink (GSM900) (PCS1800)	**890-915 MHz; 124 channels** **1710-1785 MHz**
Downlink (GSM 900) (PCS1800)	**935-960 MHz; 124 channels** **1805-1880 MHz**
Channel Bandwidth	**200 kHz**
FDD separation	**45 (900) / 95 (1800) MHz**
Modulation	**GMSK**
Channels	**Brdcst. Cont; Ded. Cont; Comn. Cont.= =Paging+Rndm. Access+Acc. Grnt.**
Channel Rate	**13 kbps**
TDM frames	**24 frames, 120 msec each**
Time slots	**8 slots, 0.577 msec each; (24x8=192)**

cdmaOne (IS-95)

- System deployed in 1995.
- Based on spread spectrum technology
- Retrofit to existing AMPS (dual-mode)
- Huge growth rates
- Third generation (3G) standards are based on CDMA

IS-95

- Introduced by Qualcomm in 1994
- Based on CDMA
- Two frequency bands (1.25 MHz wide),
  - One for forward channel and
  - One for reverse channel
- CDMA allows reuse of same spectrum over all cells.
- CDMA/AMPS dual mode phones
- Net capacity improvement:
  - 4 to 6 over digital TDMA (eg. GSM)
  - 20 over analog FM/FDMA (AMPS)

IS-95: physical layer

Radio bands

- co-existence with AMPS
- 20 wideband channels
- spreading rate 1.2288 Mc/s
- channel spacing 1.25 MHz