CS 294-7: Personal Communications Systems

Prof. Randy H. Katz
Computer Science Division
University of California, Berkeley
Berkeley, CA 94720-1776
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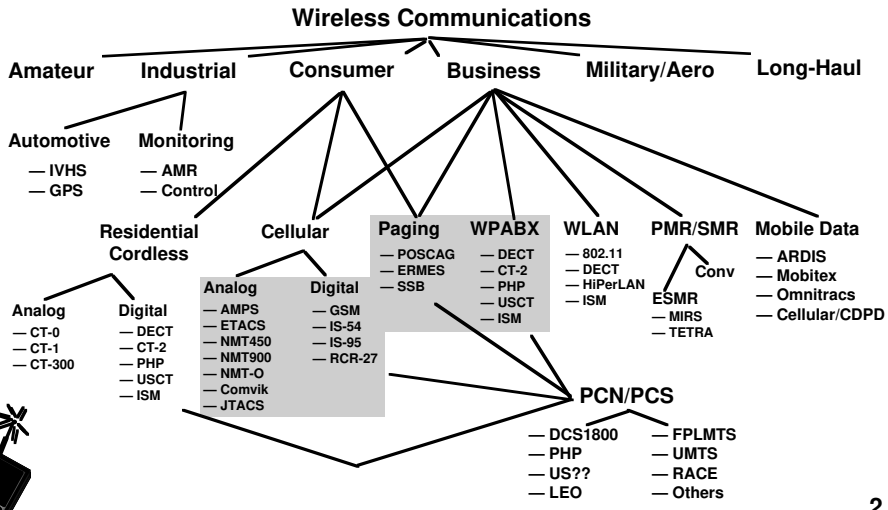
The Wireless Universe



Wireless Personal Communications

- **Mobility in Communications**
  - **Freedom from physical connection "tethers"**
  - **Freedom from network "tether"**
- **PCS: What is it?**
  - **Cellular telephony** → Circuit-switched
  - **Cordless telephony** → Circuit-switched
  - **Paging systems** → Packet-switched
  - **Wide area mobile data** → Packet-switched
  - **Wireless local area networks** → Packet-switched

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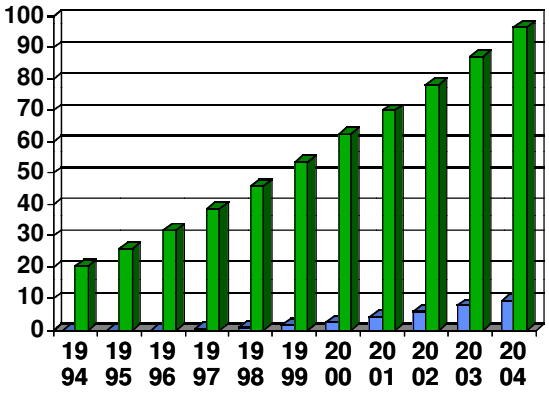
Yankee Group Forecast



$7 Billion in PCS license auctions

1994: 30 million+ paging subscribers

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Wireless Personal Communications

- **Portability and Mobility**
  - Within house or building (cordless telephone, WLAN)
  - Within campus, town, city (cellular radio, WLANs, wide area wireless data, radio paging, extended cordless telephone)
  - Throughout a state or region (cellular radio, wide area wireless data, radio paging, satellite-based wireless)
  - Throughout a large country or continent (cellular radio, paging, satellite-based wireless)
  - Throughout the world
- **Multimedia Communications**
  - Two-way voice
  - Data
  - Messaging
  - Video?

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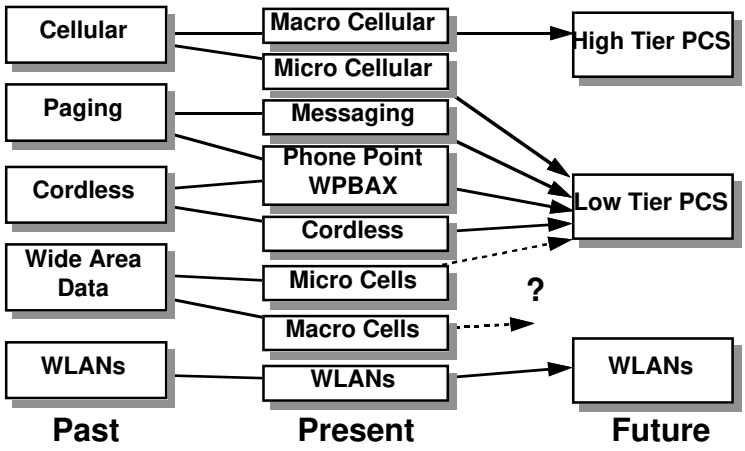
Wireless Personal Communications Options



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Cordless Telephone

- **Assumptions**
  - Few users per MHz
  - Few users per BS
  - Large number of BS per unit area
  - Short transmission range
- **Common characteristics**
  - 32 kbps ADPCM digital speech encoding
  - Ave xmit power ≤ 10 mw
  - Low complexity radio signal processing
  - Low transmission delay, < 50 ms
  - Simple frequency-shift modulation and non-coherent detection
  - Dynamic channel allocation
  - Time division duplex (TDD)

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Low Tier Cellular Standards

Parameter	CT	CT2Plu	UD-PCS	DECT
Proposer	Current Cordless	Cordless 2nd Gen	Bellcore	Ericsson 3rd Gen, In building
Radio Access Method	N-FM	TDMA/ FDMA	TDMA/ FDMA	TDMA/ FDMA
RF Channel Size	20 Khz	100 Khz	700 Khz	1.7 Mhz
Channel Rate	—	72 Kbps	514 Kbps	1.1 Mbps
Voice Channels per RF Channel	1	1	10	12
Duplex Voice Channel Size	40 Khz	100 Khz	70 Khz	144 Khz
Voice Bit Rate	—	32 Kbps	32 Kbps	32 Kbps
Handset Xmit Pwr mW max/avg	< 10	10 5	100 10	250 10
Max Cell Radius	100 m	100 m	500 m	500 m

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Cellular Mobile Radio Systems (aka High Tier PCS)

- **Assumptions & Compromises**
  - Max users per MHz
  - Max user per cell site
  - High transmitter pwr consumption
  - High user-set complexity
  - Low circuit quality
  - High network complexity
- **Commonalities**
  - Low bit-rate speech coding ≤ 8-13 kbps
  - Makes use of speech inactivity
  - High transmission delay, approx. 200 ms R/T
  - High complexity DSP
  - Fixed channel allocation
  - FDD
  - Mobile/portable set power control

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High Tier Cellular Standards

Parameter	AMPS	IS-54	GSM	QCDMA	RCDMA
Proposer	Current Standard	Interum Digital	Euro Standard	Qualcomm	Rockwell
Radio Access Method	FDMA	TDMA/ FDMA	TDMA/ FDMA	CDMA/ FDMA	CDMA
RF Channel Size	30 Khz	30 Khz	200 Khz	1.25 Mhz	40 Mhz
Channel Rate	—	48 Kbps	271 Kbps	10, 32 Kbps	20-40 Kbps
Voice Channels per RF Channel	1	3	8	20-60 per sector	126
Duplex Voice Channel Size	60 Khz	20 Khz	50 Khz	—	—
Voice Bit Rate	—	8 Kbps	13 Kbps	8-32 Kbps	16 Kbps
Handset Xmit Pwr mW max/avg	600 600	3000 200	1000 125	200 6	100 1
Max Cell Radius	> 32 Km	> 32 Km	32 Km	2.5 Km	450 m

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Wide Area Wireless Data Systems

- **Assumptions and Compromises**
  - **High mobility**
  - **Low data rate**
  - **Vehicular and pedestrian mobility**
- **Deployed packet radio systems**
  - **ARDIS**
  - **RAM Mobile/Mobitex**
  - **CDPD**
  - **Metricom Ricochet**

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Wide Area Mobile Data Summary

Metric	ARDIS	Mobitex	CDPD	IS-95	TETRA
Frequency Band					
Base TX (Mhz):	(800 Band,	935-940	869-894	869-894	(400 and 900
Mobile TX (Mhz):	45 kHz sep.)	896-901	824-849	824-849	Bands)
RF Ch. Spacing	25 kHz (U.S.)	12.5 kHz	30 kHz	1.25 Mhz	25 kHz
Channel Access	FDMA/	FDMA/	FDMA/	FDMA/	FDMA/
Multiuser Access	DSMA	Dynamic S-Aloha	DSMA	CDMA-SS	DSMA&SAPR
Modulation Method	FSK, 4-FSK	GMSK	GMSK	4-PSK/DSSS	PI/4-QDPSK
Channel Rate (kbits/s)	19.2	8.0	19.2	9.6	36
Packet Length	up to 256 bytes (HDLC)	up to 512 bytes	24 bits	(pa ser TBD)	s (short) s (long)
Open Architecture	No	Yes	Yes	Ye	
Private or Public Carrier	Private	Private	Public	Public	Public
Service Coverage	Major Metro. Areas in US	Major Metro. Areas in US	All AMPS areas	All CDMA cellular areas	European Trunked Radio
Type of Coverage	In-building and Mobile	In-building and Mobile	Mobile	Mobile	Mobile

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High Speed Wireless Local Area Networks (WLANs)

- **Assumptions and Compromises**
  - **Low mobility high speed data communications**
  - **Operates within confined region**
  - **Two alternative organizations:**
    - » **Centralized control via base station**
    - » **Self-organizing ad-hoc**
  - **ISM band allocation/spread spectrum**
  - **Data PCS (1910-1930 MHz) w/ "etiquette" rules**

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Local Area Mobile Data

	Freq (MHz)	Link Rate	User Rate	Protocol	Access	# of chan/ spread factor	Mod/Coding	Power	Network Topology
Altair-II Moto	18-19 GHz	15 Mbps	5.7 Mbps	Ethernet			4-level FSK	25 mW peak	8 devices per radio
WaveLAN AT&T	902-928 MHz	2 Mbps	1.6 Mbps	Ethernet-like	DS SS		DQPSK	250 mW	peer-to-peer
AirLAN Solectek	902-928 MHz		2 Mbps	Ethernet	DS SS		DQPSK	250 mW	radio to hub
Freeport Windata	902-928 MHz	16 Mbps	5.7 Mbps	Ethernet	DS SS	32 chips/bit	16 PSK trellis coding	650 mW	Hub
Intersect Persoft	902-928 MHz		2 Mbps	Ethernet, Token Ring	DS SS		DQPSK	250 mW	Hub
LAWN O'Neil	902-928 MHz		38.4 kbps	X.25	SS	20 users/ch; 4 chan		20 mW	peer-to-peer
WiLAN WI-LAN	902-928 MHz	20 Mbps	1.5 Mbps/ch	Ethernet, Token ring	CDMA/ TDMA	3 ch 10-15 links	Uncon-ventional	30 mW	peer-to-peer
RadioPort ALPS	902-928 MHz		242 kbps	Ethernet	SS	?/3 channels		100 mW	peer-to-peer

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Local Area Mobile Data

	Freq (MHz)	Link Rate	User Rate	Protocol	Access	# of chan/ spread factor	Mod/Coding	Power	Network Topology
ArLAN Telesys	902-928 2.4 GHz		1.35 Mbps	Ethernet	SS			1 W max	Radio to hub
RadioLink Cal Microwave	902-928 MHz	250 kbps	64 kbps		FH SS	250 ms/hop 500 Khz spacing			hub
RangeLAN Proxim	902-928 MHz		242 kbps	Ethernet, Token ring	DS SS	3 Channels		100 mW	
RangeLAN2 Proxim	2.4 Ghz	1.6 Mbps	50 kbps max	Ethernet, Token ring	FH SS	10 chan@5 kbps/ch, 15 subch each		100 mW	peer-to-peer, bridge
Netwave Xirxom	2.4 GHz	1 Mbps		Ethernet, Token Ring	FH SS	82 1 Mhz ch. or "hops"			Hub
Freelink Calbetron Sys	2.4 and 5.8 GHz		5.7 Mbps	Ethernet	DS SS	32 chips/bit	16 PSK Trellis coding	100 mW	Hub

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Other Systems

- **Paging/Messaging**
  - **Numeric/alphanumeric pagers**
  - **1-way/2-way paging systems**
  - **Local/regional/nationwide systems**
- **Satellite-Based Mobile Systems**
  - **Wide area, expensive infrastructure**
  - **Large regional coverage outside buildings**
  - **Low capacity cells**
  - **LEOs/MEOs/GEOs**

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PCS Proposals

Proposal	Mobility	Supporters
CDMA (IS-95)	High	Qualcomm, AT&T, Motorola, ALPS, GSIC, Samsung, Sony, US West, Sprint Bell Atlantic, Time Warner
DCS1800	High	Pac Bell, Nokia, MCI, Siemens, Kycom
IS-54	High	AT&T, McCaw
Omnipoint	High/Low	Omnipoint, Rockwell
WACS	Low	Bellcore, Motorola, Panasonic, US West, Sprint, Bell Atlantic, Time Warner
DECT	Low	Ericsson
PHP	Low	NEC, Panasonic, Hitachi, Toshiba, PCSI
5 MHz CDMA	Low	Interdigital, Oki

- Standards bodies currently favoring WACS and CDMA
- But pressure for worldwide interconnectivity - 87 operators provide 51 countries with GSM
- DECT/GSM interconnectivity being studied in Europe
- Desire for products that work in licensed and unlicensed bands

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Latest Developments in PCS

- March 1995 A and B auctions
- Three major players
  - PCS PrimeCo
    - » AirTouch, US West, Bell Atlantic, NYNEX Mobile
    - » Qualcomm CDMA chosen as the technology
  - Sprint Telecommunications Venture (STV)
    - » CDMA technology chosen
    - » Vendors may include Qualcomm,. NorTel, Motorola, AT&T
  - AT&T Wireless
    - » Digital TDMA most likely technology choice
- Other players
  - PacBell, Bell South have chosen GSM technology

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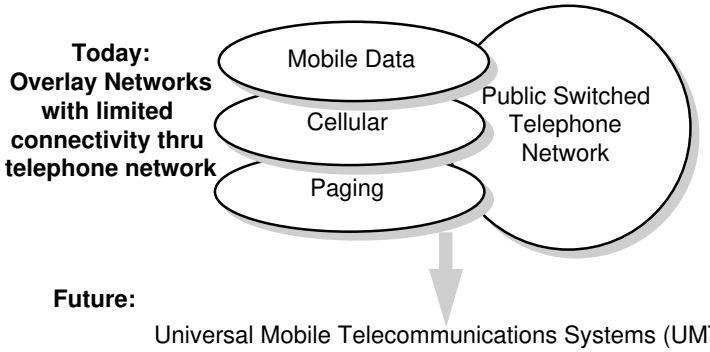
Grand Unification?



Future:

Universal Mobile Telecommunications Systems (UMTS)

European RACE program: Pan-European Standards

Low cost pocket communicator for speech & medium data services at home, office, and outdoors

Future Public-Land-Mobile Telecommunications Systems (FPLMTS)

CCIR: World-Wide Standards

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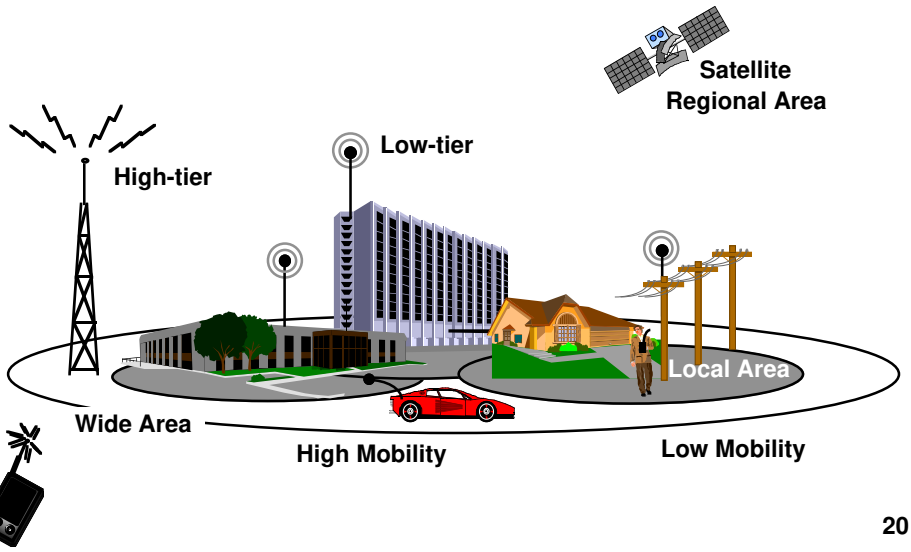
Overlay Concept



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Open Issues

- **Improved battery life for mobile devices**
- **Suitability of high complexity spread spectrum/CDMA technologies for low cost, low power, low tier PCS**
- **Single Handset or stereo/walkman analogy**
- **Multimode Radios**