Wireless and Mobile Computing

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Course Overview

- Introduction and History
- Regulatory Issues
- Fundamentals of Cellular Systems
- 1st Generation: AMPS and CDPD
- 2nd Generation: GSM
- 3rd Generation: IMT-2000
- Mobile IP
- TCP over Wireless Link

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Why "Mobile Computing" now ?

- Wireless communication widely available, heavy infrastructure investments
  - cellular systems: mainly voice traffic, increasingly used for data traffic, 2nd & 3rd generation cellular, PCS, IMT-2000, ...
  - prediction for 1999 in the US: wireless market will grow to US$ 28 billion in revenues
    - US$ 25.7 billion mobile voice
    - US$ 933 million SMR/ESMR (dispatch)
    - US$ 1.5 billion wireless data (includes paging?)
  - predictions for Canada, 1998 (from Globe & Mail, April 8, 1997):
    - C$ 3673 million mobile voice
    - C$ 208 million SMR/ESMR
    - C$ 467 million paging
    - C$ 27 million mobile data
- Portable devices become more affordable, smaller, and powerful: laptops, palmtops (WindowsCE), smartphones, wireless NCs, etc.

Subscriber Growth

	Dec. 94	June 95	Dec. 97	Dec. 99	Dec. 2001
Europe	14.7	18.5	46.3	103	175
Asia-Pacific	11.1	15.6	15	39	67
North America	26	28.2	1.3	5	11.5
South/Central America	2.4	3	0	0.25	2
Middle East	0.4	0.5	1.4	2.3	5.3
Africa	0.3	0.6	1.5	3	4.8
Total	54.9	66.4	66	155	265

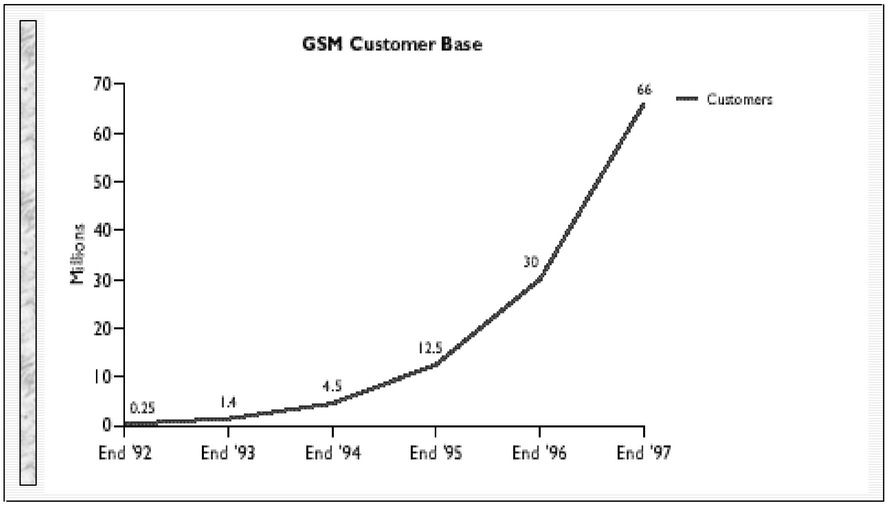
World Subscriber Growth (millions of subscribers) 1994-1995
GSM Subscribers 1997 and forecasts for 1999 and 2001

Ottawa Citizen, June 22, 1998:
- 2.4 Million Canadians use cell phones (analog or digital), about 14% of population
- 678 000 digital subscribers as of March 31, 1998

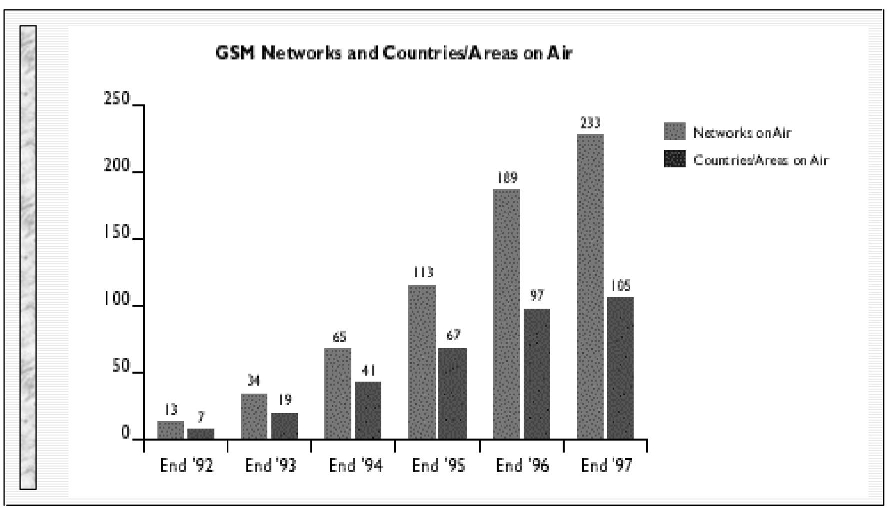
Technology Use

	December 1994	June 1995
Analog:		
AMPS	32.4	35.5
TACS	9.5	12.3
NMT-450	1.4	1.4
NMT-900	2.7	3.0
NTT	1.9	2.3
Others	1.0	0.9
Total	49.3	55.4
Digital:		
GSM	4.6	7.4
PDC	0.5	1.5
DCS1800	0.4	0.6
TDMA	1.0	1.5
Total	6.0	11.0

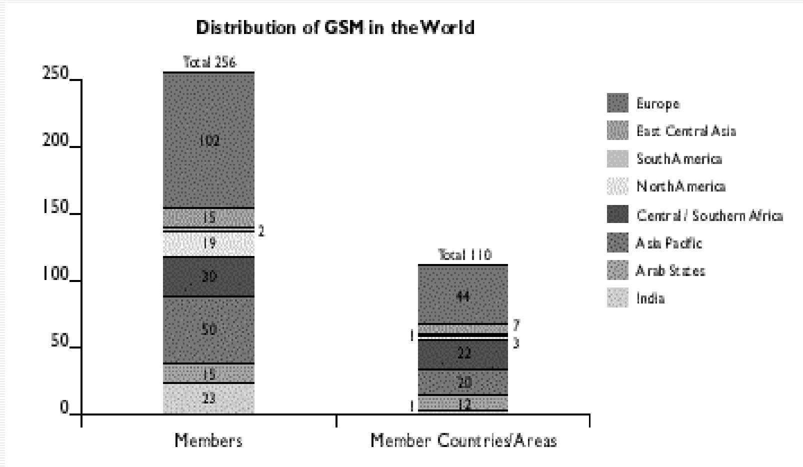
GSM Penetration Worldwide



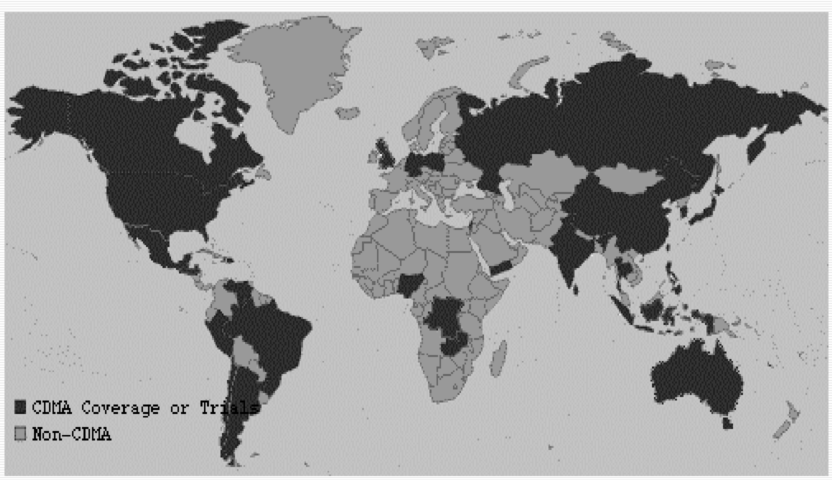
GSM Penetration Worldwide (end of 1997)



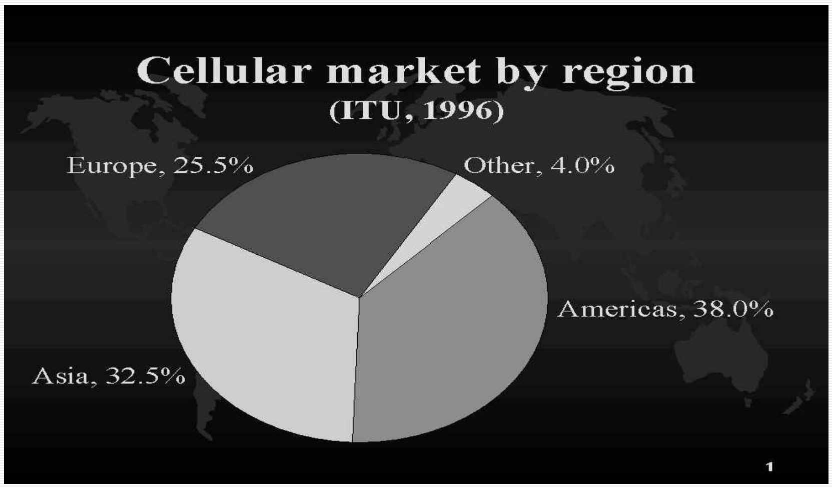
GSM Penetration Worldwide (end of 1997)



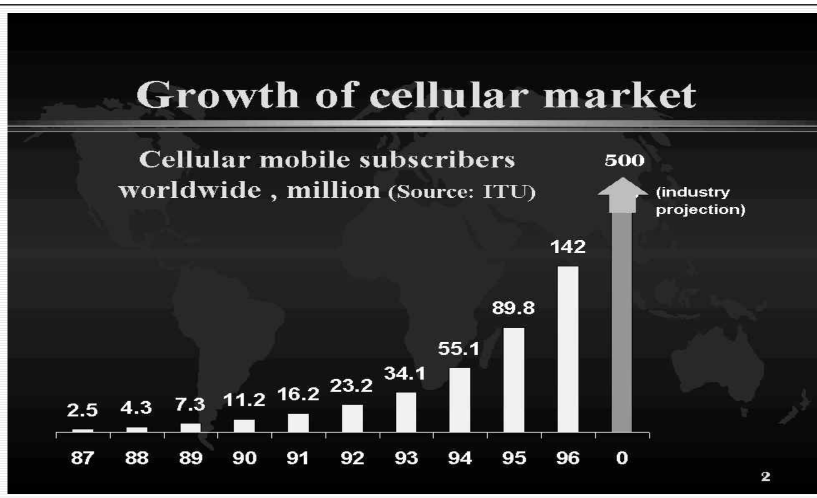
CDMA Penetration Worldwide (end of 1997)



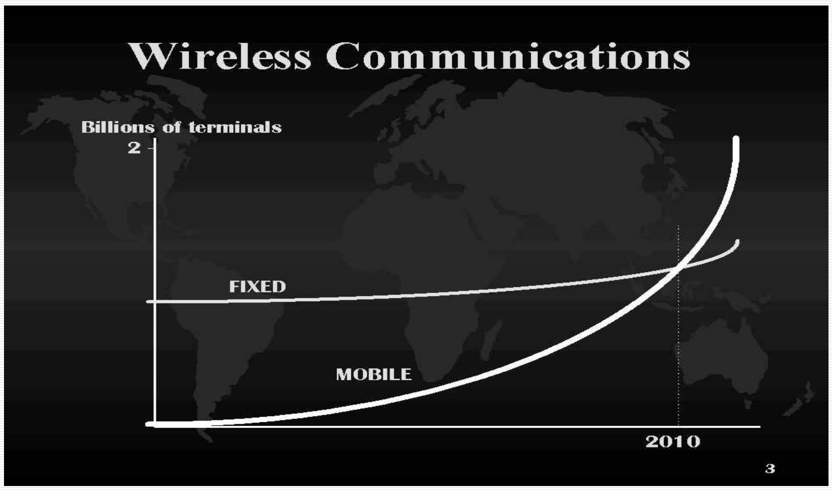
Cellular Market by Region



Growth of Cellular Market, Worldwide



Wireless and Wired Communication



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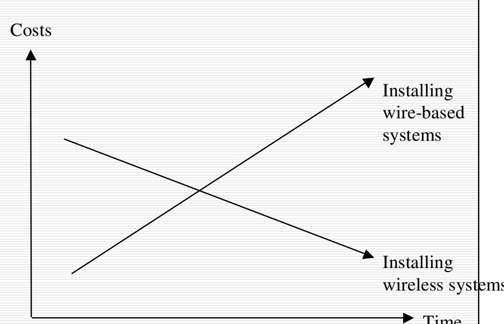
Mobile Systems Pros and Cons

Advantages:
- users are not constrained to fixed locations
- immediate access to service, regardless of person's location
- physical cabling (trenches, access lines, digging, physical rights-of-way) are not an issue

Disadvantages:
- limited frequency spectrum
- complex technology
- security/privacy issues and authentication requirements
- power supply for the small portable units
- quality of signals ("hostile" environment)



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Wireless Data Transmission

- Which infrastructure to choose?
  - geographic coverage
  - reliability of service
  - network intelligence/support
  - costs of deployment
  - performance
- ARDIS, MOBITEX, etc.
  - private specialized mobile analog radio system
  - connectionless: exchange of data packages
  - low data rate (< 2400 bps), not widely available

Wireless Data Transmission

- based on analog cellular systems
  - existing analog cellular systems:
    - AMPS (Advanced Mobile Phone System) in North America, operates at 824-894 MHz, 832 channels of 30 kHz each. Variation is N-AMPS (Narrowband AMPS) which uses 10kHz channels (three times capacity of AMPS)
    - NMT (Nordic Mobile Telephone Service) in Northern Europe: NMT450 operates at 450 MHz, NMT900 at 900 MHz
    - TACS (Total Access Communications System) in U.K. Some variants are JTACS (in Japan), E-TACS (expanded TACS in U.K.), or J-TACS (Japan, similar to N-AMPS)

Wireless Data Transmission

- data over existing cellular systems:
  - modem: costs, interoperation with handover, unreliable voice channel
  - CDPD: transmit data in short bursts during idle times in existing AMPS channels, use channel hopping to avoid collision with voice traffic
  - intersitial cellular (proprietary to Cellular Data Inc.): transmit data on unused guard bands (separate voice channels), results in 2400 bit/s X.25 data network
- widely available, limited system capacity, emphasis **not** on data service (both new and old)

Wireless Data Transmission: Comparison of Wireless Data Technologies (as of 1996)

	CDPD	ARDIS	RAM Mobile Data	Metricom Ricochet
# of Users	10,000	65,000	55,000	12,000
% of US Coverage	High	High	High	Low
Raw Throughput (bps)	19,200	4,800 – 19,200	8,000	100,000
Actual Throughput (bps)	10,000 – 12,000	2,400 – 9,600	4,000	28,800
Message Roundtrip Time (secs)	0.7 - 4	4 - 8	2 - 8	undisclosed
Connection Setup Time (secs)	< 1	< 1	< 1	< 1

Wireless Data Transmission

- employ digital (cellular) system to provide effective integrated voice and data services
  - GSM (originally "Groupe Speciale Mobile", now "Global System for Mobile Communications) developed in Europe, at 890-960 MHz with 1000 full-rate traffic channels at 270 kbps, widely spread
  - DCS1800: based on GSM, operates in 1.8 GHz band, three times capacity of GSM
  - North America: IS54 and IS95
    - two incompatible standards (TDMA versus CDMA)
    - GSM is making inroads into North America (PCS1900)

History

It started with the telegraph (mid 19th century):

"We call the electric telegraph the most perfect invention of modern times ... as anything more perfect than this is scarcely conceivable, and we really begin to wonder what will be left for the next generation, upon which to expend the restless energies of the human mind''

(Australian newspaper, 1853)

But also:

"The wireless music box has no imaginable commercial value. Who would pay for a message sent to nobody in particular?" (David Sarnoff's associates in response to his urgings for investment in the radio in the 1920s).

History

- origins of coded transmission
  - 1793, Revolutionary France: Aerial Telegraph (but what about Chinese, Romans, Native Indians?)
  - 1840s, Samuel F. B. Morse: coded transmission via electronic means, rapid spread throughout US and Europe, International Telegraph Union formed in 1865
- submarine telegraphy: 19th century high-tech
  - 1850: first submarine cable, Dover-Calais
  - 1858: first transatlantic cable (breaks after 3 months)
  - 1866: re-laid with higher quality cable

History

- typical performance of telegraph
  - 1870: London to Bombay in 4 minutes, 22 seconds
  - 1901: London to British Guiana 22 minutes
  - 1924: Telegraph around the world in 80 seconds
- radio/wireless telegraphy
  - communication with ships and other moving vehicles
  - messages sprayed into "ether," across national boundaries
  - downfall of nationally supported monopolistic telegraph companies

History

- radio/wireless telegraphy
  - 1896: Marconi demonstrates wireless telegraphy
  - first used by British Army and Navy in the Boer War
  - 1899: Reported America's Cup yacht races to shore
  - 1907: Commercial Trans-Atlantic Wireless Service (huge ground stations, beginning of end for cable-based telegraphy)
  - WW I: rapid development and deployment of communications intelligence, intercept technology, cryptography

History

- radio/wireless telegraphy
  - 1920: Marconi discovers shortwave (<100 m) radio
    - longwaves follow contour of land, require very high transmit power (200 kW+)
    - shortwaves reflect, refract, and absorb, like light (bounce of ionosphere, higher frequencies possible by vacuum tube (1906), cheaper, smaller, better quality transmitters)
- other important dates
  - 1915: wireless voice transmission NY to SF
  - 1920: first commercial radio broadcast (Pittsburgh)

History

- other important dates:
  - 1921 (or 1928): Police car dispatch radio, Detroit
  - 1935: first telephone call around the world
  - WW II: rapid development of radio technology
  - 1974: FCC (Federal Communications Commission) allocates 40 MHz for cellular telephony
  - 1982: European GSM (Groupe Speciale Mobile) established
  - 1983 (or 1984): initial deployment of AMPS cellular system