Mobile Computing Systems

Thomas Kunz
tkunz@sce.carleton.ca
http://kunz-pc.sce.carleton.ca/sce536/
Systems and Computer Engineering
Carleton University

Course Overview

- Introduction and History
- Data in Wireless Cellular Systems
- Data in Wireless Local Area Networks
- Internet Protocols
- Routing and Ad-Hoc Networks
- TCP over Wireless Link
- Services and Service Discovery
- System Support for Mobile Applications

Course Overview

- Introduction and History
  - overview of technologies for wireless communication
  - some comments on marketplace (growth, dominant technologies)
  - brief background on historical development
- Data in Wireless Cellular Systems
  - regulatory issues
  - radio access schemes
  - CDPD, GSM (GPRS)
  - 3rd generation cellular systems (IMT-2000)
- Data in Wireless Local Area Networks
  - Wireless LANs: WaveLan, IEEE 802.11
  - Personal Area Networks: Bluetooth
  - High-speed LANs: HiperLAN

Course Overview

- Internet Protocols
  - IP protocol
  - DHCP
  - Mobile IP (in IPv4 and IPv6)
- Routing
  - Internet routing (RIP, OSPF, etc.)
  - Routing in ad-hoc networks (DSDV, AODV, DSR)
- TCP over Wireless Link
  - TCP protocol and congestion control
  - TCP performance over wireless link: I-TCP, snoop

Course Overview

- Services and Service Discovery
  - RFC 2165 (Service Location Protocol)
  - Jini: Overview, Service Discovery
- System Support for Mobile Applications
  - Theoretical Model
  - File Systems and Databases
  - WWW
  - WAP (Wireless Application Protocol)

Course Overview

- Prerequisites:
  - ideally: course in computer networks, wireless communication
  - alternatively: consent of instructor
- Schedule:
  - Fridays, Sept. 13, Oct. 4, Oct. 18, Nov. 1, Nov. 15, and Nov. 29
  - Time: 9 am to 4:30 pm
  - Location: IBM Toronto Lab

Course Overview

- Marking scheme:
  - one midterm exam (30%)
    - in class, November 1
  - two assignments (10% each)
    - due Oct. 18 and Nov. 15, handout out two weeks in advance
  - one term project (50%)
    - choose a topic related to course, write a two-page proposal and submit in class October 4 (5%)
    - feedback from instructor within one or max two weeks
    - submit 15 page document in class November 29 (45%)
    - submit all documents in hardcopy and softcopy form
    - for research projects: submit software/results as ZIP file to tkunz@sce.carleton.ca by the same deadline

Course Overview

- Two possible approaches for course project:
  - Research Proposal
    - Individual effort
    - Review state-of-the-art
    - Propose detailed research project (5 pages out of 15)
    - **Goal**: Suggest a research project that will further the state-of-the-art
  - Research Project
    - Teams of up to 2 students (i.e., can be individual effort)
    - Review state-of-the-art, design experiments
    - Identify and use public-domain software package (ns-2, WAP emulator, …) to conduct experiments, analyze results
    - No purely analytical work
    - **Goal**: develop new insights/results

Course Overview

- Research proposal topics/ideas:
  - Select one of the relevant areas under study at the IETF, or any other standards body (not discussed in class), explain the problem, proposed solutions, and critically evaluate them.
  - Mobile IP, routing in ad-hoc networks, TCP over wireless links: survey current proposals (there are many more than the ones discussed in class) and compare them.
  - Survey future portable devices, discuss implications for wireless data applications (for example, in e-commerce).
  - Find and report on experiments with wireless data applications (design, performance, user evaluations and feedback, lessons learned) – ideally more than one case study.
  - YOUR OWN SUGGESTION
- Important: review state-of-the-art and suggest a detailed research project that furthers this area

Course Overview

- Research project topics/ideas:
  - Starting point similar to research proposal
  - Identify problem(s) to be explored, design experiments, find and select public-domain software that will help carry out the experiments
    - NistNet: a network emulation package that runs on Linux, allows a single Linux PC set up as a router to emulate a wide variety of network conditions (http://www.antd.nist.gov/itg/nistnet/)
    - Ns-2: a network simulator (http://www.isi.edu/nsnam/ns/)
    - WAP Phone Emulators: available from many sources, such as Nokia, Ericsson, as WWW page, etc.
    - TOOLS YOU DISCOVERED
- Important: analysis of results, comparison to state-of-the-art (i.e., what insights were learned with the experiments you conducted and the results you obtained)

Course Overview

- Document Format:
  - Final report limited to 15 pages in total (including cover page, Appendix, TOC, …..)
  - use 11pt fonts or larger
  - single-sided
  - 1 in margins all around
  - may be single-spaced
- Other comments on report/project:
  - Focus on data link layer and up, no physical layer issues (i.e., CDMA 2000 vs. W-CDMA), emphasize IP/IETF standards
  - use publicly available references, academic journals, conference proceedings (at least 5 "academic" references in final report)
  - avoid even the suspicion of plagiarism….
  - make sure reports do not "rehash" course content
  - your research should focus on **technical** issues, not marketing hype

Course Overview

- References:
  - no single textbook, but one good book is
    - Jochen Schiller, Mobile Communications, Addison-Wesley 2000, ISBN 0-201-39836-2.
  - course webpage: http://kunz-pc.sce.carleton.ca/sce536/
  - set of transparencies available from IEEE student society as course notes
  - extensive list of references provided at the end of the handout (URLs, books, journal and conference articles)

Course Overview

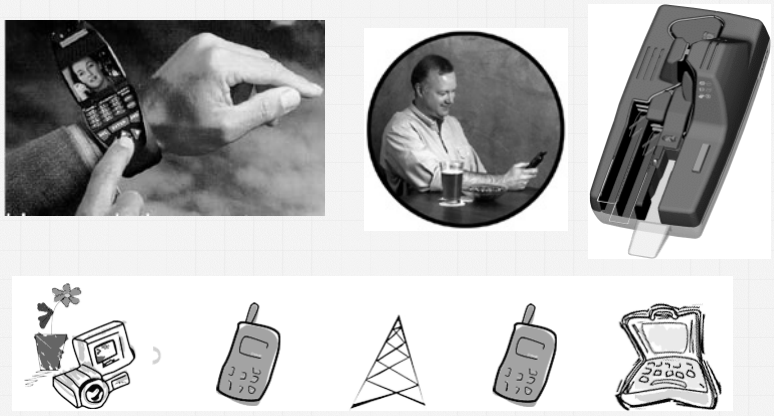
- Introduction and History
- Data in Wireless Cellular Systems
- Data in Wireless Local Area Networks
- Internet Protocols
- Routing and Ad-Hoc Networks
- TCP over Wireless Link
- Services and Service Discovery
- System Support for Mobile Applications

Portable Devices: Cellphones and Pagers

Portable Devices: PDAs, AutoPCs

Portable Devices: Laptops

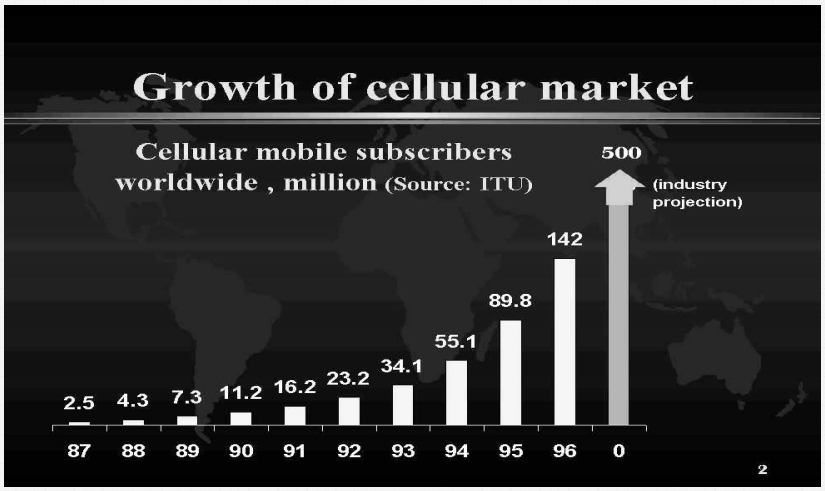
Portable Devices: The Future… ?



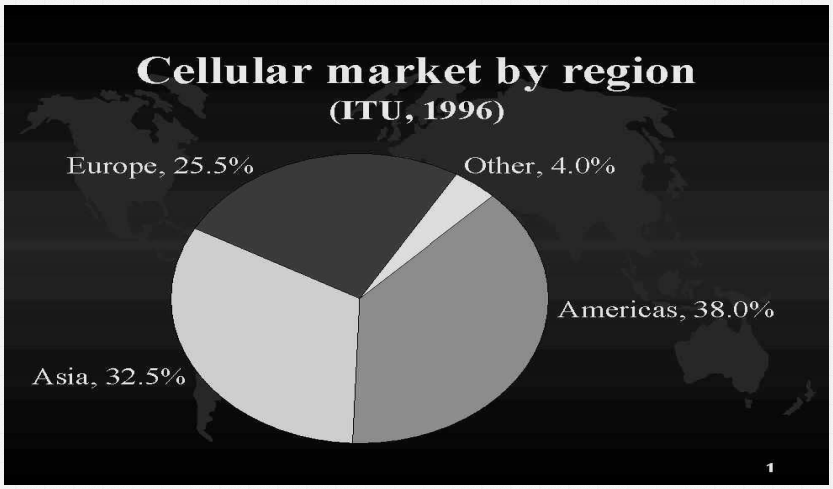
IBM: plethora of dedicated, specialized devices, not a single “universal” portable device

Growth of Cellular Market, Worldwide

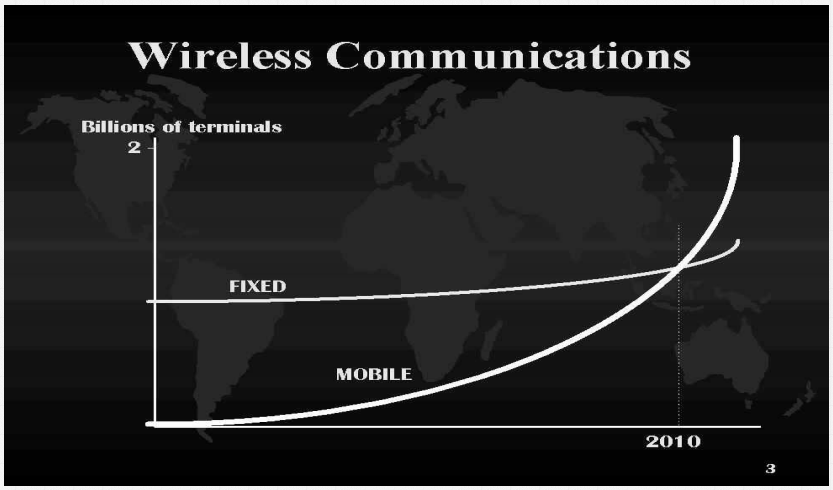
(Source: http://www.itu.int/imt/1-info/mkt-growth/index.html)



Cellular Market by Region

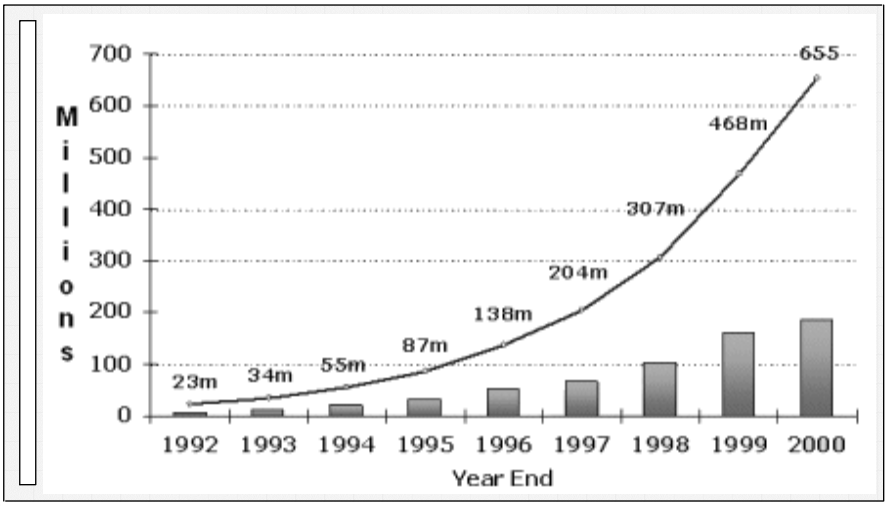


Wireless and Wired Communication

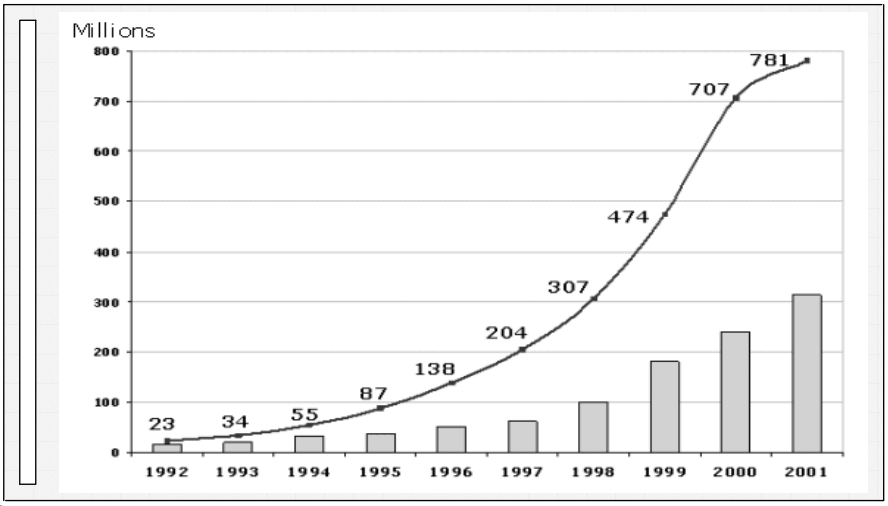


Digital Cellular Worldwide (June 2000)

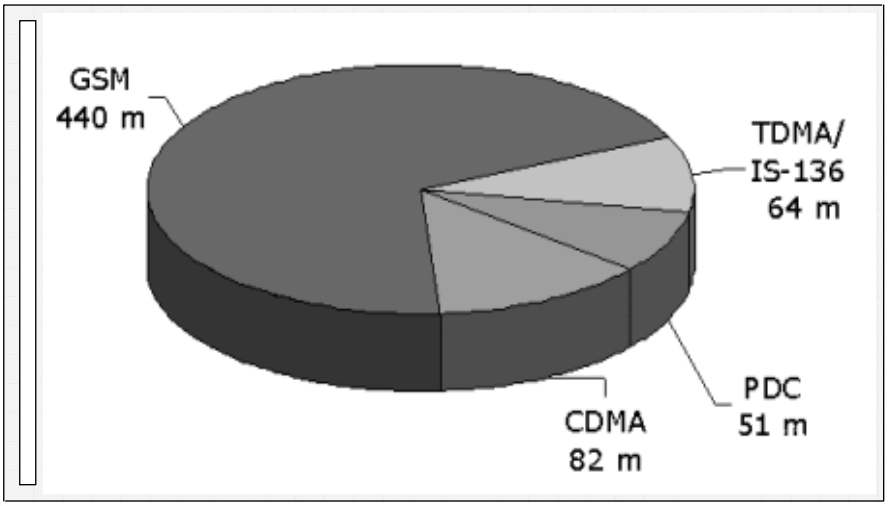
(Source: http://www.gsmworld.com/membership/mem_stats.html)



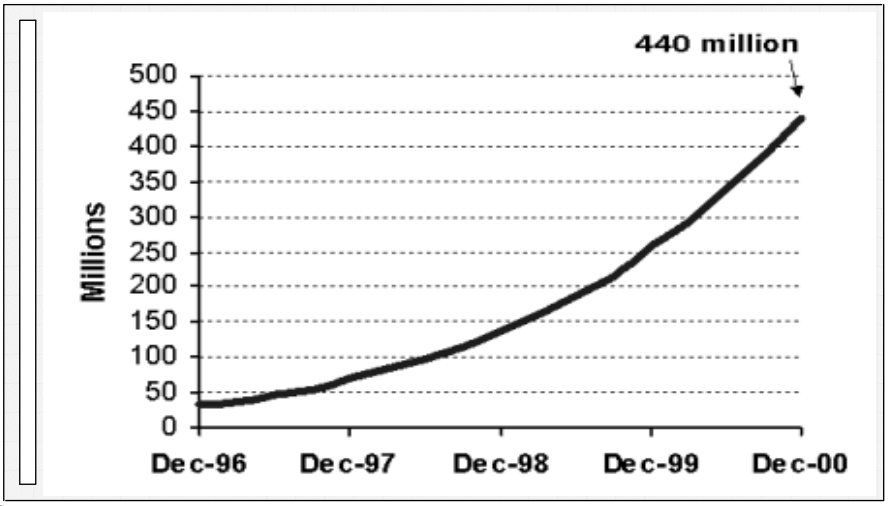
Digital Cellular Worldwide (June 2001)



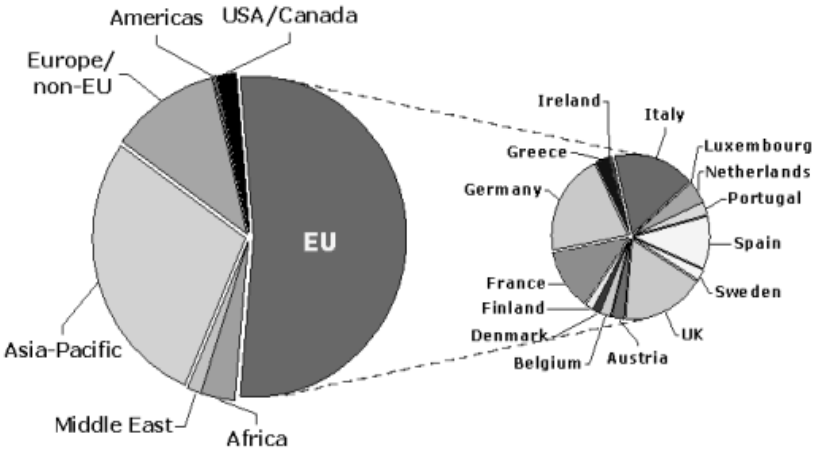
Digital Cellular: Dominant Technologies (December 2000)



GSM Subscribers (December 2000)

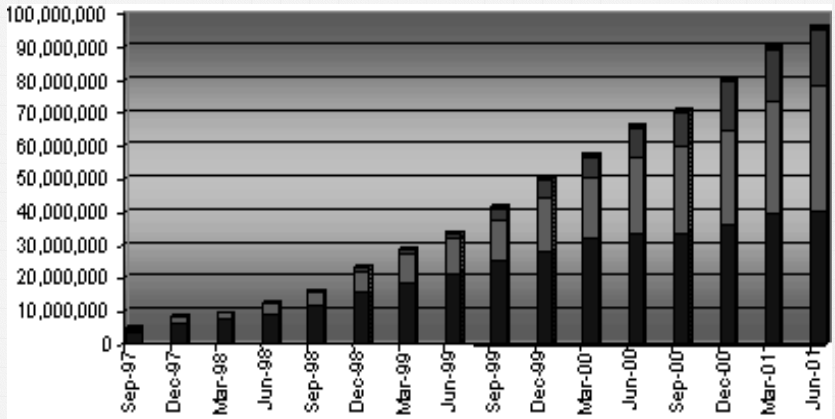


GSM: Regional Distribution



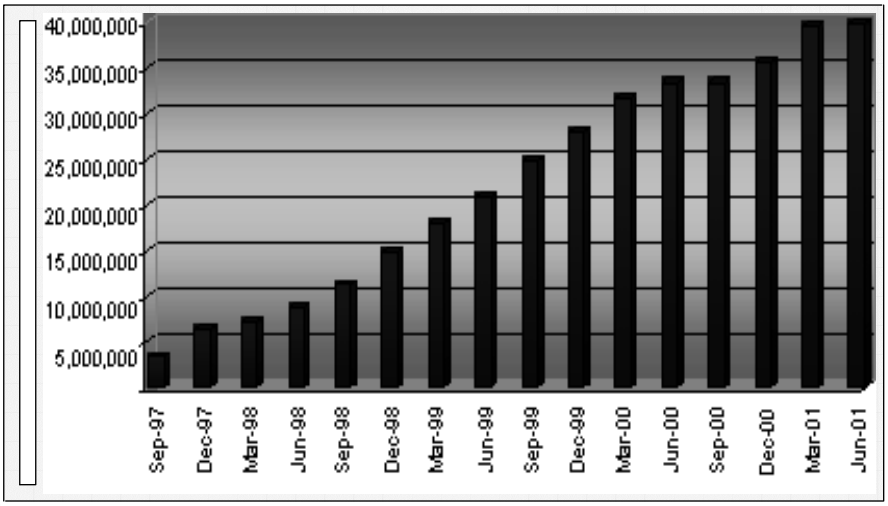
CDMA Worldwide

http://www.cdg.org/world/cdma_world_subscriber.asp

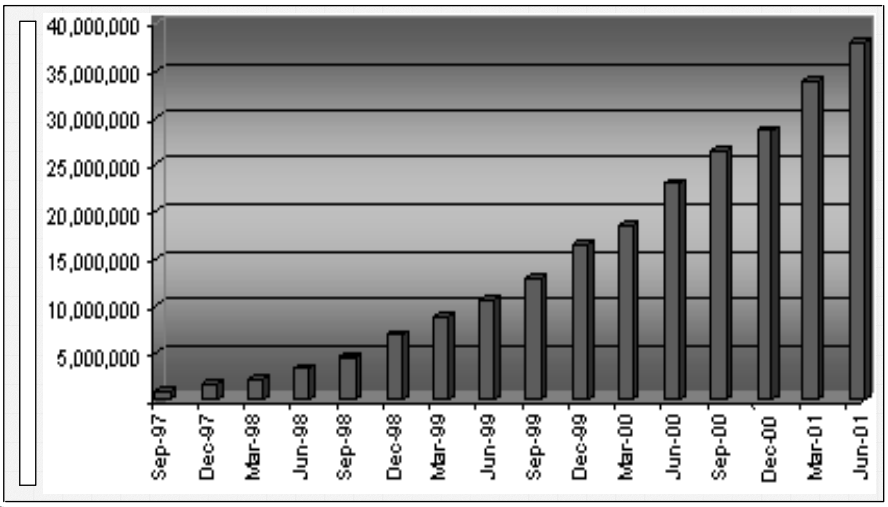


Blue: Asia-Pacific, Green: North America,
Red: Caribbean and Latin America, Black: Europe, Middle East, Africa

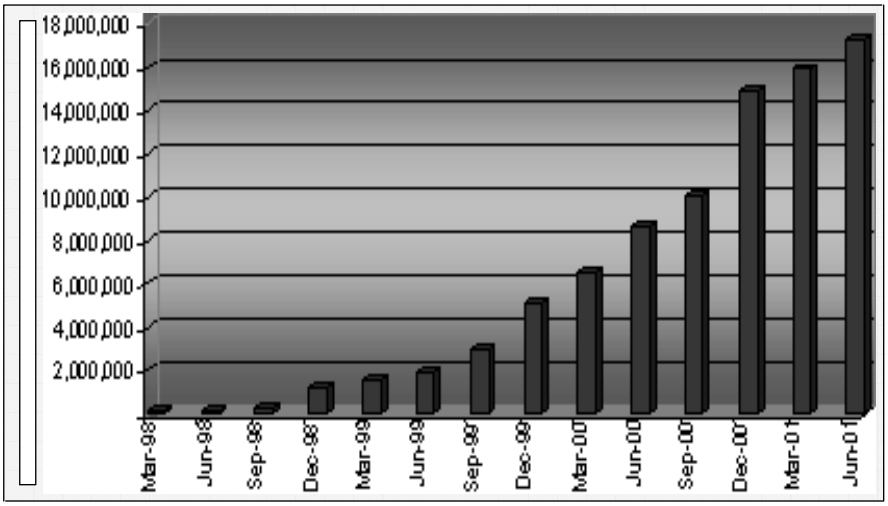
cdmaOne: Asia-Pacific



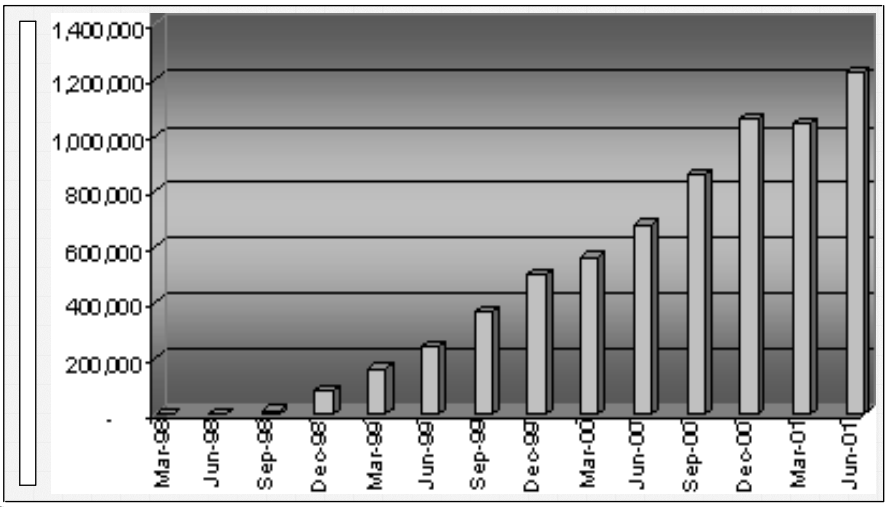
cdmaOne: North America



cdmaOne: Caribbean and Latin America



cdmaOne: Europe, Middle East, Africa



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 Special 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)

Wireless Data Transmission

- Existing 1st- and 2nd-generation cellular systems provide good coverage, but at modest data rates only
- Current research focus: 3rd-generation cellular systems (IMT-2000, UMTS)
  - provide ubiquitous coverage (including satellite)
  - international standardization
  - ambitious data rates: 144 kbps for user in vehicle, 384 kpbs for walking user, 2 Mbps for stationary users
  - overlay of different-sized cells, complicated spectrum management

Wireless Data Transmission

- For in-building wireless coverage, wireless LAN technologies are available: Proxim, WaveLan, ….
  - Smaller coverage area, more controlled environment allow higher frequency/lower power transmissions, resulting in higher bandwidth
- Other controlled environments: Bluetooth, Hiperlan, …
  - communication over short distance ("personal area networks"), again allow power/cost/bandwidth tradeoffs
- These technologies typically do not provide wide-area coverage, but "islands of high connectivity"

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