



# Chapter 1: Introduction

- **Wireless communications and mobility**
- **History of wireless/mobile communications**
- **Market penetration and growth**
- **Areas of research**





# Electronic Computing Devices & Technology Trends

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## ▣ Advances in Technology

- ▣ more computing power in smaller devices
- ▣ flat, lightweight displays with low power consumption
- ▣ user interfaces suitable for small dimensions
- ▣ higher bandwidths
- ▣ multiple wireless interfaces: wireless LANs, wireless WANs, home RF, Bluetooth



## ▣ New Electronic Computing Devices

- ▣ small, cheap, portable, replaceable and most important of all **USABLE!**

## ▣ Technology Trends

- ▣ devices are aware of their environment and adapt - “location awareness”
- ▣ devices recognize the location of the user and react appropriately (e.g., call forwarding, fax forwarding)





# Wireless and Mobile Communications

## □ Definition of mobility:

- user mobility: users communicate anytime, anywhere, with anyone
- device portability: devices can be connected anytime, anywhere to the network

## □ Definition of wireless:

- Un-tethered, no physical wire attachment

## □ Wireless vs. Mobile      Examples

- |                          |                          |                                   |
|--------------------------|--------------------------|-----------------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | stationary computer               |
| <input type="checkbox"/> | ✓                        | notebook in a hotel               |
| ✓                        | <input type="checkbox"/> | wireless LANs in legacy buildings |
| ✓                        | ✓                        | Personal Digital Assistant (PDA)  |

## □ The need for mobility creates the need for integration of wireless networks into existing fixed network environments:

- local area networks: standardization of IEEE 802.11b/g/a
- Internet: Mobile IP extension of the internet protocol IP
- wide area networks: e.g., internetworking of 3G and IP





# Applications I

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## □ Vehicles

- transmission of news, road conditions, weather
- personal communication using cellular
- position identification via GPS
- inter vehicle communications for accident prevention
- vehicle and road inter communications for traffic control, signaling, data gathering
- ambulances, police, etc.: early transmission of patient data to the hospital, situation reporting
- entertainment: music, video







# Applications II

## □ Mobile workers

- access to customer files and company documents stored in a central location
- collaborative work environments
- access to email and voice messages

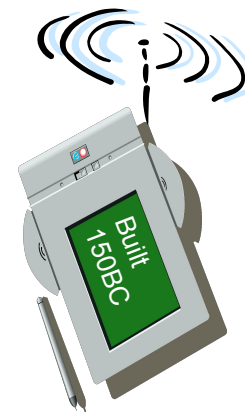


## □ Replacement of fixed networks

- remote sensors, e.g., weather, environment, road conditions
- flexible work spaces
- LANs in legacy buildings

## □ Entertainment, education, ...

- outdoor Internet access
- intelligent travel guide with up-to-date location dependent information
- ad-hoc networks for multi user games





# Mobile Devices

## Pager

- receive only
- tiny displays
- simple text messages



Sensors,  
embedded  
controllers

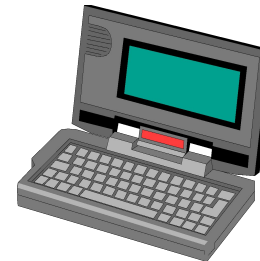
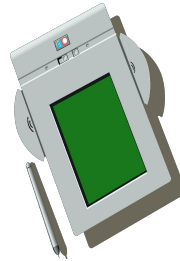


## Mobile phones

- voice, data
- simple text displays

## PDA

- simple graphical displays
- character recognition
- simplified WWW



## Palmtop

- tiny keyboard
- simple versions of standard applications

**performance**





# Impact of Portability on Device Design/Functionality

## □ Power consumption

- battery capacity - limited computing power, low quality/smaller displays, smaller disks, fewer options (I/O, CD/DVD)
- CPU: power consumption  $\sim CV^2f$ 
  - C: internal capacity, reduced by integration
  - V: supply voltage, can be reduced to a certain limit
  - f: clock frequency, can be reduced dynamically based on usage

## □ Device vulnerability

- more rugged design required to withstand bumps, weather conditions, etc.
- theft

## □ Limited/Simpler User Interfaces

- display size
- compromise between comfort/usability and portability (keyboard size)
- integration of character/voice recognition, abstract symbols

## □ Limited memory

- memory limited by size and power
- flash-memory or ? as alternative







# Wireless Networks Compared to Fixed Networks

- ❑ **Higher loss-rates due to interference**
  - ❑ other EM signals, objects in path (multi-path, scattering)
- ❑ **Limited availability of useful spectrum**
  - ❑ frequencies have to be coordinated, useful frequencies are almost all occupied
- ❑ **Low transmission rates**
  - ❑ local area: 2 – 11 Mbit/s, wide area: 9.6 – 19.2 kbit/s
- ❑ **Higher delays, higher jitter**
  - ❑ connection setup time for cellular in the second range, several hundred milliseconds for wireless LAN systems
- ❑ **Lower security, simpler active attacking**
  - ❑ radio interface accessible for everyone
  - ❑ base station can be simulated, thus attracting calls from mobile phones
- ❑ **Always shared medium**
  - ❑ secure access mechanisms important





# Location Dependent Services

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## □ Location aware services

- what services, e.g., printer, fax, phone, server etc. exist in the local environment that can be used by the user (security and authentication)

## □ Follow-on services

- automatic call-forwarding, transmission of the actual workspace to the current location

## □ Information services

- push: e.g., current special offers in the supermarket
- pull: e.g., where is the Sarah Lee New York Cheese Cake?

## □ Support services

- caches, intermediate results, state information, etc., *follow* the mobile device through the fixed network

## □ Privacy

- who should gain knowledge about the location of the user/device





# History & Development – Theoretical Foundations

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## □ Electro Magnetic (EM) waves

- 1678 Huygens work on the phenomena of light reflection and refraction
- 1819 Fresnel demonstrates the wavelike nature of light
- 1831 Faraday demonstrates electromagnetic induction
- 1864 J. Maxwell introduces the theory of electromagnetic fields, wave equations
- 1886 H. Hertz demonstrates experimentally the transmission and detection of an EM wave between two points a few meters apart
- 1896 Marconi recognized that longer waves propagate over larger distances and demonstrates a communication set-up over 3km





# History & Development: Development & Applications



- **1898 - 1901 - Guglielmo Marconi**
  - first demonstration of wireless telegraphy (Morse code - digital!)
  - long wave transmission over longer distances (transatlantic) at an operating frequency of 1MHz
- **1906 - 1<sup>st</sup> World Admin. Radio Conf. (WARC -> WRC)**
  - increasing popularity of radio systems and their extended use
  - ability to define BW using filters led to spectrum control
  - recommendations for the assignment of RF bands
- **1907 - Commercial transatlantic connections**
  - huge base stations  
(30 100m high antennas)
- **1915 - Wireless voice transmission N.Y. - San Francisco**
- **1920 - Discovery of short waves by Marconi**
  - reflection at the ionosphere
  - smaller sender and receiver -> due to the invention of the vacuum tube (1906 - Lee DeForest and Robert von Lieben)





# History & Development: Development & Applications

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- **1933 - Frequency modulation (E. H. Armstrong)**
- **1946 - Mobile Telephone Service (MTS) in US**
  - introduced in 1946, it allowed telephone calls between fixed stations and mobile users
  - one single powerful transmitter/receiver (base station) provided coverage of up to 50km
  - based on FM technology, each voice channel of 3kHz used 120KHz of spectrum, and only half duplex service was available
  - blocking probabilities were as high as 65% (only 12 simultaneous calls could be handled!)
- **1958 - A-Netz in Germany at 160MHz**
  - analog cellular, connection setup only from the mobile station, no handover, 80% coverage, 1971 only 11000 customers
- **1972 - B-Netz in Germany at 160MHz**
  - connection setup from the fixed network (location of the mobile station had to be known)





# History & Development: Analog Cellular Services

- Two major technological improvements made the cellular concept a reality:
  - the microprocessor -> allowed for complex algorithms to be implemented, and
  - digital control links between base station and mobile unit -> allowed for increased control of the system so more sophisticated services could be made available:
    - hand-overs
    - digital signaling
    - automatic location of mobile device
- 1979 - Analog Mobile Phone System (AMPS) in US
- 1979 - NMT at 450MHz in Scandinavian countries
- 1985 - France's Radiocom 2000
- 1985 - UK's TACS
- 1986 - C-Netz in Germany at 450MHz





# History & Development: Digital Cellular

- **1991 - Specification of DECT**
  - Digital European Cordless Telephone (today: Digital Enhanced Cordless Telecommunications)
  - 1880-1900MHz, ~100-500m range, 120 duplex channels, 1.2Mbit/s data transmission, voice encryption, authentication, up to several 10000 user/km<sup>2</sup>, used in more than 40 countries
- **1992 - Start of GSM**
  - fully digital, 900MHz, 124 channels
  - automatic location, hand-over, cellular
  - roaming initially in Europe - now worldwide in more than 100 countries
  - services: data with 9.6kbit/s, FAX, voice, ...
- **Early 90's - IS 54, IS 136, IS 95 in US in same spectrum as AMPS**
  - IS 54 is a TDMA digital standard that uses the old AMPS system for transmission.
  - IS 136 is the new TDMA standard and
  - IS 95 is the CDMA based standard. All 4 systems are in operation in the US!
- **1994 - GSM at 1800MHz (called Digital Cellular Service (DCS1800))**
  - smaller cells, supported by 11 countries





# History & Development: Digital Wireless Services

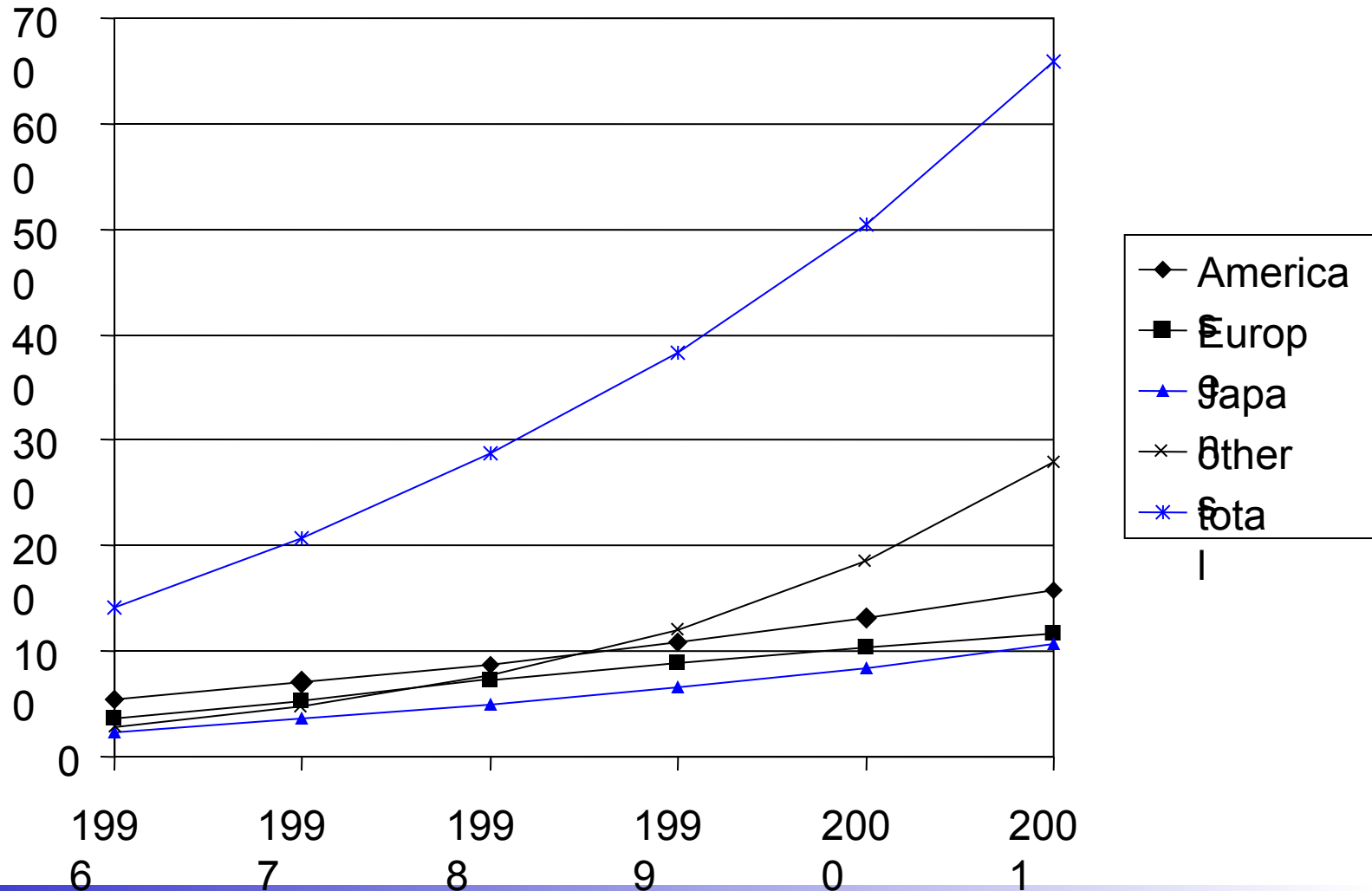
- **1996 - HiperLAN (High Performance Radio Local Area Network)**
  - ETSI, standardization of type 1: 5.15 - 5.30GHz, 23.5Mbit/s
  - recommendations for type 2 and 3 (both 5GHz) and 4 (17GHz) as wireless ATM-networks (up to 155Mbit/s)
- **1997 - Wireless LANs**
  - many products with proprietary extensions out there already
  - IEEE-Standard, 2.4 - 2.5GHz, 2Mbit/s
- **1998 - Specification of GSM successors**
  - UMTS (Universal Mobile Telecommunication System) as the European proposal for IMT-2000
- **1998 - Specification for next generation CDMA starts**
  - Qualcomm starts work on wideband CDMA spec.
- **1999 - Specification of IEEE802.11b**
  - increased BW to 11Mbit/s
- **2000 - Bluetooth Specification**
  - 1Mbit/s specification, single cell
  - Work on 10Mbit/s spec. with multi cell capability initiated





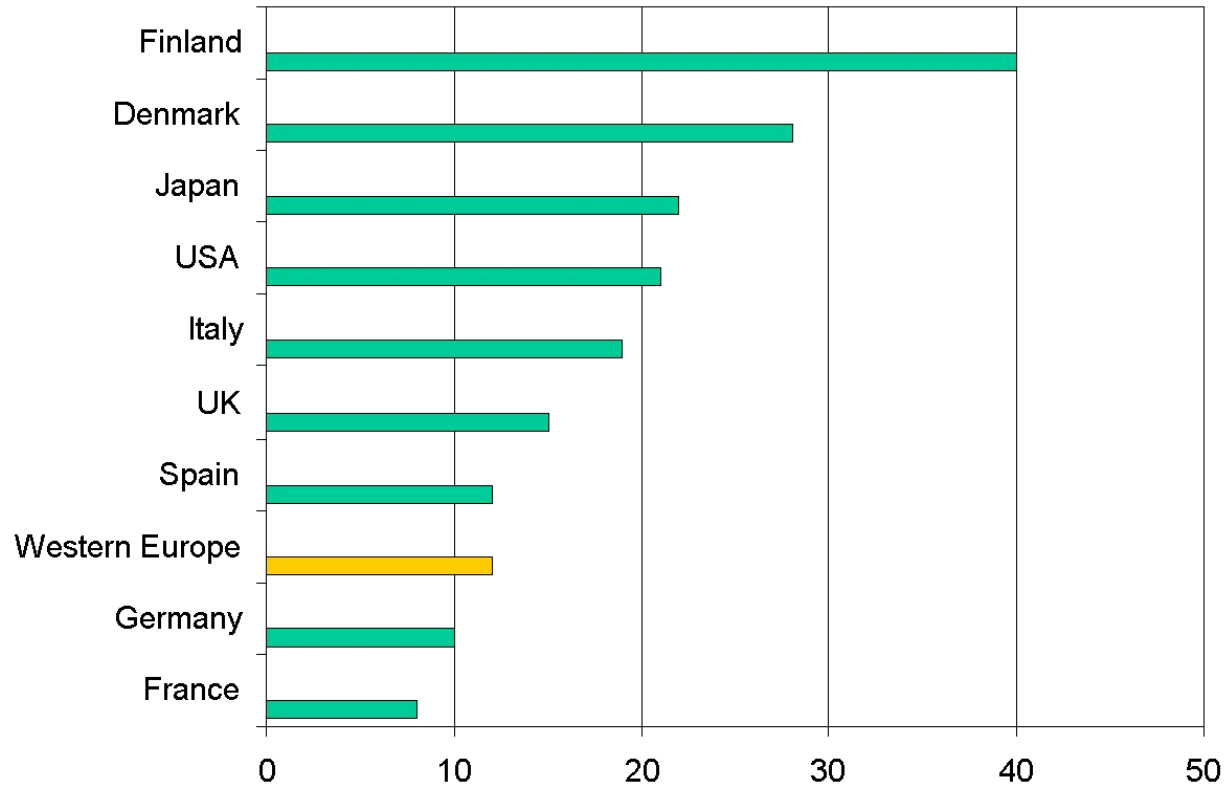


## Worldwide Wireless Subscribers (projected for 2001)





# Mobile phones per 100 people 1997





# Areas of research in mobile communication

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## □ **Wireless Communication**

- transmission quality (bandwidth, error rate, delay)
- modulation, coding, interference
- media access, regulations
- ...

## □ **Mobility**

- location dependent services
- location transparency
- quality of service support (delay, jitter, security)
- ...

## □ **Portability**

- power consumption
- limited computing power, sizes of display, ...
- usability
- ...

