Wireless and Mobile Network Architecture

Chapter 1: Introduction

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Outline

- Introduction
- PCS Architecture
- Cellular Telephony
- Coreless Telephony
- Summary

Introduction

- The term **Personal Communication Service** (enabling communication with a person at anytime, at any place, and in any form) include
  - **Various Wireless Access**
  - **Personal Mobility Services**
- Two of the most popular cellular systems
  - **High Tier Digital Cellular Systems**
  - **Lower Tier Cordless Telecommunication Systems**

Cont.

- These PCS systems are connected to the public switched telephone network (PSTN) to provide access to wireline telephones
- PCS networks can serve as a general platform to build distributed computing applications (or so called mobile computing)

Examples of Personal Communications Services (PCS)

- **High-Tier Digital Cellular Systems** (mobile phone systems)
  - Global System for Mobile Communication (GSM)
  - IS-136 TDMA based Digital Advanced Mobile Phone Service (DAMPS)
  - Personal Digital Cellular (PDC)
  - IS-95 CDMA-based cdmaOne system

Cont.

- **Low-Tier Telecommunication Systems** for residential, business, and public cordless access applications
  - Cordless Telephone (CT2)
  - Digital Enhanced Cordless Telephone (DECT)
  - Personal Access Communications Systems (PACS)
  - Personal Handy System (PHS)

Cont.

- **Wideband Wireless Systems** have been developed to accommodate Internet and multimedia
  - cdma2000
    - evolved from cdmaOne
  - W-CDMA
    - proposed by Europe
  - SCDMA
    - proposed by China/Europe

Cont.

- Special data systems
  - Cellular Digital Packet Data (CDPD)
  - RAM Mobile Data
  - Advanced Radio Data Information System (ARDIS)
- Paging systems
- Mobile-satellite systems
- ISM band technologies
  - Wireless local area networks (LAN)

1.1 PCS Architecture

- Two of the most popular are
  - Cellular telephony
  - Cordless and low-tier telephony
- The basic architecture consists of two parts. (Fig. 1.1)
  - **Radio Network**
  - **Wireline Transport Network**

Fig. 1.1 The basic PCS network architecture

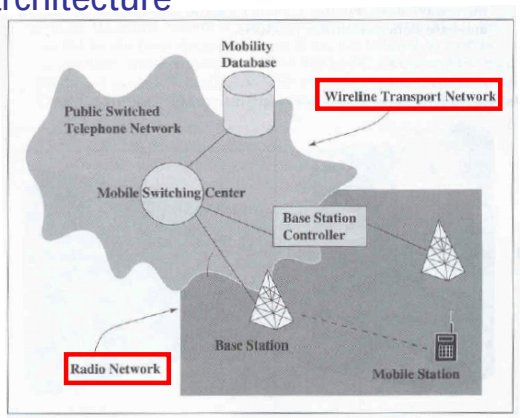

Figure 1.1 The basic PCS network architecture.

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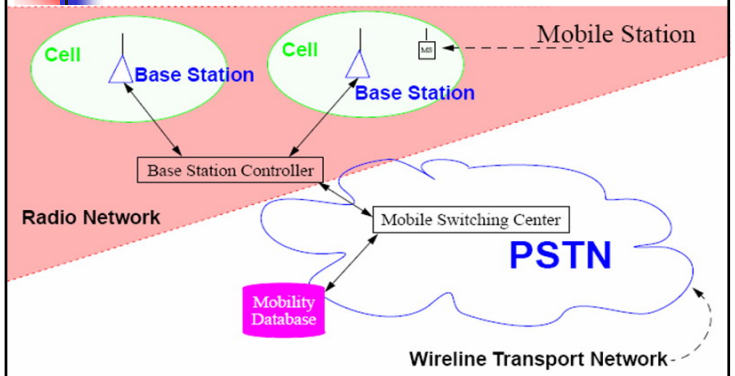

Figure 1.1: Basic PCS network architecture

Radio Network

- Handsets, Mobile Phones, Mobile Stations (MSs)
  - Modern handset technology allow the air interface to be updated over the air (e.g., from DECT to GSM) remotely.
  - The handset can also be remotely monitored by the system maintenance and diagnostic capability.

Cont.

- Base Station (BS) (Fig. 1.2 and Fig. 1.3)
  - The Radio Coverage of a BS or a sector in the BS is called a Cell.
  - For systems (e.g., GSM, cdmaOne, and PACS), the BS system is partitioned into a controller (base station controller in GSM and radio port control unit in PACS) and radio transmitters/receivers (base transceiver stations in GSM and radio ports in PACS).
  - The BSs usually reach the wireline transport network (core or backbone network) via land links or dedicated microwave links.

Fig. 1.2 CDMA base transceiver station

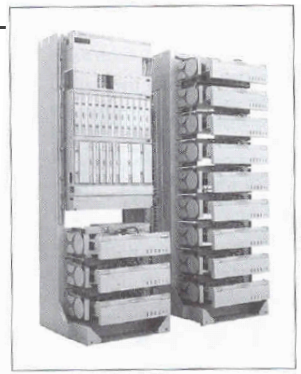

Figure 1.2 CDMA base transceiver station (by courtesy of Nortel).

Fig. 1.3 CDMA base station controller

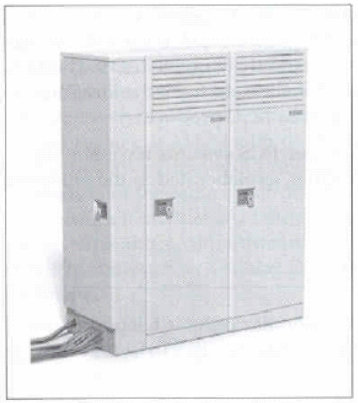

Figure 1.3 CDMA base station controller (by courtesy of Nortel).

Wireline Transport Network

- Mobile Switching Center (MSC)
  - The MSC connected to the BS is a special switch tailored to mobile applications.
    - For example, the Luccent 5ESS MSC 2000 is a MSC modified from Lucent Technologies' 5ESS switching systems.
    - The Siemens' D900/1800/1900 GSM switch platform is based on its EWSD (Digital Electronic Switching System) platform.
  - The MSC is connected to the PSTN to provide services between the PCS users and the wireline users.

Cont.

- The **Mobility Database** connected to the MSC is used to track the locations of mobile stations.

Fig. 1.4 Mobile switching center

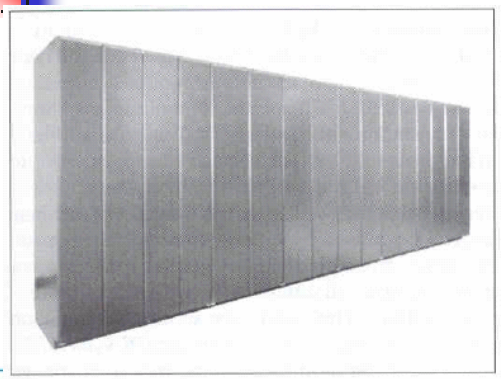

Figure 1.4 Mobile switching center (CDMA MTX MSC by courtesy of Nortel). .8

1.2 Cellular Telephony

- This section gives an overview of four popular telephony networks
  - AMPS
  - GSM
  - DAMPS (IS-136)
  - CDMA (IS-95)

Advanced Mobile Phone Service (**AMPS**)

- AMPS adopts **Frequency Division Multiple Access** (FDMA) and a frequency reuse scheme for radio communication and high-capacity issue, respectively.
- Voice channels are assigned to radio frequency using FDMA.
- Total **50** MHz = 824 – 849 MHz + 869 – 894 MHz (including 832 full-duplex channels using 1664 discrete frequencies).

Cont.

- In **frequency reuse** scheme, cells are group into clusters. Frequencies may be reused by cells in different clusters.
- In AMPS, the typical frequency reuse plan employs either a 12-group frequency cluster using omnidirectional antennas or a 7-group cluster using three sectors per BS. There are about **50** channels per cell (e.g., 4-cell, 6-sector design in Motorola AMPS system).

Cont.

- AMPS follows EIA/TIA IS-41 standard for **roaming management**.
- In 2000, Taiwan started replacing AMPS with IS-95 CDMA system.

Global System for Mobile Communications (**GSM**)

- GSM is a “Digital” cellular system developed by Groupe Special Mobile of Conference Europeenne des Posts et Telecommunications (**CEPT**) and European des Postes et Telecommunications (**ETSI**)
- In air interface, GSM combines Time Division Multiple Access (TDMA) and FDMA.
- In GSM, a frequency carrier is divided into eight time slots (speed coding rate **13** Kbps).

Cont.

- In a GSM BS, every pair of radio transceiver-receiver supports **eight** voice channels.
- **935-960** MHz for downlink, **890-915** MHz for uplink, and 200 KHz for RF channel spacing.
- The GSM air interface has been evolved into Enhanced Data Rate for GSM Evolution (**EDGE**) with variable date rate and link adaptation.

Cont.

- EDGE utilizes highly spectrum spectrum-efficient modulation for bit rates higher than existing GSM technology.
- The GSM *roaming management* protocol is specified by **GSM Mobile Application Part** (MAP).
- GSM features include most futures a digital switch can provide (e.g., point-to-point short message, group addressing, call waiting, multiparty services.)

EIA/TIA **IS-136** Digital Cellular System

- Also referred to as digital AMPS (DAMPS), American Digital Cellular (ADC), or North American TDMA (NA-TDMA), IS-136, the successor to IS-54.
- IS-136 supports a **TDMA** are interface similar to that of GSM, and is thus considered an evolutionary technology.
- Every IS-136 frequency carrier supports three voice channels, where the speed coding rate is **7.95** Kbps.

Cont.

- IS-136 operates in the same spectrum with the same frequency spacing (30 KHz) used by the exiting AMPS systems (resulting in 3 times of capability of AMPS).
- Like GSM, features of IS-136 includes
  - point-to-point short messaging, broadcast messaging, group addressing, private user groups, hierarchical cell structures.

Cont.

- IS-136 provided **slotted paging** channels to support a "sleep mode" in the handset.
- IS-136 uses the **IS-41** standard for mobility management.

EIA/TIA IS-95 Digital Cellular System

- This digital cellular system was developed by Qualcomm, and has been operating in USA since 1996.
- IS-95 is based on Code Division Multiple Access (CDMA) for the air interface.
- CDMA allows many users to share a common frequency/time channel for transmission, where user signals are distinguished by spreading them with different codes.

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Cont.

- IS-95 MSs may need to maintain links with two or more BSs continuously during phone calls, so that, as multipath varies, the BS with the best received signal on a burst-by-burst will be selected to communicate with the MS.
- The channel bandwidth used by IS-95 is 1.25 MHz.
- The capacity of IS-95 is 3-6 times of IS-136 system, and 10 times of AMPS.
- In the third-generation wideband CDMA proposal, the bandwidth has been extended to 5MHz.

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Cont.

- The speech coding rate for IS-95 is 13 Kbps or 8Kbps.
- The most significant IS-95 development was taking place in **Korea**. The commercial operation was began in April, 1996.
- The maximum capacity of 512 BTS (320 traffic channels per BTS) connected to 12 BSCs.
- These BSCs are then connected to a MSC (called MX) using 768 E1 lines.

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1.3 Cordless Telephony and Low-Tier PCS

- Cordless Telephone, Second Generation (CT2)
- Digital European Cordless Telephone (DECT)
- Personal Handy Phone System (PHS)
- Personal Access Communications System (PACS)

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Cordless Telephone, Second Generation (CT2)

- CT2 was developed in Europe, and has been available since 1989.
- CT2 is allocated 40 **FDMA** channels with a 32-Kbps speech coding rate

Digital European Cordless Telephone (DECT)

- Were published in 1992. The name has been replaced by Digital Enhanced Coreless Telephone.
- DECT supports high user density with a picocell design
- Using **TDMA**, 12 voice channels per frequency carrier. Sleep mode is employed in DECT to conserve the power of handsets.

Cont.

- DECT may move a conversation from one time slot to another to avoid interference, which is called **time slot transfer**.
- DECT also supports **seamless handoff**.
- DECT used TDD. The voice code uses a **32** Kbps speech coding rate.
- DECT channel allocation is performed by measuring the field strength, which is called *dynamic channel allocation*.

Cont.

- DECT is typically implemented as a wireless-PBX connected to the PSTN.
- An important feature of DECT is that it can interwork with GSM to allow user mobility, where the **GSM** handsets provide **DECT** connection capabilities.

Personal Handy Phone System (PHS)

- PHS is a standard developed by Research and Development Center (**RCR**), Japan.
- PHS, a lower tier digital PCS system, offers telecommunication services for homes, offices, and outdoor environment, using radio access to the PSTN or other digital networks.
- PHS uses **TDMA** and **TDD** technologies, where 4 multiplexed channels/frequency carrier.

Cont.

- 5 hrs talk time and 150 hrs standby time (due to Sleep Mode)
- 1895 – 1906.1 MHz = 300 KHz * 37 channels (home/office)
- 1906.1 – 1918.1 MHz = 300 KHz * 40 channels (public system)
- **32** Kbps (speech coding rate)

Cont.

- Like DECT, PHS supports dynamic channel allocation.
- Dedicated control channels are adopted (i.e., a fixed frequency that carries system and signaling information).
- PHS supports Group 3 (G3) fax at 4.2 to 7.8 Kbps and full-duplex modem with transmission rate speeds up to 9.6 Kbps.

Personal Access Communication System (PACS)

- PACS is a lower-power PCS system developed at Telcordia (formerly Bellcore), USA.
- PACS is designed for wireless local loop and personal communications services. (Chapter 23)
- **TDMA** is used.

Cont.

- 8 voice channels/frequency carrier.
- Both TDD and *frequency division duplexing* (FDD) are accommodated.
- The highly effective and reliable mobile-controlled handoff (MCHO) completes in less than 20 msec.

1.4 Third-Generation Wireless Systems

- Mobile telecommunication systems have been evolving for three generations.
- First Generation System: AMPS
- Second Generation System: GSM, IS-136, IS-95, and lower-tier systems.

Cont.

- Speech with low-bit-rate data services are accommodated in the 1st and 2nd systems.
- Third-Generation are targeted at better system capacity, high-speed and wireless Internet access (to **2** Mbps), and wireless multimedia services (audio and video).

Cont.

- Several technologies (e.g., GPRS and EDGE) bridge second generation into third generation systems, (which are so called 2.5 G).
- The new features for 3G includes
  - **Asynchronous Transfer Mode (ATM) backbone,**
  - **Wideband CDMA (W-CDMA) and cdma2000 for air interface.**

Summary: Characteristics of Cellular and Cordless Low-Tier PCS Technologies

Table 1.1 Characteristics of Cellular and Cordless Low-Tier PCS Technologies

SYSTEM	HIGH-TIER CELLULAR	LOW-TIER PCS	CORDLESS
Cell size	large (0.4–22 mi.)	medium (30–300 ft.)	small (30–60 ft.)
User speed	high (≤ 160 mph)	medium (≤ 60 mph)	low (≤ 30 mph)
Coverage area	large/continuous macrocells	medium micro and picocells	small/zonal picocells
Handset complexity	high	low	low
Handset power consumption	high (100–800 mW)	low (5–10 mW)	low (5–10 mW)
Speech coding rate	low (8–13 Kbps)	high (32 Kbps)	high (32 Kbps)
Delay or latency	high (≤ 600 ms)	low (≤ 10 ms)	low (≤ 20 ms)

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