Wireless Mobile Telephony

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- Why wireless mobile telephony ?
- First Generation, Analog technologies
- Second Generation, Digital :
  - GSM, D-AMPS, IS-95
- Third Generation: ITU IMT-2000
- IMT-2000 also as Internet Mobile Telecommunication

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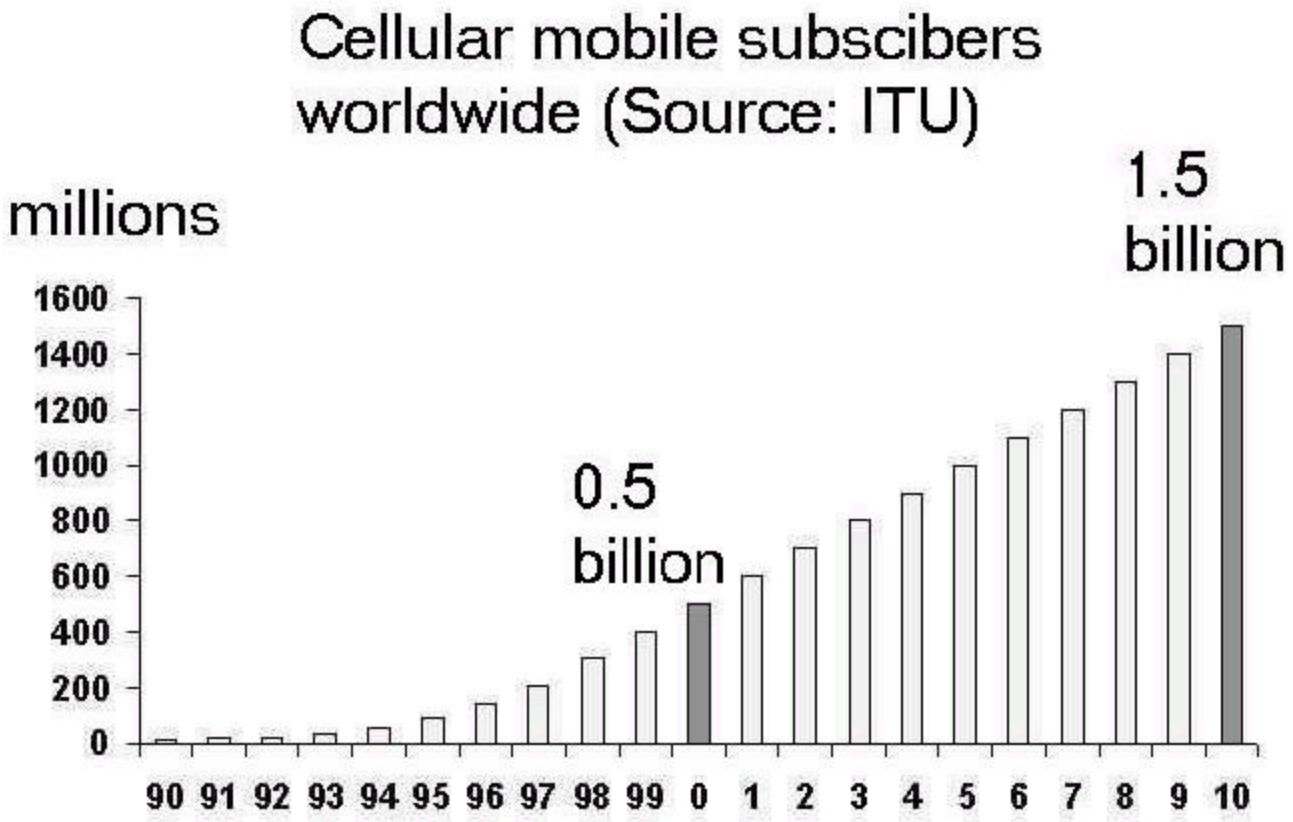
Why Wireless Mobile Telephony ?

- Negroponte Switch : Personal mobile communications go on Ether, Broadcast communications on cable
- Frequency Spectrum probably the most valuable natural resource
- Progress in microelectronic - very smart mobile terminals
- More open for business opportunities
- Mobile phone the only technology with a growth rate higher than Internet. By the year 2003: 700 millions Internet users and 830 millions mobile phone users

Growth of Cellular Market



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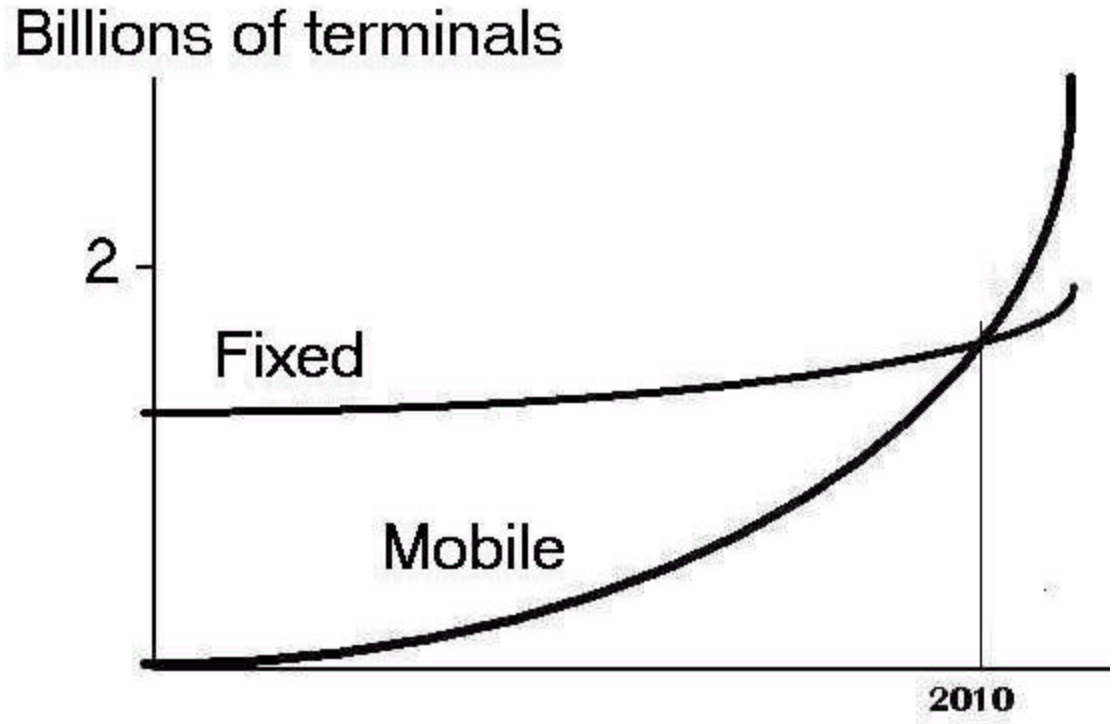
Fixed & Mobile Growth



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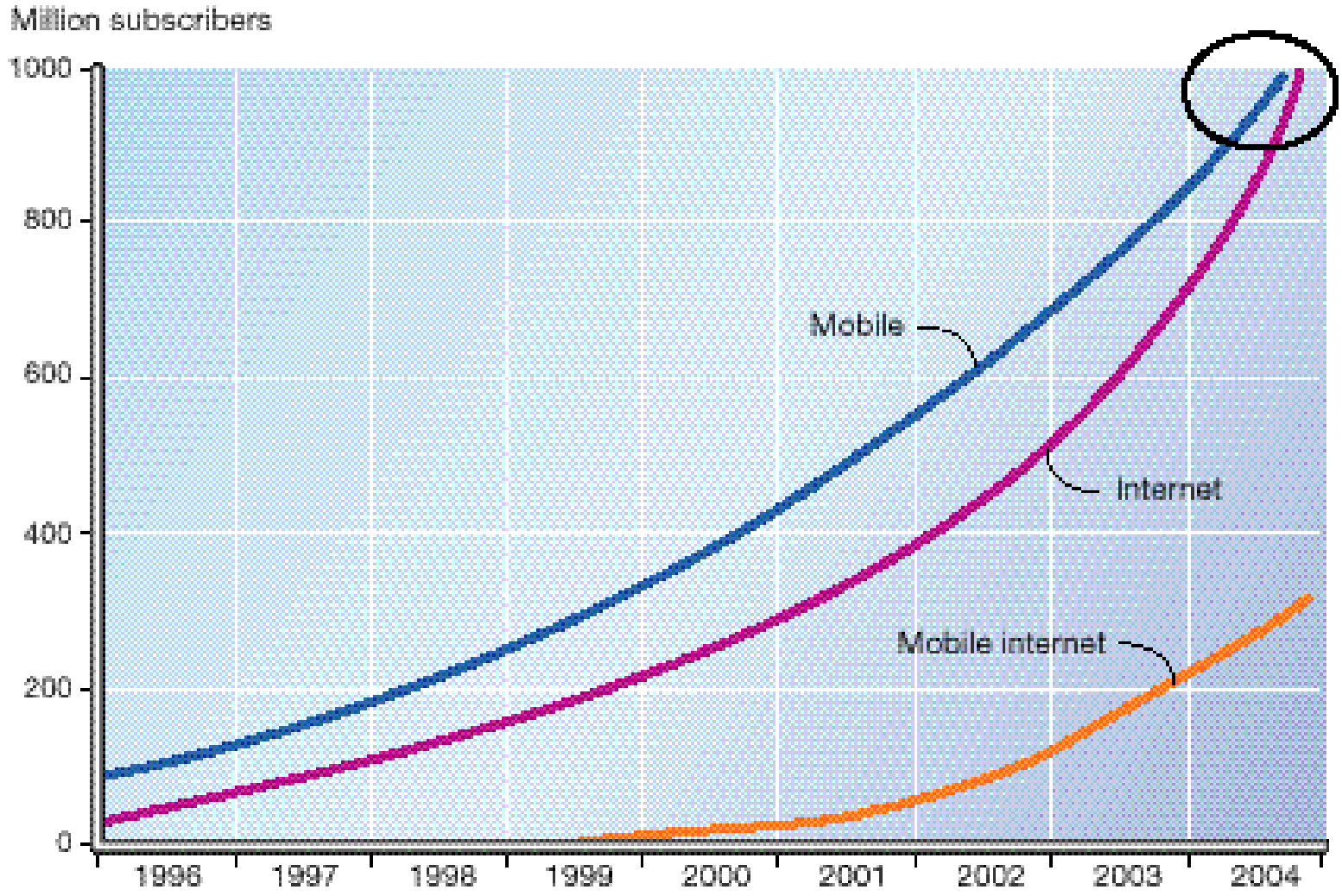
Mobile + Internet



[IPWRLSS]

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Mobile Phone First Generation

- First Generation: Analog, 70'-80', Access FDMA
  - Advanced Mobile Phone System (AMPS) 800 MHz, North America
  - Total Access Communication System (TACS) 900 MHz, Europe
  - Nordic Mobile Telephone (NMT) 450 and 900 MHz, Sweden, Norway, Denmark, Finland etc.
  - Good basic service, good territorial coverage.
  - Continue to operate profitably. Will survive for some time

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Mobile Phone Second Generation (2G)

- The need for second generation:
  - Capacity: The old systems were almost saturated
  - More services, specially value added
  - Analog system more vulnerable to physical influences and disturbances

2G (cont.)

- Second Generation. Digital Technology
  - Global System for Mobile Communication (GSM), Europe +, US too
  - Digital Advanced Mobile Phone System (D-AMPS): International Standard (IS-136), US +
  - Interim Standard 95 (IS-95): 50% of US market, Asia (South Korea), South America.
  - Personal Digital Cellular (PDC): Japan
- Third Generation in development: 2G will seamlessly evolve to provide high-speed data and support for multimedia application

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2G (cont.)

Standard	Subscribers Millions	Countries/ Networks	Monthly grow Millions
GSM	183.3	120/284	7.6
PDC	42.3	1/30.	0.6
IS-136	24.3	34/104	1.4
IS-95	31.5	12/31.	1.5

[3GSTD] Digital Cellular Standards, End of June 1999

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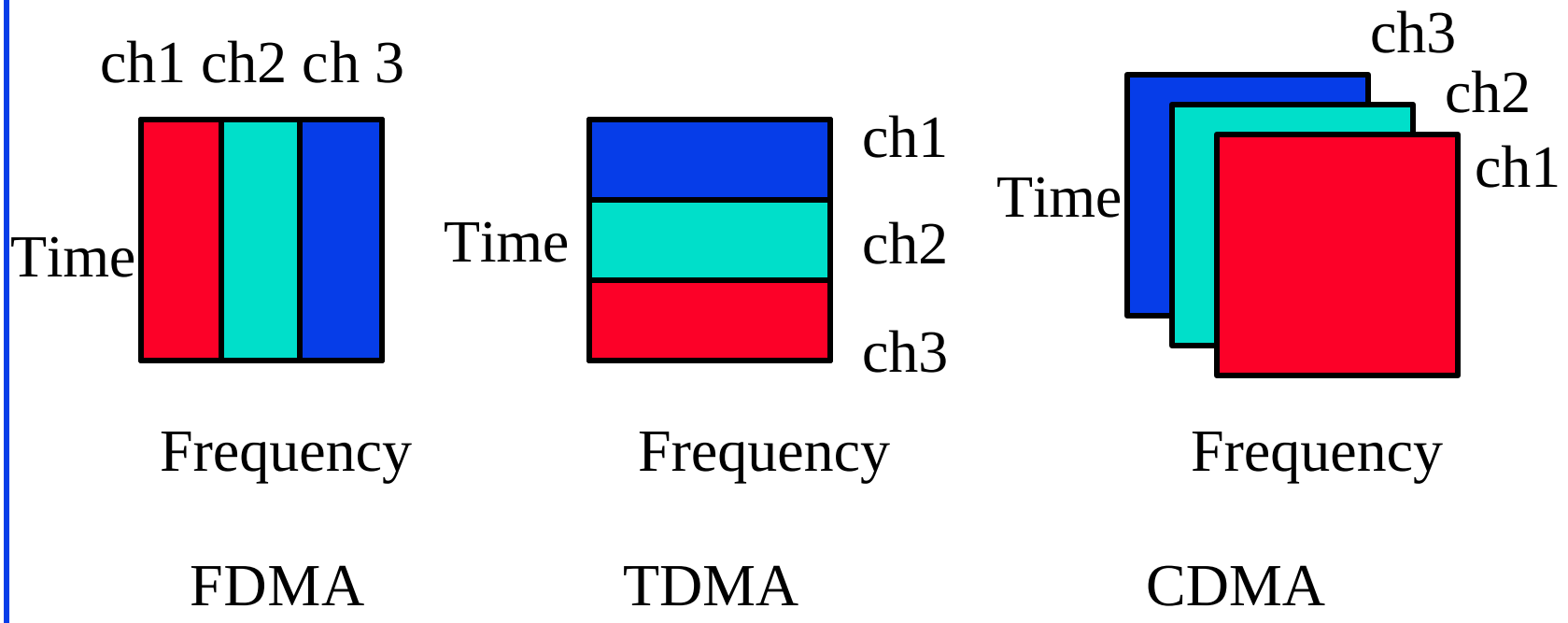
Multiple Access Schemes



- Multiple access = Supporting more than one communication channel on a radio resource
- Big debate: Who will win TDMA or CDMA?

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TDMA vs. CDMA

- Spectrum Efficiency: Which multiple access scheme has better bps/Hz.cell ?
- Flexibility: Which access scheme offers better flexibility to handle multi-rate, -cell, -load, and -services ?
- TDMA: some flexibility advantages, but has a spectrum efficiency disadvantage
- CDMA: Less flexibility but has better spectrum efficiency Has
- Actual results depend on standards details

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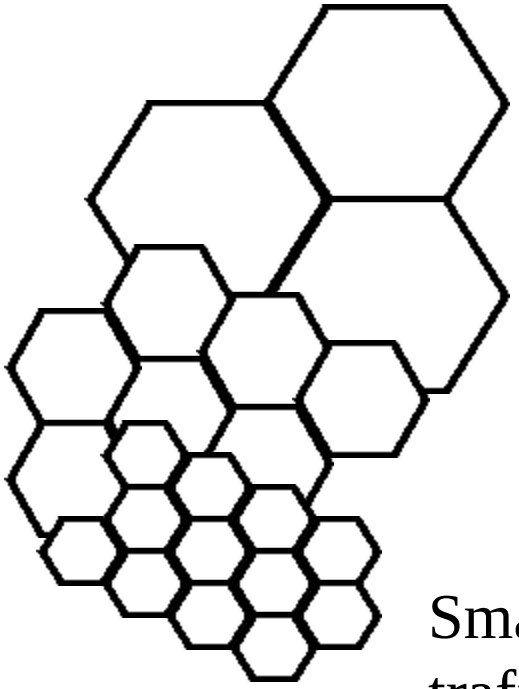
TDMA vs. CDMA cont.

- Answer unclear:
  - IS-95 is probably superior to IS-54/136
  - IS-95 vs. GSM is unclear
  - IS-95 is clearly more complex
- IS-54/136 is a grossly sub-optimum TDMA system
- GSM is a sub-optimum TDMA system (but pretty good)
- IS-95 is a sub-optimum CDMA system

Cellular System



Large cells for low density traffic areas

Small cells for high density traffic areas

- Cellular structure permits to reuse the frequencies and to distribute the resources depending on the traffic

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Radio Resource Management

- Cell planning and management quasi online [IRMA] :
  1. Simulation of radio propagation using data from satellite about the territory, building, vegetation etc.
  2. Optimization of step 1: radio parameters, power.
  3. The dimensions of the cells and number of channels are calculated from the traffic foreseen in that area.
  4. Frequency distribution among the cells, trying to reduce the interference.
- Specialized personnel, computer system: Operation Support Systems (OSS)

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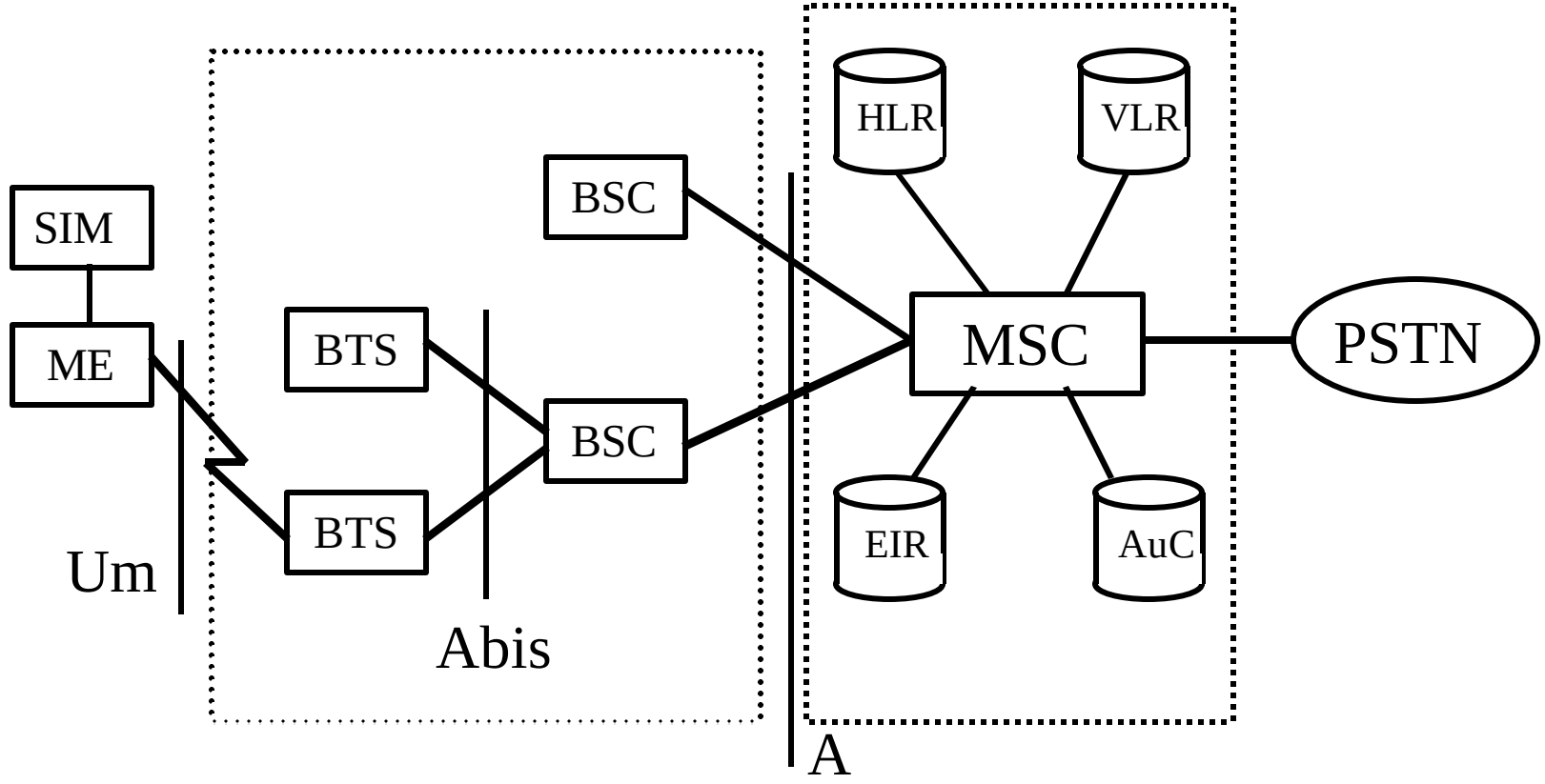
GSM

- Global System for Mobile Communication
- 1982 CEPT, 1989 ETSI, standard 8000 pages
- GSM 900 MHz, DCS 1800 MHz, DCS 1900 MHz in US and Canada
- Access scheme: TDMA /FDMA
- Services: Telephony - digitized voice 13kbs, data services up to 9.6bps soon 38.4kbps, group 3 facsimile, Short Message Service (SMS), ISDN, X.25
- International roaming: Subscribers can use the same phone terminal around the world and bill to home. This is a very attractive feature for the users.

Architecture of the GSM network



- All the interfaces are standard - this permits a fierce competition among the vendors and a multi vendor network - advantage for the operators

Elements of GSM Architecture

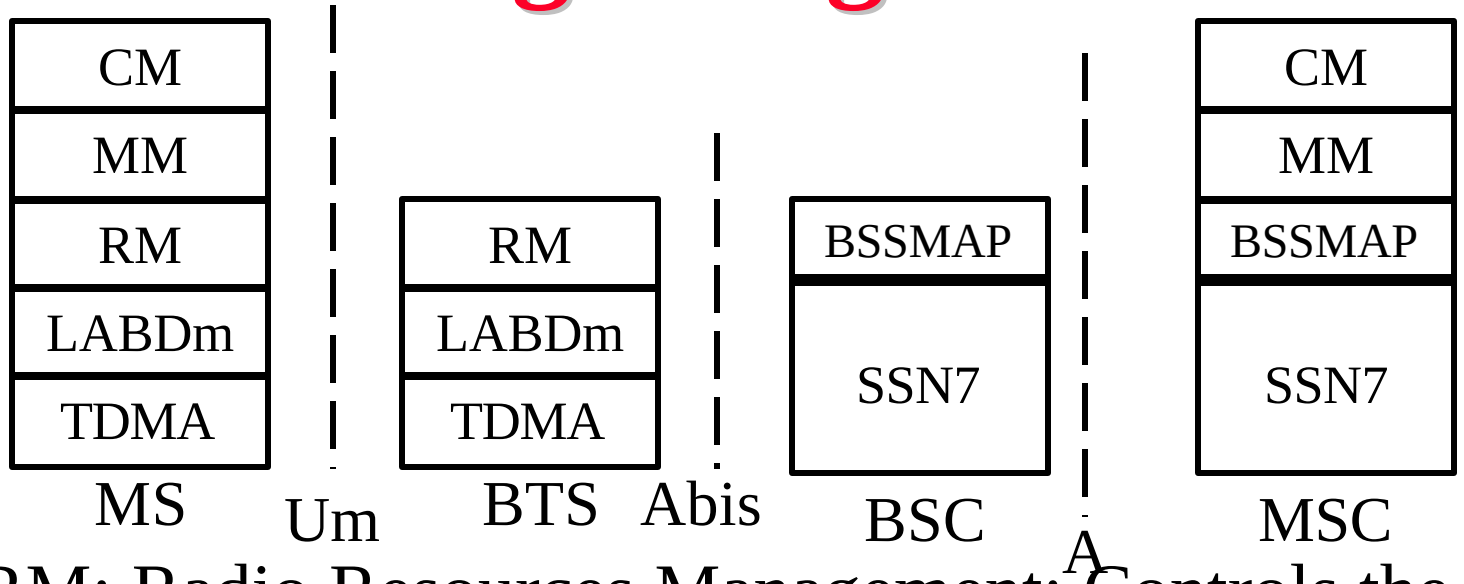
- SIM: Subscriber Identity Module contains the

  International Mobile Subscriber Identity (IMSI) used to identify the subscriber to the system, a secret key for authentication
- ME: Mobile Equipment
- BTS: Base Transceiver Station handles the radio-link protocols with the Mobile Station.
- BSC: Base Station Controller handles radio-channel setup, frequency hopping, and handovers
- HLR: Home Location Register - all the administrative information of each subscriber, and the current location of the mobile

Architecture of GSM network

- VLR: Visitor Location Register contains selected information, for call control and services for mobiles located in its geographic area.
- MSC: Mobile services Switching Center - normal switching node of the PSTN (Public Switched Telephone Network), plus functionality for registration, authentication, location updating, handovers, and call routing to a roaming subscriber.
- EIR: Equipment Identity Register
- AuC: Authentication Center stores a copy of the secret key of each subscriber's SIM card, used for authentication and encryption

GSM Signaling Protocols



- RM: Radio Resources Management: Controls the setup, maintenance, and termination of radio and fixed channels, including handovers
- MM: Mobility Management: location updating, registration procedures, security and authentication.
- CM:Connection Management: call control.
- MAP: Mobile Application Protocol

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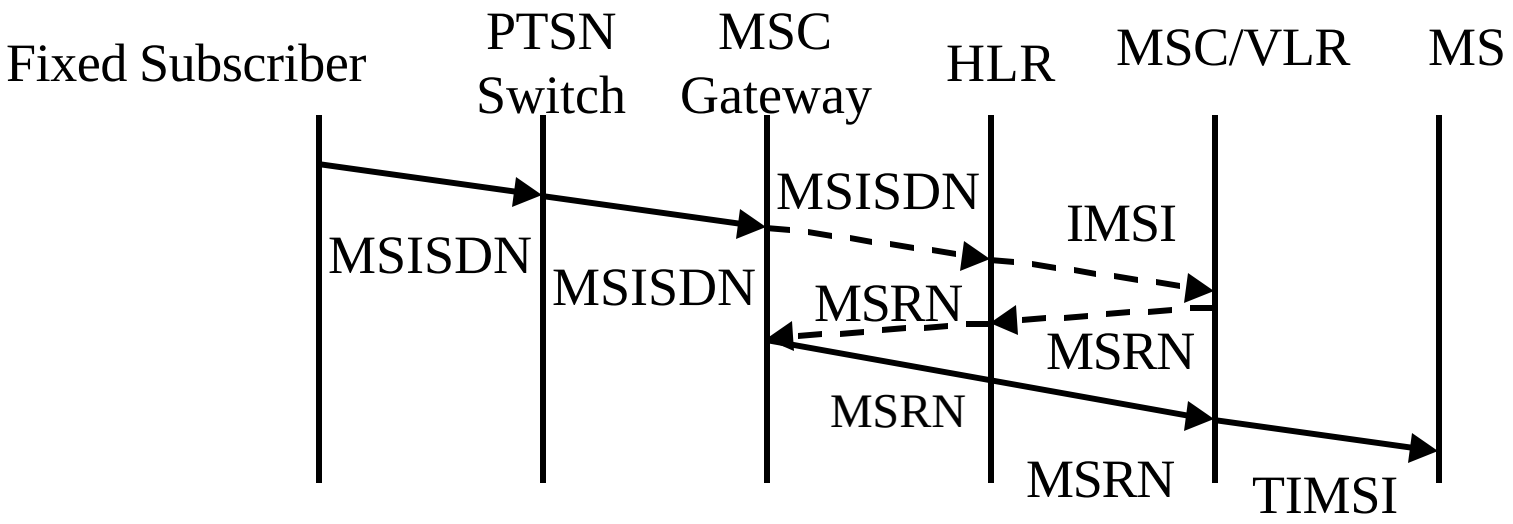
Call Routing



- MSISDN: Mobile Subscriber ISDN
- IMSI: International Mobile Subscriber Identity
- MSRN: Mobile Station Roaming Number
- TIMSI: Temporary IMSI is used in the air to protect the real identity-IMSI

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GSM features

- 124 channel of 200kHz, each channel up to eight logic channels:
  - Traffic (TCH) voice/data, Control (CCH) control and signaling, Cell Broadcast (CBCH)
- Up to eight traffic channels TCH per frequency
- Multipath equalization. The system “studies” the radio channel using a known sequence in every data time slot, than “reacts” constructing an inverse filter.
- Frequency hopping helps to reduce interference
- Automatic Power Control reduces co-channel interference
- Layered signaling protocol

GSM features

- Handover or handoff: Switch an on-going call to a different channel or cell.
- Authentication: Fraud is a problem in mobile phone.
- Security: GSM can encrypt the air transmission
- High Speed Circuit Switched Data (HSCSD): A single user is allocated more than one time slot. Using eight time slots would give a transmission rate of 76.8 kbps

GSM Evolution

- General Packet Radio Service (GPRS): Packet connection over GSM, 14 kbps over one time slot and 115 kbps over eight, allow connections to IP networks
  - Two new network elements:
    - Serving GPRS Support node (SGSN), similar functionality to packet data as MSC/VLR
    - Gateway GPRS Support Node (GGSN), interface between mobile and IP or X.25 networks
- Enhanced Data Rates for GSM Evolution (EDGE), next step to 3G, IP-based services, 384 kbps
- Wideband CDMA introduces a new air interface on a 5MHz channel

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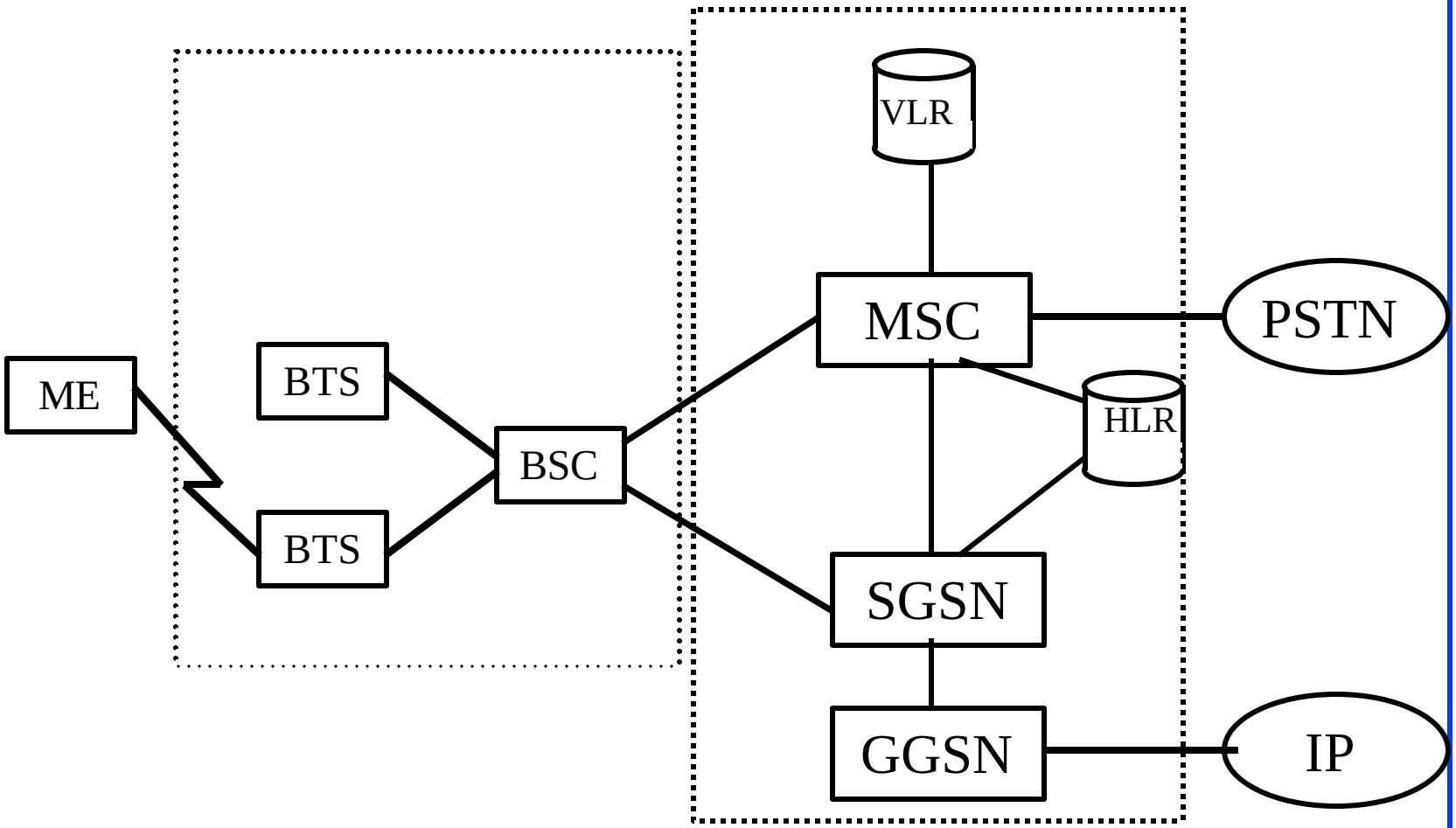
GSM/GPRS Architecture



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IS-136

- Telecommunication Industry Association TIA standard IS-136, November 1994
- IS-136 or D-AMPS is a superset of IS-54, which is a development of AMPS (analog)
- AMPS: Advanced Mobile Phone System
- Access scheme: TDMA
- Frequencies 800MHz, 1.9GHz, Channel bandwidth 300KHz
- D-AMPS worldwide network with over 24 million subscribers, analog + digital 75 million
- Voice is digitized at 8kbps

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IS-136 cont.

- It is possible to upgrade easily from an analog AMPS network to a digital D-AMPS network
- Digital and analog AMPS channels can co-exist in the same network
- A dual handset can operate in both analog and digital AMPS, in both 800 and 1900 MHz.
- Asynchronous data service, fax, Short Message Service, Sleep Mode capability
- Allow hierarchical cell structures to be implemented
- D-AMPS offers CDPD service

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IS-136 Evolution to 3G

- First phase: IS-136+, significantly improves voice and data services, allow connectivity to IP networks
  - IS-136+ data service will be based on GPRS architecture (see GSM evolution)
- Second phase: IS-136HS High Speed extended data rate to 384kbps, will embrace the EDGE standard (at least outdoor) to meet 3G requirements.

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IS-95

- Telecommunication Industry Association (TIA) standard IS-95, July 1993, also known as cdmaOne and ANSI-95.
- Developed from Qualcomm's proposal
- Access scheme: narrowband CDMA, Walsh codes - mutually orthogonal
- Frequencies: 800 MHz, 1.9 GHz. Radio channel bandwidth 1250 KHz. The band is divided in 20 full duplex carriers with up to 64 channels each.
- Limited international roaming

IS-95 cont.

- Services: Telephony - digitized voice 8 and 13kbs, data services up to 9.6 bps and 14.4 kbps, fax.
- The mobile stations add a “pseudo random code” to the useful data, but with different time shift.
- Unique time offsets ⇒ Time synchronized.
- A pilot channel: demodulation reference for initial synchronization and power measurement for handover.
- A Sync channel conveys the timing and system configuration information to the mobile station
- Coverage, quality and capacity are related and must be balanced off of each other to arrive at the desired level of system performance. More difficult to be tuned.

IS-95 cont

- Simplified cell planning through the use of the same frequency in every cell
- Capacity increase, compared to GSM, but at the cost of quality and coverage.
- Automatic power control
- Soft handover: allows the mobile to communicate with multiple base stations simultaneously and chose the best of them.
- Effective fraud control
- Technology with a strong potential

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IS-95 Evolution

- Two phases: IS-95B and cdma2000, the key advantage for the operators is preservation of capital investments, maintain backward compatibility with existing IS-95 infrastructure
- IS-95B will provide enhanced data rates 76.8 kbps or 115.2 kbps
  - Use burst mode: allowing up to 8 simultaneous transmissions/receptions on multiple channels
- cdma2000 will include wider channel bandwidth, combination of 1.25 MHz and 3.75 MHz, higher chip rate 3.68 MHz chip, permits the stations when is idle to release the traffic channel.

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Third Generation (3G)

- 2G systems brought mobile telephony to mass market
- 3G will introduce value beyond basic telephony
- The challenge for 3G: To merge mobile telephony coverage with Internet and multimedia applications
  - Flexible multimedia management
  - Internet access: Provide mobile Internet
  - Flexible services
  - Cost-effective packet access for best-effort services

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Third Generation (3G)

- Goals:
  - Multi-rate: 2Mbps indoor, 384 kbps pedestrian, 144 kbps mobile
  - Multi-service: Mobile Internet, Multimedia, packet and circuit switched services
  - Multi-cell: Seamless coverage across pico-, micro-, and macro-cells
  - Multi-Operator: Easy sharing of band at lowest granularity
  - High spectrum efficiency: Efficient utilization of the frequency spectrum
- Market driven standardization: de facto standards

ITU International Mobile Telecommunication (IMT) 2000

- December 1998: ARIB and TTC (Japan), ETSI (Europe), T1 (USA), and TTA (Korea) launched the "3rd Generation Partnership Project" (3GPP)
- March 1999 Ericsson and Qualcomm agree to harmonize WCDMA and to address the IPR issues
- March 1999 ITU approves key characteristics for the IMT 2000 radio interface: a family of standards
- Radio interface - Combination of : wideband CDMA (WCDMA), time division CDMA (TD-CDMA), cdma2000, IS-136HS
- GSM network architecture will be integrated.

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3G: Mobile Internet

- Huge potential market: good match Internet + mobility
- I-mode in Japan build on IP-over-packet PDC, Sept. 1999: 1.4 million subscribers with a weekly grow of 90,000 subscribers, simple, inexpensive
- Mobitex in US, Palm VII supports Web clipping with a Mobitex radio interface
- Mobile terminal and communicator manufacturers are fully ready to provide handsets for the mobile Internet
- First step: data best effort, for example GPRS (in GSM and IS-136), and voice circuit switched
- Next step: Data over IP, Voice over IP requires real-time IP

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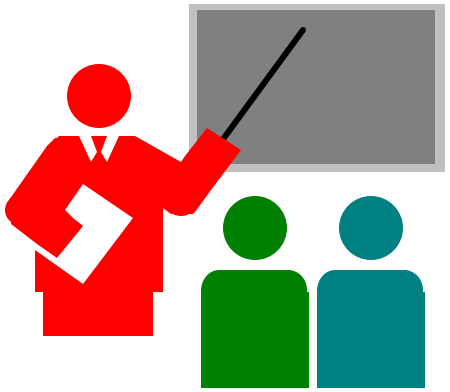
3G: Mobile Internet

- 1999-2001
  - Best-effort packet data, for example: GPRS, EDGE
  - Voice circuit switched GSM/TDMA/CDMA
- By 2003:
  - WCDMA/EDGE/cdma2000
  - Real-time IP voice and data

Summary



- Wireless mobile telephony, three generations
- Longtime debate TDMA vs. CDMA
- GSM, IS-136, and IS-95
- Third generation hopefully will be a unique system
- Mobile Internet

Key References

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