Wireless Mobile Telephony

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- Why wireless mobile telephony ?
- First Generation, Analog technologies
- Second Generation, Digital :
  - D-AMPS, GSM, IS-95
- Third Generation: IUT IMT-2000

Why Wireless Mobile Telephony ?

- Negroponte Switch : Personal mobile communication on Ether.
- Frequency Spectrum the most probably valuable natural resource
- Progress in microelectronic - very smart mobile terminals
- Mobile phone the only technology with a growth rate higher than Internet. By the year 2001 there will be more than 500 million Internet users and 600 millions mobile phone users

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Mobile Phone Generations

- 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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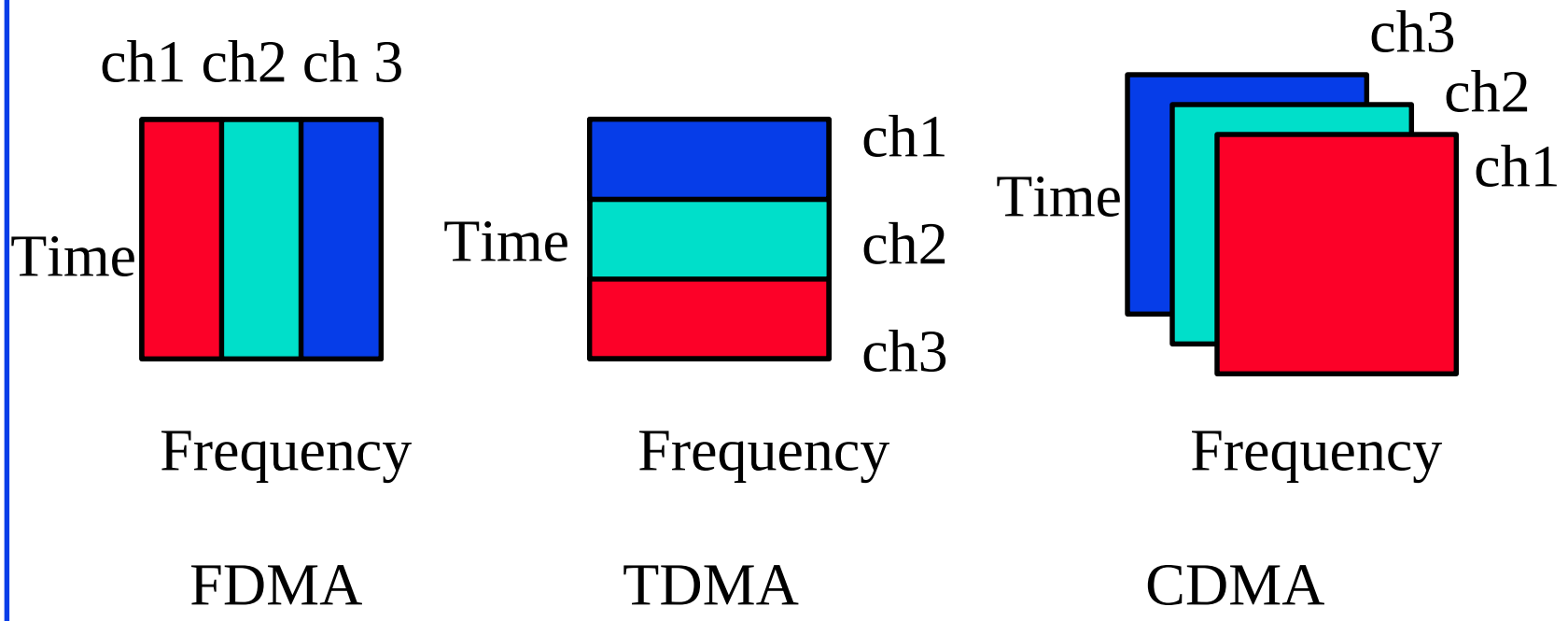
Generations (Cont)

- 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

Generations (Cont)

- Second Generation. Digital Technology
  - Global System for Mobile Communication (GSM), Europe +, in 120 countries (US too) , 82 million subscriber, 33% of the world market.
  - Digital Advanced Mobile Phone System (D-AMPS): International Standard (IS-136), US +
  - Interim Standard 95 (IS-95): US, Asia, South America.
  - Personal Digital Cellular (PDC): Japan, 27 million subscribers
- Third Generation in development

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: Has some flexibility advantages, but has a spectrum efficiency disadvantage
- CDMA: Less flexibility but has better spectrum efficiency
- Actual results depend on standards details

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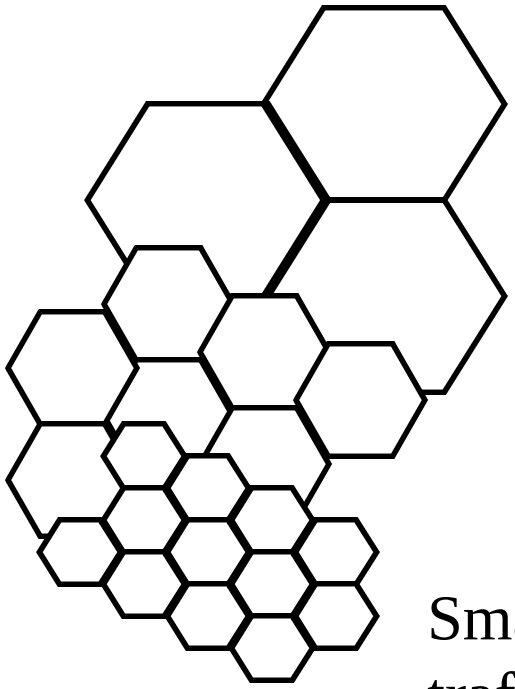
TDMA vs. CDMA cont.

- 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 :
  - 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.

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 12 million subscribers, analog + digital 72 million
- Voice is digitized at 8kbps

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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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.

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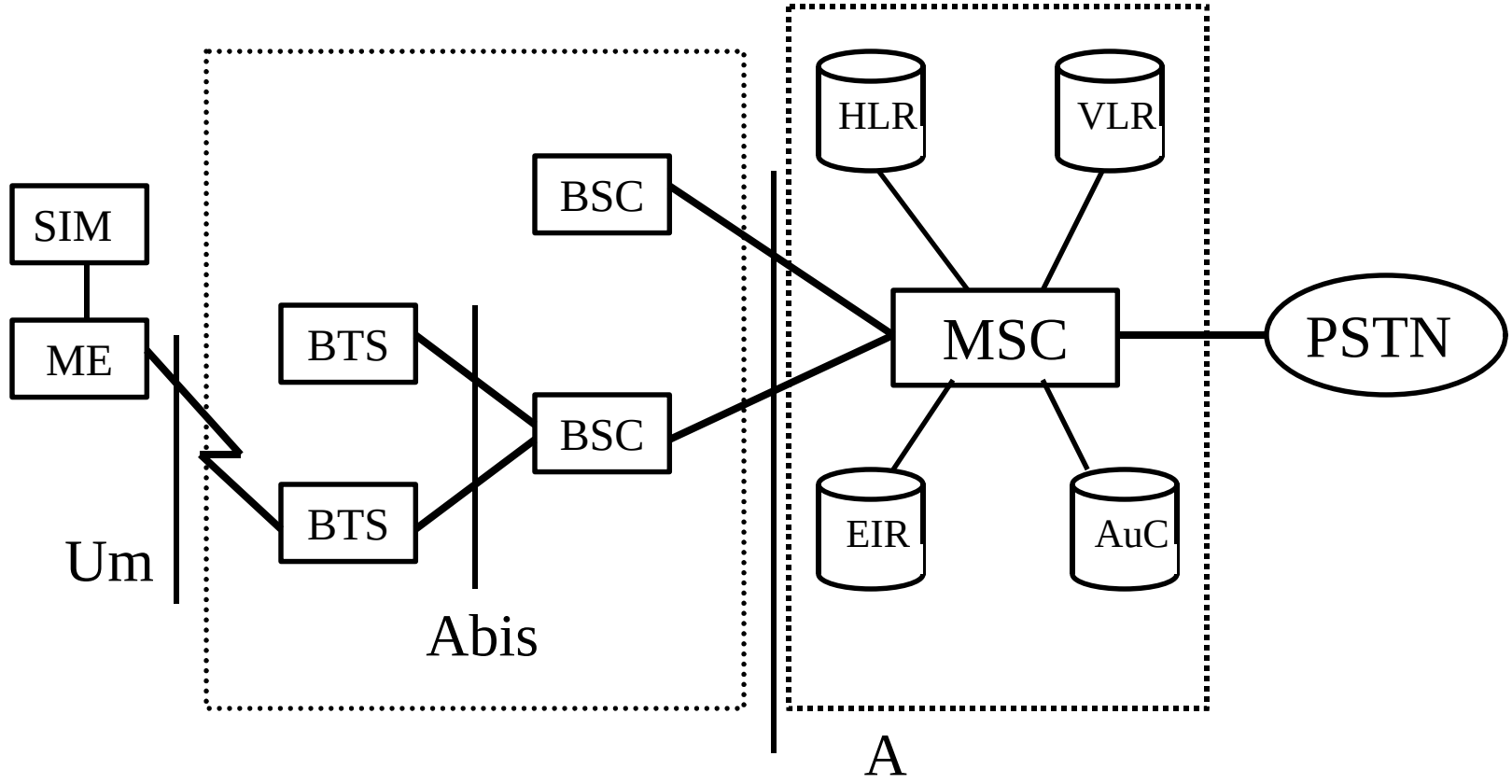
Architecture of the GSM network



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

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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 the GSM network

- VLR: Visitor Location Register contains selected information, for call control and services for mobiles located in its that 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 stored in each subscriber's SIM card, used for authentication and encryption

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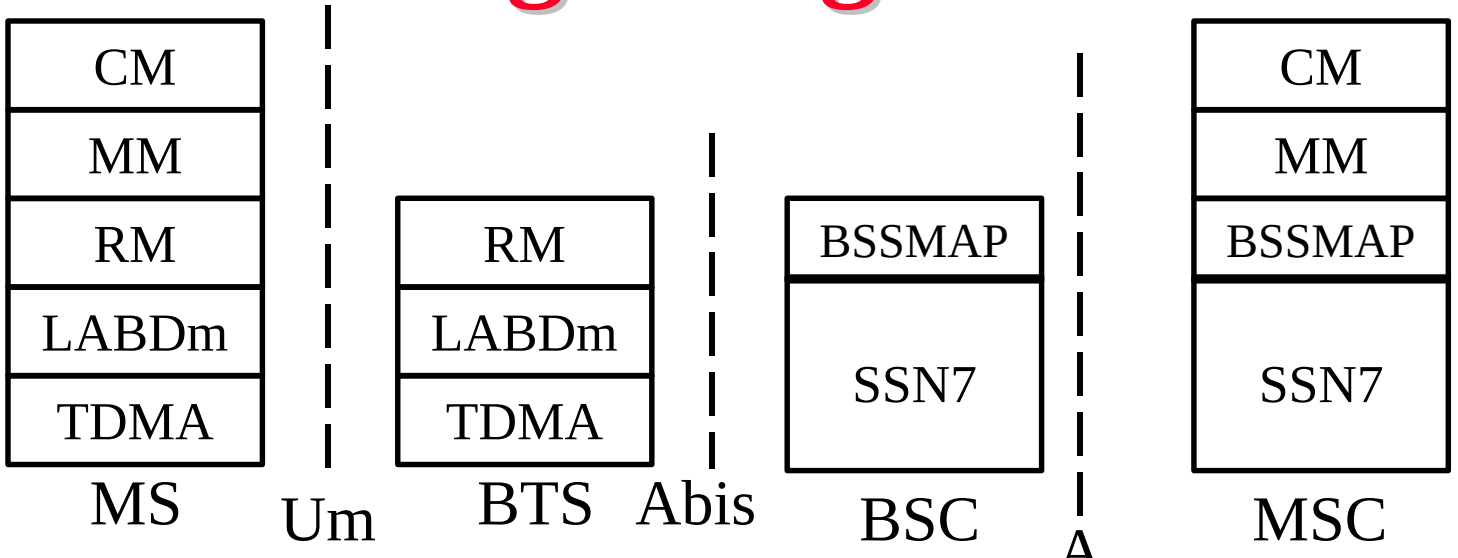
GSM Signaling Protocols



- 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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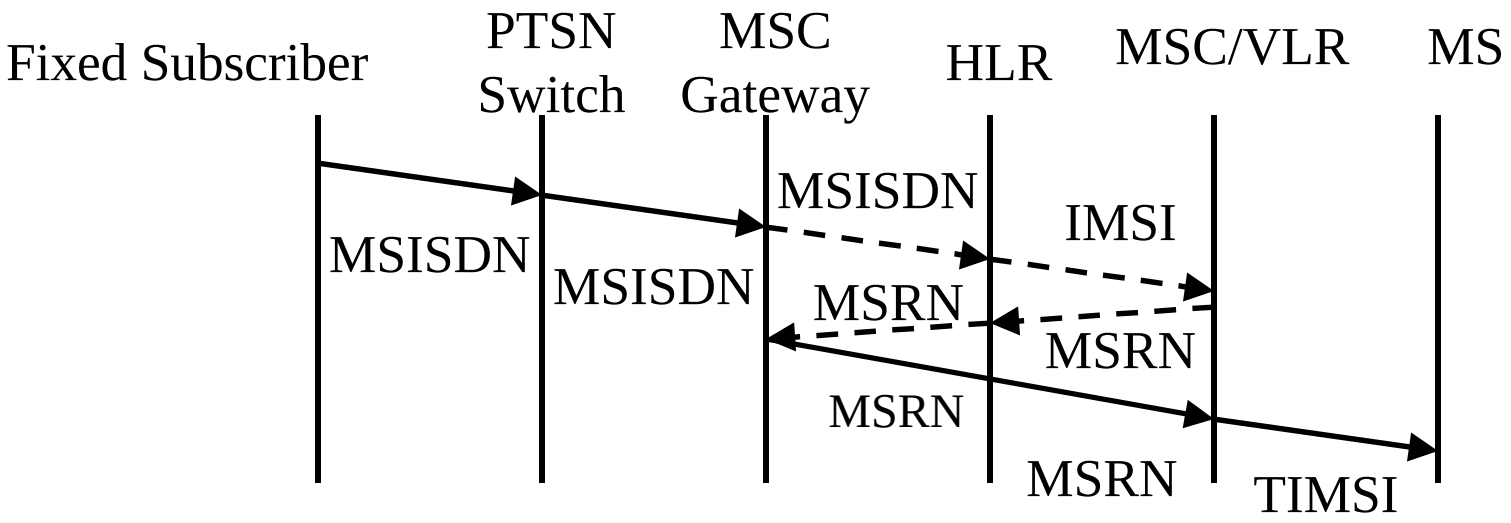
Call Routing



- MSISDN: Mobile Subscriber ISDN
- IMSI: International Mobile Subscriber Identity
- MSRN: Mobile Station Roaming Number
- TIMSI: Temporary IMSI

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GSM features

- 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
- Uses a layered signaling protocol
- 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 encrypts the air transmission

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New GSM features

- 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
- General Packet Radio Service (GPRS) should be available next year. Packet connection over GSM, 14 kbps over one time slot and 115 kbps over eight.

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: CDMA
- Frequencies: 800 Mhz, 1.9 GHz. Radio channel bandwidth 1250KHz. The band is divided in 20 full duplex carriers
- 50% of the US market, also in Asia
- Limited international roaming

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IS-95 (Cont)

- Services: Telephony - digitized voice 8 and 13kbs, data services up to 9.6bps and 14.4kbps, 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 is reserved for power measurement and initial synchronization
- 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
- Use soft handoff, which allows the mobile to communicate with multiple base stations simultaneously and is chose s the best of them.
- Effective fraud control
- Technology with a strong potential

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Third Generation Wireless Telephony

- Goals:
  - Multi-rate: 2Mbps indoor, 384 kbps pedestrian, 144 kbps mobile
  - 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

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IUT IMT2000

- January 1998: Leading international telecommunications manufactures, ETSI SMG membership agreed on a common proposal for third generation. Also supported by ARIB (Association of Radio Industries and Businesses) , the Japanese standard body
- Radio interface: Combination of two different technologies: wideband CDMA (W-CDMA) and time division CDMA (TD-CDMA). Also embraced by the Japanese PDC
- GSM network architecture will be integrated.
- The proposal will be presented to IUT for IMT-2000

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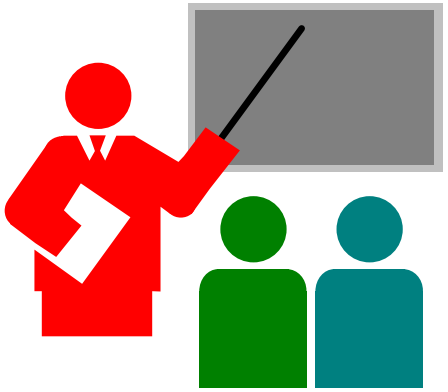
Summary



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

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Key References

- A very good and concise GSM reference by John Scourias: http://www.gsmdata.com/overview.htm
- CDMA development group: http://www.cdg.org

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