Wireless Standards

This lecture describes two representative cellular radio systems standards: the TDMA GSM system and the CDMA IS-95 system.

TDMA Example - GSM

Unique Features

- composed of MS (mobile station), BTS (base station transceiver), MSC (mobile switching center) and BSC (base station controller)
- a novel feature was the SIM (subscriber identity module) card, a chip containing a unique ID number, home network(s), encryption keys, other information
- GSM also defined standardized interfaces A (MSC-BSC), Abis (BSC-BTS), and the air interface

Air Interface

- uses paired 25 MHz bands (890 to 915 reverse, 935-960 forward), 45 MHz frequency separation
- the RF channel (ARFCN : absolute radio frequency channel numbers) separation is 200 kHz, 125 RF channels total
- there is one 100 kHz guard band at each band edge
- there are 8 time slots per frame, 3 slot separation between transmit and receive slots
- therefore supports maximum of 992 simultaneous slots/channels
- data is transmitted using BT=0.3 GMSK at 270.833 kb/s
- the frame duration is 4.615 ms (216 Hz), slot duration is 576.92 μs (156.25 bits)
- a combination of an RF channel and a time slot constitute

  physical channel
- logical channels are mapped onto physical channels
- logical channels are of two types: traffic channels (TCH) and control channels (CCH)

Traffic Channels

- full-rate TCH (1 slot/frame) (speech at 13 kb/s or data at 9600 to 2400 bps)
- half-rate TCH (1 slot/2frames) (speech at 6.5 kb/s or data at 4800 to 2400 bps)

Control Channels

- divided into common control channels (CCCH) (used by all users) and dedicated control channels (DCCH) (used for one user only)
- only 34 of the ARFCNs are used to carry the common control channels and only TS0 is used (reduces number of channels that need to be scanned)
- the common control channels use a 26-frame multiframe structure and different control channels are time multiplexed within this multiframe

Common Control Channels

- BCH - broadcast channels:
  - BCCH - broadcast control channel (cell and network ID)
  - FCCH - frequency correction channel - synchronization
  - SCH - synchronization channel - synchronization

- PCH - paging channel - informs MS of incoming call (also used for SMS)
- AGCH - access grant channel - used to move MS to TCH

Dedicated Control Channels

- DCCH dedicated control channels (carried multiplexed on a traffic channel)
- SDCCH stand-alone control channel occupies traffic channel before call is established
- SACCH slow associated control channel - normal power control and timing adjustments, uses up one frame per multiframe
- FACCH fast associated control channel - "steals" slots from TCH for fast response (handover)
- the reverse channel (TS0 on each control ARFCNs) is only used for the RACH random access channel to allow MS to acknowledge page or to original call

Burst Types

- there are 5 different types of bursts, specialized for the needs of particular functions within the air interface
- normal or dummy bursts contain 3 start bits, 57 data bits a "stealing" bit, 26 training bits, 57 more data bits, another "stealing" bit, 3 stop bits and 8.25 bit times for a guard time
- FCCH and SCH bursts have special structure for synchronization
- RACH has a longer start, synchronization and guard times
- a normal frame carries 114 bits of encrypted speech

Other Processing

- the full-rate RELP (residually excited LPC) speech coder generates 260 bits every 20 ms (13 kb/s)
- about 2/3 of the bits are FEC coded using a rate-1/2 convolutional resulting in a data rate of 22.8 kb/s
- data and control channels also use a rate-1/2 convolutional encoder and other FEC methods
- the 20ms block is interleaved across 8 time slots
- the data is encrypted using the key stored in the SIM
- both authentication and encryption algorithms are used
- receiver uses the training sequence in the middle of the burst to adjust an equalizer

Frequency Hopping

- an operator may choose to implement slow frequency hopping
- up to 64 channels may be grouped in a hop sequence
- all MS and BTS hop to a new channel in each frame

CDMA Example - IS-95

- developed by Qualcomm
- designed for operation on the 824-849 (reverse channel) and 869-894 (forward channel) paired frequency bands (45 MHz offset)
- single 1.25 MHz channel shared among all users (10% of the 12.5 MHz per service provider)
- variable data rate to take advantage of speech activity detection

- codes used on the forward channel can be synchronized for all users, with a different orthogonal code for each user

- on reverse channel users are not synchronized, cannot ensure orthogonality and must use accurate power control

- maximum data rate of 9.6 kb/s with spreading factor of 128 results in chip rate of 1.2288 MHz

- forward channel uses 20 ms frames, a rate-1/2 constraint-length 9 convolutional coder, block-interleaving (24x16), one of 64 orthogonal Walsh spreading codes and a length-2^{15}scrambling code

- a pilot channel, synchronization channel and paging channels are also transmitted on forward link

- the forward channel scrambling code is unique to each user and has period $2^{42}-1$

- scrambling coder starts out with public code and switches to private code after authentication

- uses 24x16 block interleaver in 20 ms frames

- speech activity detection is used to reduce data rate to 1200 bps when users are not talking

- reverse channel uses: rate-1/3 convolutional code, mapping to orthogonal symbols and 4-fold spreading using user-specific and base-specific spreading codes

- forward link includes an 800 b/s power control feedback channel to control the reverse channel power in 1 dB steps

- power control is transmitted by puncturing parity bits

- receiver uses RAKE (multiple correlators) receivers to combine several signals paths if they are sufficiently separated in time

- additional correlators are used to monitor the pilot signal for the serving and adjacent base stations

- 14.4 kbps voice coder can be accommodated by using a rate 1/2 instead of rate 1/3 convolutional coder on reverse link and puncturing the forward channel code from rate 1/2 to rate 3/4.