Multiple Access Techniques

FDMA

- frequency-division multiple access
- total service frequency allocation divided into channels
- each channel can support one call
- a channel cannot be re-used within a cluster
- typically uses FDD
- for FDD systems each user is assigned a channel pair (forward and reverse)
- each frequency pair has a fixed difference (e.g. 45 MHz) between transmit and receive frequencies
- base and remote transmit continuously
- a duplexer (narrow filter) protects receiver from transmitter power and allows one antenna to be used for both simultaneously
- simple to implement, can be almost completely analog

TDMA

- time-division multiple access
- total frequency allocation divided into channels
- each channel is divided in time into *slots*
- each channel and slot supports one call
- requires that "training" or "pilot" symbols be sent for carrier frequency and bit timing synchronization in each slot
- guard times must be left between slots to allow for propagation delays (and/or users must adaptively adjust the timing of their transmissions)
- can use FDD (cellular) or TDD (cordless phone)
- with FDD uses offset transmit and receive time slots to avoid need for a duplexer at the remote unit (still required at the base if all slots are to be used)
- flexible allocation of bandwidth - one user can use more than one slot if necessary
- during unused slots the receiver can check other base station control channels to see if a handover would improve call quality ("mobile-assisted" handover, MAHO)
- only practical with digital implementation, most functions can be integrated and implemented inexpensively

FH/SS - FHMA

- total frequency allocation is divided into channels as with FDMA
- each call uses ("hops") to different channels at different times during the call
- each call uses a different hopping sequence
- two types: "fast" frequency hopping (FFH) - multiple hops per symbol, and "slow" (SFH) - many symbols (usually complete frames) per hop
- FH provides frequency diversity
- also reduces probability of detection
- SFH is often coordinated between users and is over a small number of channels
- instantaneous bandwidth is narrow (the same as a conventional system)
- average bandwidth is much larger

- interference between users is negligible except during collisions
- is not susceptible to reduction in capacity due to near-far effect (see below)

DS/SS - CDMA

- the total service frequency allocation is used as one channel (or a very small number of channels)
- all users transmit on the same channel at the same time
- transmitter uses PN sequence to spread information over the large bandwidth
- receiver uses a correlator to increase the power of the desired (correlated) signal over the power of the interference by an amount equal to the spreading factor
- total received power of other (uncorrelated) users determines the noise "floor"
- for the reverse channel, if a user is nearer to the base the path loss is lower, potentially by many 10s of dBs
- if power control is not used this user will be received with a stronger signal
- this results in a higher SIR for that user but also a corresponding increase in noise for all other users
- we must use power control to control this near-far effect or system capacity is greatly reduced
- typically requires very accurate power control - cannot be done "open loop" if high capacity is desired
- a fast feedback channel from the base to the mobile is required to compensate for fading
- remote transmitter power must be controlled over range of many tens of dBs with resolution of a fraction of < 1 dB

SDMA

- can be applied in addition to any other multiple-access method
- can increase capacity without need of additional bandwidth or additional base stations
- the concept is similar to sectorization: antennas can split the cell up geographically
- base uses an array of antennas
- signals from the different antennas can be combined in different ways to synthesize different antenna patterns from the same set of antennas at the same time
- *adaptive* antenna arrays can accurately cancel interference from undesired users in the same cell
- this allows the *same* channel to be re-used within the cell
- however, it's difficult to make the forward channel antenna pattern match the reverse channel antenna pattern
- still area of active research interest