Wireless Networks

Lecture 15
Analog Mobile Phone System

outlines

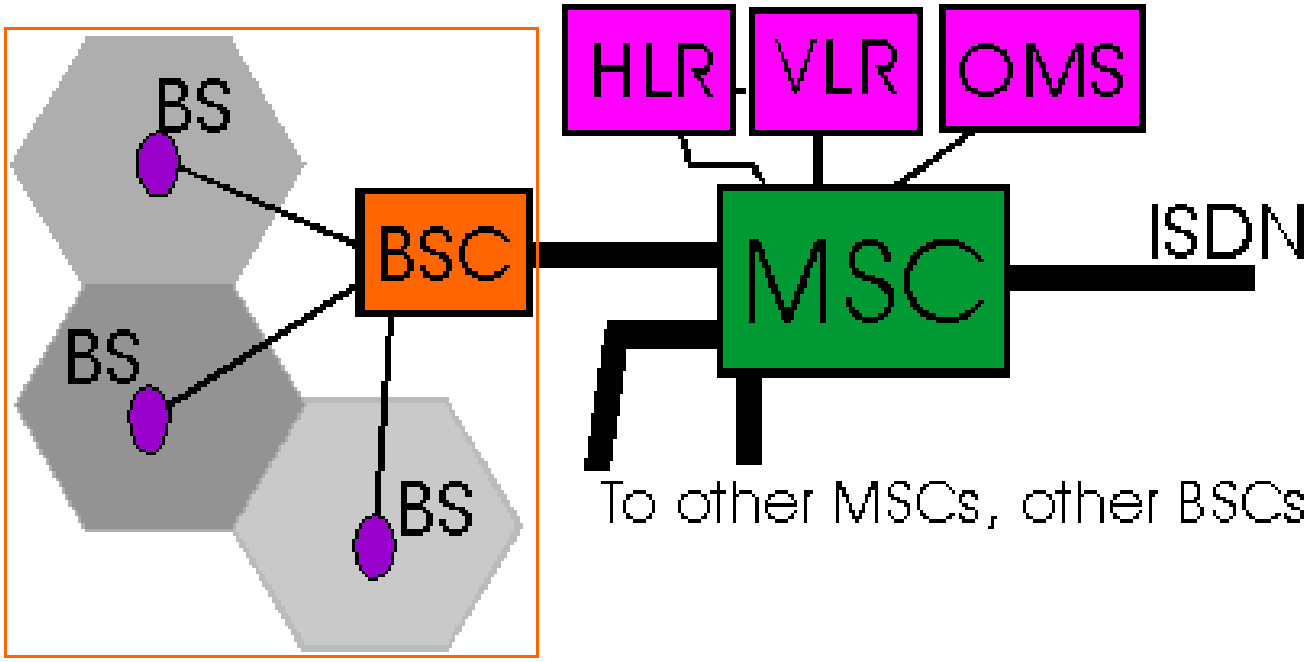
- AMPS introduction
- System Overview
- Call handling
- Air interface
- Supervisory signals
- N-AMPS

AMPS Introduction

- First deployed in late 1983 in urban and suburban areas of Chicago.
- Total of 40 MHz in 800 MHz band allocated by FCC
- Later on, Additional 10 MHz allocated as user demand increased
- First AMPS systems used large cells and omni directional antennas to minimize initial equipment cost
- It covered approximately 2100 square miles

- AMPS system uses 7-cell reuse pattern with provision of sectoring and cell splitting to increase system capacity.
- The smallest reuse factor which satisfies this requirement using 120 degree directional antenna is N = 7
- ETACS: European Total Access Communication System
  - Identical to AMPS except scaled to 25 KHz as opposed to 30 KHz
  - Different format of mobile identification number (MIN) due to need of accommodating different country codes in Europe as opposed to area code in US

AMPS Architecture



System Overview

- AMPS and ETACS both use FM and FDD for radio transmission like other 1G systems
- In US,
  - transmissions from mobiles to BS (reverse link) use frequencies between 824-849 MHz
  - While BS transmits to mobiles (forward link) using frequencies between 869-894 MHz
  - A separation of 45 MHz between forward and reverse channels is due to use of inexpensive and highly selective duplexers in mobile units.
- The control channel and blank-and-burst data streams are transmitted at 10kbps in AMPS and 8kbps in ETACS

- Each BS has
  - one control channel transmitter that transmits on forward control channel (FCC)
  - One control channel receiver that listen to reverse control channel (RCC) to set-up a call
  - 8 or more duplex voice channels
  - Commercial BS supports as many as 57 voice channels
- Forward Voice Channel (FVC) carry the conversation originating from landline caller to cellular subscriber
- Reverse Control Channel (RVC) in opposite

- The actual number of control and voice channels varies widely depending on the traffic, maturity of the system and location of other BSs.
- The number of BS in a service area varies widely as well from few towers in rural area to several hundred or more BS in a large city.
- Each BS continuously transmits digital FSK data on FCC at all times so that idle subscriber units can lock onto the strongest FCC.
- The BS RCC receiver constantly monitors transmission from subscribers that are locked onto the matching FCC

- In US AMPS, there are 21 control channels and ETACS supports 42 control channels per provider
- Thus any cellular phone needs to scan limited number of control channels to find best serving BS
- It is upto the service providers to make sure adjacent FCC are not assigned to nearby BSs
- The nonwireline service provider ("A" provider) is assigned odd system identification number (SID) and wireline service provider ("B" provider) is assigned even SID.
- SID is transmitted once every 0.8 seconds on each FCC, along with other overhead data which reports the status of cellular system
- In ETACS area identification numbers (AID) are used instead of SID.

Call handling

- Call: landline user → cellular subscriber
  - From PSTN arrives at MSC.
  - A paging request is sent out with subscriber MIN simultaneously on every BS FCC.
  - If intended subscriber receives its page on FCC, it responds with ACK on RCC.
  - The MSC directs the BS to assign FVC and RVC pair to take place call
  - The BS also assigns supervisory audio tone (SAT) and a voice mobile attenuation code (VMAC) as it moves the call to the voice channels

- SAT
  - it allows user and BS to distinguish each other from co-channel users located in different cells
  - Transmitted continuously on the both FVC and RVC at three different frequencies 5070 Hz, 6000 Hz, 6030 Hz
- VMAC
  - Instructs the user to transmit at a specific power level
- Once on the voice channel, wideband FSK data is used by BS and subscriber in a blank-and-burst mode to initiate handoffs, change transmitter power as needed and provide other system data
- Blank-and-burst signaling allows the MSC to send bursty data on voice channels by temporarily omitting speech and SAT and replacing with data.

➲ Call: mobile user → landline user

- Subscriber transmits request (MIN, electronic serial number, station class mark and destination number on RCC
- If received correctly by BS, sent to MSC
- MSC check if user is properly registered, connects to the PSTN
- Assigns FVC and RVC with SAT and VMAC

- During a call, MSC issues numerous blank-and-burst commands which switch
  - Between different voice channels on different BS depending on where the user is traveling
- The MSC uses scanning receiver called locator in nearby BS to determine RSSI for handoff

- When a new call request arrives from PSTN or subscriber
  - Voice channels may be occupied
  - MSN holds line open while instructing current BS to issue directed retry to subscriber on FCC
  - It forces the subscriber to switch to different control channel or BS depending on radio propagation effects, current traffic, location of subscriber
  - However it may or may not succeed.

AMPS and ETACS air interface

Parameter	AMPS	ETACS
Multiple Access	FDMA	FDMA
Duplexing	FDD	FDD
Channel BW	30 KHz	25 KHz
Traffic channels per RF channel	1	1
Reverse channel freq	824-849 MHz	890-915 MHz
Forward channel freq	869-894 MHz	935-960 MHZ
Voice modulation	FM	FM
Data rate on control/wideband channel	10kbps	8kbps
Spectral efficiency	0.33 bps/Hz	0.33 bps/Hz
Number of channels	832	1000

Supervisory signals (SAT and ST tones)

- Allow each user and BS to confirm that they are connected during a call
- SAT always exists during use of any voice channel.
- AMPS and ETACS use three SAT signals at frequencies of 5970 Hz, 6000 Hz or 6030 Hz
- BS constantly transmits one of three SAT tones on each voice channels when in use
- SAT is superimposed on voice signal on both forward and reverse channels
- The particular frequency of SAT denotes location of BS and is assigned by MSC

- When a call is setup and a voice channel is issued
  - SAT is transmitted immediately on FVC
  - Subscriber unit begins monitoring FVC, it must detect, filter and demodulate SAT
  - Similarly it reproduces SAT on RVC
  - This is required to dedicate a voice channel
  - If SAT is not presented or improperly detected within a one second interval, Both BS and subscriber unit cease transmission

➲ Signaling Tone (ST)

- ► It is a 10 kbps data burst which signals call termination by the subscriber
- ► It is a special "end-of-call" message containing alternating 1s and 0s sent on RVC for 200 ms
- ► Unlike blank-and-burst messages which briefly suspends SAT transmission, ST tone must be sent simultaneously with SAT.
- ► Alerts the system that user has deliberately terminated the call as opposed to being dropped by the system

Wideband Blank-and-burst Encoding

- AMPS voice channels carry wideband (10 kbps) data streams for blank-and-burst signaling
- The wideband data stream is encoded using Manchester coding
- The advantage is that the energy of the Manchester coded signal is concentrated at the transmission rate frequency of 10 KHz and little energy leaks into audio band below 4 KHz

Narrowband AMPS (N-AMPS)

- 10 KHz channel: 3 times large number of users and bandwidth
- Uses same SAT, ST and blank-and-burst except signaling was done by using sub-audible data streams