Οικονομικό Πανεπιστήμιο Αθηνών
Τμήμα Πληροφορικής

Ευφυή Κινητά Δίκτυα: Κυτταρική Δομή Κινητών Επικοινωνιών Συστήματα Κινητής Τηλεφωνίας 1ης & 2ης Γενιάς

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Κυτταρική Δομή Κινητών Επικοινωνιών

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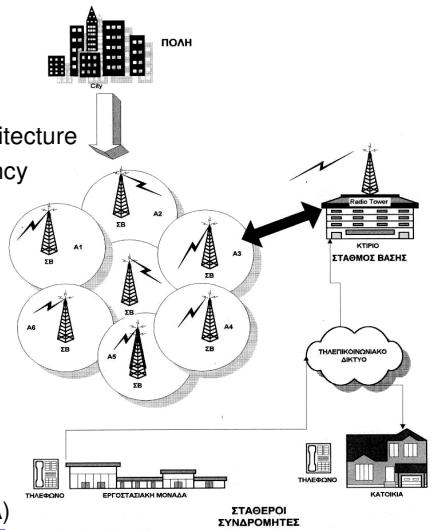
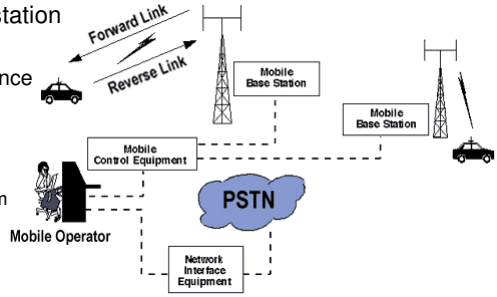
- Cellular System Components
- Digital Cellular
- Time Division Multiple Access (TDMA)



Mobile Communications Principles

- each mobile (station)
  - uses a separate, temporary radio channel to talk to the cell site
- the cell site (base station)
  - talks to many mobiles at once, using one channel per mobile
- a pair of frequencies are used for communication
  - one (the forward link) for transmitting from the cell site
  - another frequency (the reverse link) for the cell site to receive calls from the users
- mobiles must stay near the base station
  - to maintain communications
  - radio energy dissipates over distance
- mobile (voice) networks include
  - mobile radio service
    - operates in a closed network
    - no access to the telephone system
  - mobile telephone service
    - interconnection to the telephone network



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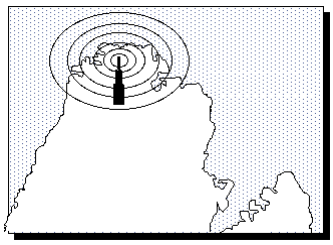
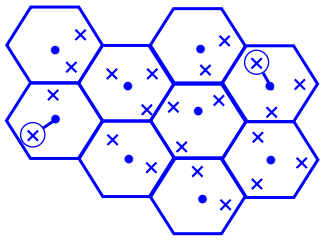
Early Mobile Telephone System Architecture

- Traditional mobile service
  - structured in a fashion similar to TV broadcasting
  - one powerful transmitter in a (e.g., metropolitan) area
    - could broadcast in a radius of up to 50 km
- The cellular concept
  - different!
  - many low-power transmitters placed throughout an area





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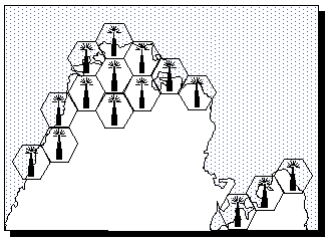
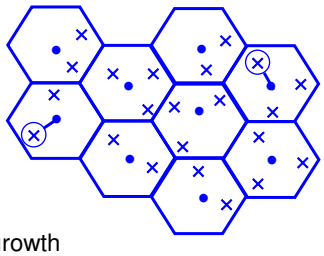
Co-channel Interference and Frequency Reuse

- co-channel interference
  - caused by mobile units using the same channel in adjacent areas
  - all channels cannot be (re-)used in every cell
  - areas have to be skipped before the same channel is reused
- frequency reuse is still a key technique for mobile communications systems
- interference
  - is *not* proportional to the distance between areas, but to the ratio of the distance between areas to the transmitter power (radius) of the areas
  - reducing the radius of an area by 50%, increases the number of potential customers in an area 4x
    - systems with a 1 Km radius can have 100 times more channels than systems with areas 10 Km in radius



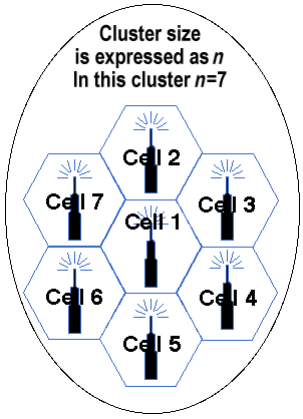
The Cellular Concept



- variable low-power transmission levels
  - allow cells to be sized according to
    - subscriber density
    - traffic demands
- as the population or traffic grows
  - cells can be added to accommodate that growth
- frequencies used in one cell cluster can be re-used in other clusters
- conversations can be handed-off from cell to cell
  - to maintain continuous service as the user moves between cells
- the base station can communicate with mobiles as long as they are within range

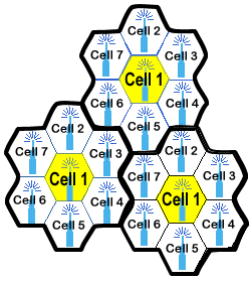
Cellular System Architecture

- engineering plan
  - clusters
  - frequency reuse
  - handovers
- cells
  - basic geographic unit of a cellular system
  - base stations transmit over small geographic areas
  - often represented as hexagons
  - true shape of cells is not a perfect hexagon
    - because of constraints imposed by
      - natural terrain
      - man-made structures
  - cell size varies depending on the landscape
- clusters
  - a group of cells
  - no channels are reused within a cluster



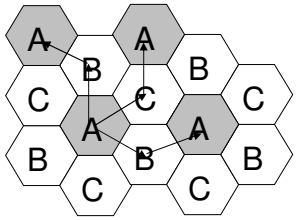
Frequency Reuse

- no channels are reused within a cluster
- cells with same number have same group of frequencies
  - they are far enough so that there is no interference
- number of available frequency groups is 7
  - frequency reuse factor=7
  - each cell is using 1/7 of available channels
- Hexagon cell pattern, values of N=1,3,7,9,12,13,16,19,21

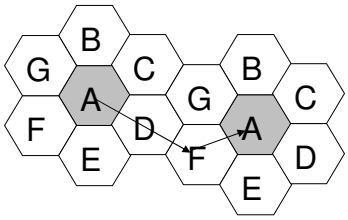


Reuse patterns

N = 3

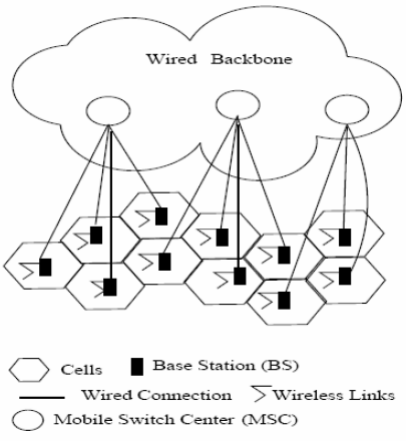


N = 7



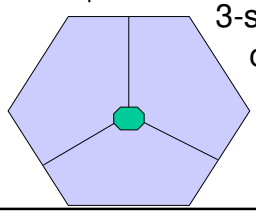
Cellular architecture

- Cellular backhaul or Radio Access Network: interconnect base stations to backbone
- Can be wired or wireless (point-to-point)



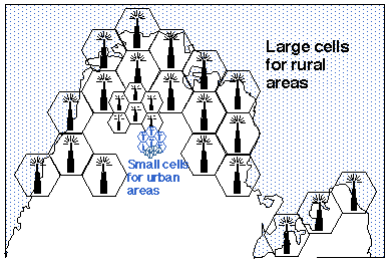
Increasing cellular capacity

- Frequency borrowing
  - congested cells borrow frequencies from less congested cells
  - dynamic allocation of frequencies
- Cell breathing
  - Increase/decrease cell coverage based on demand
  - Cell coverage control by base station power
- Cell splitting
  - smaller cells in high demand areas
  - smaller cells => more base stations & more frequent handoffs
  - smaller cells (micro cells) => reduced transmission power
- Sectorization
  - cell divided into sectors (typically 2-6)
  - use directional (sector) antennas



Cell Splitting

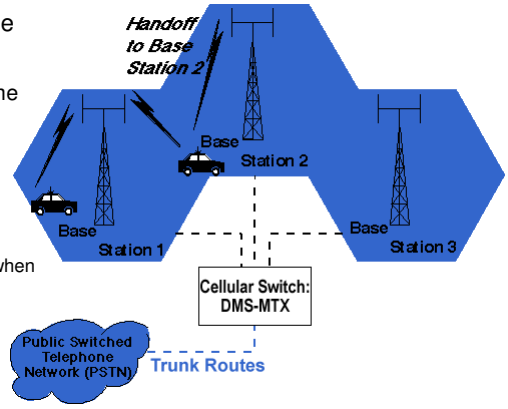
- creating full systems with many small areas impractical
- cell splitting
  - as a service area becomes full of users
  - split a single area into smaller ones
- urban centers
  - can be split into as many areas as necessary
  - to provide acceptable service levels in heavy-traffic regions
- rural regions
  - larger, less expensive cells



Handoff

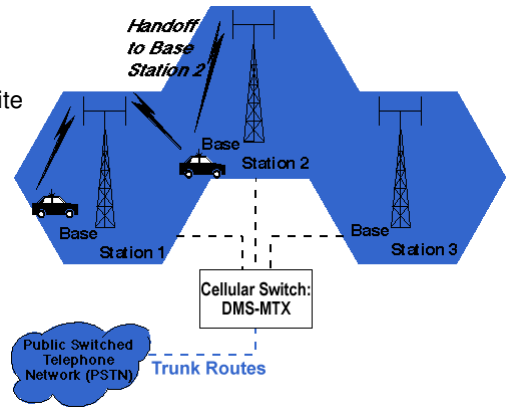
- mobile subscriber travels from one cell to another during a call
  - adjacent cells do not use the same radio channels
  - call must either
    - be dropped or
    - transferred

    from one radio channel to another when a user crosses cells
  - dropping the call is unacceptable
- hand-off (US, hand-over in UK)
  - mobile telephone network automatically transfers a call
  - from radio channel to radio channel, as a mobile crosses adjacent cells



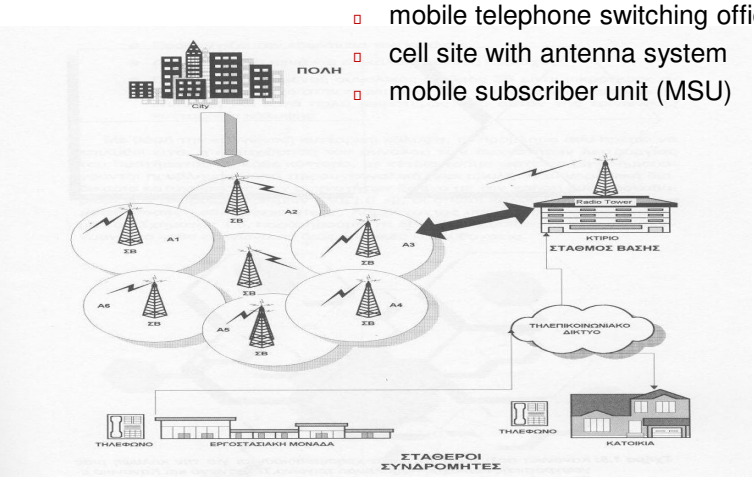
Handoff Initiation

- when MS moves out of the coverage area of a given cell site
  - the reception becomes weak
  - the cell site (in use) or the MS requests a handoff
  - system switches the call to
    - a new site (and channel) with
    - a stronger signal
  - without interrupting the call or alerting the user
  - call continues as long as the user is talking, and the user does not notice the handoff at all



Cellular System Components

- public switched telephone network (PSTN)
- mobile telephone switching office (MTSO)
- cell site with antenna system
- mobile subscriber unit (MSU)



Συστήματα Κινητής Τηλεφωνίας 1ης & 2ης Γενιάς

- 1st generation - Analog
  - AMPS
- 2nd generation - Digital
  - GSM
  - DAPMS, IS-54, IS-136 (TDMA)
    - CDPD (Packet Data extension)
  - IS-95 (CDMA)

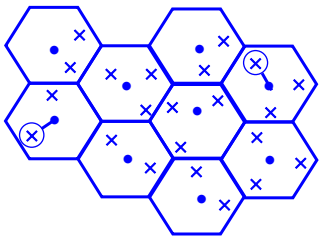
Συστήματα Κινητής Τηλεφωνίας 2ης Γενιάς

- GSM (discussed extensively later)
- TDMA (IS-54, then IS-136)
- CDMA (IS-95)
  - "marketing name" PCS (IS-95 based)
    - smaller cells, higher speeds

AMPS/DAMPS Comparison

	Analog	Digital
standard	EIA–553 (AMPS)	IS–54 (TDMA + AMPS)
spectrum	824 MHz to 891 MHz	824 MHz to 891 MHz
channel bandwidth	30 kHz	30 kHz
channels	21 CC/395 VC	21 CC / 395 VC
conversations per channel	1	3 or 6
subscriber capacity	40 to 50 conversations per cell	125 to 300 conversations per cell
TX/RCV type	continuous	time shared bursts
carrier type	constant phase variable frequency	constant frequency variable phase
mobile/base relationship	mobile slaved to base	authority shared cooperatively
privacy	poor	better—easily scrambled
noise immunity	poor	high
fraud detection	ESN plus optional password (PIN)	ESN plus optional password (PIN)

GSM - Global System Mobile



- European, introduced in 1992
- digital cellular, TDMA based
- extended for data traffic at 9.6 Kb/s
- short messages (160 Bytes)
- frequencies
  - 900 Mhz, 1800 Mhz (DCS), in Europe
  - 1900 Mhz in the U.S.