



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

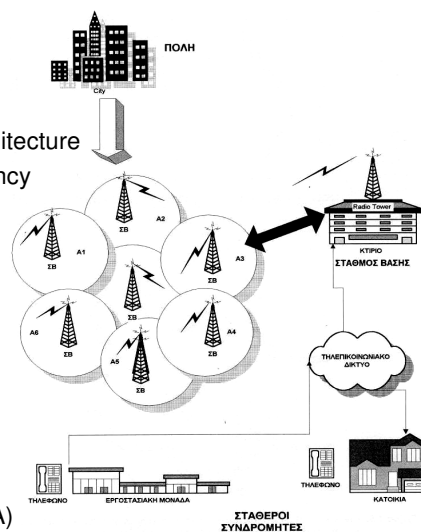
Χειμερινό Εξάμηνο 2024-25

Βασίλειος Σύρης

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Κυτταρική Δομή Κινητών Επικοινωνιών

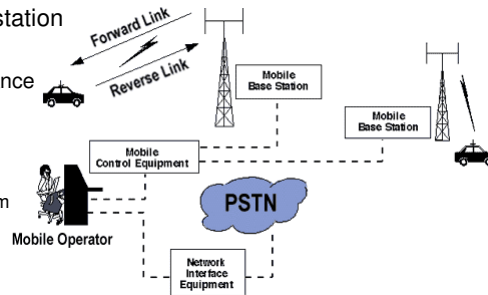
- Mobile Communications Principles
- Early Mobile Telephone System Architecture
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- The Cellular Concept
- Cellular System Architecture
- Frequency Reuse
- Cell Splitting
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- Handoff Initiation
- Cellular System Components
- Digital Cellular
- Time Division Multiple Access (TDMA)



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Mobile Communications Principles

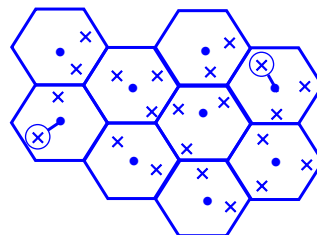
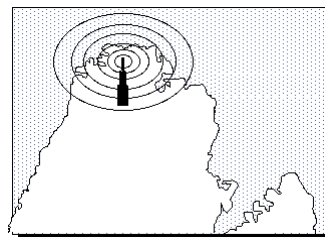
- each **mobile** (station)
 - uses a separate, temporary radio channel to talk to the cell site
- the cell site (base station)
 - talks to many mobiles at once, using **one channel per mobile**
- a pair of frequencies are used for communication
 - one (the **forward link**) for transmitting from the 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

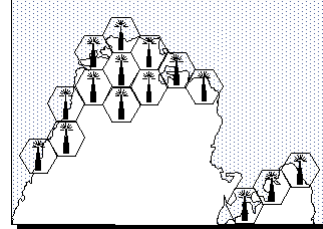
- Traditional mobile service
 - structured in a fashion similar to TV broadcasting
 - one powerful transmitter in a (e.g., metropolitan) area
 - could broadcast in a radius of up to 50 km
- The cellular concept
 - different!
 - many low-power transmitters placed throughout an area



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Co-channel Interference and Frequency Reuse

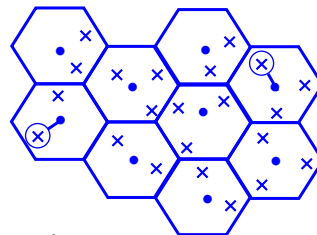
- ▣ **co-channel interference**
 - ▣ caused by mobile units using the same channel in adjacent areas
 - ▣ all channels cannot be (re-)used in every cell
 - ▣ areas have to be skipped before the same channel is reused
- ▣ **frequency reuse** is still a key technique for mobile communications systems
- ▣ **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



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The Cellular Concept

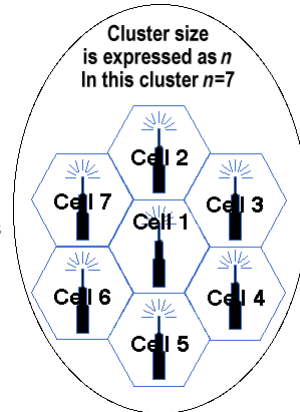
- ▣ variable low-power transmission levels
 - ▣ allow cells to be sized according to
 - ▣ subscriber density
 - ▣ traffic demands
- ▣ as the population or traffic grows
 - ▣ cells can be added to accommodate that growth
- ▣ frequencies used in one cell cluster can be **re-used** in other clusters
- ▣ 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**



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Cellular System Architecture

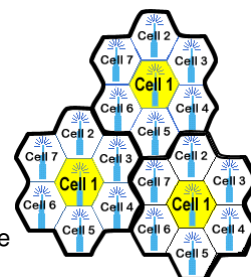
- engineering plan
 - clusters
 - frequency reuse
 - handovers
- **cells**
 - basic geographic unit of a cellular system
 - base stations transmit over small geographic areas
 - often represented as hexagons
 - true shape of cells is not a perfect hexagon
 - because of constraints imposed by
 - natural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



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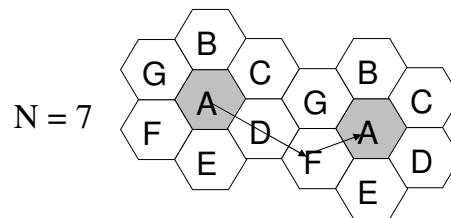
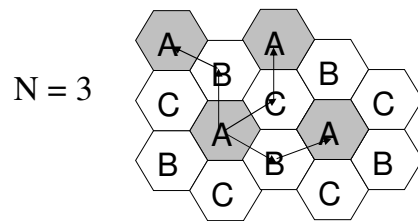
Frequency Reuse

- 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 $N=1,3,7,9,12,13,16,19,21$



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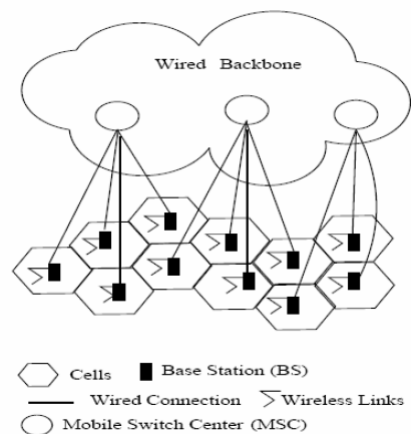
Reuse patterns



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Cellular architecture

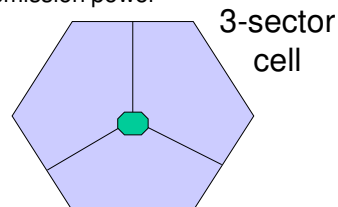
- ▣ Cellular backhaul or Radio Access Network: interconnect base stations to backbone
- ▣ Can be wired or wireless (point-to-point)



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Increasing cellular capacity

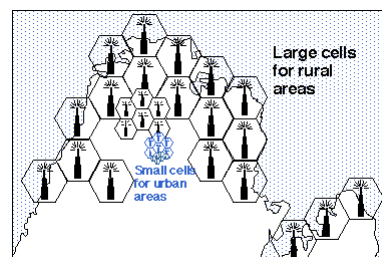
- ▣ Frequency borrowing
 - ▣ congested cells borrow frequencies from less congested cells
 - ▣ dynamic allocation of frequencies
- ▣ Cell breathing
 - ▣ Increase/decrease cell coverage based on demand
 - ▣ Cell coverage control by base station power
- ▣ Cell splitting
 - ▣ smaller cells in high demand 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



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Cell Splitting

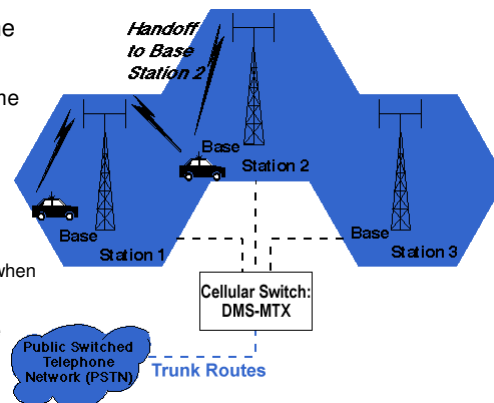
- ▣ creating full systems with many small areas impractical
- ▣ cell splitting
 - ▣ as a service area becomes full of users
 - ▣ split a single area into smaller ones
- ▣ **urban centers**
 - ▣ can be split into as many areas as necessary
 - ▣ to provide acceptable service levels in heavy-traffic regions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



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Handoff

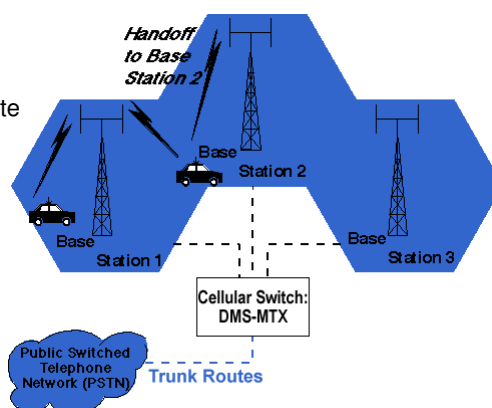
- ▣ mobile subscriber travels from one cell to another during a call
 - ▣ adjacent cells do not use the same radio channels
 - ▣ call must either
 - ▣ be dropped or
 - ▣ transferred
 from one radio channel to another when a user crosses cells
 - ▣ dropping the call is unacceptable
- ▣ hand-off (US, hand-over in UK)
 - ▣ mobile telephone network **automatically** transfers a call
 - ▣ from radio channel to radio channel, as a mobile crosses adjacent cells



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Handoff Initiation

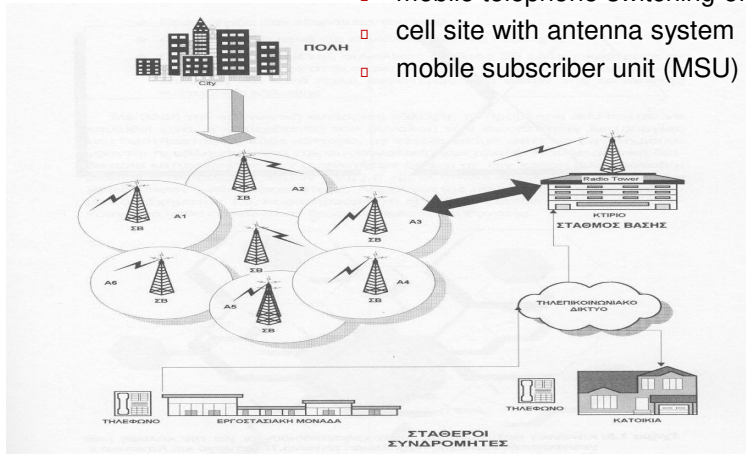
- ▣ when MS moves out of the coverage area of a given cell site
 - ▣ the reception becomes weak
 - ▣ the cell site (in use) or the MS requests a handoff
 - ▣ system switches the call to
 - ▣ a new site (and channel) with
 - ▣ a stronger signal
 - ▣ **without interrupting the call** or alerting the user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



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Cellular System Components

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



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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)

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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

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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)

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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.

