

# **Cellular Network Planning**

# Cellular systems

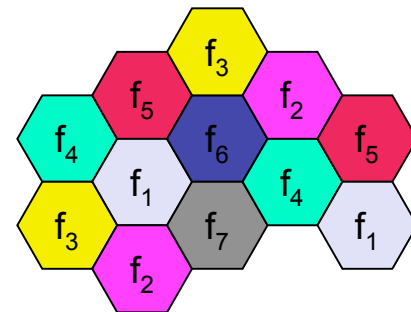
- Implement Space Division Multiplexing (SDM)
- Each transmitter (base station) covers a certain area (cell)
- Cell radius varies from 10s of meters to 10s of kms
- Cell shapes depend on environment, weather and system load

# Cellular systems II

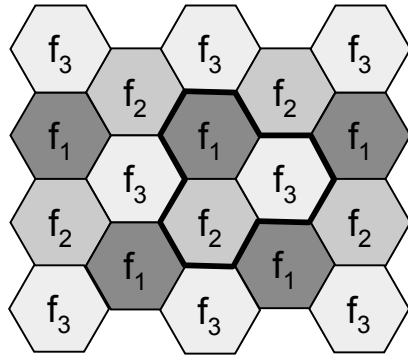
- Advantages
  - Higher capacity, more users with SDM frequency reuse
  - Less transmission power with smaller cells
  - Local interference only
  - Robustness, failures only affect small cell area
- Disadvantages
  - Infrastructure required to connect base stations
    - Antennas, call forwarding switches, location registers
  - Handover needed: often for small cells
  - Interference with other cells using same freqs.

# Frequency planning

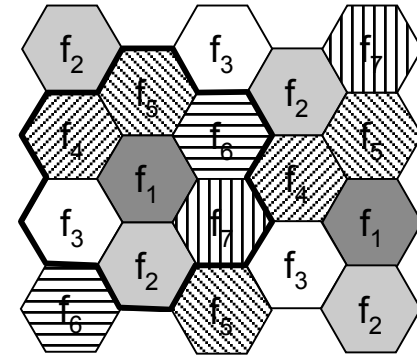
- Transmitters in cells use FDM (+ TDM)
- Clusters: cell patterns to minimise interference
  - Cells in cluster use disjoint frequencies
  - Sender transmission power limited to avoid interference with other cells with same frequencies
  - Sectorised antennas: reduce interference further
    - Several sectors per cell
    - Used for large-radius cells



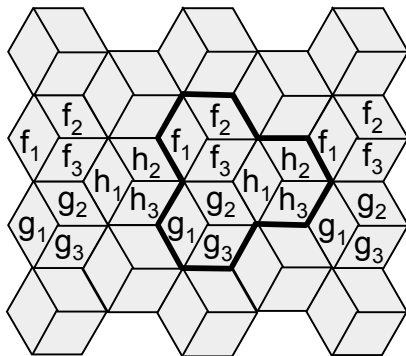
# Frequency planning II



3 cell cluster



7 cell cluster



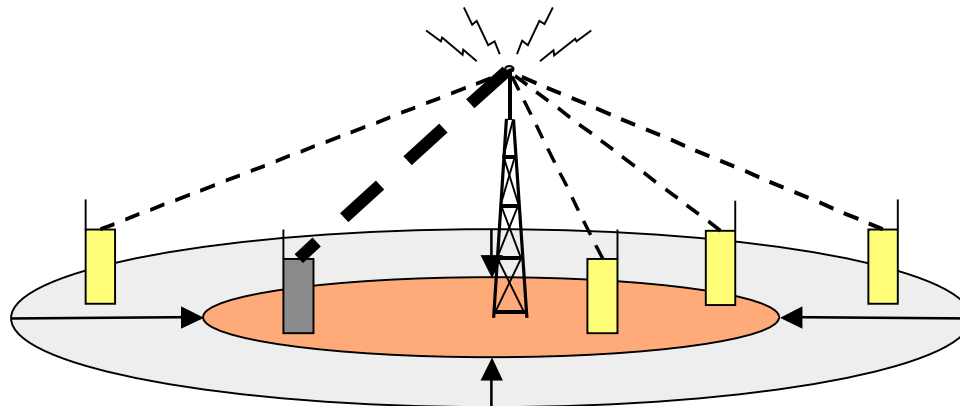
3 cell cluster  
with 3 sector antennas

# Frequency planning III

- Fixed frequency allocation
  - Each cell has certain frequencies assigned
  - Requires careful traffic analysis, load prediction
  - Fixed Channel Allocations (FCA) used in GSM
- Dynamic frequency allocation
  - Base stations choose frequencies depending on usage on neighbour cells
  - More capacity available on higher-load cells
  - Assignment can be based on interference levels

# Cell breathing

- CDM systems do not need dynamic frequency allocation
  - Users separated by code
- Cell size varies with load: “breathing”
  - Growing noise with additional users causes higher path loss and errors
  - Receivers far from base station end up dropping out of the cell



# Network planning

- Outcomes
  - Base station installation plan
    - Location, capacities, transmitter/receiver characteristics
  - Frequency plan
  - Fixed network architecture
    - Base station controllers, switching centers, databases
  - Transmission network to link it all
- A poorly planned network will provide bad Quality of Service, call interruptions and high blocking rates



# Network planning II

- Considerations
  - Characteristics of the area
    - Morphology and propagation
    - Subscribers density and behaviour
  - Cost minimisation
    - Urban areas cost effective in short term
    - Rural areas no guarantee of profit
  - Quality of Service constraints
- Cell dimensioning
  - (Sub)urban areas: no. of cells relative to traffic density
  - Rural areas: ensure coverage with minimum number of base stations
  - QoS indicators: blocking rate and waiting time

# Traffic dimensioning

- Required when
  - Planning network before deployment
  - Evaluating impact of future service
  - Evaluating impact of tariff change
  - Predict future demand
- Two main types of traffic
  - Call processing traffic: calls, voicemail/data services
  - Signaling: location updates, handover, roaming
- Factors: demography, economic activity, road traffic, existing traffic volume, population mobility
- Erlang: traffic unit
  - Channel occupation rate

# Planning process

- Planning stages of a cellular network
  1. Survey to find most appropriate sites for base stations
    - High points, buildings, grain silos, hilltops
  2. Site info processed by software with digital maps
    - Calculate interference levels
    - Draw cellular coverage
    - Determine antenna and equipment locations and characteristics
  3. Take measurements to optimise model
    - Determine real-world pathloss attenuation

# Fixed network planning

- Fixed network plan defined after radio planning
- Includes
  - Number and location of base station controllers (BSC) and mobile switching centres (MSC)
  - Define base station links to BSC, and BSC to MSC
  - Define inter-MSC connections
  - Capacity and location of databases
- Planning reviewed constantly
  - Freq. plans change during network lifetime
  - Efficiency and cost effectiveness evaluated