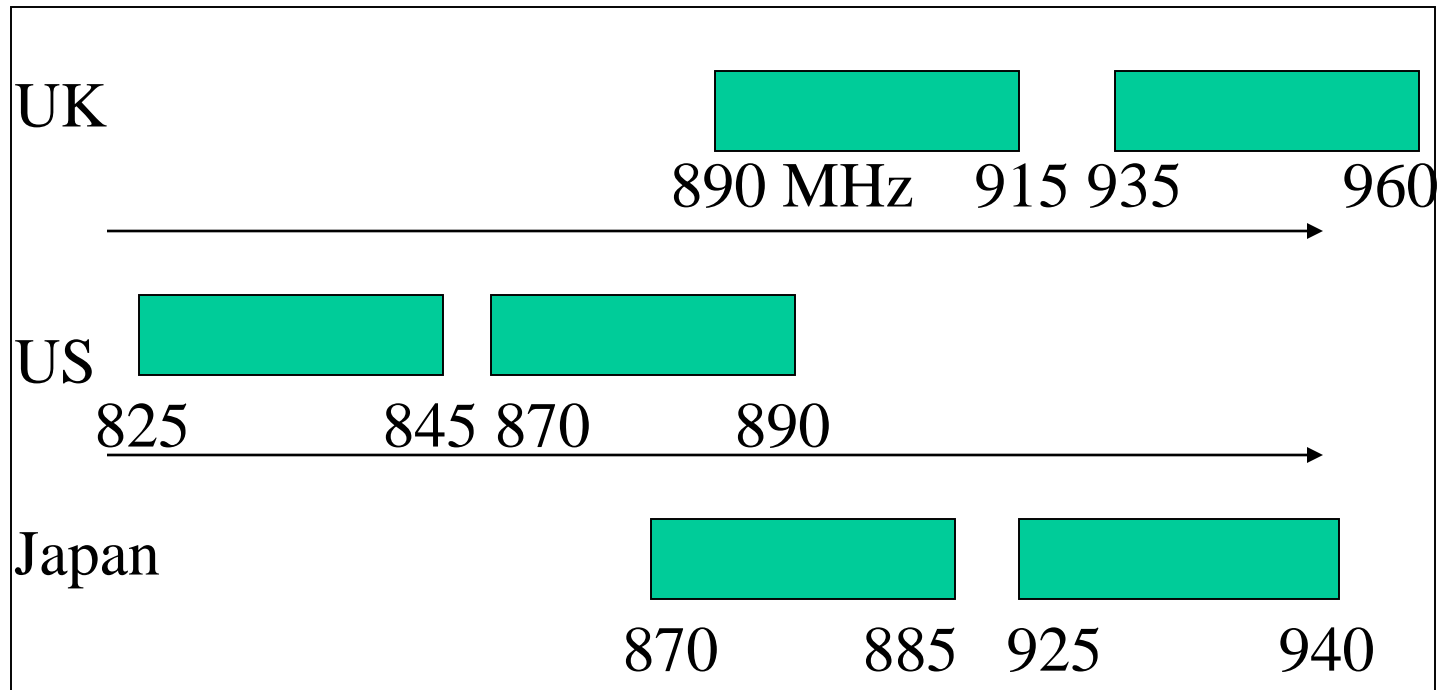


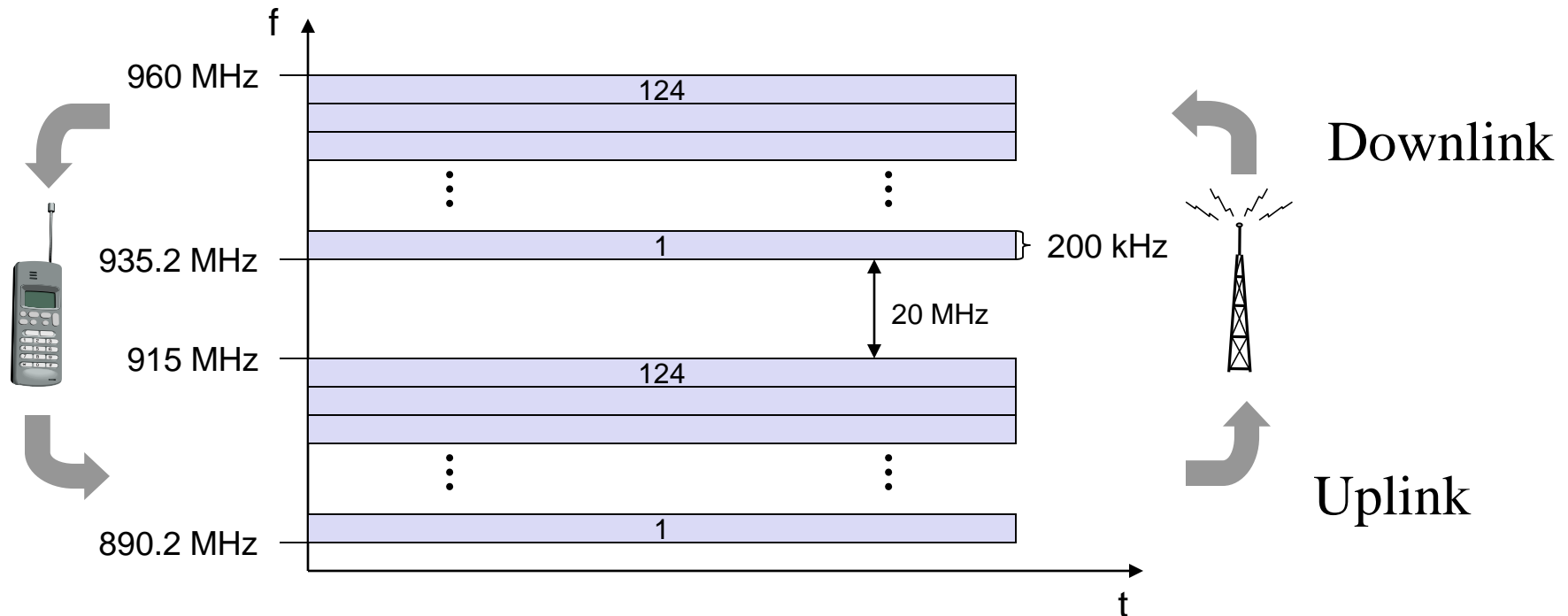
# Cellular Systems

Dr. Muhammad Nadeem Majeed

# Frequency Assignments



# Frequency usage in GSM at Europe



Bandwidth per channel is 200 kHz

Each user is assigned channel for an uplink and a downlink

So at most 124 simultaneous calls. Wow!

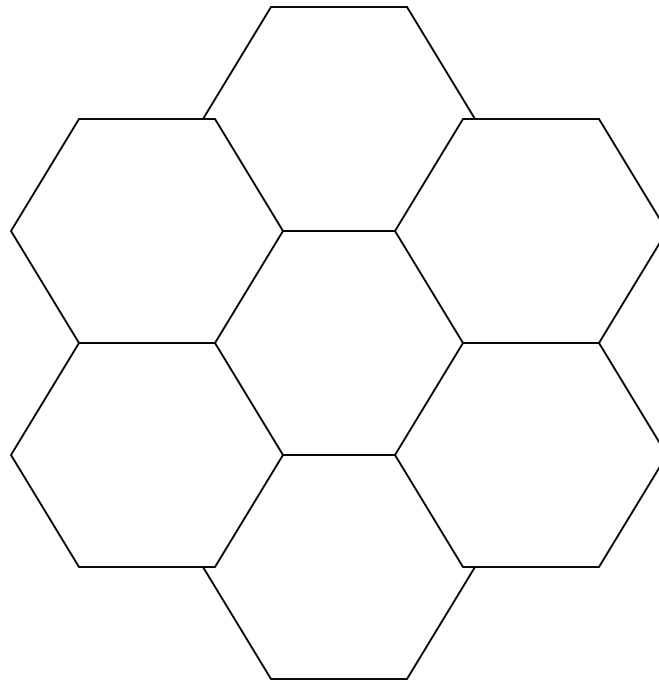
# Goals

- Low power transmitter system
- Increase network capacity
- Frequency reuse
- Build robust scaleable system
- Architecture to deal with different user densities at different places

# Idea!

- Partition the region into smaller regions called cells.
- Each cell gets at least one base station or tower
- Users within a cell talks to the tower
- How can we divide the region into cells?

# “Cell”ular Structure



# Properties of Cell structure

- Typical Cell sizes
  - some cites few hundred meters
  - country side few tens of kilometers
- Advantages of cell structures:
  - more capacity due to frequency reusage
  - less transmission power needed
  - more robust, tolerate failures
  - deals interference, transmission area locally
- Problems:
  - fixed network needed for the base stations
  - handover (changing from one cell to another) necessary
  - interference with other cells

# Inside a cell

- Center-excited cell where the tower is placed somewhat near the center with a omni-directional antenna
- Edge-excited cell where the towers are placed on three of the six corners with sectored directional antennas.



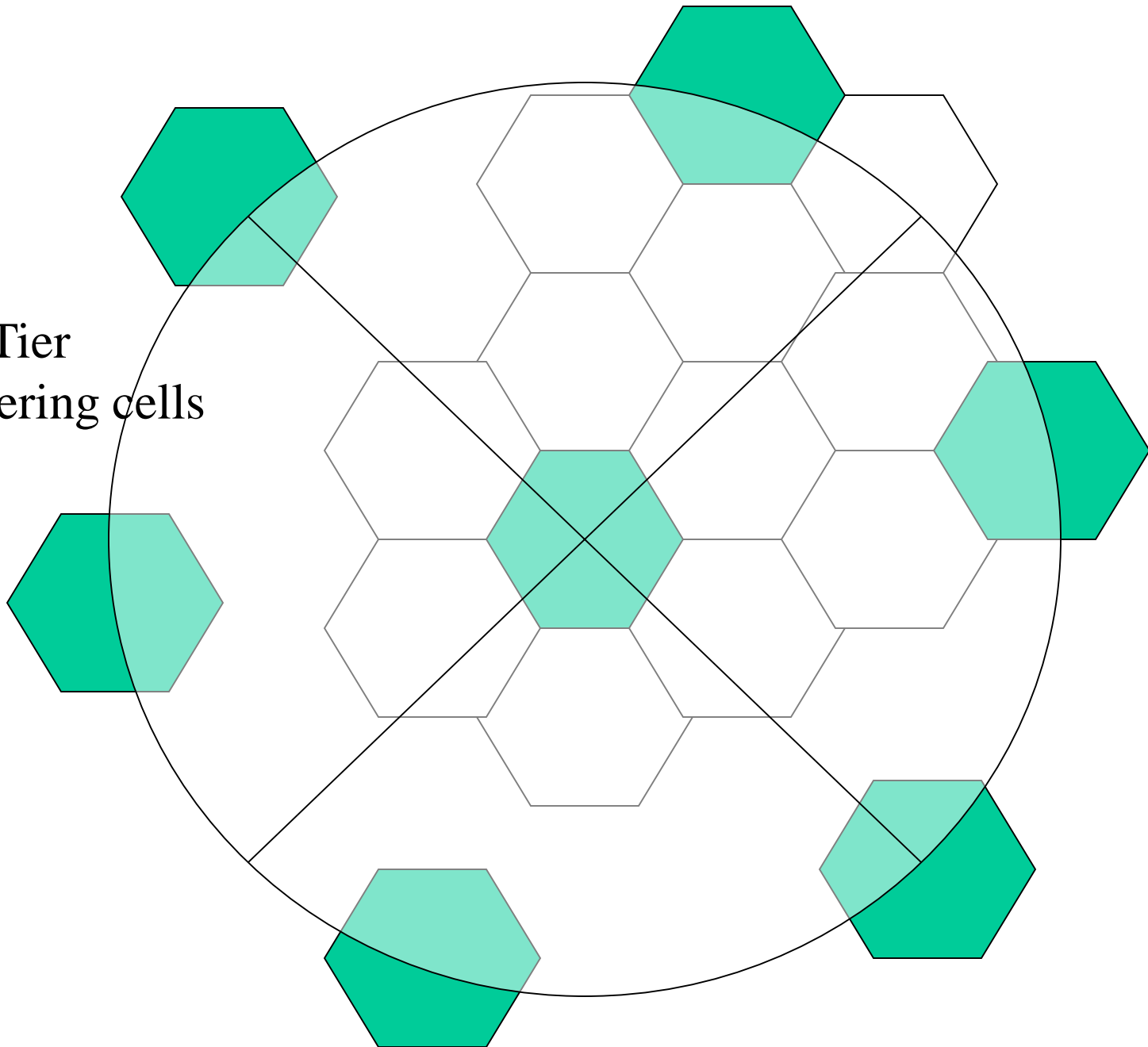
# Channels Reuse

- Cell structure can reuse frequency only when certain distance is maintained between cells that use the same channels.
- Fixed frequency assignment:
  - certain frequencies are assigned to a certain cell
  - problem: different traffic load in different cells
- Dynamic frequency assignment:
  - base station chooses frequencies depending on the frequencies already used in neighbor cells
  - more capacity in cells with more traffic
  - assignment can also be based on interference measurements

# Interference

- Co-channel interference
  - Signals from cells that share a channel cause co-channel interference
  - Can't remove it by increasing power.
- Adjacent channel interference
  - Signals from adjacent cells cause this.
  - Use filter to reduce it
- But, available channels decrease for incoming calls.

First Tier  
Interfering cells



# Handoff

- What happens when a user is mobile?
  - Especially when crossing a cell boundary while continuing the call.
- Handoff strategy is invoked.
  - Find a new base station
  - Process handoff
  - higher priority over new call invocation

# Who and When

- Who initiates handoff
  - Network directed ( tower determines )
  - Terminal assisted ( user helps the tower)
  - Terminal directed ( user determines )
- When to initiate handoff
  - When the mean signal (over some predetermined time) is below some threshold

# Types of Handoff

- Hard handoff
  - Mobile user is passed between disjoint towers that assign different frequency or adapt different air-interface technology
- Soft handoff
  - Mobile user communicates to two towers simultaneously and the signal is treated as a multipath signal

# High priority for Handoff

- Fraction of available channels is kept for handoff purpose. These channels are called guard channel.

# Other problems with handoff

- High speed vehicles can cross many “small” cells in a short time.
  - Umbrella cell. Large cell with a powerful tower to handle high speed vehicles
- Another problem is called cell dragging.
  - Happens when the user moves slowly away from the cell and the tower didn't recognize it due to strong average signal.



# Improving Capacity

- Sectoring
- Cell splitting
  - Process of subdividing a congested cell into smaller cells.
  - Each has its own base station
  - Smaller antenna and reduced transmission power
  - These smaller cells are called microcells

# Generations

- 1G - First generation (Analog and FM)
- 2G - Second generation (Digital, TDMA, CDMA)
- 3G - Third generation (Multi-media)
- 4G - Fourth generation ()

Thanks