EEG473 Mobile Communications
Module 2 : Week # (5)

The Cellular Concept –
System Design Fundamentals

1. Channel Assignment Strategies

- Channel assignment strategies can be classified as either **fixed or dynamic.**

- The choice of channel assignment strategy **impacts the performance of the system**, particularly as to how calls are managed when a mobile user is handed off from one cell to another.

Fixed channel assignment strategy

- Each cell is allocated a predetermined set of voice channels. Any call attempt within the cell can only be served by the unused channels in that particular cell.

- If all the channels in that cell are occupied, **the call is blocked** (the subscriber does not receive service).

- **The borrowing strategy**, (variation of fixed strategy) a cell is allowed to borrow channels from a neighboring cell if all of its own channels are already occupied.

- **MSC supervises such borrowing procedures** and ensures that the borrowing of a channel does not disrupt or interfere with any of the calls in progress in the donor cell.

Dynamic channel assignment strategy (1)

- voice channels **are not allocated** to different cells permanently.
- Each time a **call request** is made, **the serving base station requests a channel from the MSC**.
- MSC then allocates a channel according to different algorithm such as:
  - the likelihood of future blocking within the cell,
  - the frequency of use of the candidate channel,
  - the reuse distance of the channel,
  - and other cost functions.

Dynamic channel assignment strategy (2)

Advantages

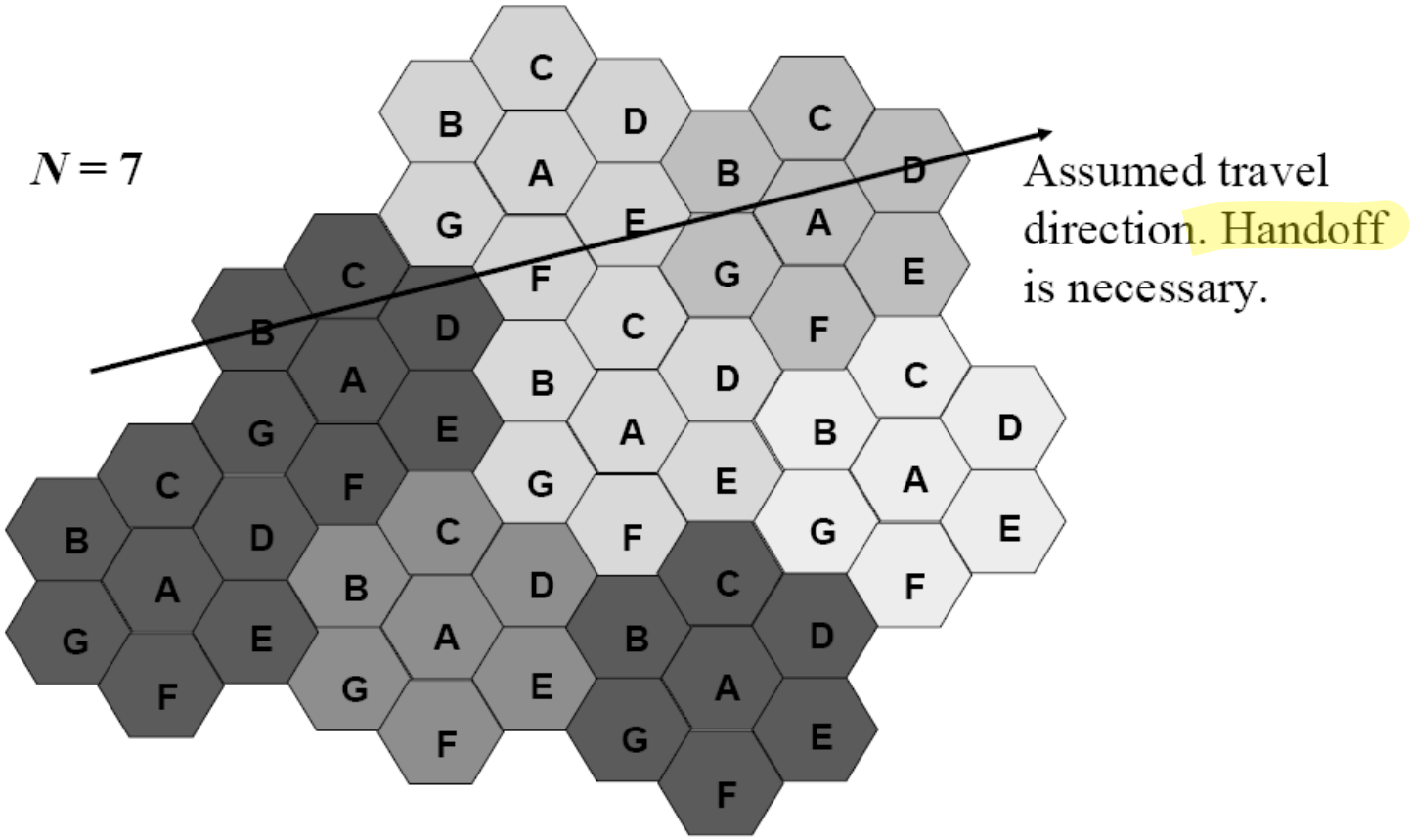
- Reduce the likelihood of blocking,
- Increases the trunking capacity of the system,

(since all the available channels in a market are accessible to all of the cells).

Disadvantages

- It requires the MSC to collect real-time data on a continuous basis on
  - Channel occupancy,
  - Traffic distribution, and
  - Radio signal strength indications (RSSI) of all channels.

This increases the storage and computational load on the system.


N = 7
Assumed travel direction. Handoff is necessary.

2. Handoff Strategies

1. When a mobile **moves into a different cell** while a conversation is in progress,

2. the **MSC automatically transfers the call to a new channel belonging to the new base station**.

3. **also requires that the voice and control signals be allocated to new base station channels**.

- **Optimum signal level** must be specify **to initiate a handoff**.
- **Minimum usable signal** is specified for acceptable voice quality at the base station receiver (normally 100 dBm),
- **A slightly stronger signal level is used as a threshold** at which a handoff is made.
- A margin, given by "Δ = P(handoff) – P(minimum usable)" cannot be too large or too small. (is chosen carefully to meet these conflicting requirements).
- If Δ is too large, unnecessary handoffs which burden the MSC may occur, and
- If Δ is too small, there may be insufficient time to complete a handoff before a call is lost due to weak signal conditions.

Handoffs – the basics

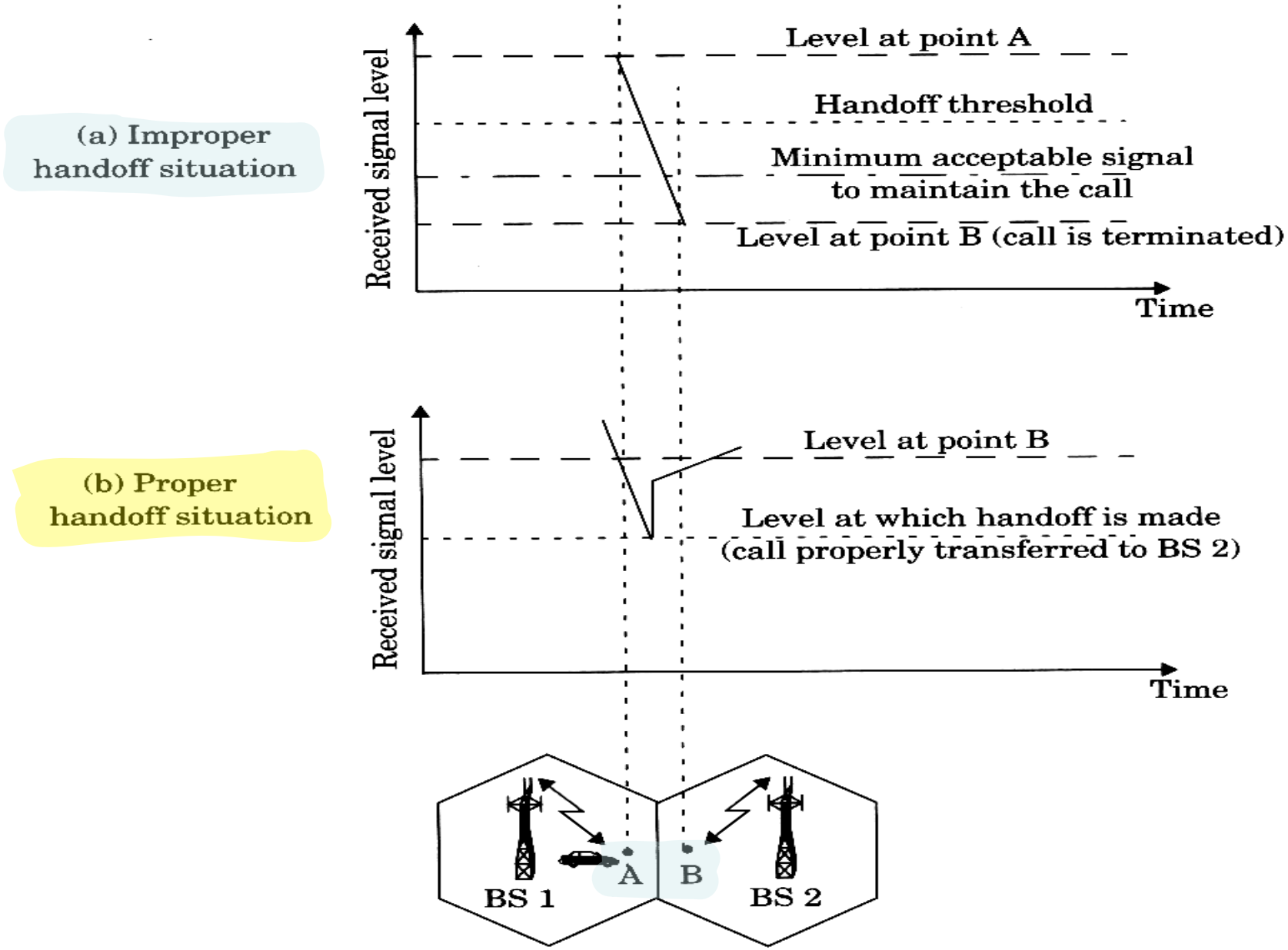


Figure 3.3 Illustration of a handoff scenario at cell boundary.

Dropped call event can happen (handoff is not made) **when**

- excessive delay by the MSC due to computational loading in assigning a handoff. (high traffic conditions)
- threshold  is set too small for the handoff time in the system.
- no channels are available on any of the nearby base stations (thus forcing the MSC to wait until a channel in a nearby cell becomes free).

- To ensure that Handoff is needed not due to momentary fading. (unnecessary handoffs are avoided) :

  the base station monitors the signal level for a certain period of time before a handoff is initiated.

- The time needed to decide if a handoff is necessary depends on the speed at which the vehicle is moving.

dwell time

- **Is the time over which a call may be maintained within a cell, without handoff.**

- Depends on: propagation, interference, distance between the subscriber and the base station, and other time varying effects. (the speed of the user and the type of radio coverage)

- Ambient motion in the vicinity of the base station and the mobile can produce fading, thus **even a stationary subscriber may have a random and finite dwell time**.

Handoff in second generation systems

Mobile assisted handoff **(MAHO):**

- every mobile station measures the received power from surrounding base stations
- continually reports the results of these measurements to the serving base station.
- A handoff is initiated when the power received from the BS of a neighboring cell begins to exceed the power received from the current BS.

- The MAHO method enables handoffs at a much faster rate than in **1G analog systems**. Where, **signal strength measurements are made by the base stations** and supervised by the MSC.

Intersystem Handoff

- if a mobile moves from one cellular system to different cellular system controlled by a different compatible MSC.

- when a mobile signal becomes weak in a given cell and the MSC cannot find another cell within its system to which it can transfer the call in progress.

Prioritizing Handoffs

- Some systems handle handoff requests in the same way they handle originating calls. In such systems, the probability that a handoff request not served equals the blocking probability of incoming calls.

- However, from the user's point of view, having a call abruptly terminated while in the middle of a conversation is more annoying than being blocked occasionally on a new call attempt.

Prioritize handoff requests over call initiation requests when allocating voice channels.

Prioritizing Handoffs

- (1) **The guard channel concept,** whereby a fraction of the total available channels in a cell is reserved exclusively for handoff requests from ongoing calls which may be handed off into the cell.

- This method has the disadvantage of reducing the total carried traffic, as fewer channels are allocated to originating calls.

- Guard channels, however, offer efficient spectrum utilization when dynamic channel assignment strategies, which minimize the number of required guard channels by efficient demand- based allocation, are used.

- **(2) Queuing of handoff requests** is another method to decrease the probability of forced termination of a call due to lack of available channels.

Practical Handoff Considerations

In practical cellular systems, several problems arise when attempting to design for a wide range of mobile velocities.

- High speed vehicles pass through the coverage region of a cell within a matter of seconds, whereas pedestrian users may never need a handoff during a call.

(1) Particularly with the addition of microcells to provide capacity, the MSC can quickly become burdened if high speed users are constantly being passed between very small cells.

(2) Another practical limitation is the ability to obtain new cell sites. in practice it is difficult for cellular service providers to obtain new physical cell site locations in urban areas.

The umbrella cell approach

- Is used **to provide large area coverage to high speed users** while providing small area coverage to users traveling at low speeds.

- By using different antenna heights (often on the same building or tower) and different power levels, it is possible to provide **"large" and "small"** cells which are co-located at a single location.

- The number of handoffs is minimized for high speed users and provides additional microcell channels for pedestrian users.

- **If a high speed user in the large umbrella cell** is approaching the base station, and its velocity is rapidly decreasing, the base station may decide to hand the user into the co-located microcell, without MSC intervention.

Umbrella Cells

an umbrella cell which is co-located with some smaller microcells.

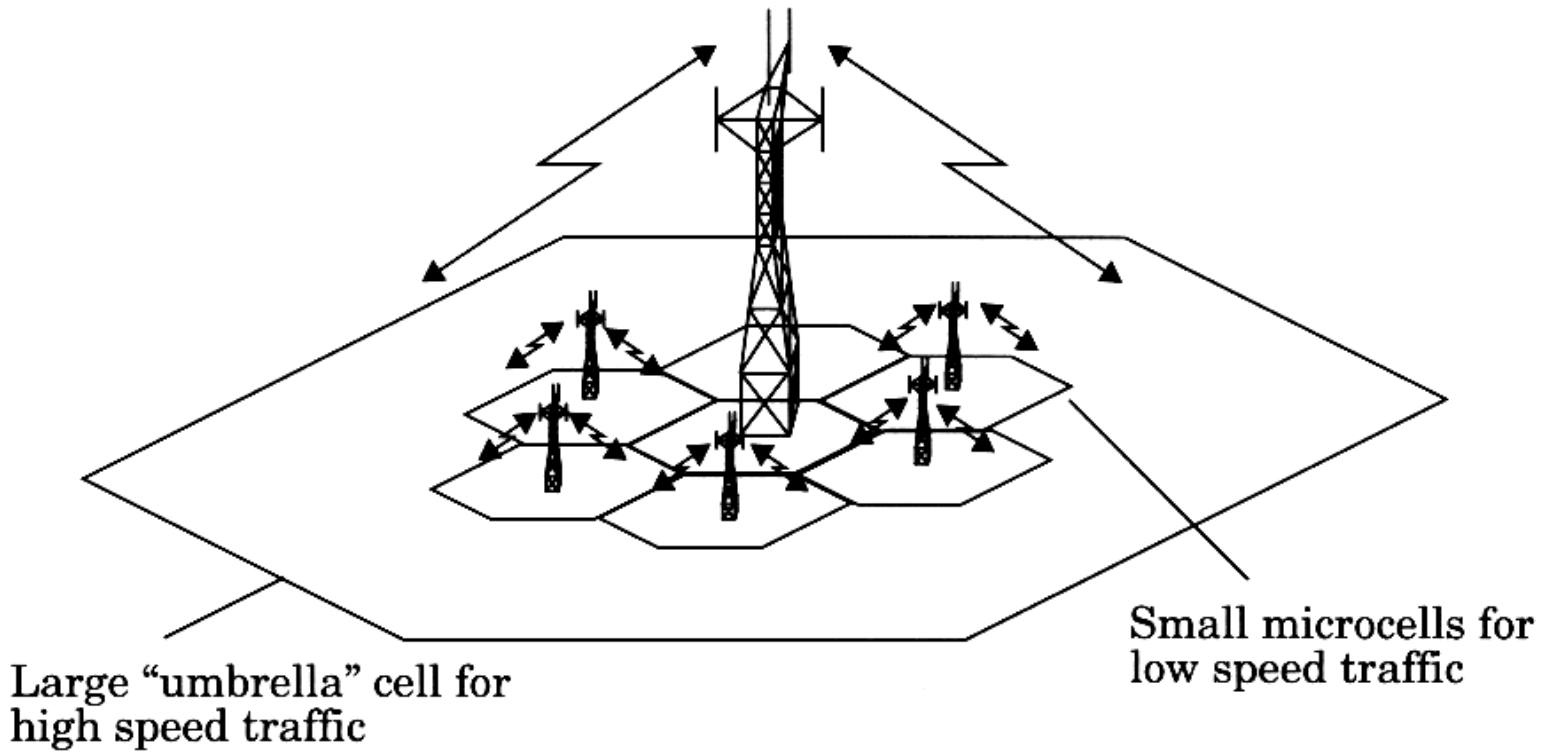


Figure 3.4 The umbrella cell approach.

Cell Dragging

- Another practical handoff problem in microcell systems.
- Cell dragging results from pedestrian users that provide a very strong signal to the base station. (LOS path between the subscriber and the base station). As the user travels away from the base station at a very slow speed, the average signal strength does not decay rapidly.
- Even when the user has traveled well beyond the designed range of the cell, **the received signal at the base station may be above the handoff threshold, thus a handoff may not be made**.
- This creates a potential interference and traffic management problem, since the user has meanwhile traveled deep within a neighboring cell.
- To solve the cell dragging problem, **handoff thresholds and radio coverage parameters must be adjusted carefully**.

summary

Handoff is important. Without the ability to handoff mobiles could not freely move from cell to cell.

- MSC controls handoff
  - Identifies new cell (base station) and transfers both voice and control signals to appropriate channel under control of new base station.
  - Handoff often has priority over initiation of new call.
- Handoff Guard Channel
  - Fraction of the total number of channels allocated to a cell are reserved for handoffs.
  - Having guard channels reduces the total number of calls that can be initiated.
- Umbrella cells
  - Higher transmitted power or higher antenna height can result in a base station having greater coverage.
  - Minimize handoff to high speed users. Low speed users use microcells.