CELLULAR NETWORK DIMENSIONING
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Agenda

- Major things to consider
- Capacity demand
- Coverage
  - Frequency reuse
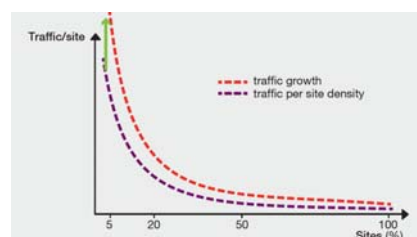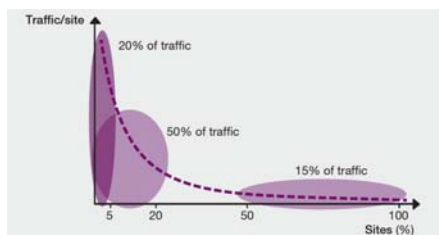- Capacity
  - Cell splitting
  - Cell sectoring
- Conclusion

Major things to consider

1- coverage

2- capacity

3- backhaul and core network

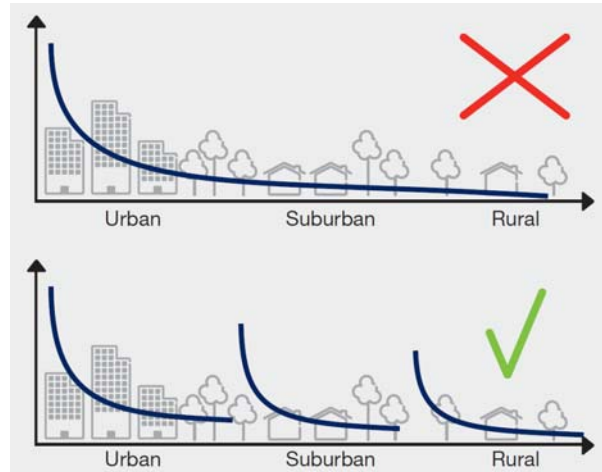Coverage; the area that UEs should be able to connect and stay connected

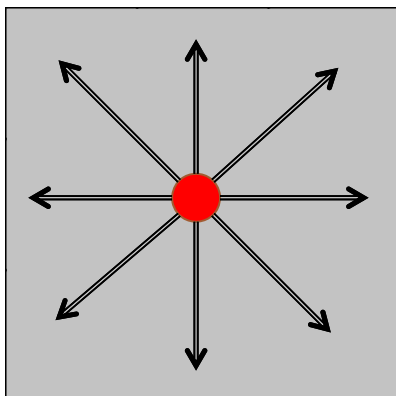Capacity; cellular networks are dimensioned based on max data rate
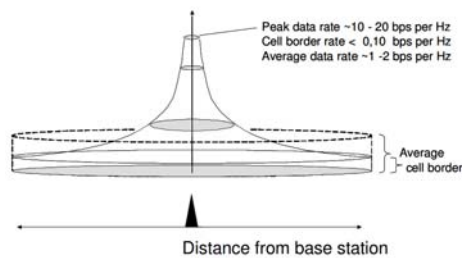
Capacity demand

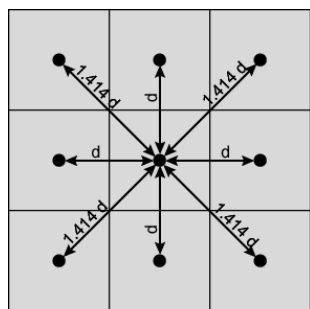Source: Ericsson review 2014

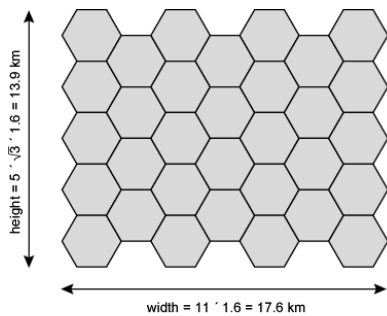# Capacity demand

Coverage
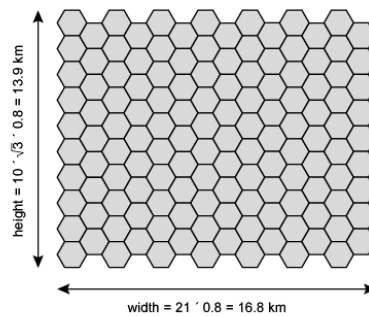
Coverage
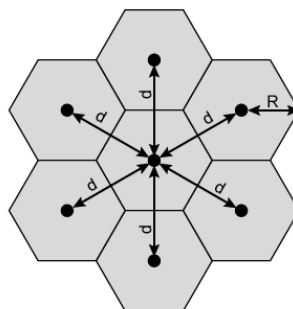
(a) Square pattern   (b) Hexagonal pattern

Source: William Stalling

Coverage

(a) Cell radius = 1.6 km   (b) Cell radius = 0.8 km

Source: William Stalling

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Coverage

□ Area divided into cells
- Each with own antenna
- Each with own range of frequencies
- Served by base station
  - Transmitter, receiver, control unit
- Adjacent cells should be on different frequencies to avoid crosstalk

Frequency Reuse

□ Power of base transceiver controlled
- Allow communications within cell on given frequency
- Limit escaping power to adjacent cells
- Allow re-use of frequencies in nearby cells
- Use same frequency for multiple conversations
- 10 − 50 frequencies per cell

□ *E.g.*
- N cells all using same number of frequencies
- K total number of frequencies used in systems
- Each cell has K/N frequencies
- Advanced Mobile Phone Service (AMPS) $K=395$, $N=7$ giving *57* frequencies per cell on average

Characterizing Frequency Reuse

- □ D = minimum distance between centers of cells that use the same band of frequencies (called co-channels)
- □ R = radius of a cell
- □ d = distance between centers of adjacent cells (d = R)
- □ N = number of cells in repetitious pattern
  - ■ Reuse factor
  - ■ Each cell in pattern uses unique band of frequencies
- □ Hexagonal cell pattern, following values of N possible
  - ■ $N = I^2 + J^2 + (I \times J)$, I, J = 0, 1, 2, 3, …
- □ Possible values of N are 1, 3, 4, 7, 9, 12, 13, 16, 19, 21, …

- □ D/R= $\sqrt{3N}$

- □ D/d = $\sqrt{N}$

Frequency Reuse Patterns
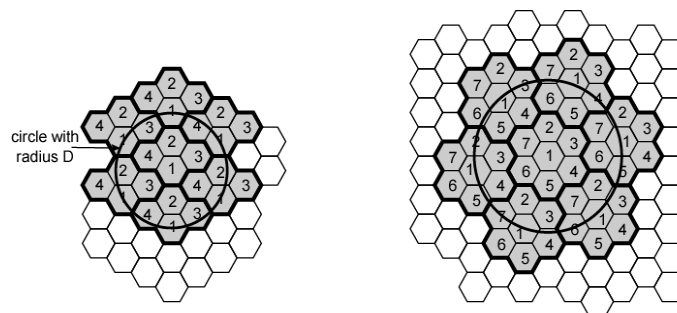
(a) Frequency reuse pattern for N = 4   (b) Frequency reuse pattern for N = 7

Source: William Stalling

Is that it?

- What about the capacity !!!

- Bottom up calculation (coverage oriented)
  - $C_{ss} = B * N_s * Eff_s$ **BANDWIDTH**

- Top down calculation (demand oriented)

Capacity

- Add new channels
  - The addition of sectors and carriers increase network capacity by adding more radio frequency channels.

- Frequency borrowing
  - Taken from adjacent cells by congested cells
  - Or assign frequencies dynamically

Cell Splitting

- The unit area of RF coverage for cellular network is called a *cell*.
- In each cell, a *base station* transmits from a fixed *cell site* location, which is often centrally located in the cell.
- In base stations where the usage of cellular network is high, these cells are split into smaller cells.

Cell splitting
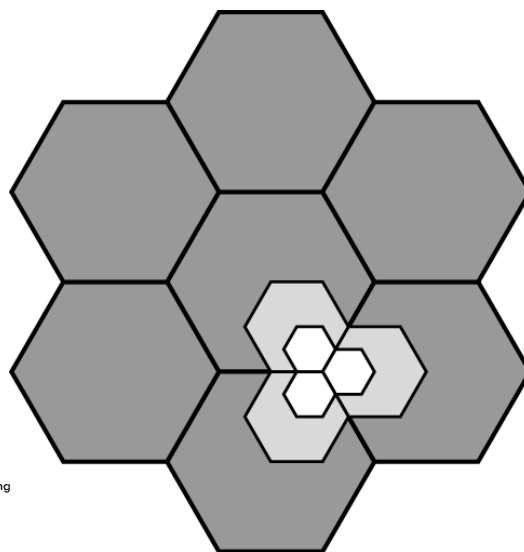
Source: William Stalling

Cell Splitting (con't)

- The radio frequencies are reassigned, and transmission power is reduced.

- A new cell site must be constructed when a cell is split

- Cell splitting is one of the easy and less costly solution when increasing the capacity of cellular network.

- Splitting the cells into smaller ones also lead to a new solution called cell sectoring.

Cell Sectoring

- Sectorization consists of dividing an *omnidirectional* (360 degree) view from the cell site into non-overlapping slices called *sectors*.
- When combined, sectors provide the same coverage but they are considered to be separate cells.
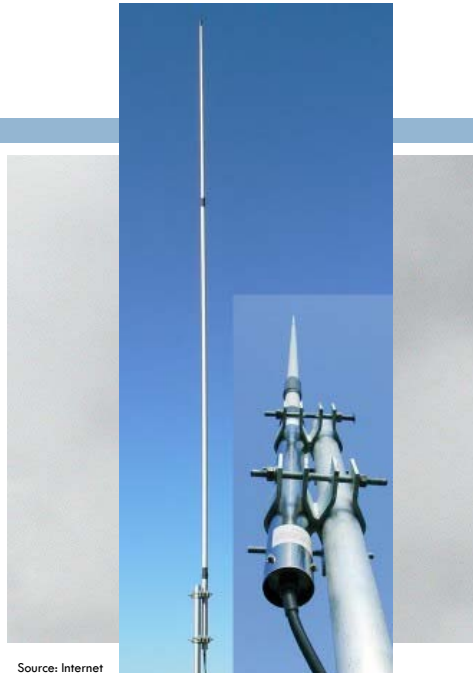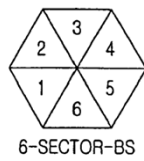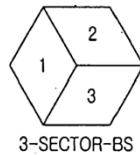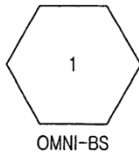- Also considered as one of easy and inexpensive capacity increasing solution.

Cell Sectoring

- In basic form, antennas are omnidirectional
- Replacing a single omni-directional antenna at base station with several directional antennas, each radiating within a specified sector.
- achieves capacity improvement by essentially rescaling the system.
- less co-channel interference, number of cells in a cluster can be reduced
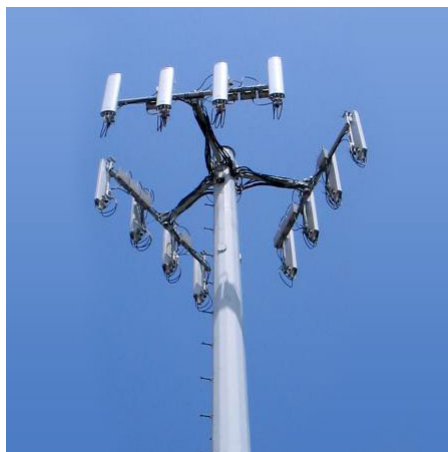- Larger frequency reuse factor, larger capacity

Cell Sectoring

- Cell Sectoring
  - Cell divided into wedge shaped sectors
  - 3 – 6 sectors per cell
  - Each with own channel set
    - Subsets of cell's channels
  - Directional antennas
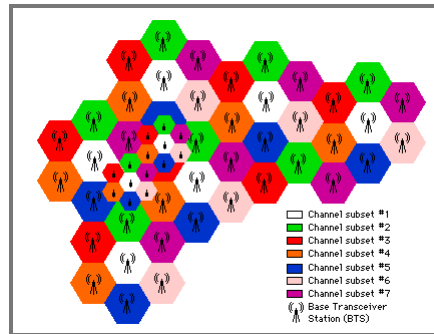
Cell sectoring

1
OMNI-BS

2
1
3
3-SECTOR-BS

3 4
2   5
1 6
6-SECTOR-BS

Source: Internet

Cell sectoring – addition of carriers

Source: Internet

Conclusion

Source: Internet

□ http://opensignal.com/coverage-maps/Sweden/

Cool stuff

□ http://c-apps.nordeca.com/net1_v2/?country=SE&zoom=5&showbigmap=&lat=6643945.3125&lon=624609.375&modem=wlan&language=sv&bestSender=

□ https://www.netradar.org/