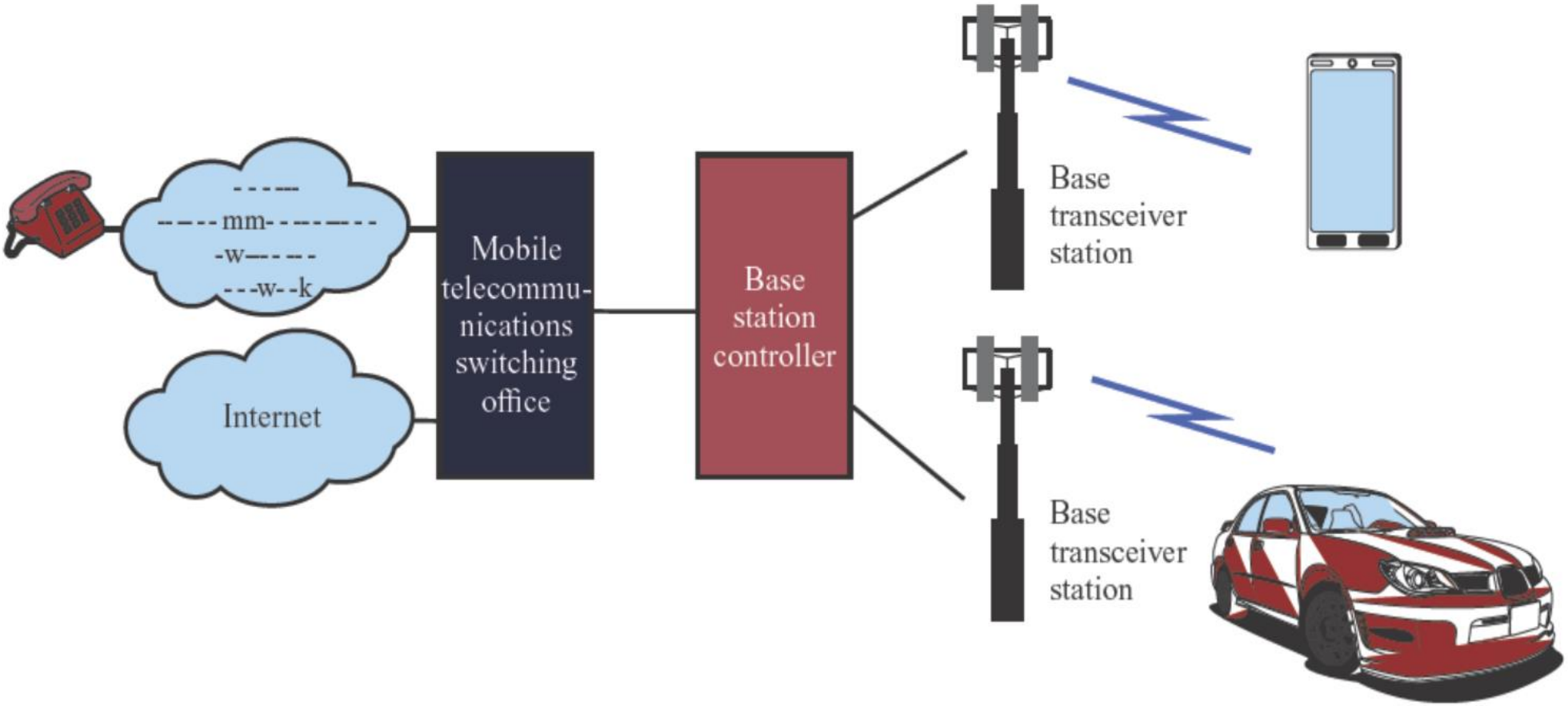
Overview of Cellular System



Overview of Cellular System

Wireless Communication Definitions

- **Base Station**
  - A fixed station in a mobile radio system used for radio communication with mobile stations.
  - Base station are located at center or on the edge of a coverage region and consist of radio channels and transmitter and receiver antennas mounted on a tower.

Overview of Cellular System

- **Forward Channel**
  - Radio channel used for transmission of information from the **base station** to **the mobile**.
- **Reverse Channel**
  - Radio channel used for transmission of information from the **mobile** to the **base station**.
- **Control Channel**
  - Radio channel used for transmission of call setup, call request, call initiation and other bacon or control purposes.

Overview of Cellular System

- Q1 a: what are types channels in cellular system between the base station and the mobiles

Solution:

1) Forward Voice Channel (FVC): This channel is used for the voice transmission from the BS to the MS.
2) Reverse Voice Channel (RVC): This is used for the voice transmission from the MS to the BS.
3) Forward Control Channel (FCC): The FCC is used for control signaling purpose from the BS to MS.
4) Reverse Control Channel (RCC): This is used for the call control purpose from the MS to the BS. Control channels are usually monitored by mobiles

Overview of Cellular System

- **Mobile Switching Center**
  - Switching center which coordinates the routing of calls in a large service area. In a cellular radio system, MSC connects the cellular base station and mobiles to PSTN.
- **Page**
  - Brief message which is broadcast over the entire service area.
- **Transceiver**
  - A device capable of simultaneously transmitting and receiving radio signals.

The Cellular Concept- System Design Fundamentals

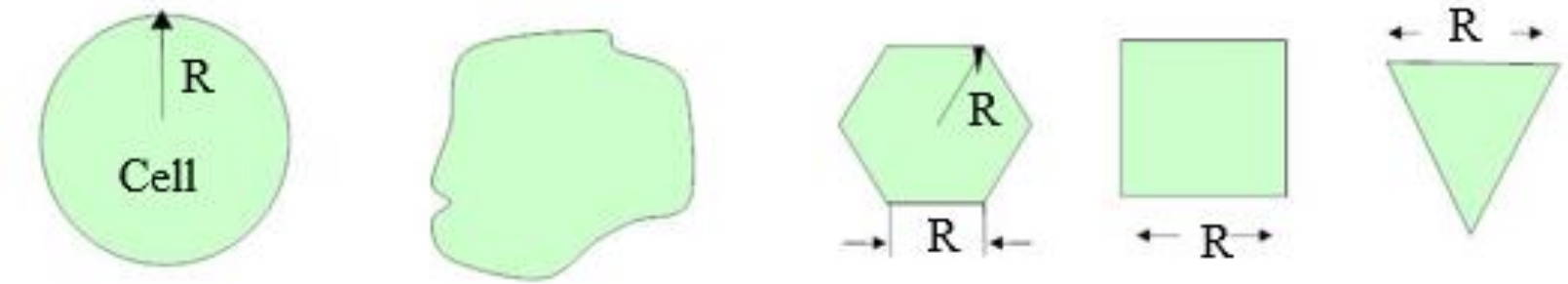
Cellular concept

- Cellular concept is system level idea, which calls for replacing single high power transmitter with many low power transmitters.
- It offer very high capacity in a limited spectrum allocation.
- Each base station is allocated portion of the total number of channels available to the entire system.
- Neighboring base stations are assigned different groups of channels so that interference between base stations is minimized.

What is cell?

- Each cellular base station is allocated a group of radio channels to be used within small geographic area called a cell

Cell Shape



(a) Ideal cell (b) Actual cell (c) Different cell models

What is cell types?

- Each cellular base station is allocated a group of radio channels to be used within small geographic area called a cell

1) **Macro-cells:** coverage area is large (approximately 6 miles in diameter) used in remote areas . high power transmitter and receiver are used.
2) **Micro-cells:** coverage area is small(about0.5 miles diameter) .used in Urban zones. Low power transmitter and receiver are used to avoide interference with cells in another clusters

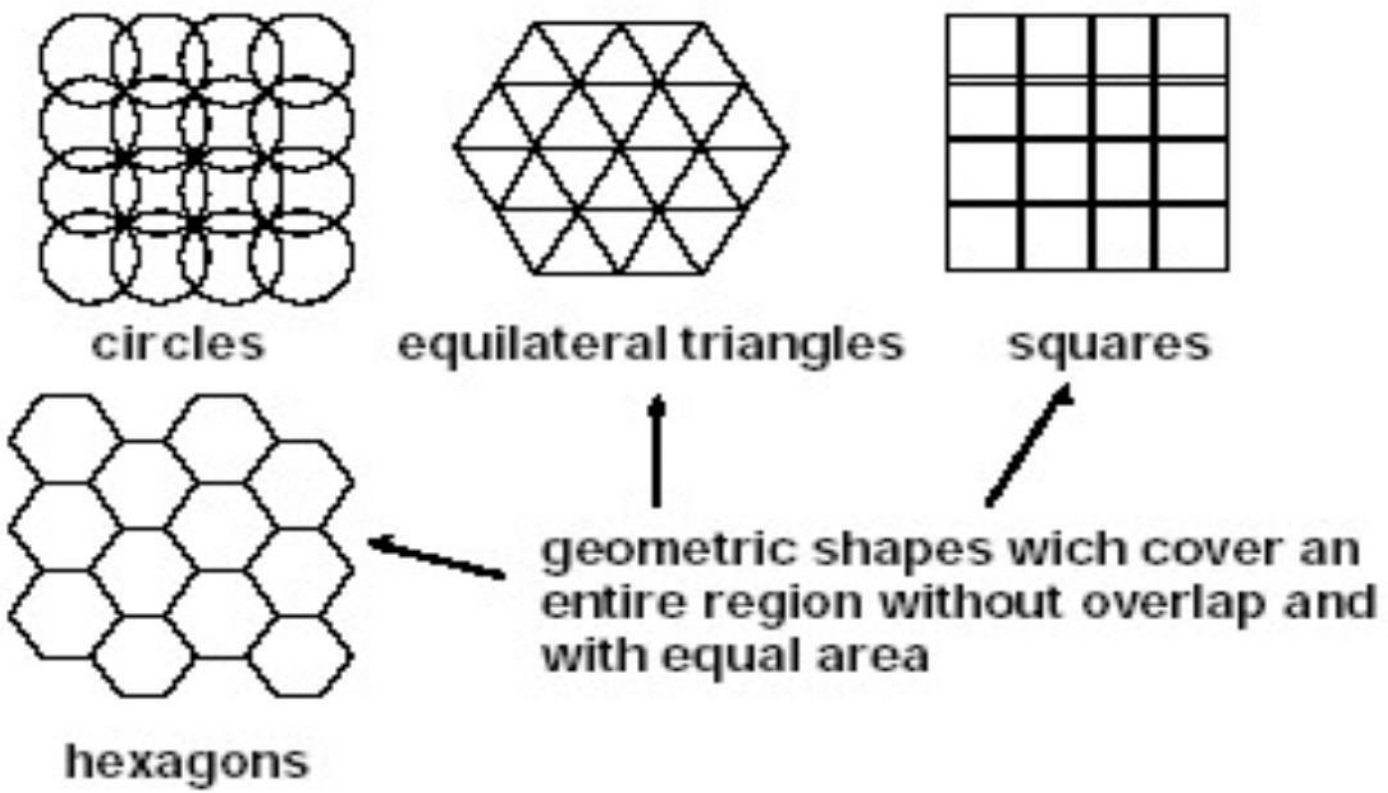
What is cell types?

- Each cellular base station is allocated a group of radio channels to be used within small geographic area called a cell

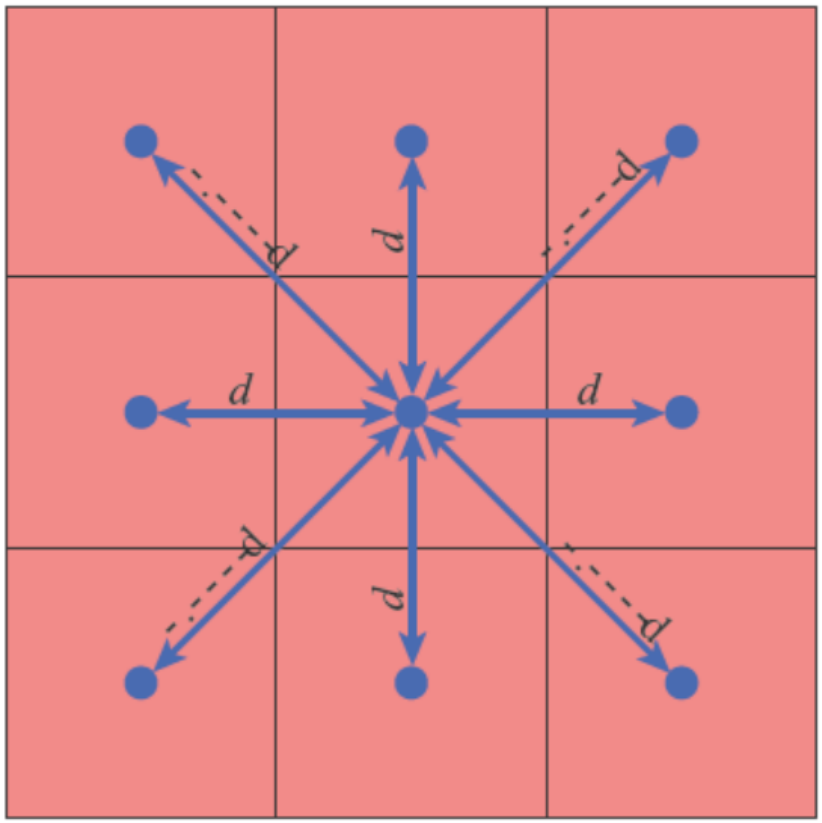
3) **Pico-cells:** is a small cellular system typically covering small cellular areas such as in building (offices, shopping malls, train station) .

4) **Selective-cells:** located at the entrance of tunnels, where coverage of 360 degree is not needed In this case, a selective cell with a coverage of 120 degree is used.

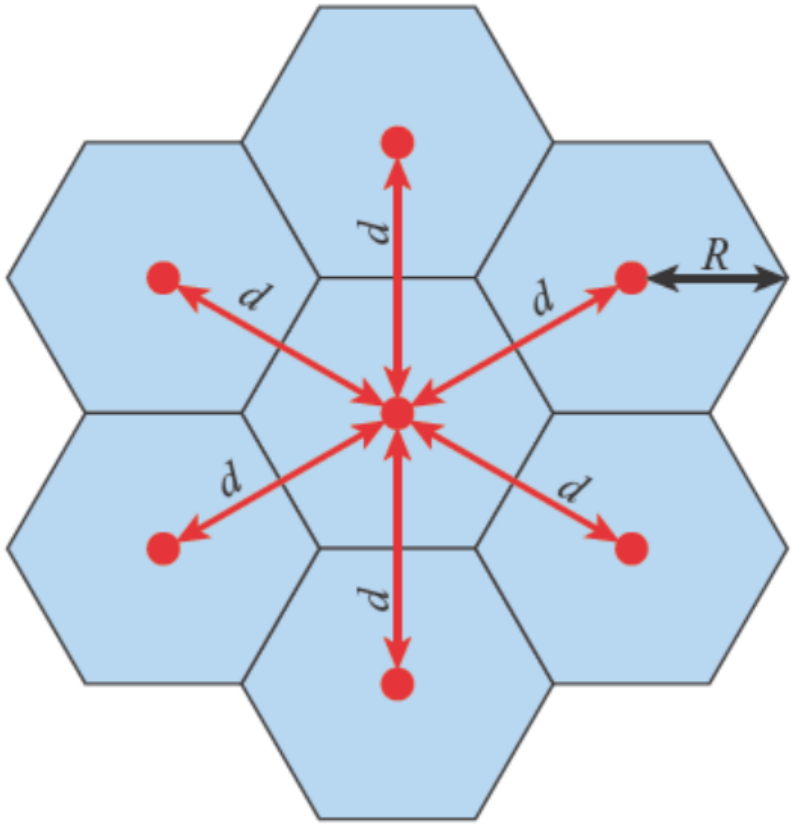
Cell Shape


circles
equilateral triangles
squares
hexagons
geometric shapes wich cover an entire region without overlap and with equal area

Cellular Geometries



(a) Square pattern

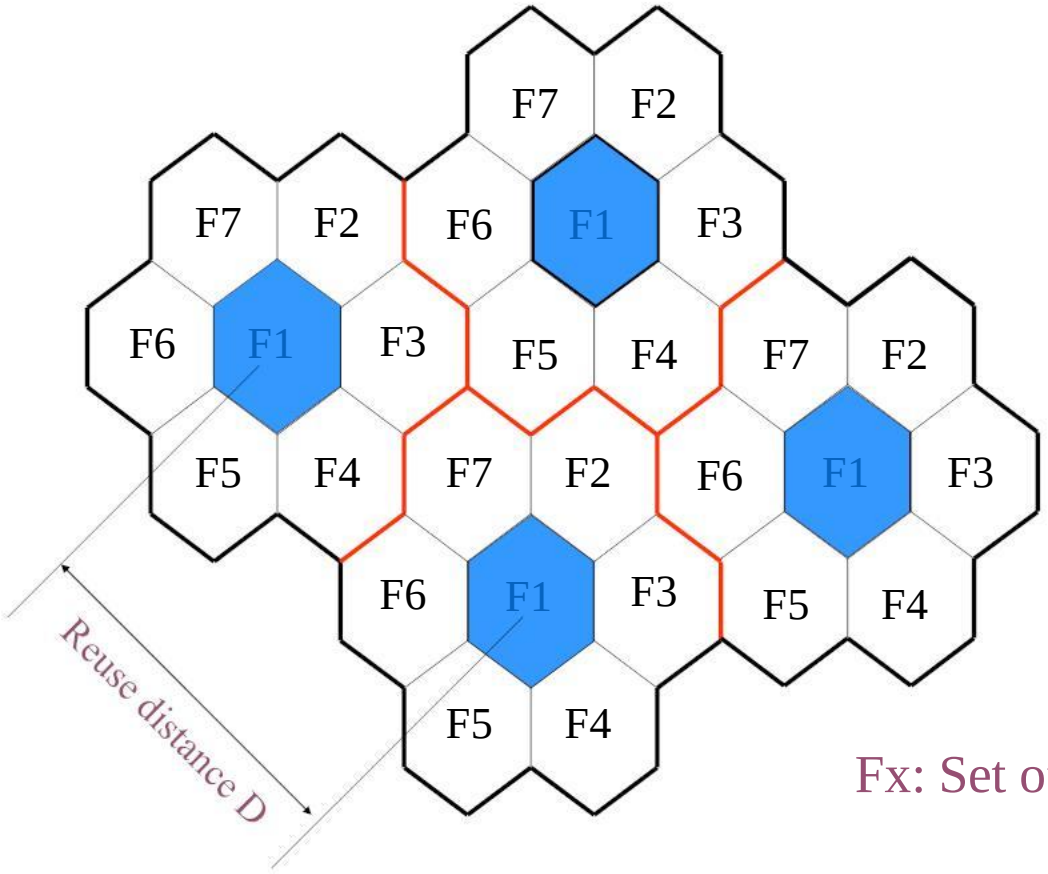


(b) Hexagonal pattern

Frequency Reuse

- By limiting the coverage area to within the boundaries of a cell, the **same group of channels** may be used to cover different cells that are separated from one another by distances large enough to keep interference levels within tolerable limits.
- The design process of selecting and allocating channel frequencies for all cellular base stations within a system is known as frequency re-use or frequency planning.

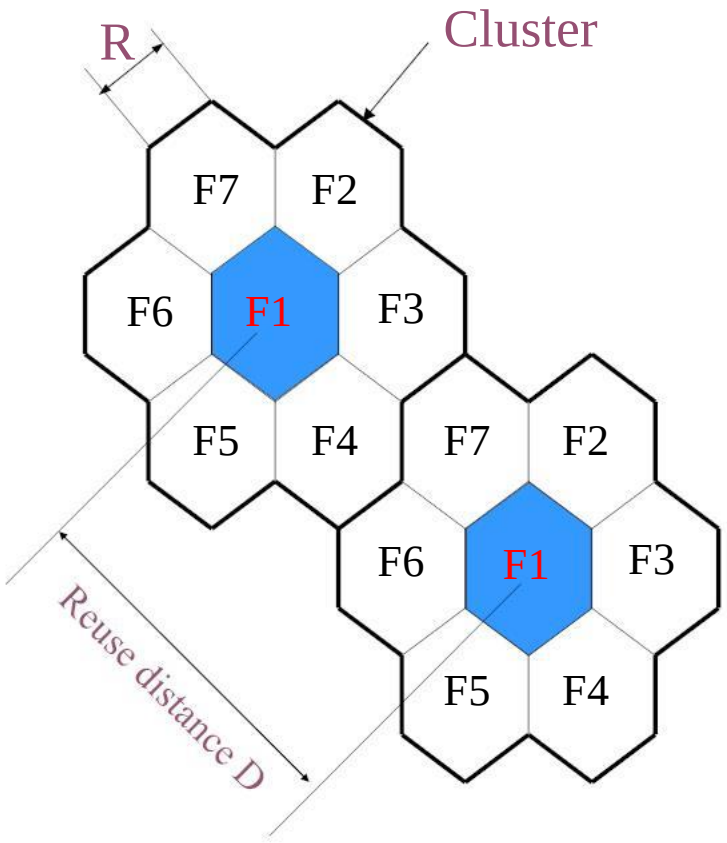
Frequency Reuse



Fx: Set of frequency

7 cell reuse cluster

Reuse Distance



- For hexagonal cells, the reuse distance is given by

$$D = \sqrt{3N}R$$

where R is cell radius and N is the reuse pattern (the cluster size or the number of cells per cluster).

- Reuse factor is

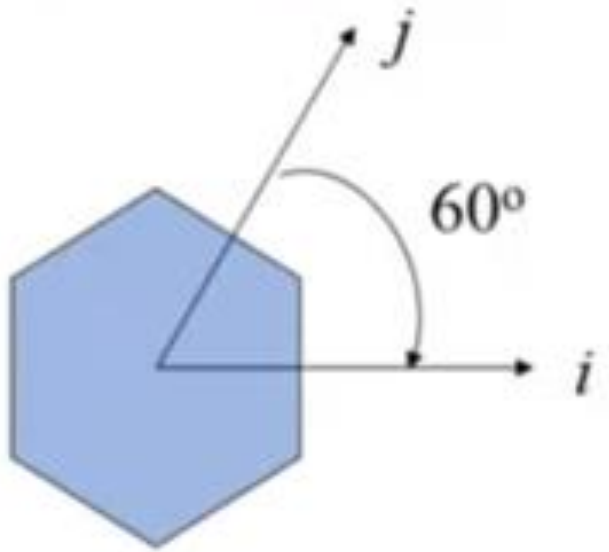
$$q = \frac{D}{R} = \sqrt{3N}$$

Reuse Distance (Cont'd)

- The cluster size or the number of cells per cluster is given by

$$N = i^2 + ij + j^2$$

where i and j are integers.



- N = 1, 3, 4, 7, 9, 12, 13, 16, 19, 21, 28, …, etc.

  The popular value of N being 4 and 7.

Reuse Distance (Cont'd)

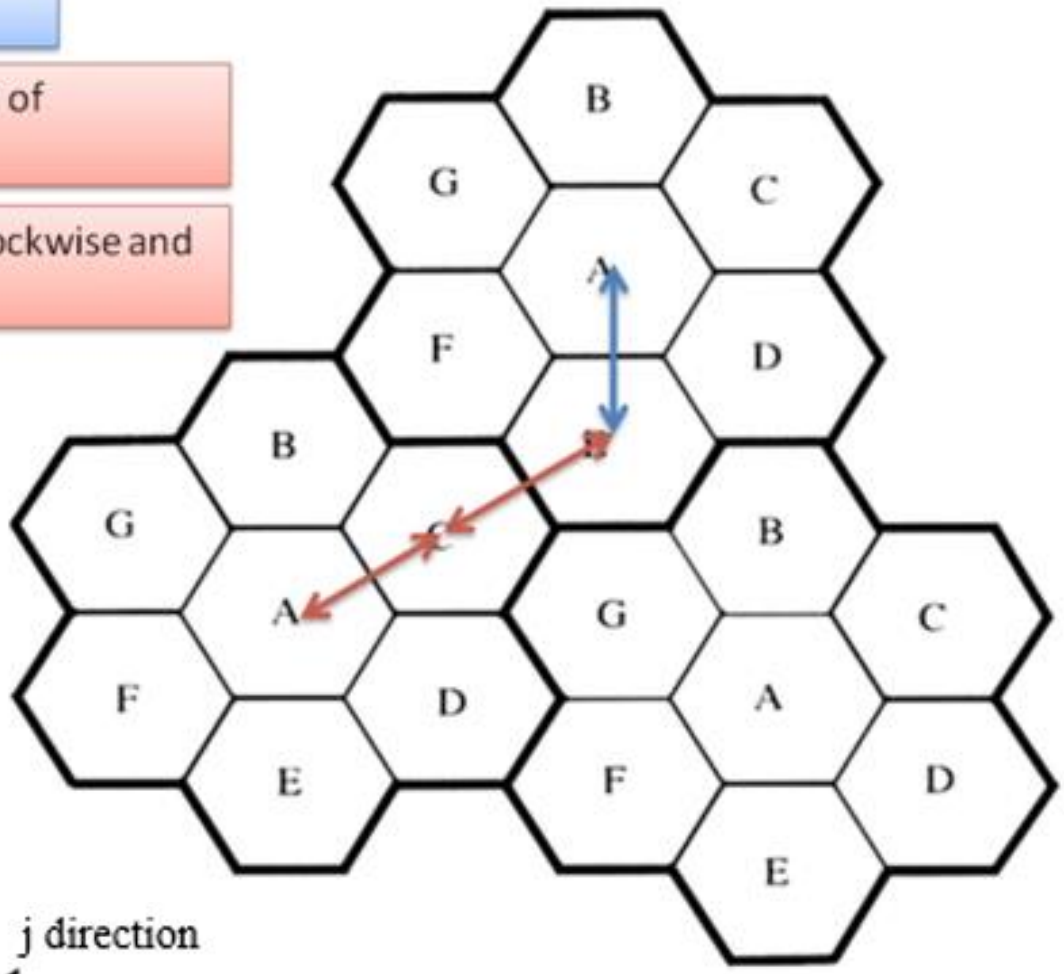
Find nearest co-channel.

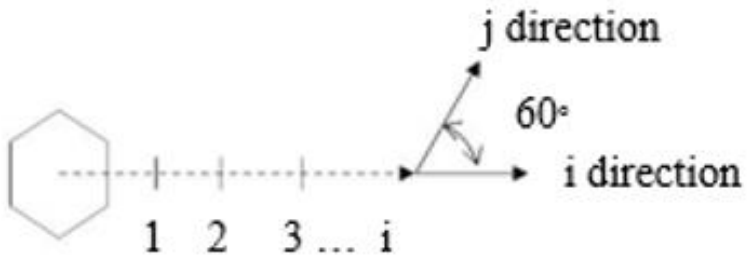
move i cells along any chain of hexagons then,

turn 60 degrees counter-clockwise and move j cells.

i=2
j=1

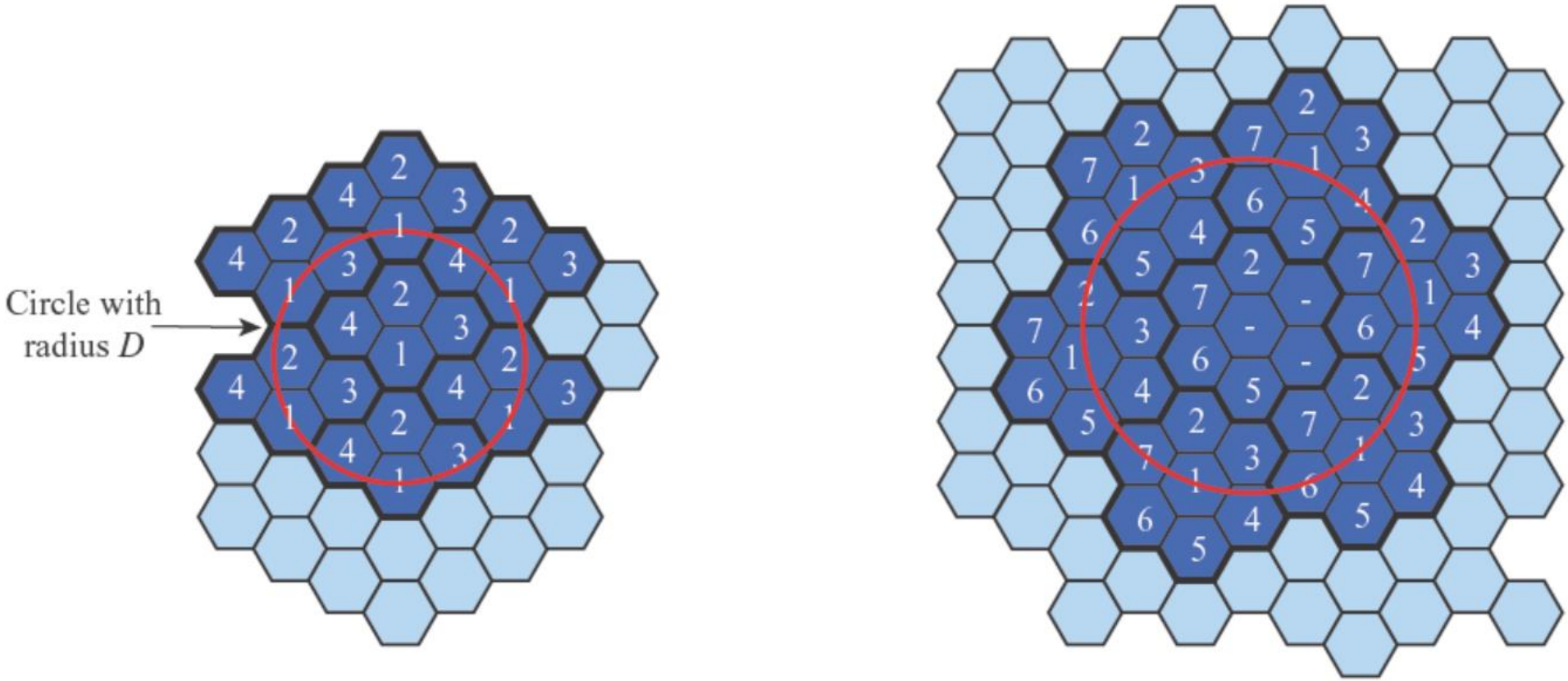
N=7





(a) Finding the center of an adjacent cluster using integers i and j (direction of i and j can be interchanged).

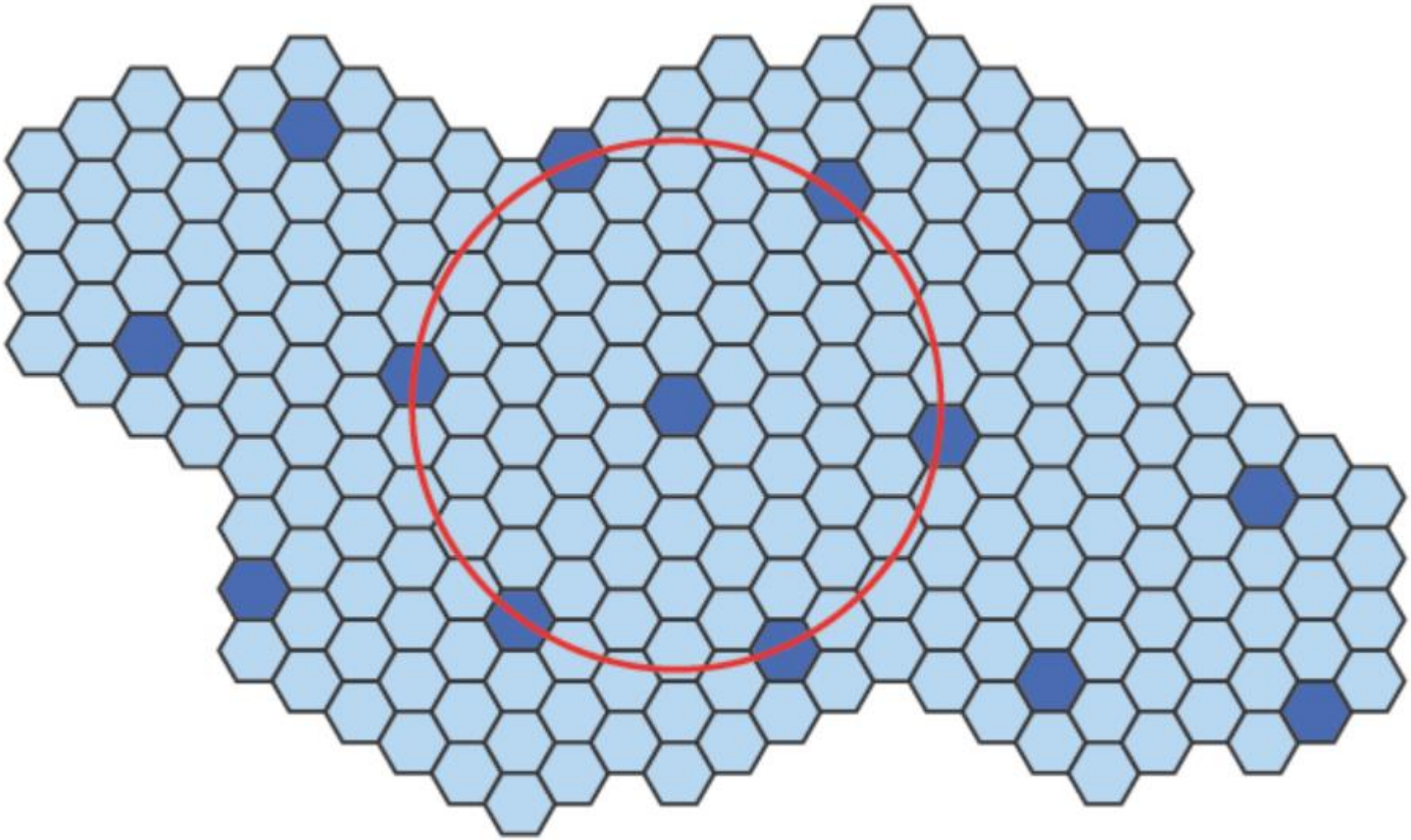
Reuse Distance (Cont'd)



(a) Frequency reuse pattern for $N = 4$

(b) Frequency reuse pattern for $N = 7$

Reuse Distance (Cont'd)

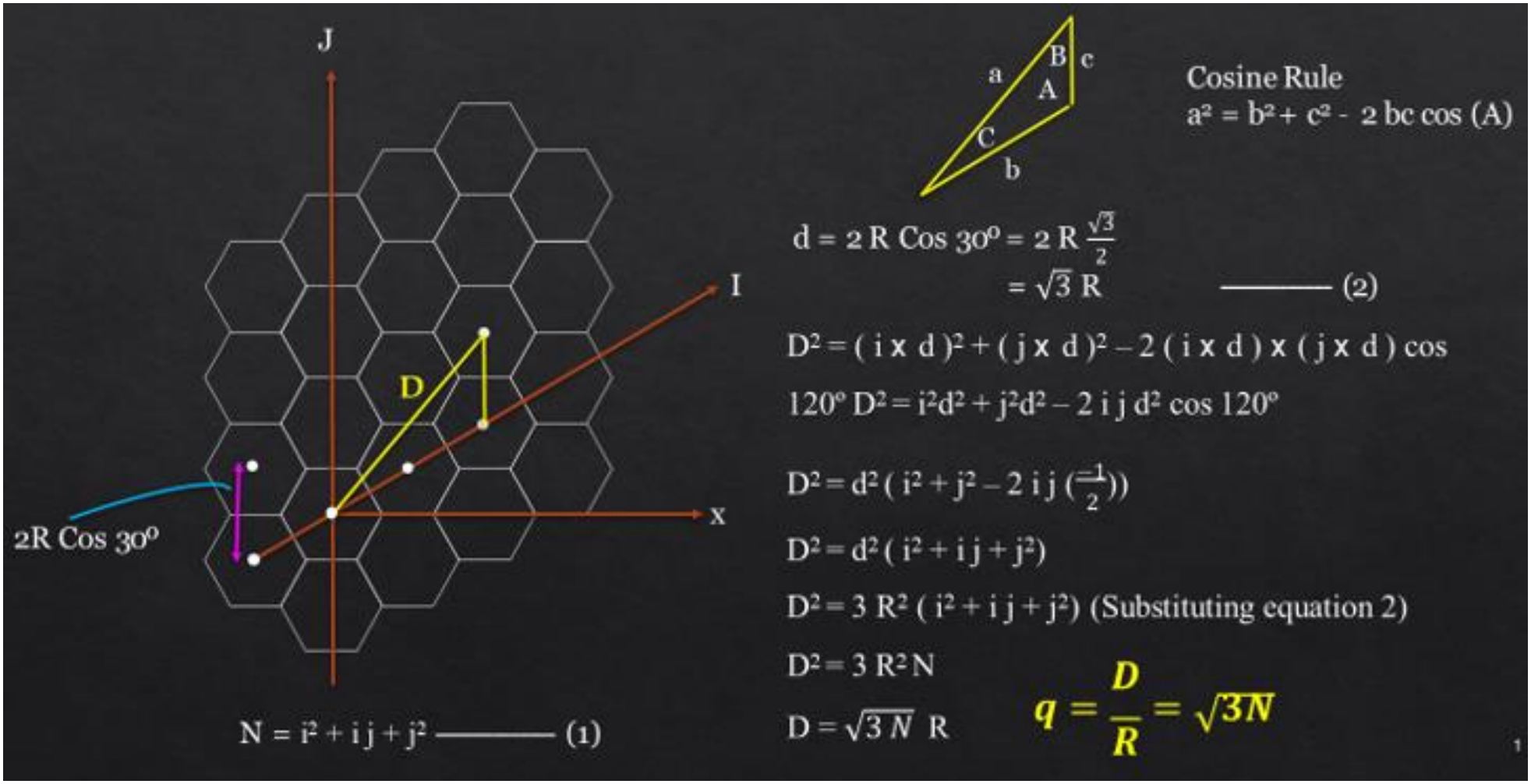


(c) Black cells indicate a frequency reuse for $N = 19$

Frequency Reuse Concept

- If the pattern consists of N cells and each cell is assigned the same number of frequencies, each cell can have K/N frequencies, where K is the total number of frequencies allotted to the system.
- For one first- generation system, $K = 395$, and $N = 7$ is the smallest pattern that can provide sufficient isolation between two uses of the same frequency. This implies that there can be at most $395/7 \approx 57$ frequencies per cell on average.

Proof of Co-channel Frequency Reuse Ratio



Problem 1

If a total of 33 MHz of bandwidth is allocated to a particular FDD cellular telephone system which uses two 25 kHz simplex channels to provide full duplex voice and control channels, compute the number of channels available per cell if a system uses

(a) four-cell reuse,

(b) seven-cell reuse

(c) 12-cell reuse.

If 1 MHz of the allocated spectrum is dedicated to control channels, *determine an equitable distribution of control channels and voice channels in each cell for each of the three systems*.

Problem 1

Solution

- Given: Total bandwidth = 33 MHz
- Channel bandwidth = 25 kHz × 2 simplex channels = 50 kHz/duplex channel
- Total available channels = 33,000/50 = 660 channels
- (a) For N = 4, total number of channels available per cell = 660/4
  ≈ 165 channels.
- (b) For N = 7, total number of channels available per cell = 660/7
  ≈ 95 channels
- (c) For N = 12, total number of channels available per cell = 660/12
  ≈ 55 channels.

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Problem 1

Solution

If 1 MHz of the allocated spectrum is dedicated to control channels, *determine an equitable distribution of control channels and voice channels in each cell for each of the three systems*.

- A 1 MHz spectrum for control channels implies that

Control channels = 1MHZ/50KHz

=1000/50

= 20 channels out of the 660 channels available

Voice channels = Total channels – Control channels

=660-20

= 640 voice channels.

Problem 1

Solution

If 1 MHz of the allocated spectrum is dedicated to control channels, *determine an equitable distribution of control channels and voice channels in each cell for each of the three systems*.

❖ A) Cluster size N=4 cells

- Control channels = 20/4

  = 5 control channels

- Voice channels per cell = 640/4

  = 160 voice channels.

In practice, however, each cell only needs a single control channel (the control channels have a greater reuse distance than the voice channels). Thus, one control channel and 160 voice channels would be assigned to each cell.

Problem 2

Assume a system of **32** cells with a cell radius of **1.6** km, a total frequency bandwidth that supports **336** traffic channels, and a reuse factor of **N = 7.** what geographic area is covered, how many channels are there per cell, and what is the total number of concurrent calls that can be handled?

Solution

The area of a hexagon of radius R is

$$Area_a = \frac{3\sqrt{3}}{2} R^2 = \frac{3\sqrt{3}}{2} (1.6)^2 = 6.65\,\text{km}^2$$

The total area covered is $6.65 \times 32 = 213\ \text{km}^2$.

Problem 2

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Solution

For $N = 7$, the number of channels per cell is $K/N = 336/7 = 48$,

Total number of concurrent calls that can be handled is

$$Capacity = 48 \times 32 = 1536 \text{ channels}$$