**Project Name:** Frequency Channel Allocation to GSM network simulator.

**Team members:** Mohammed Yasser Bendebache
Dana Hassnein
Gohar Kunjiyan
Shivam Kavathe

**Guidance:** Prof. Mohamed Hakim MABED
Prof. Oumaya Baala CANALDA

## Abstract:

In a GSM network every antenna can have multiple frequency channels, which can range from 1 to 6. While assigning frequency channels to the antennas in the network, there are multiple factors that need to be considered in order to have an optimised solution. Major problem in this project is being addressed is Interference. Which can be occurred by following parameters:

1) Distance between transmitters
2) Geographical position
3) Power of the signals
4) Direction in which signals are transmitted
5) Weather conditions
6) Assigned frequencies
7) Co-channel interference
8) Adjacent-channel interference

Considering all parameters above excluding weather conditions, Simulator assigns the frequencies to the antennas provided as inputs to the simulator.

## Summary of the Project:

In the GSM network. There are a number of transmitters placed as per availability of area. Each transmitter is transmitting the electromagnetic oscillation of a certain frequency over the area covered by it. If electromagnetic oscillations of the same or higher powered adjacent frequencies collid , the level of noise increases significantly. Due to this effect quality of communication decreases in certain areas.

The Major parameters need to be consider while assigning frequencies are:

1) Distance between transmitters:
   The Distance between transmitters should be kept as far as possible, while adjacent frequencies or same frequencies are being used on those antennas. If two or more antennas are using the same or adjacent frequencies and their coverage area overlaps the interference will be higher, which will increase signal to noise ratio significantly for communication with Mobile stations in the area of overlap.

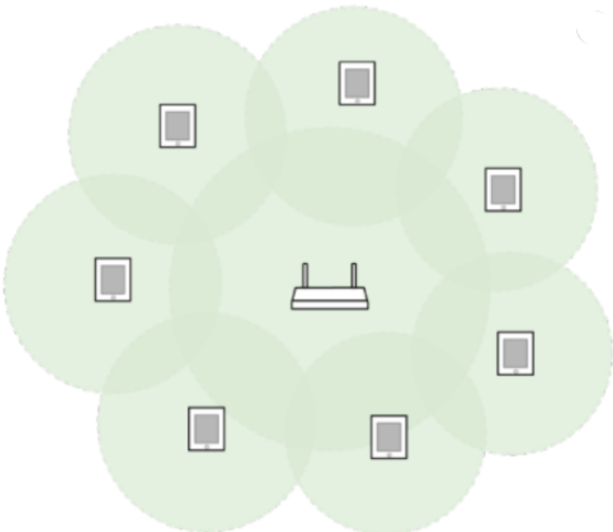
2) Geographical position:
It is not possible to place the Transmitter as per convenience. There are major placing constraints because of city planning and availability zones. Due to that, one has to choose the transmitter locations as per availability and assign frequencies using certain algorithms. So choose location as per available , In this project Geographical Map is provided.

3) Power of the signals:
The more power provided to a certain frequency, it will cover more area. If the power of adjacent frequencies and co channel frequencies are more it will increase the noise. In this project, the radius of the transmitter is directly proportional to the power.

4) Direction in which signals are transmitted:
Direction of the antennas are mostly 360 degrees. In this project , there is only one possibility to set up a transmitter with an omni directional antenna. So, Coverage area will be 360 degrees.

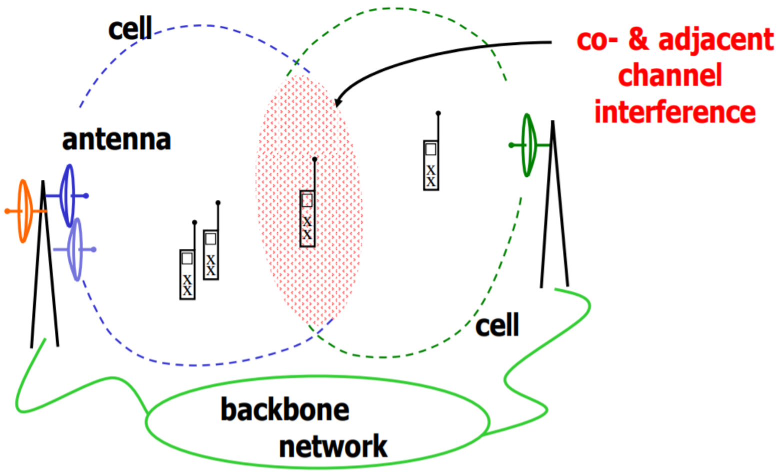
5) Assigned frequencies:
The major controllable aspect of this project is strategically assigning frequency in order to achieve minimum interference between any pair of antennas. The frequencies available in the whole network are limited to the carrier company. The quality of communication depends on the frequencies assigned to all antennas over the whole network of the same carrier.

6) Co-channel interference:
This Interference takes place when in some area two or more transmitters using the same frequency channel.



Co-channel interference is not actually an interference but more a sort of congestion. It hinders the performance by increasing the wait time as the same channel is used by different devices. The CCI forces other devices to defer transmissions and wait in a queue until the first device finishes using the transmission line and the channel is free.

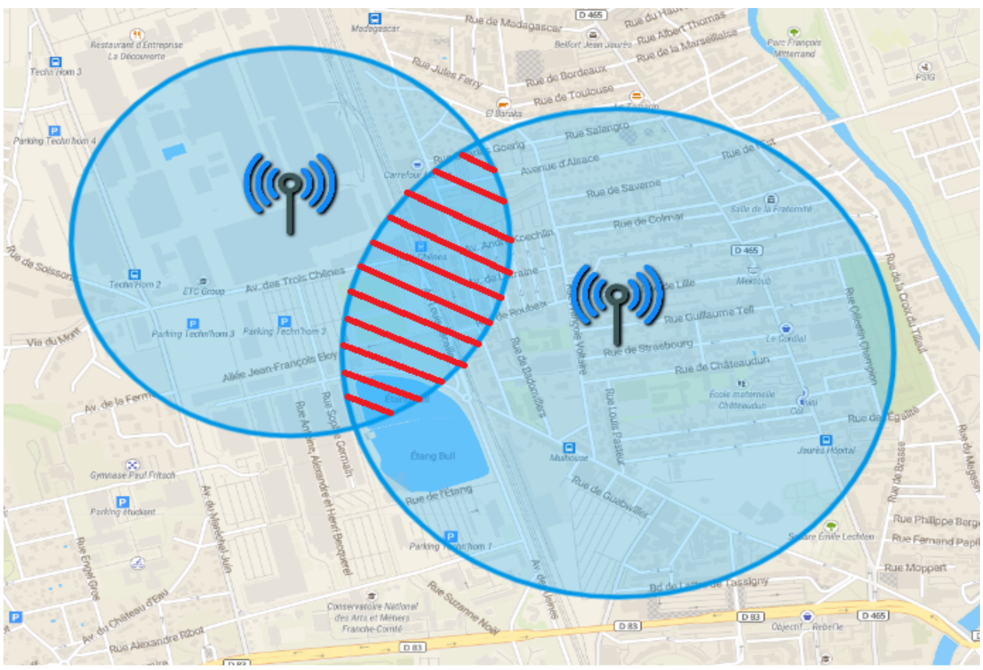
7) Adjacent-channel interference:
Signals which are adjacent in frequency to the desired signal cause adjacent channel interference. It is due to higher power in the adjacent frequencies.



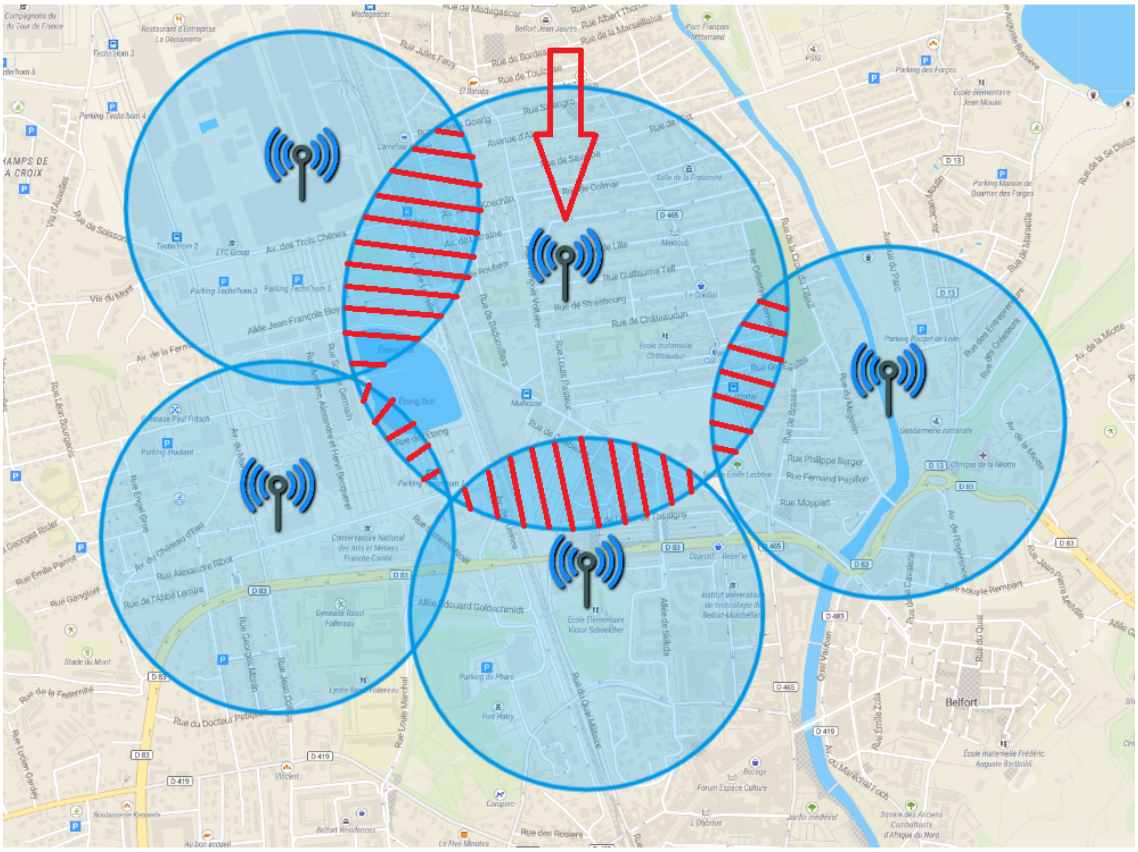

## Algorithm:

To minimise the interference, this project proposes an algorithm. Which is as follows:

1) **Step 1:** Find which antennas' coverage zones are overlapping each other. Make an overlapped Matrix.

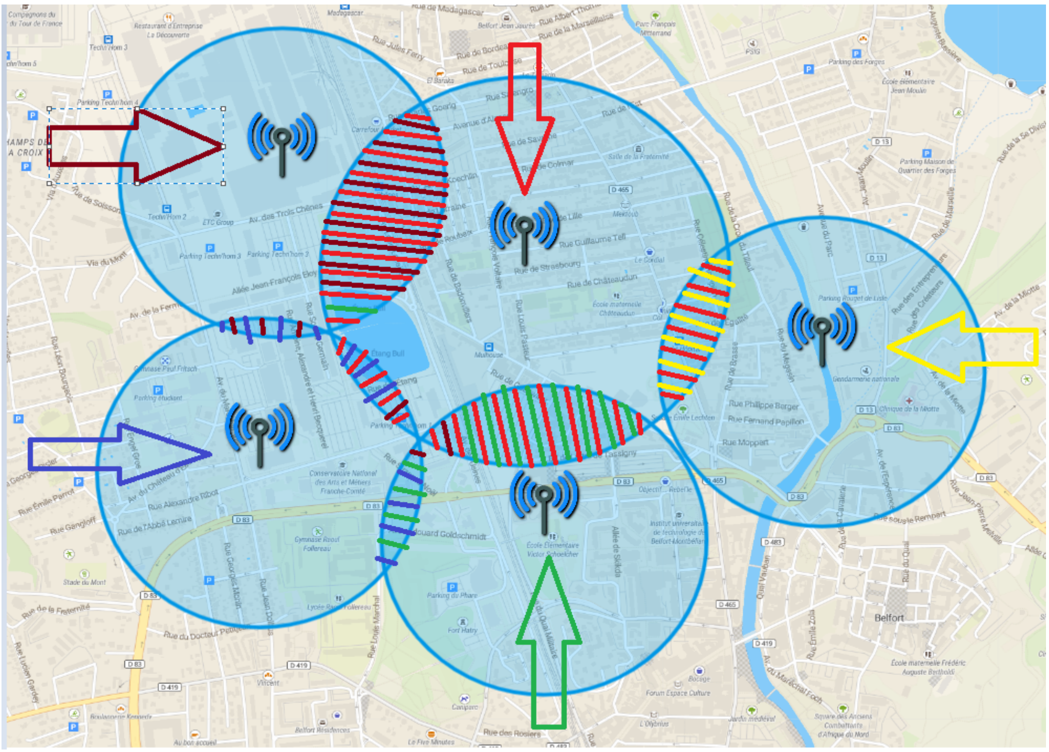


2) **Step 2:** Calculate the overlapped area of every antenna zone to any other antenna and store it in Matrix. Calculate the total area of each antenna which is overlapping on any other antenna. Store the total overlapped area of every antenna in the array sequentially.



In the following figure the total area overlapped indicated by the red strips for only 1 antenna.

3) **Step 3:** Make the Descending order of the antennas by the total overlapped area.



In this figure above , every antenna has an overlapping area indicated by different colours. Summation of the same coloured area will give a coefficient for the corresponding antenna.with this coefficient , new sequence is obtained.

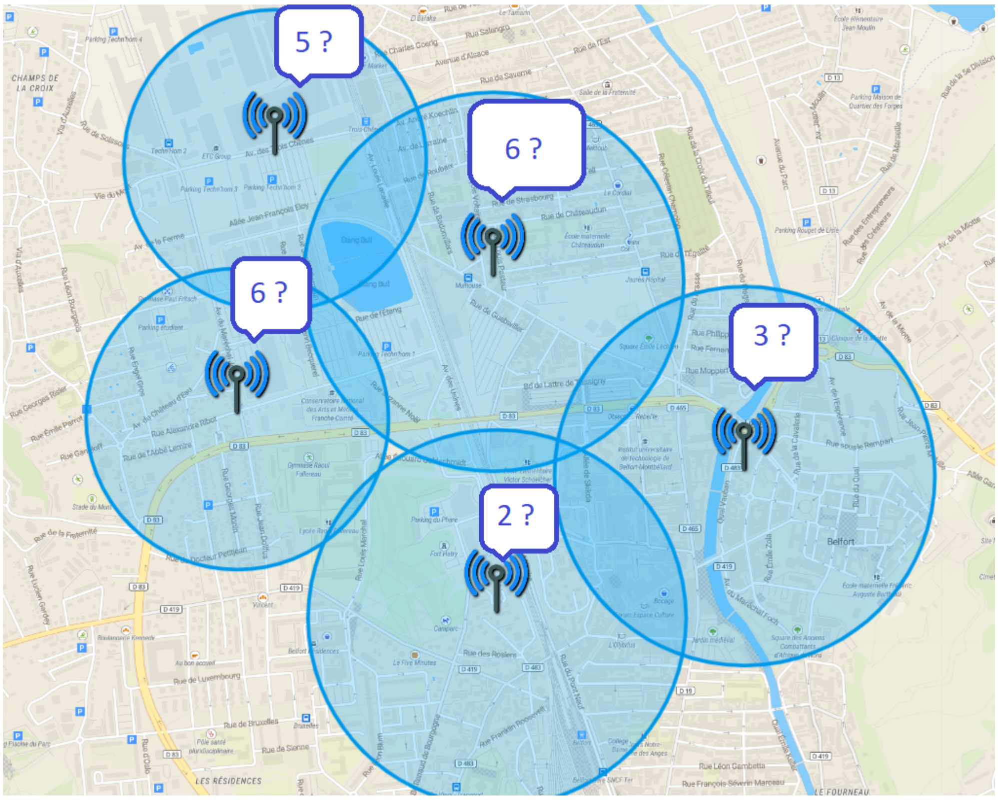
Now, It has a new sequence of the antennas. Old sequence of antennas depends on the input applied on the simulator. New sequence depends on the antennas which have more overlapped areas.

4) **Step 4:** Check the total number of frequencies available for the whole network.

5) **Step 5:** Make the sequence of the frequencies with a gap of 3 frequencies. E.g.- (f1,f4,f7) or (f42,f45,f48). When the sequence reaches to the end it starts from 1st frequency again with the same gap of 3 frequencies. E.g.: (if total frequencies are 60) - (f58,f1,f4) or (f59,f2,f5)

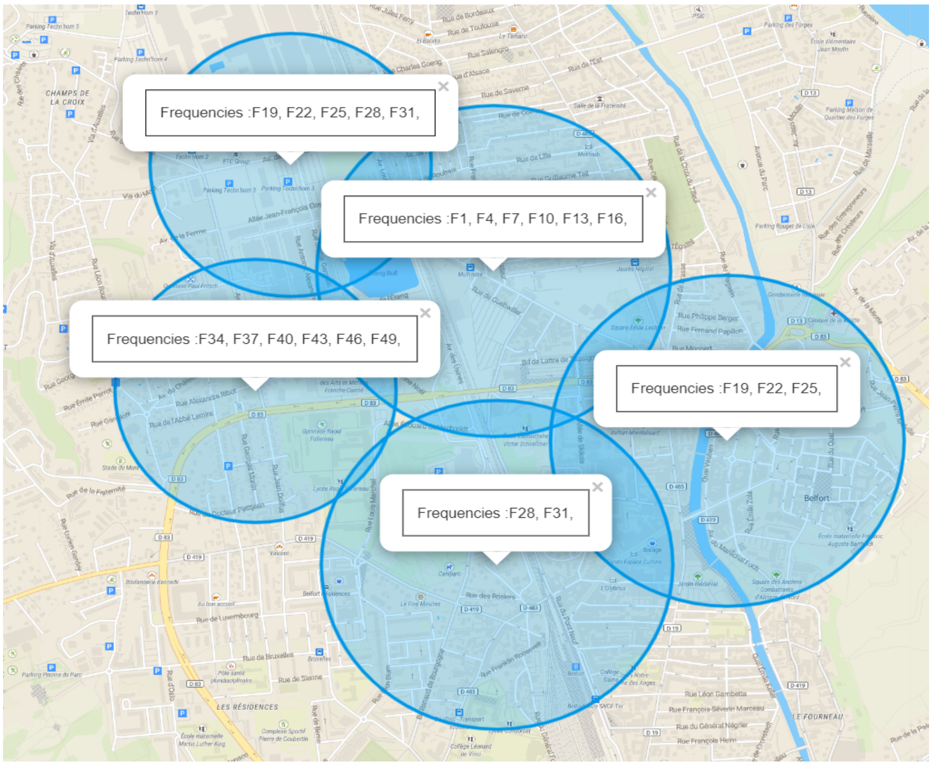
6) **Step 6:** Apply a greedy colouring algorithm for assigning frequencies as per requirement of each antenna.

   For Greedy colouring algorithm,use a new sequence of antennas to colour. As per colouring algorithm every adjacent vertex should have a different colour. In this case every adjacent antenna will have a different sequence of frequencies.




In this figure the 1st antenna in the list asks for 6 frequencies, So first 6 frequencies in a list will be assigned to it. And furthermore the next antenna in the list will ask for a specific number of frequencies and so on.

7) **Step 7:** Find the number of frequencies required for each antenna in a new sequence of antenna. And assign as per requirement.



As can be seen in the figure, the same frequency series is not being used in adjacent antennas which are overlapping areas.

With this approach, no adjecticent antenna will have frequencies near to each other. And each antenna will have a sequence of frequencies with at least a gap of 3 frequencies. Which is considered to be having 0 interference. So interference will be negligible.

8) **Step 8:** Calculate the interference between each antenna pair which has coverage overlap area.

From previous studies, this equation can be used to calculate the interference:

$$INT(f_i, d_i/f_j, d_j) = \frac{1}{\Delta d + \epsilon} \times \frac{1}{\Delta f + \varepsilon}$$

Where,
i and j = any pair of antennas
$fi$ and $fj$ = List of frequencies assigned.
$\Delta\, d$ = Distance between two antennas
$\Delta f$ = Distance between each frequency pair between two antennas
ε = bias number to not let denominator become zero

But, with this equation The distance between two antennas are being considered. As per our algorithm distance between antenna pairs is a negligible factor in order to assign the frequencies. Because some antenna covers more area than another, The better solution will be to use the coverage overlapped area of the antenna.

This project introduces a new equation that will consider the factors which affect the interference.

$$INT(f_i, C_i/f_j, C_j) = \frac{C}{\Delta f + \varepsilon}$$

i and j = any pair of antennas
$fi$ and $fj$ = List of frequencies assigned.
$\Delta\, d$ = Distance between two antennas
C = Coefficient, coverage area overlapped.
ε = bias number to not let denominator become zero

## Conclusion:

As per our observation and analysis, we can say that the algorithm proposed works  very efficiently in order to minimise the interference. In this solution the best possible compromise has been introduced for complex situations like more than 10 antenna areas' are overlapped on every other antenna. Even in this kind of situation, algorithm performs well and provide the best possible outcome. Even calculation of the interference is also more realistic than previously proposed by the other researchers.