Mini-Project for EG7023 Radio Communications

Student: Yan Fei

Tutor: Dr. David Siddle

I declare that this assignment is my own work, that sources of reference are acknowledged and that it has not been submitted for any other course. I understand that plagiarism is a serious offence under the University’s regulations and that appropriate penalties will be applied if I am found to have submitted plagiarism work.

# Design of the Mobile Telephone System

## Requirement for the Mobile Telephone System in Rome

1. Estimation of traffic. We have a license for up to 600 channels.
2. The blocking factor should be no more than 2%.
3. Co-channel interference should be considered.
4. We assume that in order for the mobile unit to receive a call the signal power should be higher than -85dBm.
5. We should investigate the effect of signal fading in the above calculation.
6. The height of mobile units may be taken as 1.5m.
7. The frequency of transmission is 1.8GHz.
8. We should minimise the base station power.
9. No base station antenna can be placed more than 4m above the skyline.
10. We just are responsible for a subarea with sides of between 1.5 and 2km.

## Preparation for the Mobile Telephone System

After knowing the requirement for the system, firstly, we should consider the population and population density in Rome in order to provide the good service that keeps all the clients can use the system as well as possible.

Through some investigation, we find the population condition in Rome for 2006 on the website:

http://www.citymayors.com/statistics/largest-cities-density-125.html

**Largest cities in the world ranked by population density**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Rank** | **City / Urban area** | **Country** | **Population** | **Land area (in sqKm)** | **Density (people per sqKm)** |
| 77 | **Goiania** | Brazil | 1,475,000 | 479 | **3,100** |
| 78 | **Munich** | Germany | 1,600,000 | 518 | **3,100** |
| 79 | **Stuttgart** | Germany | 1,250,000 | 414 | **3,000** |
| 80 | **Dublin** | Ireland | 1,075,000 | 365 | **2,950** |
| 81 | **Kuwait** | Kuwait | 1,600,000 | 544 | **2,950** |
| 82 | **Nizhni Novgorod** | Russia | 1,500,000 | 505 | **2,950** |
| 83 | **Rome** | Italy | 2,500,000 | 842 | **2,950** |
| 84 | **Phnom Phen** | Cambodia | 1,500,000 | 518 | **2,900** |
| 85 | **Beirut** | Lebanon | 1,800,000 | 648 | **2,800** |
| 86 | **Brasilia** | Brazil | 1,625,000 | 583 | **2,800** |
| 87 | **Essen/Düsseldorf** | Germany | 7,350,000 | 2,642 | **2,800** |

Comparing with the data from other database, we think the population density 2950p/km2 in Rome is the reasonable one. So we use this as the population density for the further calculation of the Mobile Telephone System.

In this system, I want to use the seven-cell cluster which can be described as the graph below:



The reason I use this frequency reuse-pattern is that for the fixed number of channels, population density and area, the size of the cell and the available channels in the cell is the most reasonable choice for the system. The 12-cell cluster which could reduce the co-channel interference (20.7dB) will reduce the available channels in each cell and the size of the cell. It means that we will need more base station in the area. That will increase our cost for the system.

## Calculation for the Mobile Telephone System

The last thing we should do before implementing the system is that we should calculate the size of the cell through the preparations above.

From the Erlang B values table the offered traffic with 85 available channels (cell) for a blocking probability of 0.02 is

The carried traffic is

We assume that the each user makes an average of 3 calls/hour, each call lasts an average of 3 minutes. So the traffic intensity by each user is

Therefore, the maximum number of users that can be supported by this cell is:

Because the population density is about 3000p/km2, the cell size will be



So the radius is



The distance between two cells is

## Distribution of the Antennas

I choose the region (51420<x<51600, 5033800<y<5035800) as the area where I should allocate the antennas in.

Firstly, I allocate the antennas and channels as following graph:



We can see that there are 20 antennas in this area which use 7-cell cluster frequency reuse pattern.

After this, I set the first antenna with the location(x=514465.52, y=5035398.64) and carrier as 0.Then I can calculate all the locations of other antennas and carriers. The data is as below:

|  |  |  |  |
| --- | --- | --- | --- |
| Antenna | X | Y | Carrier |
| A1 | 514465.52 | 5035398.64 | 0 |
| A2 | 514465.52 | 5035007.74 | 3 |
| A3 | 514465.52 | 5034616.84 | 5 |
| A4 | 514803.04 | 5035593.87 | 1 |
| A5 | 514803.04 | 5035203.07 | 2 |
| A6 | 514803.04 | 5034812.17 | 6 |
| A7 | 514803.04 | 5034421.27 | 0 |
| A8 | 514803.04 | 5034030.37 | 3 |
| A9 | 515142.62 | 5035398.64 | 5 |
| A10 | 515142.62 | 5035008.54 | 4 |
| A11 | 515142.64 | 5034618.44 | 1 |
| A12 | 515142.64 | 5034227.54 | 2 |
| A13 | 515480.14 | 5035593.94 | 6 |
| A14 | 515480.14 | 5035203.04 | 0 |
| A15 | 515480.14 | 5034812.14 | 3 |
| A16 | 515480.14 | 5034421.24 | 5 |
| A17 | 515480.14 | 5034030.34 | 4 |
| A18 | 515819.72 | 5035398.64 | 1 |
| A19 | 515819.72 | 5035007.74 | 2 |
| A20 | 515819.72 | 5034616.84 | 5 |

Hereto, we have finished the calculation for the mobile telephone system. Then we will use winprop software to test this system we design.

# Implement for the Mobile Telephone System

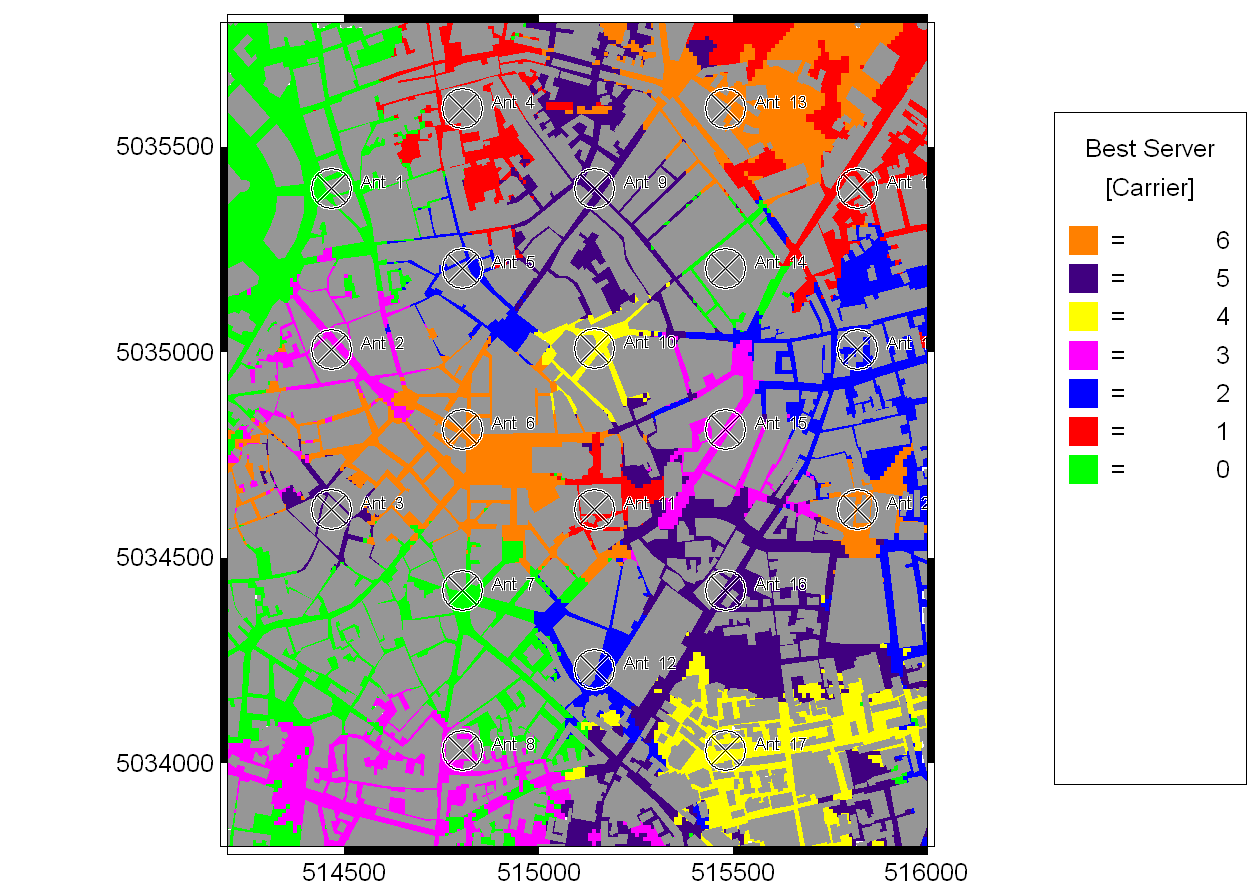
## The Mobile Telephone System for Original Design

### Setting Parameters

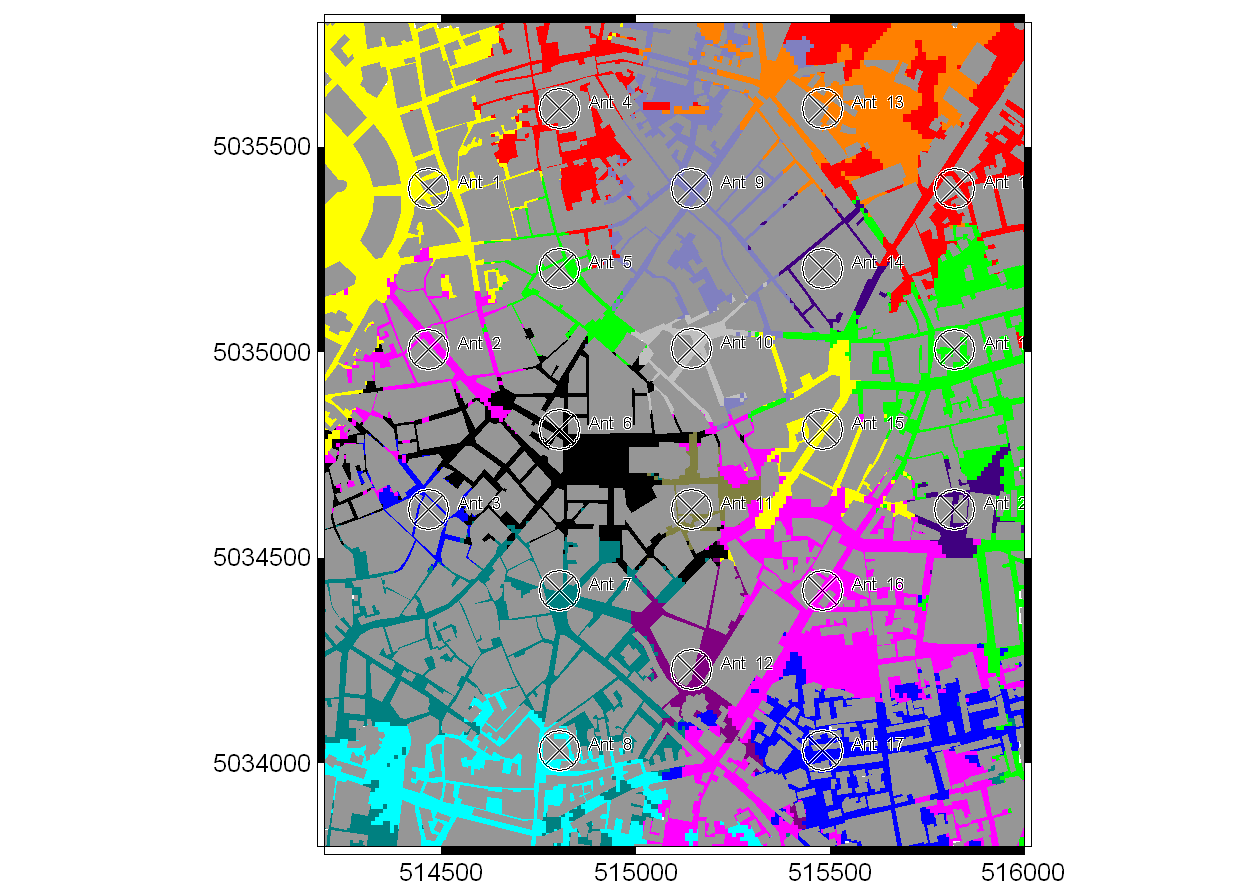
In the winprop, we use the default antenna power 10w. The prediction height is 1.5m and frequency is 1800MHz. All the heights of the antennas are set up as the tallest buildings nearby with 4m high. Because in this step, we just set all the parameter as the data we calculate above, there may be something unsuitable, and we will improve it later.

### Analysing Results

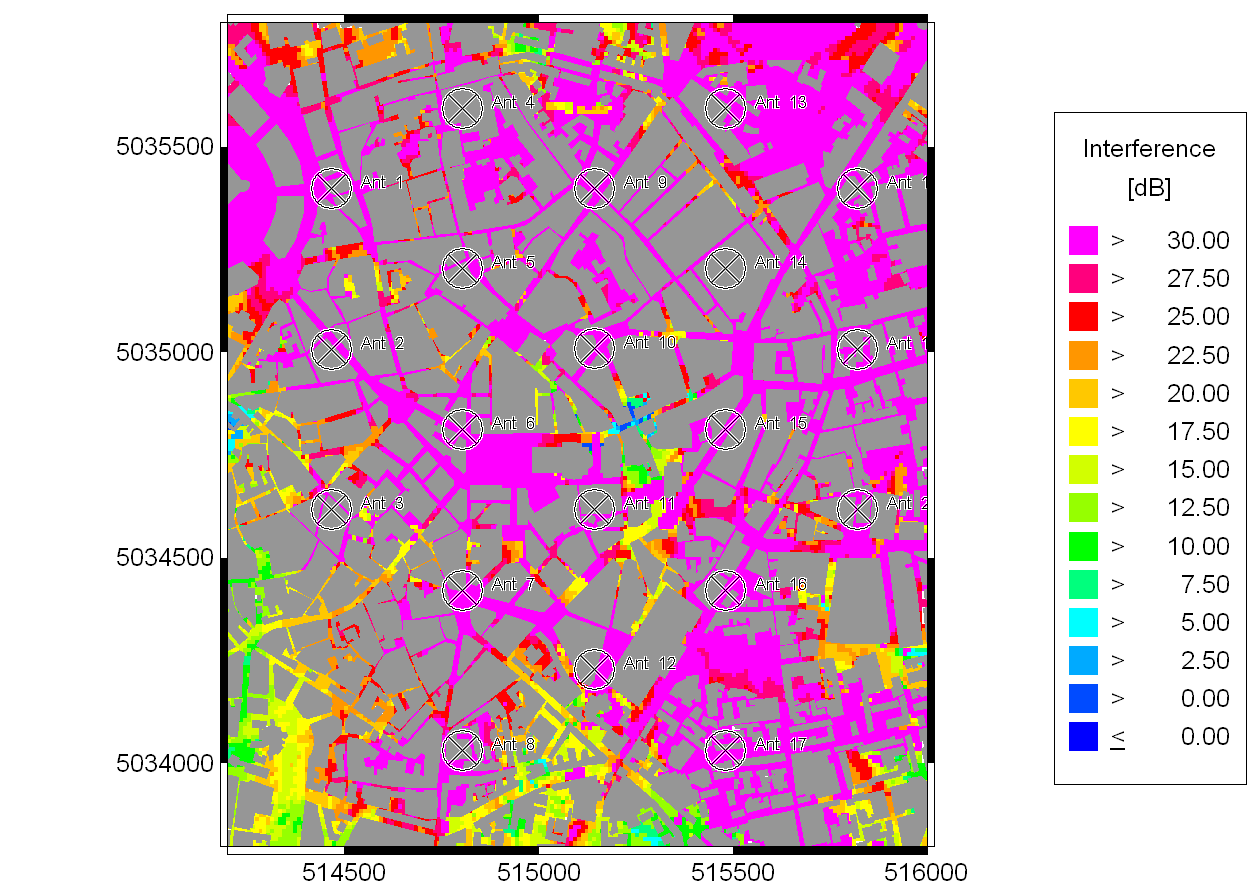
Through the propagation project, we calculate the data from each of the 20 antennas and put the data into the network project. Then we get the output result of Best Server, Cell Area, CoChannel Interference, Maximum Power and Nr Received Channels from the original design.



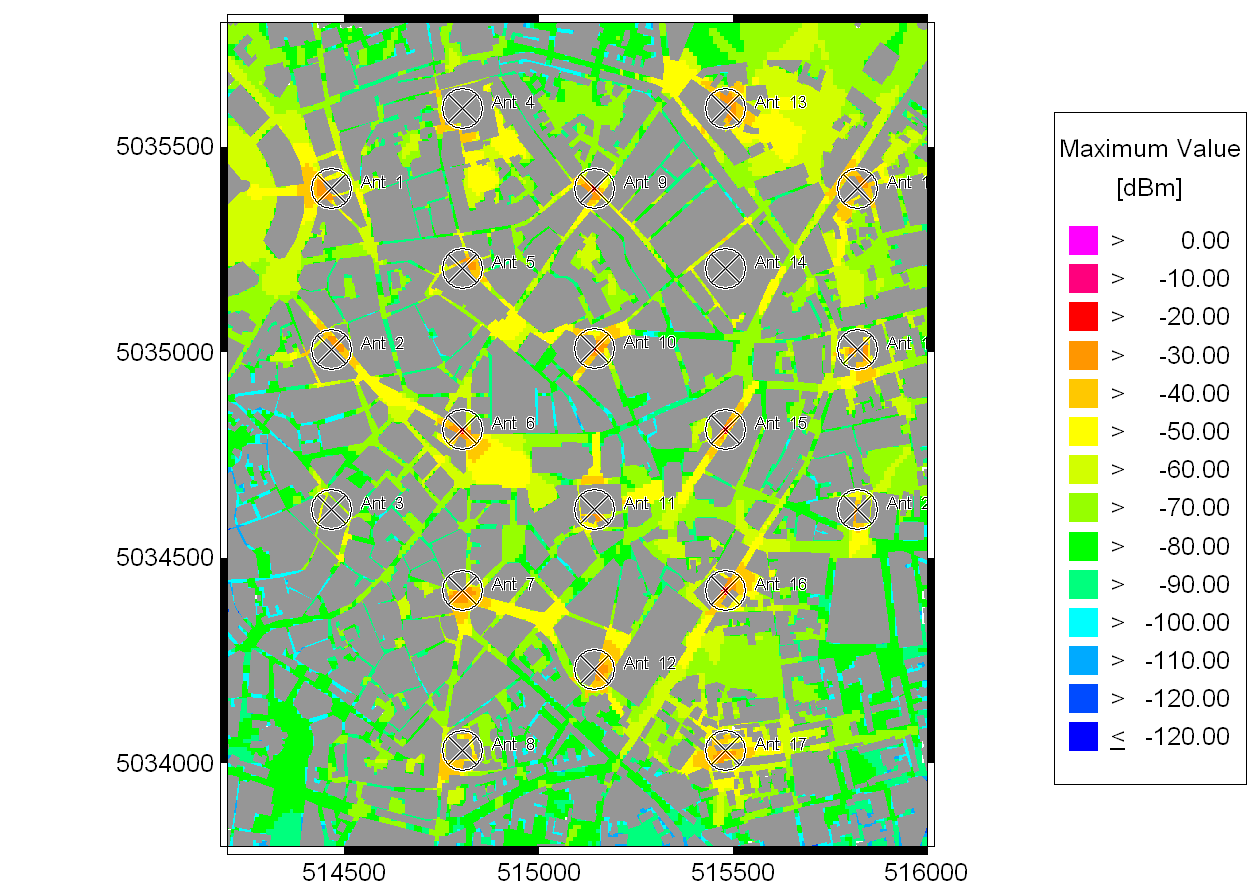
We can see that the best carrier for each pixel in the graph is almost as the carrier of the closest antenna. The areas with same carriers are separated by the areas which use different carriers. That will reduce the co-channel interference.



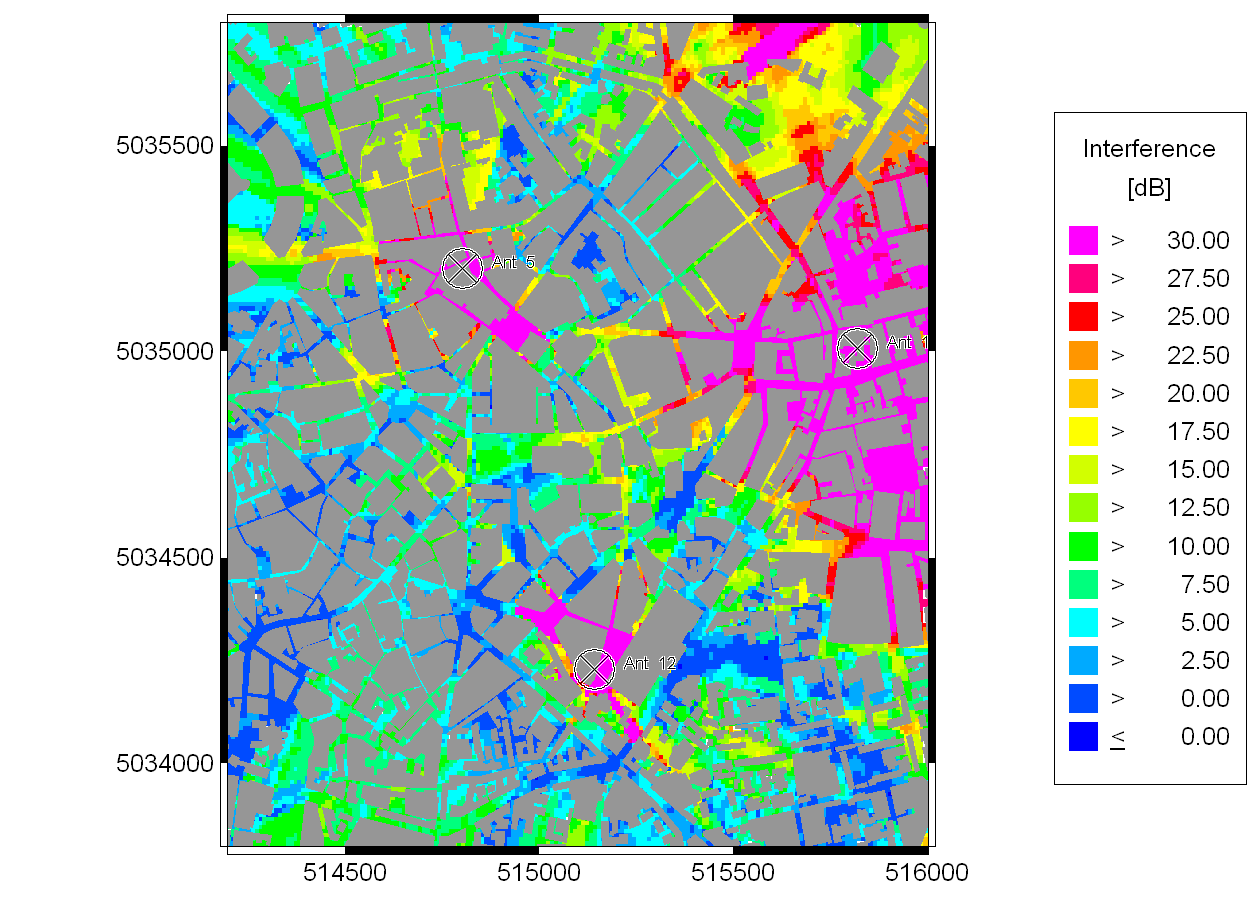
This is the cell area graph which indicates coverage of each cell. This picture is similar to the best server graph. We can see that each cell cover different areas with different sizes.



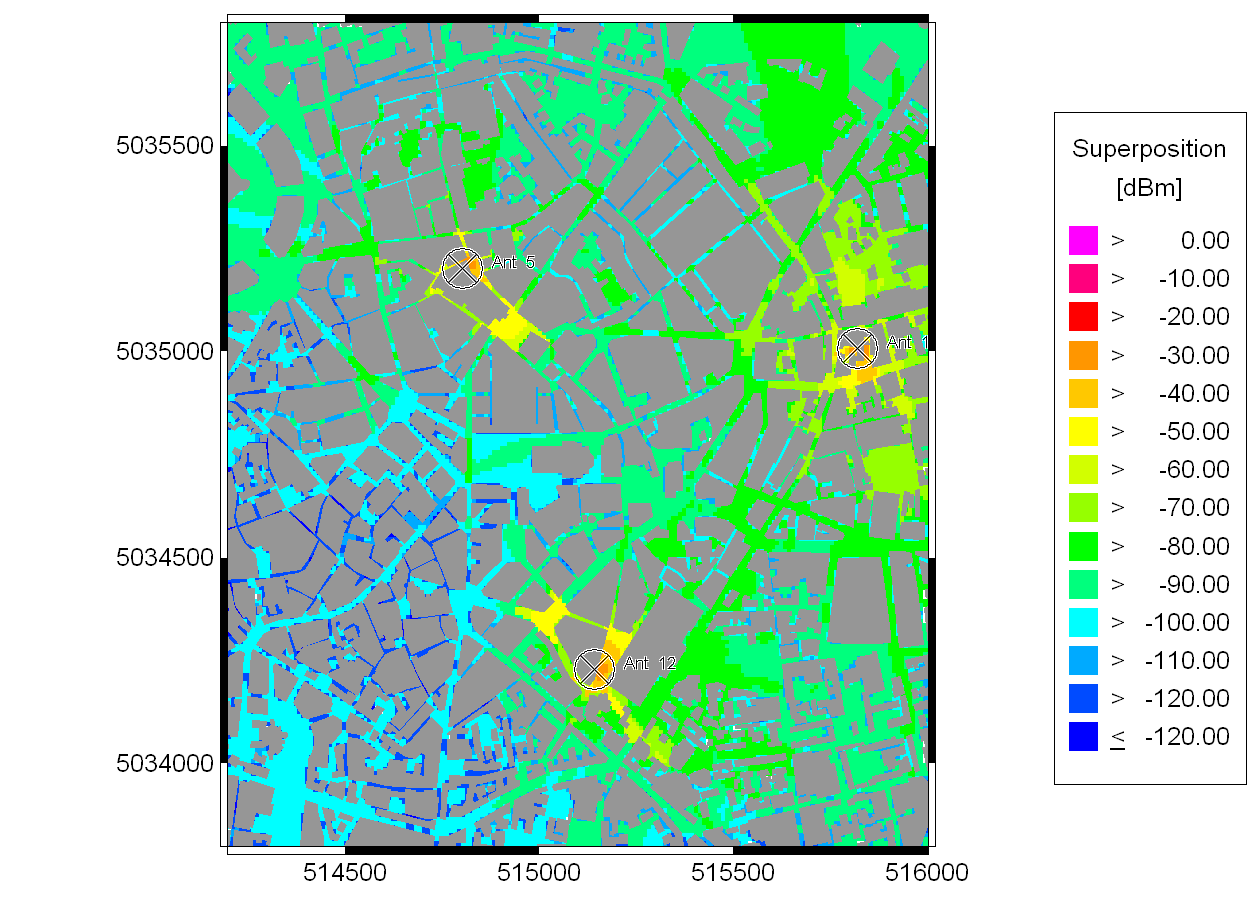
This is the output data of co-channel interference. From the figure above, we can see that the interference of every location is almost above the threshold and most of them overpass 30dB. There just a small area in the centre of the graph with serious interference. So we will improve it later.

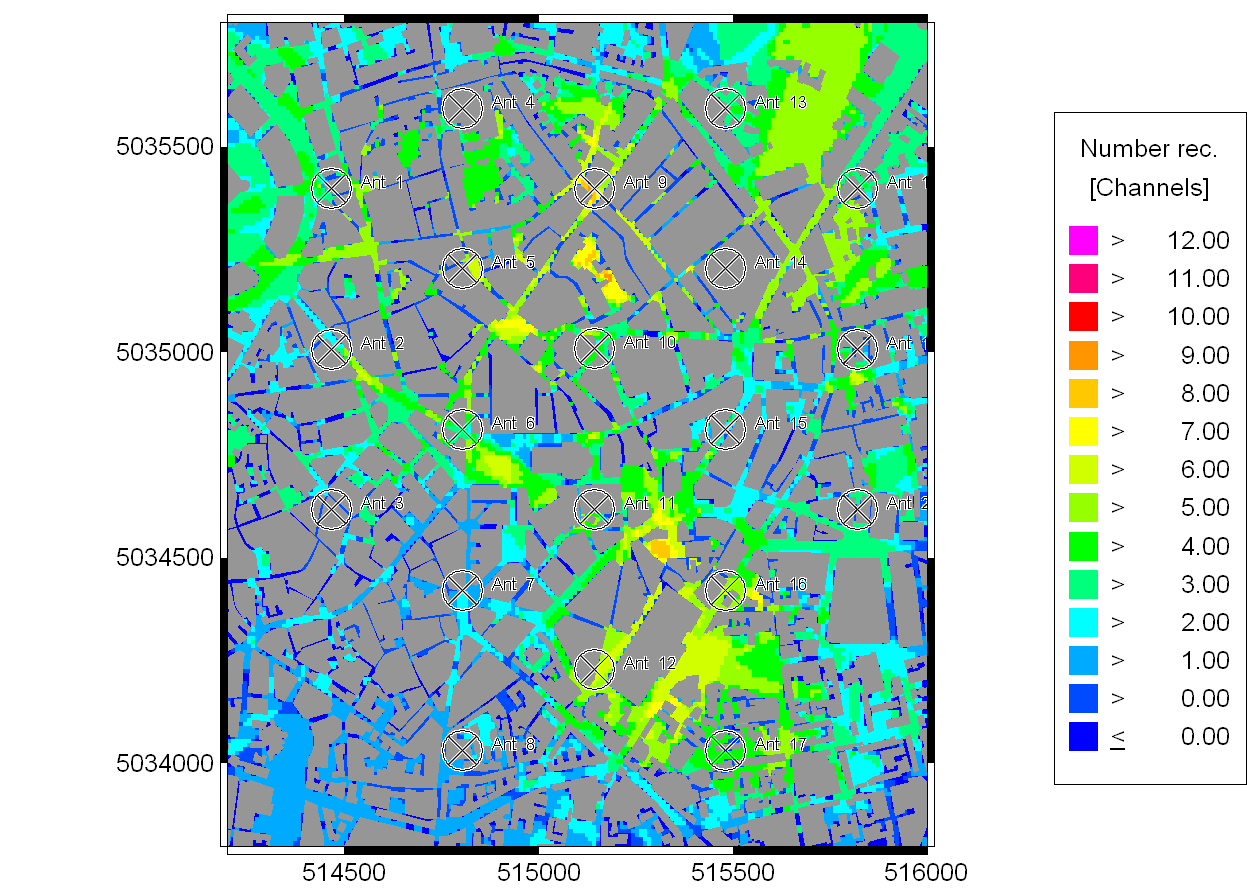


From this figure, we can see that the signal power in most area is bigger than the -85dB.It means that the clients can get the signal and make a call in most area within this region. So the power 10w we use in antennas is enough for this system.

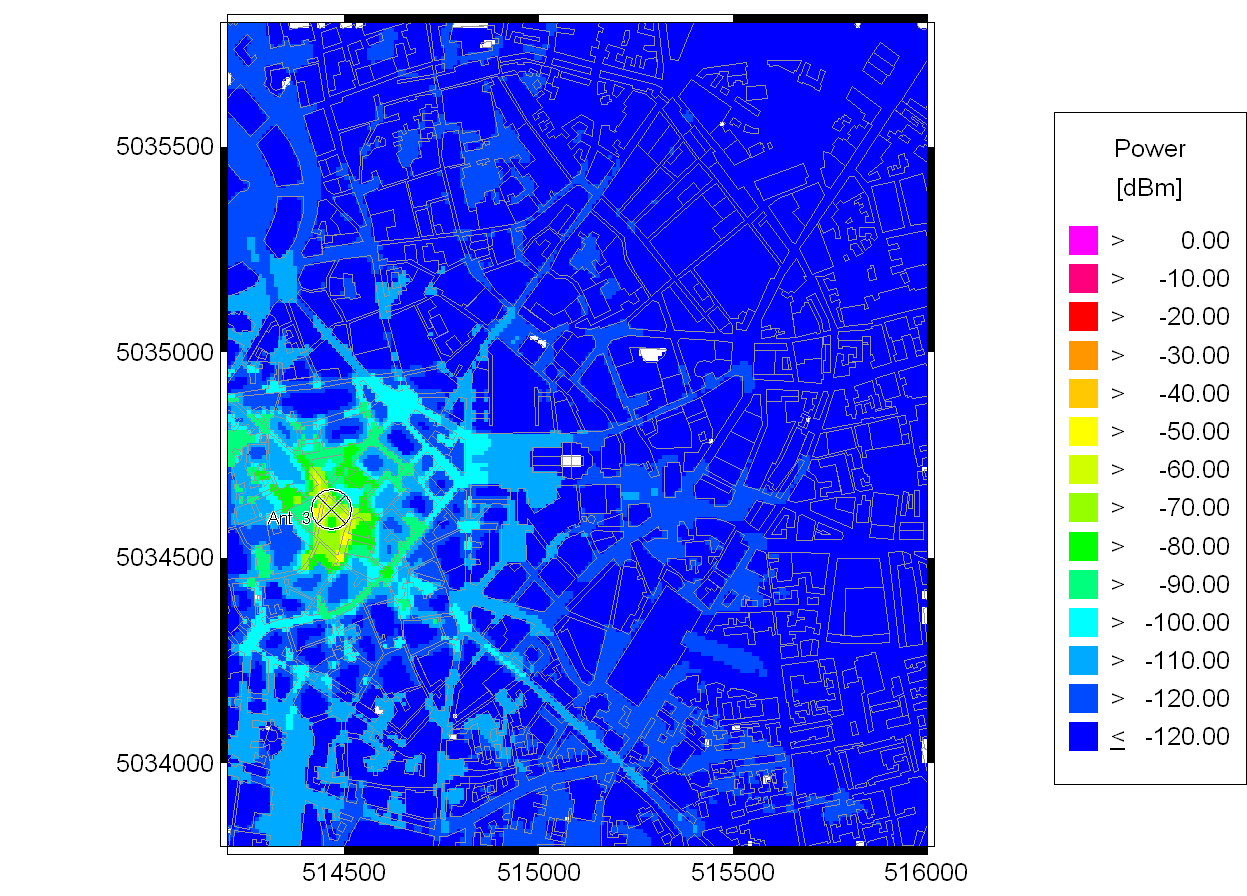


The picture shows that the co-channel interference of same carrier (2) with antenna 5, 12 and 19. We can see that the interference condition is much good due to the 7-sell cluster for frequency reuse pattern.

 This figure illustrates the power distributions for the antenna 5, 12 and 19. We can see that the power condition is good under these antennas with the carrier 2.



This figure shows that how many channels are available in each pixel. We have set the threshold as -85dB. We can see that there are some areas can receive more than one channel. That means the signal power with different carriers from different antennas is higher in these regions. So clients in these areas will have more channels to choose. For instance, if the signal quality is decreased by people’s move, the system can switch the client to use other channels which have better signal quality. This will avoid the disconnection of the call. There also some areas which cannot get channels at all, but these areas are not too large and we can improve it by some methods which we will do later. Some specific areas which still cannot get the channels could be neglected.



This is the picture showing the power distribution of the antenna 3, which we want to use to compare the power condition between outdoor and indoor. We can see that the areas closer to the antenna have good power condition and the outdoor power is 30-50dB higher than indoor’s.

### Conclusion

Through the result above, we can see the system we design is fairly good for use. However, we can see that there are some areas which can not fit for the situation for mobile communications. Thus, we will try to improve the system by adding more antennas, moving the location of the antenna, increasing the height of the antenna to increase the signal power and reduce the co-channel interference.

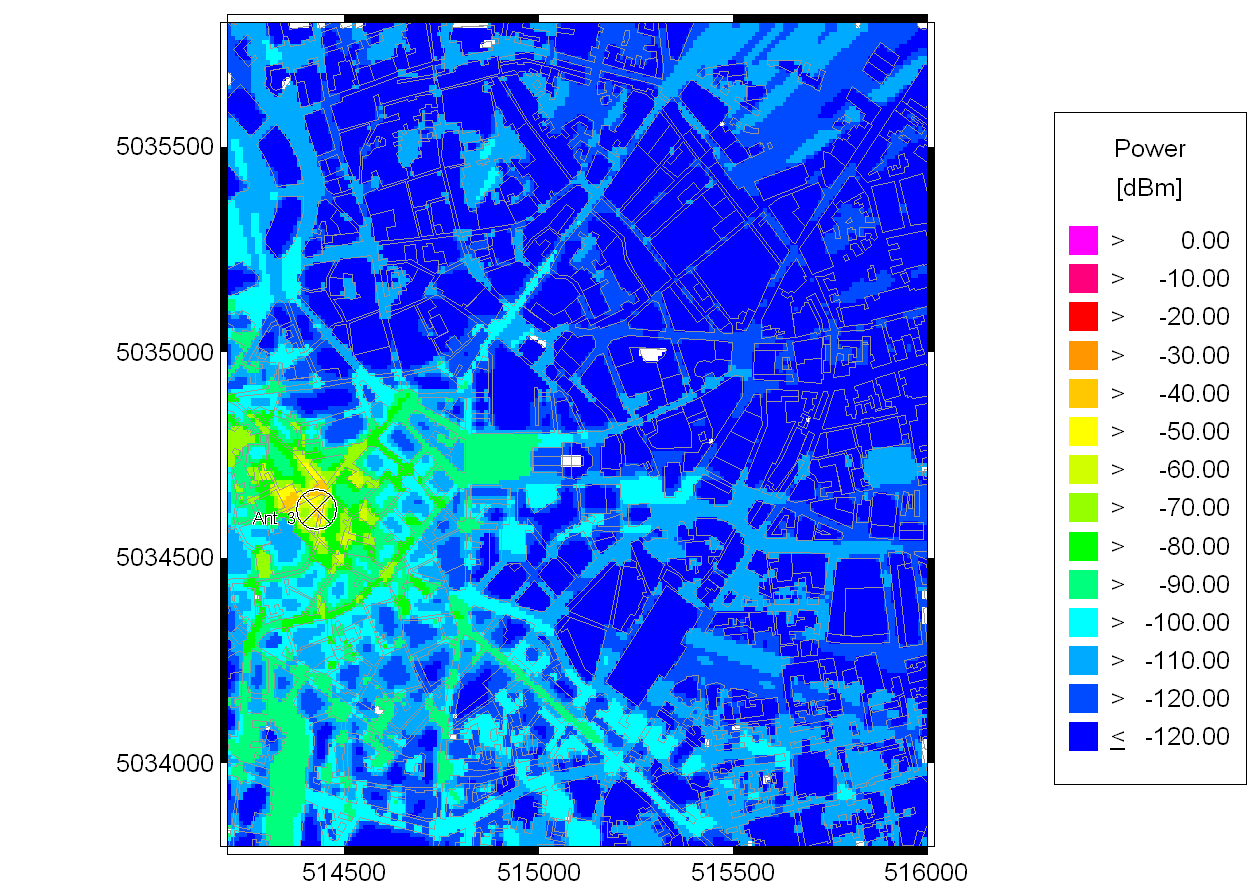
## Improving the Signal Power by Changing the Location and Height of Antenna

### Setting Parameters

In this improving procedure, we try to improve signal power distribution by moving the antenna and increasing the height of the antenna.

I find the power distribution of antenna 3 is not good, so I move the antenna 3 to the location (x=514426.71, y=5034616.55) and increase the height of it from 16m to 24m.

### Analysing Results



This is the graph showing the power distribution of antenna, which is better than that before.

## 