# Cellular Mobile Network Operator Simulator

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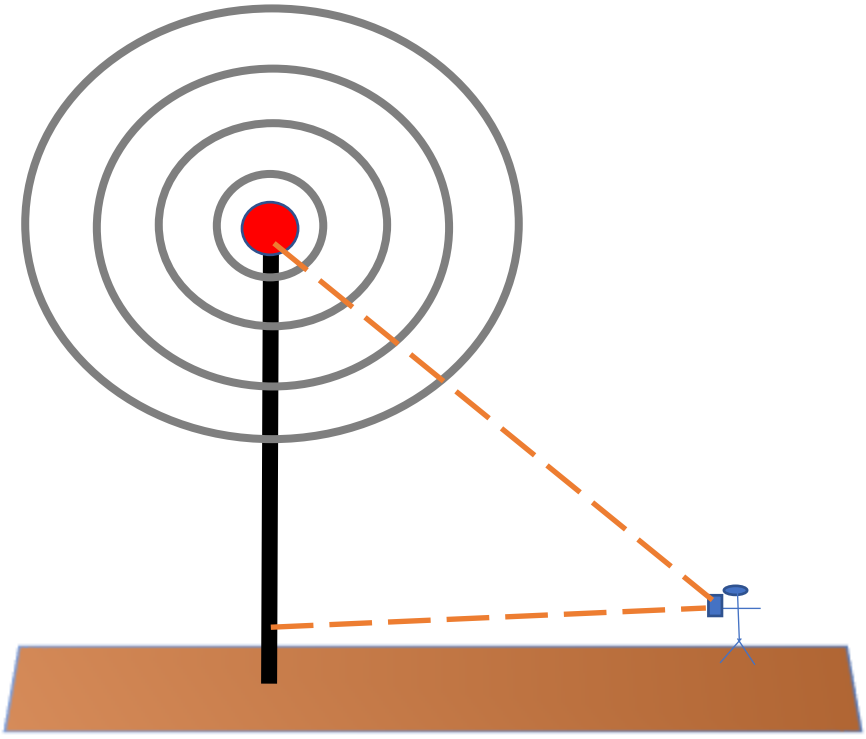
## 1. Background

To call someone with a mobile phone, the user needs to dial the number and press the call button. Then the user's phone send out the signal to the 1st base station, and the 1st base station forwards the signal to other base stations. Eventually, at the last base station, the antenna of the base station forwards the signal to the call receiver's phone. One of the key factors of the caller's user experience is the signal power received at the receiver's phone. The higher the received power, the better the call quality. We focus on the last base station to receiver's phone problem but simplify it to suit our course as follows:



The antenna at the base station is assumed to be isotropic and has power 1 [unit Watt]. We consider the signal traveling in 3D surface and the cell tower is 21 meters above the ground. The user holds the phone in the hand at roughly 1 meter above the ground. The minimum power the mobile phone can identify the signal is $10^{-5}$ [unit Watt], there will be no service if the received power is lower than $10^{-5}$ [unit Watt]. When the received power is above $10^{-4}$ [unit Watt], the service quality is high. Low service quality is achieved when the received signal power is between $10^{-4}$ and $10^{-5}$ [unit Watt]. The user always connect to the base station that provides the best quality.

## 2. Scenario

### (Scenario A)

You manage a circular area with a radius of 300 meters. The center of the circular area is at the origin (0,0). There are 9 base stations in the area, the coordinates of the base stations are: (0,0), (0,150), (0,-150), (150,0), (-150,0), (106,106), (-106,-106), (-106,106), (106,-106).

Answer the following questions:

1. Does these 9 base stations cover the entire area?
2. Visualize the coverage condition.

If I would like to start from (0,0) and walk to the boundary of the circular area in the closed 1st quadrant along a radius line:

3. Does a path without full coverage exist? Give an example.
4. Does a path with full coverage exist? Give an example, mention the sequence of base stations the phone connects to.

If I walk along the x axis at a speed of 90 meters per minute from (-300,0) to (0,300),

5. Calculate/simulate the time of coverage and disconnected time. During coverage, list the coverage time with a table for each base station the phone connects to.
6. *(Only for exploratory bonus)* Create an animation with matplotlib to demonstrate the process.

### (Scenario B – Only for exploratory bonus)

You manage a 200 * 200 square area.

Answer the following questions:

1. Design a strategy to place the base stations such that you can fully cover the area with the least amount of base stations.
2. Draw the coverage map of your strategy, mark the coverage area with different colors for different base stations.
3. I would like to walk on the diagonal line at a speed of 90 m/min, from (0,0) to (200,200). Create an animation with matplotlib to demonstrate the process. Provide a coverage table for each base station the phone connects to. If it's possible, identify when I have high quality service, low quality service, and no service.

## 3. Deliverables

1. A short report, clear and to the point.
    a. Min 1 page A4, max 7 pages A4 (excluding appendix)
    b. Suggested structure:
        - Introduction:
            - ✓ What is the task?
            - ✓ What needs to be analyzed?
        - Method:
            - ✓ How did you approach this problem?
            - ✓ Calculations you need by hand and/or simulations strategy.
            - ✓ How did you structure your code?
        - Results:
            - ✓ How to use your code?
            - ✓ Is it fully functional?
            - ✓ Answering the questions above.
        - Reflection:
            - ✓ What did we do good?
            - ✓ What can be improved?
            - ✓ What did we learn while working on this code?
2. Your code in appendix.

### 3.1 Report guideline

- Very concise and straight to the point. You do not need a cover page, you do not need contents like: "The purpose of this project……" You do not need 3rd person perspective language, just say "We decided……","We write ……". You do not need background and too much description in detail.
- The report must be logical and easy to read, free from grammar & spelling mistakes.
- Screenshots must be clear and readable.
- I strongly suggest you to just copy and paste your code to the appendix, do not use screenshots, do not worry about the colors and general format that make your code look good, just make sure indentations are there when needed. Do make sure that the code readable, a direct copy from a dark theme IDE may make your code unreadable.
- Recommended format normal text: A4 paper, Arial, size 12, line space: multiple 1.25.
- Submit the report in groups, remember to include your names and student numbers on the report.

### 3.2 Code guideline

- It should work like what is described in the assignment.(Section 1 of this document)
- You should have necessary comments to the extent that you still can understand each line after leaving it for a week. You must be able to explain your code.