ELECTRICAL ENGINEERING, UNIVERSITY OF CAPE TOWN

EEE4087F Module A Lab 1

March 14, 2018

Due date: 21/03/2018

1 Lab Objectives

Simulation is a widely used tool to validate new ideas in telecommunication, therefore this lab aims to familiarise the students with the following concepts:

- Formulate a problem in mathematical and programming terms.
- Establish and validate a simulation model.
- Evaluate and process the outputs of the simulation model.
- Present results in a logical and comprehensive manner.

2 Programming Language

The simulation model is to be programmed in Python or Java.

3 Problem Overview

Consider a scenario where there are m mobile base stations, and each mobile base station is denoted by B_i. Assume that the signal coverage of each base station is circular with radius r. Furthermore, there are n users originally connected to each mobile base station and each mobile base station can provide a maximum rate of R for each user. However the achievable rate R_a that each user receives is inversely proportional to the distance D_{ij} between the j^{th} user and the i^{th} base station.

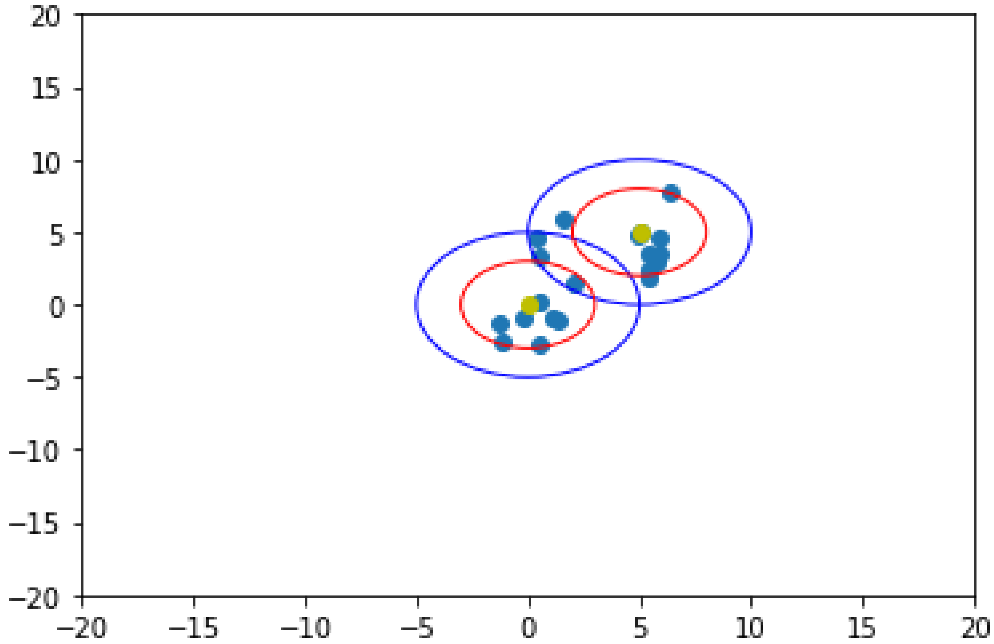

Figure 3.1: Visualisation of the simulation model

3.1 Achievable Rate R_a

In this simplified model, the impact of signal propagation is described as:

$$R_a = \alpha R \tag{3.1}$$

$$\alpha = 1 - \frac{D_{ij}}{r},\; i = 1,2,3\ldots m, j = 1,2,3\ldots n \tag{3.2}$$

Where α is the attenuation factor.

3.2 User Position Generation

The users are classified into two categories, namely U_c and U_f. U_c are users who are less than C away from the base station, and U_f are users who are equal to or more than C away from the base station. We define a random variable X which denotes the event of whether a user is less than C away from the base station. In other words, if $P(X = less) = 1$ then all users should be less than C away from the base station. We then randomise the position of the user based on the $P(X)$.

3.3 Validation of Model

You should validate your model to ensure results generated are plausible, for this model it would be a good idea to examine if $P(X)$ holds in the model.

3.4 Illustration

An example of above simulation model is shown in Figure 3.1 where:

- Yellow dot: Base station.
- Blue dot: Users.
- Blue Circle: Coverage of base stations.
- Red Circle: Distance C from base stations.

4 Optimisation and Analysis

After the establishment of above simulation model, you might realise that the association between the users and the base station is not optimal, because some users are closer to other base stations than the one it is currently connected to. Thus, you are required to do the following:

- Re-arrange the connections to achieve a maximum aggregate achievable rate $\sum_j^{mn} R_a$, in other words, the sum of achievable rates of mn users should be maximised.
- Calculate $\sum_j^{mn} R_a$.
- Find the optimal location of the base station if there is only 1 base station instead of m. Assume that the new base is able to provide coverage for all users.
- Investigate how the optimisation affects the load of each base station.
- Investigate how change in C, $P(X)$ affects $\sum_j^{mn} R_a$ and the load of each base station
- Run 10 iterations for each **set** of parameters and record the average values of above.
- Store all outputs as files.

5 Simulation Parameters

The simulation parameters are defined as following:

- Assume that all base stations have infinite capacity
- Position of base stations: $(0,0),(5,0),(0,5),(5,5)$
- number of users per base station: 20
- $r = 5$
- $R = 1000$
- $C = 1,2,3,4$
- $P(X) = 0.1, 0.2, 0.3, \ldots 1$

6 DELIVERABLES

The following should be submitted as a single ZIP file before due date via Vula:

- Code for simulation and a batch file that calls the programme.
- A report that contains detailed explanation of your model design, validation as well as results on optimisation and analysis. You do not have include all results, a few results that show similar trend would be sufficient to prove your findings.