Department of Electrical Engineering

EE 764: Wireless and Mobile Communications (Spring 2018)

Course Instructor: Prof. Abhay Karandikar

Simulation Assignment 2

Due Date: 15th Feb, 2018

Instructions:

- *Use either MATLAB or SciLab for simulations in this assignment.*
- **Please Note: This assignment is NOT a group assignment and has to be submitted by each student individually.**
- Submit a tarball/zip file with the following files:
  1. Plots wherever asked for.
  2. Discussion of results and your inferences in the form of a PDF file.
  3. Simulation code files for assignment with detailed comments.
- The filename of the uploaded file should be in the format : RollNumber_assign2.

Simulation Settings: Consider a cellular scenario as shown in Figure 1. Base stations (BSs) are located at the center of each hexagonal cell of radius $R_c = 250$ m. Each BS is transmitting at power $P_T = 30$ dBm. We refer to the cell in the center as the reference cell, which is surrounded by two tiers of cells. We simulate low, medium and high speed mobility in this simulation assignment. An MS can move at a speed of 3, 30 or 120 km/hr corresponding to low, medium and high speed mobility, respectively. Every MS is randomly assigned a speed v from the set $V = \{3, 30, 120\}$. The speed of an MS, once fixed, does not change over time. The MS then moves at v km/hr in a direction θ, where θ is a uniformly chosen between $0°$ and $360°$.

The direction of the movement once chosen by an MS remains fixed until it reaches the boundary of the 'bouncing circle'. As shown in Figure 1, an MS is initially placed in the reference cell and it follows the trajectory depicted in blue. It is then reflected back from the bouncing circle. Take the radius of the bouncing circle to be $3.12R_c$.

While moving, an MS passes through different cells and thus makes handovers to different BSs. An MS is handed over from BS1 to BS2, when the moving average of it's Received

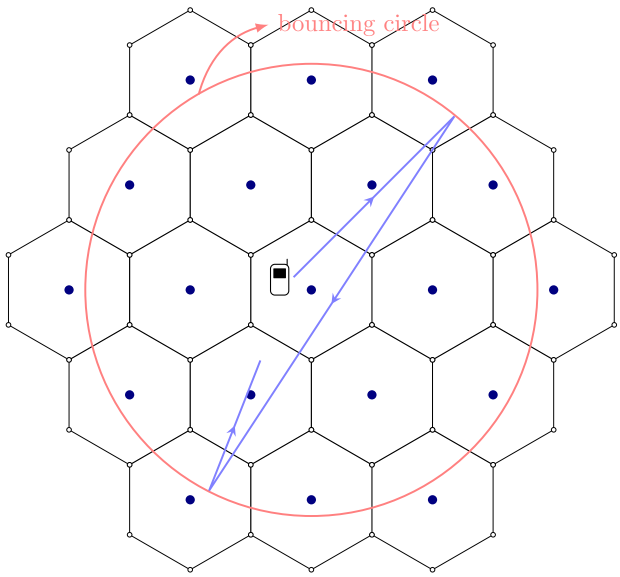

Figure 1: Illustration of the simulation scenario

Signal Strength (RSS) from BS2 exceeds that of BS1 by a threshold known as hysteresis H. We use $\overline{RSS_i}$ to denote the moving average of the RSS from BS i. So, the handover from BS1 to BS2 takes place when:

$$\overline{RSS_2} > \overline{RSS_1} + H.$$

The moving average is evaluated by taking last $N = 10$ samples of RSS measurement by the MS. RSS samples are assumed to be gathered at intervals of 50 ms. In other words, every 50 ms interval, the MS measures RSS from different BSs and evaluates $\overline{RSS}$ for each of them, and if handover criterion is satisfied, it makes a handover. An illustration of the handover procedure is provided in Figure 2.

The RSS (in dBm) measured by an MS m from BS i is given by:

$$RSS_i = P_T - \big(15.3 + 37.6 \log(d_{im})\big) + 10 \log(X) \tag{1}$$

where d_{im} is the distance between the BS i and the MS m in meters. Note that the second term on the right hand side of Equation (1) is the free-space path loss with path loss exponent $\gamma = 3.76$ and the third term accounts for random variations in the channel. X is distributed according to an exponential distribution with mean 1, i.e., the probability density function of X is:

$$f_X(x) = e^{-x}.$$

Simulation Procedure: For the simulations in this assignment, you need to drop one MS at a time in the reference cell and assign it a speed and direction. Then conduct the

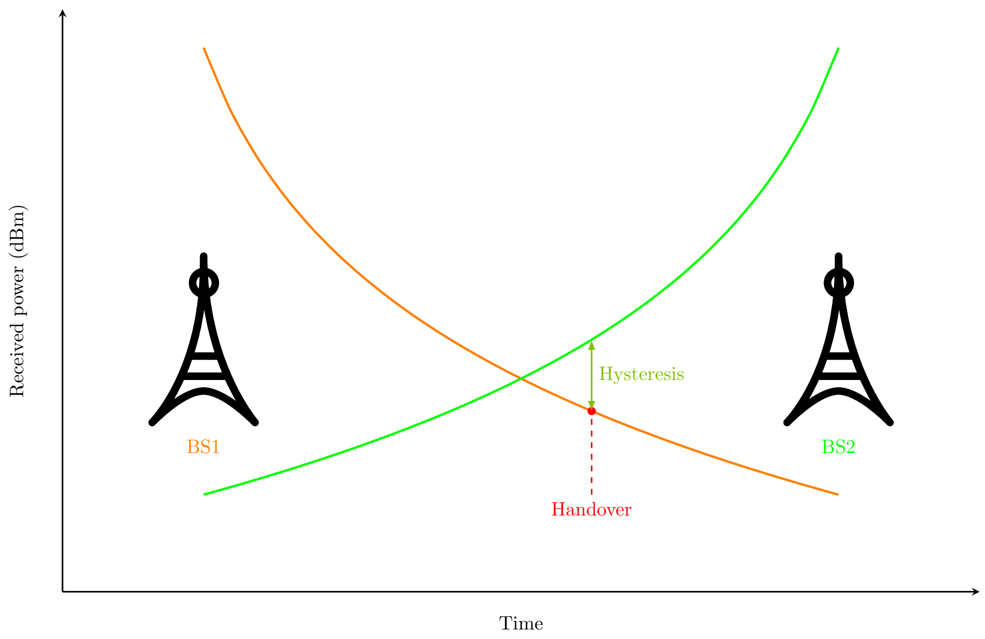

Figure 2: Handover Procedure.

required simulation for this MS for about 200 handovers. Repeat this procedure for 3 different MSs with 3 different speeds to generate 3 different trajectories.

1. **Trajectory:** In this problem, you are required to plot the movement trajectory and indicate the handover instances for a single MS in the system.

2. **Performance metrics:** The efficiency of handover is measured using performance metrics explained below. Evaluate each of these metrics for the given simulation scenario.

   (a) **Ping-pong rate for the system:** An MS is said to experience a 'ping-pong' handover when it undergoes two consecutive handovers within a short time interval (denoted by δ), such that the first handover is from BS1 to BS2, while the second one is from BS2 to BS1. Assume $\delta = 1$ s for this problem.

   We define Ping-pong Rate (PPR) of the system as the ratio of the total number of ping-pong handovers and the total handovers encountered in the system. Vary hysteresis H from 0 dB to 4 dB in steps of 1 dB and evaluate PPR for each hysteresis value for each $v \in V$.

   (b) **Number of handovers v/s speed:** Number of handovers encountered by an MS depends on its speed. Consider hysteresis $H = 2$ dB and plot the number of handovers encountered for each speed $v \in V$.

3. **Optimal hysteresis margin for a constant speed user:** In this problem, the optimal value of the hysteresis H needs to be determined. The value of H is said to be optimal when the number of handovers for a given user is minimized. In order to simulate this, assume that a given user is moving with a constant speed $v \in V$. Vary the values of H between $[0, 3]$ dB in steps of 0.2 dB and observe the number of handovers experienced by the user for a given value of H. Repeat the simulation for different values of v. Plot graphs for the number of handovers v/s H for each value of v, and provide your inferences on the optimal value of the hysteresis in this range for different user speeds.