Introduction to Wireless and Mobile Networking — Homework 2

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Github: https://github.com/awinder0230/2017-Spring-Wireless-and-Mobile-Networking

Problem Description:

19 base stations are located in an urban area with temperature 27°C, which form a 19-cell map shown in Fig. 0. The coordination of the central BS is (0, 0) and ISD is 500 m. The channel bandwidth is 10MHz. All BSs use the same carrier frequency .The power of each base station is 33dBm. The power of each mobile device is 23dBm. The transmitter antenna gain and the receiver antenna gain for each device, including base station and mobile devices, are 14 dB. The height of each base station is 1.5m, which is located on the top of a 50m high building. The position of each mobile device is 1.5m high from the ground. Consider the path loss only radio propagation. Use Two-ray-ground model as the propagation model for your simulation.

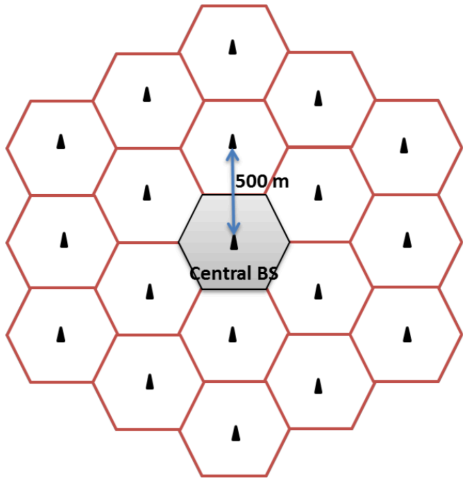


Figure 0. 19-cell map

Submission Files:

- report: b03901032_hw2_report.pdf
- readme: b03901032_hw2_readme.pdf
- codes:
  - main.m
  - gen_hexagon.m: a function to generate hexagon with radius r center at (x,y).
  - gen_hexrand.m: a function given hexagon, generate random dots inside the hexagon.
  - received_power_dB.m: given BS power, BS height, MS height, distance, transmitter gain, and receiver gain, compute received power in dB based on two-ray-ground model.
  - SINR.m: a function a function given signal, interference, and noise power, calculate SINR.
  - thermal_noise_power.m: a function given temperature and bandwidth, calculate thermal noise power.
  - two_ray_ground_model.m: given distance, height of transmitter and receiver, calculate gain of channel.
  - dB_2_watt.m: a function convert units from dB to Watt.
  - dBm_2_watt.m: a function convert units from dBm to Watt.
  - watt_2_dB.m: a function convert units from Watt to dB.

Usage:

1. Put all the *.m codes under the same directory.
2. Open Matlab and run main.m to get the simulation result.

Result:

1. [Downlink] Assume there are 50 mobile devices uniformly random distributed in the central cell. All the BSs are transmitting at the same time. The downlink interference for a specific mobile device comes from other BSs. Do not consider ISI in the case.

Figure 1-1

The figure shows three simulations to validate the mobile devices are randomly distributed. In each simulation, there are a central BS located at (0,0) and with 50 uniformly random distributed mobile devices in the central cell. The units of x-axis and y-axis are both in meter. The hexagon cell was generated by the function gen_hexagon, and random distributed mobile devices are generated by the function gen_hexrand.

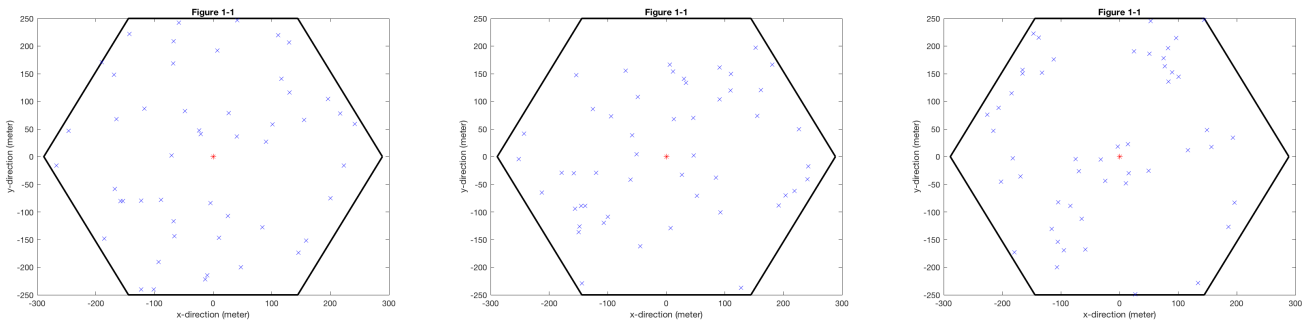
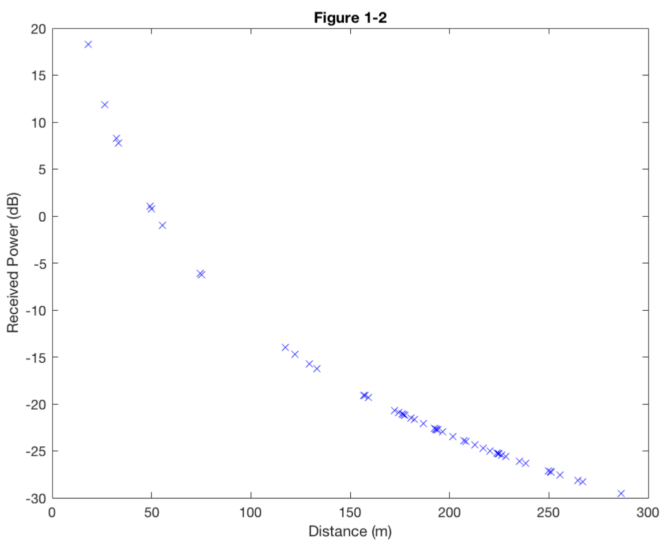


Figure 1-1.

Figure 1-2

- x-axis: distance between the BS and each mobile device
- y-axis: received power in dB of each mobile device



Received Power (dB) =
base station power (dB)
+ transmitter antenna gain (dB)
+ gain of propagation channel (dB)
+ receiver antenna gain (dB)

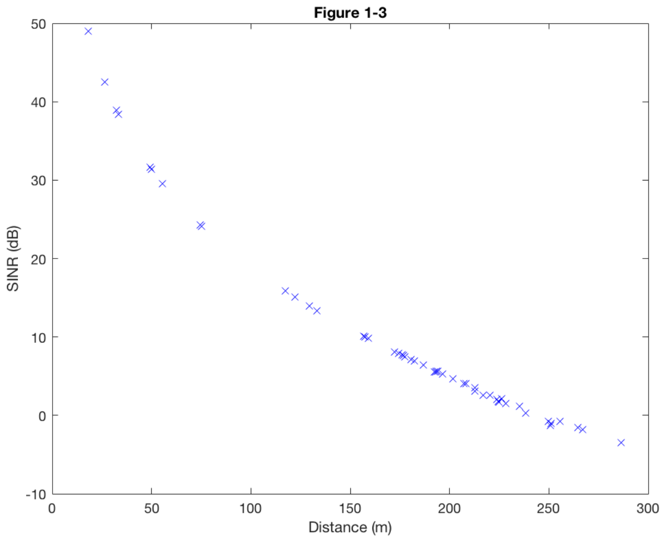
Gain of the propagation channel is computed by applying two-ray-ground model, and the others are given in problem description.

Figure 1-2.

The simulation result of Figure 1-2 is based on the locations of randomly distributed mobile devices of the rightmost result in Figure 1-1. It is obvious that there are tend to be more mobile devices with larger distance away from BS due to uniform distribution, and this assumption is also verified in Figure 1-2 which has more dots with larger distances. Since we consider only path-loss and use two-ray-ground model as the propagation model, received power decreases smoothly as distance increases.

Figure 1-3

- x-axis: distance between the BS and each mobile device
- y-axis: SINR in dB of each mobile device



SINR = Received Power / (Interference + Noise)

Received Power: computed in 1-2.

Noise: compute with thermal noise model given temperature and bandwidth.

Interference: For each mobile device, sums up the received power from all the other BSs except the central one as interference. Received power is calculated according to two-ray-ground model.

Figure 1-3.

The simulation result of Figure 1-3 is based on the locations of randomly distributed mobile devices of the rightmost result in Figure 1-1. The SINR of each mobile device was computed by considering both thermal noise and received power from other BSs. The interference in this problem is due to downlink signals from all the other base stations.

2. [Uplink] Consider only the central cell in this problem. Assume 50 uniformly random distributed mobile devices uplink to the central BS at the same time. The uplink interference for a specific mobile device happens at the BS side due to the concurrent uplink transmission of other mobile devices.

Figure 2-1

This problem is actually identical to 1-1. Thus, here we show only the result and skip from details due to redundancy.

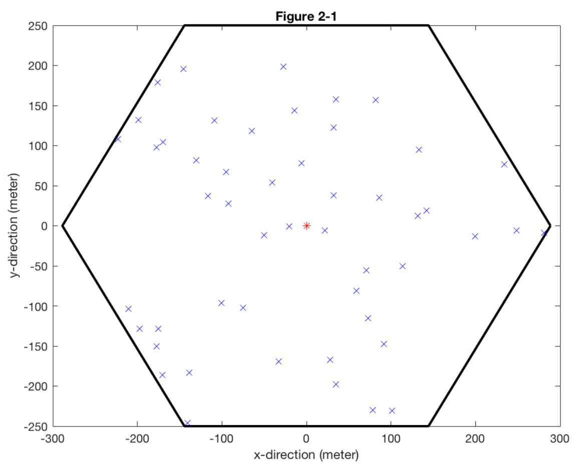
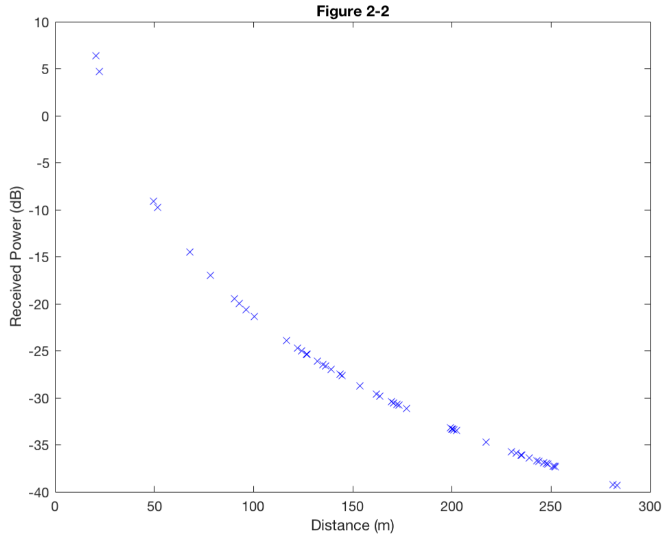


Figure 2-1.

Figure 2-2

- x-axis: distance between the BS and a specific mobile device
- y-axis: received power in dB of the central BS from a specific mobile device



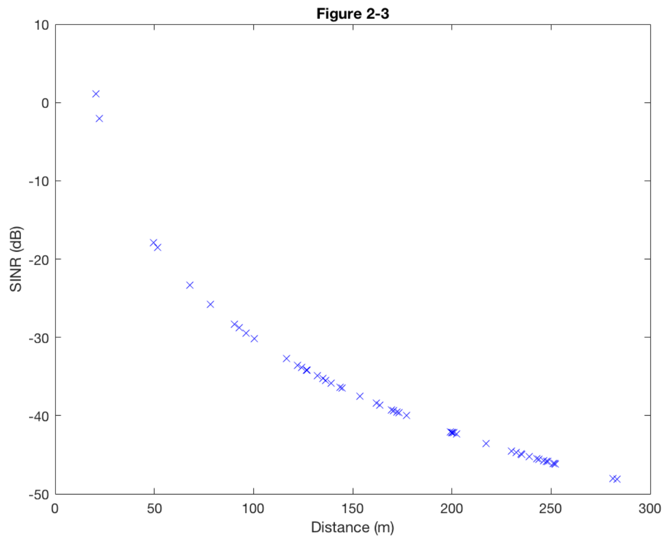
Received Power (dB) =
mobile device power (dB)
+ transmitter antenna gain (dB)
+ gain of propagation channel (dB)
+ receiver antenna gain (dB)

Gain of the propagation channel is computed by applying two-ray-ground model, and the others are given in problem description.

The subtle difference between Figure 1-2 and Figure 2-2 is that: the former one is the received power of mobile devices, and the latter one is the received power of central base station. Thus, although gains of antenna and propagation channel are the same, the power of base station and mobile device are different. Nevertheless, both simulation results are based on two-ray-ground model.

Figure 2-3

- x-axis: distance between the BS and the mobile device
- y-axis: SINR in dB of the central BS from a specific mobile device



SINR = Received Power / (Interference + Noise)

Received Power: computed in 2-2.

Noise: compute with thermal noise model given temperature and bandwidth.

Interference: For each mobile device, sums up the received power of central BS from all the other mobile devices except itself as interference. Received power is calculated according to two-ray-ground model.

Different from the downlink case in problem 1-3, the interference in this problem comes from all the other mobile devices in the same cell transmitting to the base station simultaneously. Thus, when computing interference, we sums up the received power of central BS from other mobile devices in the same cell, rather than considering other base stations or mobile devices in other cells.

Bonus. [Uplink] Consider 19 cells shown in Fig. 0 in this problem. There are 50 uniformly random distributed mobile devices in each cell. Assume all the uniformly distributed mobile devices uplink to their corresponding BSs at the same time. The uplink interference for a specific mobile device happens at the BS side due to the concurrent uplink transmission of other mobile devices.

Figure B-1

The figure shows three simulations to validate the mobile devices are randomly distributed. In each simulation, there are 19 BSs centered at given coordinates and with 50 uniformly random distributed mobile devices in each cell. Therefore, there are total 50 x 19 mobile devices in each simulation result. The units of x-axis and y-axis are both in meter. The hexagon cell was generated by the function gen_hexagon, and random distributed mobile devices are generated by the function gen_hexrand.

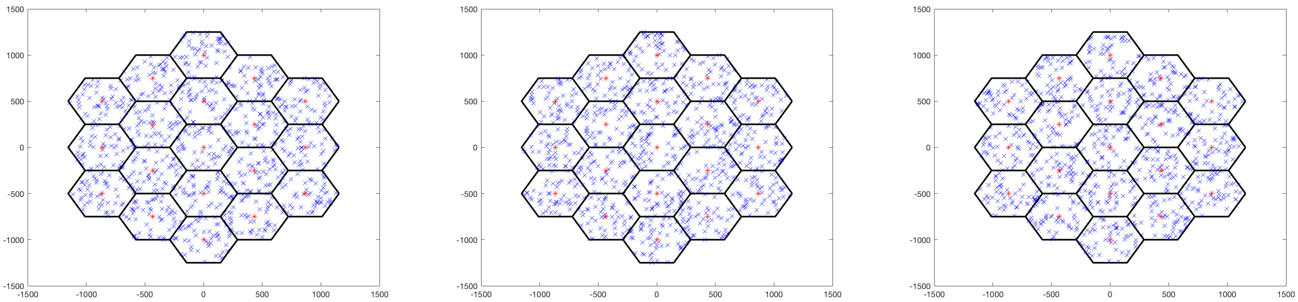
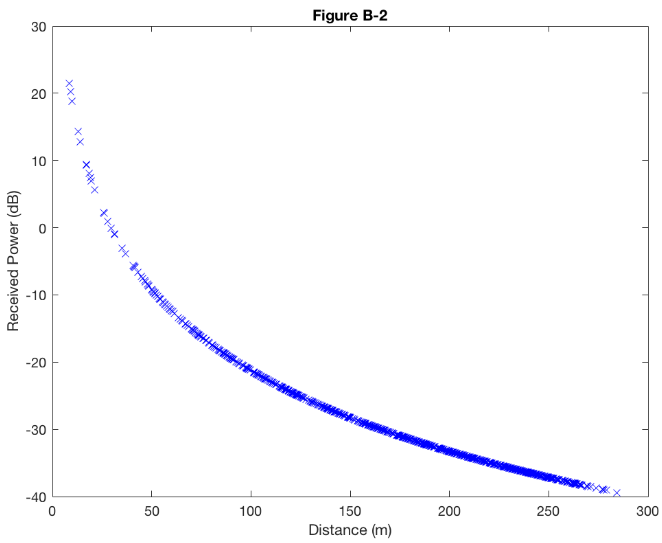


Figure B-1.

Figure B-2

- x-axis: distance between the specific mobile device and the corresponding BS
- y-axis: received power in dB of each BS from the specific mobile device



Received Power (dB) =
mobile device power (dB)
+ transmitter antenna gain (dB)
+ gain of propagation channel (dB)
+ receiver antenna gain (dB)

Gain of the propagation channel is computed by applying two-ray-ground model, and the others are given in problem description. To get the result, simply iterate over base stations, and compute received power from each mobile devices in that cell.

The simulation result of Figure B-2 and B-3 is based on the locations of randomly distributed mobile devices of the rightmost result in Figure B-1. The interesting part of the result is that: for each mobile device, it only transmits signal to the base station which it belongs to. Therefore, all the dots are going to lie on the same curve as Figure B-2 shows, and this result will be similar to Figure 2.2 if we increase the number of mobile devices in that case.

Figure B-3

- x-axis: distance between the specific mobile device and the corresponding BS
- y-axis: SINR of each BS in dB from a specific mobile device

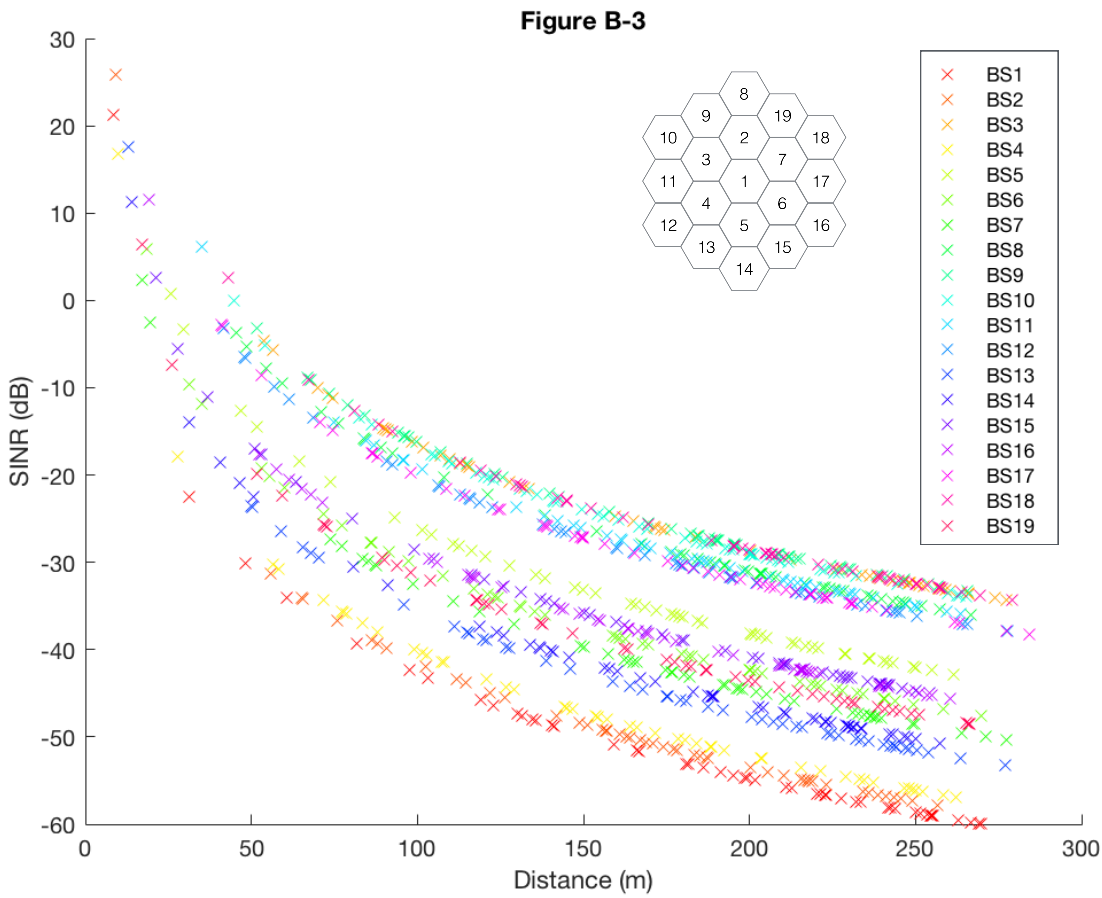


Figure B-3.

SINR = Received Power / (Interference + Noise)
Received Power: computed in B-2.
Noise: compute with thermal noise model given temperature and bandwidth.
Interference: For each mobile device, sums up the received power of corresponding BS from all the other mobile devices (including those in other cells) as interference. Received power is calculated according to two-ray-ground model.

To compute SINR, both thermal noise and received power of each BS from the specific mobile device had been calculated in problem B-2. But for uplink interference in problem B-3, we have to further consider all the concurrent transmission of other mobile devices in other cells to current base station, instead of consider only the transmission in current cell which is the case in problem 2-3. Since the location of hexagons are different and so as the distance between each mobile device with base stations, there are 19 curves in the result shown above.