Introduction to Wireless and Mobile Networking: Homework 5

Submission rule

1. The file name of the report should be **b07901xxx_hw5_report.pdf**
2. The file name of the readme should be **b07901xxx_hw5_readme.pdf**
3. The readme should describe **how to "USE" your code** to get the result in your report
4. If you use C++, please DON'T submit .exe
5. Put the <u>report</u>, <u>readme</u> and <u>codes (MATLAB or C++ or Python)</u> in the same folder, which is named **b07901xxx_hw5**
6. Compress the folder to **b07901xxx_hw5.rar/b07901xxx_hw5.zip**
7. Submit the .rar/.zip to Ceiba before deadline.

   Please note that the homework submission system will turn off upon deadline.

   If you have troubles so that you cannot submit on time, please email to TA.

   However, the grade of late submission will be lower compared to those submitted on time.

Problem description

Device-to-Device (D2D) is a technology that enables adjacent mobile devices to directly communicate with each other. As shown in Fig. 1a, in conventional cellular networks, a mobile device transmits the data to the base station through uplink; then, the base station transmits the data to the destination mobile device. As for D2D transmission, as shown in Fig. 1b, the base station configures a dedicated channel, on which the source device directly transmits to the destination device.
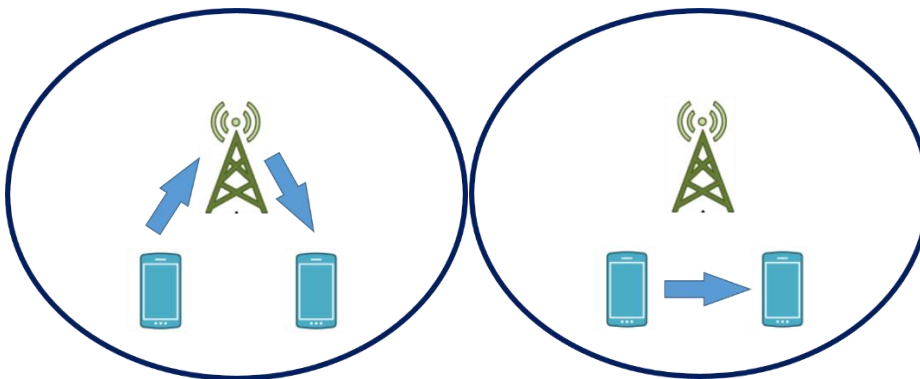

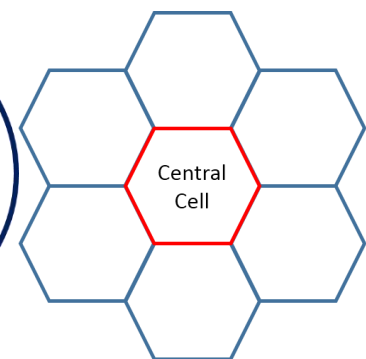Fig. 1 (a) Conventional cellular UL and DL (b) D2D transmission   Fig. 2 7-cell topology

As shown in Fig. 2, a central base station is located in an urban area with temperature 27℃. Its coordination is (0, 0) and is surrounded by 6 base stations with ISD=500m. The channel bandwidth is 10MHz. The power of the base station is **<u>23 dBm.</u>** The power of each mobile device is **<u>0 dBm.</u>** The transmitter antenna gain and the receiver antenna gain for each device, including base station and mobile devices, are **<u>0 dB</u>**. The height of the 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 (without shadowing and fading). Use Two-ray-ground model as the propagation model for your simulation.

1. **[Basic D2D Topology]**
   There are 75 pairs of mobile devices (that is, 150 devices in total) randomly dropped in the central cell. During the transmission, follow the consideration below.
   - For uplink transmissions, do NOT consider interference.
   - For downlink, the interference comes from the signals transmitted by the other base stations.
   - For D2D transmissions, the interference comes from the signals transmitted by other D2D transmitters.

   When generating D2D pairs, please follow the indication below.
   - Both of the pairing mobile devices should be dropped in the central cell
   - The distance between the pairing mobile devices should be shorter than 200 meters. The distance can be a configured fixed value or a random variable, up to your decision.

   1-1. Please give a figure of the described topology. You should clearly differentiate the D2D transmitters and the D2D receivers by different marks.
   1-2. If the data is transmitted through conventional uplink and downlink, please plot two figures:
       1-2-1. A figure with uplink SINR (in dB) as x-axis and CDF or PMF as y-axis.
       1-2-2. A figure with downlink SINR (in dB) as x-axis and CDF or PMF as y-axis.
       # You are encouraged to run the simulation multiple times for a smoother curve.
   1-3. According to the result in 1-2, calculate the DL throughput of the system
   1-4. If the data is transmitted through D2D, please plot a figure with D2D SINR as x-axis and CDF or PMF as y-axis
   1-5. According to the result in 1-4, calculate the throughput of the system.
   1-6. Increase the number of D2D pairs and calculate the corresponding system throughput. Please plot a figure with the number of D2D pairs as x-axis and the system throughput as y-axis. Briefly state and explain your observations.
   1-7. Under which conditions does D2D transmission method perform better than cellular transmission method? Why?

2. **[Traffic in D2D]**
   Consider the default topology in Problem 1. Data is generated in each D2D transmitter with Poisson arrival (arrival rate = λ bps). Each D2D transmitter has a buffer size of B_d bits, while the base station has a buffer size of B_b bits. Assume AWGN channel and we use Shannon Capacity as the ideal throughput for each entity.

   For default value, B_d = 0.5M and B_b = 15M, the arrival rate λ is fixed among D2D transmitters and its value ranges from 100kbps to 2Mbps

   2-1 If the data is transmitted through conventional uplink and downlink, please plot a figure with arrival rate as x-axis and bit loss probability as y-axis.
   2-2 If the data is transmitted through D2D, please plot a figure with arrival rate as x-axis and bit loss probability as y-axis.

2-3   From the results in 2-1 and 2-2, briefly state and explain your observations.

2-4   Is there any other factors that could affect the performance of cellular and D2D transmission? How?

2-5   Consider the case in which different D2D transmitters have different data arrival rate. If you are required to mitigate the bit loss probability, what would you do?