MIMO & Two Flow Laboratory Session

Part 1 – MIMO

General description

In this exercise we will examine the performance of several transmission and decoding in a multi antenna wireless network. Assuming the base station has **t** transmission antennas and each user has a single reception antenna.

Notice: transmission rate of a single user according to Shannon is $R_i = log\,(1 + SNR_i)$

Defining a channel

In this part we define 3 types of channels which assume that users are i.i.d:

a. An **i.i.d complex Gaussian channel** equally distributed – the connection between each receiving antenna and each of the t transmitting antennas is described by a vector of the length t so that each entry in the vector has a real and a complex parts Gaussian distributed with an expected value of 0 and a variance of 1 and is i.i.d to all other entries.
b. A **chaotic channel** model – each channel is characterized complex Gaussian distribution with a random expected value uniformly distributed U[0,1] and a variance uniformly distributed U[0,3]. The parameters for each channel's distribution are only drawn once.
c. A complete **correlative channel** – all the antennas have the same randomly drawn complex Gaussian distribution with an expected value of 0 and a variance of 1. The is only drawn once.

Selecting Users (Multi Users)

1. Assuming there are K users, what is the number of maximal users the station can simultaneously transmit to using Zero-Forcing Beam Forming (ZFBF) encoding for each of the channels?

Assuming there are K=30 users and the transmission power is P=5W. **Conduct simulations** that receives the number of antennas at the transmitter t as an input. Repeat each simulation 5,000 times and display the PDF of the total rates per transmission for each of the defined channels above.

Repeat for each of the following cases:

2. The base station chooses a single user at random and transmits to it at maximum power.
3. The base station chooses to transmit to a single user with the strongest channel (the user with the highest norm) and transmits to it at maximum power.

4. The base station chooses to transmit to t randomly chosen users using ZFBF, so that the power is equally distributed between the selected users.
5. The base station chooses to transmit to the t strongest users using ZFBF, so that the power is equally distributed between the selected users.
6. The base station tests all users subgroups of the size t and transmits to the optimal group (eg. with the highest rates) using ZFBF, so that the power is equally distributed between the selected users.
7. The base station applies the SUS algorithm for user selection subgroup of the size t and transmits to that group using ZFBF, so that the power is equally distributed between the selected users.

- Compare the user selection fairness results of the **chaotic channel** and the **i.i.d complex Gaussian channel.**

Submit your simulation code along with a .pdf including elaborated explanation of your results and with corresponding graphs to validate it.

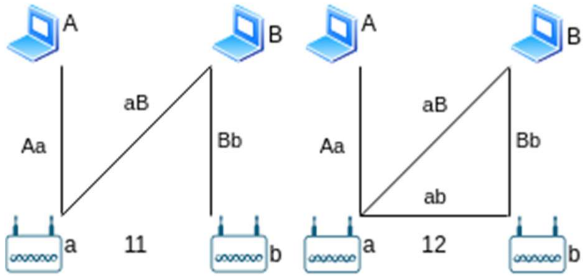
Resources

Wireless communications, Andrea Goldsmith, Stanford University, California, 2005, 9780511841224

https://ieeexplore.ieee.org/document/1603708 (SUS algorithm)

Part 2 – Two Flow

In this part the throughput for the following topologies will be tested. The topologies that will be tested are Asymmetric Incomplete State and given by Subfigures 11 and 12 in Figure 1 in the Article of Michele Garetto - Modeling Media Access in Embedded Two-Flow Topologies of Multi-hop Wireless Networks.



We want to examine the throughput received in nodes a and b using a simulation and to compare the results to the theory.

You may write your simulation in any program tool such as GNU Octave, MATLAB, Wolfram Mathematica, Python or OMNeT++

The following assumptions should be taken:

a. Garreto Model.
b. Constant Rate R Mbps per Simulation.
c. Size of a Frame is L Bytes (including headers).
d. Size of RTS and CTS frames are 20 Bytes and 14 Bytes respectively.
e. Slot Time $t_{slot} = 20\ \mu sec$
f. Minimal window size W_{min}
g. Max retry limit m.
h. EIFS = $364\ \mu ses$, DIFS = $50\ \mu sec$, SIFS = $10\ \mu sec$
i. PLCP – Physical Layer Convergence Protocol is $192\ \mu sec$, and is transmitted at $1\ Mbps$
j. Propagation time is negligible.

1. Write which results do expect to get.
2. Explain how you created these topologies; you may show it using a simulation.
3. You should run your simulation for 10 seconds, and the arrivals of messages is a modeled as Poisson Arrival Process where $\lambda = 250$.
4. Show your results for your simulation where:
    a. R = 6, 11, 54 Mbps.
    b. L = 100, 500, 1000 Bytes.
    c. W_{min} = 8, 32, 128 slots.
    d. m = 1, 5, 7
5. Repeat the simulation for a Two-Way handshake, and for Four-Way handshake (using RTS/CTS).
6. Does using Four-Way handshake results in a better throughput

Good luck!