Final Year Project

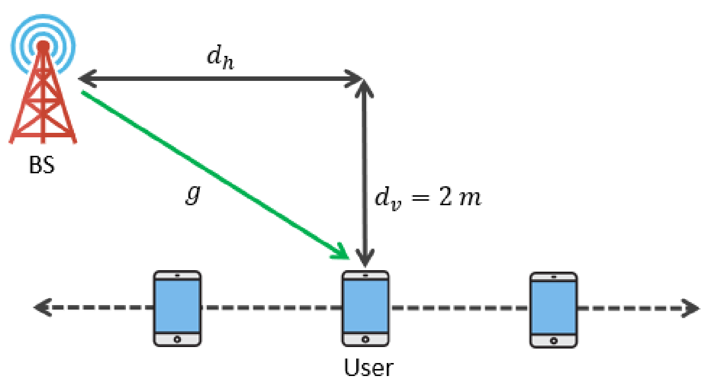
Assignment

Task-1

Consider a single user system as illustrated in Fig. 1, where d_h and d_v represent the horizontal and vertical distance between the BS and the user, respectively, and g denotes the fading channel. Plot the average received power P_r (in Watts) versus the horizontal distance d_h (in meters) for Rayleigh fading channel and path loss exponent $n = [3, 3.5, 4]$.

$$\boldsymbol{P_r = P_t * d^{-n} * |g|^2}.$$

Assume transmit power at the BS $P_t = 1$ W and $d_h = 20{:}\,5{:}\,65$. Apply Monte Carlo simulations to find the average received power.



Help for Generating the Rayleigh Fading Channel:

Generate a Rayleigh random variable g with $\mathrm{E}\{g^2\} = 1$. Remember that $g = |X + jY|$, where X and Y are zero mean, independent Gaussian random variables (RVs). Your Gaussian RVs X and Y (produced by `randn` command) must each have equal variance equal to ½.

Task-2

1. Consider an area of **500x500 m²** with **100** uniformly distributed users and **1** base station (BS), which is located at the origin. Plot the users and BS using the `scatter()` command and attach the snapshot of your network model. `(Hint: use unifrnd() function to generate the x and y coordinates of users.)`

2. The next step is to calculate the distance between the users and BS. For this, use the Euclidean distance formula given by
$$\boldsymbol{d_i} = \sqrt{\left(\boldsymbol{x_{UE}^i} - \boldsymbol{x_{BS}}\right)^2 + \left(\boldsymbol{y_{UE}^i} - \boldsymbol{y_{BS}}\right)^2},\ \boldsymbol{i} \in \{\mathbf{1}, \mathbf{2}, \dots, \mathbf{100}\}$$
where i represents the user index. Attach the screenshot of the distance matrix.

3. Calculate the pathloss for each user, given by
$$\boldsymbol{L(d_i)} = \frac{\mathbf{1}}{\boldsymbol{d_i^n}},$$
where n is the path loss exponent, and d_i is the distance between the i-th user and the BS. Consider $n = 3.5$.

4. Consider transmit power at the BS $P^t = 1W$, calculate the received power at each user using the following formula.
$$\boldsymbol{P_i^r} = \boldsymbol{P^t} * \boldsymbol{L(d_i)} * |\boldsymbol{h}|^2,$$
where h represents the Rayleigh fading channel.

5. The next step is to calculate the signal-to-noise ratio (SNR) and rate (bps/Hz) for each user. SNR at the i-th user is calculated as
$$\mathbf{SNR}_{\boldsymbol{i}} = \frac{\boldsymbol{P_i^r}}{\boldsymbol{N}},$$
where N is the noise power, consider N =-96dBm. The formula for calculating the rate (bps/Hz) is as follows.
$$\mathbf{Rate}_{\boldsymbol{i}} = \mathbf{log_2}(\mathbf{1} + \mathbf{SNR}_{\boldsymbol{i}}).$$

6. Can you state the random variables in the above analysis?

7. Calculate the outage probability for a given threshold of τ = 2 bps/Hz. `(Hint: To calculate the outage probability, first check the condition` $\text{Rate}_i < \tau$ `for a given threshold` τ`.)`

8. Perform the Monte Carlo simulations for 1000 iterations, then find the outage probability. `(Hint: Repeat step 1 to step 7 1000 times and then calculate the outage probability.)`

$$\boldsymbol{P^{i}_{outage}} = \mathbf{P}\,(\mathbf{Rate}_{\boldsymbol{i}} < \boldsymbol{\tau}\,).$$

9. Calculate the total outage probability, which is given by

$$\Theta_{\boldsymbol{OP}} = \prod_{\boldsymbol{i}=\mathbf{1}}^{\boldsymbol{M}} \mathbf{P}(\mathbf{Rate}_{\boldsymbol{i}} < \boldsymbol{\tau}),$$

where M represents the total number of users, i.e., $M = 100$. The total outage probability is the product of the total probabilities of all users in the network. Can you guess the reason for the product? `(Hint: Recall the probability of independent events)`

10. Plot total outage probability versus the threshold, $\tau = 0{:}\,5{:}\,25$ bps/Hz. Explain your result.

11. Run the above simulation for 1, 10, 100, 1000 iterations. Do you see any change in the results and curves? If yes, can you think of the reason?