Outage Probability and coverage

1 Aim

The objective of this experiment is to understand the concept of the outage probability and the cell coverage area and how they are affected by the configuration of system parameters.

2 Theory

In previous experiments, we explored fundamental concepts like pathloss and shadowing, which significantly influence wireless system design. In wireless communication, maintaining a minimum level of received power is crucial—for instance, ensuring cellular voice quality remains above a specific threshold. However, pathloss and shadowing introduce attenuation effects that impact received power. To effectively characterize this fading phenomenon, a comprehensive understanding of outage and coverage becomes essential.

2.1 Outage Probability, P_{out}

Outage probability is a critical metric in wireless communication systems, representing the likelihood that the received signal power falls below a specified threshold, making the communication link unreliable. In practical terms, it quantifies the probability that a user will experience poor connectivity or dropped calls. Mathematically, it is a function of the target minimum received power, P_{min} (threshold) and the received power at a distance, d, and can be written as

$$P_{out}\left(d, P_{min}\right) = P\left(P_r(d) < P_{min}\right) \tag{1}$$

2.2 Coverage Area

Coverage area is a fundamental aspect of wireless communication systems, defining the geographical region within which a signal from a transmitter, such as a cellular base station, can be received with good quality. Various factors, including transmission power, antenna characteristics, environmental conditions, and the effects of pathloss and shadowing influence the extent of this area.

In this experiment, we will investigate outage probability to understand its implications on wireless system design. By examining the conditions under which outage occurs, we can identify strategies to enhance coverage and reliability. This analysis will provide valuable insights into optimizing wireless networks to minimize outage probability and ensure consistent performance.

3 Pre-Test

1)What does outage probability represent in wireless communication?

1. The likelihood that a transmitter will fail
2. The probability that the received signal falls below a minimum threshold(Ans)
3. The probability of achieving maximum signal quality
4. The average power of the transmitted signal

2)What is the coverage area in a wireless communication system?

1. The area where a signal can be received with acceptable quality(Ans)
2. The area within a transmitter's physical boundary
3. The area where all users have maximum signal strength
4. The area beyond which the signal strength is zero

3)Outage probability depends on which of the following?

1. Target minimum received power
2. Distance between transmitter and receiver
3. Both A and B(Ans)
4. None of the above

4)If a cell has a low outage probability, which of the following is likely true?

1. The cell has poor signal coverage
2. The cell provides consistent signal quality(Ans)
3. Users frequently experience dropped calls
4. The cell requires additional transmitters

4 Post-Test

1)If the target minimum received power is -80 dBm, and the received power at a distance d is -75 dBm, what is the outage probability at this distance?

1. 1
2. 0 (no outage) (Ans:No outage occurs because $P_r > P_{min}$)
3. 0.75
4. 1.25

2)A receiver at distance d=1 km experiences a pathloss of 80 dBm. If the transmitter power is 35 dBm and the target minimum power is -45 dBm, does this receiver experience an outage?

1. Yes (Ans: Received power is 35-80=45dBm which is equal to the threshold)
2. No
3. May be
4. Insufficient information