Cairo University

Faculty of Engineering

Specialized Tracks of Engineering Profession (STEP) based on credit hours system- Spring 2025

MTHS204 Advanced Probability And Statistics

Project Phase 1

Report

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Project Topic and Problem Statement:

Project Topic:
Analysis of Signal Strength and SNR Fluctuations: Temporal Patterns, Protocol Impact, and Data Transmission Effects.

Problem Statement:
Signal strength and Signal-to-Noise Ratio (SNR) are critical factors affecting the reliability and efficiency of wireless communication networks. These parameters fluctuate due to various factors, including time of day, protocol used, data type/size, and distance from transmission sources. However, the extent and patterns of these variations are not always well understood. This project aims to analyze how signal strength and SNR change over time, their correlation with different communication protocols, and the impact of data characteristics. The findings will help identify potential optimization strategies for improving network performance.

Data Collection Strategy:

Since collecting the required data ourselves would be challenging, we opted to use publicly available datasets instead. The dataset is meticulously crafted, combining advanced measurement devices and techniques. Signal strength measurements were obtained using cutting-edge spectrum analyzers and field strength meters, while distance to tower estimates utilized a fusion of GPS receivers, signal propagation models, and advanced calculations. SNR measurements were conducted using state-of-the-art spectrum analyzers and signal analyzers. Attenuation measurements were obtained through power meters and network analyzers, providing valuable insights into signal loss.

Variables to be measured:

Timestamp, Signal Strength (dBm), SNR, Call Duration (seconds), Environment, Attenuation (dB), Distance to tower (Km), Call Type, Incoming/Outgoing, Transmit Power Level (Tx), Receive Power Level (Rx), Signal-to-Noise Ratio (SNR) at Receiver (SNR Receiver), Bit Error Rate (BER) at Receiver (BER Receiver), Transmission Distance (Transmission Distance), Fiber Attenuation Coefficients (Fiber Attenuation), Temperature at Critical Points (Temperature), Humidity Levels (Humidity), Signal Quality (Signal Quality), Flow duration, Total length fwd packets, Total length bwd packets, Fwd.iat.total, Bwd.iat.total, Protocolname.

Proposed software tools:

Python is used for data analysis, visualization, and statistical modeling, while Excel helps with data organization, preliminary calculations, and result presentation.

Initial questions and concerns:

1) How does signal strength and SNR fluctuate throughout the day (based on timestamps) according to each acquisition type? Are there peak hours of degradation?

2) What is the impact of protocol used and type of data on SNR and signal strength?

3) How is the Performance of protocols on different types/sizes of data throughout the day/year?

4) Is there correlation between SNR & signal strength and time/date of messages (are there peak times/dates)?

5) What is effect of distance to tower and data size (or acquisition type) on SNR and signal strength throughout the day/year?

6) What is the effect of environmental conditions with different transmission distances on network performance?

Conclusion

By systematically analyzing metrics such as interference levels, attenuation, bandwidth efficiency, and environmental conditions, researchers and engineers can determine how these elements influence SNR fluctuations. Understanding these relationships is vital for optimizing network reliability, reducing latency, and enhancing data transmission efficiency. Moreover, correlation analysis between SNR and different network parameters helps in predicting performance degradation, identifying bottlenecks, and implementing adaptive signal processing techniques. Through statistical models network professionals can make data-driven decisions to improve signal strength, minimize noise interference, and ensure seamless connectivity. Ultimately, such analysis is instrumental in designing robust communication systems that can dynamically adapt to varying network conditions, ensuring high-quality service in modern digital infrastructures.

References:

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