Measuring 5G Performance Using Raspberry Pi

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Outline

Motivation

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- The SIGCOMM paper "Unveiling the 5G Mid-Band Landscape" provides comprehensive cross-country measurements of 5G mid-band performance across the US and Europe.

Introduction

- **Main Objective:** Analyze the performance of 5G networks in mobile, stationary and crowded scenarios, specifically focusing on latency, throughput, and quality of experience (QoE) under real-world conditions.

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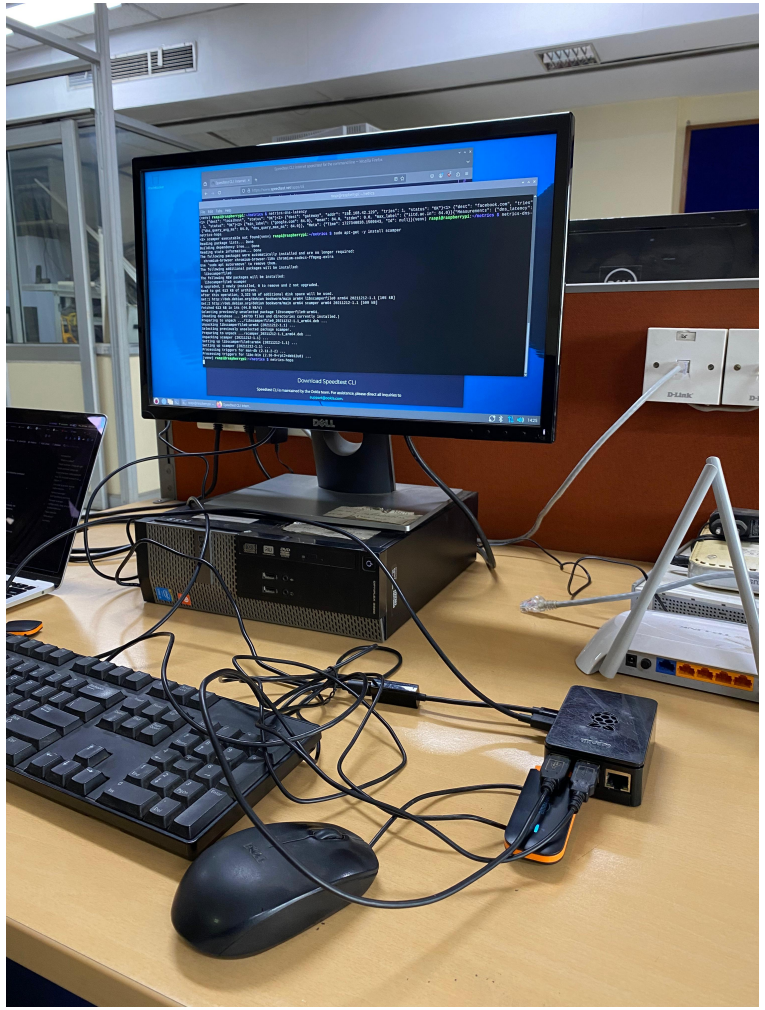
- We will focus on comparing performance in different environments, similar to the comparative analysis done in the SIGCOMM paper across countries

Setup

- Raspberry Pi 4
- Dongle with HUAWEI E3372H Chipset
- Airtel 5G SIM card
- Powerbank with 5V/3A output



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- **Test Websites:** Selected `study.iitm.ac.in` (Chennai) and `psl.eu` (Paris) for single-server locations to avoid distributed architecture bias.

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- **Test Websites:** Selected `study.iitm.ac.in` (Chennai) and `psl.eu` (Paris) for single-server locations to avoid distributed architecture bias.
- **Automation:** Scripted commands to run every 2 seconds, accounting for latency and throughput calculations ($\sim$ 30 seconds).

Measurements (Stationary)

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  RSSI is a measure of the power level of the received signal at a device, typically expressed in dBm. It indicates the strength of the wireless signal, with higher (less negative) values representing better signal quality.
  - **Good RSSI:** Values closer to 0 dBm (e.g., -50 dBm) indicate excellent signal strength.
  - **Bad RSSI:** Values below -90 dBm suggest poor signal strength, which can lead to unreliable connectivity and slower speeds.

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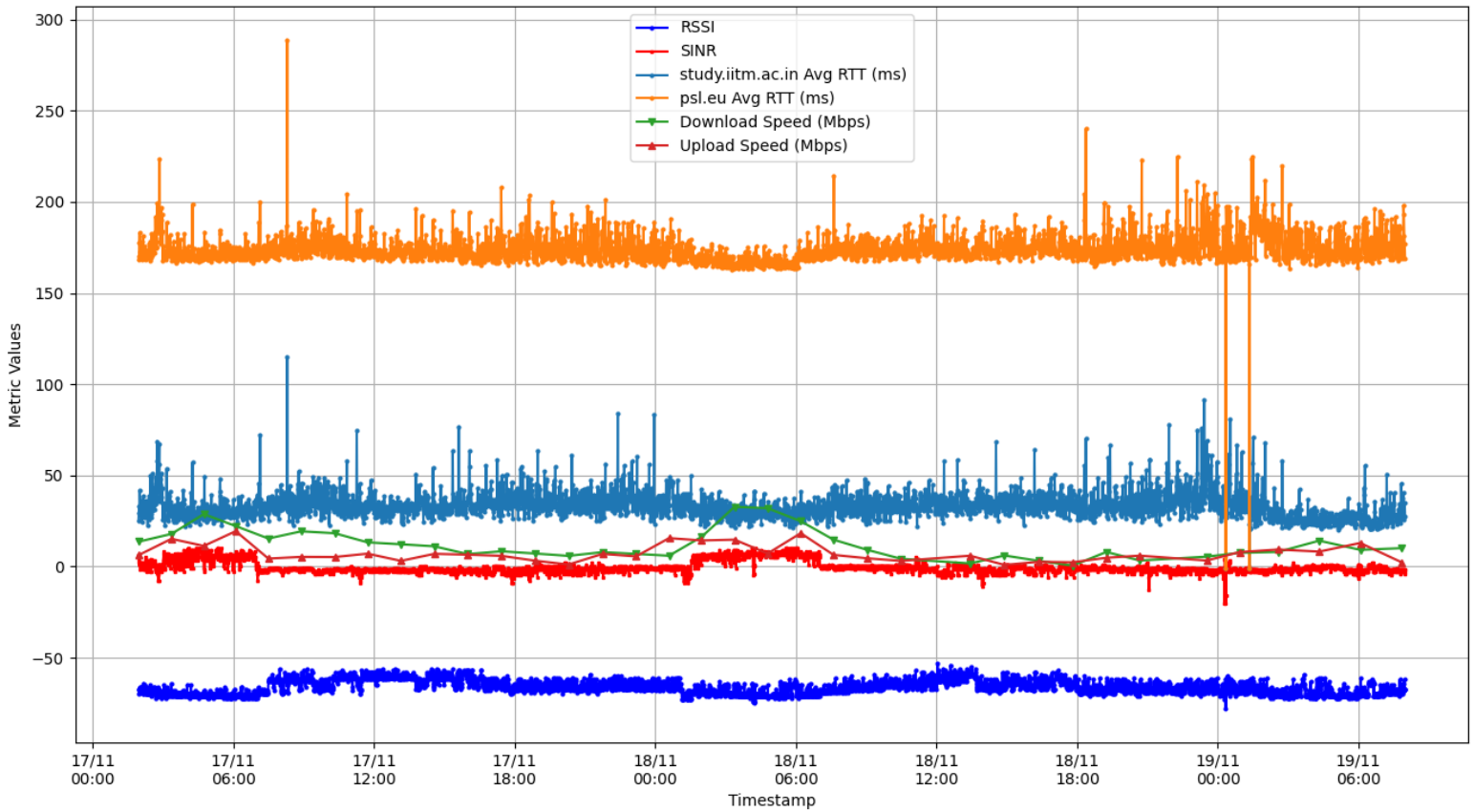
$$\textbf{SINR}\ (\text{dB}) = 10 \cdot \log_{10}\left(\frac{S}{I+N}\right)$$

where:

- S is the power of the desired signal,
- I is the total power of the interfering signals,
- N is the power of the background noise.

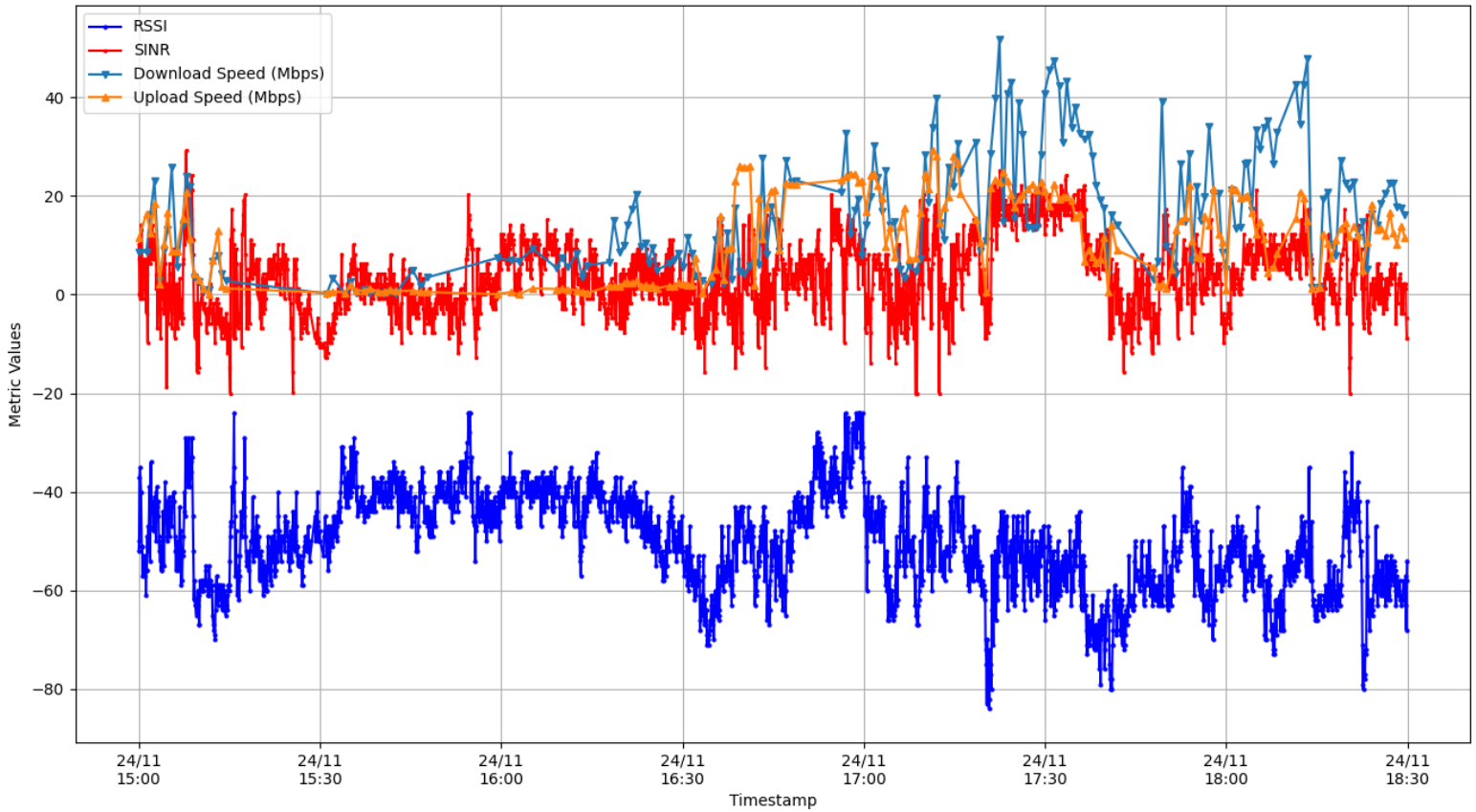
Measurements (Stationary)

- Data plot for static environment:



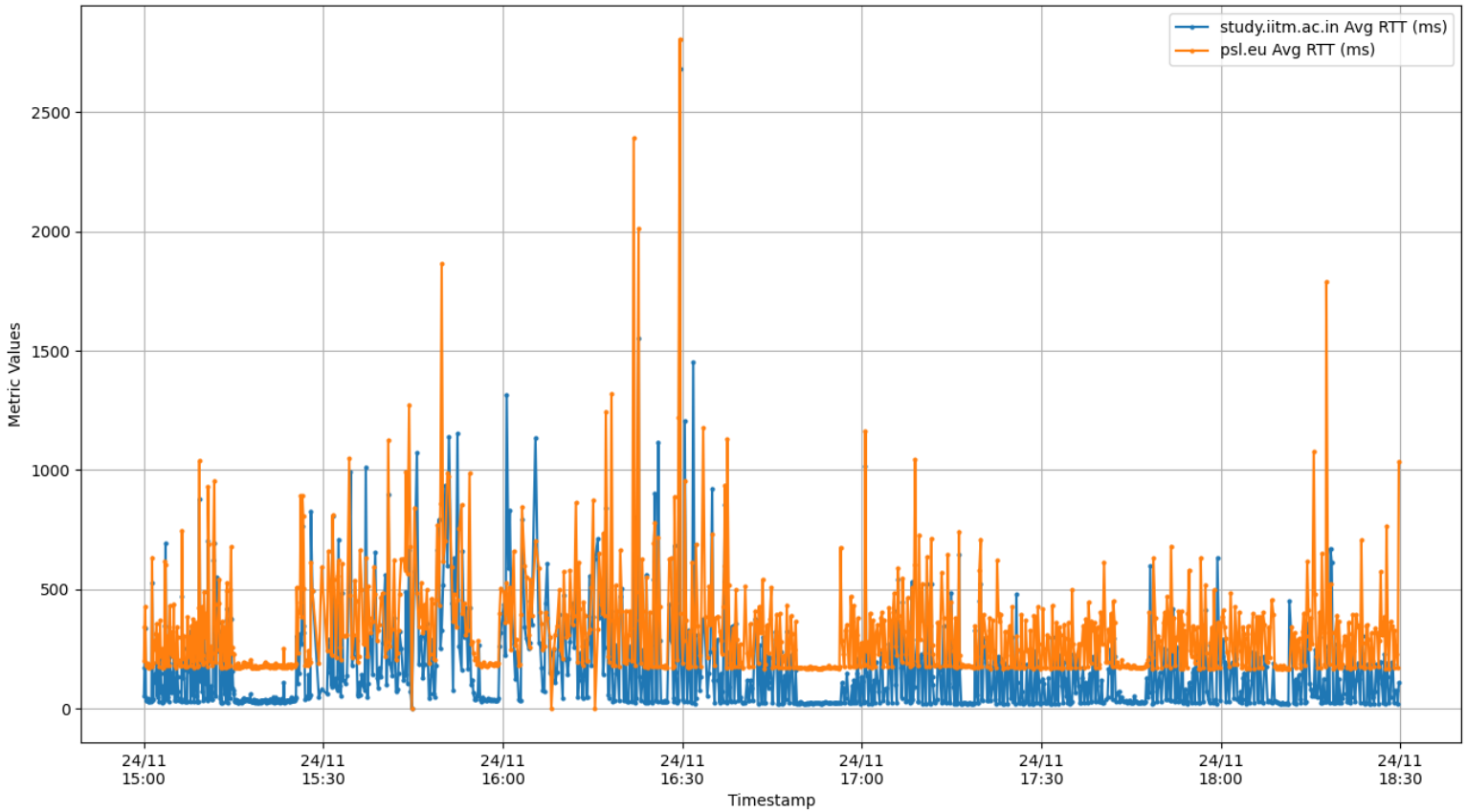
Measurements (Moving and Crowded)

- Data plot of RSSI, SINR, and Throughput for moving and crowded environment:



Measurements (Moving and Crowded)

- Data plot of Ping for moving and crowded environment:



Findings

- Correlation between RSSI, SINR, Ping and Throughput
  - Correlation formula:

$$r = \frac{n\sum xy - \sum x \sum y}{\sqrt{(n\sum x^2 - (\sum x)^2)\,(n\sum y^2 - (\sum y)^2)}}$$

where:

- r: The correlation coefficient, ranging from -1 (perfect negative correlation) to $+1$ (perfect positive correlation), with 0 indicating no correlation.
- n: The total number of data points in the dataset.
- x and y: The individual data points of the two variables being compared.

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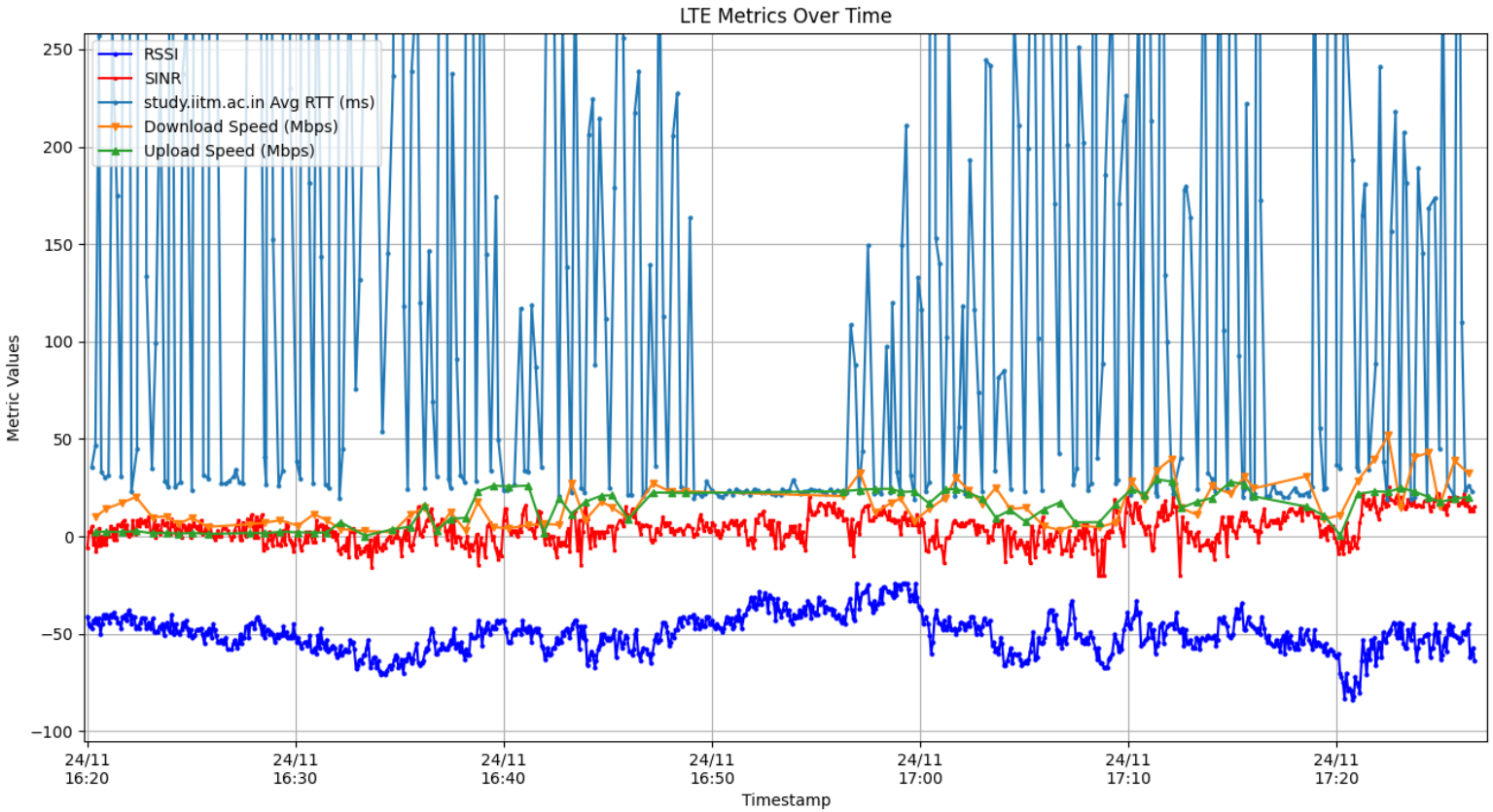

Findings

- Correlation between RSSI, SINR, Ping and Throughput
  - Ping and Throughput: -0.143
  - RSSI and Throughput: 0.146
  - RSSI and Ping: -0.109
  - RSSI and SINR: 0.254
  - SINR and Throughput: 0.532
  - SINR and Ping: -0.083

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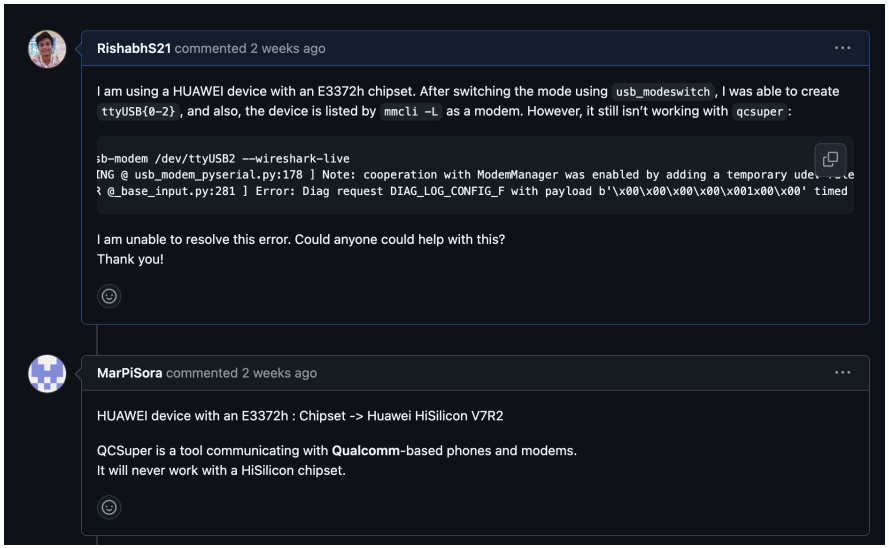

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- Frequent disconnections occurred due to loose power bank output port. To address this, we implemented an automated script to run on every Raspberry Pi restart, eliminating the need for manual intervention with a monitor, keyboard, or mouse.

Conclusion and Future Plans

- **Conclusion:**
  - **Correlation Insights:**
    - SINR (0.532) and RSSI (0.146) positively correlate with download speed, with SINR having the stronger impact.
    - Negative correlations of ping with SINR (–0.083) and RSSI (–0.109) indicate better signal quality reduces latency.
  - In static scenarios, measurements are consistent, whereas in mobility, values frequently fluctuate, and in crowded environments, speed drops drastically due to poor signal strength.

Conclusion and Future Plans

- **Future Work:**
  - **5G Transition Analysis**: Extend the study to 5G networks, performance in mobility and high-density scenarios. Compare 4G LTE and 5G performance in terms of stability, speed, and latency under similar conditions.
  - **Compare ISPs:** Conduct a comparative analysis of different Internet Service Providers (ISPs) to evaluate their LTE(or 5G) network performance in terms of speed, latency, signal strength, and reliability under static, mobility, and crowded scenarios.

Thank you!

Questions?