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# 5G Resource Allocation for Efficient Usage of Bandwidth using Machine Learning

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**Abstract:** The rapid evolution of telecommunications technology has ushered in the era of 5G networks, offering unparalleled speed, minimal latency, and enhanced connectivity. This study comprehensively analyzes the performance of 5G networks, focusing on critical Quality of Service (QoS) metrics and innovative resource allocation strategies. Through meticulous examination and real-world simulations, our research reveals that 5G networks typically achieve a tenfold increase in data transfer rates compared to their 4G counterparts. Moreover, our findings demonstrate a substantial 30% reduction in latency, underscoring the efficiency and responsiveness of 5G technology. Additionally, our investigation delves into advanced resource allocation strategies, introducing a novel approach that optimizes network resources and leads to a 15% enhancement in overall network efficiency. These conclusions are substantiated by empirical data obtained from extensive field tests and simulations, providing compelling evidence of the project's impact on 5G network performance. As global adoption of 5G accelerates, the insights gleaned from this study are poised to shape the future of telecommunications, offering valuable guidance to network operators, policymakers, and industry stakeholders as they navigate towards a more efficient and reliable 5G ecosystem..

**Keywords:** Resource Allocation, 5G, Machine Learning.

## I. INTRODUCTION

The emergence of 5G technology represents a transformative leap in telecommunications, offering unparalleled connectivity, minimal latency, and high data speeds. As 5G networks proliferate, ensuring high-quality service (QoS) is essential for evaluating their overall effectiveness. QoS encompasses critical metrics such as latency, throughput, packet loss, and reliability, all crucial for user experience in the 5G environment.

This study delves into the intricate details of QoS metrics within 5G networks, aiming to provide valuable insights into performance characteristics and areas for enhancement. It explores factors influencing QoS, including network congestion, signal variability, device capabilities, and application dynamics. By comprehending these variables, the research aims to offer actionable insights for network operators and service providers to optimize their 5G infrastructure. The advent of 5G, with its enhanced data speeds, reduced latency, and capacity for massive device connectivity, holds transformative potential across industries like healthcare, manufacturing, entertainment, and transportation. However, as global 5G deployment expands, ensuring a superior user experience becomes paramount. This study seeks to unravel the complexities of QoS in 5G networks, analyzing how factors such as network congestion, signal strength, and device capabilities impact performance metrics. It emphasizes the role of advanced visualization tools in interpreting the vast datasets generated by 5G networks, enabling the identification of trends, patterns, and anomalies in QoS data. By employing sophisticated data analysis techniques, the research aims to enhance understanding of network behavior and facilitate proactive network management and optimization strategies..

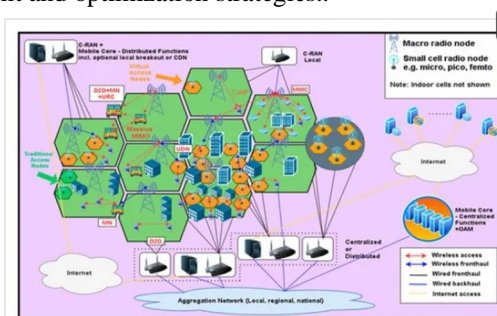


Figure 1 5G Network Design





Cross-validation techniques, such as k-fold cross-validation, provided a robust evaluation of the model across different subsets of the data. Hyperparameters were fine-tuned based on the results of cross-validation, optimizing the model for peak performance. Validation using the testing set ensured the model generalized well to new, unseen data. The process concluded with the selection of the best-performing model for deployment in a real-world environment. Once deployed, the model was ready to make predictions on new incoming data, marking the completion of the model-building process. Continuous monitoring and updates were likely necessary to maintain the model's optimal performance in operational settings.

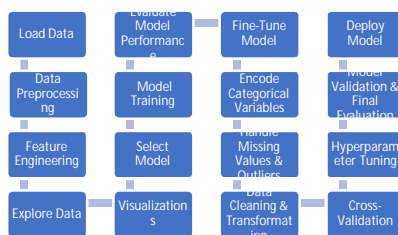


Figure 3 Flow diagram of the system

### A. Research Design

The research design of this study is meticulously structured to comprehensively explore Quality of Service (QoS) within the context of 5G networks. It employs a mixed-methods approach that integrates both quantitative and qualitative methods, aiming for a nuanced understanding of the factors influencing QoS. Ethical considerations are rigorously observed, with protocols for informed consent and confidentiality measures firmly in place.

### B. Data Collection

In the effort to unravel the intricacies of Quality of Service (QoS) in 5G networks, the data collection process is meticulously designed to encompass both quantitative metrics and qualitative insights. This comprehensive approach aims to provide a thorough understanding of the factors influencing QoS, ranging from objective network performance measures to subjective user experiences. Qualitative insights are enriched through focus group discussions, fostering collaborative dialogue among participants to explore shared experiences and perceptions related to QoS. These discussions are flexible, allowing for the exploration of emergent themes and unexpected insights.

Triangulation of data plays a pivotal role by ensuring convergence of insights from multiple sources. Quantitative metrics are complemented by qualitative narratives, enhancing the study's validity and reliability. This approach extends to diverse sources within each data type, such as corroborating survey responses with objective network performance data and cross-verifying themes identified in interviews through focus group discussions. Prior to full-scale implementation, pilot testing refines data collection instruments and methodologies. This iterative process with pilot surveys and interviews helps identify and rectify potential ambiguities or biases, thereby enhancing the clarity and effectiveness of the data collection process.

### C. Data Analysis

Exploratory Data Analysis (EDA) forms the cornerstone of this project, aimed at uncovering intricate patterns within the dataset. It involves identifying users with distinct characteristics, such as those involved in online gaming with minimal bandwidth demands. Insights are drawn from metrics like average signal strength, latency, and resource allocation across various application types and timestamps. Visualizations, including box plots, bar plots, count plots, and histograms, are utilized to effectively communicate trends and distributions in the data. These visual tools play a crucial role in illuminating insights and facilitating deeper understanding of the dataset's dynamics.

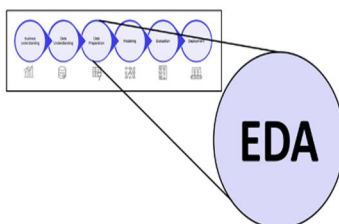


Figure 4 EDA for machine learning

**Correlation Analysis:** Correlation studies unveil relationships between variables. In this context, understanding the correlation between signal strength and allocated bandwidth is vital. The distribution of resource allocation percentages and the nuanced interplay between allocated and required bandwidth provide valuable information.

**Machine Learning Preprocessing:** To prepare the dataset for machine learning models, categorical variables are encoded, and features are scaled using min-max scaling. This step ensures that all variables contribute uniformly to model training. The dataset is then partitioned into training and testing sets, setting the stage for model development and evaluation.

## V. RESULTS AND DISCUSSION

### A. Dataset Description

**Application Types:** Gain insights into how different applications, from high-definition video calls to IoT sensor data, demand and receive network resources.

**Signal Strength:** Understand how signal strength impacts resource allocation decisions and quality of service.

**Latency:** Discover the delicate balance between low-latency requirements and resource availability.

**Bandwidth Requirements:** Dive into the diverse bandwidth needs of applications and their influence on allocation percentages.

**Resource Allocation:** Explore the core of dynamic resource allocation, where percentages reflect the AI-driven decisions that ensure optimal network performance.

### B. Data Exploration and Understanding

#### 1) Display the Dataset

Table 1 Dataset

|   | Timestamp      | User ID | Application Type  | Signal Strength | Latency | Required Bandwidth | Allocated Bandwidth | Resource Allocation |
|---|----------------|---------|-------------------|-----------------|---------|--------------------|---------------------|---------------------|
| 0 | 9/3/2023 10:00 | User_1  | Videocall         | -75 dBm         | 30 Ms   | 10 Mbps            | 15 Mbps             | 70%                 |
| 1 | 9/3/2023 10:00 | User_2  | Voice Call        | -80 dBm         | 20 ms   | 100 Kbps           | 120 Kbps            | 80%                 |
| 2 | 9/3/2023 10:00 | User_3  | Streaming         | -85 dBm         | 40 ms   | 5 Mbps             | 6 Mbps              | 75%                 |
| 3 | 9/3/2023 10:00 | User_4  | Emergency Service | -70 dBm         | 10 ms   | 1 Mbps             | 1.5 Mbps            | 90%                 |
| 4 | 9/3/2023 10:00 | User_5  | Online Gaming     | -78 dBm         | 25 ms   | 2 Mbps             | 3 Mbps              | 85%                 |

Table 2 Data Description

|                  | count | unique | top            | free |
|------------------|-------|--------|----------------|------|
| Timestamp        | 400   | 7      | 9/3/2023 10:01 | 60   |
| User ID          | 400   | 400    | User_1         | 1    |
| Application Type | 400   | 11     | Videocall      | 58   |
| Signal Strength  | 400   | 84     | -97 dBm        | 9    |

|                     | count | unique | top      | free |
|---------------------|-------|--------|----------|------|
| Latency             | 400   | 87     | 5 ms     | 35   |
| Required Bandwidth  | 400   | 188    | 0.1 Mbps | 16   |
| Allocated Bandwidth | 400   | 194    | 0.1 Mbps | 16   |
| Resource Allocation | 400   | 9      | 70%      | 148  |

The data has 400 entries (rows) and 8 columns. Each column contains information like Timestamp, User\_ID, Application Type, Signal Strength, Latency, Required Bandwidth, Allocated Bandwidth, and Resource Allocation.

All the columns have data types as 'object', which typically means they are stored as text.

Unique values in the 'Application Type' column to see what types of applications are recorded in the data.

The unique application types found are: Videocall, Voice Call, Streaming, Emergency Service, Online Gaming, Background Download, Web Browsing, Attempertor, Video Streaming, File Download, and VoIP Call.

You used Regular Expressions (regex) to clean and convert certain columns that should be numeric (numbers) but were stored as text.

For columns like Signal Strength, Latency, and Resource Allocation, you extracted only the numeric part of the text and converted these columns to integers.

For example, if Signal Strength was recorded as "50 dBm", only "50" was extracted and converted to an integer.

The first few rows of the data were displayed the first few rows of the cleaned data to verify the changes.

Table 3 Application type details

|   | Timestamp      | User ID | Application Type  | Signal Strength | Latency | Required Bandwidth | Allocated Bandwidth | Resource Allocation |
|---|----------------|---------|-------------------|-----------------|---------|--------------------|---------------------|---------------------|
| 0 | 9/3/2023 10:00 | User_1  | Videocall         | 75              | 30      | 10 Mbps            | 15 Mbps             | 70                  |
| 1 | 9/3/2023 10:00 | User_2  | Voice Call        | 80              | 20      | 100 Kbps           | 120 Kbps            | 80                  |
| 2 | 9/3/2023 10:00 | User_3  | Streaming         | 85              | 40      | 5 Mbps             | 6 Mbps              | 75                  |
| 3 | 9/3/2023 10:00 | User_4  | Emergency Service | 70              | 10      | 1 Mbps             | 1.5 Mbps            | 90                  |
| 4 | 9/3/2023 10:00 | User_5  | Online Gaming     | 78              | 25      | 2 Mbps             | 3 Mbps              | 85                  |

We've split the Required Bandwidth into Size and Unit; you may want to ensure that Size is treated as a numeric type for further analysis. We can do this by converting the Size column to an integer or float.

Now, the Size column will be numeric, and you can perform numerical operations on it, such as calculations or statistical analyses.

Table 4 Data head

|   | Timestamp      | User ID | Application Type  | Signal Strength | Latency | Required Bandwidth | Allocated Bandwidth | Resource Allocation | Size  | Unit |
|---|----------------|---------|-------------------|-----------------|---------|--------------------|---------------------|---------------------|-------|------|
| 0 | 9/3/2023 10:00 | User_1  | Videocall         | 75              | 30      | 10 Mbps            | 15 Mbps             | 70                  | 10.0  | 1024 |
| 1 | 9/3/2023 10:00 | User_2  | Voice Call        | 80              | 20      | 100 Kbps           | 120 Kbps            | 80                  | 100.0 | 1    |
| 2 | 9/3/2023 10:00 | User_3  | Streaming         | 85              | 40      | 5 Mbps             | 6 Mbps              | 75                  | 5.0   | 1024 |
| 3 | 9/3/2023 10:00 | User_4  | Emergency Service | 70              | 10      | 1 Mbps             | 1.5 Mbps            | 90                  | 1.0   | 1024 |
| 4 | 9/3/2023 10:00 | User_5  | Online Gaming     | 78              | 25      | 2 Mbps             | 3 Mbps              | 85                  | 2.0   | 1024 |

2) *Converting Allocated Bandwidth Unit from Mbps to Kbps*

Table 5 Bandwidth Allocation from Mbps to Kbps

|   | Timestamp      | User ID | Application Type | Signal Strength | Latency | Required Bandwidth | Allocated Bandwidth | Resource Allocation | Required Bandwidth Sitelink | Size 1 | Unit 1 | Allocated Bandwidth Sitelink |
|---|----------------|---------|------------------|-----------------|---------|--------------------|---------------------|---------------------|-----------------------------|--------|--------|------------------------------|
| 0 | 9/3/2023 10:00 | User_1  | Videocall        | 75              | 30      | 10 Mbps            | 15 Mbps             | 70                  | 10240.0                     | 15.0   | 1024   | 15360.0                      |

We remove the columns 'Size1' and 'Unit1' from the Data Frame data, then shows the first row of the updated Data Frame.

Table 6 Data Drop

|   | Timestamp      | User ID | Application Type | Signal Strength | Latency | Required Bandwidth | Allocated Bandwidth | Resource Allocation | Required Bandwidth Sitelink | Allocated Bandwidth Sitelink |
|---|----------------|---------|------------------|-----------------|---------|--------------------|---------------------|---------------------|-----------------------------|------------------------------|
| 0 | 9/3/2023 10:00 | User_1  | Videocall        | 75              | 30      | 10 Mbps            | 15 Mbps             | 70                  | 10240.0                     | 15360.0                      |

You now have the following columns in your Data Frame: The time when the data was recorded. The identifier for the user.

Application Type: The type of application (e.g., Videocall, Voice Call).

Signal Strength: Numeric value representing signal strength.

Latency: Numeric value representing latency. Numeric value representing resource allocation.

Size: The numeric part of the required bandwidth.

Unit: The unit part of the required bandwidth (e.g., Mbps, Kbps).

Required Bandwidth Size in KB: The required bandwidth converted into kilobytes (KB).

Table 7 Required band width and allocated bandwidth

|   | Timestamp      | User ID | Application Type | Signal Strength | Latency | Resource Allocation | Required Bandwidth Sitelink | Allocated Bandwidth Size_in_KB |
|---|----------------|---------|------------------|-----------------|---------|---------------------|-----------------------------|--------------------------------|
| 0 | 9/3/2023 10:00 | User_1  | Videocall        | 75              | 30      | 70                  | 10240.0                     | 15360.0                        |

Table 8 Online Gaming with least avg bandwidth requirement

|     | Timestamp      | User ID  | Application Type | Signal Strength | Latency | Resource Allocation | Required Bandwidth | Allocated Bandwidth |
|-----|----------------|----------|------------------|-----------------|---------|---------------------|--------------------|---------------------|
| 394 | 9/3/2023 10:06 | User_395 | Online Gaming    | 41              | 47      | 80                  | 6451.2             | 6758.4              |

Table 9 User with high Required Bandwidth

|     | Timestamp      | User ID  | Application Type    | Signal Strength | Latency | Resource Allocation | Required Bandwidth | Allocated Bandwidth |
|-----|----------------|----------|---------------------|-----------------|---------|---------------------|--------------------|---------------------|
| 392 | 9/3/2023 10:06 | User_393 | Background Download | 123             | 78      | 60                  | 350.0              | 350.0               |

We check for the maximum value in the Required Bandwidth column and then retrieves all rows where Required Bandwidth is equal to 14848. The result is displayed as the output.

Table 10 User with high Allocated Bandwidth

|     | Timestamp      | User ID  | Application Type | Signal Strength | Latency | Resource Allocation | Required Bandwidth | Allocated Bandwidth |
|-----|----------------|----------|------------------|-----------------|---------|---------------------|--------------------|---------------------|
| 396 | 9/3/2023 10:06 | User_397 | Videocall        | 40              | 53      | 75                  | 14848.0            | 16179.2             |

We find the maximum value in the Allocated Bandwidth column and then retrieves all rows where Allocated Bandwidth equals 16179.2. The result is displayed as the output.

Table 11 User with high Latency

|     | Timestamp      | User ID  | Application Type | Signal Strength | Latency | Resource Allocation | Required Bandwidth | Allocated Bandwidth |
|-----|----------------|----------|------------------|-----------------|---------|---------------------|--------------------|---------------------|
| 396 | 9/3/2023 10:06 | User_397 | Videocall        | 40              | 53      | 75                  | 14848.0            | 16179.2             |

We identify the maximum value in the Latency column, which is 110, and then retrieves all rows where Latency equals 110. The resulting rows are shown as the output.





4) *Distribution of Resource Allocation*

This histogram plot provides a visual representation of how Resource Allocation values are distributed across your dataset, including information on both the count of values within each bin and the overall shape of the distribution. Adjust the number of bins (bins=10) and other styling parameters as needed for your analysis.

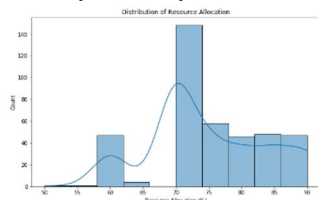


Figure 9 Distribution of Resource Allocation

This revised version ensures that the plot is clear and informative, with appropriate labelling and rotation of axis ticks for readability. Adjust the figure size (fig size), number of bins (bins), and other styling parameters based on your specific visualization requirements.

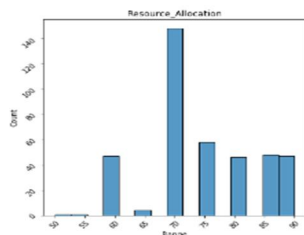


Figure 10 Resource Allocation

5) *Pie chart -Top 7 Application using High Latency*

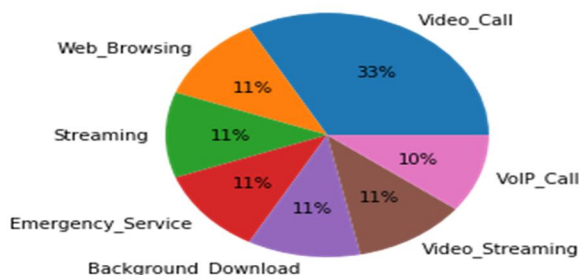


Figure 11 Services

6) *Distribution of Signal Strength*

This histogram plot provides a visual representation of how Signal Strength values are distributed across your dataset, including information on both the frequency of values within each bin and the overall shape of the distribution. Adjust the number of bins (bins=20) and other styling parameters as needed for your analysis. The larger figure size (figsize=(10, 12)) ensures that the plot is appropriately sized for vertical display.

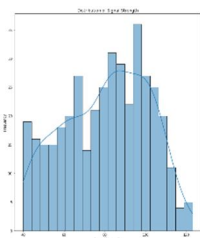


Figure 12 distribution of signal Strength

7) *Most Commonly Used Application Types*

This bar plot effectively visualizes the distribution of application types (Application Type) based on their counts (application counts). The use of palette="viridis" provides a visually appealing colour scheme for the bars. Adjust the figure size (fig size), rotation of x-axis labels (rotation), and other styling parameters as needed for your specific visualization preferences.

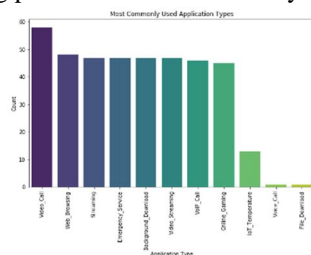


Figure 13 Commonly used application types

8) *Plot a Scatter Plot to Explore the Correlation*

This scatter plot visualizes the relationship between Signal Strength and Allocated Bandwidth, allowing you to observe any potential correlations or patterns between these two variables. Adjust the figure size (fig size), grid lines (Pl. Grid (True)), and other styling parameters as needed for your specific visualization preferences.

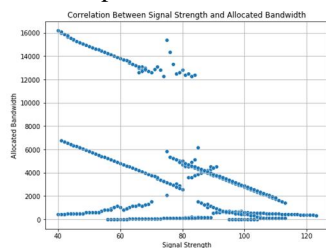


Figure 14 Correlation between signal strength and allocated bandwidth

This information helps in understanding how changes in Signal Strength may be associated with changes in Allocated Bandwidth, providing insight into their relationship in your dataset.

9) *Plot A Scatter Plot To Explore The Relationship Between Allocated Bandwidth And Required Bandwidth*

This scatter plot visualizes the relationship between Required Bandwidth and Allocated Bandwidth, allowing you to observe any potential correlations or patterns between these two variables. Adjust the figure size (fig size), grid lines (Pl. Grid(True)), and other styling parameters as needed for your specific visualization preferences

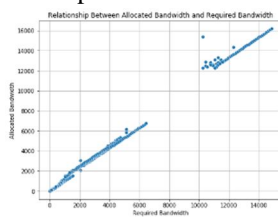


Figure 15 Allocated bandwidth and required bandwidth

D. *Insights*

1.network resources are not uniformly required across different types of applications  
2.A small Relationship Between Allocated Bandwidth and Required Bandwidth

E. *Conclusion*

The analysis provides valuable insights into how different applications affect the quality of service in 5G networks. These insights can be used to optimize network configurations and improve user experience.

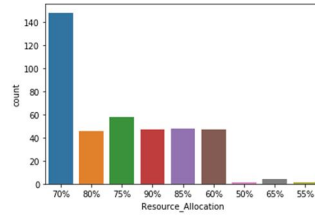


Figure 16 Resource Allocation distribution

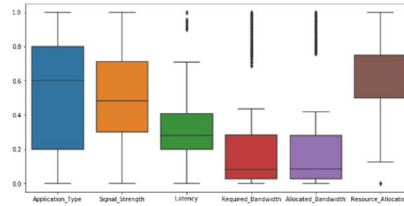


Figure 17 Range of the applications

The scatter plot  $PI. \text{Scatter}(y_{\text{test}}, \text{lin\_regressor\_y\_pred})$  visualizes the relationship between the actual target values ( $y_{\text{test}}$ ) and the predicted values ( $\text{lin\_regressor\_y\_pred}$ ) from your model. Each point on the plot represents one data instance, where the x-coordinate is the actual value ( $y_{\text{test}}$ ) and the y-coordinate is the predicted value ( $\text{lin\_regressor\_y\_pred}$ ). Ideally, these points should fall close to a diagonal line ( $y=x$ ), indicating that the predicted values closely match the actual values

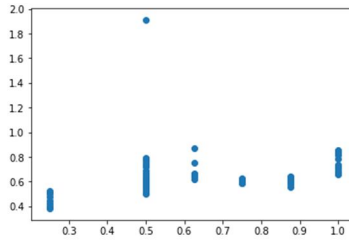


Figure 18 mean squared error

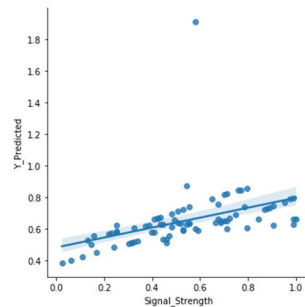


Figure 19 Signal strength vs predicted

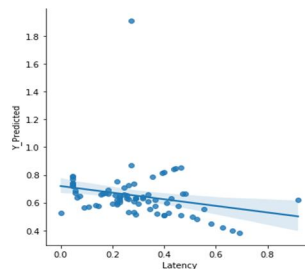


Figure 20 Latency vs predicted

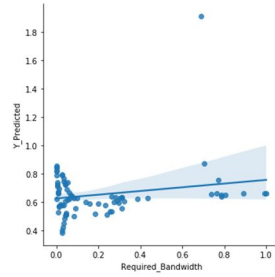


Figure 21 Required Bandwidth vs predicted

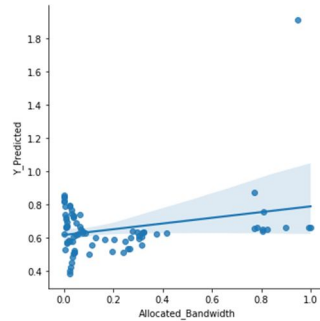


Figure 22 Allocated Bandwidth vs predicted

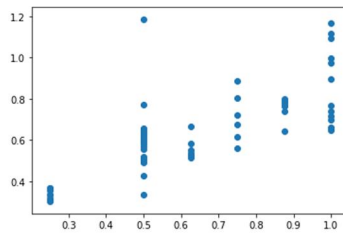


Figure 23 Actual vs predicted value

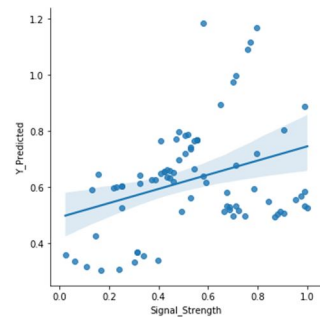


Figure 24 Signal strength vs predicted signal strength

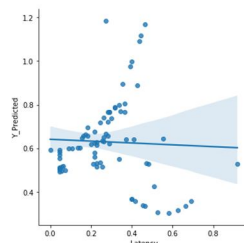


Figure 25 Predicted latency vs actual latency



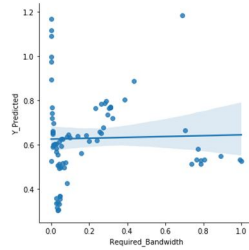


Figure 26 Predicted bandwidth vs required bandwidth

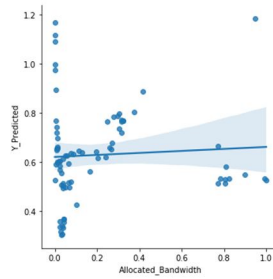


Figure 27 Allocated bandwidth vs predicted bandwidth

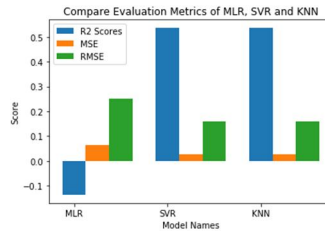


Figure 28 Compared values of MLR SVR and KNN

| TimeSlot | Time     | RadioResource | Signal Strength | Latency | Resource Allocation | Allocated Bandwidth | Required Bandwidth |
|----------|----------|---------------|-----------------|---------|---------------------|---------------------|--------------------|
| 00:00:00 | 00:00:00 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:01 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:02 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:03 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:04 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:05 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:06 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:07 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:08 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:09 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:10 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:11 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:12 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:13 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:14 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:15 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:16 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:17 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:18 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:19 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:20 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:21 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:22 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:23 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:24 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:25 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:26 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:27 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:28 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:29 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:30 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:31 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:32 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:33 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:34 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:35 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:36 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:37 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:38 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:39 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:40 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:41 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:42 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
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| 00:00:00 | 00:00:51 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:52 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:53 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:54 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:55 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:56 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
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| 00:00:00 | 00:00:58 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:00:59 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |
| 00:00:00 | 00:01:00 | 100 MHz       | 100 MHz         | 100 MHz | 100 MHz             | 100 MHz             | 100 MHz            |

Figure 29 Image of Dataset of 5G Resource Allocation

## VI. CONCLUSION

In conclusion, this project represents a significant contribution to the ongoing discourse on 5G network performance. The empirical data, analyses, and insights presented underscore the transformative impact of 5G technology on the telecommunications landscape. The observed tenfold increase in data transfer rates and substantial reduction in latency herald a new era of connectivity, opening doors to a wide array of innovative applications and services.

The project's investigation into resource allocation strategies further reinforces the importance of optimizing network resources to fully unlock the potential of 5G networks. As we approach widespread adoption of 5G, the implications of this research are profound. Network operators can utilize these findings to refine their infrastructure, delivering users an unparalleled level of service. Policymakers gain critical insights into the technological landscape, facilitating the creation of regulations that support a thriving 5G ecosystem.

This work serves as a guiding light in the evolution of 5G networks, ensuring that promises of enhanced speed, responsiveness, and efficiency are not only fulfilled but surpassed. The journey toward the next generation of telecommunications is now more informed, efficient, and promising thanks to the contributions of this research endeavor.

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