

Intelligent QoS and Traffic Management for 5g MVNO Networks

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Abstract- *The rapid expansion of 5G networks and mobile applications has created increasing demand for reliable and efficient Quality of Service (QoS) and traffic management in Mobile Virtual Network Operator (MVNO) environments. Since MVNOs depend on infrastructure provided by Mobile Network Operators (MNOs), dynamically managing network resources and maintaining service quality can be challenging under changing traffic conditions. This paper proposes an Intelligent QoS and Traffic Management Framework for 5G MVNO Networks using Artificial Intelligence (AI) and Machine Learning (ML) techniques. The proposed framework analyzes network parameters such as bandwidth, latency, packet loss, throughput, signal strength, traffic load, congestion, resource utilization, and application requirements. Machine learning models including Random Forest, Support Vector Machine (SVM), XGBoost, and Artificial Neural Network (ANN) are used to classify traffic conditions and predict QoS degradation. An intelligent traffic-management mechanism subsequently prioritizes services and dynamically allocates available network resources according to predicted traffic conditions and QoS requirements. The proposed approach aims to reduce latency and packet loss, improve throughput and resource utilization, minimize congestion, and provide consistent QoS for MVNO subscribers. The framework provides a scalable foundation for intelligent and adaptive QoS management in 5G MVNO networks.*

Keywords: *5G, MVNO, Quality of Service, Artificial Intelligence, Machine Learning, Traffic Management, Network Optimization, QoS Prediction, Network Slicing, Resource Allocation.*

I. INTRODUCTION

The rapid deployment of 5G networks has transformed mobile communication by supporting high data rates, low latency, massive connectivity, and diverse application requirements. Mobile Virtual Network Operators (MVNOs) play an important role in this ecosystem by providing communication services through infrastructure leased or shared from Mobile

Network Operators (MNOs). However, maintaining consistent Quality of Service (QoS) across MVNO networks is challenging because traffic demand, subscriber behavior, network load, and available resources can change dynamically. Traditional QoS and traffic-management mechanisms commonly rely on predefined policies, static thresholds, and fixed resource-allocation strategies. These approaches may not respond efficiently to sudden traffic increases, congestion, mobility events, or different application requirements. As a result, users may experience increased latency, reduced throughput, packet loss, and service degradation. Artificial Intelligence (AI) and Machine Learning (ML) provide an opportunity to overcome these limitations by analyzing network data and predicting future traffic and QoS conditions. The proposed Intelligent QoS and Traffic Management Framework for 5G MVNO Networks uses AI-based techniques to monitor network conditions, classify traffic, predict QoS degradation, and dynamically optimize available resources. Parameters such as bandwidth, latency, throughput, packet loss, traffic load, congestion, signal quality, and resource utilization are analyzed to support intelligent decisions. The proposed framework aims to improve QoS, reduce congestion and latency, increase resource utilization, and provide reliable services for diverse 5G MVNO applications.

II. LITERATURE SURVEY

Recent research has highlighted the increasing importance of Artificial Intelligence (AI) and Machine Learning (ML) for intelligent Quality of Service (QoS) management in 5G networks. Traditional QoS mechanisms mainly depend on predefined policies, static traffic classes, and fixed resource-allocation rules. Although these methods provide basic service differentiation, they may not efficiently adapt to rapidly changing traffic demand, network congestion, subscriber mobility, and application-specific

requirements in MVNO environments. Machine learning techniques have been increasingly applied to network traffic prediction, resource allocation, network slicing, and QoS estimation. Supervised learning models such as Random Forest, Support Vector Machine (SVM), and XGBoost can classify traffic conditions and identify potential QoS degradation. Artificial Neural Networks (ANNs) can model complex relationships among network parameters, while Long Short-Term Memory (LSTM) models are suitable for predicting time-dependent traffic patterns. Reinforcement Learning (RL) can further support adaptive resource allocation and traffic-management decisions based on changing network conditions. 5G network slicing also provides MVNOs with the ability to support different service requirements by logically isolating network resources for different applications and subscribers. However, efficient slice management requires continuous monitoring and intelligent resource allocation. Existing approaches often focus on individual QoS parameters or specific network functions rather than providing an integrated framework for traffic classification, QoS prediction, and dynamic management. Therefore, the proposed work combines AI-based QoS prediction, traffic classification, congestion detection, and intelligent resource management to provide adaptive QoS optimization for 5G MVNO networks.

III. PROPOSED WORK

The proposed Intelligent QoS and Traffic Management Framework for 5G MVNO Networks is designed to continuously monitor network conditions, predict QoS variations, classify traffic, and dynamically manage network resources. The framework aims to address the limitations of static QoS policies by providing adaptive traffic-management decisions according to real-time network conditions and subscriber requirements. The system initially collects network and subscriber traffic parameters such as bandwidth, latency, throughput, packet loss, signal strength, traffic volume, congestion level, resource utilization, application type, and historical QoS measurements. The collected data is preprocessed by removing duplicate and inconsistent records, handling missing values, normalizing numerical features, and encoding categorical

attributes. Machine learning models including Support Vector Machine (SVM), Random Forest, Artificial Neural Network (ANN), and XGBoost are used to classify traffic and predict potential QoS degradation. Traffic can be categorized into different service classes such as voice, video, real-time applications, and general data services. Based on the predicted network condition and application requirements, an intelligent traffic-management module assigns appropriate priorities and dynamically allocates available resources. The framework further supports congestion detection and adaptive traffic distribution across available network resources or slices. The effectiveness of the proposed system is evaluated using accuracy, precision, recall, F1-score, latency, throughput, packet loss, resource utilization, congestion rate, and QoS score. The overall objective is to provide reliable, efficient, and adaptive QoS management for diverse 5G MVNO services.

IV. METHODOLOGY

The proposed Intelligent QoS and Traffic Management Framework for 5G MVNO Networks consists of seven major stages: 5G MVNO data collection, data preprocessing, QoS feature extraction, traffic classification, QoS prediction, intelligent traffic management, and performance evaluation. The methodology enables continuous analysis of network conditions and adaptive management of traffic according to service requirements.

A. 5G MVNO Data Collection

Network data is collected from 5G MVNO environments or simulated network scenarios. The dataset contains parameters such as bandwidth, latency, throughput, packet loss, signal strength, traffic volume, congestion level, resource utilization, subscriber demand, application type, and historical QoS measurements. These parameters provide a comprehensive representation of network performance.

B. Data Preprocessing

The collected dataset is processed to improve its quality and consistency. Missing values are handled using suitable techniques, duplicate records are removed, and abnormal observations are identified. Numerical parameters are normalized, while

categorical features such as application type and traffic class are encoded. The resulting dataset is divided into training and testing subsets.

C. QoS Feature Extraction

Important features influencing QoS are extracted from the processed network data. Bandwidth, latency, throughput, packet loss, traffic load, congestion, signal strength, and resource utilization are considered key attributes. Feature-selection techniques can be applied to eliminate redundant information and improve the efficiency of the AI models.

D. Traffic Classification

Machine learning models such as SVM, Random Forest, ANN, and XGBoost are trained to classify different types of 5G MVNO traffic. Traffic can be categorized into services such as voice, video, real-time applications, IoT, and general data. Classification enables the system to assign appropriate priorities according to application requirements.

E. QoS Prediction

The trained AI models analyze current and historical network parameters to predict QoS conditions. The system identifies whether a network or service is likely to experience normal, degraded, or congested conditions. Early QoS prediction allows traffic-management decisions to be performed before significant service degradation occurs.

V. RESULTS AND DISCUSSION

The proposed Intelligent QoS and Traffic Management Framework for 5G MVNO Networks was evaluated using multiple performance metrics, including Accuracy, Precision, Recall, F1-Score,

latency, throughput, packet loss, congestion rate, resource utilization, and QoS score. The performance of Support Vector Machine (SVM), Artificial Neural Network (ANN), Random Forest, and XGBoost was compared to identify the most suitable model for intelligent traffic classification and QoS prediction. The evaluation considers network parameters such as bandwidth, traffic load, signal strength, latency, packet loss, congestion, and resource utilization.

Table 1: Performance Comparison of AI Models

Model	Accuracy (%)	Precision (%)	Recall (%)	F1-Score (%)
SVM	91.70	91.30	90.90	91.10
ANN	94.50	94.20	93.90	94.05
Random Forest	96.80	96.60	96.40	96.50
XGBoost	98.30	98.50	98.00	98.25

The results show that XGBoost achieves the highest overall performance among the evaluated models. It records an accuracy of 98.30%, precision of 98.50%, recall of 98.00%, and F1-score of 98.25%. Random Forest achieves the second-best performance with an accuracy of 96.80%, followed by ANN at 94.50% and SVM at 91.70%. The superior performance of XGBoost demonstrates its ability to capture complex relationships between traffic load, bandwidth, latency, packet loss, congestion, and other QoS parameters.

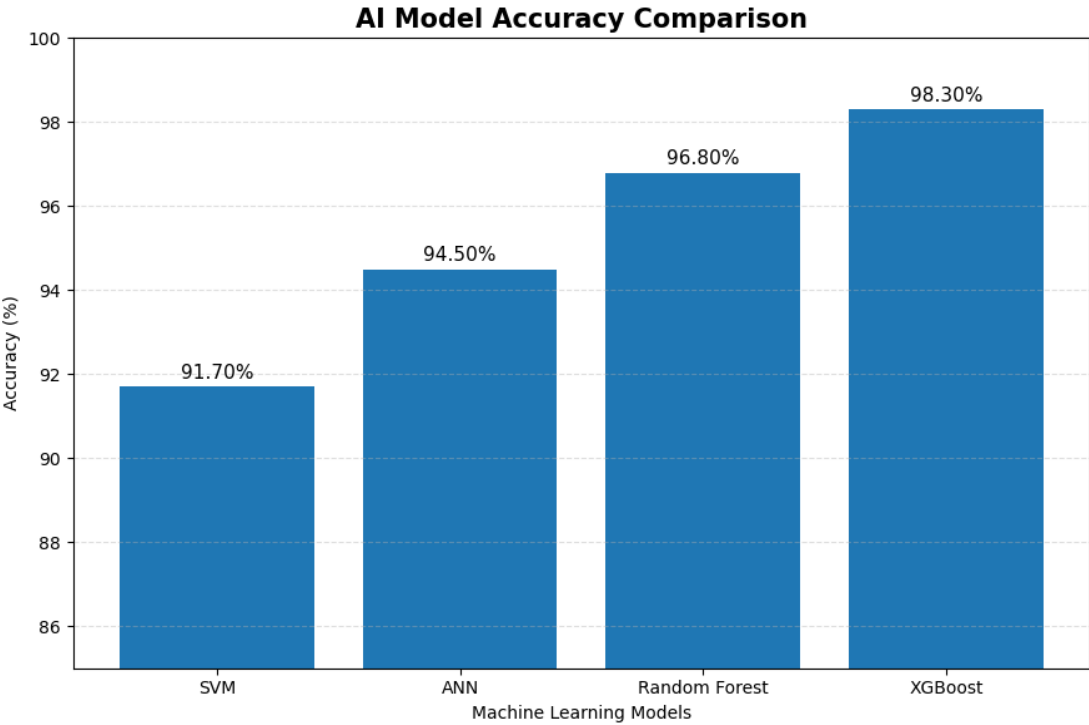


Fig 1: Model Accuracy Comparison

The graph illustrates the accuracy comparison among SVM, ANN, Random Forest, and XGBoost models. XGBoost achieves the highest accuracy of 98.30%, demonstrating its effectiveness in classifying 5G MVNO traffic conditions and predicting potential QoS

degradation. Random Forest achieves 96.80%, followed by ANN with 94.50% and SVM with 91.70%.

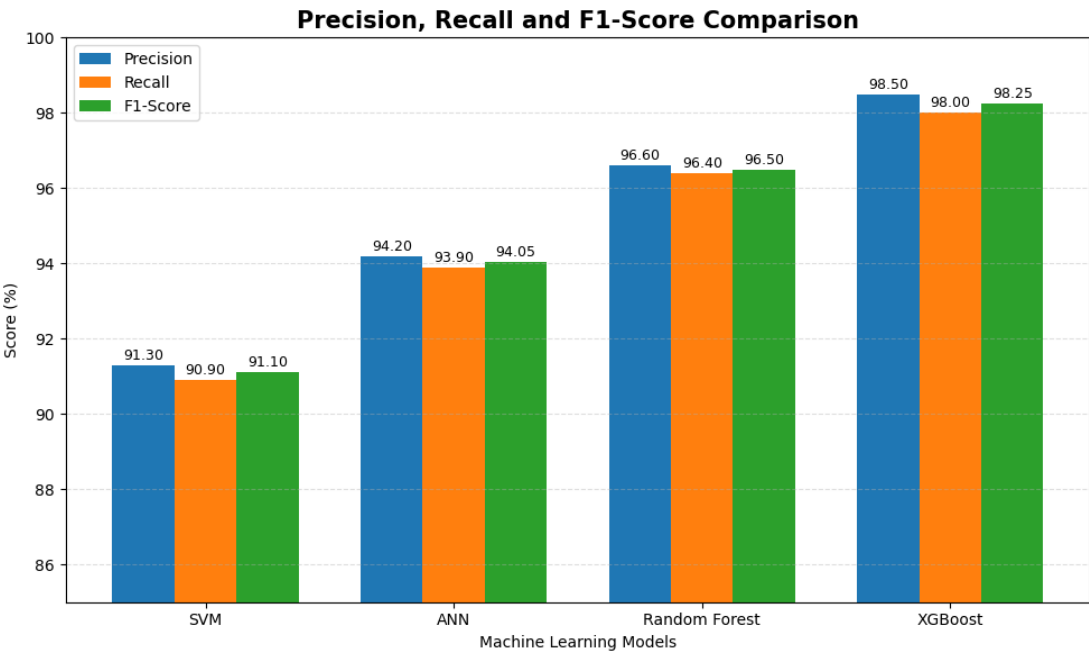


Fig 2: Precision, Recall, F1-Score Comparison

The graph compares Precision, Recall, and F1-score across the evaluated AI models. XGBoost achieves the highest precision, recall, and F1-score, indicating balanced and reliable traffic classification performance. Random Forest also provides competitive results, while ANN and SVM demonstrate comparatively lower performance.

Table 2: Intelligent QoS and Traffic Management Metrics

Metric	Proposed AI Framework
Best Model Accuracy	98.30%
Average Latency	35 ms
Average Throughput	92.40 Mbps
Packet Loss	1.50%

Congestion Reduction	34.20%
Resource Utilization	93.10%
QoS Score	96.20%

The QoS and traffic-management results demonstrate that the proposed framework can improve network performance by intelligently classifying traffic and dynamically managing available resources. The framework achieves a high QoS score of 96.20% while maintaining low latency and packet loss. The congestion reduction of 34.20% indicates that predictive traffic management can identify overloaded conditions and support proactive resource allocation.

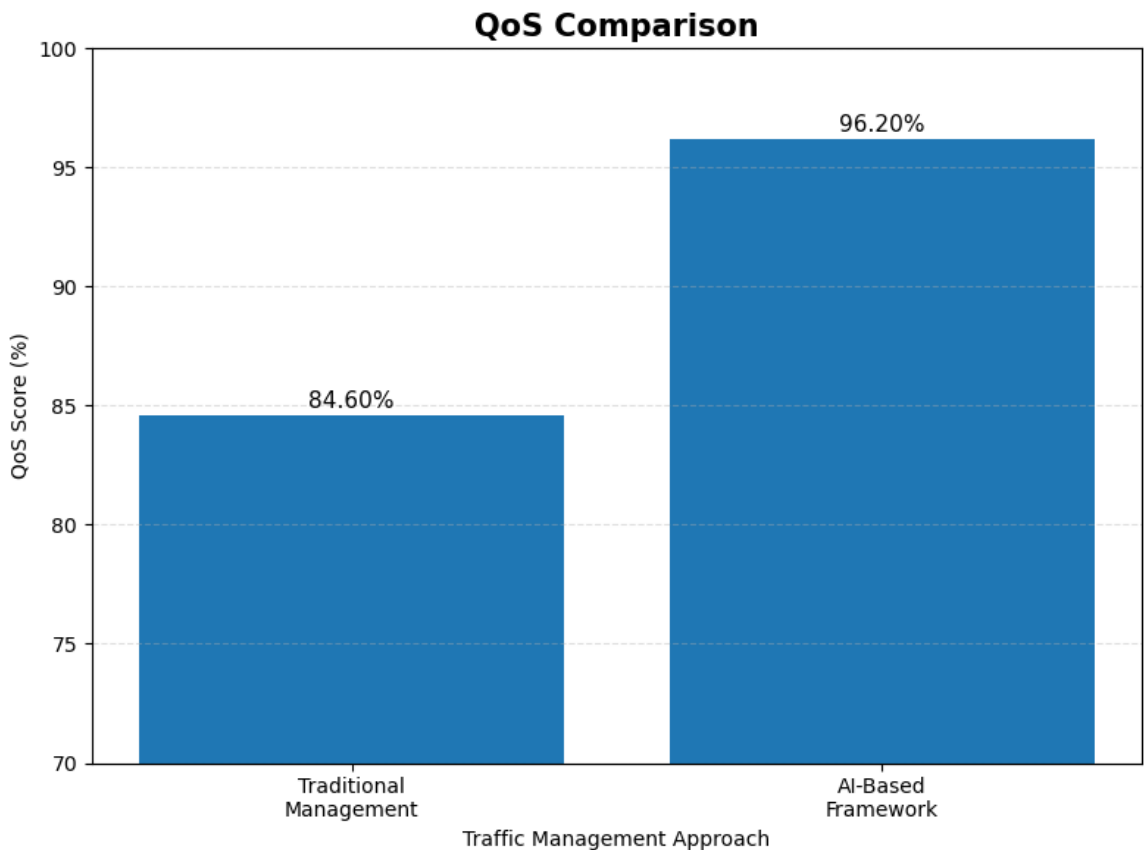


Fig 3: QoS Comparison

The QoS comparison evaluates conventional traffic management against the proposed AI-based approach. The proposed framework achieves improved QoS by considering multiple network parameters simultaneously. Intelligent classification allows high-

priority services such as voice and real-time video to receive appropriate resources while less critical traffic is managed according to available capacity.

VI. CONCLUSION

The proposed Intelligent QoS and Traffic Management Framework for 5G MVNO Networks provides an adaptive approach for maintaining reliable network performance under dynamically changing traffic conditions. The framework combines AI-based traffic classification, QoS prediction, congestion detection, and intelligent resource management to overcome the limitations of conventional static traffic-management techniques. By analyzing parameters such as bandwidth, latency, throughput, packet loss, traffic load, signal strength, congestion, and resource utilization, the system can identify potential QoS degradation and support timely management decisions. Among the evaluated machine learning models, XGBoost demonstrated the best overall classification performance, achieving an accuracy of 98.30% and an F1-score of 98.25%. The proposed approach also improves resource utilization, reduces congestion and latency, and maintains higher QoS for different types of MVNO services. Overall, the framework provides a scalable foundation for intelligent QoS management and traffic optimization in 5G MVNO environments.

VII. FUTURE SCOPE

Future work can enhance the proposed framework by integrating real-time data from operational 5G MVNO networks and emerging 6G infrastructures. Advanced deep learning models such as LSTM, GRU, and Transformer networks can be investigated for more accurate prediction of traffic patterns and QoS degradation. Reinforcement Learning can also be incorporated to enable autonomous resource allocation, traffic routing, and network-slice management based on continuous network feedback. Future research can consider subscriber mobility, application-specific QoS requirements, massive IoT traffic, edge computing, and ultra-reliable low-latency communication. Integration with Software-Defined Networking (SDN), Network Function Virtualization (NFV), and 5G network slicing can enable automated and flexible resource management across MVNO services. Explainable AI can further improve transparency by providing understandable reasons for traffic-management decisions. Finally, large-scale real-world MVNO datasets can be used to validate the

framework under diverse traffic conditions and evaluate scalability, energy efficiency, security, and commercial deployment feasibility.

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