Quality of Service (QoS) Classification in 5G Networks Using Machine Learning

EC431 - 5G Communication and Network
Indian Institute of Information Technology Vadodara - International Campus Diu

Dinesh Yadav
202211020@diu.iiitvadodara.ac.in

Isha Jangir
202211031@diu.iiitvadodara.ac.in

Kamal Meena
202211036@diu.iiitvadodara.ac.in

***Abstract*—This paper explores the integration of machine learning techniques to classify Quality of Service (QoS) flows in 5G networks. The dynamic and heterogeneous nature of 5G traffic poses challenges to traditional QoS management strategies. We review QoS parameters, discuss machine learning approaches, and examine their potential in improving network performance.**

I. Introduction

5G technology promises ultra-reliable low latency communication (URLLC), enhanced mobile broadband (eMBB), and massive machine-type communication (mMTC). These use cases require different levels of Quality of Service (QoS). Classifying and managing QoS flows accurately is crucial for efficient resource allocation and service delivery.

II. QoS Parameters in 5G

5G QoS is determined by key performance indicators such as latency, bandwidth, reliability, jitter, and packet loss. These are essential for ensuring smooth operation of real-time applications.

TABLE I
SUMMARY OF QOS PARAMETERS

Parameter	Description	Importance
Latency	Delay between request and response	Real-time feedback
Bandwidth	Throughput / data rate	High-data apps
Reliability	Consistency of service	Uninterrupted operation
Packet Loss	Lost or missing packets	Data integrity
Jitter	Variation in delay	Real-time flow

III. Machine Learning Approaches

A. Reinforcement Learning

Reinforcement Learning (RL) agents interact with the environment and learn optimal policies through feedback (rewards). RL dynamically allocates resources based on real-time demands and conditions. It adapts to changing traffic patterns, making it suitable for managing QoS in dynamic 5G environments.

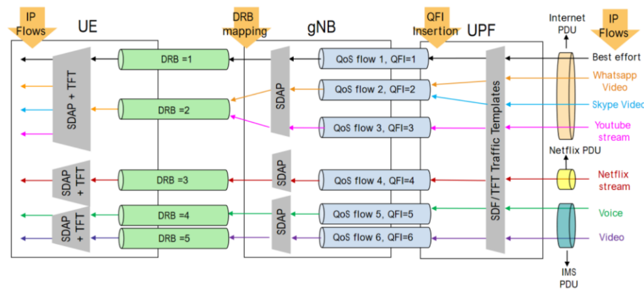

Fig. 1. 5G Quality of Service Flow

A widely used RL algorithm in this context is Proximal Policy Optimization (PPO), which balances exploration and exploitation while ensuring stable and efficient learning. PPO's clipped objective function helps prevent large policy updates, making it particularly robust for QoS optimization tasks in highly dynamic network scenarios.

B. Deep Learning

Deep neural networks (DNNs) can learn high-dimensional patterns in traffic flow and signal characteristics. Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) have shown promise in predicting and preventing QoS degradation under complex network dynamics.

IV. Model Comparison

Reinforcement Learning (RL) and Deep Learning (DL) each bring distinct advantages to QoS classification in 5G networks.

RL models, such as Proximal Policy Optimization (PPO), excel in adaptive decision-making and real-time resource allocation. They are well-suited for dynamic environments but often require extensive training time and computational resources due to their trial-and-error learning process.

DL models, including Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs), are powerful in identifying complex patterns in high-dimensional data such as traffic flow and signal characteristics. They deliver high accuracy with sufficient labeled data but may struggle to adapt rapidly to changing network conditions without retraining.

Combining both approaches in hybrid architectures can leverage the adaptability of RL and the representational power of DL, offering a promising direction for robust QoS management in 5G.

V. Discussion and Trends

Recent research indicates that combining RL and DL can lead to robust and scalable QoS classification systems. Hybrid models utilizing deep reinforcement learning (DRL) are particularly promising. Future work can explore online training and deployment on edge devices for real-time inference.

VI. Conclusion

Machine learning offers a promising approach to address QoS challenges in 5G networks. Accurate QoS classification ensures efficient resource use, better user experience, and service differentiation. Continued research will optimize these models for real-world deployment.

References

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