

# AI-Driven QoS

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## Introduction

Computer networks are a complex communication method, especially at larger scales. A number of issues exist that affect the “Quality of Service” (QoS) of the network. These include latency, packet loss, jitter, low throughput, and congestion. Latency is the delay, measured in milliseconds, of time for data to go from source to destination. Packet loss is when portions of data do not reach their destination. Jitter is when these packets arrive in irregular timing. Throughput is the rate at which data transferred over the connection. Finally, congestion is when there is more data to transport than the network has capacity for.

## Traditional QoS

Quality of Service, or QoS is an attempt at reducing the effects of these issues, leading to better network performance and ultimately a better user experience down the line. There are several methods already in use for improving the Quality of Service for traditional and modern networks. These include traffic policing, congestion management, admission control, resource reservation, and overprovisioning.

In order to implement traffic policing, policies are written to limit the speed of certain traffic based on priority. This allows more important users or data to take priority. Congestion management regulates packet queues in an attempt at limiting congestion, and does so in part by dropping lower priority packets. Admission control prevents new flows from starting in case of high congestion or other QoS issues. Resource reservation can be used in high priority networks to set aside network resources for a given flow to make sure that it works properly without competition. Finally, another option for traditional QoS is overprovisioning. This is when network infrastructure is simply over built in the hopes that it can handle even the highest congestion times. In practice most, if not all, of these methods are combined to ensure the best balance between cost and quality. [1]

## The Problem

Traditional Quality of Service methods have been effective for many years, however, many emerging technologies require more complex and reliable networking. Fortunately, artificial intelligence is now a viable possibility for improving network QoS. Upcoming 6G networks will

likely need to rely on Artificial Intelligence in order to operate reliably and provide benefits over 5g. The future of networked vehicles will introduce new challenges that will require modern QoS solutions. Other areas that would benefit from AI-driven QoS are low Earth orbit satellites, smart cities, disaster communications, real time communications, video transmission, edge computing, and drone systems.

The problem with traditional Quality of Service methods is that they are primarily static and reactive, rather than flexible and proactive. They also often require significant configuration, management, and expense. They are also not always able to see the bigger picture and compile that information for an overall best approach. Fortunately, Artificial Intelligence solutions can remedy many of these downsides. AI-driven QoS is easier to manage, more dynamic, predictive, and reliable. One study found that their AI QoS solution led to a faster, more reliable, and more efficient network [2].

## AI-Driven QoS

AI based and traditional Quality of Service methods have several fundamental differences. The first is that traditional methods rely on human programmed rules, while AI methods take a dynamic learning approach with less human intervention. Another difference is that some AI methods are able to perform more behavior and deep packet inspection while many traditional methods rely solely on header information. Finally, AI systems are more scalable due to automation and lower requirements for human management. These factors give AI-Driven QoS benefits in speed, reliability, efficiency, and long-term cost. [3]

As it is a developing field, there are varying methods of implementing AI into QoS solutions. Most likely, they would combine traditional QoS methods with some of the following Artificial Intelligence and Machine Learning techniques. The first is traffic classification. AI models can be much more flexible and dynamic when classifying traffic and make decisions based on combined information. The AI model types proposed for this task are convolutional neural networks (CNN) and recurrent neural networks (RNN) [2].

The next technique is predictive analytics. Predictive analytics are key to providing proactive management in order to prevent issues from occurring in the first place, rather than simply reacting to and fixing them. Historical data such as traffic patterns are taken into account and updated continually. [4]

AI agents can also help with dynamic resource slicing. Instead of predefined slices, they can be updated on the go, separating the higher and lower priority traffic. Finally, deep reinforcement learning can be used to motivate continuing improvement. AI agents are able to evaluate the quality of service, and are motivated to make it better [5].

## Internet of Vehicles

The promise of self-driving cars has been a popular topic in recent years. There are currently so called “autonomous” vehicles that are an impressive show of technology. However, they’re currently pretty limited and we are not close to fully replacing human drivers. However, the advent of modern AI may be able to enable the next step in self-driving cars. Instead of each car relying on its own sensors to make decisions, each car could communicate with each other and their surroundings. This is referred to as the Internet of Vehicles (IoV). While not a complete solution, this could be a much better and safer version of self-driving cars. [6]

Presently, self-driving cars are categorized in 5 levels. Levels 0 and 1 can be found in many new cars and are more of additional safety features than “self-driving.” Level 2 provides a lot more, but still requires the driver’s full attention and hands on the wheel. In many scenarios the driver takes over. The current iteration of Tesla Autopilot falls in this category. In level 3 the car drives itself in many scenarios, but the driver must be ready to take over when it is unable to continue safely. Level 4 is fully autonomous but within certain scenarios only. Services like Waymo fall in this category. Level 5, or “Full Automation” would require that the car be fully capable of driving anywhere a human driver could drive with no interaction or attention required of the driver. [7]

In order to advance along the levels of automation, vehicles must eventually communicate with each other and their surroundings. Imagine that some condition causes two vehicles to be on a trajectory for collision. Instead of simulating human behavior, they could instantly collaborate to decide on the best course of action. This would not only be a great safety feature, but if all vehicles on the road could communicate with each other, they could collaborate to reduce traffic congestion and increase safe travel speeds. Various proposals for the Internet of Things suggest connecting cars to information such as traffic conditions, weather reports, traffic control infrastructure, speed limits, emergency services, and construction information. Along with this new technology comes a number of questions regarding ethics, law, and responsibility, but that is a topic of its own.

A network that could achieve such a task would be highly complex. Not only would it be more complex, but it would also come with a high responsibility for risk of safety to passengers and pedestrians. Therefore, there is a need for better Quality of Service management than currently available. This can be done with Artificial Intelligence.

One specific paper suggests a system that combines communication vehicle to vehicle, vehicle to base station, base station to controller, and controller to internet. See figure 1. AI agents would be involved at each step, ensuring quality of service in the network. The AI agents would aggregate data, optimize routing, and provide data management. One specific component of the system is “Mobility Scoring.” The AI system takes into account velocity, acceleration, and nearby vehicles to make decisions. Routing would be done via graph traversal algorithms. [8].

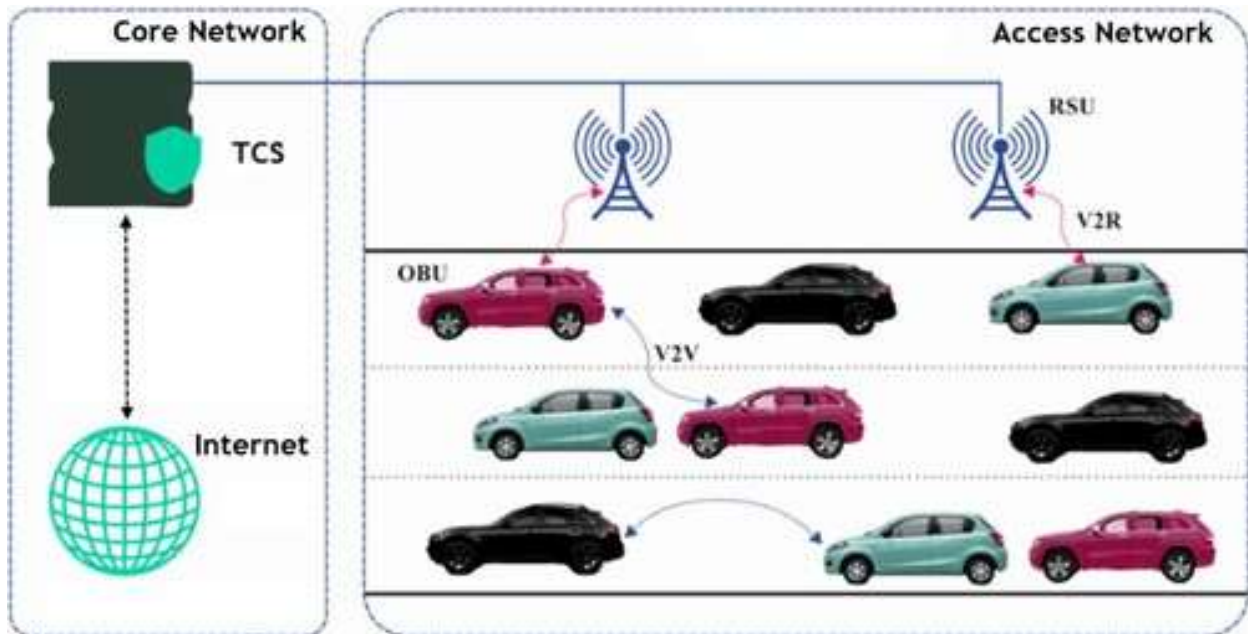


Figure 1

The paper concluded that this system reduces hardware overhead, optimizes load balancing, and provides a safer option for self-driving vehicles. However, there are some drawbacks to consider. For example, for a system like this to exist in real life there would need to be full collaboration and standardization between manufacturers of all vehicles, traffic infrastructure, and governments. It would also be nearly impossible to build a system like this that could extend everywhere someone might want to drive, for example in rural areas.

## Conclusion

Overall, there is a need for an improvement of Quality of Service for modern network use-cases such as networked vehicles. AI-driven QoS is more predictive and flexible compared to static and reactive traditional methods. It is better for speed, efficiency, reliability, and cost.

## Sources

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