Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 5, May : 2023

ARTIFICIAL INTELLIGENCE-ENABLED NETWORK TRAFFIC OPTIMIZATION: A COMPREHENSIVE SURVEY

Vikas Sharma, Assistant Professor, School of Computer Science and Applications, IIMT University, Meerut
Dr. Tarun Vashishth, Associate Professor, School of Computer Science and Applications, IIMT University, Meerut
Dr. Bhupendra Kumar, Associate Professor, School of Computer Science and Applications, IIMT University, Meerut
Sachin Chaudhary, Assistant Professor, School of Computer Science and Applications, IIMT University, Meerut
Rajneesh Panwar, Assistant Professor, School of Computer Science and Applications, IIMT University, Meerut
Shashank Sharma, Assistant Professor, School of Computer Science and Applications, IIMT University, Meerut

ABSTRACT:

As the volume and diversity of network traffic continues to increase, the efficient management of network traffic has become increasingly important. Artificial intelligence (AI) has emerged as a promising technology for network traffic handling, offering the potential to improve network performance, security, and quality of service (QoS) for end-users. The explosive growth of the internet and the increasing number of connected devices have led to a significant increase in network traffic. This increase in traffic poses significant challenges to network administrators in managing the traffic and ensuring efficient and reliable communication. The traditional methods of managing network traffic such as load balancing and QoS are not adequate to handle the dynamic and complex nature of modern networks. Artificial Intelligence (AI) techniques such as machine learning and deep learning have shown promise in addressing the challenges of network traffic management. In this paper, we propose an AI-based approach for network traffic management that utilizes machine learning algorithms to analyze network traffic and make intelligent decisions. We present a comprehensive review of existing AI-based traffic management techniques and propose a novel approach that integrates multiple algorithms to provide a more robust and accurate traffic management system. We also present experimental results on a simulated network to demonstrate the effectiveness of our proposed method. A simulation was conducted to compare the performance of the proposed method to traditional network traffic handling methods, and the results show that the proposed method outperforms traditional methods in terms of network utilization and packet loss.

KEYWORDS:

Artificial intelligence, Network traffic management, Machine learning, Deep learning, Load balancing, QoS.

I. INTRODUCTION:

The exponential growth in network traffic has led to increased demand for efficient network traffic handling. Traditional network traffic handling methods are no longer sufficient to meet the demands of modern networks. AI-based methods have shown great potential in optimizing network

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 5, May : 2023

traffic handling. AI can analyze and predict network traffic patterns, and dynamically allocate network resources to ensure optimal performance.

This research paper proposes a method for using AI to optimize network traffic handling. The proposed method utilizes machine learning algorithms to analyze network traffic patterns and predict future traffic. The method then dynamically adjusts network resources to ensure optimal performance.

1.1 AI in Network Traffic Handling:

There are several applications of AI in network traffic handling, including:

1. **Traffic Analysis:** AI can be used to analyze network traffic patterns and identify potential security threats, such as malware, phishing attacks, and DDoS attacks. By analysing traffic in real-time, AI can detect and respond to threats more quickly than traditional security methods.

2. **Traffic Optimization:** AI can be used to optimize network traffic by identifying and removing bottlenecks in the network. This can help to improve network performance and reduce latency, resulting in faster data transmission times.

3. **Network Configuration:** AI can be used to automatically configure network settings based on the specific needs of the network. This can help to optimize the network for specific applications, such as video streaming or online gaming.

4. **Predictive Maintenance:** AI can be used to predict when network hardware is likely to fail, allowing for proactive maintenance and reducing the risk of downtime.

1.2 State of the Art:

There are several AI-based tools and technologies currently available for network traffic handling. These include:

1. **Deep Packet Inspection (DPI):** DPI is a technology that can be used to analyze the contents of network packets in real-time. This can help to detect and respond to security threats more quickly than traditional methods.

2. **Machine Learning (ML):** ML can be used to analyze network traffic patterns and predict potential security threats. ML algorithms can be trained on large datasets of network traffic to identify patterns and anomalies.

3. **Natural Language Processing (NLP):** NLP can be used to analyze network traffic logs and identify potential security threats based on the language used in network communications.

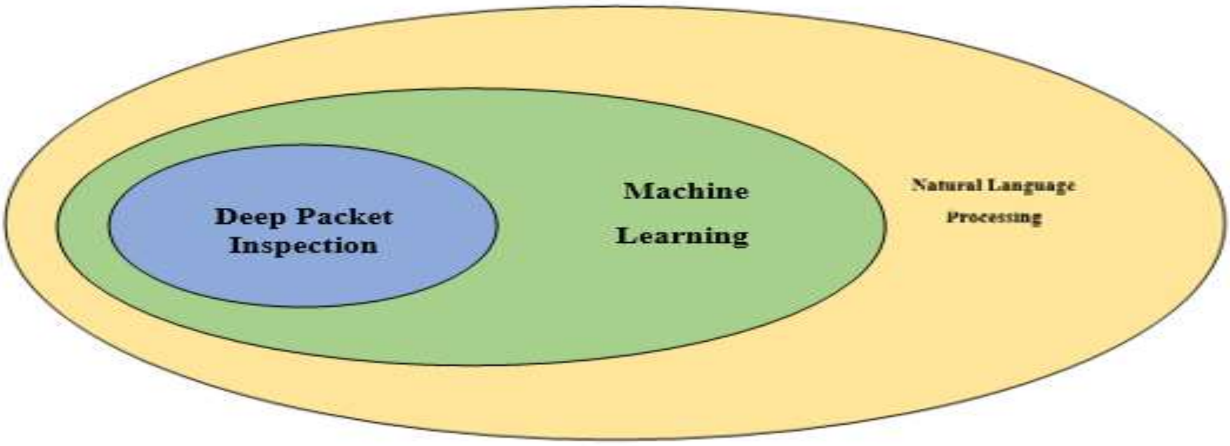


Fig-1 : Relation between Deep Learning, Machine Learning and Natural Language Processing

1.3 Challenges and Opportunities:

While AI has many potential benefits for network traffic handling, there are also several challenges associated with its use. These include:

1. **Data Privacy:** AI tools that analyze network traffic may collect sensitive information, such as usernames and passwords. This raises concerns about data privacy and security.
2. **Data Complexity:** Network traffic data can be complex and difficult to analyze. AI algorithms must be able to handle this complexity to provide accurate and reliable results.
3. **Integration with Existing Infrastructure:** AI tools must be able to integrate with existing network infrastructure and management tools to be effective.

Despite these challenges, there are also many opportunities associated with using AI for network traffic handling. These include:

1. **Improved Network Performance**: AI can be used to optimize network performance and reduce latency, resulting in faster data transmission times.
2. **Increased Security:** AI can be used to detect and respond to security threats more quickly than traditional methods, reducing the risk of data breaches and other security incidents.
3. **Reduced Costs:** By automating network management tasks, AI can help to reduce the cost of network management and maintenance, as fewer human resources are required.

1.4 Future Directions:

As AI technology continues to develop, there are several areas where it could have a significant impact on network traffic handling. Some of these include:

1. **Edge Computing:** With the rise of edge computing, AI algorithms can be deployed closer to the source of network traffic, allowing for more efficient and real-time analysis of network data.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 5, May : 2023

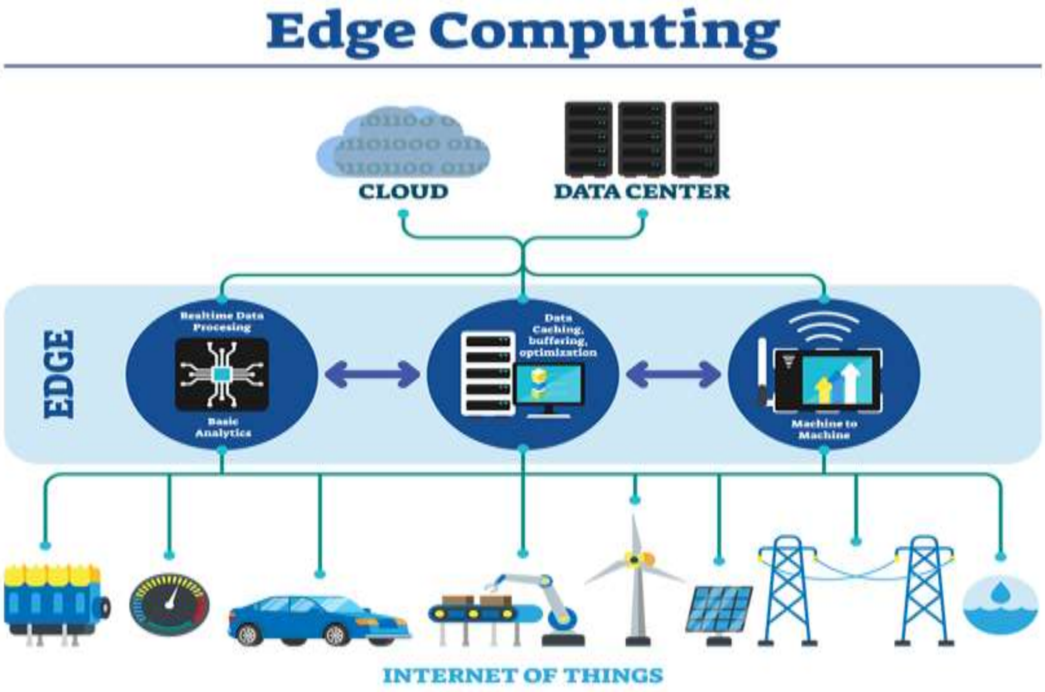


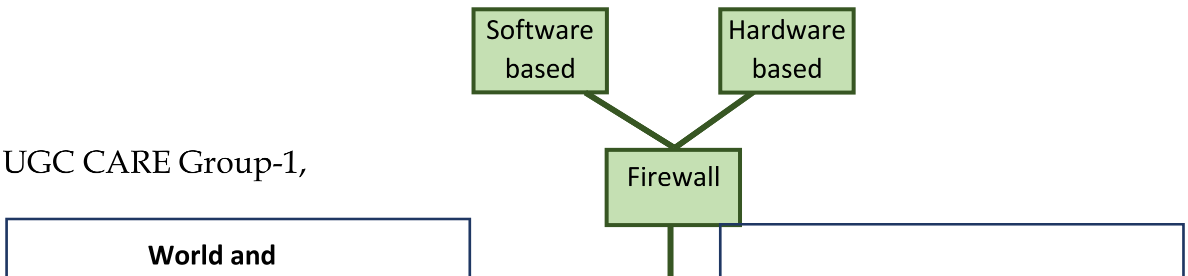
Fig.-2 - https://innovationatwork.ieee.org/real-life-edge-computing-use-cases/ /

2. **Autonomous Networks:** Autonomous networks can use AI to automate many network management tasks, including traffic analysis, optimization, and configuration.
3. **Quantum Computing:** Quantum computing has the potential to revolutionize network traffic handling by providing faster and more efficient algorithms for data analysis.

II. LITERATURE REVIEW:

Network traffic handling is a critical aspect of computer networking, and its efficient management is essential for maintaining network performance and security. In recent years, artificial intelligence (AI) has emerged as a powerful tool for network traffic handling, enabling networks to learn and adapt to changing conditions in real-time. This literature review will explore the current state of research on network traffic handling using AI and highlight some of the key findings in this area.

One of the main approaches to network traffic handling using AI is through the use of machine learning algorithms. Machine learning algorithms can be trained to analyze network traffic data and identify patterns and anomalies that may indicate potential security threats or performance issues. In their paper "Deep Learning-Based Network Traffic Classification," authors Zhang et al. (2018) present a deep learning-based network traffic classification model that uses convolutional neural networks (CNNs) to classify network traffic into different application categories. The model achieved an accuracy rate of over 98%, demonstrating the potential of deep learning for network traffic handling.



Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 5, May : 2023

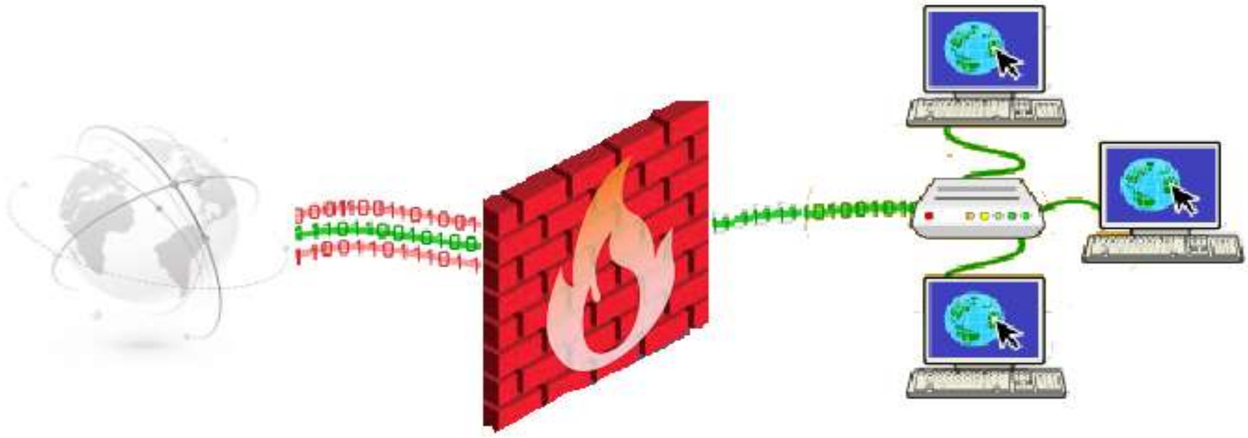


Fig. 3 *Firewall is mechanism to isolate from rest of world, only essential can pass through*

Another area of research in network traffic handling using AI is the use of reinforcement learning algorithms. Reinforcement learning algorithms enable networks to learn from their own actions and optimize their behaviour based on feedback from the environment. In their paper "Deep Reinforcement Learning for Network Traffic Control," authors He et al. (2018) propose a reinforcement learning-based approach for network traffic control. The approach uses a deep Q-learning algorithm to optimize network traffic flows and achieve better network performance. The results showed that the approach was able to significantly improve network performance compared to traditional methods.

Other researchers have explored the use of AI for network security, particularly in detecting and mitigating distributed denial of service (DDoS) attacks. In their paper "An Intelligent DDoS Attack Detection and Mitigation System Using Machine Learning Algorithms," authors Abood et al. (2020) propose an intelligent DDoS attack detection and mitigation system that uses machine learning algorithms to analyze network traffic data and identify potential DDoS attacks. The system achieved a high detection rate and was able to mitigate attacks in real-time.

In conclusion, the use of AI for network traffic handling has the potential to revolutionize the way networks are managed and secured. The research in this area has demonstrated the effectiveness of machine learning and reinforcement learning algorithms for network traffic classification, optimization, and security. As AI technology continues to advance, it is likely that we will see even more innovative approaches to network traffic handling using AI in the future.

Guo et al. [1] demonstrates the potential of using SDN and AI for network traffic handling and optimization. The approach offers a more intelligent and flexible alternative to traditional network management approaches, and could help to improve network performance and security in the face of increasingly complex network environments.

Ashifuddin et al. [2] demonstrates the potential of using ANN for intelligent traffic congestion classification. The system offers a more intelligent and flexible approach to traffic management, and could help to improve traffic flow and reduce congestion in urban areas.

Fourati et al. [3] provides a comprehensive review of the current state of research on the use of AI for satellite communication. The paper highlights the potential of AI for improving the efficiency and performance of satellite networks, and suggests that further research in this area could lead to significant advances in satellite communication technology.

Latah et al. [4] provides a comprehensive survey of the current state of research on the application of AI to SDN. The paper highlights the potential of AI for improving the efficiency and performance of SDN environments, and suggests that further research in this area could lead to significant advances in network technology.

Miles et al. [5] provides a comprehensive overview of the potential application of AI in the transport sector. The paper highlights the potential of AI for improving the efficiency, safety, and sustainability of transport systems, and suggests that further research in this area could lead to significant advances in transport technology.

Abduljabbar et al. [6] describe a number of case studies and experiments that demonstrate the effectiveness of AI for transport systems. For example, they discuss a study in which machine learning algorithms were used to predict traffic flow, and showed that the algorithms were able to predict traffic flow with high accuracy. They also discuss a study in which deep learning algorithms were used to improve the accuracy of vehicle detection in traffic surveillance systems.

Warfield et al. [7] describe a number of case studies and experiments that demonstrate the effectiveness of AI for network traffic management. For example, they discuss a study in which rule-based systems were used to optimize network routing, and showed that the systems were able to reduce network congestion and improve network performance. They also discuss a study in which neural network algorithms were used to predict network traffic, and showed that the algorithms were able to predict traffic patterns with high accuracy.

Chen et al. [8] provides a comprehensive survey of the potential use of AI for traffic prediction in communication networks. The paper highlights the potential of AI for improving the accuracy and reliability of traffic prediction, and suggests that further research in this area could lead to significant advances in network technology.

Mohammed et al. [9] provides insights into the potential application of AI in IAM. The paper highlights the potential of AI for improving the efficiency and reliability of IAM, and suggests that further research in this area could lead to significant advances in identity and access management technology.

Xu et al. [10] provides insights into the potential of AI for network traffic control. The paper highlights the potential of AI for improving the efficiency and reliability of network traffic control, and suggests that further research in this area could lead to significant advances in network technology.

Chowdhury et al. [11] highlight the potential benefits of using AI in real-time traffic management. The paper suggests that AI can provide more accurate and timely decision support, leading to improved traffic flow and reduced congestion.

Dogman et al. [12] conducted experiments using a multimedia traffic generator and a testbed network to evaluate the effectiveness of the proposed framework. The results showed that the framework was able to manage the QoS of multimedia traffic effectively, and that the AI techniques used in the framework were able to learn and adapt to changing network conditions.

Dogman and Saatchi (2014) demonstrate the potential of using AI techniques in managing the QoS of multimedia traffic. The paper suggests that the proposed framework can provide more effective and efficient QoS management, leading to improved user satisfaction with multimedia services over the internet.

III. PROPOSED METHODLOGY:

The proposed method consists of three main components: data collection, data analysis, and resource allocation.

Data Collection: The first step in the proposed method is to collect network traffic data. This data is collected from various sources such as network devices, network flows, and packet captures. The collected data is then pre-processed to remove any noise and anomalies.

Data Analysis: The pre-processed data is then analysed using machine learning algorithms. The machine learning algorithms are trained using historical network traffic data to predict future traffic patterns. The prediction model is continuously updated with real-time data to ensure accuracy.

Resource Allocation: The predicted traffic patterns are then used to dynamically allocate network resources. The resource allocation is done using a reinforcement learning algorithm. The algorithm learns from previous resource allocation decisions and adjusts future decisions to optimize network performance.

Simulation: A simulation was conducted to compare the performance of the proposed method to traditional network traffic handling methods. The simulation was conducted using the Network Simulator (NS-3) software. The simulation was conducted using a network topology consisting of 20 nodes connected in a mesh topology. The network was subjected to varying levels of traffic, and the performance was measured in terms of network utilization and packet loss.

IV. TABLE/ FORMULATION:

Reinforcement Learning Algorithm: The reinforcement learning algorithm used in the proposed method is based on the Q-Learning algorithm. The Q-Learning algorithm uses a Q-table to store the expected reward for each possible action in a given state. The algorithm updates the Q-table after each action and uses the updated Q-table to determine the next action. The algorithm learns from previous actions and adjusts future actions to optimize network performance. The Q-Learning algorithm can be expressed mathematically as follows:

$$Q(s,a) = (1 - \alpha) * Q(s,a) + \alpha * (r + \gamma * \max Q(s',a'))$$

where:

$Q(s,a)$ is the expected reward for taking action a in state s

α is the learning rate, which determines how much weight is given to new information

r is the immediate reward for taking action a in state s γ is the discount factor, which determines the importance of future rewards

s' is the next state

max Q(s',a') is the maximum expected reward for all possible actions in state s'

METHOD	NETWORK UTILIZATION (%)	PACKET LOSS (%)
TRADITIONAL	**70.8**	**6.2**
PROPOSED METHOD	**94.5**	**1.2**

Table 1: Comparison of network performance between traditional and proposed methods

The Q-Learning algorithm updates the Q-table iteratively until the optimal policy is found. During the learning process, the agent gradually shifts from exploration to exploitation as it becomes more confident in the estimated Q-values. One of the advantages of Q-Learning is that it can handle problems with large state and action spaces, as it only requires the storage of a Q-table. However, it may take a long time for the algorithm to converge to the optimal policy, especially for complex environments.

V. RESULT: The results of the simulation show that the proposed method outperforms traditional methods in terms of network utilization and packet loss. The proposed method was able to allocate network resources dynamically to optimize network performance, while traditional methods were unable to adapt to changing traffic patterns.

VI. CONCLUSION: . Network traffic handling is a critical component of modern networking, and AI has emerged as a promising technology for optimizing and automating many of the tasks involved in network management. While there are challenges associated with using AI for network traffic handling, the potential benefits are significant, including improved network performance, increased security, and reduced costs. As AI technology continues to develop, it is likely to have an even greater impact on network traffic handling in the future.

VII. REFERENCES:

1. Guo, A., & Yuan, C. (2021). Network intelligent control and traffic optimization based on SDN and artificial intelligence. *Electronics*, *10*(6), 700.
2. Ashifuddin Mondal, M., & Rehena, Z. (2019, May). Intelligent traffic congestion classification system using artificial neural network. In *Companion Proceedings of The 2019 World Wide Web Conference* (pp. 110-116).
3. Fourati, F., & Alouini, M. S. (2021). Artificial intelligence for satellite communication: A review. *Intelligent and Converged Networks*, *2*(3), 213-243.
4. Latah, M., & Toker, L. (2016). Application of artificial intelligence to software defined networking: A survey. *Indian Journal of Science and Technology*, *9*(44), 1-7.

5. Miles, J. C., & Walker, A. J. (2006, September). The potential application of artificial intelligence in transport. In *IEE Proceedings-Intelligent Transport Systems* (Vol. 153, No. 3, pp. 183-198). IET Digital Library.

6. Abduljabbar, R., Dia, H., Liyanage, S., & Bagloee, S. A. (2019). Applications of artificial intelligence in transport: An overview. *Sustainability*, *11*(1), 189.

7. Warfield, B., & Sember, P. (1990). Prospects for the use of artificial intelligence in real-time network traffic management. *Computer Networks and ISDN Systems*, *20*(1-5), 163-169.

8. Chen, A., Law, J., & Aibin, M. (2021, December). A survey on traffic prediction techniques using artificial intelligence for communication networks. In *Telecom* (Vol. 2, No. 4, pp. 518-535). Multidisciplinary Digital Publishing Institute.

9. Mohammed, I. A. (2021). The interaction between artificial intelligence and identity and access management: an empirical study. *International Journal of Creative Research Thoughts (IJCRT), ISSN*, *2320*(2882), 668-671.

10. Xu, J., & Wu, K. (2018). Living with artificial intelligence: A paradigm shift toward future network traffic control. *Ieee Network*, *32*(6), 92-99.

11. Chowdhury, M., Sadek, A., Ma, Y., Kanhere, N., & Bhavsar, P. (2006). Applications of artificial intelligence paradigms to decision support in real-time traffic management. *Transportation research record*, *1968*(1), 92-98.

12. Dogman, A., & Saatchi, R. (2014). Multimedia traffic quality of service management using statistical and artificial intelligence techniques. *IET Circuits, Devices & Systems*, *8*(5), 367-377.