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Analysis the Performance of SDN Controller and AI System for Future Network

Afshaar Ahmed [1*], **Abdul Moid Khan** [2], **Najma Ismat** [3], **Jawad Ali Arshad** [4], **Shakil Ahmed Khan** [4], **Manzar Ahmed** [4]

[1]Department of Computer Science university of South Asia lahore, Pakistan; [2]Department Electronic Engineering Sir Syed University of Engineering & Tech Karachi- Pakistan ; [3]Department Computer Engineering Sir Syed University of Engineering & Tech Karachi-Pakistan; [4]Department Electrical Engineering Sir Syed University of Engineering & Tech Karachi- Pakistan

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Abstract The SDN is new network controller concept and it provide faster packet data receiving and dynamic path in large network. It can work with old systems via creating new nodes. It can monitor activities of traffic routing, flowing and congestion and on the basis of these updated from all routers in the network. It can provide best shortest route to data packet in few seconds. But the main issue is that its location and controlling of huge data. The network controller can be track and data can be hack by hackers. The AI (artificial intelligence) system can help SDN controller to work batter, improve speed of the system and provide security to control network. In this paper, the methods working of AI with SDN controller will be analyzed to make system faster and save from cyber-attack and a solution will be proposed based on analyses of SDN Network.

***Correspondence author email address:** afshaarahmed786@hotmail.com
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1 Introduction

In the last decade, the overall voice and data communication system was based on the analog system Public Switch Telephone Network (PSTN) and Advanced Mobile Phone System (AMPS) mobile communication system. The main parts of this system were analog modulation, multiplexing, and multiple access techniques. This system suffered from many issues such as transmission losses, noise, signal-to-noise ratio, carrier-to-noise ratio, and fading. The message was sent and received through packets of fixed or variable length using certain bandwidth. There was a loss of bandwidth and the speed of the net was slow.

After the introduction of digital systems, TDMA and CDMA, the number of users and data rate increased, voice quality improved in the communication system, and losses were reduced. The fixed-length packets are sent through fiber optic and wireless networks at high speed. The issues such as noise, attenuation, and bit error rate are still present. Currently, fiber optic cable is used as a communication medium because it has low losses and

high bandwidth.

All over the world, the internet demand has increased rapidly after COVID-19 for online study, classes, and medical applications. The demand for more bandwidth and high data rate has increased because more communication devices have been added to the system, such as IoT devices. The system needs to be upgraded to accommodate the public demand for fast internet, in real-time video or audio.

Software-Defined Networking (SDN) is the most popular network used for sending data in packets, which administrators manage and provide network resources in a flexible but centralized way. However, there are security issues present in the infrastructure that can be attacked in different ways. Man-in-the-middle (MITM) attacks and distributed denial-of-service (DDoS) attacks are the most common [1]. In old data networks, data was transmitted in packets of fixed or variable length, depending on the system and users, with high delay in broadcast data like TV, video, and movies. The tolerance was bearable, but in real-time communication like video calls, audio calls, live broadcasts, and live conferences, the delay was unbearable. Therefore, researchers are focusing on increasingly efficient systems with more bandwidth and high data rates.

The modern system comes with software because through software the data can be sent to the destination with minimum risk of cyber threats. With software, the network can be controlled, errors can be measured, and proper filters and algorithms can be used to address the issues in seconds. In the present network, routers perform all tasks or functions such as IP address and routing plan handling.

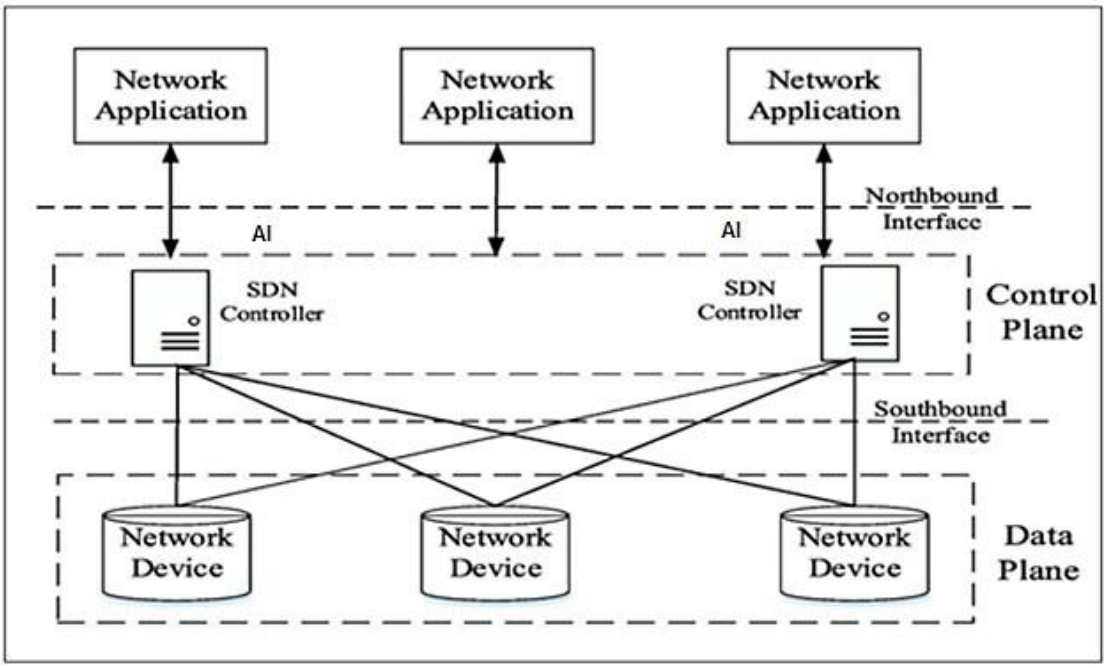

Figure 1. SDN Network controller architecture [2]

TThe AI system can be applied for monitoring and safely processing the data and controlling the SDN network. The data travels in packet form in the computer network. The packets may be of fixed or variable length. To reduce the delay a fixed packet length is used.

In Figure 2, the fixed length packet. A transmission system in the datagram network is given. The key issues related to data transmission are packet delay, shortest path finding, and security. In the old network, the packet sent from computer A (source) reached computer B (destination) after passing the router. The router plays a vital role in packet forwarding and processing.

The first router checks the IP address and selects the shortest path to send the packet. However, there were issues such as information about neighbors and the next node and traffic congestion issues in the network. For routers, it was not possible to keep all information about the shortest path and traffic updates in the network. [3].

To solve this issue the researchers proposed an SDN controller by separating the control of the network from the router and creating separate nodes to monitor and control the traffic in the network. The routing decisions are taken based on router configuration in the router and routes learned from the adjacent nodes or adjacent routers

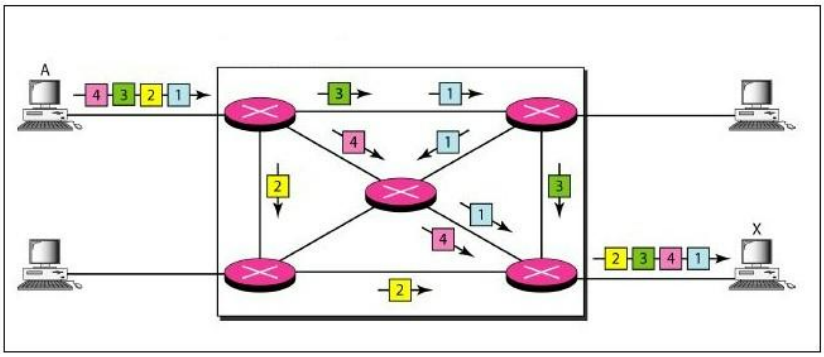

Figure 2. the datagram packet network [4]

The SDN controller controls routing, quality of service, and traffic as given in Figure 3. However, in SDN, there are some issues such as location and cyber threats because it is controlling large networks and the bulk of data it must process. For this, the researchers are searching for methods to make the system more powerful, fast, and safe [5].

For this reason, the researcher proposed artificial intelligence systems and blockchain. The AI system is machine science programming machines that can think like humans from learning. AI technology can process substantial amounts of data in seconds

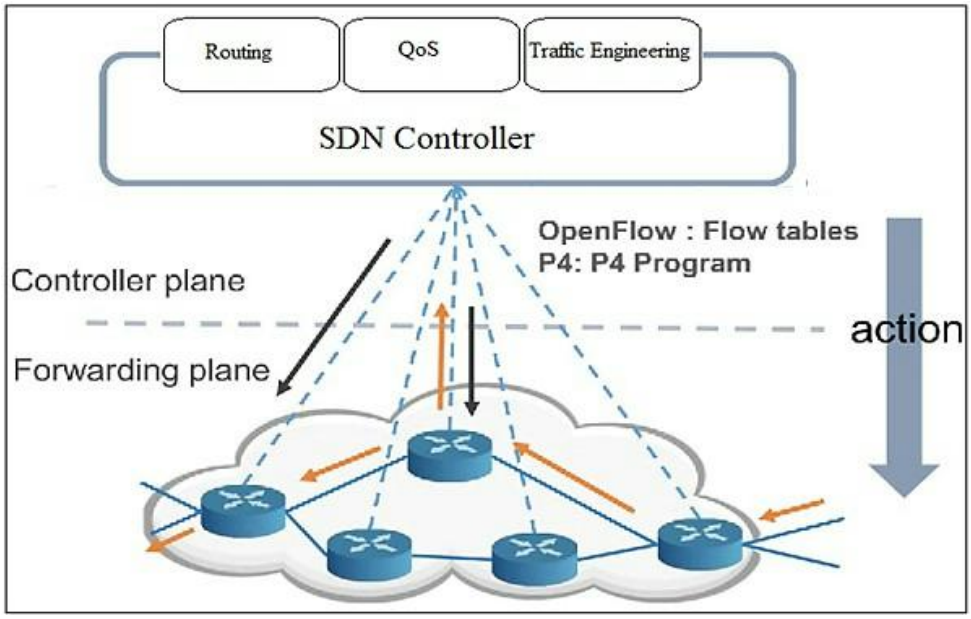

Figure 3. SDN Network Architecture [4]

unlike humans. The goal for AI is to be able to do things such as recognize patterns, make decisions, and judge like humans. Artificial intelligence (AI) can be thought of as a computer system that is capable of performing complex tasks that historically only a human could do, such as reasoning, making decisions, or solving problems.

Some researchers proposed AI for SDN controllers.

To apply intelligent decisions, AI algorithms can be used in the SDN network for fast decisions and smart network control such as can help to identify and isolate malware attacks in the SDN network. at present all researchers are focusing toward integration of ISDN network with AI and Blockchain.

II. Literature Review

The demand for the internet has increased in recent years globally, and people demand high bandwidth and high data rates to download movies, videos, or audio, large files, documents, and run many video and audio applications at the same time through the internet using laptops or mobiles.

The speed of the network with malware data depends on the fast detection of malware data, which results in DR and FPR detection with high-rate and low-rate DDoS attacks in the SDN controller, as explained by the author in this paper [6]. In this paper, the authors present a systematic review of SDN security, privacy, and taxonomic issues of cyber-attacks. They also identified the reason for the attacks and their impacts [4]. An overview of AI techniques in the SDN paradigm was presented in this paper.

Various AI techniques are under focus by researchers to solve networking issues and problems introduced by the SDN paradigm [7]. In this paper, the authors describe a prototype model of IoT networks to reduce costs and increase efficiency. The IoT network has constraints in heterogeneity and scalability, and the present network architectures integrate computing units of low intelligence, which cannot support the scheduling for diverse and complex industrial flows, especially for case scenarios with delay-sensitivity requirements.

The only solution is utilizing the AI-enabled SDN technique described by the authors [8]. In this paper, the authors describe the technological convergence of AI and SDN as shaping the future of computer networking and communication. The study shows four perspectives: descriptive information, countries, authors, and content on 474 unique literatures on the WoS database from 2009 onwards. Finally, it discusses the challenges and potential for future AI-SDN convergence [9].

At present, there is a large development in SDN and AI technologies, which made it feasible to design and control IoT networks [10]. In this paper, the authors describe how AI and SDN technologies can be integrated to improve the security and functionality of these IoT networks [11]. The IoT devices exchange data over the internet, and with recent advances in network technologies such as cloud and edge computing, the security issues must be addressed as highlighted by authors in a research paper.

The authors also claim that due to huge data, networks are becoming more complex to manage a high number of devices and optimize traffic balance [12]. Infrastructure and operations in any organization need to be efficient, and the transformation of communication mode from traditional to SDN gives centralized control. AI with SDN network has changed the concept of service providers and users and introduced many current trends which are impacting IO, as claimed by authors in this paper [5]. In this paper, a new design of network control mechanisms of network intelligent control and solutions for traffic optimization based on SDN and artificial intelligence was presented. Additionally, in this article, authors also present the main goal of route optimization, path calculation method, and routing technique for the operator's network [13].

In this paper, the authors present experimental results to verify the impact of the control mechanism on routing algorithms for SDN networks and artificial intelligence networks and claim that the results were accurate [14]. When results are verified and reproduce the data, sometimes it is hard to verify results. Keeping in view this situation, these results will be checked in a real-time environment in an SDN network with AI control and route optimization algorithm to solve the problems in the future, mentioned by the authors in this paper [15].

In this paper, the authors highlighted that the artificial intelligence technology with an SDN controller is more suitable, more accurate, and effective for traffic scheduling. If it is based on traffic types, it will improve the use of

network resource optimization problems for operators [3]. The authors highlighted that the traditional network architecture has a single static processing method, which is unsuitable for data center network traffic scheduling and suffers from many issues. However, after the introduction of cloud computing and SDN network architecture, which provides a programmable interface and a good solution for the uniform distribution of network traffic, the bandwidth and flexibility of traffic scheduling have improved [16].

This paper focuses on the load balancing of the IoT controller based on the SDN architecture of the data center. Bayesian network is used to predict the load congestion degree of the SDN controller. Based on the prediction results and reinforcement learning, the optimal action strategy is made to balance the load of the SDN controller, and results show that the proposed algorithm effectively reduces the average time delay from the switch to the controller [17].

Multiple load-balancing techniques in SDN networks boost network performance since the SDN controller should be capable of providing a comprehensive overview of the available resources, claimed in this paper by the authors [18]. To solve the issues in traditional SDN like dynamic fluctuation in traffic, the authors introduce two models, e-SDN and d-SDN, in this paper. For moderate network traffic, SDN shows throughput of around 12% and a reduced packet delay and jitter of around 19% and 25%, respectively. This improves the quality of service for the network, but the major improvement was realized in medium traffic systems with around 8% improvements in output, around 99.9% reduction in delay, and 85% in jitter, as claimed by authors [19].

In this paper, the authors introduce a new network control mechanism for intelligent control and route optimization-based algorithm for SDN networks with AI. The author also describes route optimization and calculation [20]. In summary, the authors are mostly working on AI and cyber threats, but there are other parameters that need to be worked out, such as dynamic routing in SDN and the location of the SDN controller.

III. SDN Network Controller and AI System

Software-defined networking uses network controllers using software programming for interfaces (APIs) to communicate with hardware and direct traffic data on the network with the help of AI for fast decisions and predictive maintenance. AI Algorithms can identify patterns, anomalies, and trends to anticipate potential issues before they impact system

The AI work as human brain quick decision and learning time by time. In figure 4, the working of SDN controller with the help of AI is given. The present state of the system will be feed to the AI agent and the AI agent will check all information and updates regarding network and will provide plan such as shortest path to avoid traffic congestion to save the time and will remove all unexpected data to save the network from cyber-attack

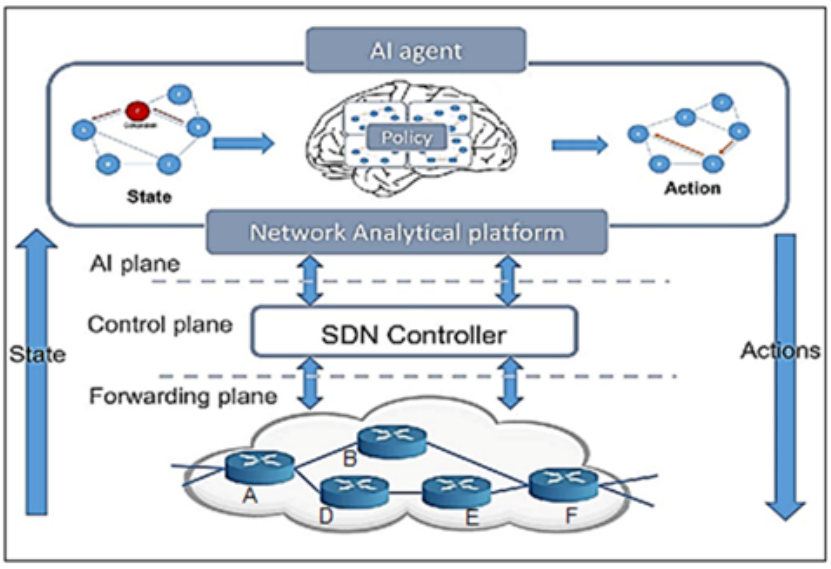

Figure 4. the main working idea of SDN and AI [4]

III. Potential limits, Issues and Challenges

For large network measuring the performance of the SDN controller is complex issue because it is centralized system

with huge data to control and chances of the cyber-attack also increase. With support of AI with SDN Controller, many issues can be address.

There are many challenges but few are such as;

- . Cyber attack
- . Congestion
- . Location of controller
- . Quick Decision making
- Information and planning of routing

In this research work we will consider cyber-attack; congestion and quick decisions planning using AI for SDN network controller.

IV. Proposed Architecture

In the SDN optical network, the optical controller plays a vital role in making decisions and providing the shortest path to packet data. If we use AI in a controller-like brain it can improve decision power and the system will be provision to learn from the previous history and all neighbor nodes. The main architecture of the SDN controller and AI is given in Figure 4 below.

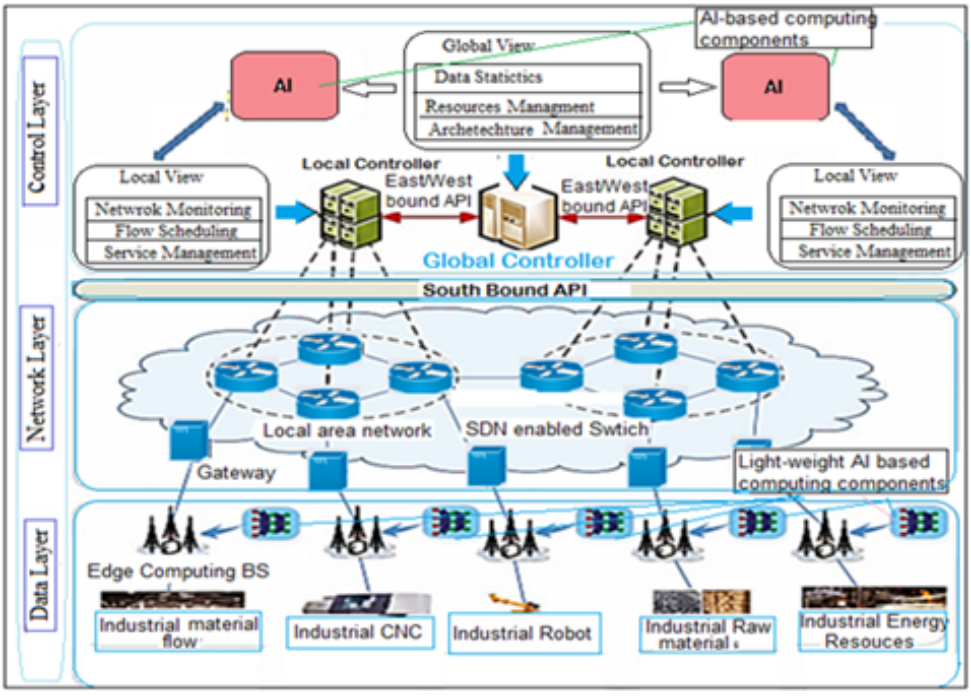

Figure 5. proposed diagram of SDN network work

In Figure 5, the main architecture is given, one in the local view and the other in the global view, and the local view includes three layers such as control, network, and data layers [5]. In global view data statistics, resources management, and in the controls layer the AI monitors the network view parameters such as network monitoring, flow scheduling, and service management, and service management is monitored and controlled by an AI system in Figure 6, the working steps are given.

There are four components SDN node, SDN controller, AI authentication, and KGC. At first, the SDN node boosts up and gathers updates from the neighbor nodes and SDN controller send messages to install a new node and SDN node accept request to authentication server and approved node and new node created and all formalities are completed as given in diagram.

V. Methodology

The performance of the network depend on the packet delivery time, end to end delay, jitter and number of packet loss and throughput. The working steps are given in step by step in figure 6.

There are nodes, SDN controller, AI authentication server and KGC. In SDN network when a new request of data sending receive the new node is created via SDN Controller and AI server authenticate new node and start process by controller.

The AI model can help SDN controllers for fast decisions and quick network management and Integrate AI into SDN-based IoT networks to enhance the speed of IoT networks [14]. In this paper, the author discusses how AI-enabled SDN technologies can help IoT networks improve network architectures, new algorithms, and future research directions. The virtualization brought by software-defined networking (SDN) to 5G allows administrators to control and change the network remotely, which requires an SDN controller to manage the traffic accessing the cache and orchestrate as explained in this paper [15]. This section takes you through the step-by-step process of building an AI system.

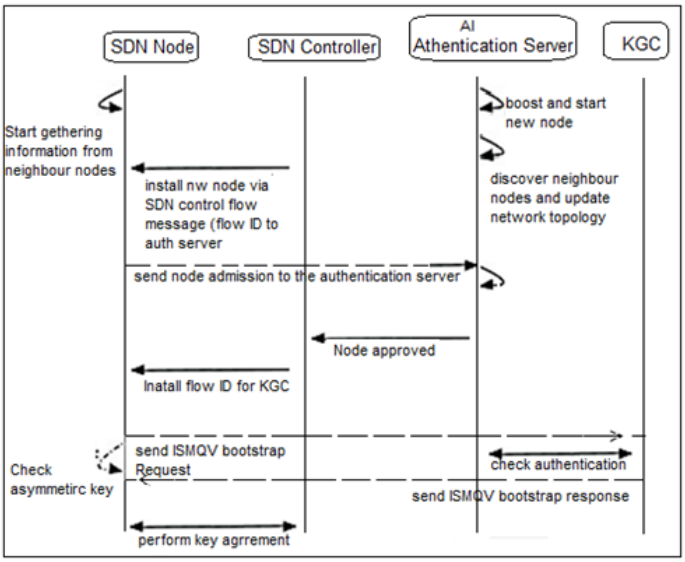

Figure 6. The working steps of SDN and AI

Task	Method
Integrating Data	Gather data and pass it to AI for training.
Data Pre-processing	Analyze data, separate bad sectors, fix issues, ensure data is updated.
Model Selection	Automatically select the best fit AI model.
Model Training	Use AI model for data training.
Model Testing	Test data to produce accurate results.
Model Optimization	Modify parameters of the selected model to enhance performance.
Implementation	Integrate both new AI and current model.
Continuous Learning	Use AI model and old and new data for learning and producing excellent output.

Table 1. Training of an AI System Steps

The three types of AI Models are available as supervised learning, which depends on human-labeled data to learn and gain knowledge, unsupervised learning

Network Type	Output (Gbps)	Packet Delay (ms)	Jitter (ms)
Traditional	0.08	84.00	0.20
S-SDN	0.09	68.00	0.15
d-SDN	0.09	0.120	0.02

Table 2. Network Performance for Moderate Traffic

which depends on unlabeled data and learning patterns to gain knowledge and reinforcement learning which depends on the AI's interactions with the environment to learn from mistakes and gain knowledge. Deep learning models transform data through multiple layers.

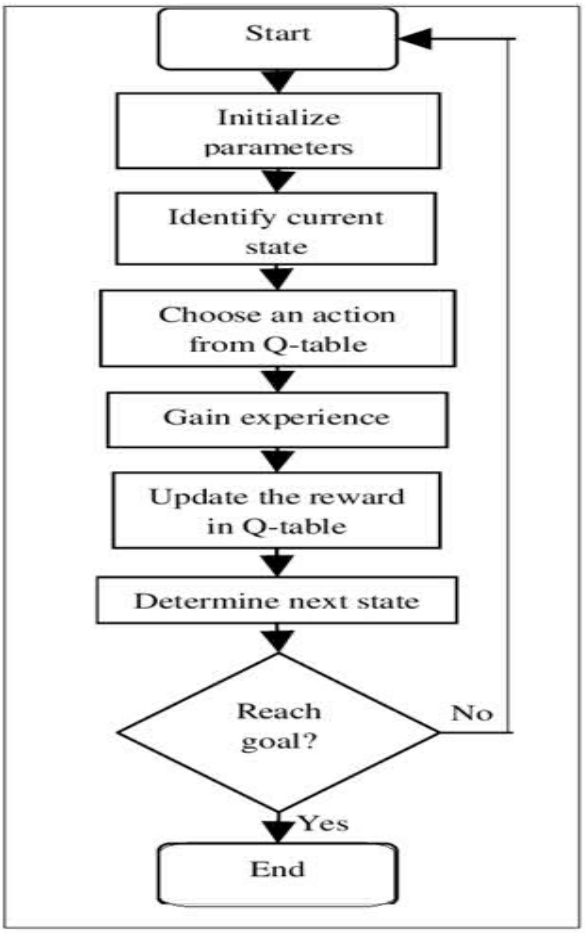

Figure 7. the packet delivery using Q- method

The model selection will depend on the following factors such as the amount of data you have, time, total resources, type of data, and total budget. The working steps of AI system step-by-step process given in table 1.

For Intelligent Routing there are several methods on which researcher are focusing such as using Q-Table is a highly advanced technology that utilizes Artificial Intelligence and Machine Learning algorithms to optimize the routing of internet traffic dynamically. The flow chart of the packet delivery using Q-Table method is given in Figure 7. In Figure 8, the comparison of the different SDN and traditional networks

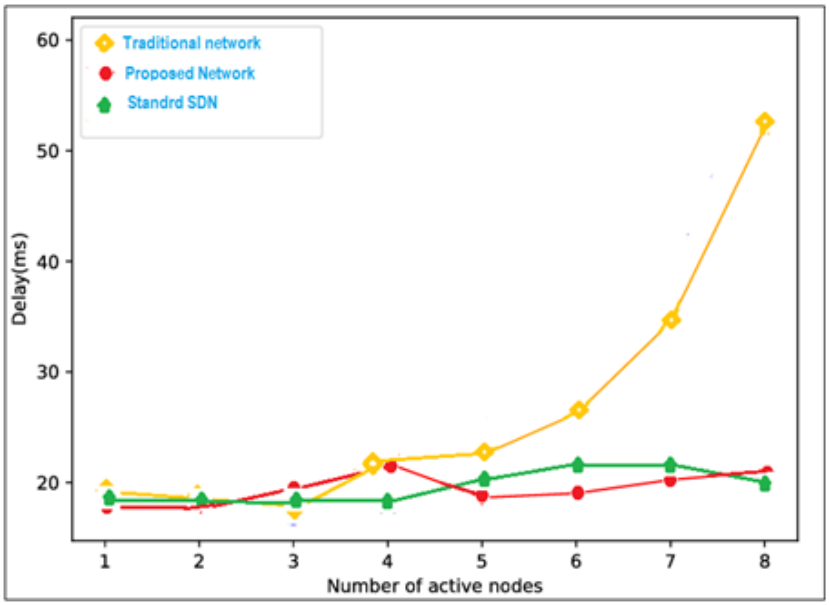

Figure 8. the comparison SDN network with others

is given. From the figure, it can be concluded that delay in traditional networks is high as compared to SDN networks and throughput is high. There is a low difference in jitter, which can be adjusted in circuits.

The calculation of delay, jitter, and throughput is given in Figure 9. In summary, from the results it can be concluded that the proposed dynamic network SDN controller is best for high-speed networks and high throughput as compared to the traditional network and other SDN network With AI the SDN controller working can be enhanced more and decision can be taken fast to avoid cyber threats in large network.

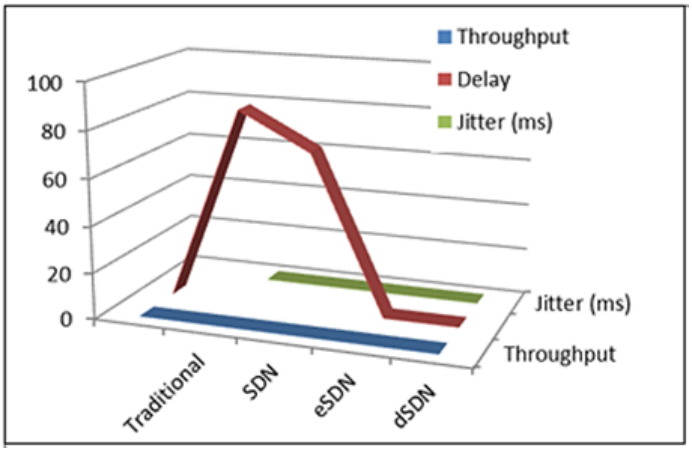

Figure 9. the calculation of delay, jitter and throughput

CONCLUSION

In this paper, the AI model was investigated for SDN network. The AI model can support SDN network for fast decision and in routing. The overall performance of the network can be measured in term of delay, through put and packet delivery time.

After the comparison of traditional, proposed and e-SDN network from the results, it can be analyzed that the SDN network packet delay and jitter is less, and throughput is more as compared to traditional network and system performance enhanced.

The advances in ML techniques such as deep learning and hybrid AI approaches can provide better results compared with traditional ML approaches. The AI algorithm is an especially useful tool for SDN networks. In the future, more research should be focus toward AI and blockchain technique for larger network for SDN network to improve speed of system and minimizing security threats.

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CREDIT AUTHOR STATEMENT

Afshaar Ahmed: Methodology and Research implementation **Abdul Moid Khan:** Data visualization and investigation **Najma Ismat:** Result Comparisons, **Jawad Ali Arshad** Writing-Original Draft Preparation. **Shakil Ahmed Khan:**Data visualization and investigation, Data creation. **Manzar Ahmed:** Final Evaluation of Experiments, Final Manuscript Preparation, Proof-Reading.

Data availability: All data generated or analyzed during this study are included in this published article

Compliance with Ethical Standards

It is declare that all authors don't have any conflict of interest. Furthermore, informed consent was obtained from all individual participants included in the study.

References

[1] K. I. Hamza, J. Kilani, F. Bensalah, and Y. Baddi, "Evaluation and analysis of network safety mechanisms in sdn infrastructure," December 2022.

[2] M. A. Aladaileh, M. Anbar, J. Ahmed, H. Hasbullah, A. A. Bahashwan, T. Al-Amiedy, and D. R. Ibrahim, "Effectiveness of an entropy-based approach for detecting low- and high-rate ddos attacks against the sdn controller: Experimental analysis," *Journal of Applied Sciences*, January 2023.

[3] J. Ali and B. H. Roh, "Management of software-defined networking powered by artificial intelligence," *Computer-Mediated Communication*, April 2021.

[4] J. Jiang, C. Lin, G. Han, A. M. Abu-Mahfouz, S. B. H. Shah, and M. M. Garcia, "How ai-enabled sdn technologies improve the security and functionality of industrial iot network: Architectures, enabling technologies, and opportunities," *Digital Communications and Networks*, vol. 9, pp. 1351–1362, December 2023.

[5] R. Vinuesa, "The role of artificial intelligence in achieving the sustainable development goals," *Nature Communications*, vol. 11, no. 1, pp. 1–10, 2020.

[6] M. S. Farooq, S. Riaz, and A. Alvi, "Security and privacy issues in software-defined networking (sdn): A systematic literature review," *Electronic Journal*, July 2023.

[7] M. Latah and L. Toker, "Artificial intelligence enabled software-defined networking: a comprehensive overview," *Journal of Electrical Material and Applications*, vol. 8, pp. 79–99, March 2019.

[8] F. Sahran, H. Hamza, M. Altarturi, and N. B. Anuar, "Exploring the landscape of ai-sdn: A comprehensive bibliometric analysis and future perspective," *Journal of Electronics*, December 2023.

[9] Y. J. Wu, P. C. Hwang, W. S. Hwang, and M. H. Cheng, "Artificial intelligence enabled routing in software defined networking," *Applied Sciences*, vol. 10, no. 18, p. 6564, 2020.

[10] A. Akbar, M. Ibrar, M. A. Jan, A. K. Bashir, and L. Wang, "Sdn enabled adaptive and reliable communication in iot-fog environment using machine learning and multi-objective optimization," *IEEE Internet of Things Journal*, October 2022.

[11] P. Castro, V. Ishakian, V. Muthusamy, and A. Slominski, "The rise of serverless computing," *Communications of the ACM*, vol. 62, no. 12, pp. 44–54, 2019.

[12] M. R. Belgaum *et al.*, "A behavioral study of task scheduling algorithms in cloud computing," *International Journal of Advanced Computer Science and Applications*, vol. 10, no. 7, pp. 498–503, 2019.

[13] R. Chaudhary, "Blockchain-based secure energy trading in sdn-enabled intelligent transportation system," *Computers & Security*, vol. 85, pp. 288–299, 2019.

[14] Y. Pathak, P. V. N. Prashanth, and A. Tiwari, "Ai meets sdn: A survey of artificial intelligent techniques applied to software-defined networks," pp. 395–412, October 2023.

[15] M. R. Belgaum, Z. Alansari, S. Musa, M. M. Alam, and M. S. Mazliham, "Impact of artificial intelligence-enabled software-defined networks in infrastructure and operations: Trends and challenges," *International Journal of Advanced Computer Science and Applications (IJACSA)*, vol. 12, no. 1, 2021.

[16] A. Guo and C. Yuan, "Network intelligent control and traffic optimization based on sdn and artificial intelligence," *Journal of Electronics*, March 2021.

[17] S. Liang, W. Jiang, F. Zhao, and F. Zhao, "Load balancing algorithm of controller based on sdn architecture under machine learning," *Internet of Things*, vol. 22, July 2021.

[18] A. H. Alhilali and H. Montazerolghaem, "Artificial intelligence based load balancing in sdn: A comprehensive survey," *Internet of Things*, vol. 22, July 2023.

[19] A. Sharma, V. Balasubramanian, and J. Kamruzzaman, "A novel dynamic software-defined networking approach to neutralize traffic burst," *Journal of Computers*, June 2023.

[20] A. Guo and C. Yuan, "Network intelligent control and traffic optimization based on sdn and artificial intelligence," *Journal of Electronics*, March 2021.