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Analysis of Wireless Multimedia Big Data Transmission Based on Adaptive Scheduling Algorithm

Abstract: - The increasing demand for wireless multimedia applications has prompted the need for efficient data transmission strategies that can adapt to dynamic network conditions and diverse Quality of Service (QoS) requirements. This paper analyzes wireless multimedia big data transmission using an innovative Adaptive QoS-Aware Scheduling Algorithm (AQOS-ASA). The proposed algorithm aims to optimize the transmission of multimedia data by dynamically adjusting the scheduling based on QoS considerations and real-time network conditions. Through adaptive scheduling, the algorithm ensures that high-priority multimedia data receives optimal transmission treatment, balancing the quality preferences set by users. The algorithm dynamically allocates time slots based on the changing network conditions, allowing for efficient utilization of the available bandwidth. The paper analyses the algorithm's performance in different wireless network scenarios through simulations and evaluations, highlighting its effectiveness in adapting to varying QoS requirements and network conditions. The results demonstrate that the proposed algorithm significantly enhances the quality and efficiency of wireless multimedia big data transmission, making it well-suited for applications with diverse multimedia content and dynamic network environments. The findings contribute valuable insights to wireless multimedia communication and provide a foundation for further advancements in adaptive scheduling algorithms for improved Quality of Service.

Keywords: Quality of Service, Big data, Multimedia, Scheduling algorithm

1. Introduction

In this era, big data is dominated by proliferation, where data generation and collection are occurring at an unprecedented pace. The expeditious processing, delivery, and analysis of these data hold the potential for substantial social and economic benefits [1]. The pervasive deployment of wireless communication systems in recent times further amplifies the significance of wirelessly transmitting a substantial portion of this big data [2]. Notably, smart mobile devices are pivotal in generating big data [3]. Over the preceding years, mobile data traffic has exhibited a remarkable compound annual growth rate exceeding 40% [4]. This growth trajectory is anticipated to gain even more momentum in the forthcoming years, fuelled by the increasing popularity of mobile broadband applications. The study explores efficient and reliable strategies for transmitting big data across fading wireless channels, particularly examining the wireless transmission of substantial data volumes from the perspective of transmission time [5]. Transmission time, denoting the duration required to transmit a specific data quantity, holds significant implications for the analysis and design of wireless communication systems [6]. Transmission time is intricately linked to the service time in queuing setups, playing a crucial role in analyzing delays and throughputs in diverse wireless transmission strategies [7]. Moreover, it has been employed to investigate the extended delivery time of secondary transmission with interweave cognitive radio implementation [8], [9]. Additionally, transmission time is a vital characterization of channel occupancy, directly influencing the collision probability in random access protocols over wireless channels [10].

Furthermore, given that the energy consumption of the transmitter is a product of transmission time and transmits power, the analysis of transmission time becomes instrumental in the design of energy-efficient wireless communication systems [11]. As the landscape of wireless systems evolves to support big data transmission effectively, the corresponding transmission strategies, access protocols, and scheduling policies require adaptation or redesign [12]. Characterizing transmission time for big data traffic over fading wireless channels emerges as a critical consideration in this evolving process [13]. Prior works in this domain often assume a constant transmission time for a fixed data quantity [14]. The transmission time over a point-to-point link is typically computed as the ratio of data quantity to the transmission rate when the rate is constant [15].

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However, constant-rate transmission proves inefficient and unreliable in fading wireless channels. Adaptive transmission is an attractive technology to enhance transmission efficiency over wireless channels while ensuring reliability [16]. With rate-adaptive transmission, the transceiver can dynamically adjust the transmission rate based on the prevailing channel conditions, optimizing for higher rates in favorable channel conditions and maintaining reliability with lower rates in poor channel quality. Assuming continuous rate adaptation, researchers derive the distribution function of transmission time over fading channels by transforming random variables [17]. Various traditional methods were used, such as a new hybrid method based on a Convolutional Auto Encoder (CAE) network and Gated Recurrent Unit (GRU) [18], big data analytics [19], and Wireless Sensor Network [20] to resolve the problem, but no proper results were formed. So, a new deep learning method is implemented to improve the performance in this paper.

The following parts of this study are outlined as follows: part 2 defines the most recent categories of literature; Part 3 explains the system description and problem statement; Part 4 deals with the workflow of the suggested methodology; Part 5 presents the achieved results and discussion, and part 6 wraps up the research paper.

2. Related Works

Feng and Yuan [21] introduced a visualization method and constructed an intelligent operation auxiliary decision-making model. The calculation results were used to record the threshold and distribution density of big data transmission. Subsequently, the redundant characteristics of big data were compressed based on the cyclic segmentation calculation method, and both conventional data and redundant data of extensive big data were stored. Experimental simulations were conducted to validate the proposed method, demonstrating an enhancement in massive big data storage compatibility. The results indicated improved accuracy and flexibility in the storage of big data. Visualization methods provide a clear and intuitive representation of complex data, making it easier for individuals to grasp patterns, trends, and relationships within the information. While visualizations aim to simplify complex data, there is a risk of misinterpretation.

Liazid *et al.* [22] explored the combination of the previously developed prediction scheme, EADPS (Extended Adaptive Dual Prediction Scheme), and the data aggregation technique based on temporal correlation as a robust solution for addressing communication reduction challenges in connected IoT-based Wireless Sensor Networks (WSNs). Initially, the impact of each technique was investigated independently before considering their integration. The evaluation focused on the multi-hop ring model of IoT-based WSNs. Results revealed that while the aggregation technique demonstrated superiority over the DPS prediction scheme, this advantage diminished for smaller WSN sizes (less than five rings) when applying the EADPS schema. Moreover, the impact of data correlation on reducing transmission rates was found to be relatively weak. Based on imposed tolerance thresholds, the proposed scheme demonstrated a substantial reduction in average transmission rates ranging from 85% to 96% across the entire network.

Jiang, Y. and Wang, B. [23] elucidated the specific concept of power monitoring system network information security, established safety regulations for the electric power monitoring system, formulated corresponding ideas for ensuring the safety level of the electric power monitoring system, and contributed to the long-term development of China's electric power enterprises. The secure operation of the power monitoring system directly impacted the stability of all power supply systems and, consequently, the broader social economy. Network security management in China's power monitoring system is not overly optimistic. The research focused on multimode multimedia data, organized research dynamics in network security protection technology, and deliberated on future research trends.

Zhang, X. [24] demonstrated a robust capacity to drive economic development. The integration of big data technology and 5G communication technology effectively bolstered the advancement of related technologies, providing substantial support for the progress of artificial intelligence. This integration laid a firm foundation for China's high-quality development. The paper delved into the application of big data technology in enhancing the 5G communication architecture, addressing challenges in the development of 5G networks, leveraging the advantages of 5G communication networks and big data technology, discussing practical applications of big data technology, and analyzing the significance and value of the application of big data technology.

Jiang, Y. and Wang, B. [25] demonstrated a robust capacity to drive economic development. The integration of big data technology and 5G communication technology effectively bolstered the advancement of related technologies, providing substantial support for the progress of artificial intelligence. This integration laid a firm foundation for China's high-quality development. The paper delved into the application of big data technology in enhancing the 5G communication architecture, addressing challenges in the development of 5G networks, leveraging the advantages of 5G communication networks and big data technology, discussing practical applications of big data technology, and analyzing the significance and value of the application of big data technology.

3. System model

The system model for analyzing wireless multimedia big data transmission based on an adaptive scheduling algorithm encompasses various components to ensure efficient and reliable data transmission. In this model, the wireless multimedia big data transmission system is considered, consisting of multiple nodes or devices that communicate over a wireless network. Each node is equipped to handle multimedia data, and the adaptive scheduling algorithm is crucial in optimizing the data transmission process. The challenges in the wireless multimedia big data transmission based on an adaptive scheduling algorithm are shown in Figure 1.

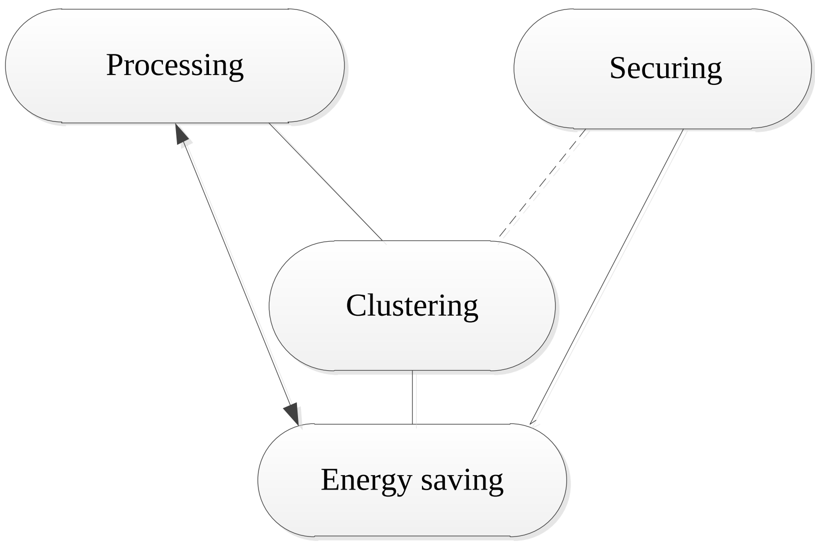

Figure 1. System model

The adaptive scheduling algorithm dynamically adjusts the transmission schedule based on the network conditions, data priorities, and available resources. It considers factors such as channel conditions, bandwidth availability, and the nature of multimedia content. The algorithm aims to maximize the utilization of the wireless network while ensuring that multimedia data, which often has stringent quality requirements, is transmitted reliably and promptly. This adaptive approach allows the system to adapt to changing network conditions, providing a flexible and efficient solution for wireless multimedia big data transmission. Furthermore, the system model incorporates feedback mechanisms to continuously assess the performance of the adaptive scheduling algorithm. This feedback loop enables the system to learn and improve, adjusting the scheduling parameters based on the observed outcomes. By iteratively refining the scheduling algorithm, the system strives to achieve optimal performance in handling the challenges associated with wireless multimedia big data transmission, ensuring a seamless and high-quality user experience.

4. Proposed Methodology

The proposed methodology for wireless multimedia big data transmission revolves around utilizing an Adaptive QoS-Aware Scheduling Algorithm. This methodology aims to enhance the efficiency and reliability of transmitting large multimedia data over wireless networks. The first step involves developing and integrating the Adaptive QoS-Aware Scheduling Algorithm into the existing transmission framework. This algorithm is designed to dynamically adjust scheduling parameters based on Quality of Service (QoS) requirements, network conditions, and data characteristics. In the second phase of the proposed methodology, extensive simulations and experimental validations are conducted to evaluate the system's performance. Various scenarios, such as different network loads, diverse types of multimedia content, and varying channel conditions, are simulated to assess the adaptability and effectiveness of the algorithm. The methodology significantly emphasizes QoS-awareness, ensuring that the scheduling algorithm prioritizes multimedia data with specific quality requirements. The block diagram of the proposed AQOS-ASA is shown in Figure 2.

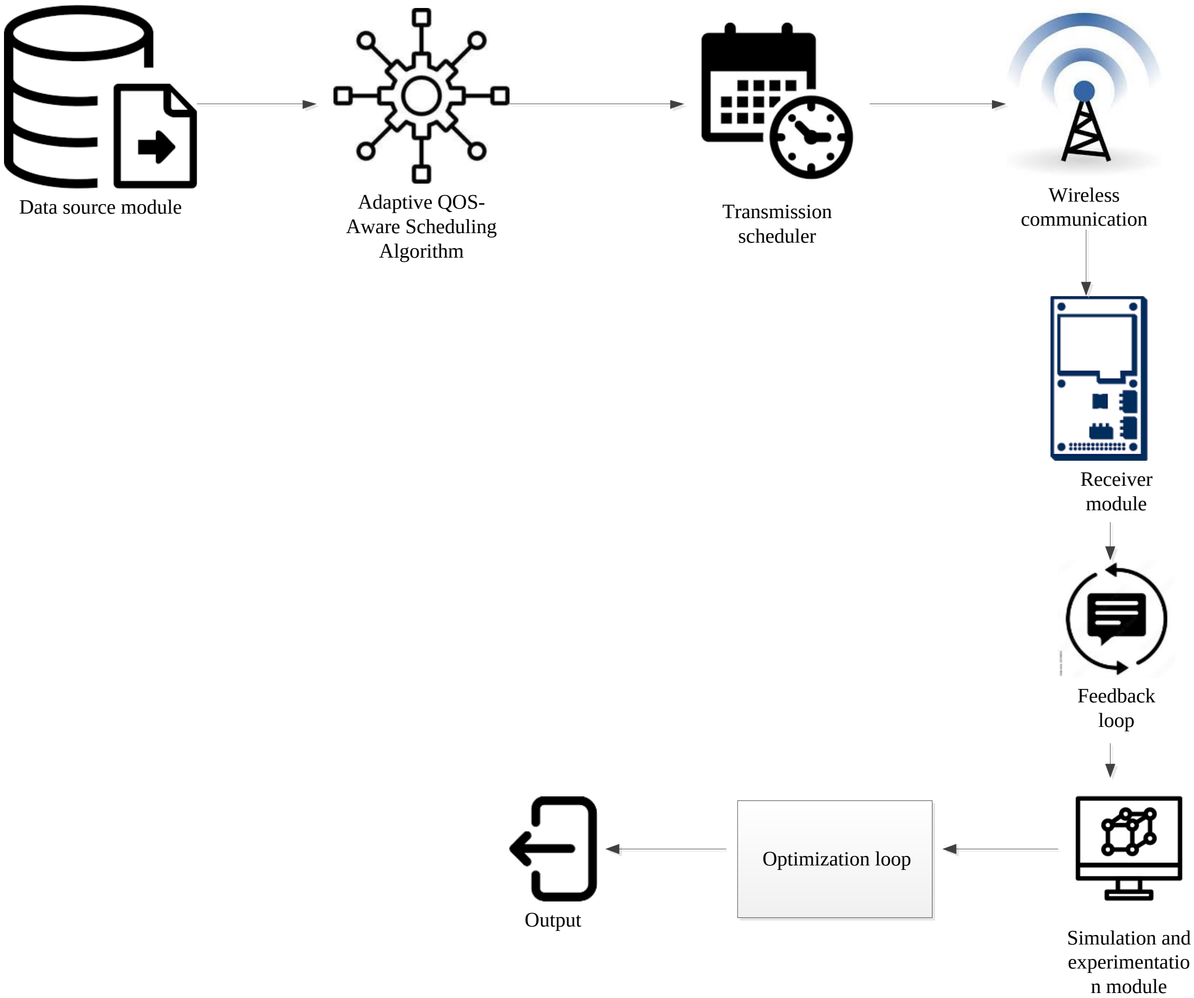

Figure 2. Architecture for the proposed Adaptive QOS-Aware scheduling algorithm

The results obtained from these simulations are thoroughly analyzed to fine-tune the parameters of the Adaptive QoS-Aware Scheduling Algorithm (AQOS-ASA), aiming to achieve optimal performance in wireless multimedia big data transmission. This iterative process of refinement and validation contributes to the robustness and reliability of the proposed methodology, making it well-suited for addressing the challenges associated with transmitting large-scale multimedia data over wireless networks.

4.1 Process of AQOS-ASA methodology

Generally, low latency average packets arrive at a very low bit rate. The eMBB flow (γ_0) is much larger than the other flows (γ_1 and γ_2). For QOS flow v, the total number of packets receiv O_r^u ed at every interval continues the Poisson distribution with the known value $v_r = w_r.\gamma$, w_r representing the bitrate factor.

Considering the discrete nature of radio resources in 5G networks, the radio access network (RAN) resource within the gNB is partitioned into O_{seg} small segments at a time u. The time interval between consecutive resource scheduling events is represented as an u interval. The association between the l^{th} resource segment and the r^{th} QoS flow at a time u is denoted by $\rho_{rl}^{u} = 1$. When β_r it signifies that the l^{th} resource segment is allocated to QoS flow u. Consequently, the service rate of β_r QoS flow can be determined by the following expression:

$$\beta_r^u = \sum_l (\rho_r^u l.F / T_q) \quad (1)$$

4.1.1 Delay Model

In this paper, the term packet delay refers to the overall transmission time of a packet from the MEC server to UEs. The packet delay can be defined as:

$$E_{pkt} = E_{\Pr p} + E_{\Pr c} + E_{radio} \quad (2)$$

Where the propagation delay of the signals is represented as $E_{\Pr p}$ in the optical fiber, $E_{\Pr c}$ represents the delay in processing in the Gnb, and the radio delay the in the remote radio head is denoted as d_{radio}. The delay in the processing of the packet can be expressed as,

$$E_{prc}(q_r^{n,o}) = \beta_r^u, q_r^u \text{ is served} \quad (3)$$

Hence, β_r^u can be represented by,

$$\beta_r^u = \arg\min(M_r^u - \beta_r^{u+1} ....\beta_r^u)^2 \quad (4)$$

To assess the effectiveness of multimedia multiservice, a Quality of Service (QoS) evaluation function is formulated as:

$$S_r^n = \gamma_r - e_{pkt} / q_r^u \quad (5)$$

4.1.2 Adaptive QoS-Aware Scheduling Algorithm (AQOS-ASA)

The Adaptive QoS-Aware Scheduling Algorithm (AQOS-ASA) is an advanced scheduling mechanism designed to optimize the transmission of multimedia data in wireless networks while prioritizing Quality of Service (QoS) parameters. This algorithm leverages adaptability and intelligence to dynamically adjust scheduling decisions based on the evolving conditions of the network. Its primary objective is to ensure users a seamless and high-quality multimedia experience by efficiently managing packet delay, packet loss ratios, and overall throughput. AQOS-ASA integrates QoS awareness, allowing it to make informed decisions about resource allocation and packet transmission. It adapts to real-time changes in the network environment, responding to traffic load and interference fluctuations. By incorporating adaptive decision-making processes and assessing its performance through key metrics like average packet delay and throughput, AQOS-ASA is a robust solution for improving the efficiency and reliability of multimedia data transmission in wireless networks. This approach enhances the overall user experience, making it particularly valuable for diverse multimedia applications in dynamic wireless communication scenarios. In the QOS, the assessment neural network (NN) can undergo training through function approximation. In simpler terms, the Q-value is t expected to progressively approach the target value through learning over multiple iterations. The target value is determined by:

$$R^*(t,b,\theta) = s(t,b) + \lambda \max R^*(t',b',\theta') \quad (6)$$

4.1.3 Fitness function

The goal of creating this simulated/artificial data is to reduce the difference between it and the real data that can be drawn statistically. Moreover, fitness is important in virtualizing the work without affecting performance. The fitness function is calculated based on the probability rate. The fitness function attains a lesser value for an effective result.

$$F(\theta) = (R*(t,b,\theta) - R(t,b,\theta))^2 \quad (7)$$

Table 1. Algorithm for AQOS-ASA approach

Algorithm for AQOS-ASA approach
Input: Configuration, Traffic Characteristics, Resource Constraints
The service rate of β_r QoS flow is calculated by using the equation (1)
$$\beta_r^u = \sum_l (\rho_r^u l.F / T_q) \quad (1)$$
The packet delay can be defined by equation (2)
$$E_{pkt} = E_{\Pr p} + E_{\Pr c} + E_{radio} \quad (2)$$
{
//Adaptive scheduling algorithm //
}
The delay in the processing of the packet can be expressed as,
$$E_{prc}(q_r^{n,o}) = \beta_r^u, q_r^u \text{ is served} \quad (3)$$
Quality of Service (QoS) evaluation function is formulated as:
$$S_r^n = \gamma_r - e_{pkt} / q_r^u \quad (5)$$
The target value is determined by:
$$R^*(t,b,\theta) = s(t,b) + \lambda \max R^*(t',b',\theta') \quad (6)$$
//Calculate the fitness using equation (7)
$$F(\theta) = (R*(t,b,\theta) - R(t,b,\theta))^2 \quad (7)$$
End
Stop
Output: Performance Metrics

The pseudo-code for the Analysis of wireless multimedia big data transmission based on the Adaptive QoS-Aware Scheduling Algorithm (AQOS-ASA) encompasses a set of instructions designed to optimize the scheduling of multimedia data transmission in wireless networks. It dynamically adapts to changing network conditions through a series of algorithmic steps, considering factors such as packet delay, packet loss ratios, and throughput. The pseudo-code includes decision-making processes that intelligently allocate resources and adjust transmission parameters based on real-time assessments of the network state. This adaptive scheduling algorithm aims to enhance multimedia applications' Quality of Service (QoS), ensuring efficient and reliable data transmission in varying wireless communication scenarios. The flowchart representation is shown in Figure 3.

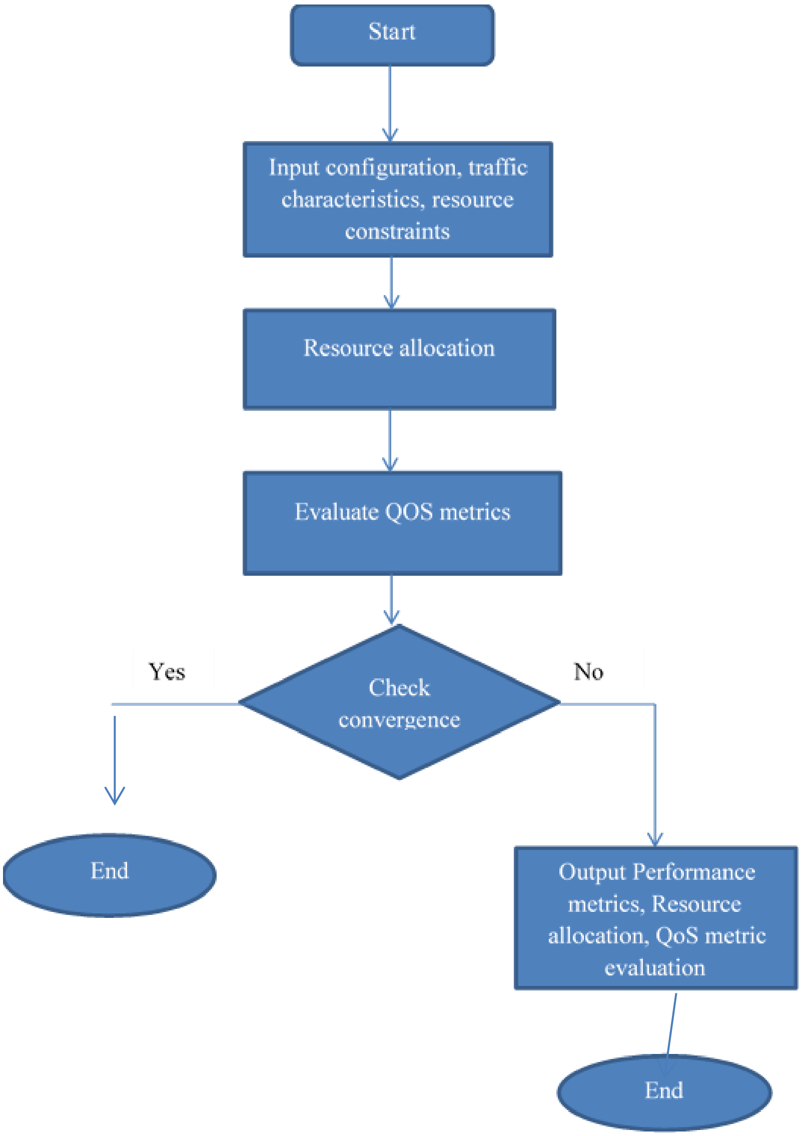

Figure 3. Flowchart representation

5. Results and discussion

This section discusses the outcomes of the suggested AQOS-ASA. The proposed AQOS-ASA's performance is examined, and the results are contrasted with those obtained using cutting-edge methodology.

5.1 Performance metrics

The graph in Figure 3 illustrates the average delay of packets served across all three QoS flows. When $\gamma_{min} = 6$, the PB scheduler exhibits an average packet delay of up to 44.1 ms, and the RR scheduler records approximately 33.0 ms. In contrast to RR and PB schedulers, the DQN-based scheduler demonstrates a gradual increase in average packet delay, remaining below 2.5 ms even when $\gamma_{min} = 6$.

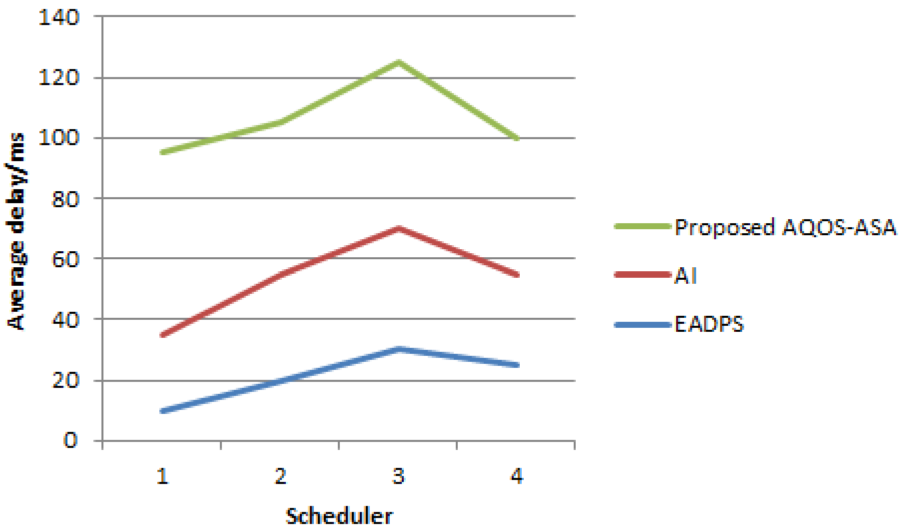

Figure 3. Average delays for all the packets

Figure 4 presents the average packet loss ratios, indicating a consistent ratio of 0 for the DQN-based scheduler. Conversely, both RR and PB schedulers show an increase in average packet loss ratios as $\gamma_{\min}$ they rise. At $\gamma_{\min}$ = 6, the PB scheduler reaches a packet loss ratio of 0.130, while the RR scheduler records about 0.329.

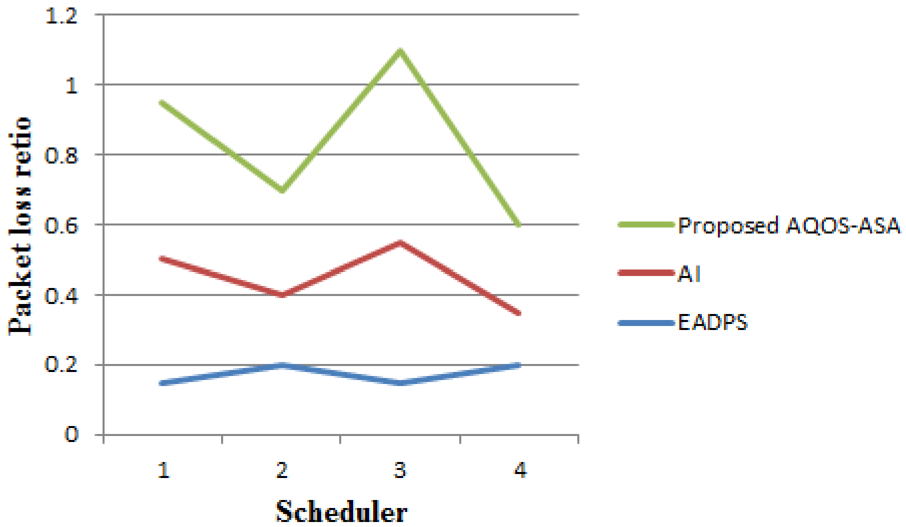

Figure 4. Packet loss ratio

Figure 5 displays the throughput curves, revealing an ascent in throughput for the DQN-based scheduler from 200 Mbps to nearly 300 Mbps as it $\gamma_{\min}$ increases. The PB scheduler's throughput increases from approximately 193 Mbps to 253 Mbps, with a slower growth observed when $\gamma_{\min} \geq 5$. The RR scheduler experiences an increase in throughput for $\gamma_{\min} \leq 4$ but undergoes a decline when $\gamma_{\min} \geq 4$. The maximum throughput for RR is below 184 Mbps at $\gamma_{\min} = 4$.

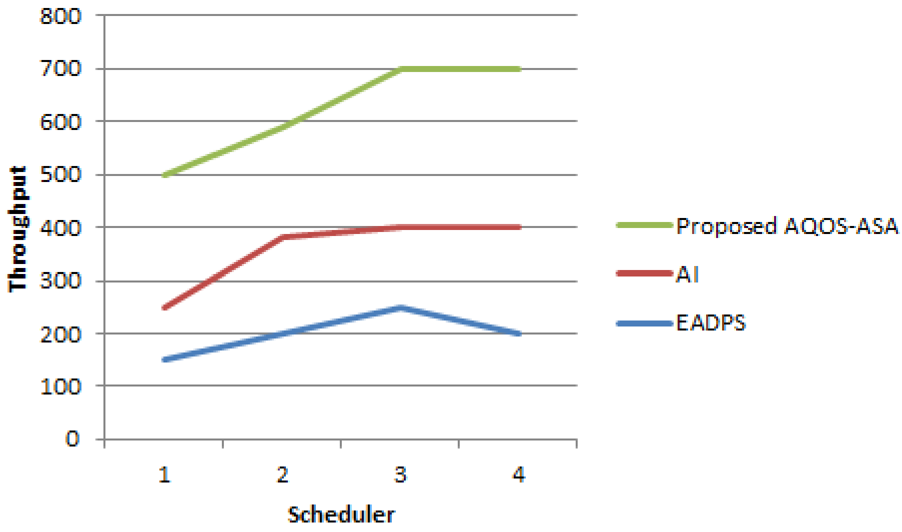

Figure 3. Throughput of the proposed AQOS-ASA

5. Conclusion

In conclusion, the study evaluated the performance of different scheduling algorithms, including RR, PB, and DQN-based schedulers, considering factors such as average packet delay, packet loss ratios, and throughput. The results indicated that the DQN-based scheduler outperformed RR and PB schedulers regarding average packet delay, gradually increasing and consistently maintaining lower delays even at higher λmin values. Additionally, the DQN-based scheduler exhibited a remarkable average packet loss ratio of 0, highlighting its effectiveness in minimizing packet losses compared to RR and PB schedulers. Throughput analysis revealed that the DQN-based scheduler achieved higher throughput values, ranging from 200 Mbps to nearly 300 Mbps, showcasing its ability to adapt and optimize network resources. On the other hand, the PB scheduler exhibited slower throughput growth, and the RR scheduler experienced fluctuations in throughput as λmin values changed. These findings underscore the effectiveness of the DQN-based scheduler in enhancing the performance of wireless multimedia big data transmission, offering lower delays, minimal packet losses, and improved throughput. The Adaptive QoS-Aware Scheduling Algorithm and the proposed methodology contribute to advancing scheduling strategies for multimedia data transmission in wireless networks.

Acknowledgement:

Research on the safety and quality traceability platform of jujube in northern Shaanxi based on cloud computing ", scientific research topic of Xianyang Vocational and Technical College.(Project No.: 2021KJB05")

Smart Campus - Development of a public intelligent service platform，, scientific research topic of xianyang Vocational and Technical College.(Project No.: 2021KJB10）

References

1. Rajeshkumar, K., Dhanasekaran, S. and Vasudevan, V., 2024. A novel three-factor authentication and optimal mapreduce frameworks for secure medical big data transmission over the cloud with shaxecc. Multimedia Tools and Applications, pp.1-29.
2. Wajgi, D.W. and Tembhurne, J.V., 2024. Localization in wireless sensor networks and wireless multimedia sensor networks using clustering techniques. Multimedia Tools and Applications, 83(3), pp.6829-6879.
3. Frank, L. and Stephen, M., A Consolidated Data Analysis Platform Designed with Big Data for the Financial Sector.
4. Goswami, C., Tamil Selvi, P., Sreenivas, V., Seetha, J., Kiran, A., Talasila, V. and Maithili, K., 2024. Securing healthcare big data in industry 4.0: cryptography encryption with hybrid optimization algorithm for IoT applications. Optical and Quantum Electronics, 56(3), p.366.
5. Wang, F., Wang, H. and Ranjbar Dehghan, O., 2024. Machine Learning Techniques and Big Data Analysis for Internet of Things Applications: A Review Study. Cybernetics and Systems, 55(1), pp.1-41.

6. Hireche, S., Dennai, A. and Kadri, B., 2024. Toward a Novel RESTFUL Big Data-Based Urban Traffic Incident Data Web Service for Connected Vehicles. The Computer Journal, 67(2), pp.557-580.
7. Jin, K., Zhong, Z.Z. and Zhao, E.Y., 2024. Sustainable digital marketing under big data: an AI random forest model approach. IEEE Transactions on Engineering Management.
8. Zhang, S., He, J., Liang, W. and Li, K., 2024. MMDS: A secure and verifiable multimedia data search scheme for cloud-assisted edge computing. Future Generation Computer Systems, 151, pp.32-44.
9. Talukder, M.A., Islam, M.M., Uddin, M.A., Hasan, K.F., Sharmin, S., Alyami, S.A. and Moni, M.A., 2024. Machine learning-based network intrusion detection for big and imbalanced data using oversampling, stacking feature embedding and feature extraction. Journal of Big Data, 11(1), pp.1-44.
10. Venkatesh, S., Kori, S.P., William, P., Meena, M.L., Deepak, A., Hasan, D.S. and Shrivastava, A., 2024. Data Reduction Techniques in Wireless Sensor Networks with Internet of Things. International Journal of Intelligent Systems and Applications in Engineering, 12(8s), pp.81-92.
11. Hasan, R., Kamal, M.M., Daowd, A., Eldabi, T., Koliousis, I. and Papadopoulos, T., 2024. Critical analysis of the impact of big data analytics on supply chain operations. Production Planning & Control, 35(1), pp.46-70.
12. Veeraiah, V., Thejaswini, K.O., Dilip, R., Jain, S.K., Sahu, A., Pramanik, S. and Gupta, A., 2024. The Suggested Use of Big Data in Medical Analytics by Fortis Healthcare Hospital. In Adoption and Use of Technology Tools and Services by Economically Disadvantaged Communities: Implications for Growth and Sustainability (pp. 275-289). IGI Global.
13. Zhang, H., Xia, R., Ye, H., Shi, D., Li, P. and Fan, W., 2024. Multi-cluster high performance computing method based on multimodal tensor in enterprise resource planning system. Physical Communication, 62, p.102231.
14. Dong, D. and Feng, H., 2024. Design and use of a wireless temperature measurement network system integrating artificial intelligence and blockchain in electrical power engineering. Plos one, 19(1), p.e0296398.
15. Kamdjou, H.M., Baudry, D., Havard, V. and Ouchani, S., 2024. Resource-Constrained eXtended Reality Operated With Digital Twin in Industrial Internet of Things. IEEE Open Journal of the Communications Society.
16. Januszewski, A. and Żółtowski, D., 2024. The State of Research on Emerging Information and Communication Technologies for Sustainable Development. In Adoption of Emerging Information and Communication Technology for Sustainability (pp. 27-49). CRC Press.
17. Zhou, J., 2024. Virtual Reality Revolutionizing Digital Marketing Design and Optimization of Online English Teaching in Universities with Wireless Network Technology Support in the Context of 5G. Computer-Aided Design and Applications, 21, pp.248-258.
18. Singh, S.K., Kumar, M., Tanwar, S. and Park, J.H., 2024. GRU-based digital twin framework for data allocation and storage in IoT-enabled smart home networks. Future Generation Computer Systems, 153, pp.391-402.
19. Reddy, N.M., Budati, A.K., Islam, S. and Ramesh, G., 2024. Enhanced elliptic curve-diffie hellman technique with bigdata analytics for satellite image security enhancement in internet of things systems. Earth Science Informatics, 17(1), pp.711-723.
20. Han, H., Tang, J. and Jing, Z., 2024. Wireless sensor network routing optimization based on improved ant colony algorithm in the Internet of Things. Heliyon, 10(1).
21. Feng, Y., 2023, April. Research on Application of Computer Big Data Technology in Mobile Communication System. In 2023 IEEE International Conference on Control, Electronics and Computer Technology (ICCECT) (pp. 649-653). IEEE.
22. Liazid, H., Lehsaini, M. and Liazid, A., 2023. Data transmission reduction using prediction and aggregation techniques in IoT-based wireless sensor networks. Journal of Network and Computer Applications, 211, p.103556.
23. Jiang, Y. and Wang, B., 2023. Analysis on Network Information Security Protection Technology of Intelligent Terminal Power Monitoring System of Substation under the Support of Multimodal Multimedia Information. Advances in Multimedia, 2023.
24. Zhang, X., Zhang, X. and Jin, Z., 2023, March. Big Data Technology Driven 5G Network Optimization Analysis. In The International Conference on Cyber Security Intelligence and Analytics (pp. 151-159). Cham: Springer Nature Switzerland.
25. Jiang, Y. and Wang, B., 2023. Analysis on Network Information Security Protection Technology of Intelligent Terminal Power Monitoring System of Substation under the Support of Multimodal Multimedia Information. Advances in Multimedia, 2023.