International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

A Lightweight IoT Evaluation Model for Threat Flow Prediction with SDN and IoT Integration

R. Raja*[1], A. Srinivasa Reddy[2], R. Muruganantham[3], N. Satheesh[4]

Submitted: 30/12/2023 **Revised**: 06/02/2024 **Accepted**: 14/02/2024

Abstract: In the present era, several applications have looked into network edges to reduce communication and administration expenses. They are also connected to the Internet of Things (IoT) to provide a flexible network infrastructure for multimedia applications that offers a range of services. Numerous suggested methods are helping to speed up the response time for crucial networks and establish reliable protocols. However, the majority of them lack the bandwidth and dynamic qualities necessary to handle heavy multimedia traffic forwarding procedures. In an unpredictable context, they also raise the incidence of data loss and jeopardize network performance by lengthening delivery times. To maintain real-time data gathering while utilizing the fewest resources possible, this research provides a lightweight IoT evaluation model (LIoT-EM) framework for sensors employing IoT that has customizable edges. It begins by leveraging the IoT, constructing a multi-hop network, and guaranteeing the necessary operations to support restricted networking with reliable resource management. It surpassed previous solutions, according to test results, in terms of delivery rate (on average), processing delay, network overheads, packet loss ratio, and packet retransmission.

Keywords: *software defined network, network resources, sensors, resource management, and latency.*

1. Introduction

In the last ten years, improvements in wireless technology have given rise to the revolutionary paradigm known as the Internet of Things (IoT) [1]-[4]. In order to connect objects or things to the internet, Kevin Ashton proposed this paradigm. Home automation, connected cities, healthcare, transportation, and many other applications of the IoT are being utilized to collect and analyze real-time data for the community[5]- [7]. An emerging paradigm is provided by incorporating the use of constraint-oriented sensor networks in the Internet of Things (IoT), which provides assurance for multimedia communication and presents advances [8]. Media servers, embedded systems, intelligent equipment, and graphic data are all components of the multimedia sector that maximize production efficiency [9]-[12]. To monitor environmental conditions and transmit the gathered data to the end-user online, IoT-based sensors are dispersed and installed in a variety of items. Numerous applications in the last few decades, including those in agriculture, healthcare, the military, transportation, and multimedia, have provided remote users with smart services as well as physical communication controllers[13]- [14]. For real-time applications, IoT nodes' constrained resources provide a number of limitations. As a result, multimedia-based networks cannot be directly used with the majority of existing systems. Additionally, when the size of the network grows, IoT-based cameras, cars, sensors, etc. must transmit a significant quantity of data, which drains their batteries and negatively affects network performance [15]-[17]. Wireless topologies, in contrast to wired networks, are more adaptable when it comes to managing and distributing data transmission across various communication channels [18]. There are several security risks available to IoT-based networks due to the shared nature of the wireless medium. In the IoT, for storage and processing, sensors send a substantial amount of audio and video data to the public cloud. To sustain the multimedia routing phase, most systems place further communication burdens on users [19][20].

Numerous researchers have recently focused on the management of routing algorithms in IoT networks by simultaneously taking into consideration the resource constraints of sensors [21]-[23]. IoT network environment also needs data security attributed to the existence of deplorable computers on the web that could interfere with the system for exchanging data between IoT devices and leak personal data [24]-[26]. In this study, a multimedia IoT quality assurance method is presented that integrates edge intelligence with security against potential assaults. By adding intelligent edges with little to no time lag, it advances the multimedia industry's data transmission evolution. The recommended method effectively uses the workload on IoT nodes when delivering multimedia data while reducing the possibility of data congestion across wireless channels [27]. The proposed paradigm improves the multimedia sector's

---

[1] *Associate Professor, Department of CSE (CS), CVR College of Engineering, Hyderabad, India, nsraja1984@gmail.com*
[2] *Associate Professor, Department of CSIT, CVR College of Engineering, Hyderabad, India, srinivas.asr@gmail.com*
[3] *Professor, Department of IT, TKR College of Engineering and Technology, Hyderabad, India, muruganantham1979@gmail.com*
[4] *Professor, Department of CSE (AI), SET, Jain Global Campus, Jain University, Bangalore, India, nsatheesh1983@gmail.com*
* *Corresponding Author Email: nsraja1984@gmail.com*

productivity while preserving confidentiality and integrity and lessening its vulnerability to intrusions from fake entries. The suggested approach's security phase also protects end users' media device data and deals with unauthorized access by malevolent machines [28].

This work offers an optimization model for multimedia sensors using SDN architecture and IOT artificial intelligence in order to provide dependable functionality in regard to QoS and give an effective performance for resource limitations. Additionally, without endangering the identities of devices or information, the offered methodology offers reliable data transfer to network applications. It uses mobile edge artificial intelligence to enable low-cost communication overhead and multi-hop routing services. When constructing the initial routes, quality variables are taken into account together with the fundamental requirements of each network domain. Additionally, mobile edges use SDN controllers to govern the flow and "perform" as borders. Mobile edges talk to the control plane to stay up to date on multimedia traffic and network health. In order to accurately grasp the network's state and contribute to the efficient, centralized management of the network's resources, the controller, therefore, retrieves data from the control plane. The communication system's effectiveness is increased by the switches and controller's employment of a cost-effective encryption technique to deal with data privacy issues and identify confused multimedia traffic. The suggested framework secures the network data from anonymous behaviours in addition to offering increased bandwidth for larger media data employing mobile edges. The following are the suggested model's three primary contributions:

1. Throughout the investigation, it provides a technique of learning with a multimedia algorithm based on node predictions, and it additionally allows efficient performance for delivery with effective network bandwidth management.
2. It provides a lightweight IoT evaluation model (LIoT-EM) for managing resource constraints with integration boundary edges for delayed restricting multimedia applications and reduce response time.
3. By improving the support of the network applications and centralizing the detection process, multimedia traffic safeguards against repeated attempts at interference.

The writing is organized as follows: Section 2 provides a thorough study of several techniques. Section 3 provides further detail on the approach, while Section 4 provides the numerical findings and comments. Section 5 has the summary portion.

2. Related Works

One of the biggest problems with the smart city is effective traffic monitoring and management. There are many approaches based on microwave radars, magnetic loops, and infrared detectors to deal with this issue [29]-[30]. These traditional methods are inaccurate and have high installation and maintenance expenses. The researcher suggested IoT-based solutions to accurately gauge traffic flow, identify its source, and predict congestion. The Internet of Things is envisioned as a tool to enhance the road management system. Authors in [31] presented a machine vision-based, ontology-driven, context-aware IoT architecture for traffic forecasting that gathers CCTV footage, counts the number of cars on the road in real-time, and distinguishes between moving and stationary vehicles based on how much stationary traffic is using the road in relation to a threshold amount. In this case, Dynamic Bayesian Networks (DBN) with time-varying properties will be employed, which essentially compares the cause of traffic congestion using the Multimedia Web Ontology Language (MOWL) [32]. Traffic officers may start sending out automatic notifications to prevent a backup. The author in [33] outlines an IoT architecture for traffic surveillance and accident prevention that uses Raspberry and Pi cameras. Based on traffic data sets from VIRAT and MIT, the authors evaluated their concept using a powerful edge detection Gaussian Mixture Model (GMM). This chapter also addresses a number of systems that have been found to be highly effective for precisely identifying accidents and tracking moving objects, such as Lucas-Kanade, K-means clustering methods, and hidden Markov and neural networks [34].

An effective method for managing network traffic is required due to the significant increase in multimedia traffic. For the IoT video surveillance system, Rego et al. in [35] present an intelligent network management approach that utilizes Artificial Intelligence (AI) and SDN. The AI module is integrated into SDN to guarantee the quality of service and quality of experience dictated by latency, jitter, and loss rate. The authors list data categorization and resource estimate as the AI module's two primary functions [36]. The SDN is managed by a controller. Data from IoT Network Heads (NHs) is gathered by the SDN controller and sent to the AI module, which is then tasked with organizing the data. Traffic analysts consider multimedia data to be crucial [36]. The article also discusses the basic guidelines for classifying the data set as critical and rating it from 1 (non-critical traffic) to 5 (extremely crucial traffic) in ascending order. Several Machine Learning (ML) approaches were used to produce the best results while training the AI traffic classification module such as Neural Networks (NN), statistical methods (Kernel), and Support Vector Machines (SVM) are contrasted. The Bayes statistic model is used to calculate network resource usage based on traffic priority, route traffic, buffer management, bandwidth fluctuation, activate backup nodes, and network node resting time [37] - [41]. The Open Flow architecture is used by the SDN controller and NHs to interact. Additionally, the authors suggest a specific messaging protocol for use in conversations between NH and IoT nodes, as well as the SDN controller and the AI module. Several findings are reported after experiments utilizing the Mininet emulator were carried out. Results show that the AI module is 77% accurate.

Alvi et al. defines the concept of IoT in [42]. The two parts of the paper are divided into the following categories: IoT applications and use cases and IoT vision. The authors in the initial group discussed the objectives of the IoT and proposed a multi-agent, four-layer IoT architecture. This section also covers each layer's requirements and unresolved problems. IoT has also been thoroughly examined in the area of multimedia data. The writers have also covered a number of methods for compressing and encoding video [43]-[44]. The many multimedia applications and IoT use cases are described in the second part. A thorough analysis of IoT is not, however, covered in this paper. There is a lack of a comprehensive description of the many enabling technologies, such as MAC protocols and network layer protocols. There is no mention of integration with fifth-generation (5G) cellular connectivity or future machine-type communication [45]. Additionally, the Information-Centric Network (ICN) strategy and numerous QoS and QoE-dependent aspects are not included.

3. Methodology

The suggested methodology for predicting energy in IoT can be easily expanded to any hop data gathering relays. Additionally, we assume that the wireless channel will slowly fade over the course of one optimization period. We must establish a link between the anticipated reduction in distortion of sky camera images, the energy required for sensor network transmission, and the IoT capacity for energy harvesting in order to tackle this optimization challenge. Define E_r (h,t_0) and P_s (h,t) for the power remaining in the battery that is rechargeable and the component's output power for gathering energy, respectively for a specific node h. Then, the expression for this node's available power from time t_0 to time t_1 is:

$$E(h,t_0,t_1) = \int_{t_o}^{t_1} P_s(h,t)dt + E_r(h,t_0) \qquad (1)$$

Let E_t (j,h_i) be the power used to transport the image packet of data j via the h_i hop, and let R_j ={h_i} be the group of nodes that make up a secure packet's transmission route. This node h's energy usage can be stated as follows:

$$E_{asn}(h) = \sum E_t(j,h) \qquad (2)$$

Let D_j stand for the data packet's contribution to distortion reduction, and let ρ_j stand for the data packet j's total transmission packet loss rate. The overall quality requirement is expressed as follows:

$$D_{total} = \sum \rho_j * D_j \qquad (3)$$

The basic problem can therefore be correspondingly interpreted to optimize Dtotal for the time window from t_0 to t_1, subject to total energy:

$$E_{asn}(h) < E(h,t_0,t_1) \qquad (4)$$

Transmission power and receiver-to-transmitter distance of separation have the biggest effects on the channel Bit Error Rate (BER). The system's signal loss can be generally computed as follows if λ and d stand for the carrier wavelength and distance, respectively.

$$A^{-1} = \left(\frac{4\pi d}{\lambda}\right)^2 \qquad (5)$$

Rs stands for the symbol rate, N0 for the noise power density ratio and the bit error rate by e. The amount of transmission power P_tis necessary to convey data using phase modulation to a specific receiver side. There are several ways to express BER:

$$P_t = R_s.b.[erfc^{-1}(2e)]^2.N_0.A^{-1} \qquad (6)$$

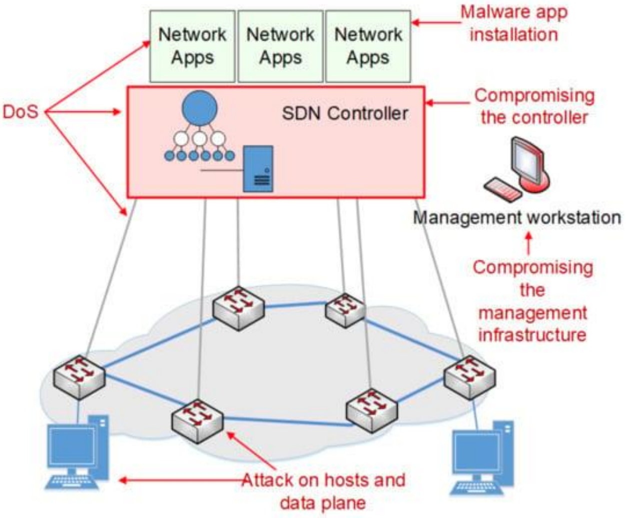

Fig 1 Attack flow in SDN with IoT

Accordingly, ρ(i,j,e_ij) and ρ(i,j) should be used to express the estimated the predicted channel BER eij and the anticipated packet loss rate from the relay node i to the destination node for transmitting packet j from the origin node to the relay node i. Following the relay, the overall transmission packet loss rate may be predicted to be as follows:

$$\rho_{ij} = 1 - \left[1 - \rho\left(i, j, e_{ij}\right)\right].\left[1 - \rho'(i,j)\right] \quad (7)$$

Eq. (7) demonstrates the relationship between the bit error rate (BER) and the symbol rate, carrier wavelength, transmission power, and communication distance.

$$e_{ij} = \frac{1}{2} erfc\left(\frac{P_t \,.\, \lambda^2}{16\pi^2 . d^2 . R_s . b . N_o}\right) \quad (8)$$

Where L_j is the dimensions of the data packet j, the following equation represents the data packet loss rate:

$$\rho\left(i, j, e_{ij}\right) = 1 - \left(1 - e_{ij}\right)^{L_j} \quad (9)$$

Eq. (9) can be used to calculate the end-to-end If the relay node is, the data packet loss rate is to node $G's$ BER is represented by e_i'.

$$\rho'(i,j) = 1 - (1 - e_i')^{L_j} \quad (10)$$

$$\rho_{ij} = 1 - [1 - \frac{1}{2} erfc\left(\frac{P_t . \lambda^2}{16\pi^2 . d^2 . R_s . b . N_o}\right)^{L_j} [1 - e_i']^{L_j} \quad (11)$$

Let P_t' and T_s stand for the relay node's transmission power and the amount of time it took to transmit this packet, respectively. The following formula can be used to determine the amount of energy required for transmitting data packet j:

$$E_{asd} = \frac{(P_t + P_t') * L_j}{T_s} \quad (12)$$

IoT's transmission efficiency can be determined mathematically as follows if D_r stands for the data packet j distortion reduction:

$$E_e = \frac{D_r * (1 - \rho_{ij})}{E_{asd}} \quad (13)$$

Each node should save its state of residual energy, its capacity for energy storage, and it's nearby relay nodes. The energy consumption of packet transmission can be determined using different power and relay options using Eq. (13). A basic search for sending the present packet in compliance with energy efficiency and energy profiles will reveal the optimal power and relay control option. To optimize image quality while carefully adhering to energy limits, the aforementioned technique will choose the most suitable relay node and the most effective power source for each packet of data containing a sky-camera image. The following is a description of the algorithm: Estimate the amount of energy that can be harvested over the following few days, for example. Next, determine every single transmission nodes predicted quality-energy effectiveness using several strategies for choosing relay nodes and power nodes. According to the anticipated energy, select the best-transmitting option for every single source packet of data as the algorithm's last step. The outcome of the method determines if the packet of data is going to be transmitted, the relay node to be used, and the amount of transmission power needed to transfer the packet from the node that generated it to the relay node.

4. Numerical Results and Discussion

We explain the simulation environment and experiments in this section. The research community frequently uses MATLAB 2020a to simulate network standards and technologies, which is how the experiments were carried out. On a laptop with a 4.40 GHz Intel processor, 256 GB of RAM, and a 16 M cache, we ran the simulations. Over 1000 x 1000m area, the performance was compared to already implemented plans. Each node's transmission range was estimated to be 10 meters. We randomly installed 10 malicious nodes to assess the security relevance. Additionally, the controller was deployed together with switches and routers. Each sensor node's energy resource was initially set at 2j. For 1000 seconds, the simulation was run. The data block was configured to be 64 bits in size. Under the conditions of diverse network nodes and data-receiving overheads, the studies concentrated on the packet loss rate, processing time, delivery rate, and network overhead. The suggested model was compared to current methods using the smart collaborative routing protocol is reported. Table 1 contains a list of the standard parameters.

Table 1 Parameter setup

Parameters	Value
Simulation region	$1000 * 1000m$
Sensor Nodes	500
Attack nodes	10
Blocks	64 bits
Energy (initial)	$2j$
Transmission power	10m
Interval	1000s
Radius	10m
Data transmission	Regular or Periodic

Fig 2 Detection rate comparison

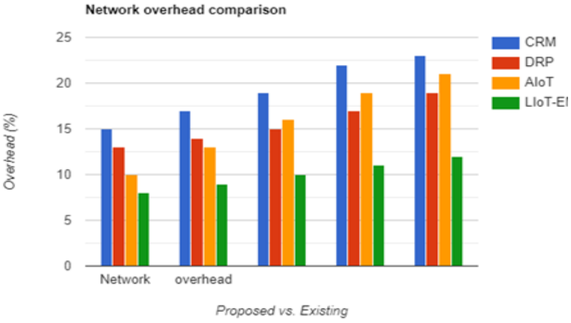

Fig 3 Network overhead comparison

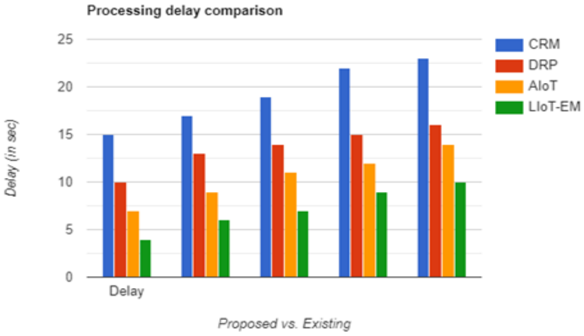

Fig 4 Delay comparison

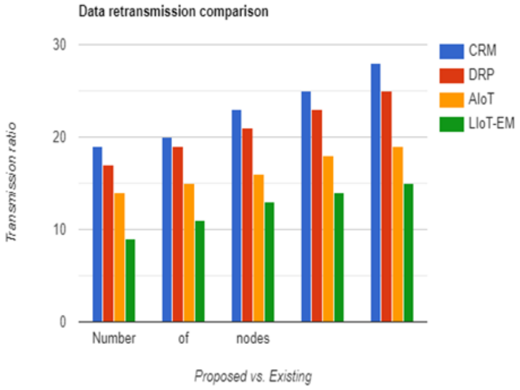

Fig 5 PDR comparison

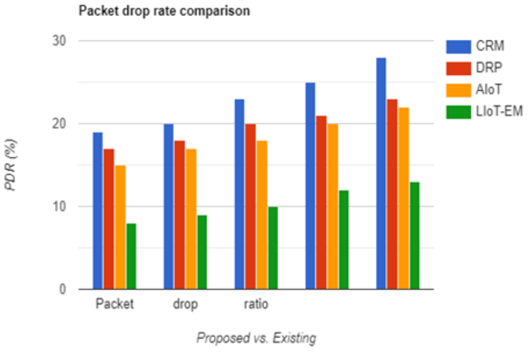

Fig 6 Data retransmission rate comparison

The experimental findings are shown in Fig 2 to Fig 5 and show that, when compared to other options, the suggested model increases packet delivery rates by 30% and 40%. The suggested model optimizes the forwarding decision while using a multi-hop transmission approach to send the IoT data. Successful packet delivery is enhanced by intelligent decision-making, which in particular determines the packet variation factor for the neighbour nodes. While being protected against hazardous transmissions, the communication channel maintains resources properly as well. In order to ensure robust transmission while reducing the amount of overcrowding on the wireless channels, the suggested approach is used. The suggested architecture improves data management effectiveness by utilizing mobile edge, high-performance computing nodes, and IoT data collection from sensors. In contrast to existing alternatives, the suggested architecture reduces the number of control messages sent between nodes, thereby increasing the IoT network's throughput. When compared to other options, Fig 3 shows how well the suggested model performs in terms of routing overheads. It has been found that the suggested architecture minimizes routing overheads by 38% to 44%, depending on the number of nodes. Contrary to the existing framework, which frequently transfer route request and control signals across nodes in a scenario of a network that is bigger in size, the design suggested intentionally avoiding this activity. When the selection criteria fall below a predetermined level, the IoT node is solely chosen as a data forwarder. Additionally, the suggested architecture reduces message routing speed and effectively uses the IoT nodes' energy resources as in Fig 6. Thanks to mobile edge computing nodes, IoT nodes also impose relatively low costs for communication when relaying and choosing the optimum path.

5. Conclusion

Using artificial intelligence of things, a mobile edge optimization model for multimedia sensors is presented in this study with the goal of improving network resource management in multimedia traffic while protecting transmission. For crucial IoT-based applications, it offers a real-time paradigm and supports production with great dependability. Additionally, communication is shielded from hostile nodes using the Intelligent SDN technology and the IoT network's lightweight nodes' power. It makes informed decisions for mobile edges and enhances the network's efficiency by evaluating the QoS attributes. The lightweight IoT evaluation model (LIoT-EM) framework is also used to verify nodes against each other and with secret shares. It has already been demonstrated through data analysis that the suggested model excels compared to benchmark solutions when it comes to time delay, packet drop ratio, delivery rate, routing overheads, and dependability. The tests were run using the MATLAB

2020a simulator. The suggested architecture uses edge computing to provide some intelligence, but in order to select the best forwarders, communication costs must be paid. In order to develop the IoT network utilizing a collection of real-time data, we want to use the transfer method of learning in the near future.A conclusion might elaborate on the importance of the work or suggest applications and extensions.

Conflicts of interest

The authors declare no conflicts of interest.

References

[1] El Saddik, A.: Digital twins: the convergence of multimedia technologies. IEEE Multimedia. 25(2), 87– 92 (2018)

[2] S. Reddy, "Performance of VANET over MANET in Mobile Computing Environment," 2022 7th International Conference on Communication and Electronics Systems (ICCES), Coimbatore, India, 2022, pp. 659-664.

[3] Raja, R., Kumar, P.G. ”Designing a novel framework for evaluation of trust in mobile ad-hoc networks”, Journal of Computational and Theoretical Nanoscience, 2018,15(1), pp. 338–344.

[4] Lokesh, S. , Chakraborty, S., Pulugu, R. ,Pulugu, D. , Muruganantham, R. AI-based big data analytics model for medical applications,Measurement: Sensors, 2022,24, 100534

[5] Muruganantham, R., Ganeshkumar, P.Bichromatic reverse nearest neighbours approach for processing object tracking in wireless sensor netresearchs based on RNN monitoring algorithm,Asian Journal of Information Technology, 2016, 15(23), pp. 4705–4710.

[6] Satheesh N. & etl: Flow-based Anomaly Intrusion Detection using Machine Learning Model with Software Defined Networking for OpenFlow Network, Journal of Microprocessors and Microsystems, October 2020.

[7] Qin, Z., Denker, G., Giannelli, C., Bellavista, P., Venkatasubramanian, N.: A software defined networking architecture for the internet-of-things. In: 2014 IEEE network operations and management symposium (NOMS), IEEE, pp 1–9 (2014)

[8] Das, S., Sahni, S.: Network topology optimization for data aggregation. In: 2014 14th IEEE/ACM international symposium on cluster, cloud and grid computing, pp. 493–501. IEEE, Piscataway (2014)

[9] Raja, R., Ganeshkumar, P. “QoSTRP: A Trusted Clustering Based Routing Protocol for Mobile Ad-Hoc Networks”,2018, 44(6), pp. 407–416.

[10] Satheesh N. & etl: Trust Based Ad Hoc On Demand Distance Vector Routing Protocol Against Wormhole Attack, Journal of Theoretical and Applied Information Technology, December 2014. Vol.70 No.3 – 2014.

[11] Muruganantham, R., Ganeshkumar, P.Quality of Service Enhancement in Wireless Sensor Network Using Flower Pollination Algorithm, Programming and Computer Software, 2018, 44(6), pp. 398–406

[12] Hernandez-Valencia, E., Izzo, S., Polonsky, B.: How will nfv/sdn transform service provider opex? IEEE Network 29(3), 60–67 (2015).

[13] A.S. Reddy and P. C. Reddy, "Novel Algorithm based on Region Growing Method for Better Image Segmentation," 2018 3rd International Conference on Communication and Electronics Systems (ICCES), Coimbatore, India, 2018, pp. 229-234.

[14] Hakiri, A., Berthou, P., Gokhale, A., Abdellatif, S.: Publish/subscribe-enabled software defined networking for efficient and scalable iot communications. IEEE Commun. Mag. 53(9), 48–54 (2015)

[15] Satheesh N. & etl: Biological Feature Selection and Classification Techniques for Intrusion Detection on BAT, International Journal of Wireless Personal Communications, 09 July 2021.

[16] Diro, A.A., Reda, H.T., Chilamkurti, N.: Differential flow space allocation scheme in sdn based fog computing for IoT applications. J. Ambient Intell. Humaniz.Comput. (2018).

[17] Raja, R., Saraswathi, R. “A Delicate Authentication Mechanism for IoT Devices with Lower Overhead Issues”, Lecture Notes on Data Engineering and Communications Technologies , 2023, 141, pp. 87–97.

[18] Jazaeri, S.S., Jabbehdari, S., Asghari, P., Javadi, H.H.S.: Edge computing in sdn-iot networks: a systematic review of issues, challenges and solutions. Clust.Comput. (2021).

[19] A.S. Reddy, P.C. Reddy, A hybrid K-means algorithm improving low-density map-based medical image segmentation with density modification, Int. J. Biomed. Eng. Technol. 31 (2) (2019) 176–192.

[20] Tang, F., Fadlullah, Z.M., Mao, B., Kato, N.: An intelligent traffic load prediction-based adaptive channel assignment algorithm in sdn-iot: A deep learning approach. IEEE Internet Things J. 5(6), 5141–5154 (2018)

[21] Satheesh N. & etl: Improvements in cluster-based routing to protect malicious node attacks on taodv routing protocol using MANET, Applied Mathematics and Information Sciences, 2019, 13(6), pp. 899–911.

[22] Vimal, V., Muruganantham, R. , Prabha, R.,Chanthirasekaran, K. , Reddy Ranabothu,G. Enhance Software-Defined Network Security with IoT for Strengthen the Encryption of Information Access Control,Computational Intelligence and Neuroscience, 2022, 2022, 4437507

[23] Selem, E., Fatehy, M., Abd El-Kader, S.M.: mobthe (mobile temperature heterogeneity energy) aware routing protocol for wbaniot health application. IEEE Access 9, 18692–18705 (2021)

[24] Raja, R., Satheesh, N., Dennis, J.B., Raghavendra, C. “Routing with Cooperative Nodes Using Improved Learning Approaches”, Intelligent Automation and Soft Computing, 2023, 35(3), pp. 2857–2874.

[25] S. Reddy, R.Raja, N.Satheesh, and R.Muruganantham, “Brain Tumor Prediction using Adaptive Connected Component based GLCM and SVM Method”, IJRITCC, vol. 11, no. 9s, pp. 485–491, Aug. 2023.

[26] Yu, W., Liang, F., He, X., Hatcher, W.G., Lu, C., Lin, J., Yang, X.: A survey on the edge computing for the internet of things. IEEE Access 6, 6900–6919 (2017)

[27] León, L.F.A.: Eyes on the road: surveillance logics in the autonomous vehicle economy. Surveill. Soc. 17(1/2), 198–204 (2019)

[28] Yu, W., Liang, F., He, X., Hatcher, W.G., Lu, C., Lin, J., Yang, X.: A survey on the edge computing for the internet of things. IEEE Access 6, 6900–6919 (2017)

[29] Fancy, C., Pushpalatha, M.: Traffic-aware adaptive server load balancing for software defined networks. Int. J. Electr. Comput. Eng. (2088-8708) 11(3), 2211–2218 (2021).

[30] Raja, R. , Saraswathi, R, ”An GMM Method in IoT Approach to Improve Energy Efficiency in Smart Building” , Proceedings - 5th International Conference on Smart Systems and Inventive Technology, ICSSIT 2023, 2023, pp. 407–414.

[31] Saha, N., Bera, S., Misra, S.: Sway: Traffic-aware qos routing in software-defined iot. IEEE Trans. Emerg. Top.Comput. 9, 390–401 (2018a)

[32] Llopis, J.M., Pieczerak, J., Janaszka, T.: Minimizing latency of critical traffic through sdn. In: 2016 IEEE international conference on networking, architecture and storage (NAS), IEEE, pp 1–6 (2016)

[33] Saha, N., Misra, S., Bera, S.: Qos-aware adaptive flow-rule aggregation in software-defined iot. In: 2018 IEEE global communications conference (GLOBECOM), IEEE, pp 206–212 (2018b)

[34] Tomovic, S., Yoshigoe, K., Maljevic, I., Radusinovic, I.: Software-defined fog network architecture for iot. Wirel. Pers. Commun. 92(1), 181–196 (2017)

[35] Misra, S., Saha, N.: Detour: dynamic task offloading in software-defined fog for iot applications. IEEE J. Sel. Areas Commun. 37(5), 1159–1166 (2019)

[36] Bera, S., Misra, S., Saha, N.: Traffic-aware dynamic controller assignment in sdn. IEEE Trans. Commun. 68(7), 4375–4382 (2020)

[37] Mao, B., Tang, F., Fadlullah, Z.M., Kato, N., Akashi, O., Inoue, T., Mizutani, K.: A novel non-supervised deep-learning-based network traffic control method for software defined wireless networks. IEEE Wirel. Commun. 25(4), 74–81 (2018)

[38] Satheesh N. & etl: IDS detection based on optimization based on WI-CS and GNN algorithm in SCADA network, Lecture Notes in Networks and Systems, 2021, 196, pp. 247–265.

[39] S. Reddy and G. Malleswari, "Adaptive Energy Routing Protocol using Spider Optimization in Wireless Sensor Networks," 2023 International Conference on Computer Communication and Informatics (ICCCI), Coimbatore, India, 2023, pp. 1-6.

[40] Elrawy, M.F., Awad, A.I., Hamed, H.: Intrusion detection systems for IoT-based smart environments: a survey. J. Cloud Comput. Adv. Syst. Appl. (2018).

[41] Bellavista, P., Giannelli, C., Lagkas, T., Sarigiannidis, P.: Quality management of surveillance multimedia streams via federated sdn controllers in fiwi-iot integrated deployment environments. IEEE Access 6, 21324–21341 (2018)

[42] Adhami, H., Al Ja’afreh, M., El Saddik, A.: Ontology based framework for tactile internet applications. In: International conference on smart multimedia, Springer, Cham, pp 81–86 (2019)

[43] Chandramohan, S. and Senthilkumaran, M. (2022), "SDN-based dynamic resource management and scheduling for cognitive industrial IoT", International Journal of Intelligent Computing and Cybernetics, Vol. 15 No. 3, pp. 425-437.

[44] S. Reddy and G. Malleswari, "Efficient Brain Tumor Segmentation using Kernel Representation," 2023 7th International Conference on Intelligent Computing and Control Systems (ICICCS), Madurai, India, 2023, pp. 1006-1011.

[45] Ja’afreh, M., Adhami, H., Alchalabi, A.E. et al. Toward integrating software defined networks with the Internet of Things: a review. Cluster Comput 25, 1619–1636 (2022).