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Integrating Artificial Intelligence & Deep Learning Hybridization for Optimization of Secure Routing in the Critical Infrastructure of the Internet of Things (IoTs) with Intrusion Detection Capability based on Software-defined Network (SDN) and Machine Learning Technique

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Article Details

Keywords: Machine Learning, ResNet, Deep Neural Network, CNN, Prediction Models, Hybrid Machine Learning, Routing Attacks Detection

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ABSTRACT

The invention of deep learning in secure routing triggered an exceptional expansion of the Internet of Things (IoTs). Concurrent analysis of human body data occurs in the fog layer after sensors and actuators collect information from smart medical devices. The combination of criticality with increased complexity and dynamic capabilities causes H-IoT devices to be incompatible with typical network configurations which generates security and QoS problems. The identification of appropriate fog nodes together with unnecessary data reduction proves to be a complicated process. This paper incorporates SDN-driven DL to design a secure and intelligent framework for H-CIoT networks which solves existing network challenges. The SDN architecture stands out as a suitable solution because it enables network infrastructure reconfiguration while managing distributed IoT network architecture through separate data and control planes. The Proposed ML based AODV and AOMDV offers enhanced network security through centralized control and programmability, allowing for fine-grained security policies and real-time adjustments. The AOMDV security module serves as an implementation to detect multiple attack types that appear in the IoT network. The training process of the Deep Learning model utilizes IOT devices archival data in industry. The system uses acquired information to determine if data needs to be transferred to the fog layer. The suggested framework utilizes deep learning hybridization and CNN for selecting the optimal fog node alongside its features. The simulation of the proposed framework demonstrated 99.59% accuracy and achieves 80% detection ratio together with a 0.99% ideal throughput and datagram delivery rate of 0.89%, a minimum energy of 0.11 m joules, at a maximum speed of 0.84 bps, and a negligible delay of 0.3415 ms when tested with 30 nodes. alongside 4% increased F1-score performance at 10 ms faster latency and lower energy usage of 25 W and 0.66% better probability.

INTRODUCTION

The first key function of SDN services operate as a network system for data transfer between users who become part of the SDN subscription. A SDN contains all private network characteristics because its operational design mandates this privacy feature. The question remains valid since we need to determine what makes a network system private. The deployment of private network services creates a secure environment that provides exclusive network-related access to chosen users [1, 2]. All teletraffic starting and ending inside a private network uses only network nodes that exist within its domain. As a feature of private networks, there exists traffic isolation. The private traffic network exists independently from all other types of traffic that are not part of this network. Last but not least the virtual nature defines SDN as a characteristic element [3, 4]. The superimposed virtual network topology operates on top of the present physical information and telecommunications infrastructure. SDN stands for Virtual Private Network as an additional private network that extends through shared or public telecommunications systems like the Internet. A SDN enables transferring data across one or more computers and multiple internetworks to transmit data through shared networks that operate as though they share the same direct node connectivity. The development and setup process for a virtual private network operates under the term virtual private networking [5, 6].

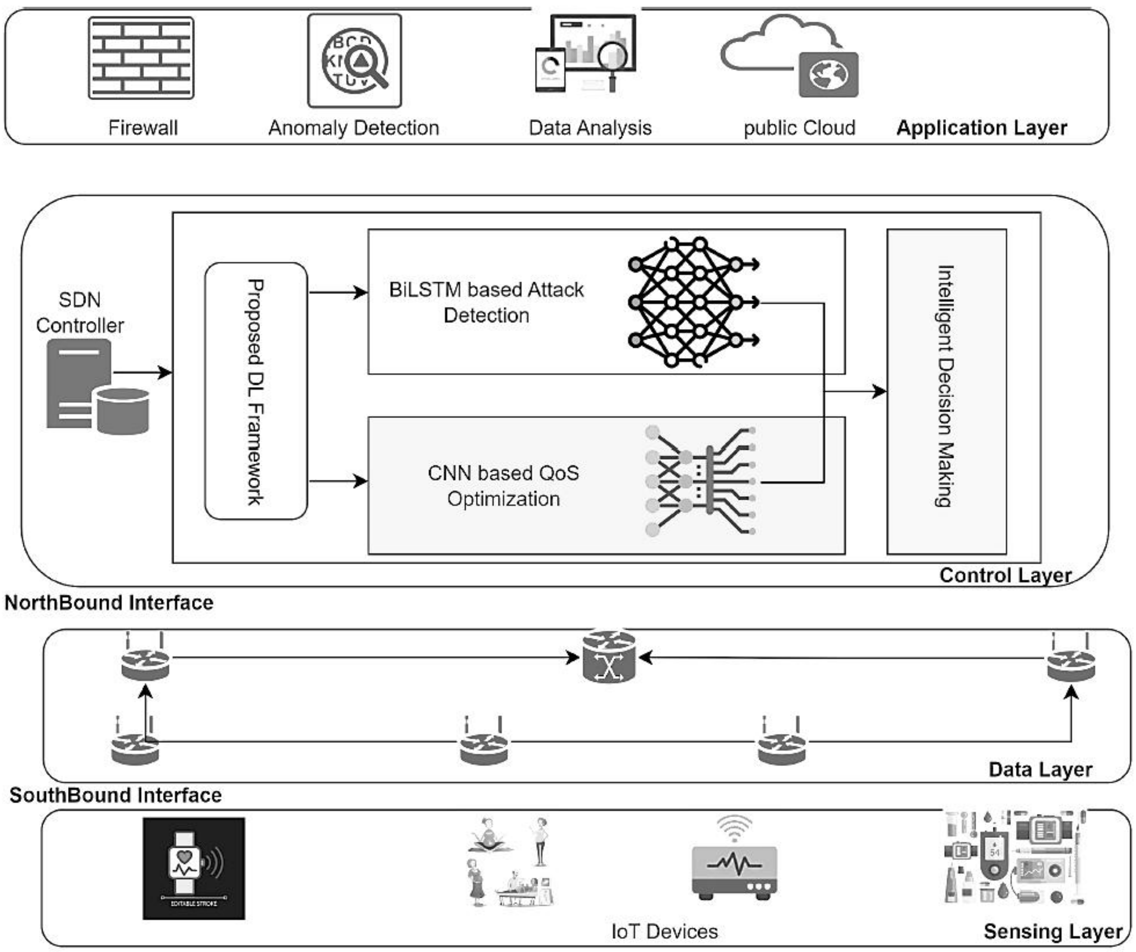

FIGURE 1: DEMONSTRATION OF PROPOSED ML-BASED SDN NETWORK SYSTEM [7]

DATAGRAM DELIVERY (DD)

The datagram delivery (DD) transmit shows the throughput of datagram Delivery represented as:

$$DD = \frac{no.\,of\,datagram\,received\,(a_i)}{no\,of\,datagram\,sent\,(b_i)} \qquad \text{Eq (1)}$$

Similar to the point-to-point link described in [8] headers enclose the data which travels between shared and public internetworks towards its destination point. The goal of encryption becomes security as the system operates to duplicate private link operations. The captured packets on shared or public networks become unreadable until the encryption keys are provided for decryption. A virtual private network (SDN) connection contains private data that has been either encoded or secured. A user can establish a secure corporate Internet server connection through the Internet routing structures using a SDN connection from home or any other location [9, 10].

MACHINE LEARNING ALGORITHMS

They provide the Network with the capacity to take in large amounts of information and learn from it to then decide what to do with that data. Humanoid Networkics uses the following ML algorithms. This involves training algorithms typically includes techniques like neural networks or decision trees. For example, convolutional neural networks (CNNs) have achieved well over 90% accuracy on benchmark tasks like object recognition [11, 12]. This method can be thought of as a Network looking for patterns of unlabeled data For example, clustering and dimensionality reduction for anomaly detection and feature extraction are implemented using these methods. For example, k-means clustering has been successfully used for Network vision data segmentation. This method requires the training of Networks by rewarding them whenever they take a good course of action. But, more interestingly, it is well suited for discovering complex behaviors and adaptive control [13].

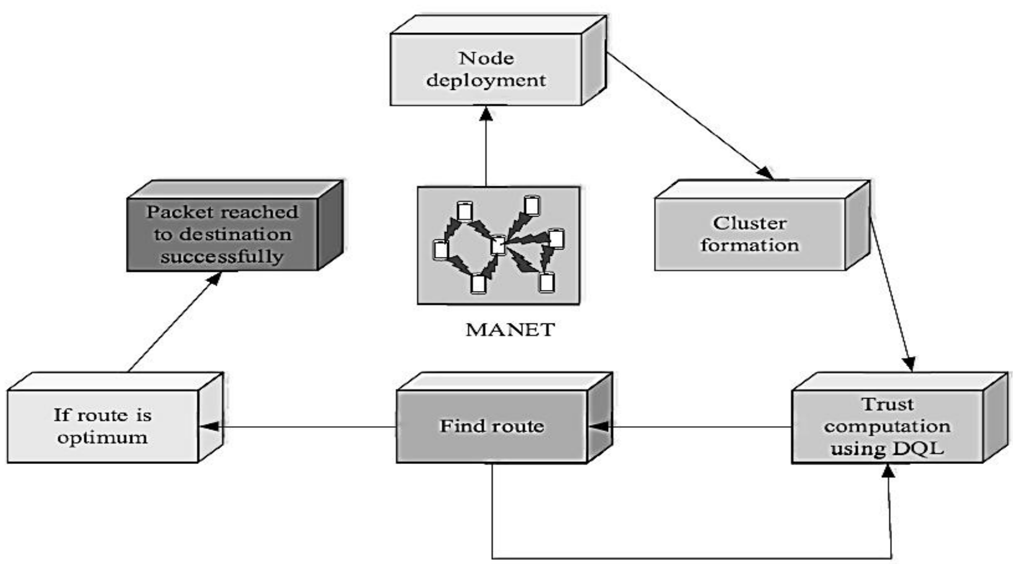

FIGURE 2: SECURE ROUTING INFRASTRUCTURE FOR INTERNET OF THINGS (IOTS) [14]

Traditional Q-learning and deep Q-networks (DQN) algorithms are capable of achieving state-of-the-art Network navigation and manipulation performance improvements on a subset of benchmark tasks. Mathematical representation of Q-learning algorithm [15]. The network correlation coefficient (r) has the following equation used for IoT-based Networks as shown in Equation (1).

$$\mathbf{r} = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}} \qquad \text{Eq (2)}$$

$$Q(s,a) \leftarrow Q(s,a) + \alpha[r + \gamma \max a' \ Q(s', a') - Q(s,a) \qquad \text{Eq (3)}$$

RELATED WORK

The Internet of Things (IoT) stands as the prevalent notion concerning Internet expansion during the third wave. Medical Internet of Things exists as a group of Internet-connected medical equipment that helps health processes through procedure execution and service delivery [16]. With the use of tiny wearable devices or implanted sensors. MIOT represents a new healthcare technology that collects vital patient data while monitoring pathological conditions through its system. MIOT applications that use wireless body area networks (WBAN) to implantable medical devices have proven their ability to enhance healthcare for people. IOMT operates as a worldwide system that links medical devices into a single network available for universal access at any point in time [17, 18]. The health industry has transformed because of its advancing development patterns. The IOMT-based e-health application landscape dominates wellness services which motivate millions of global human beings to choose healthier lifestyles according to research findings in [19] and [20]. Healthcare services have developed into user-directed and accurate comprehensive customized pervasive healthcare solutions which include 24-hour private healthcare services [21, 22].

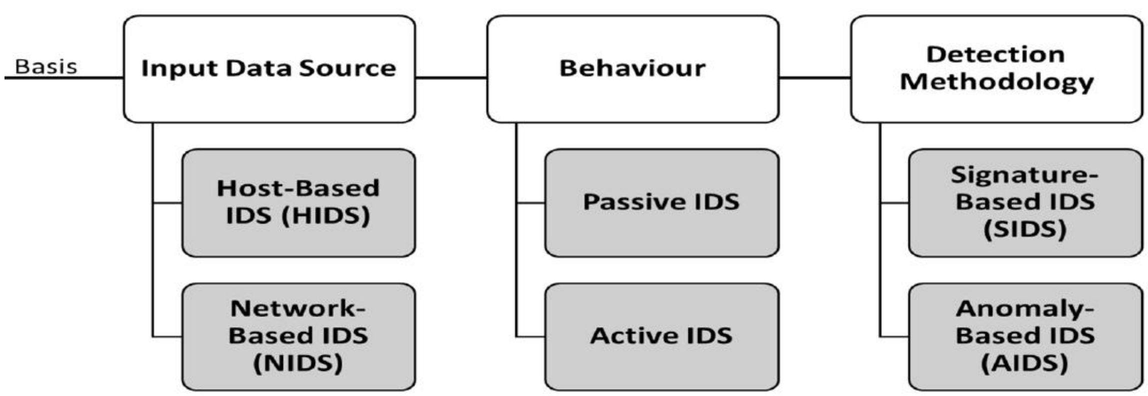

FIGURE 3: MACHINE LEARNING BASED IDS FOR IOTS [23]

$$u(t)=K_p e(t)+K_i \int e(t)\,dt+K_d \frac{de(t)}{dt} \quad \text{Eq (4)}$$

These are responsible for image classification, and object detection tasks to help Networks see, interpret, and understand the visual world. CNNs have been extremely successful, with architectures like AlexNet getting a top-5 error rate of 15.3% on the ImageNet dataset. Research about mammalian visual cortex mechanisms formed the basis of Convolutional Neural Networks (CNNs) [24]. CNNs reproduce brain functionality which enables neurons to analyze various spatial patterns in visual information [25]. CNN architecture refers to an essential mathematical approach that enables weight sharing along with local processing and spatial pattern retention. The LeNet-5 model created by Kate and Shukla marked the first successful implementation of CNNs for handwritten number detection during the 1980s [26, 27]. Document recognition progressed a great deal after the model introduced gradient-based learning mechanisms. CNNs demonstrate exceptional performance in data arrangements with grid-like structures such as images that equal two-dimensional pixel grids. The study reviewed the foundation of neural networks and their advanced structures alongside their primary medical diagnostic applications [28, 29].

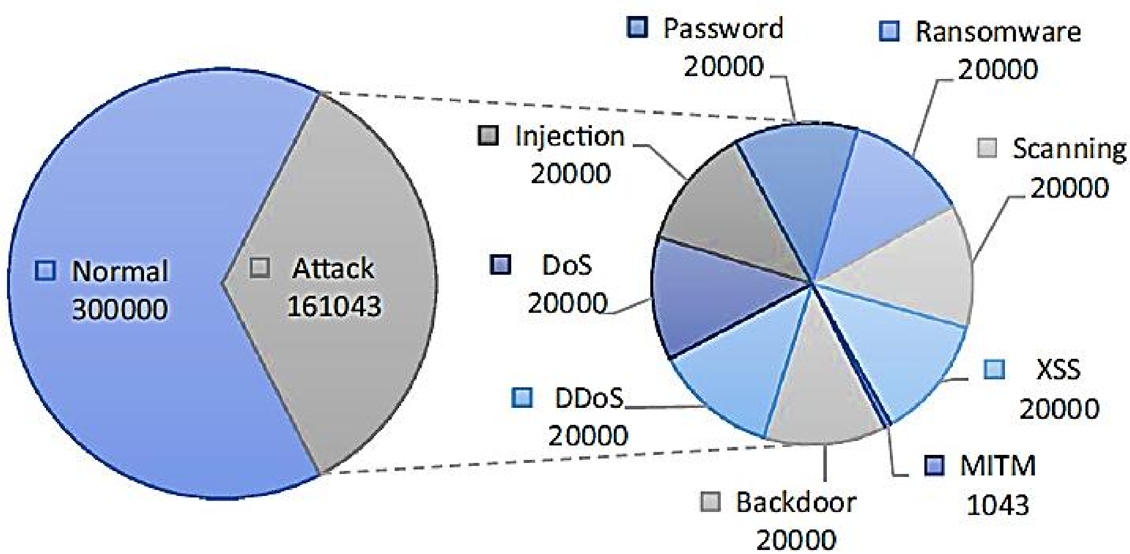

FIGURE 4: DIFFERENT ATTACKS IN IOT NETWORK DATASET USED IN IOTS [30]

3. Machine Learning Based Deep Learning Hybridization for Optimization of Secure Routing

In today's interconnected world, network security and privacy are more crucial than ever. As we rely more on digital platforms for both personal and business activities, the threats to our online security have grown significantly. Rapid technological advancements have brought greater convenience, but they've also introduced new vulnerabilities in how we communicate and share data. Which helps ensure secure and private communication, especially over potentially unsafe networks like the public internet. However, cyber threats are constantly evolving. Sophisticated hacking techniques, data interception, and identity theft create significant challenges for network security. Additionally, the increasing rise of surveillance by governments, data collection by corporations, and even censorship complicate the ability to maintain personal privacy online. The research problem centers on understanding and addressing these growing challenges to network security and privacy. Protocols that not only ensure secure communication but also protect against emerging threats while maintaining privacy in the increasingly complex online world.

This research adopts a qualitative approach, focusing on the conceptual analysis of Routing protocols through an extensive ML-based approach. The goal is to gain insights into the operational mechanics, security features, and performance aspects of various Network protocols. By leveraging academic papers, industry reports, and technical documentation, this approach aims to build a well-rounded protocol function in modern network environments.

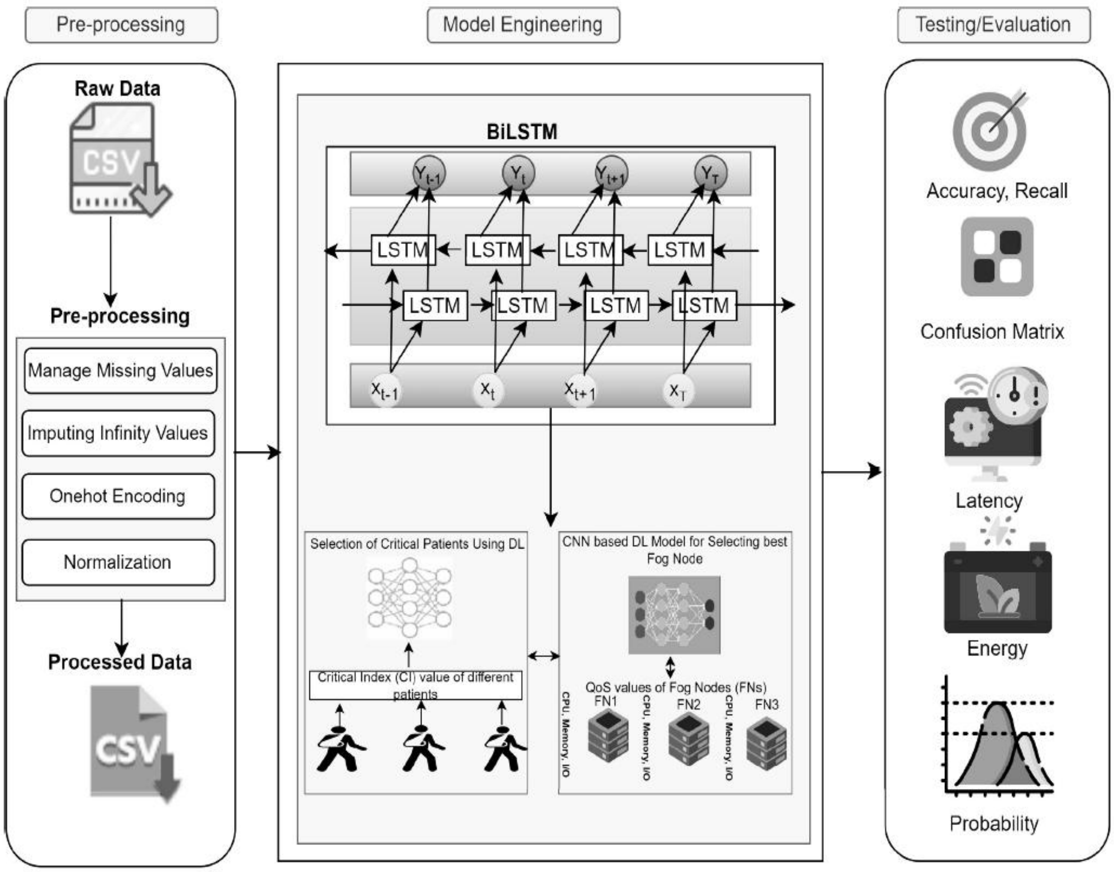

FIGURE 5: PROPOSED FRAMEWORK BASED ON ML AND SDN NETWORK

$$B = \{B_1, B_2, \ldots, B_k, \ldots, B_l\}$$ Eq (5)

$$E_c = \frac{1}{K} \times \sum_{g=1}^{k} J_v^{b,t} - k_v$$ Eq (6)

$$B_{m,n}(q+1)\left(1 - \frac{1 - X(0,1) - X(-1,1)}{1 - c_{m,n} \times f_{mn}(q)}\right) = X(0,1) \times R_{s,n}$$ Eq (7)

The proposed classifier contains i to represent random units of b-layer units and y to represent the total b-layer units.

$$S_i^{(b,t)} = \sum_{z=1}^{E} p_{iz}^{(b)} J_z^{(b-1,t)} + \sum_{i'}^{y} x_{ii'}^{(b)} J_{i'}^{(b,t-1)}$$

Eq (8)

$$J_i^{(b,t)} = \beta^{(b)}(S_i^{(b,t)})$$

Eq (9)

$$P(w) = \sqrt{\frac{t}{f(w)}} + \frac{t}{f(w)},$$

Eq (10)

$$f(w) = \frac{count_w}{totalno.oftokens},$$

Eq (11)

$$f_t = \sigma(W_f.[h_{(t-1)}, x_t] + b_f)$$

Eq (12)

The Naive Bayes framework stands as a fast ML model which relies upon execution of Multiple data attributes that are assessed by the algorithm to make predictions regarding query assignments between normal and malicious classes. The model delivers successful results because its features operate independently from one another.

$$P(L|R) = \frac{P(R|L).P(L)}{P(R)}$$ Eq (13)

This model provides simple implementation and quick execution periods to Baselines. This method succeeds in discrimination tasks where data contains easy to interpret structured information. Numerous factors of decision tree functionality depend on achieving maximum information Gain throughout data splitting procedures. Pruning techniques were used to minimize chances of under fitting.

$$G(x) = 1 - \sum_{i-1}^{k} R_{\bar{i}}^{2} \qquad \text{Eq (14)}$$

x. Particular node of decision tree.

k. Intruders packers in SQL.

The support vector machine (SVM) achieved non-linear classification optimization through the implementation of its Radial Basis function kernel. A grid search optimization yielded optimal performance results concerning both the C parameter and γ coefficient in the SVM model.

The SVM decision function:

$$f(x) = k^T l + \quad p \qquad \text{Eq (15)}$$

$\boldsymbol{K}$ is the vector representing weight.

$\boldsymbol{L}$ is an input vector.

$\boldsymbol{p}$ indicated the bias term.

An ensemble model uses 1,000 decision trees learns through samples acquired randomly by bootstrapping techniques. A feature important analysis was conducted by the analysts to identify the best suitable features. The model implements two hidden layers which include 256 neurons per layer. The dropout operation together with Batch normalization improved both model convergence speed and protected it from overfitting.

RESULTS AND CLASSIFICATION OF PERFORMANCE

Algorithms are simulated before they are deployed in the real world. Simulations provide a way to evaluate Network behaviors and interactions in controlled environments and can highlight issues that might appear.

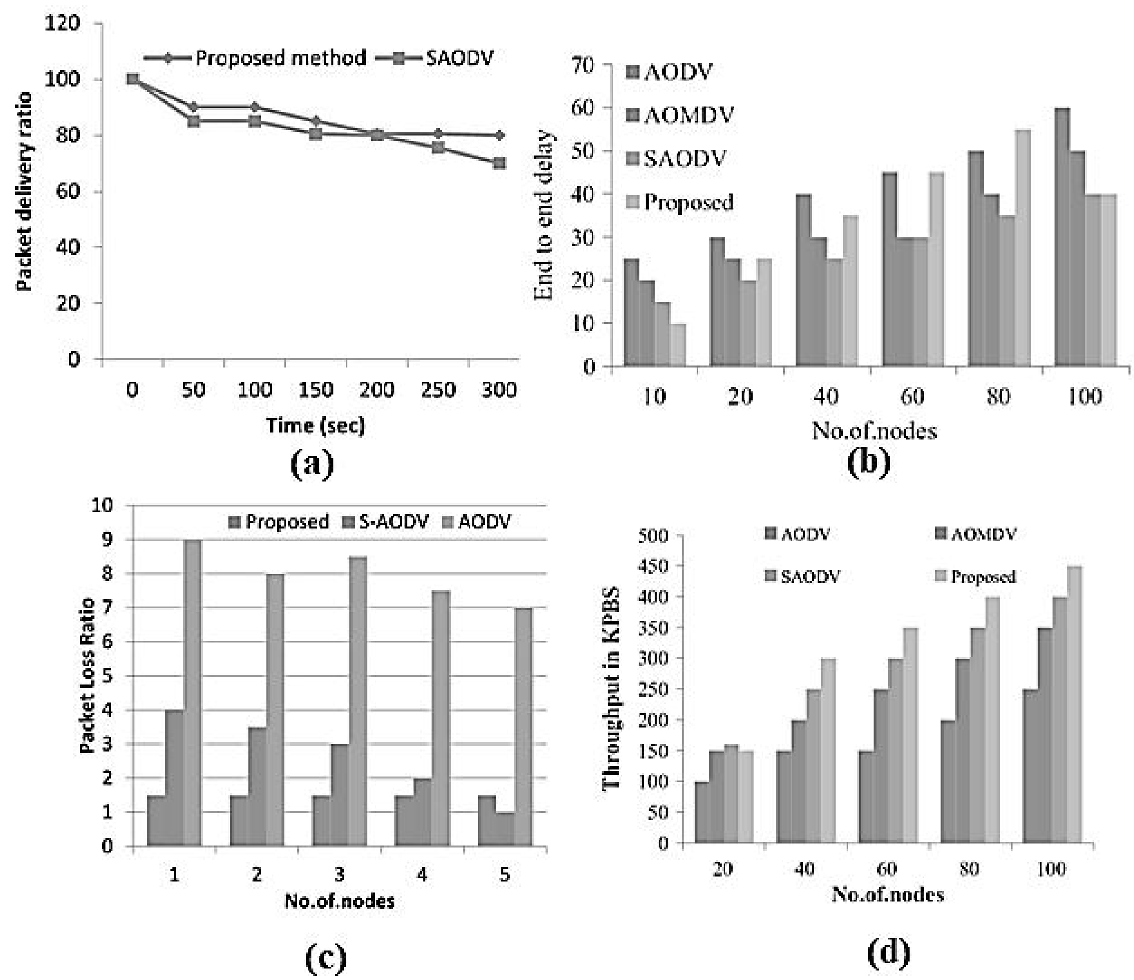

FIGURE 6: (A) DELIVERY OF PACKET RATIO VERSUS TIME (B) NODE TO NODE DELAY (D) DATAGRAM LOSS RATIO VERSUS NO OF NODES (E) THROUGHPUT PERFORMANCE VERSUS NO OF NODES

$$i_t = \sigma(W_i . [h_{(t-1)}, x_t] + b_i), \quad \text{Eq (16)}$$

$$\tilde{C}_t = tanh(W_c.[h_{(t-1)}, x_t] + b_c), \quad \text{Eq (17)}$$

$$C_t = f_t * C_{(t-1)} + i_t * \tilde{C}_t, \quad \text{Eq (18)}$$

$$O_t = \sigma(W_O.[h_{(t-1)}, x_t] + b_o), \quad \text{Eq (19)}$$

PERFORMANCE DATAGRAM LOSS (DL)

The indicator represents the complete total of dropped packets during transmission. The ratio of total lost packets to all received payload determines this value. Performance of datagram Loss Ratio vs. No of Nodes is shown below

Dl = no. of datagram lost/ datagram at receiving end

TRAINING AND VALIDATION ACCURACY OF AODV

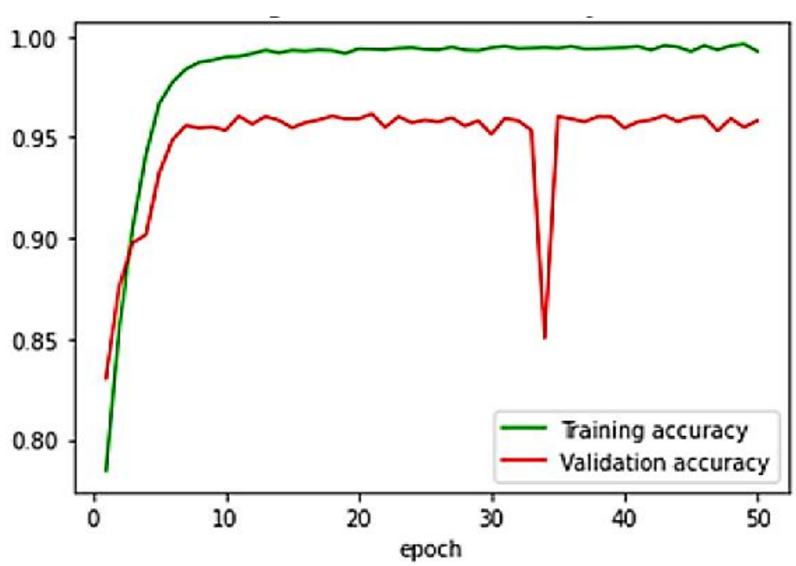

FIGURE 7: TRAINING AND VALIDATION ACCURACY OF DEEP LEARNING HYBRIDIZATION (AODV)

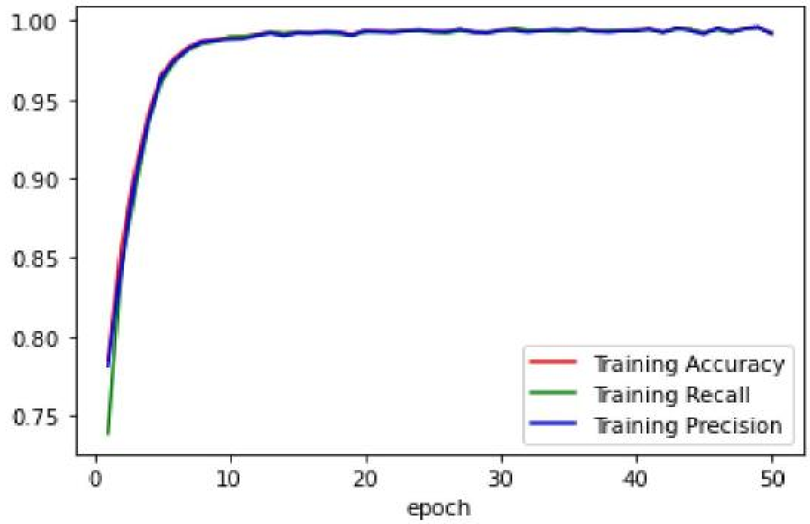

FIGURE 8: TRAINING AND VALIDATION ACCURACY, RECALL AND PRECISION OF DEEP LEARNING HYBRIDIZATION (AODV)

TRAINING AND VALIDATION ACCURACY OF (AOMDV)

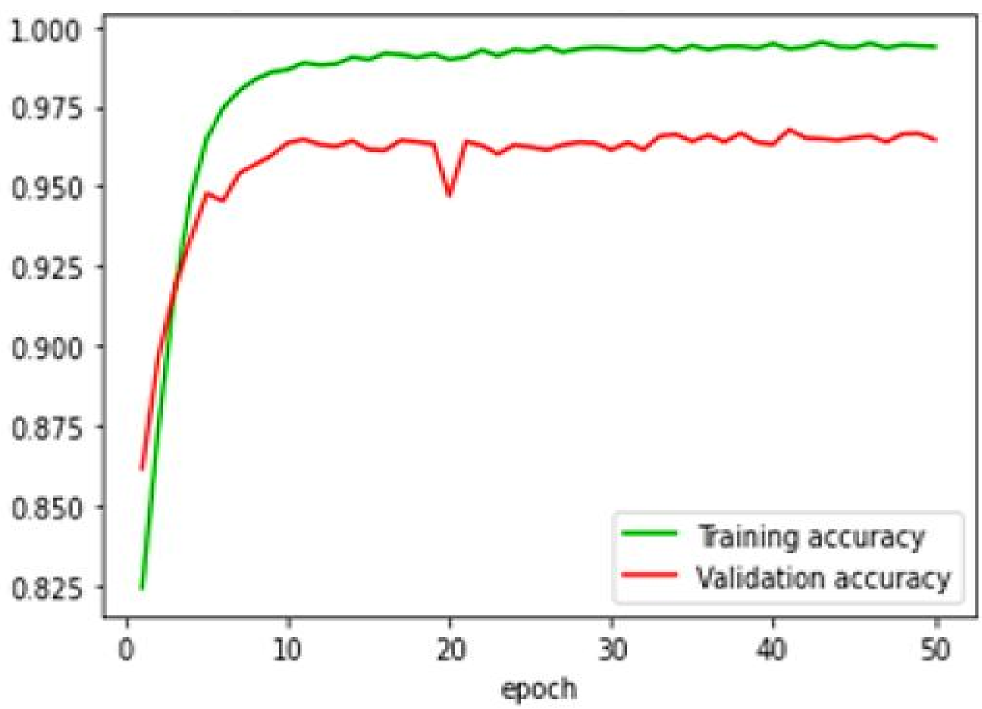

FIGURE 9: TRAINING AND VALIDATION ACCURACY OF AOMDV

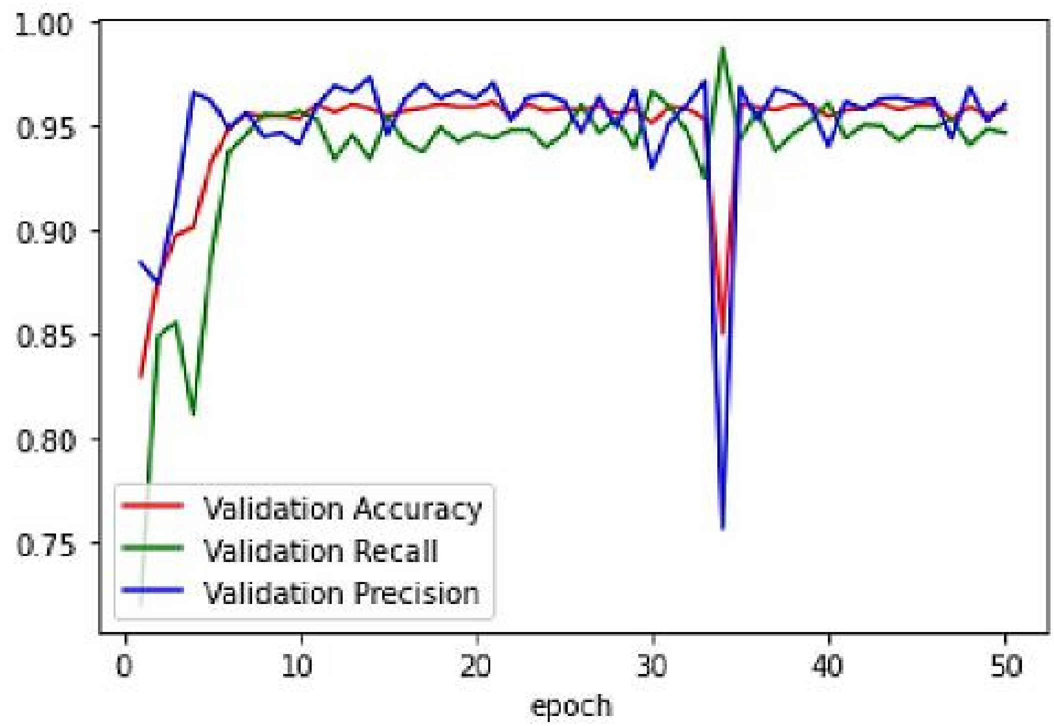

FIGURE 10: TRAINING AND VALIDATION ACCURACY, RECALL AND PRECISION OF AOMDV

TABLE 1: COMPARATIVE ANALYSIS OF NUMEROUS STANDARDS BASED ON CRITICAL INFRASTRUCTURE OF THE INTERNET OF THINGS (IOT) WITH INTRUSION DETECTION (AODV)

Method	Attack Type	Average Throughput	Delay	TH1 (Packet drop)	TH2 (Detection Rate)	TH3 (Max Speed)
(AODV) Critical Infrastructure of IoTs	Passive	0.3198	0.1581	0.5814	0.9216	0.84 bps
	Active	0.1184	0.2119	0.1985	0.3325	0.74 bps
	Passive	0.4555	0.3813	0.4144	0.1231	0.64 bps
	Active	0.1986	0.5449	0.1985	0.2351	0.77 bps
	Passive	0.0416	0.2215	0.666	0.1342	0.17 bps
	Active	1.0516	0.2331	0.155	0.531	0.45 bps

TRAINING AND VALIDATION ACCURACY OF SAODV

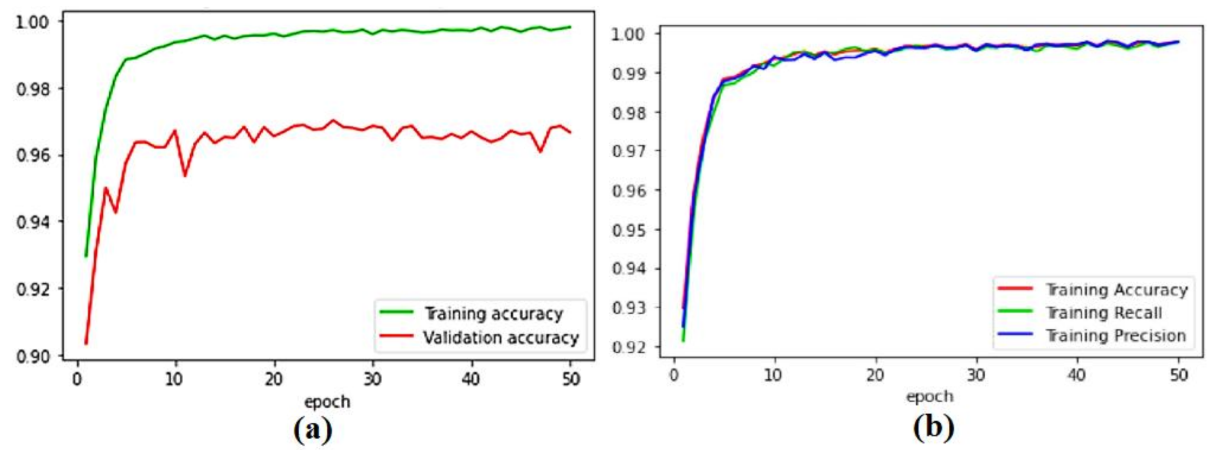

FIGURE 11: (A) TRAINING AND VALIDATION ACCURACY OF SAODV (B) TRAINING AND VALIDATION ACCURACY, RECALL AND PRECISION OF SAODV

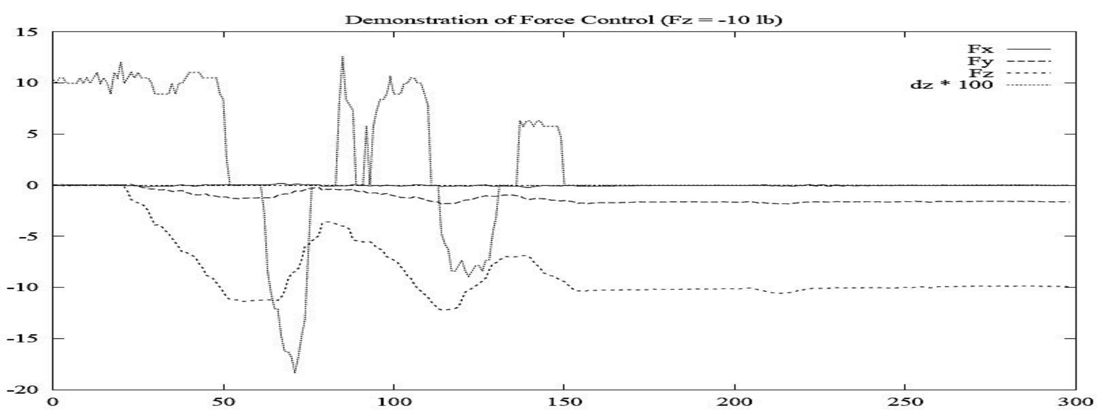

FIGURE 12: SIGNAL STRENGTH BASED ON IOTS ROUTING NETWORK USING SDN

TABLE 2: COMPARATIVE ANALYSIS OF NUMEROUS STANDARDS BASED ON CRITICAL INFRASTRUCTURE OF THE INTERNET OF THINGS (IOT) WITH INTRUSION DETECTION (AOMDV)

Method	Attack Type	Average Throughput	Delay	TH1 (Packet drop)	TH2 (Detection Rate)	TH3 (Max Speed)
	Passive	0.2241	0.2351	0.3581	0.3216	0.94 bps
	Active	0.3198	0.6581	0.4814	0.2435	0.51 bps

(AOMDV)	Passive	0.3184	0.5119	0.6985	0.3431	0.52 bps
Critical	Active	0.4555	0.4813	0.7144	0.4321	0.43 bps
Infrastructure	Passive	0.4986	0.7449	0.8985	0.3531	0.67 bps
of IoTs	Active	0..2222	0.3421	0.3431	0.3451	0.76 bps

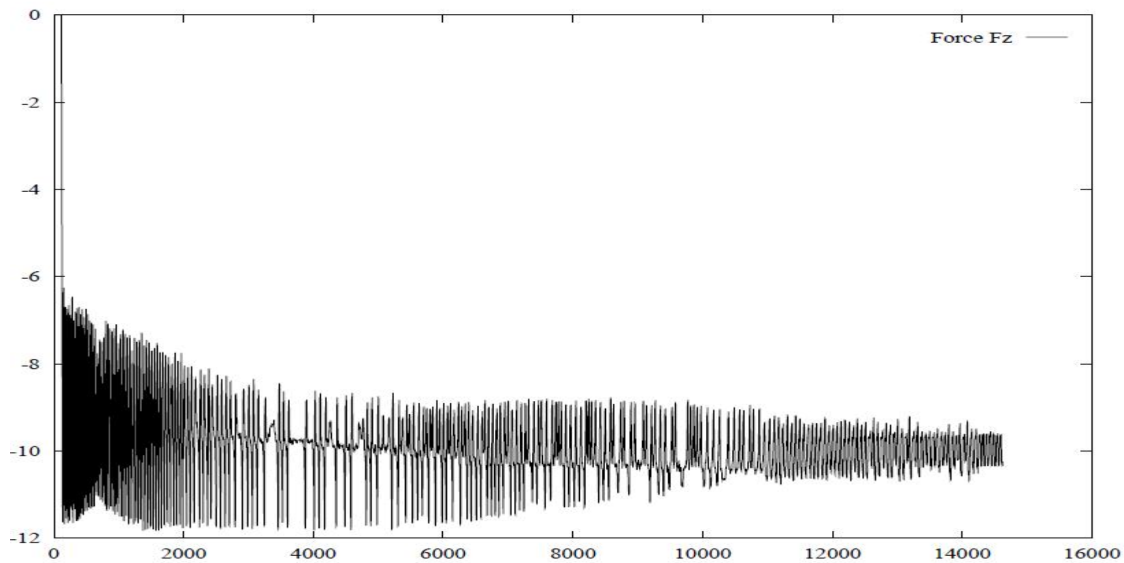

FIGURE 13: DEMONSTRATION OF SNR AT NOISE WITH (FZ= 10LB)

TABLE 3: COMPARATIVE ANALYSIS OF NUMEROUS STANDARDS BASED ON CRITICAL INFRASTRUCTURE OF THE INTERNET OF THINGS (IOT) WITH INTRUSION DETECTION SYSTEM

Attack	Method	Average Throughput	Delay	TH1 (Packet drop)	TH3 (Max Speed)
Black hole attack	AODV	0.3441	0.3431	0.3411	0.64 bps
	AOMDV	0.7119	0.4985	0.5431	0.61 bps
	SAODV	0.8813	0.7644	0.6321	0.72 bps
	Proposed	0.9449	0.7785	0.7531	0.83 bps
	AODV-1	0.1813	0.8844	0.8451	0.97 bps
	AOMDV-2	0.2449	0.5585	0.6751	0.86 bps

CONCLUSION AND RECOMMENDATIONS

The scientific fields show great interest in mobile ad hoc network uses. The Integration of Artificial Intelligence & Deep Learning Hybridization plays a vital role in Software-defined Networks (SDN). The scientific community is strongly interested in the mobile applications of IOT networks that require Optimization of Secure Routing in the Critical Infrastructure of the Internet of Things (IoTs) with controlled Intrusion Detection systems (IDS). Such networks maintain exposure to numerous possible attacks because of their basic operational aspects. Wide variety of attacks due to their inherent characteristics. A key barrier to the widespread adoption of these IOTS. The network's two main problems are energy consumption and security weaknesses. The routing system protects against energy depletion and security risks in a safe manner including power crises and security challenges. The implementation of machine learning-based optimization computations succeeded in developing an effective solution using SDN for secure routing of data. Applying the AODV and AOMDV fuzzy clustering method together with maximum feasible values to execute the process identification of trusted nodes depending on values of indirect trust direct trust and recent trust. The node intrusion detection process happens through a set threshold value. The data travels through several hops before CHs direct it to the drain. One hybrid optimization approach, C-SSA optimization, Studies show that the implementation of AODV and AOMDV optimization with its combination of SDN results in maximum effectiveness. Choosing new routing protocols in MANET depends on the selection method referred to for optimization. This proposed method achieves faster convergence in its operational process. The deep learning hybrid system places storage productivity demands before everything else. The Proposed framewrok achieved a 80% detection ratio together with a 0.99% ideal throughput and Datagram delivery rate of 0.85%,with 0.121 joules of energy, with speed 0.814 bps, with absolute latency of 0.3415 ms when trained and tested the model with 30 system..

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REFERENCES

[1] Islam, M. K., Rahman, M. M., Ali, M. S., Mahim, S. & Miah, M. S. Enhancing lung abnormalities diagnosis using hybrid dcnnvit- gru model with explainable ai: A deep learning approach. Image Vis. Comput. 142, 104918 (2024).

[2] Gao, J., Wang, H., & Shen, H. (2020). Task failure prediction in cloud data centers using deep learning. IEEE Transactions on Services Computing, 1111–1116. https:// doi.org/10.1109/BigData47090.2019.9006011 ...

[3] Guo, X., Aviles, G., Liu, Y., Tian, R., Unger, B. A., Lin, Y. H. T., & Kampmann, M. (2020). Mitochondrial stress is relayed to the cytosol by an OMA1–DELE1–HRI pathway. Nature, 579(7799), 427–432.

[4] Jindal, A., Aujla, G. S., & Kumar, N. (2019). SURVIVOR: A blockchain-based edge-as-a-service framework for secure energy trading in SDN-enabled vehicle-to-grid environment. Computer Networks, 153, 36–48. Khoramshahi, M., & Billard, A. (2019). A dynamical system approach to task adaptation in physical human-Network interaction. Autonomous Networks, 43(4), 927–946.

[5] Lin, K., Li, Y., Sun, J., Zhou, D., & Zhang, Q. (2020). Multi-sensor fusion for a body sensor network in a medical human-Network interaction scenario. Information Fusion, 57, 15–26. Manogaran, G., Baskar, S., Hsu, C. H., Kadry, S. N., Sundarasekar, R., Kumar, P. M., & Muthu, B. A. (2021).

[6] FDM: Fuzzy-optimized Data Management Technique for Improving Big Data Analytics. IEEE Transactions on Fuzzy Systems, 29(1), 177–185. Manogaran, G., Shakeel, P. M., Priyan, R. V., Chilamkurti, N., & Srivastava, A. (2019). Ant colony optimization-induced route optimization for enhancing the driving range of electric vehicles. International Journal of Communication Systems, e3964. https://doi.org/10.1002/dac.3964

[7] Gesture-based human-Network interaction for human assistance in manufacturing. The International Journal of Advanced Manufacturing Technology, 101(1), 119–135. Nguyen, N. T., Liu, B. H., Pham, V. T., & Huang, C. Y. (2016). Network under limited mobile devices: A new technique for mobile charging scheduling with multiple sinks. IEEE Systems Journal, 12(3), 2186–2196.

[8] Preeth, S. S. L., Dhanalakshmi, R., & Shakeel, P. M. (2020). An intelligent approach for

energy efficient trajectory design for mobile sink based IoT supported wireless sensor networks. Peer-to-Peer Networking and Applications, 13(6), 2011–2022.

[9] Priyan, M. K., & Devi, G. U. (2018). Energy-efficient node selection algorithm based on node performance index and random waypoint mobility model on the Internet of vehicles. Cluster Computing, 21(1), 213–227.

[10] Ramprasad, L., & Amudha, G. (2014, February). Spammer detection and tagging based user generated video search system—A survey. In International Conference on Information Communication and Embedded Systems (ICICES2014) (pp. 1–5).

[11] H. Khan, I. Uddin, A. Ali, M. Husain, "An Optimal DPM Based Energy-Aware Task Scheduling for Performance Enhancement in Embedded MPSoC", Computers, Materials & Continua., vol. 74, no. 1, pp. 2097-2113, Sep. 2023

[12] Khan, S., Ullah, I., Khan, H., Rahman, F. U., Rahman, M. U., Saleem, M. A., ... & Ullah, A. (2024). Green synthesis of AgNPs from leaves extract of Saliva Sclarea, their characterization, antibacterial activity, and catalytic reduction ability. Zeitschrift für Physikalische Chemie, 238(5), 931-947.

[13] U. Hashmi, S. A. ZeeshanNajam, "Thermal-Aware Real-Time Task Schedulabilty test for Energy and Power System Optimization using Homogeneous Cache Hierarchy of Multi-core Systems", Journal of Mechanics of Continua and Mathematical Sciences., vol. 14, no. 4, pp. 442-452, Mar. 2023

[14] Ali, M., Khan, H., Rana, M. T. A., Ali, A., Baig, M. Z., Rehman, S. U., & Alsaawy, Y. (2024). A Machine Learning Approach to Reduce Latency in Edge Computing for IoT Devices. Engineering, Technology & Applied Science Research, 14(5), 16751-16756.

[15] Nasir, M. S., Khan, H., Qureshi, A., Rafiq, A., & Rasheed, T. (2024). Ethical Aspects In Cyber Security Maintaining Data Integrity and Protection: A Review. Spectrum of engineering sciences, 2(3), 420-454.

[16] Khan, A. Ali, S. Alshmrany, "Enery-Efficient Scheduling Based on Task Migration Policy Using DPM for Homogeneous MPSoCs", Computers, Materials & Continua., vol. 74, no. 1, pp. 965-981, Apr. 2023

[17] Abdullah, M., Khan, H., Shafqat, A., Daniyal, M., Bilal, M., & Anas, M. (2024). Internet of Things (IoT's) in Agriculture: Unexplored Opportunities in Cross–Platform. Spectrum of

engineering sciences, 2(4), 57-84.

[18] Khan, S. Ahmad, N. Saleem, M. U. Hashmi, Q. Bashir, "Scheduling Based Dynamic Power Management Technique for offline Optimization of Energy in Multi Core Processors", Int. J. Sci. Eng. Res., vol. 9, no. 12, pp. 6-10, Dec. 2018

[19] H. Khan, M. U. Hashmi, Z. Khan, R. Ahmad, A. Saleem, "Performance Evaluation for Secure DES-Algorithm Based Authentication & Counter Measures for Internet Mobile Host Protocol", IJCSNS Int. J. Comput. Sci. Netw. Secur., vol. 18, no. 12, pp. 181-185, July. 2018

[20] Khan, K. Janjua, A. Sikandar, M. W. Qazi, Z. Hameed, "An Efficient Scheduling based cloud computing technique using virtual Machine Resource Allocation for efficient resource utilization of Servers", In 2020 International Conference on Engineering and Emerging Technologies (ICEET), IEEE., pp. 1-7, Apr. 2020

[21] Naz, H. Khan, I. Ud Din, A. Ali, and M. Husain, "An Efficient Optimization System for Early Breast Cancer Diagnosis based on Internet of Medical Things and Deep Learning", Eng. Technol. Appl. Sci. Res., vol. 14, no. 4, pp. 15957–15962, Aug. 2024

[22] Akmal, I., Khan, H., Khushnood, A., Zulfiqar, F., & Shahbaz, E. (2024). An Efficient Artificial Intelligence (Al) and Blockchain-Based Security Strategies for Enhancing the Protection of Low-Power loT Devices in 5G Networks. Spectrum of engineering siences, 2(3), 528-586.

[23] H. Khan, M. U. Hashmi, Z. Khan, R. Ahmad, "Offline Earliest Deadline first Scheduling based Technique for Optimization of Energy using STORM in Homogeneous Multi-core Systems", IJCSNS Int. J. Comput. Sci. Netw. Secur., vol. 18, no. 12, pp. 125-130, Dec. 201

[24] Waleed, A. Ali, S. Tariq, G. Mustafa, H. Sarwar, S. Saif, I. Uddin, "An Efficient Artificial Intelligence (AI) and Internet of Things (IoT's) Based MEAN Stack Technology Applications", Bulletin of Business and Economics (BBE)., vol. 13, no. 2, pp. 200-206, July. 2024

[25] Y. A. Khan, "A GSM based Resource Allocation technique to control Autonomous Networkic Glove for Spinal Cord Implant paralysed Patients using Flex Sensors", Sukkur IBA Journal of Emerging Technologies., vol. 3, no. 2, pp. 13-23, Feb. 2020

[26] Hassan, H. Khan, I. Uddin, A. Sajid, "Optimal Emerging trends of Deep Learning Technique for Detection based on Convolutional Neural Network", Bulletin of Business and Economics (BBE)., vol. 12, no. 4, pp. 264-273, Nov. 2023

[27] Khan, A. Yasmeen, S. Jan, U. Hashmi, "Enhanced Resource Leveling Indynamic Power Management Techniqueof Improvement In Performance For Multi-Core Processors" ,Journal of Mechanics of Continua and Mathematical Sciences., vol. 6, no. 14, pp 956-972, Sep. 2019

[28] Javed, M. A., Anjum, M., Ahmed, H. A., Ali, A., Shahzad, H. M., Khan, H., & Alshahrani, A. M. (2024). Leveraging Convolutional Neural Network (CNN)-based Auto Encoders for Enhanced Anomaly Detection in High-Dimensional Datasets. Engineering, Technology & Applied Science Research, 14(6), 17894-17899.

[29] Khan, I. Ullah, M. U. Rahman, H. Khan, A. B. Shah, R. H. Althomali, M. M. Rahman, "Inorganic-polymer composite electrolytes: basics, fabrications, challenges and future perspectives", Reviews in Inorganic Chemistry., vol. 44, no. 3, pp. 1-2, Jan. 2024

[30] Y. A. Khan, U. Khalil, H. Khan, A. Uddin, S. Ahmed, "Power flow control by unified power flow controller",sss Engineering, Technology & Applied Science Research., vol. 9, no. 2, pp. 3900-3904, Feb. 2019