The Seybold Report

ISSN 1533-9211

DOI 10.17605/OSF.IO/83UQZ

AN ARTIFICIAL INTELLIGENCE BASED APPLICATION PORTFOLIO FOR TRUSTED ROUTE ANALYSIS IN FOG-IOT

RUCHI BHATNAGAR [1] and K.K. SHARMA [2]

[1, 2] SoCSA, IIMT University, Meerut, U.P., India.
Orcid: [1]0000-0002-3268-6129. Email: [1]ruchi.asmank@gmail.com, [2] kks57@gmail.com

Abstract

The smart and connected devices with 6G competence extended the Internet of Things expectations enormously for providing versatile services but also witness some criticalities in the real time environments. Although, the real time routing solutions provide significant development for routing reliability but observes several hurdles of sensor nodes characteristics in smart applications scenario. The inclusion of Fog-Edge devices improving the states of routing as well as trust by enabling Computational Intelligent among applications. Such an Artificial Intelligence based application introduces a routing method using optimization for heterogeneous node portfolio with 6G networking configuration and then transmitted data securely using authenticated three-way handshake communication. The Proposed Protocol verify by AI modular approach and guaranteed an efficient way of secure routing using Fog Cloud computing model.

Keywords: Autonomous System, 6G Network, Genetic Algorithm Optimization, Efficient Routing Protocol, Three Way Handshake

1. INTRODUCTION

An IoT devices has plenty of opportunities in smart enabled technologies using 6G [1]. It's an extended version of 5G that enriched with numerous facility. The Industrialist believe in this technology fully for the development of smart intelligent and autonomous systems [2]. The Smart applications are more data driven as well as optimized such a way so that achieves its full functionalities. Fog based IoT applications and 6G capabilities made the real time technologies into new heights. And the developers of real time applications need more to be concerned about that; the system must respect certain rules and deadlines, coding of software and components, precise decision algorithms and mostly important synchronization between different devices and optimization of delay between them [3]. The integration of Fog paradigm, with IoT using 6G extension is a deep dive analysis task which also bind with several benefits but related with some challenges also. The 6G networks are apparently care the high speed and technical standard of the transmission of big data generated through smart sensors and also included better resource management in the new portfolio of connected devices [4], [5], [6]. The numerous routing algorithms are devised in Fog-IoT paradigm; Yet the motivation comes from the extension of old applications and introduction of new applications with technology updates; but sometimes reduces the ability to perform well within limited timeframe due to poor cumbersome routing algorithm. While most of applications either new or old suffers from high service delay; thus paper contributes for the development of optimal routing scheme for extended 6G service in Fog-IoT framework; that solves the problem of delay and provide secure data transmission facility using AI based system.

The Seybold Report
ISSN 1533-9211
DOI 10.17605/OSF.IO/83UQZ

The objective of this research work is to design an optimized Routing Algorithm for the secure Fog-IoT architecture using real time application with inclusion of high connectivity by 6G; as optimization process is to find out best solution among n feasible solutions. In particular, we proposed an optimization process for energy efficient and secure routing of data as per applications requirement. Furthermore, this research also elaborates that this Efficient and Secure Routing proposal respond better than other proposed methods. This article is organized in the following subsections; the background and problem statement is presented in Section 2, the review of literature elaborated in section 3, proposed protocol is described in Section 4, the evaluation environment is covered in Section 4, along with an explanation of the experimental data. In the end, Section 5 concludes this work.

2. BACKGROUD AND PROBLEM STATEMENT

The IoT is enabling technology world; latest by smart sensing devices, advanced communication technology and versatile internet protocols and applications. This makes our lives digitally smart and advanced. In this portfolio of working smart sensors sensed information without any human involvement and forward such sensing information using diversified communication technology [7] [8] [9]. However, sincere efforts and advanced modules are necessary to envies the huge data generation and its secure delivery in real time scenario thus easing the communication in connected devices portfolio. Although many dynamic routing algorithm and its implementation perform well with the heterogeneous sensor nodes infrastructure but they suffer from many research issues like nodes energy constraints, network coverage availability, malicious node attacks and many more [10] [11]. On the other hand, the Fog based architecture of connected devices make the applications work in a simpler, smarter and secure ways by introducing modular Artificial Intelligence Apps using 6Generation communication techniques. This important Fog layer does not only support the data preprocessing, interoperability between applications but also enhanced the routing, load distribution, resource management and data security hence improve its industry, social and technical involvement now a day. The Enormous advancements in communication and computing ideas enabled the intelligent Fog architecture with more sophisticated version of the AI based data routing, with basic purpose of warranting safe data delivery [12] [13]. Numerous sensor based optimization techniques as well as data routing proposed and formulated that provide excellent data routing in IoT infrastructure yet Fog based secure routing is one of major issue for researchers. Figure 1 depicts the structure of the Fog-IoT model with IoT application based sensors for data collection and processing using 6G connectivity. The effectiveness of Fog-IoT is highly dependent on the size, and quality of the shared data. However, a large amount of this data is sensitive to privacy and authenticity concerns. Therefore, route the data, preprocessed the data and security are some unresolved issues in such portfolio. The development of AI based modular system is a challenging task, including a secure and computational intelligence decision [14]. This research work aims to offer the routing protocol for automatic decision making with secure data forwarding scheme using Fog based technology.

ISSN 1533-9211

DOI 10.17605/OSF.IO/83UQZ

The following are the primary contributions of the proposed protocol:

1) It gives the AI based modular system using optimization architecture and guaranteed quality service required to gather data from sensor nodes.
2) The proposed routing procedure not only provides the robust system for the IoT applications but on the other side, it also generates less delay based data routing facility.
3) The proposed protocol not only offers a risk-aware routing method but also uses three-way handshake verification and authentication.
4) It is analysed on waste management system.

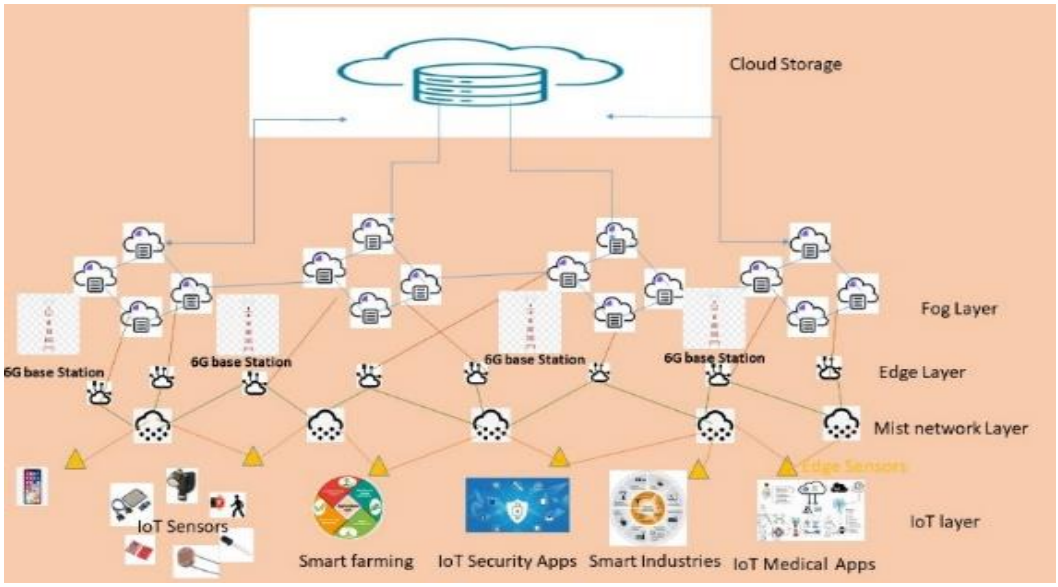


Figure 1: 6G Infrastruture based Fog-Cloud Model

3. RELATED WORK

Real time applications are the major technological milestones of today's smart world; in which the result of application majorly depends upon timeliness and predictable computations. These applications are operated within limited time frame; sensing, analysing and acting on streaming data immediate to take preventive actions. It uses event-driven approach on asynchronous streaming data. With the growing demand of smart devices and wireless connectivity in daily applications Fog Computing accompanied with IoT, Cloud Computing, mobile computing and an interoperable environment of applications. It acts as a powerful tool to provide both communication and data processing simultaneously. This integrated environment act as a smart tool to be collected data from edge devices, processed them in intelligent servers and provide instant results to the time constraint applications. The upcoming research standard for wireless cellular communication and the successor of fifth-generation (5G) is the 6G networks, which provide high levels of efficiency and support a wide range of diverse devices and environments for distributed systems [15], [16]. Due to the functional effectiveness of communication

The Seybold Report
ISSN 1533-9211
DOI 10.17605/OSF.IO/83UQZ

operations, the role of artificial intelligence in 6G networks contributes expressively to real-time routing decisions, many research initiatives are going on in this field where most of them focused on energy efficient routing. Manisha Verma, Neelam Bhardwaj, and Arun Yadav [17] developed a new scheduling policy in their research for load balancing in Fog Computing environment, which satisfy demand of real time users by complete real tasks within deadline and finally increase throughput and network utilization and maintaining data consistency. The simulated results were tremendously good, and provide minimum execution time, consistency along with proper resource and bandwidth utilization as compared to the existing algorithms like FCFS, Priority and Multi Objective Tasks scheduling algorithm in fog computing environment. Sodhro, A. H. et al [18] proposed Qos-TPC (Transmission Power Control based Quality of service) approach to explains the strength of received power at the destination node and is evaluated by the time, transmission power (TP) and distance among other nodes then performs data processing of nodes based on key constraints and achieve Quality of services parameters. In the similar way the Li et. all [19] providing high-performance computing services for delay-sensitive Internet of Things (IoT) applications. As per literature instead of load the task on remote cloud; it can be offloaded on distributed fog computing server through which the delay performance can be greatly improved. They investigated a workload allocation scheme in an IoT–fog–cloud cooperation system for reducing task service delay, aiming at satisfying as many as possible delay-sensitive IoT applications' and quality of service (QoS) requirements. In this proposal they formulate the workload allocation problem in an IoT-edge-cloud cooperation system, which suggests optimal workload allocation among local fog node, neighboring fog node, and the cloud center to minimize task service delay. Then, the stability of the IoT-fog-cloud queueing system is theoretically analyzed with Lyapunov drift plus penalty theory. Based on the analytical results, this delay-aware online workload allocation and scheduling (DAOWA) algorithm is achieved the goal of reducing long-term average task serve delay. The work done in research paper [20] proposes Trust based Routing Protocol for Low Power and Lossy Networks (RPL) to protection against routing or other forms of attacks; with behavior-based analysis of entities in the system with the power to predict future behavior. As new nodes join and old nodes leave; somewhere issue of trust arises in fog computing while this lightweight recommendation based on trust mechanism also impart security to Routing Protocol for Low Power and Lossy Networks (RPL). Fog computing with IoT also supports intelligent transportation; A. Paul and S. Mitra, [21] devised system uses real time data of the vehicles and re-route them by executing a Next hop selection algorithm. It uses to calculates the sequence and duration of green signal for the lanes dynamically as well real time data of the vehicles and re-route vehicles by executing a Next hop selection algorithm; which performs better as compared to Dijakstra and A* Algorithm. As IoT applications enhances quality of services in life but huge data generation places the pressure on resources of traditional cloud data centers; thus it suffers delay sensitive data applications. Mohammad Reza Akbari, Hamid Barati, Ali Barati [22] research consider an efficient energy routing method based on the overlapping clustering inspired from the Grey theory. In this proposal researchers selected the best node for route the data in a hierarchical method using a symmetrical tree of processed data to the server. The simulation results show that it decreases the response time more than 20.1% and 25.78% and increase packet delivery rate more than 23.1% and 28.78% and lifetime more than 25.1%

The Seybold Report
ISSN 1533-9211
DOI 10.17605/OSF.IO/83UQZ

and 28.78% compared other approaches. Abohamama, A.S., El-Ghamry, A. & Hamouda, E. [23] proposed a semi dynamic real-time task scheduling algorithm for bag-of-tasks applications in the cloud–fog environment. This proposal formulates task scheduling as a permutation-based optimization problem. In this case an enhanced and revised version of the genetic algorithm is used to provide different permutations for arrived tasks at each scheduling round. Then, the tasks are assigned, in the order defined by the best permutation, to a virtual machine, which has sufficient resources and achieves the minimum expected execution time. Additionally, the proposed algorithm is compared with first fit, best fit, the genetic algorithm, and the bees' life algorithm in terms of make span, total execution time, failure rate, average delay time, and elapsed run time for solution have become a pillar for enhancing the quality of life. Although all the aforementioned research works have analyzed and proposed diverse domains with the distinct goal and target; yet the aim of all to developed a routing mechanism with targeted challenges. The reviewed literature motivated us to analyzed all the key concern about Fog – IoT portfolio and proposal of an Efficient Routing algorithm; which will perform efficiently routing and secure data delivery.

4. EFFICIENT AND TRUSTED ROUTING PROPOSAL

In this section, we present the explanation of an efficient and secure routing protocol for the IoT devices. Also, its developed architecture components are discussed in detail. The main challenges that occur is the interaction of devices in real time with one another. Moreover, the performance of the Architecture depends on efficient data delivery among nodes and provides sufficient security in terms of authentication, integrity, and confidentiality. The proposed protocol is comprised of two main components. In the first component, the issue of routing the messages from the source toward the destination is addressed through the use of an artificial intelligence-based Perturbative metaheuristic technique. This technique utilizes the genetic algorithm optimization approach which not only allows to select specialized nodes that can pave optimized routing path from sensor nodes to cloud infrastructure through Fog gateways by local search and inhibit a scalable solution for real time application. In the second component, the protection and security of the communicating devices in the network are achieved through the use of session-based authentication and in the proposed protocol, the 6G technology is executed on the upper tier between network edges and sink nodes that explore the communication limitations for the distributed applications. This AI based configuration modules provides routing strategy; that act as intelligent decision maker and will choose best route among n feasible route with high security. The proposal has 2 steps:

Before you begin to format your paper, first write and save the content as a separate text file. Complete all content and organizational editing before formatting. Please note sections A-D below for more information on proofreading, spelling and grammar.

Keep your text and graphic files separate until after the text has been formatted and styled. Do not use hard tabs, and limit use of hard returns to only one return at the end of a paragraph. Do not add any kind of pagination anywhere in the paper. Do not number text heads-the template will do that for you?

ISSN 1533-9211

DOI 10.17605/OSF.IO/83UQZ

a) Routing Algorithm by exploring genetic Algorithm Optimization

This section provides the routing process among nodes using optimizing technique. In this solution we explore the genetic algorithm techniques to efficiently route the nodes for eg. garbage trucks at the right route so it doesn't waste their time to search for empty bins. The genetic algorithm leads end-to-end optimal solutions by utilizing empty bins status and right route. At the beginning of the process, the garbage truck starts its journey from predefined path using starting routing table; as smart IoT sensor with smart dustbin update the route based on its full or empty condition to the Fog servers; the routing table updated using such status and then to select the route where next full dustbin is there. When the route for initially started; garbage truck follows the predefined route but the update done using the threshold parameters stored in selected Fog servers which act as route decision maker; and get selected by natural selection genetic algorithm heuristic. On the basis of smart bin threshold optimized route among predefined route get selected. As the Fog servers are main components to updating the routes and saving the bin status for optimizing routing; the clustering within Fog Layer gather information from the sensors and edge devices and send it to the Fog Head Node. Additionally, Head Nodes decided the route; updated the table and provide the Quality of service. With GA [24] the number of Intelligent Nodes in the network can be selected for taking important decision based on applications introduced at that nodes and thus the routing of garbage truck must be efficient and network to operate fast to using 6G services in less delay time frame. The AI based such heuristic optimization frame clusters and optimized an intelligent fog server within them; that act as Intelligent Head Node and perform an Efficient Routing decisions using threshold set to sensor nodes. The route updation referred in Figure 2.

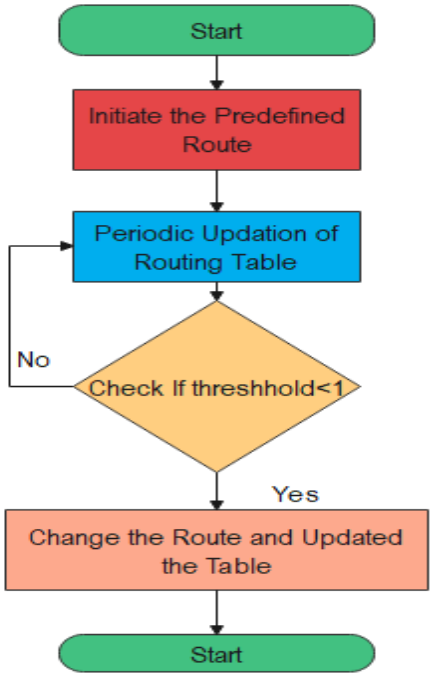


Figure 2: Flowchart for Route Table Updation

ISSN 1533-9211

DOI 10.17605/OSF.IO/83UQZ

b) Security Enabled Algorithm using Three-way handshake

This section explains the establishment of the Garbage truck trust and secure communication for data transferring. The proposed protocol provides session key generated handshake communication to ensure authentication and data privacy between movable garbage truck and intelligent Fog servers. It makes use of network edges as a local controller for authentication between truck and the intelligent Fog node [25]. When the truck needs to communicate with the Fog server, it first sends the request packet SYN to the edge device. Upon receiving the SYN packet, the edge device checks its detail in the routing table, if it is found then the edge node generates a one-time session key Ki and share with the fog server and sink node. After receiving the Ki, the fog server and sink node send acknowledgment packets SYN, ACK towards the edge device. To initiate the data routing between truck and fog server / sink node, the fog and sink nodes send again the ACK, Data to initiate data transfer procedure. Thus three-way handshake between movable truck and sink or Fog server must be authentic and secure. The security of the proposed solution also provides strong authentication and data privacy against unknown identities. Without proper mutual connection the data cannot be routed toward the sink node. Furthermore, the record of each vehicle is maintained by edge devices and supports uncompromised access to crucial data. All the communication between devices is mutual authenticate and when the connection is declared as verified, both devices can initiate their data forwarding. By exploring the proposed security procedures, the shared information is secured. The referred flowchart is depicted in Figure 3.

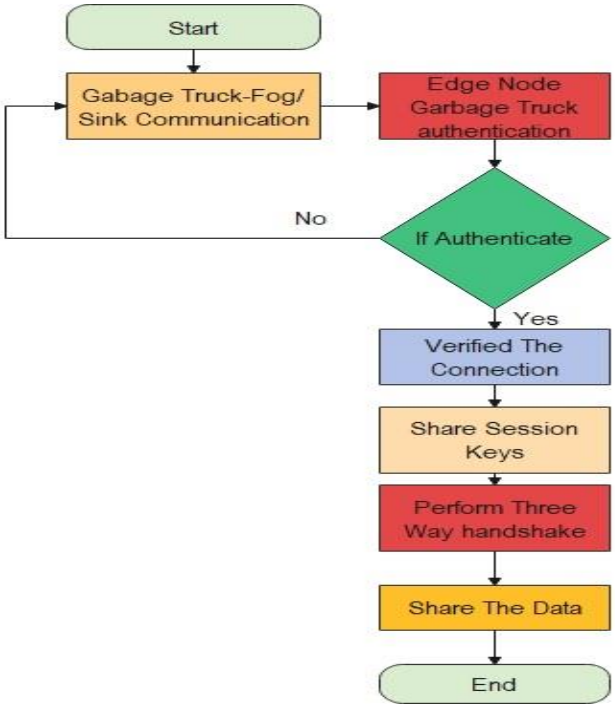


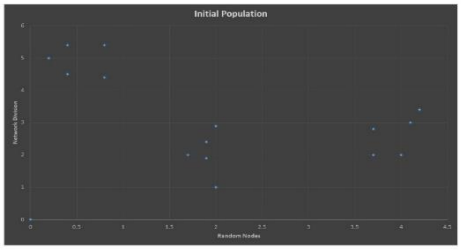
Figure 3: Flow Chart for Trusted Communication

The Seybold Report
ISSN 1533-9211
DOI 10.17605/OSF.IO/83UQZ

5. PROPOSAL EVALUTION

The proposal of efficient and secure routing using Edge-Fog architecture has following steps to route the garbage truck smartly so their efficient time does not waste to pick empty bins regarding waste management IoT use case. The routing algorithm using Genetic optimization of fog servers performs listed steps:

Step 1: Initial Population: The process of natural selection in genetic algorithm start from creating initial population. Every node can be treated as individual and having parameters in form of genes. These genes are joined in string to form chromosomes. In targeted architecture the random selected fog servers; which are the essential units of Fog layer; form the initial population with the constraints (less load, High transmission power and distance parameter). As per observation we have taken 15 fog nodes as an input for initial population distributed geographically.



Step1: Initial Population Generation of Fog Servers

Step 2: Calculate Fitness: In the next step of optimization; a problem domain is to evaluate Fitness of individual using selection operator; which is form next generation. This process define through which individual are selected for mating based on parameters; where crossover and Mutation elaborated the Search area. In this procedure create an objective function and calculate fitness of Chromosomes. By rank selection operator method, a chromosome is selected for mating having low fitness value and higher probability. Finally, the sum of set of calculated parameters used as fitness function. This process continues till an optimum solution is achieved, or generation reaches its maximum limit. An Algorithmic description illustrate as:

N is the number of individuals in the population, Pos the position of an individual in this population (least fit individual has Pos=1, the fittest individual Pos=N) and SP the selective pressure. The fitness value for an individual is calculated as: in Linear ranking:

$$\text{Fitness}(Pos\_i) = 2\text{-}SP + 2(SP-1)\ \frac{(i-1)}{(N-1)}$$

Assume The Selective Pressure = 2.0

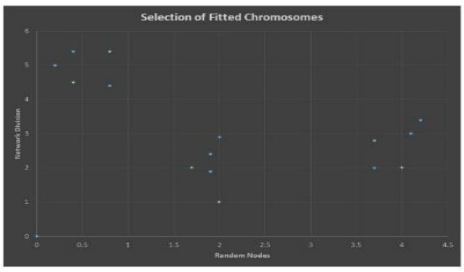
Individual $1 \leq i \leq n$

Probability $P(Ri) \geq 0$

Ri- Rank Positions $\Sigma P(Ri)=1$ for $i=1$

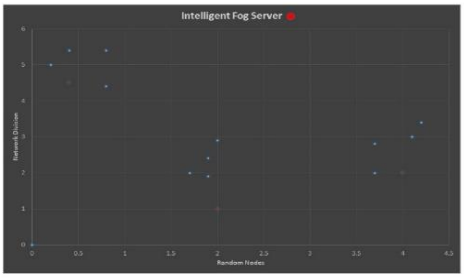
The Seybold Report
ISSN 1533-9211
DOI 10.17605/OSF.IO/83UQZ

By calculating the Fitness among 15 Nodes 6 Nodes are having indexed with less scheduled task treated as fitted node for Optimization



Step2: Selection of Fitted Chromosomes

Step 3: Intelligent Fog Node Selection: When an objective function value has reached a predefined value an intelligent head must be selected; among P Population after Nth generation. These Intelligent servers are highly resource capable in terms of processing power with less task allocation and more Processing ability and would take part in routing through updating the routes and balancing route optimization within 6g concerted real time applications.



Step 3: Optimized Intelligent Server

After performing the optimization of nodes the trusted data communication proposal has been evaluated by following procedure using 3-way Handshake method. In this step of security measures the handshake protocol for the data sharing from garbage truck to fog/sink node by using Edge node the key Ki is generated.

The transmitted node performs X-OR operation between Ki and its ID Vi and then formed New key i.e. Kj using postulate 26.

$$Kj = Ki \text{ XOR } Vi \qquad [26]$$

The sink node again performed the XOR operation between Kj and Ki and get garbage truck verification id i.e. Vi

$$Vi = Ki \text{ XOR } Kj$$

Later, the Garbage truck performs the encryption using own key Ki and then sink node performs decryption using the key Kj and hence this Asymmetric encryption process also guarantee the

ISSN 1533-9211

DOI 10.17605/OSF.IO/83UQZ

trust between information sharing and its authentication so that change their route according to new route devised by sensor information based upon empty bins. Thus the proposal of an Efficient and Trusted routing within 6G concerted portfolio based upon AI based decision maker components to route the garbage truck efficiently and transfer the data securely to other connected devices depicted in Figure 4.

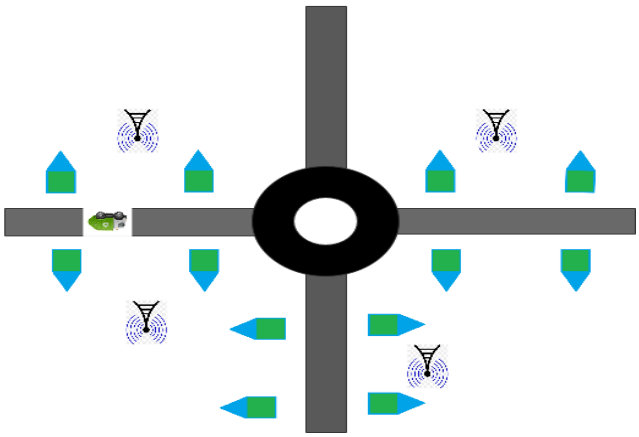


Figure 4: An AI based Fog Decision Maker in Waste Management

6. CONCLUDING REMARKS AND FUTURE SCOPE

IoT networks and sensors are performing a dynamic role in every aspect of smart world and the 6G networks offer significant benefits in terms of high quality of service and data delivery performance in this portfolio. This research work proposed an efficient and secure routing and data transmission scheme based on probability matrices and network statistics parameters of geographically distributed Nodes. Although most of routing algorithm guarantee Quality of service parameter yet remains security challenges unresolved; while this Fog based Solution performs well with AI based Fog modular application decision maker. The optimization in determining the network routes and reducing the processing overheads with the secure data transmission using Fog nodes is performed well with the waste management IoT Use case. This proposal also benefitted in the terms of less delay in real time decision making as implemented over Fog-edge based computing model. In future work, we aim to analyze the performance of the proposed protocol on real data sets and exploit an unsupervised machine learning approach to predict the more robust data transportation strategies.

References

1. Zakria Qadir, Khoa N. Le, Nasir Saeed, Hafiz Suliman Munawar, Towards 6G Internet of Things: Recent advances, use cases, and open challenges, ICT Express, 2022, ISSN 2405-9595, https://doi.org/10.1016/j.icte.2022.06.006.
2. D. C. Nguyen et al., "6G Internet of Things: A Comprehensive Survey," in IEEE Internet of Things Journal, vol. 9, no. 1, pp. 359-383, 1 Jan.1, 2022, doi: 10.1109/JIOT.2021.3103320.
3. Dulac-Arnold, G., Levine, N., Mankowitz, D.J. et al. Challenges of real-world reinforcement learning: definitions, benchmarks and analysis. Mach Learn 110, 2419–2468 (2021). https://doi.org/10.1007/s10994-

The Seybold Report
ISSN 1533-9211
DOI 10.17605/OSF.IO/83UQZ

021-05961-4

4. Shakeel P.M., Baskar S., Fouad H., Manogaran G., Saravanan V., Xin Q. Creating collision-free communication in IoT with 6G using multiple machine access learning collision avoidance protocol Mob Netw Appl, 26 (3) (2021), pp. 969-980
5. Lu Y., Zheng X. 6G: A survey on technologies, scenarios, challenges, and the related issues J Ind Inf Integr (2020), Article 100158
6. Verma S., Kaur S., Khan M.A., Sehdev P.S. Toward green communication in 6G-enabled massive internet of things IEEE Internet Things J, 8 (7) (2020), pp. 5408-5415
7. R. C. Shit, S. Sharma, D. Puthal and A. Y. Zomaya, "Location of Things (LoT): A Review and Taxonomy of Sensors Localization in IoT Infrastructure," in IEEE Communications Surveys & Tutorials, vol. 20, no. 3, pp. 2028-2061, thirdquarter 2018, doi: 10.1109/COMST.2018.2798591.
8. Zhang Z., Xiao Y., Ma Z., Xiao M., Ding Z., Lei X., Karagiannidis G.K., Fan P. 6G wireless networks: Vision, requirements, architecture, and key technologies, IEEE Veh Technol Mag, 14 (3) (2019), pp. 28-41
9. Giuseppe Aceto, Alessio Botta, Walter de Donato, Antonio Pescapè, Cloud monitoring: A survey, Computer Networks, Volume 57, Issue 9, 2013, Pages 2093-2115, ISSN 1389-1286, https://doi.org/10.1016/j.comnet.2013.04.001.
10. antao Pan, Xicheng Lu, Energy-efficient lifetime maximization and sleeping scheduling supporting data fusion and QoS in Multi-SensorNet, Signal processing, Volume 87, Issue 12, 2007, Pages 2949-2964, ISSN 0165-1684, https://doi.org/10.1016/j.sigpro.2007.05.008.
11. Sobin, C.C. A Survey on Architecture, Protocols and Challenges in IoT. Wireless Pers Commun 112, 1383–1429 (2020). https://doi.org/10.1007/s11277-020-07108-5
12. Eshrag Refaee, Shabana Parveen, Khan Mohamed Jarina Begum, Fatima Parveen, M. Chithik Raja, Shashi Kant Gupta, Santhosh Krishnan, "Secure and Scalable Healthcare Data Transmission in IoT Based on Optimized Routing Protocols for Mobile Computing Applications", Wireless Communications and Mobile Computing, vol. 2022, Article ID 5665408, 12 pages, 2022. https://doi.org/10.1155/2022/5665408
13. Zhanyang Xu, Wentao Liu, Jingwang Huang, Chenyi Yang, Jiawei Lu, Haozhe Tan, "Artificial Intelligence for Securing IoT Services in Edge Computing: A Survey", Security and Communication Networks, vol. 2020, Article ID 8872586, 13 pages, 2020. https://doi.org/10.1155/2020/8872586
14. Ding A.Y., Peltonen E., Meuser T., Aral A., Becker C., Dustdar S., Hiessl T., Kranzlmüller D., Liyanage M ,Maghsudi S., et al. Roadmap for edge AI: A Dagstuhl perspective ACM SIGCOMM Comput. Commun. Rev., 52 (1) (2022), pp. 28-33
15. Mahmoud H.H.H., Amer A.A., Ismail T. 6G: A comprehensive survey on technologies, applications, challenges, and research problems Trans Emerg Telecommun Technol, 32 (4) (2021), Article e4233
16. Akhtar M.W., Hassan S.A., Ghaffar R., Jung H., Garg S., Hossain M.S. The shift to 6G communications: vision and requirements Hum-Centric Comput Inf Sci, 10 (1) (2020), pp. 1-27
17. Manisha Verma, Neelam Bhardwaj Arun Yadav ," Real Time Efficient Scheduling Algorithm for Load Balancing in Fog Computing Environment", April 2016, International Journal of Information Technology and Computer Science 8(4):1-10, DOI: 10.5815/ijitcs.2016.04.01
18. Sodhro, A.H.; Pirbhulal, S.; Sangaiah, A.K.; Lohano, S.; Sodhro, G.H.; Luo, Z. 5G-Based Transmission Power Control Mechanism in Fog Computing for Internet of Things Devices. Sustainability 2018, 10, 1258. https://doi.org/10.3390/su10041258
19. Lei Li , Mian Guo , Lihong Ma, Huiyun Mao and Quansheng Guan " Online Workload Allocation via Fog-Fog-Cloud Cooperation to Reduce IoT Task Service Delay", September 2019 Sensors 19(18):3830,

The Seybold Report
ISSN 1533-9211
DOI 10.17605/OSF.IO/83UQZ

DOI:10.3390/s19183830

20. N. Subramanian, S. Mitra G.B., J. P. Martin and K. Chandrasekaran, "HTmRPL++ : A Trust-Aware RPL Routing Protocol for Fog Enabled Internet of Things," 2020 International Conference on COMmunication Systems & NETworkS (COMSNETS), Bengaluru, India, 2020, pp. 1-5, doi:10.1109/COMSNETS48256.2020.9027387.
21. A. Paul and S. Mitra, "Real-Time Routing for ITS Enabled Fog Oriented VANET," 2020 IEEE 17th India Council International Conference (INDICON), New Delhi, India, 2020, pp. 1-7, doi:10.1109/INDICON49873.2020.9342463.
22. Akbari, M.R.; Barati, H.; Barati, A. A Hierarchical Routing Method based on Fog Technology using the Grey system Theory in Internet of Things. Preprints 2020, 2020110650 (doi:10.20944/preprints202011.0650.v1).
23. Abohamama, A.S., El-Ghamry, A. & Hamouda, E. Real-Time Task Scheduling Algorithm for IoT-Based Applications in the Cloud–Fog Environment. J Netw Syst Manage 30, 54 (2022). https://doi.org/10.1007/s10922-022-09664-6
24. R. Bhatnagar, D. Sinha and P. Rawat, "An Intelligent Fog Node Solution for Application Interoperability in 5G enabled Fog-IoT paradigm," 2022 IEEE Delhi Section Conference (DELCON), New Delhi, India, 2022, pp. 1-5, doi: 10.1109/DELCON54057.2022.9753524.
25. Venčkauskas, A.; Morkevicius, N.; Jukavičius, V.; Damaševičius, R.; Toldinas, J.; Grigaliūnas, Š. An Edge-Fog Secure Self-Authenticable Data Transfer Protocol. Sensors 2019, 19, 3612. https://doi.org/10.3390/s19163612
26. halid Haseeb, Amjad Rehman, Tanzila Saba, Saeed Ali Bahaj, Huihui Wang, Houbing Song, Efficient and trusted autonomous vehicle routing protocol for 6G networks with computational intelligence, ISA Transactions, Volume 132, 2023, Pages 61-68, ISSN 0019-0578, https://doi.org/10.1016/j.isatra.2022.09.035