Journal of Al-Qadisiyah for Computer Science and Mathematics Vol. 16(2) 2024, pp Comp.13–22

University Of AL-Qadisiyah

Available online at www.qu.edu.iq/journalcm

JOURNAL OF AL-QADISIYAH FOR COMPUTER SCIENCE AND MATHEMATICS

ISSN:2521-3504(online) ISSN:2074-0204(print)

Wireless Sensor Network Predictions of Dynamic Target Tracking Algorithm for Error Tolerance

Mustafa Hussein Mohammed[1]

[1]*Al-Mustaqbal University, Hillah, Iraq, Mustafa.hussein@uomus.edu.iq*

ARTICLE INFO

Article history:

Received: 06/05/2024

Rrevised form: 28/05/2024

Accepted : 29/05/2024

Available online: 30 /06/2024

Keywords:

wireless sensor network; mobile network; fault tolerance; target tracking; genetic algorithm

ABSTRACT

The use of wireless sensor networks (WSNs) in tracking moving objects has increased significantly in recent years. Target node coverage, a criterion for choosing the right node or nodes for monitoring moving targets, is described in this research utilizing the proposed algorithm that is based on the combined genetic algorithm and MTR (Multiple Target Research). The suggested approach combines factors according to a basic strategy, and while choosing the right node, better attributes are taken into account. The suggested approach determines which node or nodes are suitable for covering and tracking network objectives based on their degree of overlap, distance to the well, and best remaining energy. Criterion for selecting the appropriate node or nodes for tracking moving targets are presented in the form of target node coverage. In the proposed method, parameters are combined based on a fundamental strategy, and superior characteristics are regarded when selecting the appropriate node. Fewer nodes are positioned in the appropriate coverage region, according to the results. Furthermore, given that the communication.

MSC..

https://doi.org/10.29304/jqcsm.2024.16.21538

1. Introduction

The wireless sensor network is rapidly transforming all aspects of people's daily lives [1]. It connects millions to billions of devices under multiple networks [2]. The development of the global economy has also had an impact on the industry [3]. Information and communication technology industry is on an upward trajectory [4]. Technological developments, greater competition, and the removal of trade obstacles have all led to a decrease in the cost of ICT (Information and Communication Technologies) goods and services [5]. As a result, other investment strategies have emerged that substitute labor for ICT-based tools and equipment, and capital has become a conventional approach [6]. Nevertheless, it is impossible to ignore this technology's drawbacks. Maintaining fault tolerance and the potential for faults is one of the biggest drawbacks and challenges associated with this technology's advancement [7, 8, 9]. Because every connected device in a wireless sensor network is potentially a gateway to personal data or network infrastructure, mistakes made unintentionally could result in the loss of sensitive data and information, while mistakes made on purpose due to hostile attackers could result in privacy violations and the misappropriation of data and facilities. In wireless sensor networks, fault tolerance solutions are used to stop and lessen the likelihood of faults occurring in connected devices [10, 11, 12].In this research, A fault-tolerant

∗Corresponding author

Email addresses:

Communicated by 'sub etitor'

dynamic target tracking algorithm framework is proposed. Optimal clustering is used in the suggested design to achieve defect tolerance. In order to predict the circumstances of the error's occurrence and neutralize it should the error arise; it also uses the genetic optimization technique to optimize the clustering.

1.1. Problem Statement

Wireless sensor networks, which have attracted a lot of attention in recent years, offer study areas with quick growth and tremendous interest due to the advancement of electronic device manufacturing technology and the cost-effectiveness of large-scale sensor networks [13, 14, 15, 16]. Many uses and challenges arise from large-scale wireless sensor networks with hundreds to tens of thousands of sensors [17, 18, 19]. These networks' special qualities enable their application in security and military care, border protection, accident-prone area control and investigation, and more [20, 21, 22]. One of the most important uses for these networks that is planned is target monitoring [23]. In this use case, wireless sensor networks employ their sensor base to perceive, identify, and track a particular target over the network's surveillance area [24, 25]. The issue of power consumption and error-free tracking of numerous moving targets simultaneously in these networks must be closely monitored due to the energy constraints of the sensors in these kinds of networks and the wireless nature of sensor connection [26, 27, 28, 29].

1.2. Research objectives

1- Enhancing the error tolerance of a prediction-based dynamic target tracking algorithm in a wireless sensor network

2- Reducing the latency in wireless sensor network dynamic target tracking

3- Enhancing the effectiveness of dynamic target monitoring within a wireless sensor network

4- Reducing the energy usage of dynamic target monitoring in wireless sensor networks

1. 3 Research methods

This study looks into the error tolerance issue when tracking moving objects with wireless sensor networks utilizing the library method. As a result, the basis of the suggested solution is clustering that has been genetic algorithm optimized. Based on this, after the sensor network is put into place and the best possible combination of sensors is chosen in accordance with sink mobility, the error tolerance of the moving object tracking algorithm is examined, and factors like latency, efficiency, and energy usage are assessed. This will be accomplished using MATLAB.

1.4 Proposed Approach

The suggested technique locates the destination (usually the sink node) and tries to find numerous viable routes by aggregating and changing the routing tree between each node, based on the TARA article by Kim et al. (2017). Consequently, the proposed work using the evolutionary algorithm, an optimizing technique that produces the best path tree for delivering sensor data when combined with TARA is optimized, a routing system. Each cluster node will try to use up to three pathways to transmit its data to the cluster leader following optimization put another way, the energy vacuum problem and lengthen the network's lifetime by increasing the cluster head node's lifespan in order to address the hot spot issue is tackled. Temperature-based routing for intra-cluster communication uses less energy than inter-cluster communication, which reduces energy loss at the cluster head and lengthens the network's lifespan [29, 30].

1.5 Paper Organization

Section 2 illustrates TARA intra-cluster routing algorithm. Section 3 discusses Creation of path tree by combined algorithm. Section 4 describes Measuring the reliability of routes. Then, Section 5 discusses how to Keeping track. Section 6 explains Sending data. Section 7 is dedicated for Experiments and Results implementation. Furthermore, Section 8 presenting discussions. Finally, Section 9 illustrates conclusions.

2.TARA intra-cluster routing algorithm

The TARA algorithm is the first clustering-routing protocol to incorporate temperature as a routing criterion, using it to estimate the temperature of neighboring nodes. Then, if the temperature of a neighboring node exceeds a predetermined threshold, the cluster will identify that node as a hot spot and eliminate it from the information transmission path. In addition, there are two categories of thresholds in this algorithm. The initial criterion is a dynamic criterion. Each node transmits its data to a neighboring node based on the shortest path and the fact that the following neighboring nodes have passed this dynamic threshold. The second criterion is the static criterion. If the temperature of the next node exceeds this fixed threshold, the transmissions are buffered until the temperature falls below the threshold. With these explanations, MTR algorithm is proposed in the 2017 article by Kim et al.

3. Creation of path tree by combined algorithm

The proposed algorithm is based on protocols for on-demand clustering. In on-demand algorithms, when the source has data to send to a specific destination but lacks a route to the destination, it initiates a route discovery procedure. In this instance, the origin dispatches a flood of request bodies to all of its neighbours. In its future head, each route request packet contains the list of scores it transmits. Due to the source's extensive dissemination of these hands, it is feasible for the destination to receive multiple manager request packets from distinct routes. The destination can then send multiple manager responses (requests) to the source via multiple managers.

4. Measuring the reliability of routes

In the proposed solution for selecting a number of routes from all discovered routes to send data, the reliability parameter of the manager is measured. In actuality, the source utilises more reliable routes to send data to the destination. In order to achieve this goal, the degree of a manager's dependability should be measured during both the route discovery and manager maintenance processes.

5. Keeping track

In the proposed design, the source node always attempts to send its data to the destination via two channels simultaneously. It distributes the sent packets evenly between two administrators for this purpose. The central tenet of the proposed concept is to transmit data via more reliable routes. With the aid of the maintenance mechanism, the origin attempts to discover the strongest paths over time for this purpose.

6. Sending data

In order to mitigate for a portion of the latency caused by the route discovery phase, two or three managers can be utilized concurrently during the data transmission phase. In simulation implementations, Simultaneously, two paths are used to transmit data, resulting in significant enhancements in end-to-end latency reduction. Using these mechanisms, it is possible to balance network traffic by distributing information burden across multiple administrators, which is relevant to the discussion of traffic control and congestion, end-to-end bandwidth, and consequently parallel data transmission. can drastically shorten the delay.

Figure 1 illustrates the internal structure of the sensor/operator node.

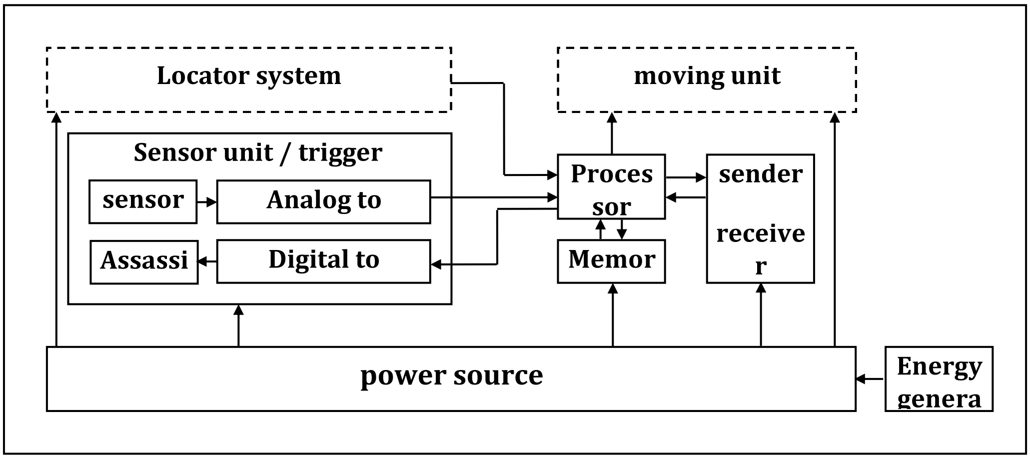


Figure (1) : The internal structure of the sensor/operator node

7. Experiments and Results implementation

This section discusses main problem parameters and variables and concentrate on obtained results and analysis.

7.1 Parameters and variables of the problem

In this study, all mobile network components are mobile and the network is dynamic (i,e. can be increased with more components). Therefore, it is presumed that some network nodes are being targeted and that other nodes should provide coverage. Therefore, the proposed algorithm attempts to determine the optimal target coverage range. In the proposed model, variables related to the network's dimensions and other sensor-related specifications are used.

To implement the proposed method based on the required parameters, algorithm functions are modified. On this basis, the fitness function can calculate each searcher's fitness level. Due to the fact that each seeker represents the arrangement of all sensors on a 3D display, the fitness of each seeker is determined by the total number of points on the display that are tracked. The arrangement is superior the greater the coverage range of moving targets (the more locations that are covered). (The fewer uncovered points, the better).

7.2 Results

In this section, results will be displayed using the default values. Figures 2 and 3, show a view of the coverage of moving targets in the network is shown.

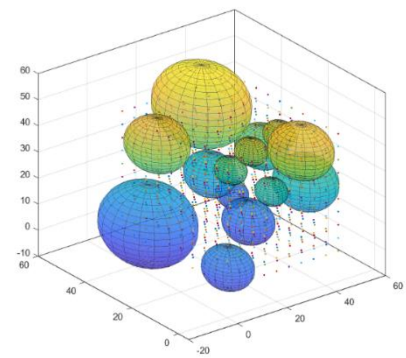


Figure (2) : Covering moving targets in the network from the front view

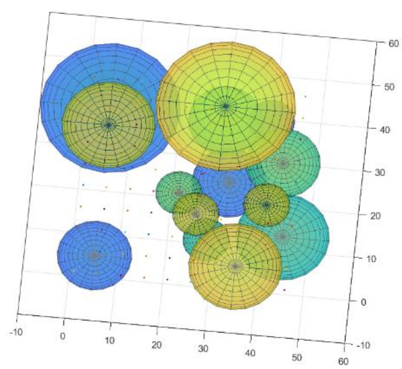


Figure (3) : Coverage of moving targets in the network from the top view

As shown in Fig.2 and Fig.3, the coverage radii of the moving targets vary, and only those targets contained within the circles are covered. These numbers indicate that the fourteen considered sensor groups were able to cover a substantial portion of the network's target nodes. In addition, it is important to pay attention to the absence of overlap between nodes. This problem is shown in Fig.4.

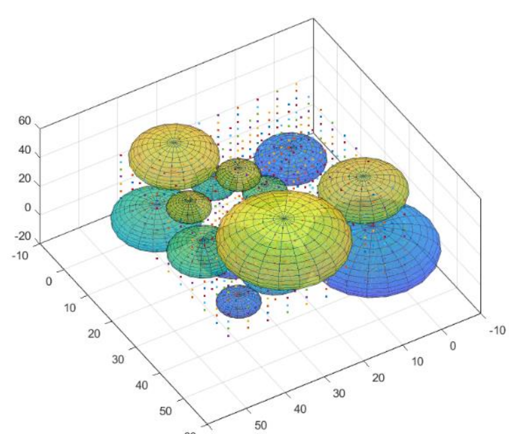


Figure (4) : Non-overlapping of nodes in order to cover the moving targets of the network

The processing of these results took 182.234364 seconds, and at the conclusion it was determined that 685 nodes did not fall within the targets' coverage scope.

Next, while maintaining the same number of sensors and sensor groups, the network's dimensions would be increased from 50*50*50 to 100*100*100 cubic meters. The effect of these modifications on network moving target coverage is depicted in Fig.5. As shown in Fig.3, the increase in network dimensions has resulted in a rise in the number of network sensors, since the coverage radius has remained unchanged, fewer targets are covered.

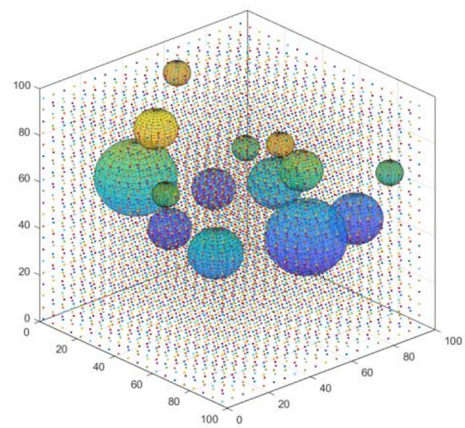


Figure (5) : The amount of coverage of network targets in the conditions of increasing the dimensions of 50*50*50 cubic meters to 100*100*100 cubic meters.

Finally, it was determined that 7566 network nodes do not fall within the target coverage area. Similarly, the duration of this program's execution was 305.437497 seconds.

In the following phase, the network's dimensions are adjusted to 50*50*50 cubic meters, and the communication radius is increased from [15 10 8 5] meters to [20 15 13 10] meters. In other words, the results of target coverage are evaluated by expanding the communication radius by 5 meters for each group. The result is presented in Fig.6.

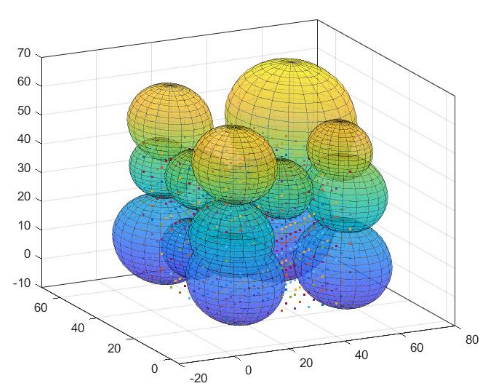
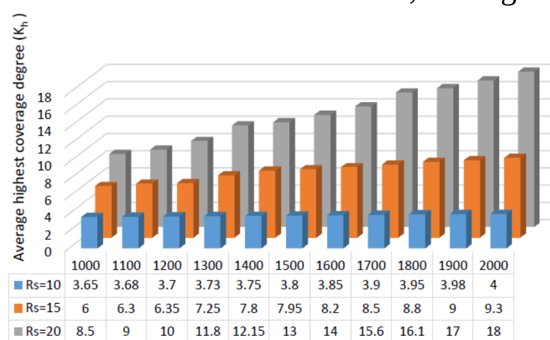


Figure (6) : The result of covering network targets by increasing thecommunication radius of nodes by 5 meters.

As shown in Fig.6, as more nodes are positioned, the greatest average degree of coverage (Kh value) increases. This problem demonstrates that the number of moving targets in the network is directly proportional to the node density (Kh value). Clearly, the greater the node placement density and sensing range of each node positioned in the surveillance area, the greater the number of target nodes that can be used to reduce overlap and background in the coverage area. In addition, Fig.6 illustrates the average effect of the Kh value for varying numbers of placed nodes on the average percentage of target overlap area. For a given average value of Kh, the average percentage of overlapping area will increase if the number of nodes placed increases. The percentage of average overlap area increases linearly as Kh increases for a given number of embedded nodes. Therefore, the algorithm is suitable for very dense placement situations



	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000
Rs=10	3.65	3.68	3.7	3.73	3.75	3.8	3.85	3.9	3.95	3.98	4
Rs=15	6	6.3	6.35	7.25	7.8	7.95	8.2	8.5	8.8	9	9.3
Rs=20	8.5	9	10	11.8	12.15	13	14	15.6	16.1	17	18

Figure (7) : Average highest degree of coverage (Kh) of different detection almonds

8. Discussion

In the deterministic distribution of network nodes, it is evident from the research findings that the problem of covering the objectives in the mathematical dimension prior to placement is debatable. In random distribution, however, obstacles are encountered such as an overabundance of coverage at some locations or the presence of points with no coverage or inadequate coverage. In this dissertation, using the proposed algorithm based on the combined genetic algorithm and MTR, a criterion for selecting the appropriate node or nodes for monitoring moving targets is presented in the form of target node coverage, which has been able to compare to other methods in the literature. The efficacy of the simulation environment is enhanced. In the proposed method, parameters are combined based on a fundamental strategy, and superior characteristics are regarded when selecting the appropriate node. According to the proposed method, the node or nodes with the best remaining energy, distance to the well, and degree of overlap are deemed appropriate for covering and tracking network targets.

In general, the simulation outcomes of the proposed algorithm have been evaluated and contrasted across a number of experiments conducted under diverse conditions. The results indicate that the proposed method has been able to perform better than other methods in the following criteria:

- Average percentage of overlapping area
- Average moving distance
- The average number of nodes covered by target tracking

9. Conclusion

In this research's proposed model, parameters such as the length, width, and height of the sensor network, the structure of sensor information data, the spatial information of the screen points, the number of sensors, the number of sensor groups, the communication range of sensors, the number of chromosomes, and the number of repetitions were taken into account as network variables. The results of varying the problem's parameters revealed that, because the target coverage radius remained constant, fewer nodes were positioned in the target coverage area as the network's dimensions increased. Conversely, as the communication radius of nodes increases, the number of nodes that are not covered decreases while the likelihood of overlap between groups of nodes increases. In addition, it was discovered that as the number of groups increased, the number of nodes that were not subjected to coverage decreased relative to the initial state, whereas the analysis time increased significantly. Lastly, it was discovered that as the number of chromosomes increased, the number of non-covered nodes decreased, indicating the availability of more appropriate solutions to increase the coverage of moving network targets..

References

[1] Najavi, Mohammad Javad, 2013, investigation of reliable routing methods in wireless sensor networks, BA project, Azad University

[2] Qolipour Moghadam, Milad, Saleh Namdi, Mohammad, 2015, a review of clustering methods in wireless sensor networks, the first national conference of electrical engineering, Islamic Azad University, Langrod branch.

[3] Alizadeh, Elham and Sanjabi, Saeed and Malekshahi, Amir, 2013, fault tolerance in cloud computing, National Conference of Computer Science and Engineering focusing on national security and sustainable development, Mashhad

[4] Nabai, Golnoosh Sadat and Mousavi, Syed Morteza, 2014, Presenting a new method for topology control in wireless sensor networks in order to increase fault tolerance, International Conference on Applied Research in Information Technology, Computers and Telecommunications, Torbet Heydarieh.

[5] Sheikhi, Hammet and Barkhoda, Seyyed Wafa, 2018, improving fault tolerance in wireless sensor networks by creating k-connected networks, the first international conference on smart city challenges and strategies, Shiraz

[6] Qu, Z., Xu, H., Zhao, X., Tang, H., Wang, J., & Li, B. (2022). A fault-tolerant sensor scheduling approach for target tracking in wireless sensor networks. Alexandria Engineering Journal, 61(12), 13001-13010.

[7] Hameed, S., Khan, F. I., & Hameed, B. (2019). Understanding security requirements and challenges in Internet of Things (IoT): A review. Journal of Computer Networks and Communications, 2019.

[8] Bhatti, S., Xu, J., & Memon, M. (2011). Clustering and fault tolerance for target tracking using wireless sensor networks. IET wireless sensor systems, 1(2), 66-73.

[9] Paradis, L., & Han, Q. (2017). A survey of fault management in wireless sensor networks. Journal of Network and systems management, 15(2), 171-190.

[10] Yuan, Y., Yi, W., & Choi, W. (2022). Dynamic Sensor Scheduling for Target Tracking in Wireless Sensor Networks with Cost Minimization Objective. IEEE Internet of Things Journal.

[11] JAYA, N. V. (2022). Efficient Cluster Head Selection and Fault Tolerant Routing Method for Mobile Wireless Sensor Networks. Adhoc & Sensor Wireless Networks, 51.

[12] Mahmood, T., Li, J., Pei, Y., Akhtar, F., Butt, S. A., Ditta, A., & Qureshi, S. (2022). An intelligent fault detection approach based on reinforcement learning system in wireless sensor network. The Journal of Supercomputing, 78(3), 3646-3675.

[13] Choudhary, A., Kumar, S., Gupta, S., Gong, M., & Mahanti, A. (2021). FEHCA: A fault-tolerant energy-efficient hierarchical clustering algorithm for wireless sensor networks. Energies, 14(13), 3935.

[14] Adhami, M. H., & Ghazizadeh, R. (2021). Secure multiple target tracking based on clustering intersection points of measurement circles in wireless sensor networks. Wireless Networks, 27(2), 1233-1249.

[15] Qu, Z., & Li, B. (2022). An Energy-Efficient Clustering Method for Target Tracking Based on Tracking Anchors in Wireless Sensor Networks. Sensors, 22(15), 5675.

[16] Zieliski, Z., Chudzikiewicz, J., & Furtak, J. (2019). An approach to integrating security and fault tolerance mechanisms into the military IoT. In Security and Fault Tolerance in Internet of Things (pp. 111-128). Springer, Cham.

[17] Mohamed, N., Al-Jaroodi, J., & Jawhar, I. (2019, January). Towards fault tolerant fog computing for IoT-based smart city applications. In 2019 IEEE 9th Annual Computing and Communication Workshop and Conference (CCWC) (pp. 0752-0757). IEEE.

[18] Gope, P., Gheraibia, Y., Kabir, S., & Sikdar, B. (2020). A secure IoT-based modern healthcare system with fault-tolerant decision making process. IEEE Journal of Biomedical and Health Informatics.

[19] Zavalyshyn, I., Given-Wilson, T., Legay, A., & Sadre, R. (2020, November). Brief Announcement: Effectiveness of Code Hardening for Fault-Tolerant IoT Software. In International Symposium on Stabilizing, Safety, and Security of Distributed Systems (pp. 317-322). Springer, Cham.

[20] Alfandi, O., Otoum, S., & Jararweh, Y. (2020, April). Blockchain solution for iot-based critical infrastructures: Byzantine fault tolerance. In NOMS 2020-2020 IEEE/IFIP Network Operations and Management Symposium (pp. 1-4). IEEE.

[21] Samanta, A., Esposito, F., & Nguyen, T. G. (2021). Fault-Tolerant Mechanism for Edge-Based IoT Networks with Demand Uncertainty. IEEE Internet of Things Journal.

[22] Kiadehi, K. B., Rahmani, A. M., & Molahosseini, A. S. (2021). A fault-tolerant architecture for internet-of-things based on software-defined networks. Telecommunication Systems, 77(1), 155-169.

[23] Zhu, B., Joseph, A., & Sastry, S. (2011, October). A taxonomy of cyber attacks on SCADA systems. In 2011 International conference on internet of things and 4th international conference on cyber, physical and social computing (pp. 380-388). IEEE.

[24] Li, Y. X. (2019). Finite time command filtered adaptive fault tolerant control for a class of uncertain nonlinear systems. Automatica, 106, 117-123.

[25] Giannarakis, N., Beckett, R., Mahajan, R., & Walker, D. (2019, July). Efficient verification of network fault tolerance via counterexample-guided refinement. In International Conference on Computer Aided Verification (pp. 305-323). Springer, Cham.

[26] Sharma, K., & Yadav, R. N. (2020). An adaptive, fault tolerant, flow-level routing scheme for data center networks. Computer Networks, 175, 107235.

[27] Borja, L. J. (2020). Assessing Priorities towards Achieving Dependable and Secure Computing in the US ICBM Force. Science & Global Security, 28(1), 2-27.

[28] Singh, G., Raj, B., & Sarin, R. K. (2018). Fault-tolerant design and analysis of QCA-based circuits. IET Circuits, Devices & Systems, 12(5), 638-644.

[29] Dreany, H. H., & Roncace, R. (2019). A cognitive architecture safety design for safety critical systems. Reliability Engineering & System Safety, 191, 106555.

[30] Kim, B. S., Kang, S., Lim, J., Kim, K. H., & Kim, K. I. (2017, January). A mobility-based temperature-aware routing protocol for wireless body sensor networks. In 2017 International Conference on Information Networking (ICOIN)(pp. 63-66). IEEE.