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Energy through Multi-Hop Routing Protocol for WSNS

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ABSTRACT

Consuming energy at the maximal level is a major concern in wireless sensor networks (WSNs). Many researchers focus on reducing and preserving the energy. The duration of active network of WSNs is affected by energy consumption of sensor nodes. For typical applications such as structure monitoring, border surveillance, integrated in the external surface of a pipeline, and clambered along the sustaining structure of a bridge, sensor node energy efficiency is an important issue. We present modified chemical reaction optimization (MCRO) algorithm to form clusters and select cluster head (CH) among the cluster members. The simulation result shows that the proposed routing protocol provides significant energy efficiency with network lifetime over the existing routing protocols.

Keywords: Energy efficient; Multi-Hop; Hybrid Optimization Algorithm; Clusters; Cluster Head.

I. INTRODUCTION

Immense methodology has been proposed in recent years on development of wireless sensor networks and its applications. The solutions for minimal energy issue in WSN are overcome by routing protocol which consumes limited energy while functioning [1-5]. The sensors involved in WSN monitor the object location, humidity, impact of air pollution, and measure of water density. WSN consists of tiny sensor nodes [5-15] and three subsystems which includes a communicating unit for the transmission of data, unit to sense the data and capture the data available in environment and a unit to process the data which has been gathered. The sensor nodes functioning is based on battery duration and are deployed in neglected atmosphere. Lifetime of the power source has to be maximum since sensor consumes more power for sensing the atmosphere throughout the application. Inconvenience arises while recharging the battery often. Sustaining the lifetime of WSN network through battery operating nodes seems to be major issue to be focused [16-20].

The major objective of the proposed routing protocol is effectively utilizing the energy generated by the nodes. In order to improve the processing time of the nodes routing protocols have been proposed to maintain the stability of the network [6]. During the static phase the hole coverage probability is greater. The energy of some partitions of the network is low leading to a coverage hole [21-38]. Coverage holes are the greatest barriers to WSN because the entire network area if some nodes fail to function.

The effective way to handle the consumption of energy is through the process of clustering [39]. The effective scheme on routing is increasing the scalability and lifetime of active sensor nodes. Therefore, they can be grouped into clusters and a cluster head (CH) can be identified [40]. The data is gathered by the cluster from the sensor network in direct ways or multi hop ways. Data obtained from the nodes belonging to the same cluster seem to be highly correlated. During the above process data aggregation occurs as a result of which lot of energy is consumed [41-45]. The data obtained is sent to the base station as a result of transmission.

II. RELATED WORKS

Zhang et al. [46] have proposed circumventing a null routing protocol based on virtual routing circle (BVR-VRC), which uses void detecting, mapping of virtual coordinate and division of void region for solving the void problem, and establishing a path around the void based on the virtual coordinates of edge nodes. The virtual circle can shield lively sending from shelling by this method, so that overhead control and the standard length of sorting out ways can be reduced. The simulation results depict the BVR-VRC routing protocol has its own advantages in terms of avoiding the delay in transmission, consistent delivery ratio and average hops that occur. Lin et al. [47] proposed a Fan Shaped Clustering (FSC) to divide large scale network into fan shaped clusters. Energy saving method differs based on the clustering theme adopted by selecting the cluster head (CH), location where re- clustering took place and solution to problem arised due to hotspot. The FSC

proves its efficiency compared to hybrid methodologies of forming energy efficient distributed clustering.

Tang et al. [48] proposed a highly secure and efficient cost-aware secure routing (CASER) protocol for addressing conflicting issues the energy balance control (EBC) and probabilistic-based random walking. The energy consumption is not proportional to the uniform energy deployment in the provided network topology. Higher range of it is reduced in the lifetime of sensor networks. For optimizing the lifetime and message delivery ratio of energy generated same resources and security enhancement an efficient fluctuating energy deployment strategy is adopted. The theoretical view as well as the simulation results generated by OPNET ensures that efficiency in routing of CASER protocol and balance in energy is maintained achieving the extension of lifetime for sensor networks.

III. PROBLEM IDENTIFICATION AND SOLUTION

An adaptive energy aware cluster-based routing protocol for enhancing the energy conservation and performance of data delivery (AECR) [49-53]. It generates balanced size clusters based on nodes distribution and prevention of random formation of clusters. It plays a major role in optimizing intra-cluster and inter-cluster routing paths for improving the performance of data delivery and balancing the data traffic on constructed forwarding routes and at the end, for reducing the consumption of excessive energy and emphasizing load distribution, the role of CH is dynamically shifted among nodes by manipulation of network conditions. Other than adaptability some amazing issues are impact the execution of AECR custom looks works evaluated in related works [55]. Authors provide balanced clusters without efficient or optimal technique that are not suitable for larger sensor network. In AECR, central point based cluster formation technique not effectively group the nodes in the network. Moreover, clustering and CH selection process depends only on network size. Reliability of routing not achieved by AECR protocol because they not consider the node mobility. The energy conservation achieved by conventional method i.e. shorten the transmission distance, which not effective for route computation between source to destination [54-60].

3.1 Network model

The cluster process divides the network area into several groups i.e. clusters and each cluster consists of cluster members and a CH node. The base station (BS) gathers multiple constraints such as consumption of energy , delay at the source and destination , received signal strength and mobility from individual sensor nodes in the network and it is optimized by the proposed MCRO algorithm. From an optimal result the CH node is selected among multiple members and it is eligible to gather information from members in the cluster and it is forwards via multi-hop routing path. We consider different metrics including minimum cluster in intra region, minimum distance between sink, and minimum energy in mobility for cluster formation [61-65]. The network model with example routing scenarios of our proposed work is shown in Figure 1.

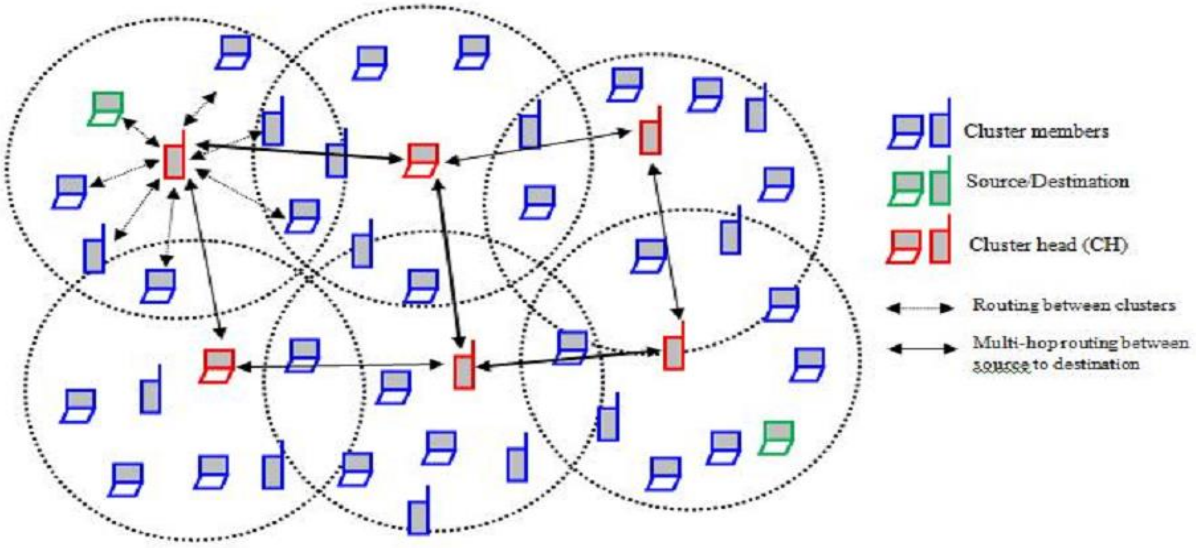

Fig. 1 System model of proposed work

IV. PROPOSED PROTOCOL

The proposed protocol consists of two processes such as clustering and route computation. The clustering is combination of cluster formation and CH selection process, here we use MCRO algorithm and it is described in subsection 4.1. Then compute the routing path using MBFS algorithm and is described in subsection 4.2.

4.1 Clustering

The optimization through chemical reaction (CRO) [25] is one among the mutable values by individuals based data on swarm meta-heuristics which rejuvenated from the creation response. In CRO a sub-atomic structure addresses a total strategy involved in the process. A particle has two sorts of energy potential energy (ξ) and kinetic energy (ψ).

The existing method is delineated by the stability of its structure, It proposes a fragment with trim ξ it down would be impeccable persistent structure. Another major part is the accuracy controlled by the particle in advance. The particle is measured by the potential central work. The main objective of this work is to identify with the ξ of a molecule. To the degree numerically past what many would consider possible can be allowed as takes after:

$$\xi_{x,y} = f(x', y') \tag{1}$$

where f is a potential centrality at remote point and rotation coordination of a molecule. For instance , a particle might change its structure from x, y to the x', y' change is reliably possible if $\xi_{x,y} \geq \xi_{x',y'}$ else we allow change absolutely when $\xi_{x,y} + \psi_{x,y} \geq \xi_{x',y'}$.

The particles setbacks can be depicted by two sorts, for instance, uni-sub-nuclear and between sub-nuclear effects. Uni-sub-nuclear effect contains two sorts of reactions that are on-divider unfit crash and disintegrating and the between sub-nuclear effect incorporates two sorts of reactions that are between sub-nuclear lacking effect and mix.

CH selection using MCRO algorithm

The proposed MCRO algorithm used to select CH among the cluster members by considering multiple constraints such as energy consumption (C_1), end-to-end delay (C_2), received signal strength (C_3), and mobility (C_4). The multiple constraints are optimized by MCRO algorithm, which enhance the CH selection process for increasing the network lifetime, normalization is achieved through all four objective functions between the range of 0 and 1 for efficient optimization of the function.

Energy model (C_1): The method adopted by most criticalness models are built through minimal of estimations focusing on suitable sensor, and the changes observed in these models tend to change the parts present in executed contraption setup and their working is based on the fixations on focus, they are used only for reenactment and observing the place from which they were generated. WSN applications are outstanding and the dependent applications are endless, so the crisis has to be handled to decrease the impact. The proportionality of the source to trade between the target to hand-off amidst conditions can be reconciled after certain period of time.

4.2 Route computation

Working function of adaptive bacterial swarming algorithm (ABSA) [26] relies on the movement by the bacteria according to content of the nutrient in the network. We modify the fitness computation with multiple constraints of ABAS, which enhance the searching capability of our routing protocol. Our modified algorithm named as modified bacterial foraging searching algorithm (MBFS). MBFS algorithm is based on foraging of bacteria searching for the nutrients through four steps chemotaxis, swarming, elimination of reproduction and dispersal process. The bacteria involved moves from one fixation to other looking for after down supplements and along these lines shapes a faultless course from the source to the goal. In setting of the supplement substance of an inside point and the best motioning between the moment bacteria, a flawless way is inspected among the most uncommon conceivable course in the given system. In the given system each middle locale is depended on upon to contain bacteria.

Chemotaxis*:* During chemotaxis the bacteria moves certain steps during the search of nutrition, it searches

either through swimming or tumbling in anticipated direction while searching for nutritious prey, they sense and communicate with each other during the searching process. Their movement is assisted by the flagella. The key level is expected to change the level of flagella i.e anticlockwise progress of the combined flagella, this lead to the forward change of the microorganisms which are considered for every client.

Swarming: This is defined as the self-organizing behavior of the bacterium. The behavior is evaluated for further processing. Bacteria completing the fulfillment attracts the swarm of microorganisms to an indistinct district in the prescribed framework by attracting each living things through hailing. Thusly in the midst of tumbling, the microorganisms' are floated to a presentation depending upon the motioning between the living creatures from an all the all the all the more steadfast and interfacing with degree. Along with these, the total content of the supplement at each sensor of the center point is the level of the entire motioning, between microorganisms, provided at the corresponding node.

V. EXPERIMENTAL RESULTS

Our proposed method is simulated using the simulator NS2. We have considered 100 nodes for the simulation. These nodes are performing in the region 1000m×1000m with the transmission range 250m. Our proposed method is simulated within 50secs.

Performance based on nodes

The performance metrics of our proposed approach is estimated for changing nodes 100, 200, 300, 400 and 500. Figure 10-13 show that packet delay, delivery ratio, energy consumption, throughput and cut detection time for varying nodes.

Figure 2 represents the ratio of delivery in our proposed approach. Due to the modified bacterial forging search (MBFS) algorithm based route selection, ratio of delivery in our proposed approach is gradually increased to 42%. Due to the cluster based transmission, the energy consumed in our proposed approach is reduced by 23% compared to that of AECR algorithm. Figure 3 shows the throughput of our proposed approach. Compared to the AECR algorithm, the throughput of our proposed approach is increased to 58%.

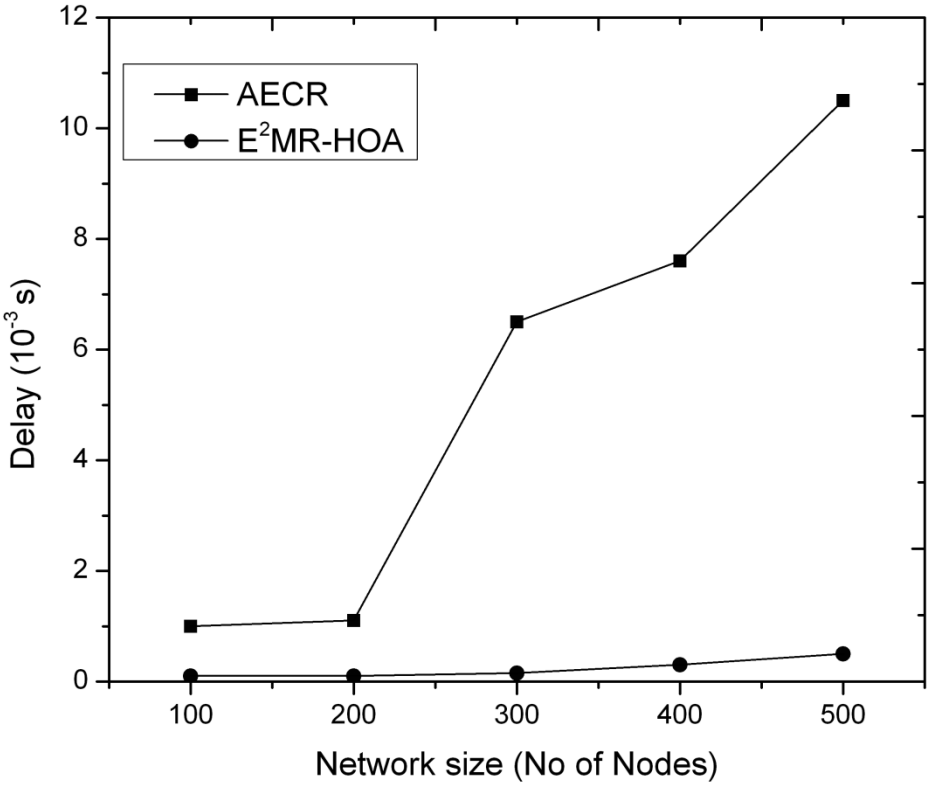

Figure 2: Node Vs Delay

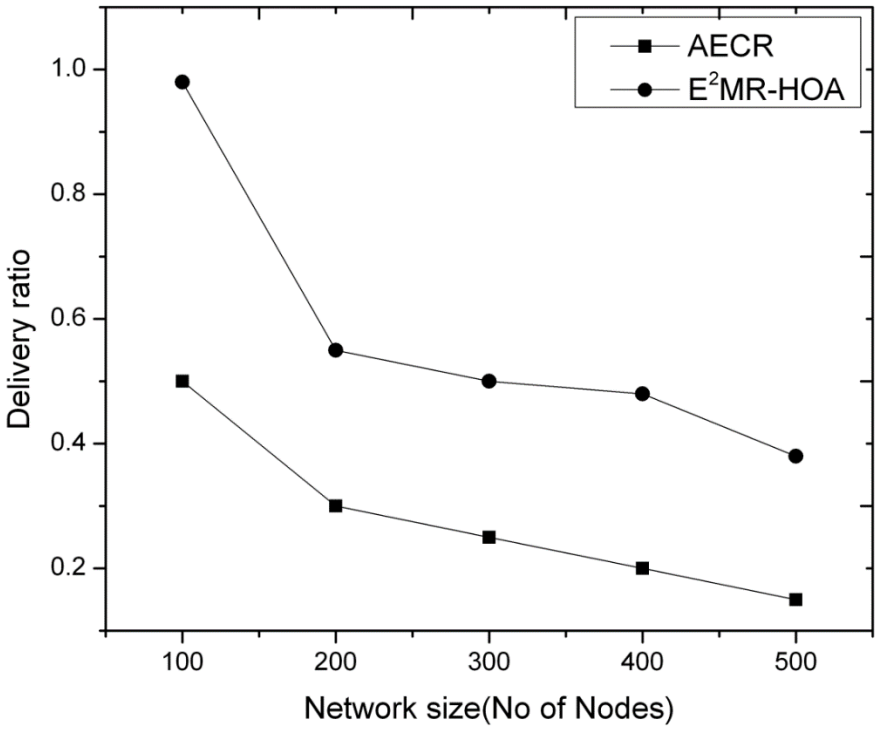

Figure 3: Node Vs Delivery Ratio

VI. CONCLUSION

The proposed hybrid optimization algorithms based energy efficient multi-hop routing protocol for WSNs and have simulated the proposed work using the network simulator. We have presented two optimization algorithms for our proposed routing protocol. Then we have established efficient routing between source and destination using our proposed modified bacterial forging search (MBFS) algorithm. Simulation results showed that energy efficiency and network lifetime of our proposed work have been improved than that of existing work

REFERENCES

[1] Anand Nayyar, Vikram Puri, Nhu Gia Nguyen, Dac Nhuong Le, Smart Surveillance Robot for the Real Time Monitoring and Control System in Environment and Industrial Applications, Advances in Intelligent System and Computing, pp 229-243, Springer

[2] Ezhilarasu, P., & Krishnaraj, N. (2015). Applications of Finite Automata in Lexical Analysis and as a Ticket Vending Machine–A Review. Int. J. Comput. Sci. Eng. Technol, 6(05), 267-270.

[3] Agrawal, U., Arora, J., Singh, R., Gupta, D., Khanna, A., & Khamparia, A. (2020). Hybrid Wolf-Bat Algorithm for Optimization of Connection Weights in Multi-layer Perceptron. ACM Transactions on Multimedia Computing, Communications, and Applications (TOMM), 16(1s), 1-20.

[4] Prasanna, S., & Ezhilmaran, D. (2016). Association rule mining using enhanced apriori with modified GA for stock prediction. International Journal of Data Mining, Modelling and Management, 8(2), 195-207.

[5] Pustokhina, I. V., Pustokhin, D. A., Gupta, D., Khanna, A., Shankar, K., & Nguyen, G. N. (2020). An effective training scheme for deep neural network in edge computing enabled Internet of medical things (IoMT) systems. IEEE Access, 8, 107112-107123.

[6] Shankar, K., Zhang, Y., Liu, Y., Wu, L., & Chen, C. H. (2020). Hyperparameter tuning deep learning for diabetic retinopathy fundus image classification. IEEE Access, 8, 118164-118173.

[7] Joshi, G. P., Perumal, E., Shankar, K., Tariq, U., Ahmad, T., & Ibrahim, A. (2020). Toward Blockchain-Enabled Privacy-Preserving Data Transmission in Cluster-Based Vehicular Networks. Electronics, 9(9), 1358.

[8] Saračević, M. H., Adamović, S. Z., Miškovic, V. A., Elhoseny, M., Maček, N. D., Selim, M. M., & Shankar, K. (2020). Data Encryption for Internet of Things Applications Based on Catalan Objects and Two Combinatorial Structures. IEEE Transactions on Reliability.

[9] Namasudra, S., & Roy, P. (2017). Time saving protocol for data accessing in cloud computing. IET Communications, 11(10), 1558-1565.

[10] Elsir, A., Elsier, O., Abdurrahman, A., & Mubarakali, A. (2019). Privacy Preservation in Big Data with Data Scalability and Efficiency Using Efficient and Secure Data Balanced Scheduling Algorithm.

[11] Ezhilarasu, P., Krishnaraj, N., & Babu, S. V. (2015). Applications of finite automata in text search-a review. International Journal of Science, Engineering and Computer Technology, 5(5), 116.

[12] Huyen, D.T.T., Binh, N.T., Tuan, T.M., Nguyen, G.N, Dey, N., Son, L.H, Analyzing trends in hospital-cost payments of patients using ARIMA and GIS: Case study at the Hanoi Medical University Hospital, Vietnam, Journal of Medical Imaging and Health Informatics, 7(2), pp. 421-429.

[13] Prasanna, S., & Maran, E. (2015). Stock Market Prediction Using Clustering with Meta-Heuristic Approaches. Gazi University Journal of Science, 28(3).

[14] Pustokhina, I. V., Pustokhin, D. A., Rodrigues, J. J., Gupta, D., Khanna, A., Shankar, K., ... & Joshi, G. P. (2020). Automatic Vehicle License Plate Recognition using Optimal K-Means with Convolutional Neural Network for Intelligent Transportation Systems. IEEE Access.

[15] Namasudra, S. (2018). Cloud computing: A new era. Journal of Fundamental and Applied Sciences, 10(2).

[16] Uthayakumar, J., Elhoseny, M., & Shankar, K. (2020). Highly Reliable and Low-Complexity Image Compression Scheme Using Neighborhood Correlation Sequence Algorithm in WSN. IEEE Transactions on Reliability.

[17] Deepalakshmi, P., & Shankar, K. (2020). Role and Impacts of Ant Colony Optimization in Job Shop Scheduling Problems: A Detailed Analysis. Evolutionary Computation in Scheduling, 11-35.

[18] Ashwin, M., Kamalraj, S., & Azath, M. (2019). Multi objective trust optimization for efficient communication in wireless M learning applications. Cluster Computing, 22(5), 10687-10695.

[19] Ezhilarasu, P., & Krishnaraj, N. (2015). Double Substring based Classification for Nondeterministic Finite Automata. Indian Journal Of Science And Technology, 8, 26.

[20] Amira S. Ashour, Samsad Beagum, Nilanjan Dey, Ahmed S. Ashour, Dimitra Sifaki Pistolla, Gia Nhu Nguyen, Dac-Nhuong Le, Fuqian Shi (2018), Light Microscopy Image De-noising using Optimized LPA-ICI Filter, Neural Computing and Applications, Vol.29(12), pp 1517–1533, Springer, ISSN: 0941-0643.

[21] Prasanna, S., Govinda, K., & Kumaran, U. S. (2012). An Evaluation study of Oral Cancer Detection using Data Mining Classification Techniques. International Journal of Advanced Research in Computer Science, 3(1).

[22] Sankhwar, S., Gupta, D., Ramya, K. C., Rani, S. S., Shankar, K., & Lakshmanaprabu, S. K. (2020). Improved grey wolf optimization-based feature subset selection with fuzzy neural classifier for financial crisis prediction. Soft Computing, 24(1), 101-110.

[23] Namasudra, S., & Deka, G. C. (2018). Introduction of DNA computing in cryptography. In Advances of DNA computing in cryptography (pp. 1-18). Chapman and Hall/CRC.

[24] Mubarakali, A., Srinivasan, K., Mukhalid, R., Jaganathan, S. C., & Marina, N. (2020). Security challenges in internet of things: Distributed denial of service attack detection using support vector machine-based expert systems. Computational Intelligence.

[25] Le Nguyen Bao, Dac-Nhuong Le, Gia Nhu Nguyen, Vikrant Bhateja, Suresh Chandra Satapathy (2017), Optimizing Feature Selection in Video-based Recognition using Max-Min Ant System for the Online Video Contextual Advertisement User-Oriented System, Journal of Computational Science, Elsevier ISSN: 1877-7503. Vol.21, pp.361-370.

[26] Ezhilarasu, P., Thirunavukkarasu, E., Karuppusami, G., & Krishnaraj, N. (2015). Single substring based classification for nondeterministic finite automata. International Journal on Applications in Information and Communication Engineering, 1(10), 29-31.

[27] Bhateja, V., Gautam, A., Tiwari, A., Nhu, N.G., Le, D.-N, Haralick features-based classification of mammograms using SVM, Advances in Intelligent Systems and Computing, Volume 672, 2018, Pages 787-795.

[28] Latha, A., Prasanna, S., Hemalatha, S., & Sivakumar, B. (2019). A harmonized trust assisted energy efficient data aggregation scheme for distributed sensor networks. Cognitive Systems Research, 56, 14-22.

[29] Krishnaraj, N., Elhoseny, M., Lydia, E. L., Shankar, K., & ALDabbas, O. (2020). An

efficient radix trie-based semantic visual indexing model for large-scale image retrieval in cloud environment. Software: Practice and Experience.

[30] Namasudra, S., Roy, P., Vijayakumar, P., Audithan, S., & Balusamy, B. (2017). Time efficient secure DNA based access control model for cloud computing environment. Future Generation Computer Systems, 73, 90-105.

[31] Lakshmanaprabu, S. K., Shankar, K., Rani, S. S., Abdulhay, E., Arunkumar, N., Ramirez, G., & Uthayakumar, J. (2019). An effect of big data technology with ant colony optimization based routing in vehicular ad hoc networks: Towards smart cities. Journal of cleaner production, 217, 584-593.

[32] Namasudra, S., & Deka, G. C. (Eds.). (2018). Advances of DNA computing in cryptography. CRC Press.

[33] Mubarakali, A., Ashwin, M., Mavaluru, D., & Kumar, A. D. (2020). Design an attribute based health record protection algorithm for healthcare services in cloud environment. Multimedia Tools and Applications, 79(5), 3943-3956.

[34] Dey, N., Ashour, A.S., Chakraborty, S., Le, D.-N., Nguyen, G.N, Healthy and unhealthy rat hippocampus cells classification: A neural based automated system for Alzheimer disease classification, Journal of Advanced Microscopy Research, 11(1), pp. 1-10

[35] Krishnaraj, N., Ezhilarasu, P., & Gao, X. Z. Hybrid Soft Computing Approach for Prediction of Cancer in Colon Using Microarray Gene Data. Current Signal Transduction Therapy, 11(2).

[36] Namasudra, S., Deka, G. C., Johri, P., Hosseinpour, M., & Gandomi, A. H. (2020). The revolution of blockchain: State-of-the-art and research challenges. Archives of Computational Methods in Engineering.

[37] Goel, N., Grover, B., Gupta, D., Khanna, A., & Sharma, M. (2020). Modified Grasshopper Optimization Algorithm for detection of Autism Spectrum Disorder. Physical Communication, 101115.

[38] Prasanna, S., Narayan, S., NallaKaruppan, M. K., Anilkumar, C., & Ramasubbareddy, S. (2019). Iterative Approach for Frequent Set Mining Using Hadoop Over Cloud Environment. In Smart Intelligent Computing and Applications (pp. 399-405). Springer, Singapore.

[39] Le, D.-N.a, Kumar, R.b, Nguyen, G.N., Chatterjee, J.M.d, Cloud Computing and Virtualization, DOI: 10.1002/9781119488149, Wiley.

[40] Raj, R. J. S., Shobana, S. J., Pustokhina, I. V., Pustokhin, D. A., Gupta, D., & Shankar, K. (2020). Optimal Feature Selection-Based Medical Image Classification Using Deep Learning Model in Internet of Medical Things. IEEE Access, 8, 58006-58017.

[41] Namasudra, S., & Deka, G. C. (2018). Taxonomy of DNA-based security models. In Advances of DNA Computing in Cryptography (pp. 37-52). Chapman and Hall/CRC.

[42] Mubarakali, A., Ramakrishnan, J., Mavaluru, D., Elsir, A., Elsier, O., & Wakil, K. (2019). A new efficient design for random access memory based on quantum dot cellular automata nanotechnology. Nano Communication Networks, 21, 100252.

[43] Ramakrishnan, J., Mavaluru, D., Sakthivel, R. S., Alqahtani, A. S., Mubarakali, A., & Retnadhas, M. (2020). Brain–computer interface for amyotrophic lateral sclerosis patients using deep learning network. NEURAL COMPUTING & APPLICATIONS.

[44] Van, V.N., Chi, L.M., Long, N.Q., Nguyen, G.N., Le, D.-N, A performance analysis of openstack open-source solution for IaaS cloud computing, Advances in Intelligent Systems and Computing, 380, pp. 141-150.

[45] Sinha, A., Shrivastava, G., Kumar, P., & Gupta, D. (2020). A community-based hierarchical user authentication scheme for Industry 4.0. Software: Practice and Experience.

[46] Namasudra, S., Devi, D., Kadry, S., Sundarasekar, R., & Shanthini, A. (2020). Towards DNA based data security in the cloud computing environment. Computer Communications, 151, 539-547.

[47] Mubarakali, A., Durai, A. D., Alshehri, M., AlFarraj, O., Ramakrishnan, J., & Mavaluru, D. (2020). Fog-Based Delay-Sensitive Data Transmission Algorithm for Data Forwarding and Storage in Cloud Environment for Multimedia Applications. Big Data.

[48] Reshmi, T. R., & Azath, M. (2020). Improved self-healing technique for 5G networks using predictive analysis. Peer-to-Peer Networking and Applications, 1-17.

[49] Namasudra, S., Chakraborty, R., Majumder, A., & Moparthi, N. R. (2020). Securing multimedia by using DNA based encryption in the cloud computing environment. ACM Transactions on Multimedia Computing Communications and Applications.

[50] Patro, K. K., Reddi, S. P. R., Khalelulla, S. E., Kumar, P. R., & Shankar, K. (2020). ECG data

optimization for biometric human recognition using statistical distributed machine learning algorithm. The Journal of Supercomputing, 76(2), 858-875.

[51] Rajagopal, A., Joshi, G. P., Ramachandran, A., Subhalakshmi, R. T., Khari, M., Jha, S., ... & You, J. (2020). A Deep Learning Model Based on Multi-Objective Particle Swarm Optimization for Scene Classification in Unmanned Aerial Vehicles. IEEE Access, 8, 135383-135393.

[52] Chakchai So-In, Tri Gia Nguyen, Gia Nhu Nguyen: Barrier Coverage Deployment Algorithms for Mobile Sensor Networks. Journal of Internet Technology 12/2017; 18(7):1689-1699.

[53] Mubarakali, A., Bose, S. C., Srinivasan, K., Elsir, A., & Elsier, O. (2019). Design a secure and efficient health record transaction utilizing block chain (SEHRTB) algorithm for health record transaction in block chain. Journal of Ambient Intelligence and Humanized Computing, 1-9.

[54] Devaraj, A. F. S., Murugaboopathi, G., Elhoseny, M., Shankar, K., Min, K., Moon, H., & Joshi, G. P. (2020). An Efficient Framework for Secure Image Archival and Retrieval System Using Multiple Secret Share Creation Scheme. IEEE Access, 8, 144310-144320.

[55] Mubarakali, A. (2020). Healthcare Services Monitoring in Cloud Using Secure and Robust Healthcare-Based BLOCKCHAIN (SRHB) Approach. MOBILE NETWORKS & APPLICATIONS.

[56] Namasudra, S. (2019). An improved attribute-based encryption technique towards the data security in cloud computing. Concurrency and Computation: Practice and Experience, 31(3), e4364.

[57] Kathiresan, S., Sait, A. R. W., Gupta, D., Lakshmanaprabu, S. K., Khanna, A., & Pandey, H. M. (2020). Automated detection and classification of fundus diabetic retinopathy images using synergic deep learning model. Pattern Recognition Letters.

[58] Govinda, K., & Prasanna, S. (2015, February). Medical dialysis prediction using fuzzy rules. In 2015 International Conference on Soft-Computing and Networks Security (ICSNS) (pp. 1-5). IEEE.

[59] Sujatha, R., Navaneethan, C., Kaluri, R., & Prasanna, S. (2020). Optimized Digital Transformation in Government Services with Blockchain. In Blockchain Technology and Applications (pp. 79-100). Auerbach Publications.

[60] Govinda, K., & Prasanna, S. (2015, February). A generic image cryptography based on Rubik's cube. In 2015 International Conference on Soft-Computing and Networks Security (ICSNS) (pp. 1-4). IEEE.

[61] Anand Nayyar, Vikram Puri, Nhu Gia Nguyen, BioSenHealth 1.0: A Novel Internet of Medical Things (IoMT) Based Patient Health Monitoring System, Lecture Notes in Networks and Systems. Springer, 2019

[62] Prasanna, S., & Narayanan, V. (2017). A Novel Approach for Generation of All-Optical OFDM Using Discrete Cosine Transform Based on Optical Couplers in a Radio-Over-Fiber Link. International Journal of Advanced Research in Engineering and Technology, 8(3).

[63] Sanjeevi, P., Prasanna, S., Siva Kumar, B., Gunasekaran, G., Alagiri, I., & Vijay Anand, R. (2020). Precision agriculture and farming using Internet of Things based on wireless sensor network. Transactions on Emerging Telecommunications Technologies, e3978.

[64] Rathi, V. K., Chaudhary, V., Rajput, N. K., Ahuja, B., Jaiswal, A. K., Gupta, D., ... & Hammoudeh, M. (2020). A Blockchain-Enabled Multi Domain Edge Computing Orchestrator. IEEE Internet of Things Magazine, 3(2), 30-36.

[65] Khanna, A., Rodrigues, J. J., Gupta, N., Swaroop, A., & Gupta, D. (2020). Local mutual exclusion algorithm using fuzzy logic for Flying Ad hoc Networks. Computer Communications.