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Security-Enabled Retransmission and Energy Conservation Architecture With Cluster-Based Multipath Routing in Heterogeneous Wireless Networks

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ABSTRACT

The primary requirements of a heterogeneous wireless network topology are adaptive and smart resource allocation to users, protocols for routing and lifetime enhancement, access to the network with security and appropriate network selections. Routing algorithms deliberate on the performance of the network to evenly distribute load and thus enhance the lifespan of individual nodes. Clustering algorithm decides on allowing the right nodes into the network for enhanced security feature and finally the ability to analyse and predict the context of individual nodes/sensors in the network. Architecture of the proposed network includes the parameters such as decision-making ability to sustain the clusters, decision on members of the clusters until the communication process is completed, local network abilities and disabilities, price, preferences of individuals, terminal and access points of the service providers. Network lifetime of the entire network is observed to be enhanced up to 91% with triple layer architecture.

KEYWORDS

Adaptive Resource Allocation, Energy Aware Protocol, Heterogeneous Wireless Networks, Multipath Routing, Network Lifetime, Optimization, QoS, Security

INTRODUCTION

Heterogeneous Wireless Sensor Networks are independent, self-regulatory organisation of individual devices, which are distributed randomly and expected to render observations. Predominant findings state that the deployed devices are limited with energy sources, thus restricting the services for a longer duration. The availability of immediate, reliable network technology enabled multiple mobile users and other applications to render service for different processing. The futuristic cellular networks will be enabled with AI by facilitating the current networks with advanced features such as spectrum, interfaces, interactions, electromagnetism, coverages (Chen, et al., 2020). Predominant services of a heterogeneous network comprise of Wireless Fidelity, WiMAX, Short Range Communications, with

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a specific functionality applicable to different applications and users. Common parameters include the availability of service, capacity of the network, reliable connectivity, delay, jitter and expense required for service until the communication process is over (Heinzelman, et al., 2002; Felemban, et al., 2006; Adel & Ahmed, 2017). Such parameters can be ensured when a linked network is used for connectivity, in case of a wireless network, the availability and connectivity depends on the application, locality and users based on authentication. Dynamic property of a heterogeneous network adds complexity, difficulty in assuring quality parameters (Hou & Shi, 2004; Akyildiz et al., 2007). A wireless system composed of heterogeneous devices and applications impose multiple conditions for instability as the service is promised to simultaneous users at the same time. Energy management schemes induce additional responsibility from network service providers, to advocate longevity and performance of network participants, despite their individuality (Wang & Hong, 2019). The devices of heterogeneous nature are deployed typically with an assistance from topology controlling mechanisms, with a primary motive of reduced structural formation and hence optimized energy utilization (Hong, et al., 2017). Similarly, devices deployed in different regions demand diverse set of services from service providers in terms of observatory, multimedia, spatio-temporal information about the environment. This is an advancement from sensory nodes employed for performing a particular observation in a specific region, devices in the form of users or applications can utilize the collected information for their individual usage (Akyildiz, et al., 2008).

Heterogeneous networks are composed of sensory nodes with judicious functionalities, where the master nodes serve the client nodes with the required service (Manjeshwar & Agrawal, 2002; Younis & Fahmy, 2004; Mao et al., 2009). Along with improvised energy utilization, the security of nodes, their observations, transmissions and hence overall communication have to be protected from unauthorized and unauthenticated sharing or usage (Morosi et al., 2019; Marabissi et al. 2021). Provisions will be measured with respect to availability, reliability, accessibility, delivery time and ratio. All these parameters will finally lead to the measurement of network lifetime. Heterogeneous networks are composed based on the energy level of nodes, where the battery powered sensory nodes contribute to the functionality of the network. Server nodes / applications possess no limitations over the battery power as they continue to serve different users now and then. These servers are also powered by different power sources or renewable sources to ensure association, connectivity and reliability (Atmel's AT86RF23, 2009; Kumar et al., 2011; Baccour et al., 2012). When sensory nodes are identified by their heterogeneity with respect to access points, link stability and bandwidth, the domain becomes a tiered or layered version of architecture. The next category will be biased on the type of hardware used by the users or applications. Platforms or frameworks will also differ accordingly, based on the type of service made available. Making the model cost effective, this model eliminates the need of entire architecture and limits the usage with a minimalistic application. Final model of establishment is by constituting the application based on security features (Kim et al., 2008; Barroca et al., 2014; Bennis et al., 2014). Server nodes / applications will be protected by tamper proof methodologies to eliminate the chances of attacks.

Heterogeneous Wireless Networks are subjected to failures due to environmental conditions like rain, increased temperatures, climatic changes and regular wear and tear. The sensors and applications might undergo serious changes whenever they are prone to multiple changes in protocol, in turn affecting the quality of service (Jae-Joon Lee et al., 2004; Shanping Li & Zhendong Wu, 2005; Li et al., 2010). Faults occurring due to environmental conditions will lead to unavailability of service during disconnections. Unlike wireless sensor networks, the recovery plan for a HWN cannot be standardized owing to participation of diverse range of users/applications. There are certain domains where the rectification of sensory nodes cannot be delayed such as disaster management, nuclear activity sensing, healthcare industry and military applications. The ultimate concern of employing a heterogeneous wireless network is to design and implement a fault tolerant network with continued service and protected access to individuals. Multipath Routing Algorithms contribute to provide a break-free linkage between nodes until the communication is completed between a source and destination. Faults of various reasons are mitigated by pre-emptive methodologies and design to implement a resilient network architecture. Primary objective of a multipath routing algorithm is to produce a list of available routes between communicating nodes. The idea of constructing the paths is to guarantee n routes, and attempt of transmission happens in n-1 route until all routes fail or all message packets are received by the destined nodes. When the number of available routes is increased, the fault tolerance capability of the algorithm is notably increased.

Various multipath routing protocols function according to the environment where the nodes and systems are demanding service. Node-Disjoint Multipath Routing algorithms rely on no predominant nodes or paths to reduce the reliability on a single node or path. Whenever a node fails, link disconnection affects the specific path alone. This guarantees durability and route stability, where pre-emptive messages are transmitted about the connectivity. Observed problem in the node-disjoint methodologies is the count and monitoring of numerous messages by every node to understand an established pathway. Braided Multipath algorithms appoint certain nodes to be standard access points for construction of routes between a source and destination. The number of messages to provide knowledge of working nodes and paths are reduced to a great extent but compromises over the fault tolerance level of the networks. When a particular node fails, an entire path fails and multipath routing algorithms should address this limitation. The proposed methodology will design and implement an architecture for heterogeneous wireless network, measure energy efficiency, ensure link quality and promise reliable resource allocation by estimating the satisfaction level of nodes/users/ applications. Fault tolerance level of the proposed multipath routing algorithms has improvised the efficiency by 30%. The next section describes the survey of different multipath algorithms, section 3 illustrates and explains the architecture and working model of proposed scheme, Section 4 evaluates the proposed model by subjecting to various tests, and section 5 lists out the concluding remarks.

BACKGROUND WORK

Extensive research has been carried out in the field of multipath routing, wireless sensor networks and heterogeneous wireless networks, over a decade. Multipath routing protocols primarily concentrate on balancing load among servers, durability, QoS servicing, security features and reliable communication through resilient networks (Nasser & Chen, 2007; Ouadjaout et al., 2008). Devising the network structure, adaptive resource allocation, fault tolerance and multipath routing are the processes of the proposed model. Node Disjoint Parallel Multipath Routing algorithm produced a mechanism to derive multiple routes between a source and destination. All the paths were to include a one-hop delay and response based on the delay time. Intermediate nodes are utilized to forward route requests based on their delegation in a path for other communications. This decision of the algorithm ensures that the nodes are disjoint and can be extensively used for route establishments.

The next Multipath Routing Algorithm concentrates on the cost of each link between one source and destination nodes, cost of one hop between intermediate nodes, focusing on disjoint nodes in the path. Localized nodes are constructed in the paths after confirming that they are disjoint to each other. Predominant focus is also applicable to energy and cost efficient network designs. When multiple routes are established between communicating nodes, the final selection is based upon the hop counts and energy consumed for transfer of message packets from one node to another (Sohrabi et al., 2000; Szewczyk et al., 2004; Stavrou & Pitsillides, 2010). The observed problem with this methodology is unsure reliability of the network. The reliability, stability and security of the network is powered by a Branching based multipath routing scheme where neighbouring nodes based on distance are constructed into a tree based structure. Every sensory node / participant exists only once in the network tree and is utilized based on the distance from the sink nodes. The number of detected routes between the nodes is limited, hence limiting the fault tolerance levels. If a node is present in only one branch, it becomes accessible to the specific path alone. This limits the reuse of the same node for a different purpose or route. When nodes and links are disjoint for establishing routes, there should not be any mutual nodes to share the service. The same purpose has proven to form a durable and resilient network. As discussed, the number of messages required for updating the status of nodes / routes are humongous and cannot be managed internally. Control overhead and difficulties in managing such scalability issue is a primary concern in terms of a multipath algorithm (Welsh et al., 2003; Smaragdakis et al., 2004; Li et al., 2006).

A combination of both braided and disjoint nodes were observed in a comparative study and concluded that braided methods possess a bigger advantage with lesser control difficulties. Yet the braided technique of multipath routing limited the usage as the link failure affected a bigger network connectivity and thus research was carried out to devise a better mechanism. Along with the braided and disjoint method, a network coding methodology was added to reduce the number of message packets when they are transmitted through multiple routes. Their approach reduced the chances of node failures and ensured better connectivity. Routes were discovered, selected and maintained by the server and clients in the next model where a centralized approach was followed to conserve energy and ensure security. This approach involved the transmission of messages about the nodes' locality to the central node, every time when a heterogeneous node connects or move out of the network. Limitations like the control messages overhead prevented the implementations in bigger networks and were common in braided strategies (Kumar, 2014; Farouk et al. 2014).

The next approach depends on the nodes in close proximity of the base station to collect and transmit the messages. Relay of messages were bound to the distance between the nodes and base stations. Exhaustion of energy of these nodes were a common problem as the energy utilisation were not equally distributed for a distributed participation of nodes in the networks. Quick depletion of energy was common near the base stations, which immediately demanded the replacement of nodes for continued service. This approach expected the nodes to be disjoint and one hop distance from the base stations. Since the base stations are assumed to the strongest nodes with maximum transmission energy and battery power, the next protocol extended the single hop to double hop distance and disjointness. The same property limited the number of pathways that can be identified for the communication process to complete. Design of a multipath routing algorithm has to decide on the selection of communication overhead or fault tolerance ideally based on the function and service of the network (Pearlman et al., 2000; Radi et al., 2011). When a network has to be fault tolerant, it should permit multiple routes to facilitate end to end communication, irrespective of number of messages. All messages will carry the information about change in mobile nodes, new participants and nodes which are completely depleted with energy.

The next technique was electing the cluster head based on various parameters like energy level, distance between the node and base stations and residual energy. Clusters are formed based on proximity or type of services demanded from the server nodes. Prevention of loopholes is another benefit of clustering approach. Data aggregation and checking the redundancy is enabled in order to conserve the energy utilization at a single node's level and overall network. Primarily, the performance of entire network is deemed by efficient utilization of energy. In advanced methods of clustering, node densities, distance and residual energy play a vital role in determining the best algorithm for implementations. The proposed methodology intends to solve the network topology, multipath routing strategy, autonomous resource allocation, security and derivation of alternative paths for a reliable connectivity between source and destination nodes.

The authors proposed a technique of constructing user preferences based clusters (Wu et al., 2018) which enhance the ability of networks to offload, regulate the transmissions and thus depute user centric base stations. Associating the users according to preferences and protecting their secrecy biased out of individual users/consumers and entire network resources are defined with betterments in throughput (Wang et al., 2018). These sub-stations will further facilitate the process of regulating the storage of cache, render services faster and thus reduce computational time. The reduction of transmission range is another benefit of the developed technique in turn promising better network lifetime. On the other hand (Chen et al., 2018) the research was carried out to ensure the quality of service parameters during the vertical handoff method implemented in the conventional network architectures. A random neural network was powered by a deciding factor to make appropriate decisions to ensure QoS in the architecture. The entire system was based on a user centric / preferences, adding call blocking facilities to improve quality aspects. Outcome of the system measured better service charges, reduced power consumption of terminal nodes to support the proposed system in this paper.

Multiple research works have been carried out to conserve the energy utilization in heterogeneous networks, increasing the difficulty during actual deployment. Automated methods of sensing energy consumption, requirements and monitoring of surplus energy generations were observed in (Li. F et al., 2018). Estimation of shortest paths between the source and destination nodes is always critical, especially in heterogeneous and dynamic networking sources. Distributed computing strategies attempt to quantify methodologies accordingly based on the threshold energy levels. The question of exact shortest paths however saw no algorithmic progress for decades (Ghaffari & Li, 2018). Research work defined a qualitative improvement of directed graphs, in a sub linear approach based on time and bi-directions of edges between source and destinations.

Having mentioned the previous research carried out in the domain, the presented study contemplates a secure association between communicating nodes of heterogeneous wireless networks, association between cluster members and cluster heads, cluster heads and base stations, and to implement physical layer security. Along with security based out on geographical positions, energy utilization is also conserved in the proposed architecture. The following points are the contributions of the proposed mechanism:

- Benefits of deploying a cluster member-cluster head association model with locality and energy based parameters.
- Secrecy of network components, communication and improved throughput of individual nodes and overall network with security enabled sensory nodes monitoring.
- Definition of energy levels and positional parameters with respect to a three-layer architecture, in turn, measuring the utilization ratio in different and predetermined iterative steps.
- Extending the architecture to accommodate the requisites of futuristic cellular 6G network frameworks.

PROPOSED METHODOLOGY

The network model is defined based on the energy levels of sensory nodes deployed in different levels of implementations. This section discusses the triple level network model with heterogeneous devices and applications. The proposed model is assumed to be constructed with nodes/devices carrying a unique ID. Individual nodes surround the Base Station and all nodes are stationary in their respective locations. The devices are enabled with a GPS device to transfer their geographical location among each other. Performance and Computing capability of every node is assumed to be the same and they possess varying energy levels owing to the distance from Base Station. Their heterogeneous category also determines the level of energy utilized and residual energy. A high chance of depleting battery as the nodes is stationary with limited options to recharge at the deployed locations. The Base Station is powered by battery, deployed at the centre of the entire network with no restrictions like client nodes. Serving the other nodes in the cluster, the Base Station is powered with highest computational capacity and energy. Every node in the network will aggregate the collected information before they are transmitted to the Base Station. Entire message is aggregated to form a single packet of information before transmission, being an additional reason for conserving the power. Estimated power usage is determined by the distance between the source node and cluster heads, cluster heads and Base Station. Signal Strength will be measured by the strength of the receiving signal.

The presented network architecture demonstrates a triple level layer of heterogeneous nodes discriminated by their energy levels and geographical locations. Sensors with higher energy are more expensive than sensors possessing lower energy levels. Affordability is a primary concern of network architecture and thus the nodes with higher cost are lesser in number when compared to that of cheaper sensors. The number of cheaper nodes with lesser energy is found to more, computed with Θ x N number of nodes. Energy level of these nodes is denoted by E_i. Θ indicates a nominal value greater 0 and less than 1. The expensive nodes are assumed to possess double the energy level of the normal nodes with minimal energy E_3. These nodes constitute the third level of the triple layer architecture. Abundant number of nodes can be deployed on the last level for covering a bigger geographical location. This will also result in a cost efficient architecture. The better nodes will possess the E_2 $(\Theta \times N)^2$ energy levels and the first layer closer the base stations will be composed of E_1 $(\Theta \times N)^3$ energy levels. Base station will be possessing Energy Level E. The energy level hierarchy is described with the following expression 1:

$$E > E_1 > E_2 > E_3 \quad (1)$$

The total energy of the network is given by the following equation:

$$\text{Total Energy} = E_3 \,.\, (\Theta \times N) + E_2 \,.\, (\Theta \times N)^2 + E_1 \,.\, (\Theta \times N)^3 \quad (2)$$

The nodes with the maximum energy in every level will be nominated as the cluster head. Energy after transmission in every round is considered for the cluster head nominations. A heterogeneous network will be possessing the initial energy described in the following equation:

$$E_{initial} = (N \times \Theta)\, E_1 \times (\Theta \times N)^2\, E_2 + (1 - \Theta - \Theta^2) \quad (3)$$

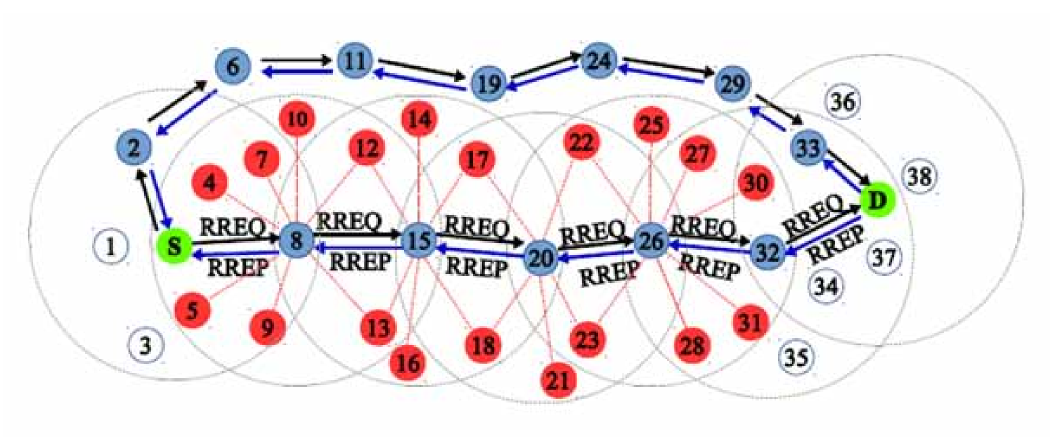
Once the cluster heads are formed and the messages are aggregated, the message packet will be transferred to the cluster heads, and to Base Stations. The quality of transmission is determined by the energy consumed for transferring the packets, quality of received packets, available routes to transmit the packets and thus a reliable communication. Packets have to be transmitted at a reasonable cost of energy and time. This Quality of Service Parameters is explained in the next sections. Signal to Noise Ratio is defined as the difference between received signal strength and noise level of the network.

Discovering the Closer Nodes

Every node, which commences to transmit the aggregated messages will attempt to find the closest node within the transmission range. As mentioned already, the last level nodes will be having the lowest energy and cannot transmit to longer distances. Even if the nodes have to transmit to a longer distance, there will be a considerable loss of energy, demanding a replacement. Closer nodes will be ready for transmission and reception of message packets directly from the source nodes and will preserve time and energy required for completion. As illustrated in the figure 1, the clusters will be formed based on the energy levels of every node. Nodes available at a one hop distance are found to the closer nodes which are in direct contact with source nodes and intermediate nodes. Final selection of the closer nodes to be a part of the communication will be determined by the geographic location, signal to noise ratio, packet delivery ratio, energy consumed and residual energy of the nodes (Chen et al., 2020; Shailendra Aswale & Vijay Ram Ghorpade, 2021).

The nodes will be represented by their active state, blocked state or terminated state. Active state indicates that the node can actively participate in a transmission of message packets, blocked state indicating the currently occupied state (forwarding) and terminated state where they exhausted all their energy.

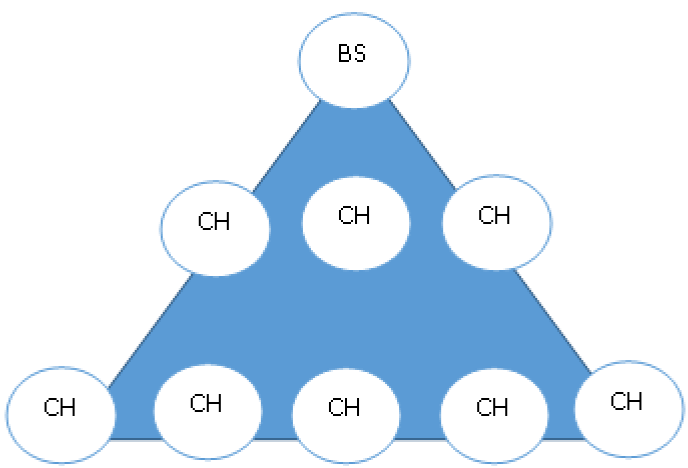
Figure 1. Multipath Routing Strategy (Shailendra Aswale & Vijay Ram Ghorpade, 2021)



ROUTE ESTABLISHMENT ALGORITHM

The geographical representation will be indicated by three levels of sensory nodes topped by one base station. Figure 2 illustrates the representation of cluster heads and base station deployed in the same geographical location. Once the nodes determine the closer nodes available at the one hop distance, all the information is updated onto a Routing Table. The routing table will also comprise of nominated cluster heads and members of those specific clusters. The source node identifies the closer node to commence the transmission. Route Request packets are transmitted to identify if they are at one hop distance. The most preferred node will be present in the shortest distance from the source node or forwarding node. Every node will update its preferred node onto the routing table. Table will also maintain the details about the active state of a node. When the closest node is either blocked or exhausted, the source node or forwarding node searches for next available closer nodes to continue finding a route. For finalizing the route between a source and destination node, all closest nodes should return a RREP message back to the RREQ message initiated by the forwarding node. The following pseudo code describes the process of proposed multipath routing algorithm. Cluster

Figure 2. Geographical Location based Clustering



head selection has been optimized by a realistic scheme of operations to estimate the fitness levels of individual nodes, as proposed to upgrade the genetic algorithms (Mishra et al., 2020). The proposed methodology adds an additional parameter of security to a multipath routing algorithm as discussed in the following algorithm.

Pseudocode

```
1: RouteREQ (Source, Forwarding Node, CH)
2: if next node = = active
   2.1: Set forwarding node = = blocked
3: else if next node = = blocked
   3.1: Roll back to step 2 at another one hop node
4: Estimate Link Cost
5: Update Routing Table with Source ® Next Node
6: Continue until Source reaches CH
7: Estimate total Route cost
8: Continue until all one hop routes are estimated
9: End Code
```

Finalizing the path

```
1: Estimate residual energy
2: if blocked node energy < threshold energy
   2.1: Check for alternative node
   2.2: Check status of alternative node
   2.3: Finalize alternative node as next node
3: Update Routing table
   3.1: Delete previous node
   3.2: Update new entry
4: End Code
```

Once the path has been confirmed by the routing table, the source node commences the transmission of message packet to the one hop nodes. The energy levels of all the nodes in the established route are checked with every hop to check the residual energy of nodes. If a node exhausts its residual energy, an alert message is raised to the routing table about the link breakage and search for a new node begins. This process will increase the time required for transmission by breaking the route. Routing protocol will continue to send the packets through the registered path without any knowledge about the broken link. The proposed protocol always forecasts the energy level of all the nodes and confirms before the nodes transmit the packets. When a node is likely to lose its energy before the packets are transmitted, message packets are stopped at the source until the Routing table is updated with an updated route. Handover is performed based on the registration within the cluster and notification of availability to the cluster heads for route constructions and finally updates in the Routing Table. Measuring the residual and available energy of the nodes will be predominant for considerations with respect.

RESULTS AND DISCUSSIONS

Performance of the proposed algorithm is compared against Two Phase Greedy Forwarding protocol and Link Quality Energy Aware Routing Protocol in the following simulation environment. The

Table 1. Simulated Parameters

Simulation Parameter	Value
Simulation deployment area	200sq.m
Number of Nodes	25 - 175
Number of sources/number of sinks	1
MAC protocol	IEEE 802.15.4
Traffic type	CBR
Transmit power	0 dBm
Receiver sensitivity	97 dBm
Channel frequency	2.4 GHz
Payload data size	100 bytes
Initial energy	50 J
Transmit power consumption	62.04 mw
Receive power consumption	57.42 mw
Simulation time	600 s

stationary nodes are enabled with a GPS device to update their locality parameters and they are deployed in a 200sqm area. The nodes are formed in a triple layer environment based on their energy levels. The base station is fixed on top every network and stationary with no limitations as energy or computational power. The following table lists out the simulated environment.

A reliable routing protocol has to be measured with its reliable packet delivery ratio and considered as a standard measure of consistency. Packet delivery ratio is the measure of total packets sent by the source node and number of packets received by receiver node. The next figure 3 illustrates the packet delivery ratio of proposed algorithm vs the TIMGR, TPGF and LQEAR algorithms. There happens to be a considerable loss of message packets due to interference of nodes internally. The packet loss is considerably lesser in case of the proposed algorithm vs the other standard algorithms Figure 4 illustrates the benefits of proposed approach with respect to loss of message packets owing to internal interference. Interference is due to transmission of message packets when a specific node fails, route changes due to node exhaustion of energy levels. In other approaches, route selection is based on shortest distance between the nodes on a routing table, that is between source node to forwarding nodes to cluster heads and finally to the base stations. Following figure 5 indicates the reduction of end to end delay in the proposed methodology owing to the efficient clustering technique and reduction of message travelling distance between every node and sink. Once the clusters are formed based on their geographical location from the base stations, the routing table is updated with the signal strength required for transmission. Followed by the new addition of parameters based on reliability, probability of successful transmission of packets and delay. The end to end delay in the proposed method has been optimized due to smaller cluster formations and positioning the node delivery at a one hop distance. The security of the packets transmission and delivery is ensured by the updates of geographical location of every node in the routing table and thus the clusters.

The delivery of packets from the source node to the Base Station and vice versa is measured as the parameter of PDR. From figure 3, it is illustrated that packet delivery ratio of proposed methodology has significantly shown 94% over the 90% of TIGMR, 82% of TPGF and 80% of LQEAR packet delivery ratio. Chances of interference have been remarkably reduced with scanning of one hop neighbours around the source nodes. Existing techniques were facing the difficulty of managing the packet interference occurring in multiple paths generated by the routing algorithm. End to End delays

Figure 3. Average Packet Delivery Ratio

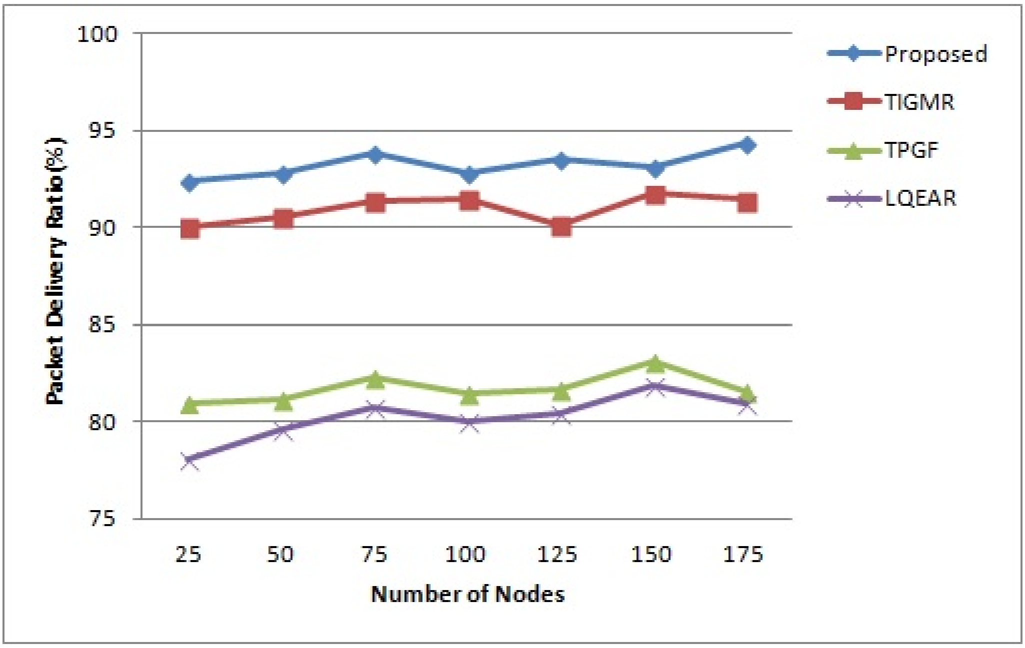


Figure 4. Packet Loss due to Interference

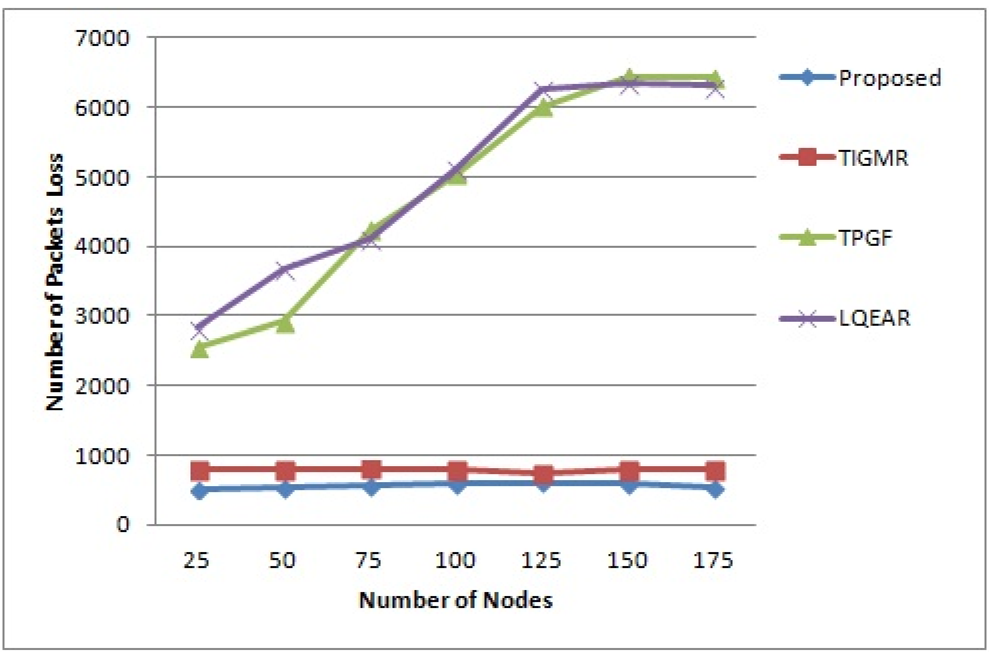
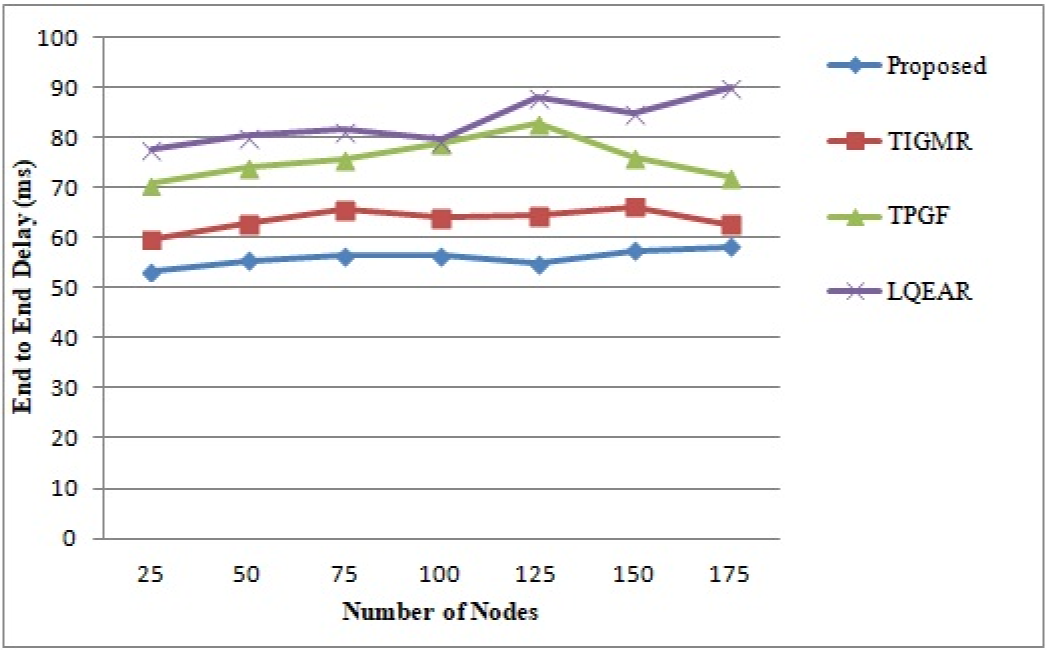


Figure 5. End to End Delay



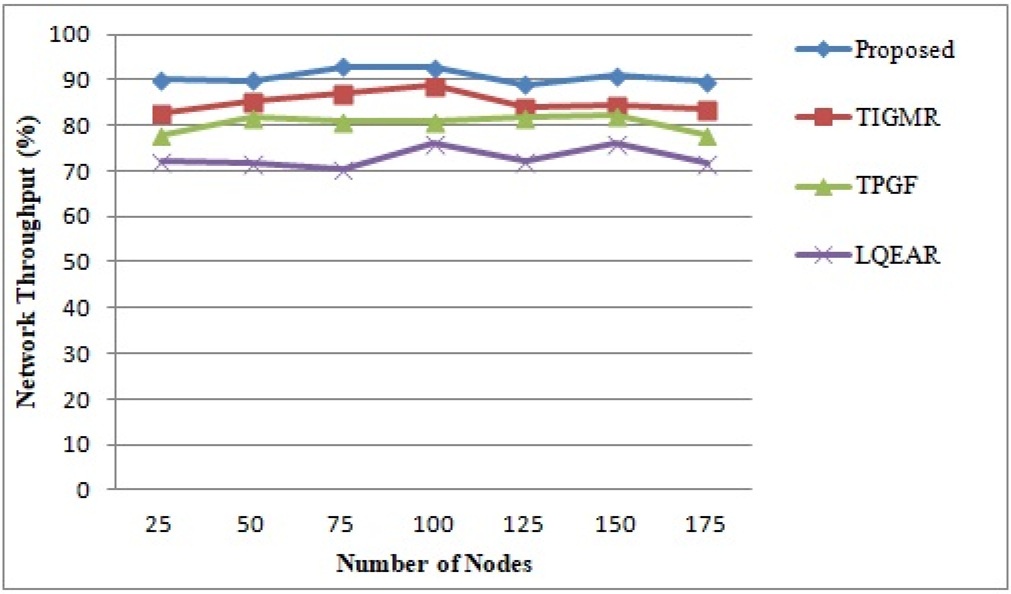
are measured as the additional time taken by every message packet to reach its destination. The delay observed in the proposed methodology is lesser owing to having the cluster formation in a confined zone of one hop neighbours and quicker transmission from one node to forwarding nodes. Observed delay was 27% lesser than LQEAR, 20% lesser than TPGF and 8% lesser than TIGMR which in turn helped in reducing the number of retransmissions required.

Figure 6 demonstrates the performance of the proposed algorithm over the existing standards, where the simulated environments test the reliability in terms if packet delivery ratio under varying number of nodes in the network. From the obtained results, it is evident that the adept methodology obtained better performance of reliability than existing schemes like 21%, 23%, and 33% due to the priority rendered to those next-hops that are optimum for message packets forwarding.

CONCLUSION

Heterogeneous networks demand a reliable routing protocol which is capable of transmitting in multiple routes. Based on the application and users of the network, the routing protocol has to be ensured for end to end connectivity. Multipath routing in a heterogeneous network cannot be standardized unlike a homogeneous or wireless sensor networks as the protocol has to focus on multiple quality of service parameters. The overall performance of a network is improvised with three-layered architecture, carefully segmented based on the energy level of sensory nodes. Further attention is paid to discriminate the nodes, cluster head selection and estimating the link costs for one-hop transfer of message packets. The proposed algorithm clusters nodes based on their energy levels, layers and cost of implementation. Forwarding nodes in the intermediate zones evaluates the node-disjoint levels, residual energy, number of packet loss, and interference levels. The minimal energy level of a node is ensured before the packets are transferred, if the node is expected to fail, an alternative route is established by the proposed algorithm. Proposed system enhances the lifetime of entire network, higher packet delivery ratio and minimal cost for transmission. The number of

Figure 6. Network Throughput



parameters included within the network computations and energy dissipation estimation account for increased computation time, despite improvised performance. The disclosure of physical locations imposes a threat through compromised nodes which can be prevented by a monitoring mechanism of authenticated devices. The monitoring framework will be a component of extended research and promise secure architecture as its future direction.

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REFERENCES

Adel, A. (2017). A real-time routing protocol with adaptive traffic shaping for multimedia streaming over next-generation of Wireless Multimedia Sensor Networks. *Pervasive and Mobile Computing*, *40*, 495–511. doi:10.1016/j.pmcj.2017.01.010

Akyildiz, I. F., Melodia, T., & Chowdhury, K. R. (2007). A survey on wireless multimedia sensor networks. *Computer Networks*, *51*(4), 921–960. doi:10.1016/j.comnet.2006.10.002

Akyildiz, I. F., Melodia, T., & Chowdhury, K. R. (2008). Wireless Multimedia Sensor Networks: Applications and Testbeds. *Proceedings of the IEEE*, *96*(10), 1588–1605. doi:10.1109/JPROC.2008.928756

Aswale & Ghorpade. (2021). Geographic Multipath Routing based on Triangle Link Quality Metric with Minimum Inter-path Interference for Wireless Multimedia Sensor Networks. *Journal of King Saud University - Computer and Information Sciences, 33*(1), 33-44.

Atmel's AT86RF231. (2009), https://www.microchip.com/wwwproducts/en/AT86RF231.

Baccour, N., Koubâa, A., Mottola, L., Zúñiga, M. A., Youssef, H., Boano, C. A., & Alves, M. (2012). Radio link quality estimation in wireless sensor networks: A survey. *ACM Transactions on Sensor Networks*, *8*(4), 34. Advance online publication. doi:10.1145/2240116.2240123

Barroca, N., Borges, L. M., Velez, F. J., & Chatzimisios, P. (2014). IEEE 802.15.4 MAC layer performance enhancement by employing RTS/CTS combined with packet concatenation. *IEEE International Conference on Communications (ICC)*, 466-471. doi:10.1109/ICC.2014.6883362

Bennis, I., Fouchal, H., Zytoune, O., & Aboutajdine, D. (2014). An evaluation of the TPGF protocol implementation over NS-2. *IEEE International Conference on Communications (ICC)*, 428-433. doi:10.1109/ICC.2014.6883356

Chen, J., Wang, Y., Li, Y., & Wang, E. (2018). QoE-Aware Intelligent Vertical Handoff Scheme Over Heterogeneous Wireless Access Networks. *IEEE Access: Practical Innovations, Open Solutions*, *6*, 38285–38293. doi:10.1109/ACCESS.2018.2853730

Chen, Y., Liu, W., Niu, Z., Feng, Z., Hu, Q., & Jiang, T. (2020). Pervasive intelligent endogenous 6G wireless systems: Prospects, theories and key technologies. *Digit. Commun. Netw*, *6*(3), 312–320. doi:10.1016/j.dcan.2020.07.002

Farouk, F., Rizk, R., & Zaki, F. W. (2014). Multi-level stable and energy-efficient clustering protocol in heterogeneous wireless sensor networks. *IET Wireless Sensory Systems*, *4*(4), 159–169. doi:10.1049/iet-wss.2014.0051

Felemban, E., & Lee, C.-G. (2006). MMSPEED: Multipath Multi-SPEED protocol for QoS guarantee of reliability and. Timeliness in wireless sensor networks. *IEEE Transactions on Mobile Computing*, *5*(6), 738–754. doi:10.1109/TMC.2006.79

Ghaffari, M., & Li, J. (2018). Improved distributed algorithms for exact shortest paths. *Proc. 50th Annu. ACM SIGACT Symp. Theory of Computing*, 431–444. doi:10.1145/3188745.3188948

Heinzelman, W. R., Chandrakasan, A. P., & Balakrishnan, H. (2002). An application-specific protocol architecture for wireless microsensor networks. *IEEE Transactions on Wireless Communications*, *1*(4), 660–670. doi:10.1109/TWC.2002.804190

Hong, Z., Wang, R., Li, X. L., & Wang, N. (2017). A tree-based topology construction algorithm with probability distribution and competition in the same layer for wireless sensor network. *Peer-to-Peer Networking and Applications*, *10*(3), 658–669. doi:10.1007/s12083-016-0514-8

Hou, R., & Shi, H. (2006). A localized algorithm for finding disjoint paths in wireless sensor networks. *IEEE Communications Letters*, *10*(12), 807–809. doi:10.1109/LCOMM.2006.061095

Kim, M., Euihoon, J., Bang, Y. C., Hwang, S., Shin, C., Jin, G. J., & Kim, B. (2008). An Energy-Aware Multipath Routing Algorithm in Wireless Sensor Networks. *IEICE Transactions on Information and Systems*, *91*(10), 2419–2427. doi:10.1093/ietisy/e91-d.10.2419

Kumar, D. (2014). Performance analysis of energy efficient clustering protocols for maximising lifetime of wireless sensor networks. *IET Wireless Sensor Systems*, *4*(1), 9–16. doi:10.1049/iet-wss.2012.0150

Kumar, D., Aseri, T. C., & Patel, R. B. (2011). A novel multihop energy efficient heterogeneous clustered scheme for wireless sensor networks. *Tamkang J. Sci. Eng.*, *14*(4), 359–368.

Lee, Krishnamachari, & Kuo. (2004). Impact of heterogeneous deployment on lifetime sensing coverage in sensor networks. *First Annual IEEE Communications Society Conference on Sensor and Ad Hoc Communications and Networks*, 367-376. doi:10.1109/SAHCN.2004.1381938

Li, F., Yang, Y. B., Chi, Z. C., Zhao, L. Y., Yang, Y. W., & Luo, J. (2018). Trinity: Enabling self-sustaining WSNs indoors with energy-free sensing and networking. *ACM Transactions on Embedded Computing Systems*, *17*(2), 1–27. doi:10.1145/3173039

Li, Q., Qingxin, Z., & Mingwen, W. (2006). Design of a distributed energy efficient clustering algorithm for heterogeneous wireless sensor networks. *Computer Communications*, *29*(12), 2230–2237. doi:10.1016/j.comcom.2006.02.017

Li, S., Neelisetti, R. K., Liu, C., & Lim, A. (2010). Efficient Multi-Path Protocol for Wireless Sensor Networks. *International Journal of Wireless and Mobile Networks*, *2*(1), 110–130.

Li, S., & Wu, Z. (2005). Node-disjoint parallel multi-path routing in wireless sensor networks. *Second International Conference on Embedded Software and Systems*, 432–437. doi:10.1109/ICESS.2005.72

Manjeshwar, A., & Agrawal, D. P. (2002). APTEEN: a hybrid protocol for efficient routing and comprehensive information retrieval in wireless. *Proceedings 16th International Parallel and Distributed Processing Symposium*, 195-202. doi:10.1109/IPDPS.2002.1016600

Mao, Y., Liu, Z., Zhang, L., & Li, X. (2009). An Effective Data Gathering Scheme in Heterogeneous Energy Wireless Sensor Networks. *International Conference on Computational Science and Engineering*, 338-343. doi:10.1109/CSE.2009.16

Marabissi, D., Mucchi, L., & Morosi, S. (2021). User-Cell Association for Security and Energy Efficiency in Ultra-Dense Heterogeneous Networks. *Sensors, 21*(2), 2-15. .10.3390/s21020508

Mishra, P., Sahoo, D., Khandelwal, H., Amman, N., & Sobhanayak, S. (2020). Minimised Jaya Algorithm-based Structure optimisation for Heterogeneous Wireless Sensor Networks. *5th International Conference on Computing, Communication and Security (ICCCS)*, 1-8. doi:10.1109/ICCCS49678.2020.9277064

Morosi, S., Mucchi, L., Marabissi, D., Dolfi, M., & Marini, K. (2019). On the trade-off between Secrecy and Energy-Efficiency in Multi-Layer Cellular Networks. *Proceedings of the 2019 IEEE 5th International forum on Research and Technology for Society and Industry (RTSI)*, 132–137. doi:10.1109/RTSI.2019.8895531

Nasser, N., & Chen, Y. (2007). SEEM: Secure and energy-efficient multipath routing protocol for wireless sensor networks. *Computer Communications*, *30*(11-12), 2401–2412. doi:10.1016/j.comcom.2007.04.014

Ouadjaout, A., Challal, Y., Lasla, N., & Bagaa, M. (2008). SEIF: Secure and Efficient Intrusion-Fault Tolerant Routing Protocol for Wireless Sensor Networks. *Third International Conference on Availability, Reliability and Security*, 503-508. doi:10.1109/ARES.2008.128

Pearlman, M. R., Haas, Z. J., Sholander, P., & Tabrizi, S. S. (2000). On the impact of alternate path routing for load balancing in mobile ad hoc networks. *Proceedings of the 1st ACM International Symposium on Mobile Ad Hoc Networking & Computing*, 3-10. doi:10.1109/MOBHOC.2000.869207

Radi, M., Dezfouli, B., Abu Bakar, K., Abd Razak, S., & Nematbakhsh, M. A. (2011). Interference-aware multipath routing protocol for QoS improvement in event-driven wireless sensor networks. *Tsinghua Science and Technology*, *16*(5), 475–490. doi:10.1016/S1007-0214(11)70067-0

Smaragdakis, G., Matta, I., & Bestavros, A. (2004). SEP: A stable election protocol for clustered heterogeneous wireless sensor networks. *Int. Workshop on Sensor and Actor Network Protocols and Applications*, 1–11.

Sohrabi, K., Gao, J., Ailawadhi, V., & Pottie, G. J. (2000). Protocols for self-organization of a wireless sensor network. *IEEE Personal Communications*, *7*(5), 16–27. doi:10.1109/98.878532

Stavrou, E., & Pitsillides, A. (2010). A survey on secure multipath routing protocols in WSNs. *Computer Networks*, *54*(13), 2215–2238. doi:10.1016/j.comnet.2010.02.015

Szewczyk, R., Mainwaring, A., Polastre, J., Anderson, J., & Culler, D. (2004). An analysis of a large scale habitat monitoring application. *The 2nd International Conference on Embedded Networked Sensor Systems*, 214–226, doi:10.1145/1031495.1031521

Wang, N., & Hong, Z. (2019). An Energy-Efficient Topology Control Algorithm for Earth Building Monitoring Using Heterogeneous Wireless Sensor Networks. *IEEE Access: Practical Innovations, Open Solutions*, *7*, 76120–76130. doi:10.1109/ACCESS.2019.2921727

Wang, S., Gao, Y., Dong, C., Sha, N., & Zang, G. (2018). Secure User Association in Two-Tier Heterogeneous Cellular Networks with In-Band Interference. *IEEE Access: Practical Innovations, Open Solutions*, *6*, 38607–38615. doi:10.1109/ACCESS.2018.2852727

Welsh, E., Fish, W., & Frantz, J. P. (2003). GNOMES: a testbed for low power heterogeneous wireless sensor networks. *International Symposium on Circuits and Systems*, 836-839. doi:10.1109/ISCAS.2003.1206350

Wu, H. C., Zhang, N., Wei, Z. Q., Zhang, S., Tao, X. F., Shen, X. M., & Zhang, P. (2018). Content-Aware Cooperative Transmission in HetNets With Consideration of Base Station Height. *IEEE Transactions on Vehicular Technology*, *67*(7), 6048–6062. doi:10.1109/TVT.2018.2809616

Younis, O., & Fahmy, S. (2004). HEED: A hybrid, energy-efficient, distributed clustering approach for ad hoc sensor networks. *IEEE Transactions on Mobile Computing*, *3*(4), 366–379. doi:10.1109/TMC.2004.41

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