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Query Aware Routing Protocol for Mobility Enabled Wireless Sensor Network

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Abstract – Mobility Enabled Wireless Sensor Network (MEWSN) plays a significant role in different fields including environmental control, traffic control and healthcare. The performance of MEWSN is dependent not only on sensing but also on routing. Multiple research works are carried out by different researchers in the domain of routing in MEWSN, but still the performance of MEWSN gets lacked. Poor routing is the root cause for the performance degradation of MEWSN. In this paper, a new routing protocol namely Query Aware Routing Protocol (QARP) is proposed to balance the load in MEWSN to prevent congestion and exhausted power utilization. Normal routing protocols either seek to match load or route, but both are considered in QARP. Also, identified routes are classified based on an enhanced relevant vector machine classification algorithm which assists in minimizing the delay and energy consumption. Using NS2, QARP is evaluated against previous routing protocols with standard performance metrics namely throughput, delay, packet delivery ratio and energy consumption. The packet delivery ratio achieved by QARP is 92.6%, where the existing routing protocols IFLIP and PARP has achieved 62.8% and 75.4% respectively.

Index Terms – WSN, MEWSN, Routing, Query, Load, Congestion.

1. INTRODUCTION

One of the emerging ad-hoc wireless networks is Mobility Enabled Wireless Sensor Network (MEWSN). MEWSN is a kind of infrastructure-based network made up of sensing nodes that provide an administrating person a capability to scrutinize and respond to action and event in a specific atmosphere [1], [2]. The sensing atmosphere may be a physical environment, a framework based on organic, or fully based on information technology-based structure. The frameworks of the sensor network are taken care by different teams. Regular sensor applications incorporate the accumulation of information, checking, reconnaissance, and medical-related information [3], [4]. Also sensing the atmosphere frequently is additionally inspired by control and enactment. The four essential elements of MEWSN are (1) assembling of sensors; (2) an interconnecting system; (3) grouping of data; and (4) centralized collection of information for clustering to deal with information relationship, occasion slanting, enquiring the status, and mining of data. Regarding the specific circumstance, the nodes that are for sensing and computing are viewed as a component of the Wireless Sensor Networks WSN [5].

Receiving support for a range of applications like traffic control, home automation, clever battlefield, environment tracking, and many more, Wireless Sensor Networks (WSN) have been developed. For the achievement of computing operations, MEWSN includes multiple sensors spread around a single node. Routing in MEWSN is an extremely critical job to be done with care [6]. To achieve better results, a novel routing technique is required to send data between the sensor nodes and the base stations. The primary criterion based in this paper is the application-dependent routing protocol [7], [8]. The problem with routing results in lower network

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lifetime and higher energy usage. Various routing protocols have also been developed to minimize energy usage and optimize network life. Specific routing challenges include energy usage, node usage, availability, accessibility, protection, and coverage [9], [10].

Several characteristics differentiate MEWSN and general wireless networks. The routing work for MEWSN is highly challenging than WSN. The following are some significant challenges: a standardized identification system for a large number of sensor nodes is almost difficult to assign. Wireless sensor's intentions are not capable of using standard IP protocols, because [11]:

✓ Sensed data flow from a variety of sources to a single base station which is mandatory. But, in traditional communication networks, this happens in a different scenario.

✓ The data traffic generated in most cases has considerable redundancy. Due to the fact, that many nodes produce the same data during sensing. It is therefore important to use the routing protocols to minimize such redundancy and to use network resources efficiently as possible.

✓ In addition, in relationships to transmitting energy, bandwidth, power, storage, and onboard energy wireless motes are firmly constrained. To resolve the routing problems in sensor networks, a range of new routing protocols are developed because of these disseminations.

1.1. Motivation

Currently, the world is moving to MEWSN from WSN due to its utilization in different fields. Among different fields, the medical field occupies a major place. In a pandemic situation, even doctors too get fear to go and discuss with patients. The only solution is to utilize mobility-enabled sensor devices to monitor patients from remote places. Routing protocol plays a vital role in making the sensed data reach the destination. This motivates the research work to develop a routing protocol that can be utilized in a pandemic situation to assist doctors in monitoring the patients.

1.2. Problem Statement

WSN has created a big impact among researchers due to its development and unsolved issues in it. Among different research issues present in WSN, this research work has focused on the issue of "routing". Even though different routing protocols are presented for WSN it is still facing a different issue. Traditional WSN is entirely different from MEWSN, where the nodes in mobility feature. The protocol developed for general WSN for other networks will not suit MEWSN [12], [13]. Routing in MEWSN has many issues due to the network's fundamental features like constrained resources, limited utilization, node mobility and

dependability. Need for the design of better routing getting increased for MEWSN to minimize the delay and energy consumption [14], [15].

1.3. Objective

The primary objective of this paper is to propose a query-based routing protocol that efficiently identifies the route based on queries that the node sent during the route discovery which results in minimum delay and energy consumption.

1.4. Organization of the Paper

The current section of the paper has given a brief introduction about MEWSN, problem statement and objective. The next section 2 discusses the related works of literature. Section 3 discusses the proposed routing protocol for MEWSN. Section 4 discusses the performance metrics with the setting used for simulation. Section 5 discusses the results. Section 6 concludes the paper with future enhancement.

2. LITERATURE REVIEW

Energy sensor-based mobile application routing protocol [16] has been proposed for avoiding the low-quality route for data transmission. In this, an attempt was made to link WSN to mobile-enabled sensor devices where the route between static WSN nodes and dynamic sensor nodes are established. Cluster-Based Energy Efficient Routing Protocol [17] is proposed to avoid delay in WSN. In this protocol, partial nodes in the network were well used and remaining nodes were not used which makes efficient data transfer. This protocol contributes to overhead networks and life reduction. Dual alert cum Charging Protocol [18] is recommended to prioritize energy conservation when the threshold value was met. Once it exceeds the threshold energy it results in network failure due to nodes stopping the collaboration with other nodes. Gaussian Routing Protocol [19] is proposed for 2D Gaussian Distribution by deploying relay-based nodes. The findings show that, even if implemented, the protocol seems abstract and insufficient for real-time application and it results in network failure. Intrusion Detection Model based on Game theory [20] is developed to ensure network protection and it tried to increase self-reported methodology in non-cooperative environments and to result in too much of energy utilization in the event of route failure.

Explicit routing strategies of WSN [21] for mobile robots were reviewed and modularized into three types according to the tasks carried out by the sink nodes (SN) to avoid link failures. The findings show the rise in energy consumption due to unexpected route connection failures. Chain-based routing protocol [22] is proposed as an optimization strategy for WSN and it is designed to increase the cooperation between clusters to boost WSN efficiency, in which the protocol weakens the WSN due to the node delay gap. Multi-Flow Network Protocol [23] is proposed to allocate channels

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for data and aircraft control, a module for increasing network speed has also been developed for each SN. The findings show that the node failure is caused by the idea of constructing a module in the SN nodes. Grid Loop Routing Protocol [24] is suggested to reduce the overhead of the sink node in WSN. This protocol divides the WSN into size-dependent grids. The results show that choosing the grid head, the WSN absorbs more energy. Reliable Routing Protocol [25] is proposed for the wind turbine environment to improve reliability. The technique of contact used was multi-hop. The protocol was not suitable for the world of Wind Turbines due to unexpected network failure.

Connection Reliable Model [26] is proposed for nodes survivability in WSN. Diverse parameters such as battery lifespan, shadow, and network noise and node location uncertainty were affected by the protocol, and this happened due to the protocol validation process. The idea of using the mobility principle for power recharge in a shared manner and data collection was proposed for a routing strategy [27], where a mobile agency, called SenCarin, has been employed. It does not only act as a recipient of data but makes roaming more comprehensive than the field to receive more data via minute message. A study [28] has been conducted on different WSN energy models and suggested an energy-saving routing protocol to increase the stability duration by considering (i) heterogeneous environment (ii) resource-based routing for optimality (iii) connection failure. Ant Colony Optimization-based routing strategy [29] is proposed to find the best route between source and destination. The protocol failed to create routing connections between clusters, leading to a reduction in network life. Low Energy Adaptive Clustering Hierarchy [30] is proposed to enhance the efficiency of routing in WSN. The protocol was intended to reduce the energy used for WSN node communication. A part of the WSN behaved greedily to save resources and to ruin the network lifetime.

Multi Adaptive Routing Protocol (MARP) [31] is proposed to enhance the lifetime of the network by utilizing the natural behavior of fishes towards searching for food. MARP is a swarm intelligence protocol where all nodes share the routing information. MARP avoids the route where the loop is present. Power-Aware Routing Protocol (PARP) [32] is proposed to minimize the power spent for data transmitting in WSN. With the utilization of the multicast tree strategy, routes are formed to send the data. The unicast concept is used data to neighbor nodes geographically where it concentrates on avoiding the malicious nodes in routing. Improved Frog Leaping Inspired Protocol (IFLIP) [33] is proposed to reduce the exhaustive energy in the network especially spent for data transmission. IFLIP is inspired by the leaping characteristics of the frog. By default, IFLIP attempts to find the different number of routes in a network to handle the issue of congestion. Different bioinspired optimization protocols [34]–[37],[38] are proposed to enhance the quality

of service. Every bioinspired optimization protocol has different specialty [39].

3. QUERY AWARE ROUTING PROTOCOL (QARP)

Taking into consideration the importance of the well-structured data routing in MEWSN, this study establishes and develops a new protocol to route data from a sender node to the receiver node. The data sent by more than one sender or all sender can be received by this protocol Sink Node (SN). To achieve this objective, the selected recipients are sent an inquiry from the SN which expects to receive the data.

The nodes that receive the REQ message verify whether or not it addresses the question and save the node that sends the REQ to the next node in the list. In the absence of a response from the node to SN, it opts for an Optimal Next Node (ONN) with the use of the fuzzy presumption strategy. If ONN not accepted, then the routing table would be removed. The current node selects a different node from its table for ONN at this stage. If acceptance is not received for ONN, then the supporting module deals with this problem by creating a node table to distinguish new neighbors. The node attempts to select a second goal to be ONN at this stage. Evidence is replied to SN despite identifiable evidence based on SN's attention. QAP Consists of six utilitarian modules that are suitable for over three phases: a route search stage(RSS), an Information Supply Stage (ISS) and a Route Maintenance Stage (RMS) phase. RSS and ISS are two consecutive phases that begin quickly when SN queries information from every few nodes, while RMS starts when the information is transmitted with disappointment.

3.1. Fuzzy Inference Model

The fuzzy Inference Model is generally synchronous with the theory of fuzzy sets, a concept that associates with groups of uncertain ranges of things with degrees of involvement. The theory of fuzzy sets includes (i) fuzzy collection, (ii) membership function, (iii) if conditions. The fuzzy Inference Model aims to use the fuzzy sets already available effectively.

3.2. Route Searching Stage

RSS begins when SN communicates with REQs to gather data from all of its related nodes. While NR Node receives such REQ using the REQ-Receiver ($REQR$) module, it enquires its neighbors to submit REQ for its state, also measure the nearby nodes state. The State Resolution Module (SRM) allows the collection of neighboring node data. Shortly, after NR's node recognizes the neighbor state, it secures the "neighbor" table. The Next State (NS) helps the current neighbor to reduce (i) battery level, (ii) total delay that exists between neighbor and SN. When the battery level is low then the messages are discarded. The REQs are transmitted at the beginning of RSS phase from the current node to the next. Before transmitting it represents the node level in the field and hops count to SN. As

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said, the battery level will get 0 at j in a REQ. This level is increased linearly to reach level one. The node checks the default conditions to enhance the REQ and to retransmit it to other nodes. It then performs RSS once the node calculates neighbor data. Finally, RSS is divided into three modules: (i) get request message, (ii) refresh request message, (iii) calculate next data modules.

The "neighbors" table accumulates data about neighbor nodes, it very well may be utilized to choose the optimum way to SN. Neighbors table is made to clear at whatever point another REQ is gotten. At the point when the node (N) gets REQ, it conjures SRM and verifies the field Req_ID of received REQ. It distinguishes it from received REQ that was received previously. It shows that REQ is different and it clears neighbors' routing table. For the most part, any node that considers REQ as a tool that varies and holds new data about the topology of the network.

To figure the power consumption and connection delay for one transmission, the node attempts to send RTS packets by accepting senders REQ message. It will act as CTS message. If a node sends RTS, it immediately sends the present time ($T1$) and battery level in ($P1$). While node gets a reply (e.g., CTS), time ($T2$) and battery level ($P2$) are saved for better routing. The round-trip time is computed using the difference of $T1$ and $T2$. The time consumed got connection delay computed by utilizing $Eq.(1)$. Then again, the power used for connection is found using the difference of CTS arrival and it can be computed utilizing $Eq.(2)$.

$$Delay(S,N) = \frac{T_{Ry} - T_{Tr}}{2} \qquad (1)$$

Where $Linkpower(S,N)$ indicates total delay exists between hops (S to N). T_{Tr} and T_{Ry} represents the time utilized for transmitting and getting reply acceptance (in ms).

$$Linkpower(S,N) = P_{Tr} - P_{Ry} \qquad (2)$$

Where P_{Tr} denotes available battery at the time transmission in mJ and P_{Rv} indicates available battery while accepting mJ. Then, the power required for transferring a single data packet is calculated using $Eq.(3)$.

$$\begin{aligned} Bit\_link\_power = &(link\ power) \\ &/(no\ of\ bits\ in\ RTS\ Packet \\ &+ no\ of\ bits\ in\ CTS\ Packet) \end{aligned} \qquad (3)$$

When a node finds a delay in connection, it attempts to find the total delay during its travel to the destination. In this, the node adds the information regarding delays that exist in connection and sends it to a neighbor. Also, the node inserts information regarding connection bit power in REQ to compute Tot_P.

3.3. Information Supply Stage (ISS)

ISS can only get started when the node is given a large-scale REQ-message from its SN node, except on a congested period. If the response is more delayed, the node begins replying to SN. The lapse time (ξ) starts if the node recognizes that SN needed data from it and it can be calculated by using Eq.(4). It acts as the answer field in the '$node\_info$' and it will always be equal to one.

$$\xi = \frac{1}{n}\sum_{i=1}^{n}\frac{Tot\_D_i}{Level_i} \qquad (4)$$

Where ξ indicates the lapse time, n indicates the number of neighbors available in neighbors table Tot_D_i, and $Level_i$ is the sum of delay.

3.3.1. Reply Data (RD) Module

The node sends a unicast message to the next selected node to test its functionality when a node is moved from its current location. Then the time (χ) determined by Eq.(4) for a statement is preserved. If no confirmation is provided, then the objective node will not be available. It might change its position or it would have faced sudden disappearance due to a very low battery. As needed, the information of a node is erased from its neighbor's table when it is not communicated back. $SN2$ is once again utilized for the next transmission to select another node. In any case, the current node starts sending a data packet to selected nodes if an affirmation is received.

Once the packet sending is fully completed, the receiver node will be converted into a new data-carrying medium with the appropriate node ID. When the carrier node has null errors and a neighboring table, the maintenance module will again start finding its new neighbors to continue the process

$$\chi = \frac{1}{n}\sum_{i=1}^{n}link\_delay_i \qquad (5)$$

Where χ indicates the time required to send an affirmation reply message, n represents the available number of neighbors in the table, $link_{delay_i}$ is the delay of connection to every neighbor.

3.4. Route Maintenance Stage (RMS)

The maintenance stage will remove any confusion that occurs when the data is replied to through the data response. Deception may occur if the neighbors of the node in a table do not respond. Then RMS will soon start replicating another table of neighbors. There is a single module named maintenance and the current neighbor table is replicated using $NREQ$ and $NREP$ messages.

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3.5. Route Classification

The proposed enhanced version of the relevant vector machine (ERVM) is a computational learning tool with robust variation inference for regression and classification issues. It uses a system of Bayesian model for training the algorithm so that it can get a small kernel. In addition, it can investigate any nonlinear relationship indirectly through the use of nonlinear functions for training results. By the proof method of conventional ERVM, the weight parameters were

determined. To determine the values of the model parameters, a validation set is required, however, and a significant number of interpretations may be necessary to select the appropriate model. This could also be insufficient for a MESVM, where data arrive sequentially as configuration changes arise in this situation frequently. In the current analysis, ERVM with a variable deduction system is created. The method suggested has a major benefit over the above studies, as it does not need testing to achieve successful generalization efficiency.
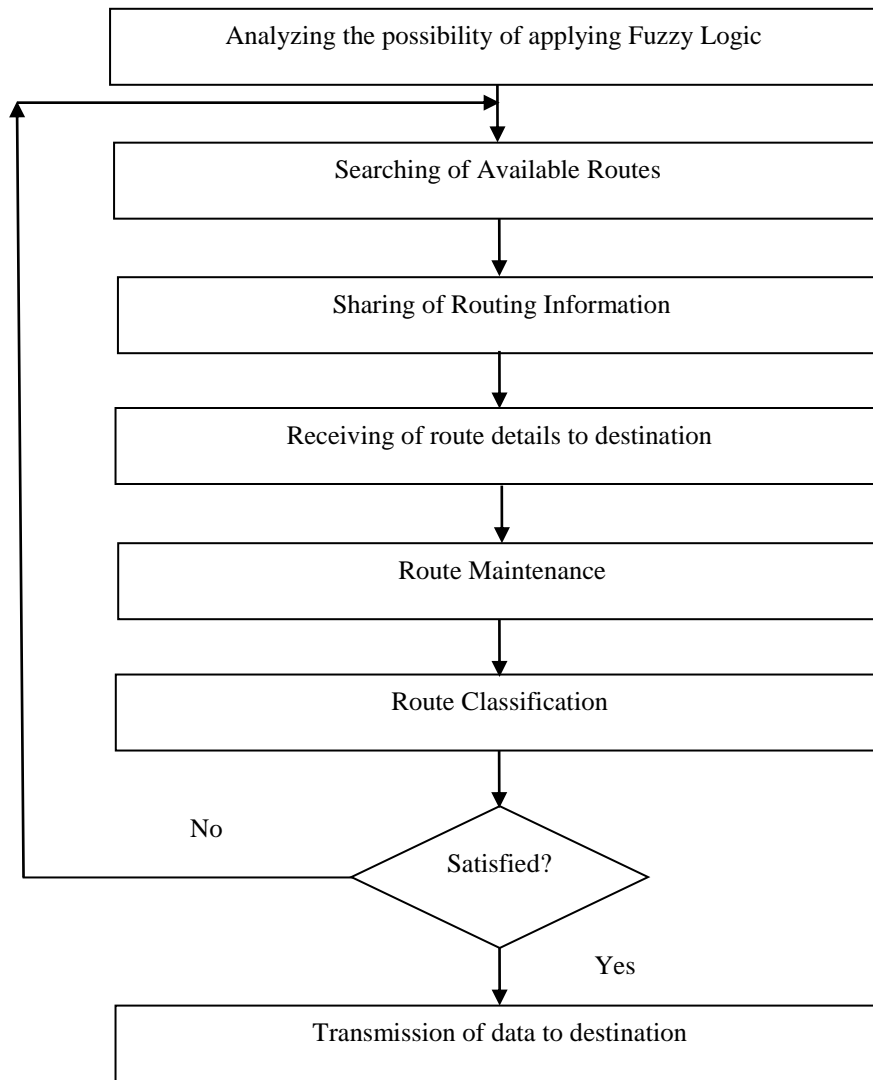

Figure 1 QARP Framework

Assume MEWSN usage details (MUD) having N pairs of input target $\{x_i, y_i\}_{i=1}^{N}$ and it has regression model based training for observation, where x_i indicates d dimensional input vector, and y_i denotes scalar output. In enhanced RVM,

an assumption is made for target values, i.e., target values have more noise/errors:

$$y_i = f(x_i, \beta) + \varepsilon_i \qquad (6)$$

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ε_i's are the samples with independent values derived from zero-mean Gaussian with the inverse variance γ. The main intention is to make an assumption using regression model $f(x_i; \beta)$ that have a good level of generalization ability by utilizing MUD. The regression model is normally described as a linear way of combining certain functions. It predicts $f(x; \beta)$ and express it in the term of N predetermined basis functions $\phi_i(x), i = 1, \dots, N$:

$$f(x; \beta) = \beta^T \phi(x) = \beta_0 + \sum_{i=1}^{N} \beta_i \phi_i(x) \qquad (7)$$

Vector $\beta = (\beta_0, \beta_1, \dots, \beta_N)^T$ indicates weight parameter model, β_0 represents the bias, and $\phi(x) = (1, \phi_1(x), \dots, \phi_N(x))^T$ denotes function vector. The two most admired basis functions are (i) polynomial kernel, (ii) Gaussian radial basis kernel.

In Eqn. (8) polynomial kernel is defined, d in Eqn. (3) indicates the parameter of polynomial degree

$$\phi_i(x) = (1 + \langle x, x_i \rangle)^d \qquad (8)$$

In Eqn.(9) Gaussian-Radial basis kernel is defined, σ in Eqn. (4) indicates the width parameter

$$\phi_i(x) = \exp\left\{ -\frac{(x - x_i)^T (x - x_i)}{\sigma} \right\} \qquad (9)$$

One of the important things to be noticed in Gaussian based noise model is it does not act robustly to outliers. Hence, if MUD is detected with outlying remarks, then Gaussian based noise model provides results that are fully inaccurate and unreliable. To handle this specific problem, ε_i' is considered as a noisy heteroscedastic variance $p(\varepsilon_i | w_i, \gamma) \sim N(0, (w_i, \gamma)^{-1})$. The w_i (i.e., weight) of outliers are estimated to be low enough to affect the regression model. However, the regression results can be impaired if these weights are wrongly calculated. Such weights are automatically calculated using a probabilistic approach in the Bayesian system during the training process.

In the observations, y_i is assumed to be more important, the likelihood of MUD is mathematically shown as:

$$p(y | \beta, w, \gamma) = 2\pi^{-\frac{N}{2}} \prod_{i=1}^{N} (w_i \gamma)^{\frac{1}{2}} \exp\left[-\frac{w_i \gamma}{2} \{ y_i - \beta^T \phi(x_i) \}^2 \right] \qquad (10)$$

Where $(y_1, \dots, y_N)^T$ and $(w_1, \dots, w_N)^T$ is represented as y and w. To make adopt the Bayesian methodology, this research work derives the below parameters to enhance the security measures.

$$p(\beta | \alpha) = \prod_{i=0}^{N} N(0, \alpha_i^{-1}) \qquad (11)$$

$$p(\alpha | A, B) \geq \prod_{i=0}^{N} Gamma(A, B) \qquad (12)$$

$$p(w | C, D) \leq \prod_{i=0}^{N} Gamma(C, D) \qquad (13)$$

For β (i.e., the regression parameter), we consider β have two hyperparameters α_i and β_i where both will be used to attain a lightweight regression model by determining the relevant level. Overall framework of QARP is provided in Figure 1.

4. PERFORMANCE METRICS AND SIMULATION SETTING

Parameter	Value	Unit
Number of runs	5	-
Number of nodes	50 to 250	Node
Node Speed	10	Meter/second
Queue size	50	packet
Simulation Area	1500 x 1500	Meter^2
Routing Protocols	IFLIP, PARP, QARP	-
Mobility Model	Random Way Point	-
Packet size	256	Byte
Transmission Range	250	Meter
Traffic Type	CBR	-
Initial Energy	10	Joules
Transmission Power Consumption	0.02	Joules
Receive power consumption	0.001	Joules
Simulation Time	60	seconds

Table 1 Simulation Settings

This research makes use of traditional metrics used in MEWSN to evaluate the proposed protocol QARP against IFLIP [33] and PARP [32]

✓ Throughput – Total packets transmitted from the source node to sink node in speculated time.

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- ✓ Delay – Time consumed by the data packet to reach the destination node.

- ✓ Packet Delivery Ratio – Data packets that are successfully received by the sink node.

- ✓ Energy Consumption – Consumption of power from the source node to the sink node during the data delivery.

- ✓ Network Lifetime – Saving of nodes energy to extend the lifetime of network.

NS2 is utilized to evaluate the performance of QARP against IFLIP [33] and PARP [32]. Settings used for the evaluation are provided in Table 1.

5.   RESULTS AND DISCUSSION

5.1. Throughput Analysis

In Figure 2, the x-axis is plotted with node count and the y-axis is plotted with throughput in percentage. Figure 2 compares the throughput of QARP against existing protocols IFLIP [33] and PARP [32]. The main intention of the existing routing protocol is to find the route but it does not concentrate on the quality and type of data to be sent on the route. Due to following the query-based route-finding mechanism, QARP optimizes its route searching and finds the exact route for the specific user's query and this makes QARP to attain better throughput. Table 2 provides the overall throughput in percentage.
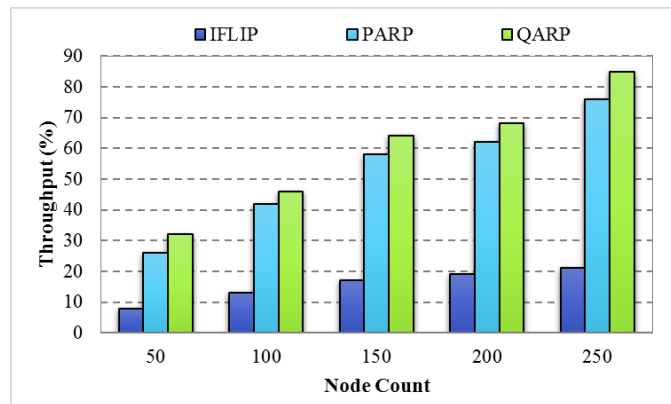

Figure 2 QARP vs Nodes

Metric \ Protocols	IFLIP (%)	PARP (%)	QARP (%)
Throughput	15.6	52.8	59

Table 2 Overall Throughput

5.2. Delay Analysis

In Figure 3, the x-axis is plotted with node count and the y-axis is plotted with delay in percentage. Figure 3 compares

the delay faced by QARP against existing protocols IFLIP [33] and PARP [32]. Existing protocols fail to gather neighbor node information inside the network and this increases delay while sending data each time. QARP gathers more information about a neighbor in the initial stage and this leads to a way to achieve low delay than existing routing protocols. Table 3 provides the overall delay in percentage.
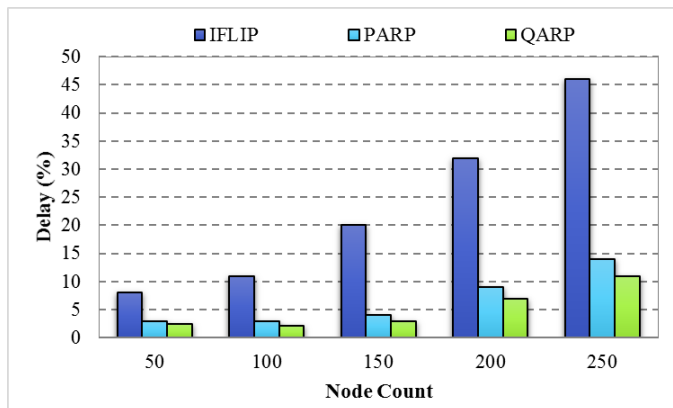

Figure 3 QARP vs Delay

Metric \ Protocols	IFLIP (%)	PARP (%)	QARP (%)
Delay	23.4	6.6	5.14

Table 3 Overall Delay
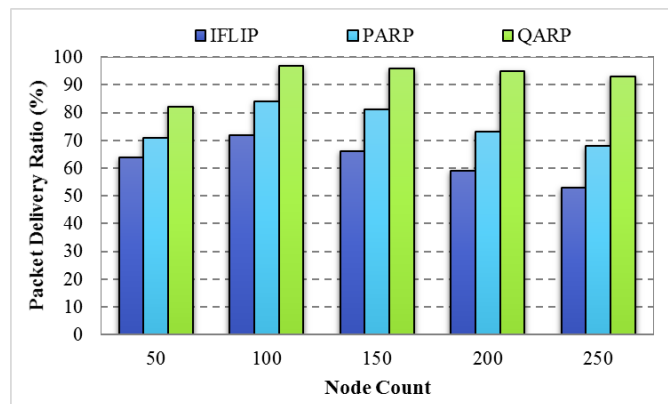
5.3. Packet Delivery Ratio Analysis

Figure 4 QARP vs Packet Delivery Ratio

In Figure 4, the x-axis is plotted with node count and the y-axis is plotted with the ratio of packet delivery. Figure 4 compares the delivery ratio of packets provided by QARP against existing protocols IFLIP [33] and PARP [32]. The utilization of fuzzy concepts in finding the route between source and destination makes QARP deliver a greater number of packets with a short duration. Existing routing protocols entirely depends on the routing table and this makes them

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deliver a lower number of packets. Table 4 provides the overall packet delivery ratio in percentage.

Metric \ Protocols	IFLIP (%)	PARP (%)	QARP (%)
Packet Delivery Ratio	62.8	75.4	92.6

Table 4 Overall Packet Delivery Ratio

5.4. Energy Consumption Analysis

In Figure 5, the x-axis is plotted with node count and the y-axis is plotted with consumption of energy. Figure 5 compares energy consumed by QARP against existing protocols IFLIP [33] and PARP [32]. Route maintenance and classification assist QARP to achieve low delay and it results in low consumption of energy to send and receive data. Due to simply sending the data in available routes existing routing protocols result in increased route failure which leads to more energy consumption to deliver the data. Table 5 provides the overall energy consumption in percentage.
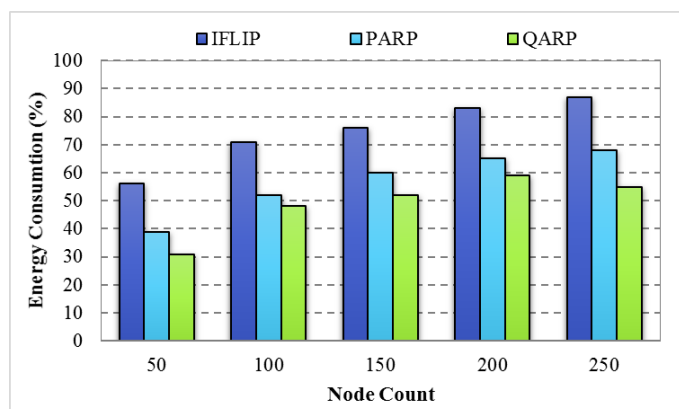

Figure 5 QARP vs Energy Consumption

Metric \ Protocols	IFLIP (%)	PARP (%)	QARP (%)
Energy Consumption	74.6	56.8	49

Table 5 Overall Energy Consumption

5.5. Network Lifetime

In Figure 6, the x-axis is plotted with node count and the y-axis is plotted with consumption of energy. Figure 6 compares energy consumed by QARP against existing protocols IFLIP [33] and PARP [32]. In QARP, Utilization fuzzy and better route classification leads a way to reduce delay which ends with increased network lifetime. Existing routing protocols lack poor route classification which leads to increased delay. It makes existing routing protocols to face a lower network lifetime than QARP. Table 6 provides the overall network lifetime in percentage.
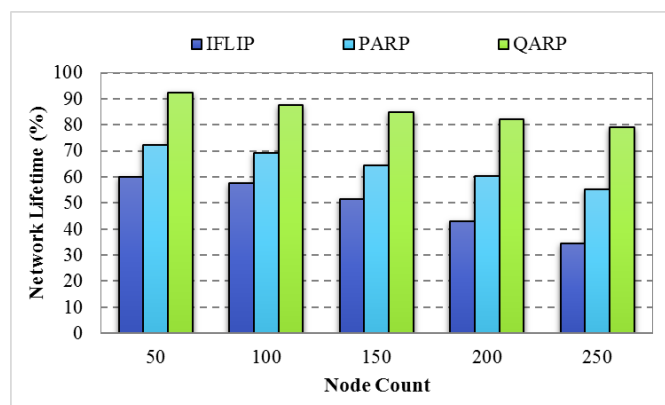

Figure 6 Network Lifetime

Metric \ Protocols	IFLIP (%)	PARP (%)	QARP (%)
Network Lifetime	49.332	64.298	85.208

Table 6 Overall Network Lifetime

6. CONCLUSION

This paper has proposed query aware routing protocol to avoid network congestion by the use of a fuzzy inference model. QARP scrutinizes 5 types of awareness, which are (a) node lifetime (b) delay time (c) shortest routing path, (d) overall cost for transmission of data and (v) classification. QARP follows three stages for better results which are (a) Route Searching Stage, (b) Information Supply Stage, (c) Route Maintenance Stage. QARP operates based on a query, so nodes in MEWSN sends messages in a free manner to all nodes. For the calculation of the performance of QARP with existing protocols namely PARP and IFLIP, the NS2 simulator is used. The results show that, for the packet delivery ratio, delay, packet delivery, and energy consumptions are better than others. Regarding the future aspects, this research work may be focused to use bio-inspired optimization algorithms for benchmarking results.

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