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QPR Based Power Optimization for Reliable and Software Defined Mobile Adhoc Networks

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Abstract - This paper puts forward routing protocol which is an optimized and energy-efficient routing protocol for ad hoc networks based on dynamic nature of forwarding to enhance network continuity and reduce packet loss. The proposed method effectively reduces route request propagation dispatches (RREQ), prolongs network continuity, and minimizes node residual energy usage to improve network performance and to reduce routing overhead compared to other standard protocols. The approach employs a method to estimate the failure of a link by using least square quadratic polynomial depending on signal level of data packets received, enabling a thorough analysis of link failure time estimation sensitivity with varying network parameters and compared with an interpolation-based approach.

Keywords: *QPR-based power optimization, RMN, Link failure, Routing overhead minimization*

I. Introduction

Routing data packets in a MANET presents various challenges and obstacles due to the topology which is changed dynamically and error-prone wireless channel. Some Issues such as centralized control unavailability, frequency of node movement, limited bandwidth in wireless network communication, and energy consumption [1] due to node mobility need to address. The main challenge in handling the wireless mediums with limited bandwidth and energy drainage is because of the mobility in the network [2]. AODV is a conventional protocol which uses a general flooding mechanism to identify the route to transmit the packets to all hops in its range from source. Each node has to check whether the node has taken this communication before. The conventional flooding system for route discovery in AODV leads to network congestion, redundancy, contention, and excessive power usage, known as the broadcast storm problem[3]. Our main moto in this work is to upgrade the performance in terms of overhead, energy consumption, and network throughput in routing protocols by contemporizing the forwarding probability. The routing protocol utilizes the mechanism of on-demand to discover the route and sequence number of the destinations to determine the most recent path, leading to efficient route establishment and reduced connection setup delay.

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II. Literature Review

The research study[4] underlines the significance of forwarding probability RREQ in the AODV, a traditional routing protocol designed to improve throughput and to reduce power consumption. AODV, a conventional routing protocol to minimize power consumption and enhance throughput. It examines the sensitivity of the AODV protocol concerning forwarding probability.

This study delves into the relationship between capacity of downlink and base station, also known as spectral efficiency or bandwidth efficiency. Analytical findings highlight that an optimal antenna down tilt can maximize the coverage for each and every base station [5].

Introducing FAF-EBRM, which is used to opt the next-hop node depending on connection cost and while incorporating a method of reestablishing the local network. Experiments reveal that FAF-EBRM (Forward Aware Factor based energy balanced routing approach) outperforms EEUC and LEACH in energy consumption balance, lifetime function, and ensuring better Quality of Service for Wireless Sensor Networks (WSN)[6].

Approximate Edge Computing IoT (AECIoT) architecture is presented as a solution for data stream in real time [7] in IoT. It utilizes a sampling technique for real-time data streams processing and produces highly accurate results even with limited resources like memory. Experimental findings demonstrate significant accuracy improvement compared to other sampling techniques.

UCNPD[5] is a novel routing protocol which is unique unequal clustering routing protocol is proposed for wireless sensor networks aiming to minimize energy consumption, prolong the lifetime of a network, and evenly distribute energy consumption among all nodes. Simulation outcomes illustrate the protocol's success in achieving these objectives.

Priority Based Neighbor Following Technique and Passive Multi-Hop Clustering (PMC)[16]

The study introduces a technique used to identify the neighbor based on the priority and PMC to ensure the stability and coverage of the cluster. PMC focuses on opting ideal neighbor nodes to join the same cluster during the selecting phase of cluster head.

In VANET, the network topology configuration is highly variable because of the unpredictable communication links resulting from vehicle movement. This unique characteristic positions VANET as a distinct case of mobile ad hoc networks (MANET). To ensure stable network connections amidst dynamic vehicle movement and address diverse quality of service (QoS) application requirements, “a reliable and self-adaptive routing algorithm (RSAR)” which will work based on a service has been proposed[8]. Tailored specifically for VANET, the RSAR effectively integrates the reliability parameter and modifies the heuristic function to enhance network performance. Additionally, a novel OLSR protocol for MANET, known as QG-OLSR, has been introduced. It leverages the OLSR and Q-learning algorithms to optimize the of multipoint relay (MPR) selection sets. This integration aims to reduce topology control overhead, enhance the rate of data packet delivery, and minimize end-to-end packet transmission delays among the nodes [10].

Introducing a personalized approach [11], the Siamese-response-deep factorization[13] machines (SRDFM) network, based on deep learning, offers a promising avenue for recommending personalized anticancer treatments. This system directly ranks drugs and identifies the most effective ones, demonstrating its potential in both single-drug and synergistic drug scenarios.

Furthermore, the focus of research has been on the Internet of vehicles (IoV) (12), resulting in the development of a offloading system (dynamically done) based on deep reinforcement learning. This innovative approach outperforms conventional methods under varying payloads and bandwidth of channel, showcasing an improvements in terms of usage of energy, overhead and delay,. Aiming to optimize multiuser fine-grained offloading scheduling for the Internet of Things (IoT), an improved NSGA-II algorithm has been proposed to efficiently manage computation tasks by achieving edge and local parallel processing. This approach significantly reduces delay and energy usage, offering potential energy savings of 10 to 50% compared to traditional methods.

In the domain of network protocols, innovative strategies have emerged to address the challenges of vehicle mobility and link quality prediction (13,14). These include a hybrid algorithm combining cellular automata (15) and “African buffalo optimization” to find the optimal path and link-defined OLSR (LD-OLSR) protocol emphasizing link quality, and a routing strategy known as Mobility-Contention-window and Link quality-multipath Routing (MCLMR) (16) to account for node mobility and link quality for optimal route selection.

Researchers have proposed mathematical techniques based on regression to identify link failure using signal level, as well as zone-based route discovery mechanisms (18) and reliable energy and link-based routing protocols (19). These efforts aim to enhance the robustness and efficiency of ad hoc network operations (17).

III. Methodology

The utilization of a hybrid broadcasting method integrates neighbor knowledge and probability approaches to achieve efficient flooding with a tone-pruning and probabilistic scheme. This approach leverages the benefits of both strategies, drawing on their strengths to optimize network performance in various scenarios.

Computation of Uncovered Nodes - In this phase of computation, the source node (Xs) dispatches RREQ packets to be reached to central nodes. Node Xi, a central node, utilizes the RREQ packet from Xs to calculate the set of its uncovered neighbors, denoted as UN(i).

The set UN(i) is determined using the following formula:

$$UN(i) = X(i) - [X(i) \cap X(s)][12] \text{--------}(1)$$

Here, X(i) and X(s) represent the neighbor sets for nodes Ni and Ns, respectively. We can observe in how broadcasting(RREQ) will be done from source to destination via neighboring nodes in Figure 1.

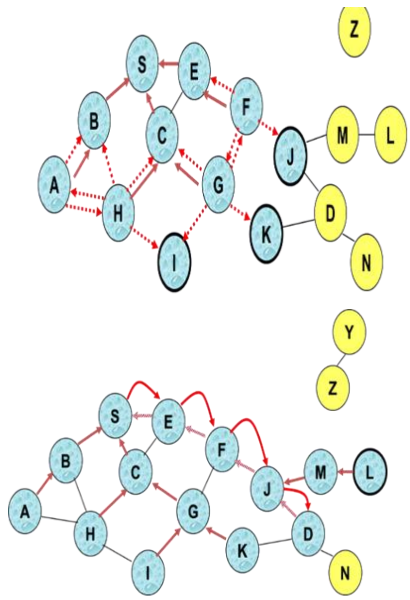

Figure 1: Forward Path setup in standard method

Describing the Proposed Algorithm- In general routing process, route requests are broadcasted to every node. However, in our approach proposed, only elected nodes broadcast the RREQ. This optimized and effective AODV routing protocol employs dynamic forwarding, introducing parameters defined as follows [20]:

Total nodes in the network – N

Node receives RREQ packet - ni, where i = 1,2,3,...n

Packet forwarding probability - Pi

Number of neighboring nodes - qi

Random number of varying conditions of network – R

Uncovered neighbors set of nodes ni – U(n-i)

We utilize a hybrid broadcasting technique by combining two algorithms [20]. The proposed algorithm will process RREQ message in the following manner where the nodes are ni, i = 1, 2, 3, . . ., n.

When a node ni processes the RREQ message initiated from source node A and destined to node B, and if ni ≠ A and B, it computes the neighbors set which are uncovered (UN {n-i}), following the formula:

$$UN\{n-i\} = X(ni) - [\ (X\ ni) \cap X(s)] \text{ --- } (2)$$

The intermediary node assesses its density of neighbor node pi. If the set is empty for uncovered nodes who are neighbors(UN), the intermediary node abstains from forwarding the packet (to be broadcasted) to its neighboring node.

If UN{n-i} ≤ D, the node forwards the RREQ packet; otherwise, it calculates the probability of message forwarding which is represented by Pi at the node Xi.

Figure 2 illustrates the communication path from the source (A) to the destination node(B), showcasing process for message transmission and reception of RREQ.

1. *Start*
2. *Source node (N_s) initiate the RREQ*
3. *The intermediate node receives the RREQ and compute the uncovered neighbor set (U_i)*
4. *If $U_i < D$*
    a. *Forward RRED*
    b. *end*
5. *else*
6. *calculate (Pi) forwarding probability to generate random number(R)*
    a. *if R< P_i goto step 4 (a) else Drop RREQ*

Figure 2: Communication path establishment from source node to destination

IV. Evaluation

After system implementation, performance testing is essential. The data extracted from trace files is processed to determine the necessary parameters.

Simulation Parameter Setup - To conduct simulation and outcome analysis, the setting of simulation parameters must be determined.

Table 1 outlines the aggregated simulation parameters.

Simulation Parameter	Metric
Time (Simulation)	300 Seconds
Number of Nodes	40, 60, 80, 100, 200
Size of Packet	512 Bytes
Mobility	Upto 50 meter/sec
Area	2500 * 2500 m
Packet rate	5 – 10 per Second

i. Performance Evaluation Metrics

In evaluating routing protocols, various quantitative metrics are utilized [21]. Our research study employs three key performance parameters to evaluate routing protocols:

Throughput: Used to measure the speed at which packets can be sent.

Avg. Throughput = (No. of Received Bytes * 8) / (Time required for Simulation * 1000 kbps) ---(4)

Energy – It plays a critical role in communications to prioritize energy efficiency. The initial energy for the node is determined by the energy level of a node at the time of initiation of simulation. The "energy" variable in the simulation indicates the current node's energy level.

Routing Overhead - The quantity of packets (control or data packets) dispatched for an intended recipient to every data packet. Routing overhead encompasses all the packets forwarded at the n/w layer and corresponds to the how many number of packets required for communication across a network.

Routing Overhead = No. of RTR packets / Data packets. (5)

4.2. Simulation Results

Effect of Mobility - The duration of the pause was adjusted from 0 to 100 seconds (from high to low based on mobility) in order to investigate mobility effects. The maximum number of connections fixed are set to 20 and the 40. Evaluate mobility influence on three performance metrics for the AODVE, protocol proposed along with AODV.

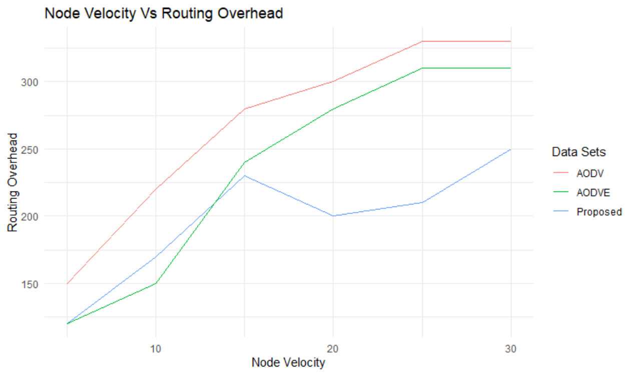

Figure 3 Routing Overhead Vs Node Density

Figure 3 illustrates that the proposed algorithm exhibits the least overhead packets compared to AODV and AODVE. This is attributed to simultaneous packet transfers enabled by a limited range of carrier sensing, along with the alternatively available routes when route failures occurs due to improved mobility of a node. However, in AODV, AODVE, and in the proposed schemes, routing overhead of packets may increase with an increase in a node velocity, leading to higher path unavailability for rapidly moving nodes. Consequently, the overheads of the latest path discovery contribute to an increase in routing overhead for packets.

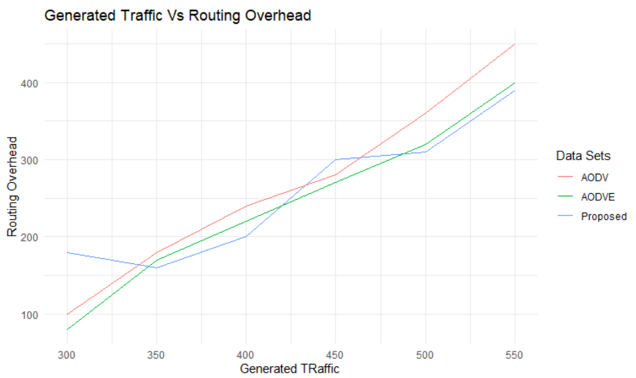

Figure 4 : Generated Traffic Vs Routing Overhead

The proposed approach generates the less overhead for packets when compared to AODV and AODVE schemes because of simultaneous transmission, less power for transmission, and proactively discovered route prior to failure of a link, thereby packet retransmission has to be minimized. In AODV, AODVE, and the proposed scheme, routing overhead packets increase with a growing number of generated data packets, leading to heightened contention and collisions.

Throughput - The suggested algorithm increases throughput at high and low mobility levels by allowing the node to transmit packet to the destination while minimizing the multiple rebroadcasts of RREQ and dropped packets.

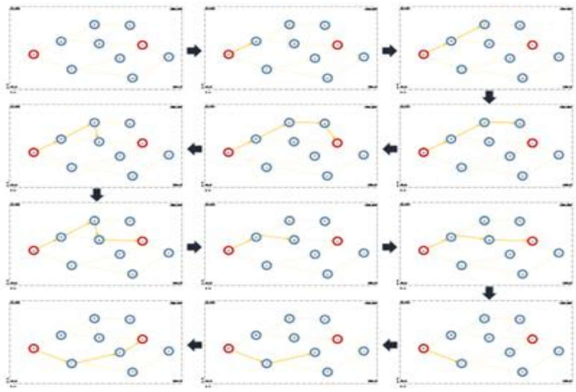

Figure 5: Route Establishment process from source to final node

Figure 6 showcases a comparison of the throughput of AODV, AODVE, and proposed protocols, indicating that the proposed algorithm attains maximum throughput compared to AODV and AODVE schemes due to its utilization of a smaller carrier sensing range, allowing a large number of nodes to transmit simultaneously. Additionally, we can observe from results that throughput is higher in AODVE when compared to AODV.

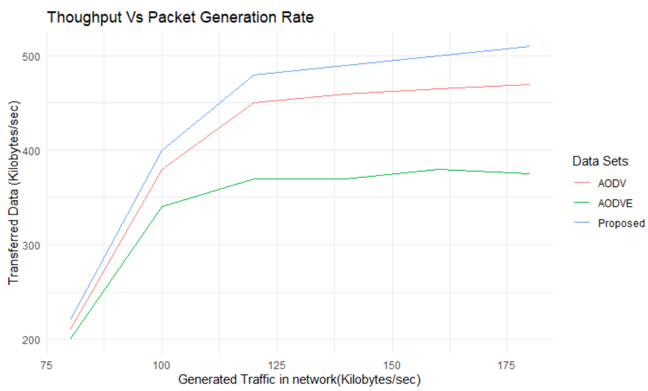

Figure 6: Transferred Data Vs Generated Traffic

The proposed algorithm yields increasing throughput as the packet generation rate increases until it saturates, indicating a higher throughput as more data is transmitted with reduced energy consumption.

Energy. The proposed algorithm uses less power for both transmitting and receiving, which boosts remaining energy by 8.97%, 6.27%, 8.05%, 6.33% for pause times 0, 30, 50, 100 respectively when compared to AODVE and AODV. Importantly, the power used during idle periods was not factored into the simulation. This algorithm selectively forwards messages to a portion of the network's neighbors based on their density, resulting in reduced energy consumption for transmission and reception. This conservation of battery power effectively doubles the network's lifetime.

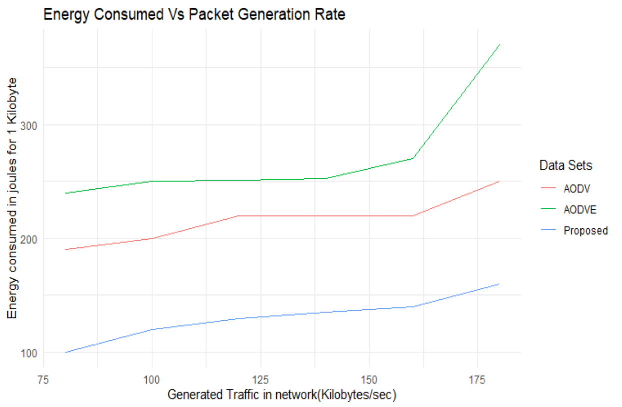

Figure 7: Generated Traffic Vs Energy Consumed

Figure 7 illustrates the variation in consumed power per one conversation which is successful with an increase in packet generation rate. The figure demonstrates the proposed scheme exhibits the lowest power consumption per successful communication compared to AODV and AODVE. The proposed scheme also proves to be the least power-consuming among different schemes, as it utilizes reduced power for communicating RTS, CTS, DATA, and ACK packets, with higher link successes and fewer packet retransmissions. However, as network load increases, the average consumption of energy in the proposed scheme, AODV, AODVE also increases due to the generation of extra packets and contention within the network, leading to higher energy consumption in the successful transmission of these packets.

5. Conclusion

The proposed algorithm simplified the route acquisition process with the help of neighbor knowledge discovery and reduced the power consumption to improve the quality of route to avoid the unwanted multiple retransmissions.

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