

A HOP-COUNT AND NODE ENERGY BASED MANET ROUTING PROTOCOL

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ABSTRACT

Mobile ad hoc network is a self-configuring network in which all participating nodes are mobile and consist of limited channel bandwidth and energy. Mobile devices are battery operated, and energy efficiency is a major issue for battery-operated devices in mobile ad hoc networks. Routing data packets from source to destination is the challenging task in mobile ad hoc networks due to node mobility and dynamic topology change in the network. Link failure or node energy depletion causes re-routing and establishing a new route from the source node to destination node which consumes extra node energy, reduces connectivity of the network and early partition of the network. Energy-related parameters consideration in routing is an important solution to enhance network lifetime. Several better performing routing schemes are presented and implemented for MANETs. Ad-hoc On-demand Distance Vector (AODV) routing protocol is one which performs well among similar routing protocols for MANET. AODV route selection base on either lowest hop-count or fresh sequence number. Many enhancements to AODV are proposed, which represents a better performance in comparison with original protocol. However, in a large network different paths to the destination could be found with the same hop-count. When efficiency is deliberated for those paths in quickly data transmission, each path performance varies in terms of throughput, end-to-end delay and packet delivery ratio due to the mobility of the nodes in the network. AODV routing protocol and enhancements suggested by other researchers do not give attention to such cases, and this paper proposes Hop-count and Node Energy based Routing Protocol (HNERP) which uses a multi-function routing strategy that incorporates with hop-count and node energy while making the routing decision. The proposed protocol is simulated by using NS2 and results show that HNERP performs better in term of packet delivery ratio and throughput, moreover it increases network lifetime and reduces end-to-end delay.

Keywords: *Hop-count, Node Energy, Route Selection, Link failure, Network Lifetime*

1. INTRODUCTION

Collection of independent nodes form the mobile ad hoc networks (MANETs), while mobile nodes function as a router for forwarding data packets for other nodes in the network towards their destination node without using infrastructure services [1-3]. MANETs are mostly used by disaster management, military rescue operations, personal area network and numerous important applications where there is no fixed infrastructure. Due to dynamic change in the topology and there is no centralized administration routing data packet is the

most significant task in MANET [4-6]. Figure 1 shows a mobile ad hoc network scenario in which all the nodes are mobile and free to connect any node in its range. There is no centralized administration for route discovery and maintenance is done by nodes themselves. Therefore, the absence of fixed infrastructure, unstable links, dynamic change in the topology and limited resources of energy are special design characteristics of mobile ad hoc networks [7-10].

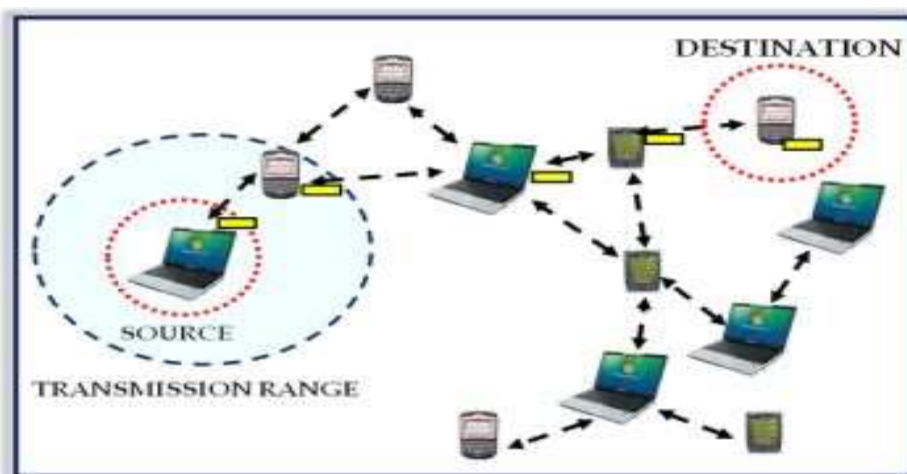


Figure 1: Mobile Ad Hoc Network [11]

The main challenge in mobile ad hoc network is the limited energy of mobile nodes. Each mobile node operated by the limited energy of battery and it is not possible to replace or change batteries during in mission-critical situation like emergency relief operations and battlefields [12-15]. Since MANET nodes act both as a host and router and mobile node mostly depend on other neighbour nodes to forward their data packets, therefore a few nodes failure due to energy depletion causes link failure and disruption of the network services [16, 17].

We address the problems faced by the existing energy efficient routing protocols in pursuit of providing reliable data delivery which limits the overall throughput, route stability and network lifetime. The standard routing protocol cannot implement due to their incapability to counter nodes energy levels and energy efficient route selection. Recently, energy efficient routing protocols have demonstrated to be more appealing to deal with node energy depletion. However, most of the current energy efficient routing protocols exhibit weaknesses when comes to handle node energy levels due to the adopted methodology which results in imprecise decision making. Also, existing schemes lack in early link failure detection in an ongoing communication which occurs in re-route searching process and creates delays in the network. Furthermore, the majority of the energy efficient routing schemes exclusively focus on selecting better routes whereas route optimization from source to destination is not considered by keeping in view significant features of MANET like limited energy resources of mobile nodes, path length and wireless interference. Therefore, it leads to inappropriate

route selection having a high probability of route failure and dead nodes which reduces route stability and network lifetime. Energy efficient multi-hop algorithm is essential for routing in MANET for data transmission from source to destination. Source initiated AODV algorithm is used in shortest path selection, and recurrent selection of specific nodes in shortest path selection consumes the energy of those nodes quickly than other nodes. Therefore, node residual energy is a compulsory factor in route selection process. Thus, energy efficient routing algorithm is needed to handle the problems mentioned above in MANET.

In this paper, we presented an enhancement in AODV routing protocol and proposed a new Hop-count and Node Energy based Routing Protocol (HNERP) for MANET that addresses the abovementioned limitations. HNERP uses hop-count and node energy as a combined routing function for energy efficient route selection in route discovery which enhances the lifetime of the network by avoiding to send data packets through nodes with low energy levels and balance the energy consumption among all nodes in the network. HNERP objective is to conserve mobile node energy which is very important for the MANET survival. Using HNERP only node which has higher energy levels are selected for routing data packets. Simulation result obtained from NS-2 shows that HNERP reveals better performance in term of network lifetime, packet delivery ratio and throughput while it reduces end-to-end delay as compared to AODV routing protocol.

The rest of the paper is ordered as follows: Section 2 deliberates the existing energy efficient

routing solutions for mobile ad hoc networks. Section 3 represents our propose HNERP scheme in details. Section 4 shows the method used in HNERP scheme design. Performance evaluation by using network simulator is presented in section 5. Finally, in section 6 conclusion of this paper is elaborated.

2. LITERATURE REVIEW

Several energy-aware routing protocols have been suggested by researchers for the mobile ad-hoc network. P. Jain and Suryavanshi [18] proposed multicast in AODV protocol with maximum energy local route repair (AODV-LRR), for link breakage it uses local route repair technique. In addition, it repairs the route in case of energy depletion of the node from the same point where the breakage occurs deprived of informing sender node. It follows two phases, firstly it chooses the path and delivers the data packets to the right node in the destination. Intermediate node selection by sender node is done on the basis of greater energy levels of neighbour node among other nodes in the network. Therefore, it always selects the nodes which have higher energy levels in route selection. In the second phase if any link breakage due to node mobility or energy reduction it reconstructs route by using local route repair technique from the point where it was broken. However, there is no provision for multiple link breakage at the same in AODV-LRR. Moreover, it compares route energy levels for better route selection which devours energy and creates delays. In addition, there is no route breakage information is sent to sender node which introduces packet error.

Another scheme Enhanced AODV is suggested by Nishanthini, et al. [19] in first step it calculates total nodes and actual power of those nodes in the route, later on if any path or link failure is found it checks for number of hops data so far travelled and remaining number of hops to reach the destination. In addition, an alternate data path is utilized for improving data delivery ratio. However, there is no mechanism in Enhanced AODV to deal with error as there is reporting for nodes in error also it calculates hops and node energy in path selection and in high mobility network model it creates the delay.

To reduce link failure a method is suggested by Fadaly, et al. [20] to repair a link through preventative local route repair in basic AODV scheme. Node residual energy is compared in Modified AODV scheme by two different values of

threshold which provides information about link failure and type of operation. After checking the certain level of node residual energy, it will provide information of insufficient node energy to stop sending data packets from the specified node it is done by modifying route request and route reply data packets. However, this scheme performs an extra procedure of node remaining energy comparison with two different threshold values which produces the delay in case of nodes are in high mobility. Moreover, there is no mechanism to deal with node error recommendations.

A threshold power value is used to route the data packet in modified AODV (MAODV) by D. Sharma, et al. [21] and proposed enhancement in AODV protocol RREP phase whereas, RREQ process is similar to AODV scheme. In the initial phase, the intermediate node with least distance will get a reply from the node in the destination. Afterwards, a threshold value is compared with all nodes in case of power limitation of any node RREP packet will be denied for acknowledgement, for nodes with limited power second lowest minimum distance will be used for selection of a different route for packet forwarding. In addition, the distance between nodes is maintained for all routes. The distance between neighbours is checked as long as the first RREP sent by the destination node. If in a fixed time it receives an acknowledgement message from a node which shows its power level is higher than the value used for threshold, else node in the destination will search the backup route in the routing table and selects the second minimum distance from remaining nodes. However, MAODV spends more time to calculate the least distance in route reply process which introduces delays. Also, the distance between nodes it maintained to find minimum distance neighbour node that is not suitable in case of high mobility of nodes. In addition, it selects only one route in the event of more than two nodes to have equal energy level for data forwarding which will drain specific nodes in the selected path quickly which decreases the lifetime of the network.

An enchantment in AODV protocol Enhanced Receiver Based AODV (ERB_AODV) is proposed by Abdulaziz Al-Nahari, et al. [22]. This scheme works in two different stages discovery and maintenance stage. In the first stage, sender node checks its routing table for existing route to the destination if no route is available then it broadcasts the control packet towards sender node in search of a path to the receiver node. Moreover, it minimizes

the control overhead by using broadcast control packet in route search in maintenance stage which reduces overhead when nodes are in high mobility and load. Furthermore, it uses the receiver control agent, so that receiver node controls communication status in the maintenance stage. However, ERB_AODV route discovery process takes longer time which creates network overhead. In addition, there is no consideration for quality of a link while selecting an intermediate node and due to variable link nature breaks the link significantly which increases retransmission of data packet, and it consumes more energy.

Better route selection and route repair is proposed by S. Liu, et al. [23] and named it B-AODV. Reverse route request BRREQ is used in this scheme in case of RREP for searching routes. B-RREQ is used as a control message for reverse route establishment. At first occurrence of B-RREQ node in source saves next hop information and data transfer starts. However, in B-RREQ routing table is updated for each B-RREQ and RREQ information which requires more energy and produces network delay. Moreover, it does not share link breakage information from sender node which creates packet transmission error.

R. Kumar, et al. [24] recommended AODV-EER (end-to-end reliable AODV) route reliability in AODV from the source node to destination node. This scheme selects a path to the destination with the minimum rate of packet dropping. If there is a breakage in the data path of the primary route, then a mechanism called backwards route entry initiates, and it increases the route stability by selecting the more stable path for sending data from source node to destination node. In the beginning, it chooses a path with those nodes which have stable links as a substitute for hop-by-hop selection. Therefore, it degrades the link breakage probabilities and failure of the network. In addition to this, node end-to-end reliability is prioritized in the selection of primary routes with high consistency. It adds extra fields in the data packet (BRR) Backward_Reliable_Route, and the other one is (BID) Backward_ID. Node address is kept by the BID for standby path to the destination while BRR keeps tracks on route consistency to the destination node from the node of the BID. In case of any route, breakage occurs between nodes, the secondary route is checked for substitution of the broken link. BID data is searched by that node in the event of no substitute route found. However, there is no solution for error in AODV-EER as it does not provide any technique to deal with

notification of error from nodes. Moreover, reliable rates of hops are used, and it selects routes which are the more reliable rate, while computation of reliability rate consumes energy and it causes the source to destination delay when nodes are in high mobility. Furthermore, it does not provide any mechanism for tracking link breakage, and there is no update for link quality.

Limitation of Reverse AODV (R-AODV) scheme is considered by Mohapatra, et al. [25] and proposed (SEAR-AODV) Stability and Energy Aware Reverse AODV scheme. It considers node reliability factor which contains energy and route stability as a metric. It selects a primary path for the route with higher reliability factor for data sending, and a secondary route is selected on the basis of next high-reliability factor. In addition, packets like R-RREQ and RREQ are broadcasted to source node as well as destination node to reduce route maintenance process. However, this scheme uses R-RREQ and RREQ broadcast which produces more overhead and energy consumption which creates the delay in data transmission. Moreover, the weaker signal of intermediate nodes is checked for each time to verify path available in the routing table. Furthermore, there is no method provided to deal with transient link failures due to nodes congestion and other causes of link failure notifications. Table 1 deliberates the summary and provides a comparison of discussed routing schemes. Associated parameters like detection mechanism of path breakage, maintenance of route, frequency to discover route, overheads of routing and stability of routes.

Locally route repair method is used to repair link breakage in mostly proposed routing schemes. However, traditional route maintenance mechanism which produces more and more route discoveries. Moreover, to detect link breakage link-layer base or Hello-based method is considered. Furthermore, default Hello-based method is deliberated in most of the on-demand routing schemes which are more susceptible for notifications of link failure and constantly states about broken link in the network without considering disruption of transmission due to link congestion.

Some researchers propose different ways to deal with efficiency enhancement Tyagi *et al.* (2016) suggested honey bee mating optimization while [10, 19, 26-29] work on node energy level and comparing it with some threshold value for selecting nodes but it suffers when nodes are in high mobility. Moreover, most of the energy efficient schemes

focus on knowledge of neighbour node energy levels and residual energy levels of intermediate nodes [1, 20, 30-32]. However, these schemes use long calculation for node energy values for selecting it for the most suitable route which creates network delay and consumes more energy.

Other researchers work on delay, route change and reply methods [9, 13, 27, 33-37] to find the most efficient route for reliable data packet forwarding, but they rely on past observations regarding forwarding data packet behavior to the mobile nodes and overlook predictable impending performance of nodes. However, most of the existing approaches [1, 2, 7, 15, 38-43] do not focus on source to destination packet delay across the network keeping in view the resource limitations of MANET. Instead, these schemes only emphasis on choosing optimal route regardless of their link quality and reliability which destabilizes the energy conservation goal in designing of energy efficient routing protocol. Therefore further investigation is needed.

To propose a new energy-aware routing protocol is the main contribution of this paper that incorporates with energy aware concept in routing protocol design which prolongs network lifetime and provides reliable data delivery from source to destination. The suggested protocol does not use more constraints and utilizes fewer resources, due to this it is more appropriate for resource constraints network environments. These features make Hop-count and Node Energy based Routing Protocol (HNERP) a suitable choice for application in MANET in comparison with existing schemes.

3. THE PROPOSED HNERP SCHEME

This section illustrates the details of proposed Hop-count and Node Energy based Routing Protocol (HNERP). Before discussing design facts of HNERP, certain assumptions used in the protocol design are elaborated first.

3.1 Assumptions for HNERP Scheme

Hop-count and Node Energy based Routing Protocol (HNERP) is developed with following fundamental assumptions:-

- i. Nodes are not added or removed from the network after initial deployment.
- ii. All nodes use the shared bidirectional wireless channel for data communication.
- iii. Same signal attenuation is used for communication between two nodes.

- iv. All nodes distribute arbitrarily position, movement and initial energy.
- v. Link layer of the node is used to read energy information of that node through the physical interface, and it is capable of response network layer.

3.2 Proposed Scheme Design

The design of HNERP contributes energy balancing between nodes, energy efficient route selection, node energy monitor and efficient route maintenance. HNERP uses those mobile nodes in route selection which have higher energy levels, and it ensures that the selected route from source to the destination node is the shortest route for data transfer. A Combined Routing Function (CRF) uses Hop counts and node energy as a weight which is implemented as a metric. Node remaining energy and Hop counts are sum up and considered as a weight to find out the CRF cost.

3.3 Route Discovery in Proposed Scheme

Hop-count and Node Energy based Routing Protocol (HNERP) customizes the control packets RREQ and RREP of AODV routing protocol for selection of shortest as well as energy efficient route for sending data from source to destination. Nodes with greater residual energy levels from fix threshold value will be selected for route the data packet. Moreover, by choosing the shortest path with higher energy level nodes allows HNERP to utilize few nodes in data transmission which minimizes overall energy consumption. For illustration, only those nodes are added by upstream nodes which have greater energy levels. Consequently, in case of lack of energy level of a specific node will ignore RREQ packet in route discovery process. A network scenario is demonstrated in Figure 2, where node *a* is source node and *d* is destination node. Only nodes with higher energy levels are selected from the source node *a* to make energy efficient route towards destination node *d* for sending data. Initially RREQ

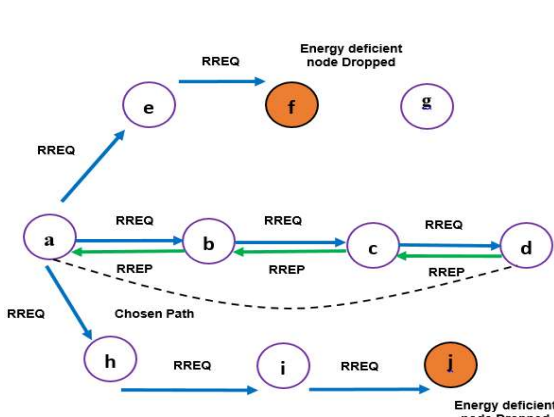


Figure 2: HNERP Route Setup Process

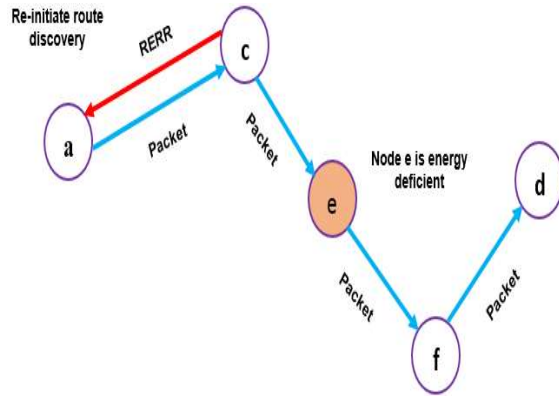


Figure 3: HNERP Route Maintenance Process

broadcasted to all nodes which are in neighborhood of source node *a*, later on the energy levels of nodes are compared with fix threshold value and if it is found less than RREQ packet will be discarded from that node as node *j*, moreover there will be no participation from that in data communication, otherwise RREQ packet will further forwarded to neighbour node and it marks a reserve route entry for the source node *a*. This process repeats until the node in the destination will receive the RREQ packet. Node *d* unicast the RREP packet towards source node *a* with reverse route. Source node *a* selects route *a* → *b* → *c* → *d* by using HNERP mechanism, as the chosen route is shortest as well as energy aware.

3.4 Route Maintenance in Proposed Scheme

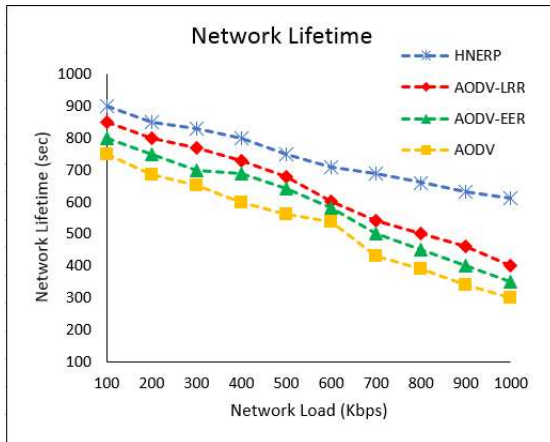
HNERP scheme uses an efficient Route Maintenance strategy that enhances the intermediate node role for power-aware route maintenance. Moreover, in case of any node energy is less than the specified threshold in an ongoing communication then HNERP restarts route discovery phase and informs upstream node for new route by eliminating energy depletion node. Figure 3 explains the situation where node *c* reports the condition $R.E < Th$ fulfils for node *e* and reflects that node *e* is energy depletion node in the routing path then node *a* sends RERR message to the source node for a new path search. Figure 4 represents the flowchart of proposed HNERP scheme route discovery process.

4. RESEARCH METHOD

NS-2 simulator [44] has been used in this study to evaluate the proposed HNERP scheme performance. Randomly allocated 10 to 100 wireless nodes are used in a Mobile Ad hoc Network for simulation environment. While network scenario utilizes random waypoint model and node mobility. The flat area of 1200 by 1200 square meter is considered for this simulation. The maximum speed of node is 10 m/s whereas minimum speed is zero m/s. Pause time is 2 seconds while 512 bytes of data payload for traffic generation. The range for transmission of nodes is 250-meter power range. IEEE 802.11 is considered for Medium Access Control. Each node energy utilization threshold value is fixed 50 joules out of 60 joules. Simulation parameters selected by default for proposed scheme are presented in this section, and their summary is in Table 2.

5. RESULTS AND DISCUSSION

Comparative results of network lifetime for HNERP, AODV-LRR, AODV-LRR and AODV protocol is represented in Figure 5. Average consumption of energy found to increase with the increment of network size.



Therefore, it decreases network lifetime. However, propose HNERP scheme sustains

Figure 5: HNERP Performance Comparison for Network Lifetime

Simulation results for an end-to-end delay are represented in Figure 7. All the routing schemes show same performance at few nodes in the network due to less network interference.

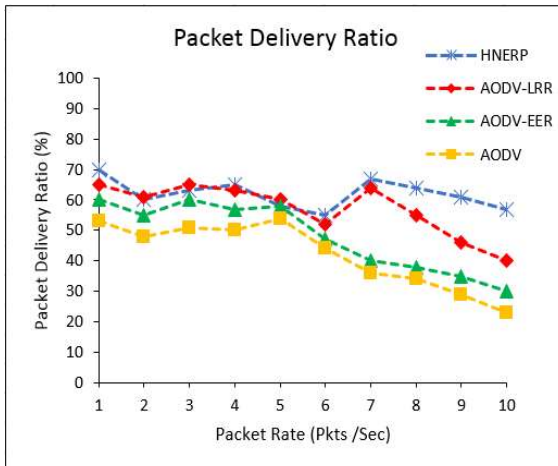


Figure 6: HNERP Performance Comparison for Packet Delivery Ratio

End-to-end delay increases remarkably with increment in a number of nodes in the network, as a result of more congestion and network load.

relatively better performance of network lifetime as a result of selecting a route which has energy efficient nodes. This is necessary to avoid only node selection on the basis of the shortest path which drains those nodes energy quickly or nodes become selfish for saving their energy resources. In addition, energy consumption is balanced between nodes by eliminating energy depletion node in route selection. Whereas, AODV-LRR, AODV-LRR and AODV protocols do not have any mechanism to check node remaining energy for balancing energy levels between nodes and uses those nodes in an active communication until end of their energy level. Therefore, it is clear from the simulation result in Figure 6 that proposed HNERP scheme performs better at packet delivery ratio in comparison with existing routing protocols.

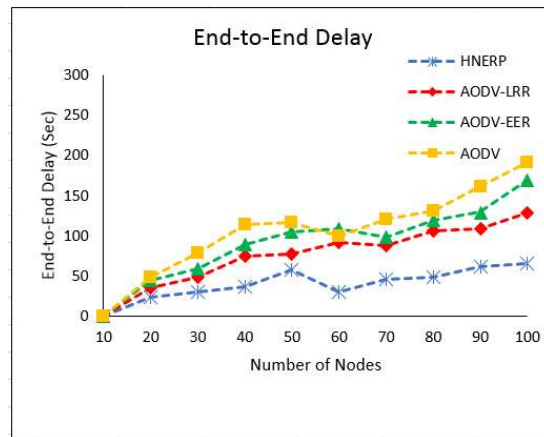


Figure 7: HNERP Performance Comparison for End-to-End Delay

Existing AODV-LRR, AODV-LRR and AODV routing schemes use conventional route maintenance method which does not consider node energy in route selection process and consequently increase route instability. Whereas, HNERP ensure that if there is an existence of energy deficient node in an active route it immediately sends early link failure report to the source node for broken link repair from energy efficient nodes and uses the shortest route from source to destination. Subsequently, link breakage and frequency of route discovery is minimized in HNERP, and end-to-end delay is reduced. Figure 8 shows the throughput performance of HNERP scheme with variant node number in contrast with AODV-LRR, AODV-LRR and AODV routing schemes.

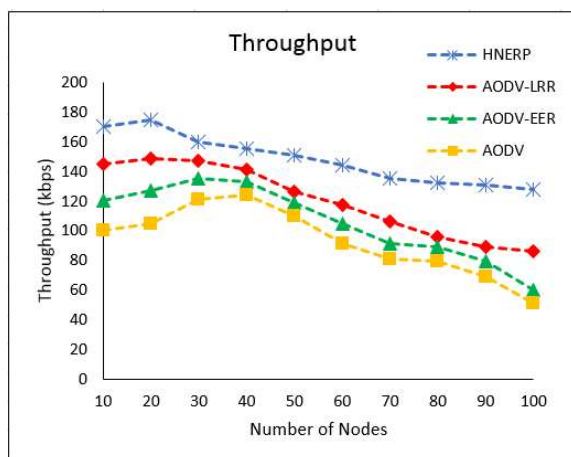


Figure 8: HNERP Performance Comparison for Throughput

All schemes show enhancement in performance with increasing nodes from 10 to 25 in the network due to load sharing for packet forwarding between nodes. However, more nodes are added up in the network, and when the number is reached to 100, it is found that as a consequence of incremental packet flood for the discovery of route and maintenance of route the network performance is decreasing. Whereas, in HNERP relatively high throughput is maintained in more nodes in the network, as it enhances route selection and route maintenance on-demand nature makes it appropriate to adjust it. Moreover, for routing HNERP use a composite metric which equally gives importance to hop count and residual energy of node to limit the number of hops in shortest path selection.

6. PROPOSED SCHEME AND PRIOR WORK COMPARISON

Proposed HNERP scheme provides a multifaceted strategy for routing data packet by minimizing network overheads and overall routing for resource constraints mobile nodes. Comparative

analysis of proposed scheme with other existing schemes is represented in Table 3. HNERP and AODV-EER use composite routing metric according to network dynamic nature. In comparison with existing schemes proposed protocol experiences less routing and network load due to its straightforward and prosperous design without utilizing more broadcasts and interchange of control packets. Moreover, proposed protocol detects early link failure and repairs route with energy efficient nodes.

Table 3. Comparative Analysis of Proposed Scheme and Prior work

| | HNERP | AODV-LRR | AODV-EER | AODV |
|--------------------------------|-----------|----------|-----------|----------|
| Routing Metric | Composite | Singular | Composite | Singular |
| Network Load | Low | Medium | High | High |
| Routing Overhead | Low | High | High | High |
| Link breakage Detection | Yes | Yes | No | No |

7. CONCLUSION

In this paper, we recommended an easily deployable and featherweight Hop-count and Node Energy based Routing Protocol (HNERP) for the mobile ad-hoc network to select energy efficient nodes in route selection and route repair. HNERP can also distinguish a node with the low energy level in current routing path from source to destination. Therefore, it could repair broken link by selecting nodes with higher energy levels and delivers the shortest path. The efficiency of the proposed scheme is proved by simulation results. Performance of HNERP scheme is compared with AODV-LRR, AODV-LRR and AODV routing protocol in the form of end-to-end delay, packet delivery ratio,

network lifetime and throughput. The results obtained from simulation show that overall performance of AODV-LRR, AODV-LRR and AODV is critically affected by energy depletion node which reduces the throughput and packet delivery ratio to intolerable limits. Whereas, HNERP significantly enhances the overall performance of the network by selecting an energy-efficient node and eliminating energy depletion node from currently selected route before link breakage. In future, we plan to include link quality parameters in the selection of the route, therefore chosen routes to have less link loss ratio.

8. FUTURE WORK DIRECTIONS

An improved energy efficient routing protocol is proposed in this research which selects an optimized route, provides consistent data delivery and efficient route maintenance for energy-

constrained mobile ad hoc networks. This research work can be further extended as a part of future work directions in many ways as listed below:

- i. This research focuses on node energy and maintain energy levels of nodes and avoid to use only a few nodes in the shortest path to drain those nodes quickly. Moreover, this research also focuses on node energy depletion and chooses the alternative shortest route from source to destination. However, the EERP scheme design can further modify to find other node misbehaviour including Sybil attack and wormhole attack.
- ii. The proposed EERP scheme selects optimal route it can further extend by including link quality parameters in route selection process. As a result composite metric for routing could consist of the parameter for link quality, therefore selected routes may demonstrate the enormous difference in link interference, link loss ratio and link capacity.
- iii. The proposed scheme is energy-efficient however, in mobile ad hoc networks some application can be delay sensitive. Therefore, proposed EERP can be extended further to incorporate with a delay-aware solution as well.
- iv. The proposed energy efficient routing protocol only deliberates random waypoint mobility model and two-ray ground propagation model in the simulation of network scenarios. However, it can be further extended to more practical models like Ricean Fading and Nakagami propagation models as they allow more realistic tests and typically used in outdoor environments.
- v. Simulation-based experimental work is used to evaluate the proposed scheme which is developed by this research, whereas a future work large-scale test-bed can apply for the real world evaluation and implementation.

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APPENDIX:

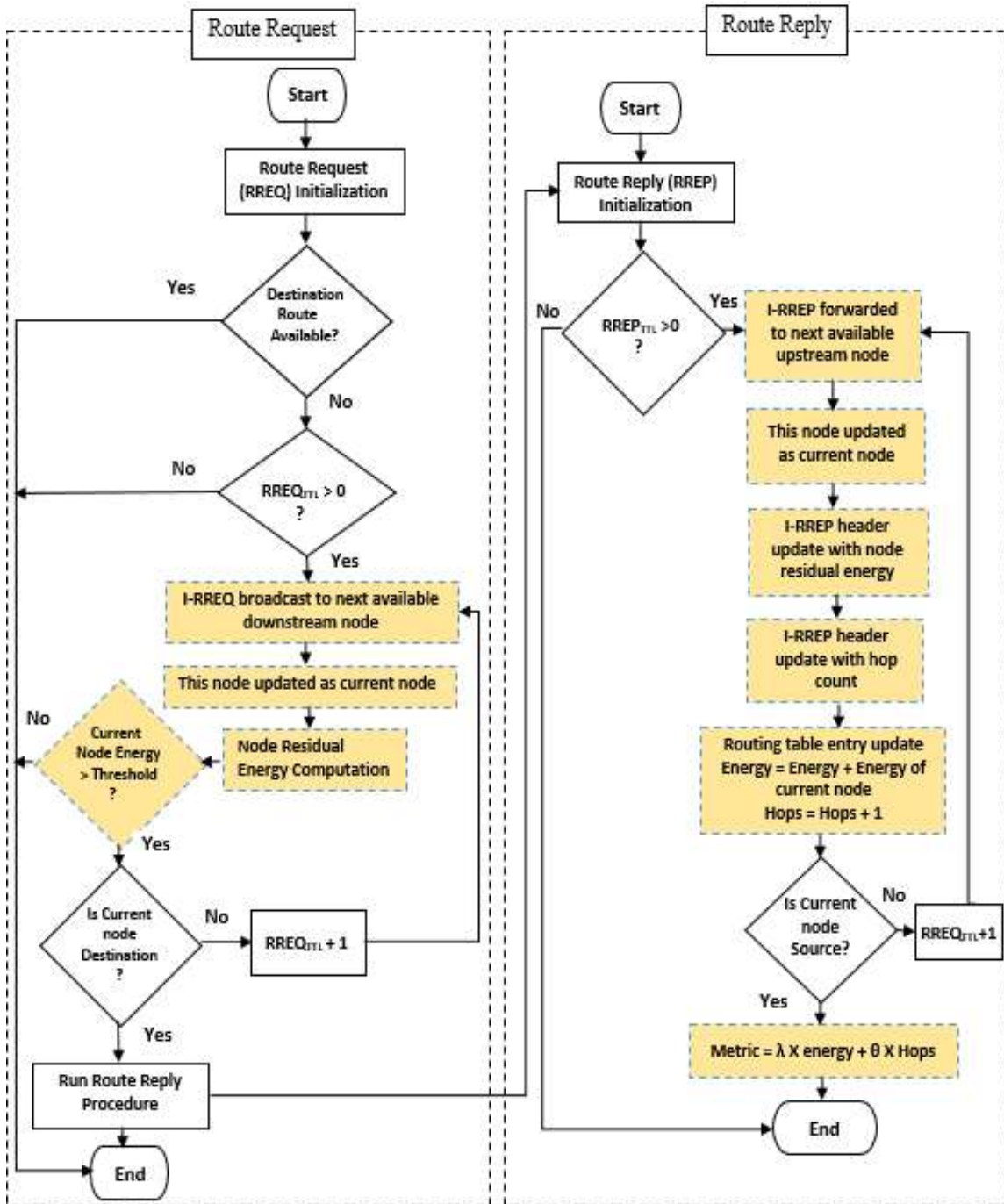


Figure 4: HNERP Route Setup Flow Chart

Table 1: Link Failure and Reporting Schemes Comparison and Summary

| Schemes | Methodology | Route Stability | Detection Mechanism | Routing Overheads | Route Discovery Frequency |
|-------------------------|--------------|-----------------|---------------------|-------------------|---------------------------|
| MAODV [21] 2015 | Backup route | Very low | Hello-based | High | High |
| SEAR-AODV [25] 2015 | Backup route | Low | Link layer based | High | High |
| ERB-AODV [22] 2015 | Local repair | Low | Hello-based | Moderate | High |
| AODV-LRR [18] 2014 | Local repair | Low | Hello-based | High | High |
| AODV-EER [24] 2014 | Backup route | Low | Link layer based | High | High |
| Modified AODV [20] 2014 | Local repair | Low | Hello-based | Moderate | High |
| Enhanced AODV [19] 2013 | Backup route | Medium | Hello-based | Moderate | Relatively Low |
| B-AODV [23] 2013 | Backup route | Low | Hello-based | High | High |

Table 2: Simulation Parameters for HNERP

| Description | Values |
|---------------------------------|-----------------------|
| Topology area | 1200mm x 1200 mm |
| Simulation time | 1000 sec |
| Number of nodes | Range from 10 to 100 |
| Transmission Range | 250m |
| Mobility model | Random way point |
| Traffic type | UDP |
| Maximum speed | 10 m/s |
| Packet size | 512 bytes |
| Weight for energy and hop count | 0.5 |
| Initial energy | 60 Joules |
| Energy threshold | 20% of initial energy |
| Pause time | 2 sec |
| Speed | 10-40 m/s |
| Channel type | Wireless channel |
| Send rate | 2 packets/sec |
| Network interface type | WirelessPhy |
| Maximum packets in queue | 50 |
| Interface queue type | Drop tail / PriQueue |