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# A Novel Algorithm for Enhancement of Energy Efficient Zone Based Routing Protocol for MANET

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**Abstract**
Mobile Ad-hoc Network (MANET) is a group of self-sustaining movable nodes which are communicating to other nodes in the networks through wireless connections. The motile nodes within the communication range can directly communicate with each other, whereas other nodes require the support of neighbouring nodes by using routing protocols. Most routing protocols are utilizing the rebroadcasting techniques to reduce the path overhead. An energy efficient zone based routing protocols are developed to reduce the redundant broadcasting through on-demand parallel collision guided broadcasting. Nevertheless, the broadcast storm is occurring due to transmit of simultaneous collision guided broadcasting which causes larger power consumption. Hence, this paper deals with a novel algorithm to increase the energy efficient zone based routing protocols which control the network topology by estimating node die out rate. Furthermore, a game theory approach with energy efficient zone based routing protocol to improve QoS routing for MANET. Finally, the experimental outcomes proved the efficiency of the proposed algorithm compared with other routing algorithms.

**Keywords** Mobile Ad hoc Networks · Routing protocols · Zone based routing protocol · QoS routing · Network topology · Energy efficient

## 1 Introduction

The continuous self arranging, infrastructure less network of mobile devices which are linked wirelessly are called as Mobile Ad-hoc Network (MANET). In a MANET, each mobile node can move in any direction and frequently changes its connections to other mobile devices without depending on other nodes in the networks. The major issue in constructing a MANET is equipment of each mobile device to constantly sustain the information needed to route the traffic properly. MANET is the type of wireless ad hoc network which consists of peer-to-peer, self-forming and self-healing network.

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In a MANET, each mobile node must learn about their neighbour nodes and how to reach them. Moreover, the transmission of packets between communication devices is controlled by standard algorithms called as ad-hoc routing protocol. Different routing protocols are available. They are proactive, reactive, hybrid of proactive as well as reactive routing protocols are developed. Proactive routing protocols like Optimized Link State Routing Protocol (OLSR), Destination Sequence Distance Vector (DSDV) are used for maintaining their paths and its destinations by regularly sharing the information of routing tables to the network. However, the major issues in proactive routing protocols are maintenance due and complexity of restructuring due to failures.

Reactive routing protocols like Dynamic Source Routing (DSR), Ad hoc On demand Distance Vector (AODV), are utilized to find the path on demand by flooding the route request messages throughout the networks. Conversely, the major drawbacks in reactive routing protocols are larger latency time and network clogging. The issues in proactive as well as reactive routing protocols are removed by combining their advantages and the protocol is called as Hybrid routing protocol. Hybrid routing protocols such as Zone based Routing Protocol (ZRP) and Zone based Hierarchical Link State

Routing Protocol (ZHLS) are established, with few proactively inspect the paths and then serve the demand of activated nodes through reactive flooding.

Zone Routing Protocol (ZRP) is defined as the mechanism which is called as Bordercast Resolution Protocol (BRP) utilized for maintaining the traffic between the zones. The network topology is divided into various zones and provided for utilizing various routing protocols within and between the zones in ZRP. If the destination is in the similar zone, then the packet is immediately delivered since the routing table is already stored by proactive protocol. If the destination extends outside of the zone as the origin, then reactive protocol is used to check every successive zone in the path for discovering whether the destination is inside that zone. Once the zone is identified as containing the destination node, then the packet is delivered by using stored route-listing table. This process is used to reduce the path overhead. Nevertheless, the drawbacks of ZRP are scalability, high memory requirement, and high routing zones overlapping.

In this paper, a novel algorithm is proposed for multiphase enhancement of Zone Routing Protocol (ZRP). The main objective of this paper is follows: a). to control the network topology based on energy dropout rate, b). to improve QoS aware routing mechanism in terms of bandwidth, packet loss ant etc. The remaining part of this paper is organized as follows: Section 2 presents the works which is related to the Zone Routing Protocol in wireless networks. Section 3 explains the concept about our proposed algorithm for improved zone routing protocol. Section 4 describes the performance evaluation of the proposed mechanism. Lastly, Section 5 concludes the research work and presents the future work.

## 2 Literature survey

Srivastava, J. R., & Sudarshan, T. S. B., [1] proposed a novel Zone based Energy Efficient routing Protocol (ZEEP) which is utilized for both immobile and mobile nodes. The excess mechanisms for route detection, path protection or sustaining large routing tables were not required. The dynamic forwarding principle was utilized to keep nodes from computation overhead. By utilizing this protocol, the energy of the nodes was measured. But, here only zone heads were utilized for packet forwarding.

Ahmad, U., & Hussain, F. B., [2] proposed novel zone based routing mechanism which is the improvement of Ad hoc On Demand Distance Vector Routing Protocol. The major objective of this protocol was to improve trustworthiness, error control techniques and to provide better connection repair with low overhead. The cost of routing information was determined by residual energy and mobility of nodes. However, this protocol does not utilize to support varying zone sizes.

Roopa Devi, B. A. S., Muruthy, J. V. B., et al. [3] proposed Secure Zone Routing Protocol (SZRP). It is hybrid form of ad-hoc routing protocol. The main objective of SZRP was to overcome the limitations by integrating the properties of proactive as well as reactive mechanisms. This protocol was denpends on the principle of Zone Routing Protocol (ZRP). It includes an integrated method of digital signature and cryptographic mechanisms. However, the path acquisition latency was high due to signature generation and authentication.

Nasser, N., et al. [4] proposed Zone based Routing Protocol for Mobile Sensor Networks is called as ZoroMSN. Here, a simple fixed zone based partition scheme was used for network partition. For energy consumption with a low overhead and to elect the zone head, the clustering scheme was used. The mobility factor of sensor node was calculated based on mobility speed and localization of sensors for selecting the ZH. However, this protocol has better performance only in smaller zones and low speed sensors in WSN.

Ravilla, D., & Putta, C. S. R., [5] focused on the security based Zone Routing Protocol (ZRP). It is hybrid of MANET protocol. It was developed by using keyed-Hash Message Authentication Code-Secure Hashing Algorithm 256 (HMAC-SHA256) to authenticate and integrate the information. Moreover, trust-based scheme was formulated to prevent the Denial-of-Services (DoS) attacks. The throughput and packet delivery ratio was increased by utilizing this algorithm. However, the processing time and end-to-end delay were increased.

Thulasiraman, P., & White, K. A., [6] investigated about energy efficient zone routing protocol for topology control of tactical wireless sensor networks. It deals with realistic insights on the practical merits as well as demerits of routing techniques for single gateway and multi-gateway tactical WSN. It investigated the various routing algorithms in terms of direct routing, low transmission energy, adaptive cluster head routing. The novel energy efficient zone clustering protocol was developed based on the node die out information. Here, the reduction of the energy depletion rate was based on the selection of cluster head.

Lin, D., et al. [7] proposed moving zone based routing protocol (MoZo) for vehicular ad hoc networks. In this protocol, vehicles were collaborating with each other in creating moving zones so the information dissemination was facilitated. This novel protocol was used to introduce the modeling of moving object and indexing mechanisms for moving object datasets into the design of VANET routing protocols. However, overall performance of MoZo was less since MoZo has not updated location information more frequently.

Basurra, S. S., et al. [8] proposed Zone based Routing with Parallel Collision Guided Broadcasting Protocol (ZCG) for mobile ad hoc networks. The parallel and distributed broadcasting technique was utilized by this protocol for reducing unnecessary broadcasting and increasing the route discovery with low energy consumption and high reachability ratio. It was utilizes the one-hop clustering algorithm which is used to separate the network into zones. However, the issue of protecting zone members from selfish behaviors decreases the performance among nodes.

Moraveji, R., et al. [9] proposed classification based routing algorithm for irregular networks. It is called as zone ordered label based routing protocol with multiple spanning trees. Based on processes of deadlock free zones, zone ordering and labeling the graph, this protocol was introduced. The deadlock-free paths were generated based on mentioned three processes. The graph labeling process was performed based on construction of multiple spanning trees in the network. However, the performance was depended upon the network topology on which routing was applied.

Helmy, A., [10] proposed contact-extended zone based transactions routing protocol called as TRANSFER. This protocol was utilized for wide-ranging wireless ad-hoc networks in order to reduce the overall energy consumption through transactions. The hybrid mechanism was utilized by TRANSFER protocol. The proactive link state protocol was used to acquires information about nodes in its zone. A novel notion of contacts was introduced for decreasing the degrees of separation between source and destination. Moreover, an on-demand protocol was developed for contacts selection which is used for transactions for discovering valid paths. However, the efficiency was high when mobility was low.

Samar, P., et al. [11] proposed an independent zone routing (IZR) protocol for ad-hoc wireless networks. This IZR protocol was developed from zone routing protocol used for allowing adaptive and scattered configuration for optimum size of every node in the network. The configuration was achieved at every node by means of examining the local path control traffic. The protocol was used for improving the performance, scalability and robustness. However, QoS and security and power consumption were not investigated.

Wang, L., & Olariu, S., [12] proposed novel hybrid routing algorithm called as two-zone routing protocol (TZRP). This protocol was an enhancement of zone routing protocol. It was decoupled the protocols with adaptive traffic characteristics and mobility. Each node in TZRP was used to maintain two zones named as Crisp zone and Fuzzy zone. The routing control overhead was reduced by modifying the sizes of the two zones. However, the adjustment of the radius of crisp or fuzzy zone was not effective.

Minh Thu, P. T., et al. [13] proposed geographical based zone routing protocol for mobile ad-hoc networks. It was developed for constraining the region to discover the new path by using the node's location details. The route request messages (RREQ) were utilized by the nodes for obtaining the new path to the other nodes in the network by using this novel protocol. Thus, this distribution mechanism was provided for finding the path from source to destination with higher probability also reducing the routing overhead. However, the energy consumption was not reduced.

Chellathurai, S. A., & Raj, G. D. P. E., [14] proposed an evolutionary zone routing protocol. It is the improvement of zone routing protocol for mobile ad-hoc networks. This protocol was introduced based on the genetic techniques to discover the multiple shortest paths for route failures. This protocol was applied to the outer zone to provide the set of available routes to the destination. However, the overall performance was not significantly improved and also the optimal path was not accurately discovered.

Malwe, R. S., et al. [15] proposed an improved zone routing protocol based on the location and selective-bordercast. This protocol was initially proposed based on selective bordercast instead of normal bordercast to estimate the path wherein path request was transmitted only by means of peripheral nodes. The table entries within the zone were limited to reduce the storage complexity of the routing table. Then, the previous location information of destination was utilized for improving selective bordercast in ZRP. This protocol was used to reduce the control overhead. However, end-to-end delay and energy consumption were not considered.

Selvi, A., & Vijayaraj, A., [16] proposed zone based routing protocol in wireless networks to improve the quality of service (QoS) in video traffic. Here, the zone routing protocol was utilized based on proactive and reactive protocols instead of OLSR protocol in ViLBaS principle. If the sender and receiver were located within the region then, proactive protocol will transmit the packet to the destination or else reactive will forward the packets to the receiver. Then the final quality of service was measured. However, the security issues when forwarding the packets were not removed.

Rajput, S. S., & Trivedi, M. C., [17] proposed a security enhanced zone routing protocol (SEZRP). This protocol was utilized the verification mechanism for securing the packet routing in ZRP and preventing commonly occurred attacks. Here, Message Authentication Code (MAC) was provided to maintain the privacy of the messages. The overhead due to dissemination and sharing the keys was reduced by key pre-distribution mechanism. However, the energy consumption was not considered.

Srivastava, J. R., & Sudarshan, T. S. B., [18] proposed a genetic fuzzy system based optimized zone based energy efficient routing protocol (OZEEP) for mobile sensor networks. This protocol was proposed to maximize the clustering and cluster head selection of zone based energy efficient routing protocol by utilizing genetic fuzzy system. The cluster head was selected by fuzzy inference system based on factors like energy, distance, density and mobility. Then the optimal cluster heads were discovered by utilizing genetic algorithm to enhance the network lifetime. However, the latency and network-wide transmissions were not reduced.

Jaiswal, A. K., & Singh, P., [19] proposed routing protocol called as optimizing velocity based adaptive zone routing protocol (OVBAZRP). It was facilitated to select various nodes in various zone radius based on every node's distinct speeds. The intrazone active routing protocol and bordercast resolution protocol were reconstructed in this proposed protocol. The routing lookup overhead was reduced by including different examination control techniques. This protocol was provided to adapt the mobility and traffic pattern for discovering paths. However, zone routing and path discovery maintenance were not improved.

Xiafeng Zhang, & Jacob, L., [20] proposed multicast zone routing protocol (MZRP) for mobile ad-hoc wireless networks. This MZRP was shared tree multicast routing protocol which is used to maintain the multicast tree membership for node's local routing zone at every node when multicast tree on-demand was established. The IP tunnel mechanism was utilized. However, the performance of MZRP was less compared with On-Demand Multicast Routing protocol (ODMRP).

Lu Canyi, Min, H., et al. [21] proposed face recognition via weighted sparse representation. Here data locality and data linearity concepts are used which becomes an extension of sparse representation based classification. An experimental result of face databases shows that WSRC is more effective than SRC.

Shanwen Zhang, Harry Wang, et al. [22] proposed two stage plant species recognition by local mean clustering and weighted sparse representation classification. In this paper, local mean based clustering (LMC) and local sparse representation based classification (SRC) (LWSRC) methods were combined which was experimented on the leaf image database. As the result, it was proved with high accuracy and low cost time and also clearly interpreted.

Hong Cheng, Xuewen Chen, et al. [23] proposed sparse representation and learning in visual recognition. This paper reviewed the various sparse representations like general, structured, high dimensional, non negative and Bayesian compressed. The applications of sparse theory like sparsity induced similarity, sparse classification and other similar topics were also introduced.

Haoxiang Wang and Jingbin Wang, [24] proposed the kernel classification based on effective image representation. The classifiers were trained by one against all rule and candidate images were classified. At last for classification responses, the new similarity measures like Euclidean classification response vectors were introduced. The experimental results on large scale image database proved that proposed techniques can overcome the problems on image retrieval.

Chujian Bi, Haoxiang Wang, et al. [25] proposed SAR image change detection using regularized dictionary learning and fuzzy clustering. Based on fuzzy clustering and regularized dictionary learning, an unsupervised change detection (CD) technique was introduced for synthetic aperture radar (SAR) images. To de-noise, regularized sparse reconstruction technique was introduced. The K-SVD dictionary learning was used for low time consuming reconstructed image. At last, the difference map was transferred into change map by using the optimized FCM technique which provided the better performance than other change detection techniques.

Chirag N. Modi and Acha. K [26] proposed the various attack to virtualization layer and intrusion detection methodology in cloud computing. It deals with various vulnerabilities and attacks at virtualization layer of cloud computing and proposed the frameworks like cloud intrusion detection system and intrusion prevention system.

Gupta, B.B., Shashank Gupta, et al. [27] proposed an algorithm to prevent the Document object model based XSS attack from the HTML5 vectors in HTML web applications. It found out all sceptical HTML5 strings from the web application and performs the clustering based on levels of resemblance. It also detects the HTML5 code in the nodes of DOM tree due to variation of HTML5 code in the HTTP response generated.

## 3 Improved energy efficient zone based routing protocol

The improved energy efficient zone based routing protocol is based on the controlling the network topology. This proposed algorithm involves three processes such as network setup, cluster head (CH) selection for each zone and packet routing. The network setup process is used to construct the network and divide the entire network into required

**Table 1** Simulation parameters and energy consumption model

| Network size | 1000 m × 800 m |
|---|---|
| Topology configuration mode | Randomized |
| Number of sensor nodes | 1000 |
| Data rate of Media Access Control layer | 2Mbps |
| Transmission capacity of sensor nodes | 40 m–70 m |
| Packet loss rate | 0.15% |
| Number of paths | 9 |
| Primary energy of common node | 0.2w |
| Primary energy of video node | 5w |
| Energy consumption at sending unit time $m_{tx}$ | 0.660w/s |
| Energy consumption at receiving unit time $m_{recv}$ | 0.395w/s |
| Energy consumption at overhearing unit time $m_{overhearing}$ | 0.195w/s |
| Energy consumption at idle unit time $m_{idle}$ | 0.035w/s |

**Table 2** Comparison of throughput (Bits/Sec)

| Number of Nodes | ZCG | IZCG | QoS-IZCG |
|---|---|---|---|
| 150 | 2000 | 2200 | 2450 |
| 300 | 2086 | 2268 | 2510 |
| 450 | 2118 | 2300 | 2597 |
| 600 | 2160 | 2384 | 2675 |
| 750 | 2198 | 2420 | 2710 |
| 1000 | 2250 | 2500 | 2750 |

**Table 3** Comparison of packet delivery ratio (%)

| Number of Nodes | ZCG | IZCG | QoS-IZCG |
|---|---|---|---|
| 150 | 58% | 67% | 75% |
| 300 | 64% | 76% | 81% |
| 450 | 70% | 83% | 86% |
| 600 | 76% | 89% | 92% |
| 750 | 82% | 94% | 97% |
| 1000 | 87% | 96% | 98% |

number of zones or clusters. The node is assigned to the zone based on the node's x-coordinate in the network. Then the cluster head selection is achieved based on the number of iterations. The group of active nodes are detected for each zone and cluster head is selected based on the maximum node energy.

Based on high battery power, less mobility and high connectivity, the Cluster Header (CH) is selected and sends a Hello message. Initially, a count-down timer sets fixed value when an idle node received a Hello message. Then, the numbers of active links to its direct neighbors which are not members of a neighbor zone are calculated. The node with the highest degree of connectivity becomes Zone Construction Organiser (ZCO) and then the zone construction call was broadcasted by ZCO. An idle node receives the call and cancels the timer countdown. Then it changes the state to Zone Construction Participant (ZCP). The ZCO also may changes the status to ZCP due to mobility. The other nearby nodes receives the zone construction call and set its states. This is achieved based on the number of iterations whereas each member of zones requires changing their status within the sufficient time allocation.

The fitness function of the nodes is calculated based on the Weighted Clustering Algorithm (WCA) for cluster process. The ZCP sorts the received fitness function, when the zone construction time gets completed. The first occurrence of the best fitness node becomes Cluster Head. Also other ZCP should identify the same CH independently. ZCP with a one hop count becomes member nodes and it puts CH's IP address in their Hello headers, thus the zones are constructed.

Each node in the zone should maintain the energy meter which is used to control the residual energy of the node. The selection of CH for each zone should attentive of all the active nodes and their residual energy in each zone. The power of each active node is reduced for every transmission of packet to the cluster head in the network. Initially, cluster head is selected randomly since all nodes are assumed to have equivalent energy level. In first iteration, CH transmits aggregated packet including with residual energy for each live node in the zone. For next iteration, the highest energy node is elected as cluster head and the energy level decrement is also measured. And also the energy dropout rate for every node in the zones is calculated which is used to retain the network topology during node die out.

## 4 An integration of energy efficient and QoS based zone routing protocol

In this mechanism, MANET is divided into number of clusters by static agent (SA) which is located centrally and mobile agent (MA) is deployed in each cluster. The MA is interacted with each other periodically. The resource information, neighbour nodes feedback are shared between every node during

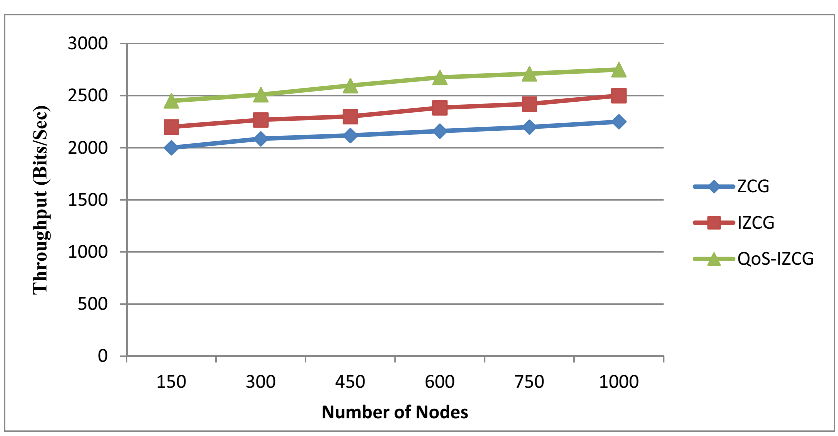



**Fig. 1** Comparison of throughput (bits/s)

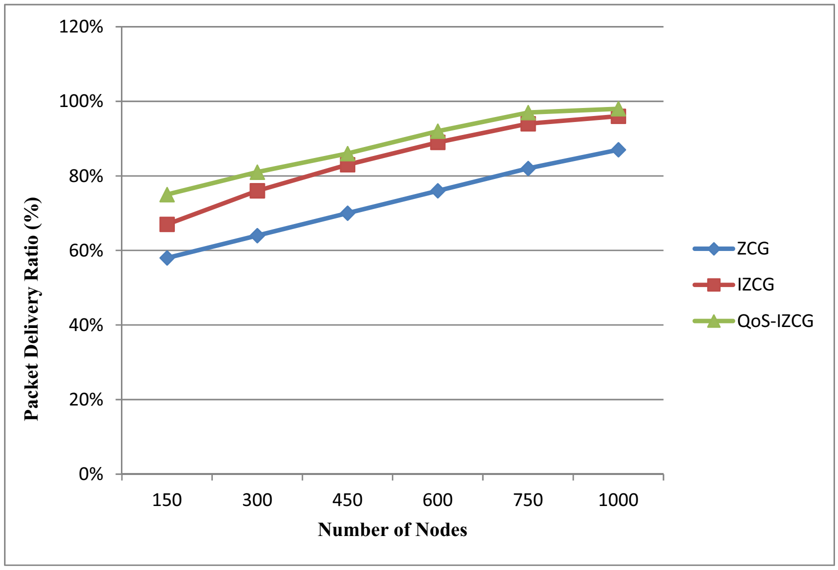



**Fig. 2** Comparison of packet delivery ratio (%)

interactions. Based on this information, the node is selected by MA. The source node provides the QoS requirements which are satisfied by the selected node. The message formats which are used for periodical interaction between mobile agent, static agents and nodes are given below.

1. Resource Message, *RM* = <*SN*, *SA*, *MA*, *Info*>, Where SN denotes sequence numbers for resource messages, SA is the source address of static nodes in a group, MA is the address of mobile nodes in a group and Info contains of required resource information, QoS resource information and neighbour node (NNs) feedback.
2. Agent Trust Value Message, *ATVM* = <*SN*, *SA*, *NA*, *Info*>, Where SN is the sequence numbers for the agent trust value messages, SA is the source address of mobile agents, NA is Neighborhood node address in a group and Info contains of the trust value of neighborhood node in a group.
3. Agent QoS value Message, *AQVM* = <*SN*, *SA*, *NA*, *Info*>, Where SN is the sequence numbers for agent QoS messages, SA is the source address of mobile agents, NA is the neighbourhood node or mobile agents address in a group and Info contains of available and required QoS data and paths.
4. Required QoS Message, *RQM* = <*SN*, *SA*, *NA*, *Info*>, Where SN is the sequence numbers for required QoS messages, SA is the source mobile agent or static address, NA is static agent or Neighbourhood mobile agents address in a group and Info contains of required QoS and cluster resource data.
5. Available QoS Message, *AQM* = <*SN*, *SA*, *MA*, *Info*>, Where SN is the sequence number for available QoS messages, SA is the source address of static agents, MA is source mobile agents address and Info contains of available QoS information and optimal QoS paths.

The trust value is computed and assigned by the MA based on the resource information which is given by neighbor nodes. The Residual Memory (RM) and Total Memory (TM) are shared by each node in the network. The mobile agents receives the details about the nodes like Computational Power (CP), Transmitter Power (TP), Total power of Node (TN), Packet Loss (PL) and Feedback about its Neighbour Nodes ($F^i_{nb}$ ). The $i^{th}$ node feedback is given by,

$$F^i_{nb} = \frac{\sum_{k=1}^{N} F_k}{N}$$

In the above equation, $F_k$ refers to feedback of k$^{th}$ node and it contains the details like the amount of packets received and acknowledged in the previous history. $N$ denotes the total amount of $i^{th}$ neighbor nodes.

The trust value of the $i^{th}$ node computed by MA is given by,

$$TV_i = \frac{\left(\frac{RM}{TM}\right) + \left(\frac{TP+CP}{TN}\right)}{2-\alpha * PL} * F^i_{nb}$$

$$\alpha = \begin{cases} 0; if\ PL = 0 \\ 1; otherwise \end{cases}$$

**Table 4** Comparison of packet drop ratio (%)

| Number of Nodes | ZCG | IZCG | QoS-IZCG |
|---|---|---|---|
| 150 | 12% | 10% | 8% |
| 300 | 15% | 12% | 9% |
| 450 | 18% | 13% | 10% |
| 600 | 20% | 19% | 11% |
| 750 | 22% | 20% | 12% |
| 1000 | 25% | 22% | 15% |

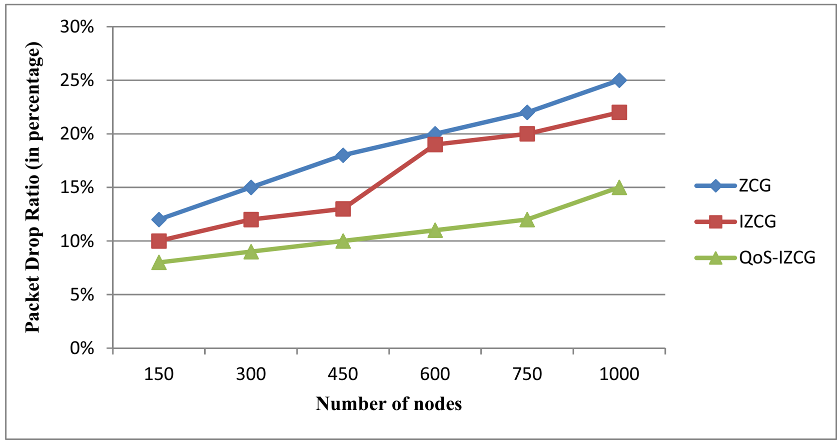



**Fig. 3** Comparison of packet drop ratio (%)

The trustworthy of the node and its trusty routing are identified by the trust values of the node. The trust nodes are utilized for selecting an alternative route from source to destination for successful transmission of packets. This process is continued until boundary node of the cluster is achieved. The trust value and QoS requirements are updated by interactions between MA and nodes regularly. The MA of cluster is used to provide the details like bandwidth, trusty nodes, cost of links, nodes and links delay, resources of nodes and etc., to the SA in interaction and stored in its database.

The considerable QoS parameters are given as follows:

The minimum available or unutilized bandwidth in source $s$ to destination $d$ is given as,

$$BW(P) = \mathrm{MIN}\{BW(Path)\}, \qquad P = s \rightarrow i \rightarrow \ldots \rightarrow d$$

$$Path = \{(s,i),(i,j),\ldots,(t,d)\}$$

The delay is given by sum of the delays likes transmitting, receiving, propagation, processing and forwarding delay on all links and source node delay.

$$Delay(P) = \sum_{i \in path} Delay(i) + Dealy(s)$$

The packet loss rate is given as,

$$loss(P) = 1 - \prod_{i \in path} (1 - loss(i))$$

The cost of links is defined as the amount of hops from source to destination and is estimated as,

$$Cost(P) = \sum_{i \in path} Cost(i)$$

The optimum QoS path from source to destination is established from the following limitations.

$$BW(P) \geq BW_{req}$$

$$Delay(P) \leq D_{req}$$

$$loss(P) \leq PL_{req}$$

$$Cost(P) \leq C_{req}$$

Then, the optimal QoS path based on the QoS parameters is given by,

$$Optimal\ QoS = BW(P)*Delay(P)*loss(P)*Cost(P)*\frac{\sum_{j=1}^{n} TV_i^j}{n}$$

In the above equation, n refers the total amount of nodes in path $i$ from source to destination. The node computes QoS resources information and provided to the MA when it is required to transmit the packets from source to destination. This process is continued until the discovery of destination node. Thus the optimum QoS route is formed by all selected nodes by using Emergent Intelligence (EI) technique. If the nodes on the selected optimal QoS path fail, then MA provides an alternate route in the network by considering the feedback from neighbour nodes. If MA fails, then SA is used to provide an alternate route through another MA by using the available information. If SA fails, then the node which is having high resources is selected as SA and it splits the MANET into clusters. Hence, selecting the trustiest nodes in the zones is achieved based on discovering an optimal QoS path by EI based QoS routing protocol.

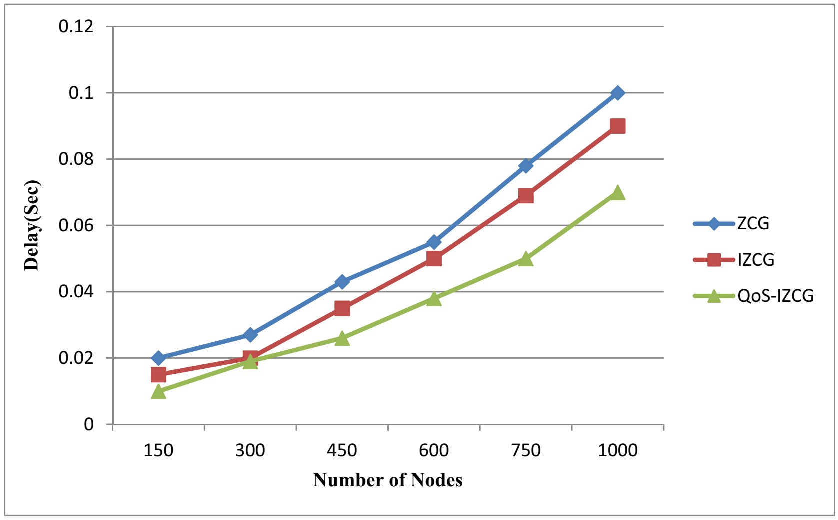
Algorithm:

**Table 5** Comparison of delay (Sec)

| Number of Nodes | ZCG | IZCG | QoS-IZCG |
|---|---|---|---|
| 150 | 0.02 | 0.015 | 0.01 |
| 300 | 0.027 | 0.02 | 0.019 |
| 450 | 0.043 | 0.035 | 0.026 |
| 600 | 0.055 | 0.05 | 0.038 |
| 750 | 0.078 | 0.069 | 0.05 |
| 1000 | 0.1 | 0.09 | 0.07 |

Begin
Consider n number of clusters, m number of neighbour nodes
Assume BN be boundary node
Assign N is the node where MA runs S  and D nodes
$for\ i = 1\ to\ n\ do$
Create SA and arrange $MA_i$ at $i^{th}$ cluster
End for
$for\ i = 1\ to\ n\ do$
$if\ N \neq BN\ then$
$MA_i$ at N forms a group which consists of m
$for\ j = 1\ to\ m\ do$
$MA_i$ collects QoS resource information
Compute and Assign TV to $j^{th}$ node
End for
$MA_i$ sends QoS information to SA and move to the next node
End if
End for
Source computes $BW_{req}, D_{req}, PL_{req}, C_{req}$ and send to MA
$if\ N \neq D\ and\ N \neq BN\ then$
MA forms group, generates and broadcasts RQM
Group of nodes responds by sending RM
MA move to the next node
End if
$if\ D\ is\ in\ same\ cluster\ then$
MA collects QoS parameters of available route (AR) to D
$for\ k = 1\ to\ AR\ do$
$if\ QoS\ limitations\ satisfies\ for\ route\ then$
Compute an optimal QoS path
End if
End for
End

Fig. 4 Comparison of delay (Sec)




## 5 Performance evaluation

The proposed improved routing protocols are simulated by using Network Simulator 2 (NS2). The simulation parameters are given below. (Table 1).

Table 6 Comparison of control overhead (Kbps)

| Number of Nodes | ZCG | IZCG | QoS-IZCG |
|---|---|---|---|
| 150 | 158 | 120 | 80 |
| 300 | 176 | 151 | 126 |
| 450 | 194 | 182 | 158 |
| 600 | 216 | 204 | 180 |
| 750 | 238 | 228 | 196 |
| 1000 | 242 | 230 | 200 |

### 5.1 Throughput

The rate of packets are delivered correctly in per unit time over the communication channel is called as throughput. The comparison values of throughput for different protocols are given in (Table 2).

Figure 1 shows that the comparison of throughput in terms of bits/s. It shows that the throughput of QoS-IZCG mechanism is high compared to the IZCG and ZCG protocols. This proves the better performance of QoS-IZCG protocol for MANET.

### 5.2 Packet delivery ratio

Packet delivery ratio (PDR) is defined as the sum of data packet received at sink node and the sum of data packets generated at source node in the networks are represented in terms of percentage. The comparison of PDR is shown in Table 3.

Fig. 5 Comparison of control overhead (Kbps)

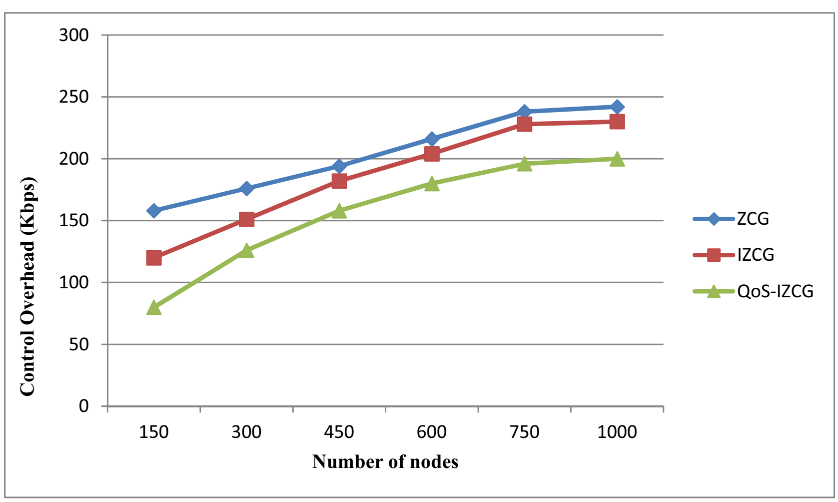


Figure 2 shows that the comparison of packet delivery ratio in terms of percentage. It shows that the PDR of QoS-IZCG mechanism is high compared to the IZCG and ZCG protocols. This proves the better performance of QoS-IZCG protocol for MANET.

### 5.3 Packet drop ratio

Packet drop ratio is defined as percentage of data packets which are lost during the transmission of packets. The comparison of PDR is shown in Table 4.

Figure 3 shows that the comparison of packet drop ratio in terms of percentage. It shows that the packet drop ratio of QoS-IZCG mechanism is less compared to the IZCG and ZCG protocols. This illustrates the better performance of QoS-IZCG protocol for MANET.

### 5.4 Delay

Delay is referred at the time, which is elapsed since the departure of the packet from source node to the arrival of the destination node. The comparison of delay is shown in Table 5.

Figure 4 shows that the comparison of delay. It shows that the delay of QoS-IZCG mechanism is minimum compared to the IZCG and ZCG protocols. This proves the better performance of QoS-IZCG protocol for MANET.

### 5.5 Control overhead

Control overhead is the total amount of control packets required by the routing protocol for 1Kbits data packets received successfully at the sink node. The comparison of control overhead is shown in Table 6.

Figure 5 shows that the comparison of control overhead in terms of Kbps. It shows that the control overhead of QoS-IZCG mechanism is less compared to the IZCG and ZCG protocols. This proves the better performance of QoS-IZCG protocol for MANET.

## 6 Conclusion and future work

This research mainly concentrates on the issues of zone routing protocol. In this paper, zone based routing with parallel collision guided broadcasting protocol (ZCG) is improved by controlling the network topology based on estimating the energy dropout rate of the node. Moreover, the energy efficiency is enhanced by an improved QoS routing protocol which is developed to find an optimal QoS path for successful routing. Hence, the proposed improved protocols are used to reduce the path overhead and improve the energy efficiency for MANET. The simulation results proved that the better performance of the proposed protocol when it is compared to the other routing protocols. Furthermore, the future extension of this work involves the congestion detection and control based on estimating average queue length. In addition, this work will be included with selfish node detection based on trust value and improved channel utilization based on multi-channel MAC protocol.

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