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Energy Efficient Routing Protocol Using Grover's Searching Algorithm for MANET

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Abstract: A Mobile Ad Hoc Network (MANETs) is a wireless network consisting of number of autonomous mobile devices temporarily interconnected into a network by wireless media. MANETs have become most prevalent areas of research in the recent years. Energy efficient routing, resource limitations, scalability and Security are greatly challenging issues in MANETs. In MANETs, routing protocols directly affect various indices of network. In this quality of service plays an important role in the network performance. To address the drawbacks associated with traditional routing protocols in MANETs, such as energy efficiency, poor anti-fading performance and slow convergence rate for basic Dynamic Source Routing (DSR), we have proposed a new routing protocol based on Grover's searching algorithm to select an optimal route for improving energy efficiency and to effectively extend the network lifetime. The Grover's searching algorithm finds an optimal path using the node vector function and the probability of each node in the network. We have used Fuzzy C-means Clustering (FCM) to group the mobile nodes into clusters by considering the distance between the nodes as a major parameter for forming clusters. FCM is a clustering technique in which nodes are grouped into clusters with certain degree. The cluster head is elected based on the energy level of each node. In this we have created mobile nodes and grouped them into set of clusters in NS2 environment using FCM algorithm. We find optimal route between these cluster of nodes using EGRP protocol by this we have increased the energy efficiency and extended network life time when compared with DSR and CBRP protocol.

Key words: Mobile devices, MANETs, DSR, network, FCM

INTRODUCTION

A Mobile Ad Hoc Network (MANET) is a set of wireless mobile nodes forming a dynamic autonomous network through a fully mobile infrastructure (Mohan *et al*., 2012). Nodes communicate with each other without the intervention of centralized access points or base stations. In such a network, each node acts both as a router and as a host. Due to the limited transmission range of wireless network interfaces, multiple hops may be needed to exchange data between nodes in the network, which is why the literature in here sometimes uses the term multi-hop network for a MANET. A mobile ad hoc network includes several advantages over traditional wireless networks, including: ease of deployment, speed of deployment, and decreased dependence on a fixed infrastructure (Bindra *et al*., 2010). MANET is attractive because it provides an instant network formation without the presence of fixed base stations and system administrators. Many critical issues have to be addressed in MANET such as uni-cast and multicast routing, QoS support, power control and security (Vamsee *et al*., 2012). It deals with the problem of uni-cast and Grover's search routing in the mobile ad hoc network.

Designing routing protocols in a mobile ad hoc network is different from wireless networks due to its fully mobile infrastructure which affects mobility management. In the literature related to routing protocols used in MANETs, there exist three main routing mechanisms proactive, reactive and hybrid. In the proactive or table-driven approach, each node keeps up-to-date routes to every other node in the network in its routing tables. Routing information is periodically transmitted throughout the network in order to maintain routing table consistency. In the reactive or on-demand approach, a node initiates a route discovery procedure only when it

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wants to communicate with its destination. Once a route is established, it is maintained by a route maintenance process until either the destination becomes inaccessible or until the route is no longer desired. In the hybrid approach each node maintains only routing information for those nodes that are within its zone and its neighboring zones. That is, it exhibits proactive behavior within a zone, and reactive behavior between zones. The size and dynamics of a zone differ from protocol to protocol (Youssef *et al*., 2012). Consequently in hybrid schemes, a route to each destination within a zone is established without delay while a route discovery and a route maintenance procedure are required for every other destination.

In addition, traditional routing protocols, such as Dynamic Source Routing (DSR), Destination-Sequenced Distance-Vector Routing (DSDV) and Ad HocOn-demand Distance Vector Routing (AODV), do not consider the effects of channel fading, additive noise and limited storage energy of wireless nodes. Also the node-centric distributed routing protocols with huge computation quantity are relatively complicated, thus causing a sharp decline in Quality of Service (QoS) performance and thus these traditional routing protocols are unsuitable for MANETs. Therefore, it is necessary to explore a new routing protocol that ensure energy efficiency for MANETs.

Literature review: The MANET provides more features as it build on to the concept of a simple networks. It uses broadcast packets, allowing for simplicity, availability and robustness. To face scalability issues and reduce collisions due to broadcasting, it takes advantage of overheard packets. Forwarding decisions are locally taken at each receiving node without any explicit signaling exchange with neighboring nodes. It indirectly implements transport functions like sequence control and retransmissions requests by embedding acknowledgments in the Interest packets. It implements techniques to face mobility of consumers and providers. MANET nodes can take the benefit of shared communication medium so that broad casted packets may be opportunistically received by more consumers simultaneously. The searching route path takes long time results in routing overhead.

Harminder proposed a performance evaluation of two reactive routing protocols of MANET using Group Mobility Model in which the reference point group mobility model is used to evaluate the performance of routing protocols in situation of traffic in the node movement. The discrepancy may incur while using DSR in MANETS is low routing overhead. Thus, there is always a greater need for updating the routing in MANET using a new protocol based on Grover's search algorithm. Vamsee Mohan *et al*. (2012) proposed a reliable routing algorithm. In MANET using fuzzy in which the topology of MANETs change dynamically due to the unpredictable nature of the hops or nodes. Frequent changes in topology leads to broken routes and greatly degrade the network performance. Therefore, it is a must to check the reliability of routing protocols that is used in MANETs. By using the degree of reliability, the most reliable route was found out. In the real-world situations, mobile ad hoc network nodes move quickly in an invariant or variant velocity which makes the link between nodes unstable (Sun *et al*., 2009). Each node has no idea when the neighboring nodes will move out of the communication range. It directly causes the routes between each node broken and brings serious consequences. The limitations of the fuzzy petri model for working on the routing protocols for MANETs is that it considers only one factor which is reliability rather than selecting the routing time and cost between nodes which is also essential while dealing with MANET.

Vetrivelan and Reddy (2008) and Timcenko *et al*. (2009) compared the Performance Analysis of MANET Routing Protocols and Mobility Models. They compare various traditional routing protocols in terms of energy and reliability. They have compared various traditional routing protocols that are basically used in MANET topology of networks by using various mobility models such as reference point Group Mobility, Random waypoints and Manhattan grid (Youssef *et al*., 2012). The analysis covers a wide range of MANET scenarios and aims to be useful in a variety of applications, for purpose of network research, design and implementation. Routing overhead was also used to evaluate the traditional routing protocols which are the ratio of generated routing messages and received data packets (Wei, 2013). The DSR is found to have low routing overhead which affects the performance of the network while handling large amounts of data. Such factors are taken into consideration and preventive analysis is made while developing a routing protocol based on Grover's search algorithm.

Sangeeta proposed Study of DSR routing protocol in mobile ad hoc network in which the dynamic Source Routing provides a prelude for new routing protocols. Dynamic source routing protocol is a robust protocol based on source routing which routes the packets to the destination based on route discovery. The new improvements in routing were developed from DSR using the Route Reply method (RREP). During route reply when more than one route replies are about to reach to source there are high chances that they create congestion at the last point. The congestion is a cause for possible collisions (Prakash *et al*., 2010). In order to reduce congestion, strategies were used such as including delay in RREP when it is one hop away from the source. But, this model consist numerous drawbacks including collision between route requests, rapid growth in the header size while routing messages between nodes.

Chansu and Lee (2011) proposed an energy efficient routing protocols for mobile ad hoc networks. The load distribution approach was implemented to balance the energy usage in the nodes and to increase the lifetime of the network by avoiding over-utilized nodes in the selection path It is stated that the most important issue in the MANETs is to provide energy efficient routes because in mobile nodes, operational time is the most critical factor

Garg and Mahapatra (2009) surveyed cluster based routing in MANET. A delay tolerant cluster based routing for Wireless Sensor Networks (WSN) consists of transceiver and mobiles. The sensed data must be transferred to sink, which act as base station. But the data cannot be directly transmitted to sink because transmission range of a mobile node is very short (Choukri *et al*., 2013). Thus the mobile nodes are grouped to form a cluster in which sensed data in a cluster get transmitted through a gateway node. This gateway node in turns transmits the data to the sink node. The mobile node should be grouped into cluster based on the mobility pattern. Delay may occur in the dynamic network due to lack of continuous communication between the mobile nodes (Sun *et al*., 2009). This delay can be eliminated by grouping the mobile nodes into clusters, based on its pair-wise contact probability. Cluster table is maintained for each node listing the cluster-id, contact probability and time stamp. The data can be transmitted through two phases. They are asynchronous and synchronous phase. In the asynchronous phase sender contacts its neighbor to identify the receiver, where in the next phase sender gain channel control and transmit its data to the receiver (Prakash *et al*., 2010). Cluster based hierarchical structure is used for collecting sensor related data to measured. The queue management scheme makes use of broadcasting the information only within the cluster.

Youssef *et al*. (2012) proposed a simulation analysis of routing protocols using manhattan grid mobility model in MANET. It describes the analysis of routing protocol with significant performance. Various mobility models are present for performing the evaluation such as Freeway Mobility Model, Gauss Markov Mobility Model and Reference point Group Mobility Model. Sun *et al*. (2009) proposed Fuzzy controller based QoS Routing Algorithm (FQRA) with a multiclass scheme for MANET. Fuzzy logic exploits uncertainty and partial truth while choosing nodes using simple linguistic statements and thereby achieves tractability, robustness and low solution cost. Non-QoS and the AODV need more time and more control overhead than the FQRA does to recover unreal paths and to discover new paths, creating a need for the new routing protocol to be implemented in MANETs. proposed a fuzzy C-means clustering scheme. They had formulated two types of clustering techniques fuzzy clustering and hard clustering. In the fuzzy clustering (Suhail *et al*., 2012) the node are divided into homogenous units so the items in the same class are as similar as possible and the items in the different classes are as dissimilar as possible and in this each point has a degree of belonging to the clusters. But in the hard clustering the node is divided into crisp clusters where each node exactly belongs to only one cluster. A pre-defined number of clusters and these clusters are represented by using a centre vector function.

MATERIALS AND METHODS

An energy efficient low-delay routing protocol for clustering based mobile ad hoc networks called Grover’s search based hybrid ad hoc routing protocol is proposed for enhancement (Meng and Song, 2013). The clustering is done using fuzzy C-means clustering algorithm which provides the energy efficient node convergence within the network (Agarwal and Motwani, 2009). Grover’s search is a hybrid scheme combining reactive and proactive approaches. Grover’s search algorithm aims at establishing the most stable path from a source to a destination in order to improve delay performance due to mobility factor. Grover’s search applies the path discovery mechanism between nodes that intends to limit flooding in the network and that filters the candidate paths as soon as possible according to the stability criteria. As stability is the most desired parameter, clustering based Grover’s search offers different mechanisms to provide an energy efficient routing along with path maintenance procedure whose complexity is reduced by the proactive nature of the routing algorithm within a zone. These procedures reduce the delay and packet loss that stems from mobility during data transmission. The cluster head is selected based on the energy level of the nodes.

Clustering: Fuzzy C-means clustering algorithm is applied to group the mobile nodes in the network which also considered energy efficiency for providing the optimal method of forwarding data packets between the source and the destination.

FCM allowed one node to belong to two or more clusters. It is based on minimization of the following objective function:

$$J_m = \sum_{i=1}^{N}\sum_{j=1}^{C} u_{ij}^m \left\| x_i - c_j^m \right\|^2, 1 \le m < \infty \quad (1)$$

Where:

m = Any real number>1

u_{ij} = The degree of membership of x_i in the cluster

j, x_i = The ith of d-dimensional measured distance

c_j = The d-dimension center of the cluster

||*|| = Any norm expressing the similarity between any measured node and the center

Fuzzy partitioning is carried out through an iterative optimization of the objective function shown above with the update of membership u_{ij} and the cluster centers c_j by:

$$u_{ij} \frac{1}{\sum_{k=1}^{c}\left(\frac{\|x_i - c_j\|}{\|x_i - c_k\|}\right)^{\frac{2}{n-1}}} \quad (2)$$

$$c_j = \frac{\sum_{i=1}^{N} u_{ij}^m x_i}{\sum_{i=1}^{N} u_{ij}^m} \quad (3)$$

This iteration will stop when:

$$\max_{ij}\left\{\left|u_{ij}^{(k+1)} - u_{ij}^{k}\right|\right\} < \varepsilon$$

Where:

ϵ = A termination criterion between 0 and 1

k = Tthe iteration steps

This procedure converges to a local minimum or a saddle point of J_m.

The algorithm is composed of the following steps:

Intialize $U = [u_{ij}]$ matrix $U^{(0)}$

At k step calculate the center vectors $C^{(k)} = [C_j]$ with $U^{(k)}$:

$$c_j = \frac{\sum_{i=1}^{N} u_{ij}^m x_i}{\sum_{i=1}^{N} u_{ij}^m}$$

update $U^{(k)}$, $U^{(k+1)}$:

$$u_{ij} \frac{1}{\sum_{k=1}^{c}\left(\frac{\|x_i - c_j\|}{\|x_i - c_k\|}\right)^{\frac{2}{n-1}}}$$

if $\| U^{(k+1)} - U^k \|$<then stop or otherwise return to step 2

Cluster energy analysis:

$$\text{Let } x = \{C_1, C_2, C_3, \ldots, Cn\} \quad (4)$$

Here x denotes the number of clusters available in the network.

Where:

$$Ci = \{n_1, n_2, n_3, \ldots, n_n\} \quad \text{where } i=1<i<n$$

In this each cluster contains a set of nodes. Total energy consumed:

$$ET = E_{idle} + E_{TX} + E_{RX} \quad (5)$$

Where:

E_{idle} = Energy Consumed when the node is idle

E_{TX} = Energy consumed during the transmission of packets

E_{RX} = Energy Consumed while receiving packets

Cluster head selection based on energy level:

$$CH_{Ci} = MAX[E(C_{nk})] \text{ ,Where } k=1<k<n \quad \text{Where } i=1<i<n \quad (6)$$

Grover's search mechanism: The main objective of the path discovery algorithm is to generate and select the most stable path between source and destination. Note that the stability is a concave function, and it is defined by the connection stability of a zone regarding its neighboring zone. Assume that a node say s wants to send data to its destination d. Before sending data to the node d, node s checks if node d exists in its intra-zone table. If so node s forwards the data towards node d according to its intra-zone table without any delay. We denote this case intra-zone routing. Otherwise, node d belongs to a different zone as node s, so that node s sends a path request PREQ to every other neighboring zone. We denote this case inter-zone routing.

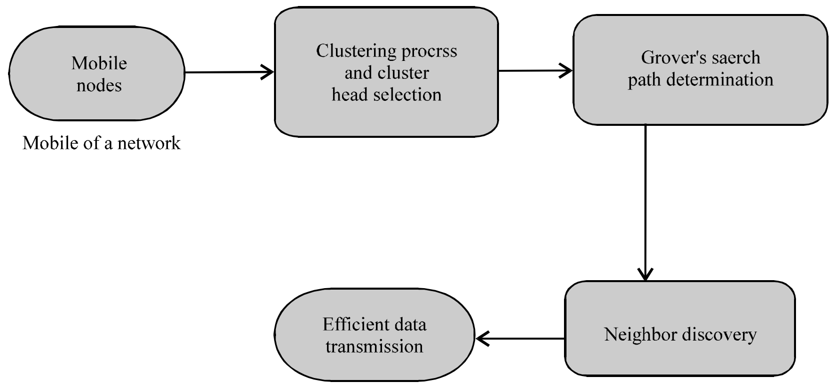

Fig. 1: Block diagram of proposed system

Grovers algorithm: Consider an unsorted database with Nentries. The algorithm requires an N-dimensional state space H which can be supplied by $n = \log_2 N$ qubits. Consider the problem of determining the index of the database entry which satisfies some search criterion. Letfbe the function which maps database entries to 0 or 1 where $f(\omega) = 1$if and only ifùsatisfies the search criterion. We are provided with (quantum black box) access to asubroutinein the form of aunitary operator, U_ω, which acts as follows (for theufor which $f(\omega) = 1$):

$$U_w|w\rangle = -|w\rangle$$
$$U_w|x\rangle = |x\rangle \quad \text{for all } x \neq w$$

The goal is to identify the index.

Algorithm steps:

- Initialize the system to the state
- Perform the following "Grover iteration" r(N) times. The function r(N) is described below
  - Apply the operator U_ω
  - Apply the operator $U_s = 2|S\rangle\langle S| - 1$
- Perform the measurement Ω. The measurement result will be λ_ω with probability approaching 1 for N>>1. From λ_ω, ω may be obtained. Our Initial state:

$$|S\rangle = \frac{1}{\sqrt{N}}\sum_x |x\rangle$$

Consider the plane spanned by |s> and |ω>. Let $|\omega^\times\rangle$ be a ket in this plane perpendicular to |ω>. Since, |ω> is one of the basis vectors, the overlap is:

$$\langle w|s\rangle = \frac{1}{\sqrt{N}} \tag{7}$$

In geometric terms, there is an angle (π/2-θ) between |ω> and |s>, where θ is given by:

$$\text{Cos}(\pi/2-\theta) = \frac{1}{\sqrt{N}}, \ \text{Sin}\ \theta = \frac{1}{\sqrt{N}} \tag{8}$$

The operator U_ω is a reflection at the hyperplane orthogonal to |ω>; for vectors in the plane spanned by |s> and |ω>, it acts as a reflection at the line through $|\omega^\times\rangle$. The operator U_s is a reflection at the line through |s>. Therefore, the state vector remains in the plane spanned by |s> and |ω> after each application of U_s and after each application of U_ω, and it is straightforward to check that the operator U_sU_ω of each Grover iteration step rotates the state vector by an angle of 2θ toward |ω>. The number of times to iterate is given by r. In order to align the state vector exactly with |ω> we need:

$$\frac{\Pi}{2} - \theta = 2\theta r \quad, \ r = \frac{(\frac{\Pi}{\theta} - 2)}{4} \tag{9}$$

However, r must be an integer, so generally we can only set r to be the integer closest to (π/θ - 2)/4. The angle between |ω> and the final state vector is O(θ), so the probability of obtaining the wrong answer is $O(1 - \cos^2\theta) = O(\sin^2\theta)$:

$$\text{For N>>1, } \theta \approx N^{-1/2}, \text{ so } \ r \rightarrow \frac{\Pi\sqrt{N}}{4}$$

Furthermore, the probability of obtaining the wrong answer becomes O(1/N) which goes to zero for large N. For any k, one of iterations will find a matching entry with a sufficiently high probability. The total number of iterations is at most:

$$\Pi\frac{N^{1/2}}{4}\left(1 + \frac{1}{\sqrt{2}} + \frac{1}{2} + ...\right) \tag{10}$$

Which is still $O(N^{1/2})$.

It is known that Grover's algorithm is optimal. That is, any algorithm that accesses the database only by using the operator U_ω must apply U_ω at least as many times as Grover's algorithm. The proposed scheme express in terms of network reliability, data collection quality and transmission cost. Packet loss is reduced and minimized to reducing energy consumption and achieving better network performance.

GROVER'S search aims at establishing the most stable path from a source to a destination in order to improve delay performance due to mobility (Fig. 1). GROVER'S search applies the path discovery mechanism between zones that intends to limit flooding in the network and that filters the candidate paths as soon as possible according to the stability criteria. As stability is the most desired parameter, GROVER'S search offers different mechanisms to provide energy efficient routing along with path maintenance procedure whose complexity is reduced by the proactive nature of the routing algorithm within a network. These procedures reduce the delay that stems from a energy consumption during data transmission.

RESULTS AND DISCUSSION

The proposed scheme has been implemented in Network Simulator (NS2). The main objective of the simulation was to enhance energy efficiency to increase the network lifetime. Total 100 nodes were randomly deployed in a 1000×1000 m area of interest. The transmission range of the node was 50 m and initial energy is assigned with 100 joules. Nodes followed the random waypoint model that finds the availability of connection paths in MANET. The proposed schemes also evaluated by comparing it with the related TOHIP and SRP protocols in terms of the packet delivery ratio, energy consumption, throughput and routing overhead. The simulation results were studied by varying the network size from 50-100. The proposed system considered the following metrics packet delivery ratio, Throughput, Routing over head, End-to-end delay, total energy consumption and packet loss. Figure 2 mentioned figure represents the formation of clusters with a set of nodes and in this the node with higher energy is elected as the cluster head using FCM algorithm. They transmit packets among the nodes to the destination based on selected optimal route.

Figure 3 shows that based on the variation in the energy level the cluster head changes and transmit the packets without causing any delay in the transmission. Optimal path is selected for transmission of packets using Grover's search algorithm and by this we have increased the energy efficiency and extended the network life time.

Remaining energy level comparison: In the energy level consumption, the proposed Energy efficient Grover Routing Protocol (EGRP) consumes less energy and performs efficiently when compared with other protocols such as CBRP, DSR and GROVER. Here, the EGRP protocols total remaining energy level is 97.5 J whereas the Grover's energy level is 97 J and the CBRP energy level is 95.6 J and finally DSR ends with energy level of 94.7 J. The EGRP consumes less energy compared by finding the optimal path using Grover's searching algorithm (Fig. 4).

Packet deliver ratio: The packet delivery ratio is defined as the ratio of data packets received by the destinations to those generated by the sources. The below graph shows a comparision betweeen the routing protocols on the basis of packet delivery ratio as function. The proposed EGRP protocol provides high PDR by delivering 97 packets/25 sec. When compared with GROVER it delivers 95 packets/25 sec, DSR it delivers 65 packets /25 sec and CBRP it delivers 75 packets/sec.The high PDR is obtained with EGRP protocol due to the integrity of Clusters using fcm clustering method which prevents failure in the transmission of packets between the nodes in the network (Fig. 5).

Network life time: Network life time generally deals with total energy that involves within the network until the entire transmission is being carried out. In this each node loses energy based on transmission ,here in this the proposed EGRP protocol is less energy consumption protocol compared with GROVER, DSR and CBRP. The EGRP protocol consumes less energy as the optimal path is selected with only the nodes which has high energy in the clusters (Fig. 6).

End to end delay: It generally describes over the general delay that occurs in delivering the packets to the destination to those generated by the sources. Here in this the delay is less in the EGRP protocol is 6.9 ms whereas in GROVER it is 8.3 m sec ,CBRP it is 11.1 m sec and in DSR protocol is 21.8 m sec. The delay in EGRP protocol is less because the cluster head with optimum energy is selected using Grover's searching algorithm which lessens the end to end delay during transmission of data packets (Fig. 7).

Total energy consumption in clusters: In this we define total energy consumption among various clusters where the energy consumed is relatively less during the transmission of packets by our proposed EGRP protocol, the average energy consumed is 3.3 J (Fig. 8).

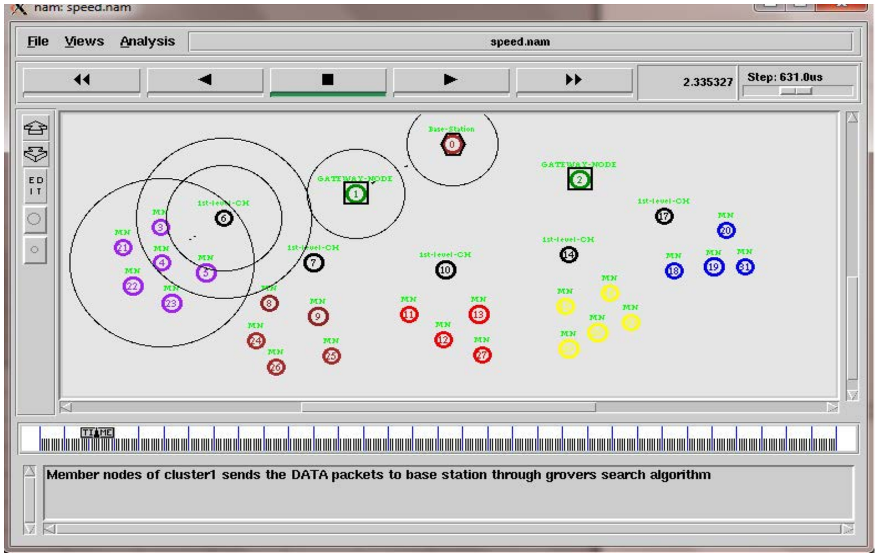

Fig. 2: Formation of clusters and selection of cluster heads

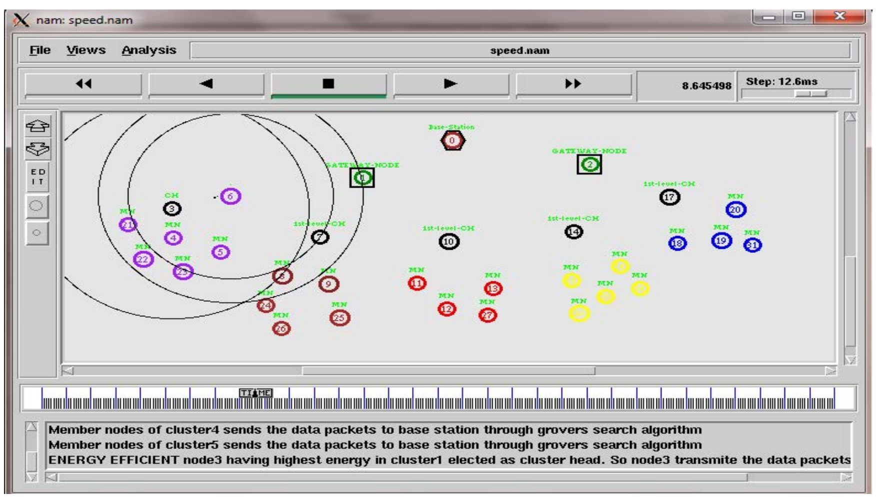

Fig. 3: Selecting cluster head based on the nodes energy level

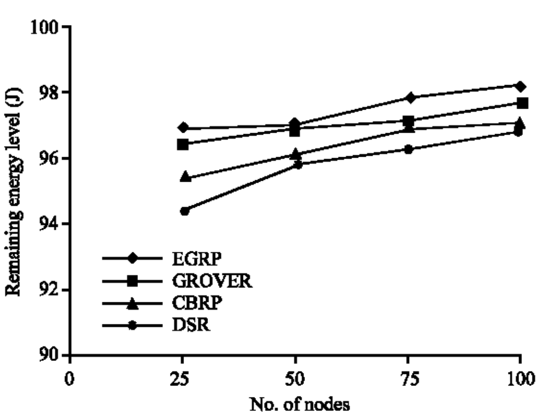

Fig. 4: Remaining energy level comparison consumption

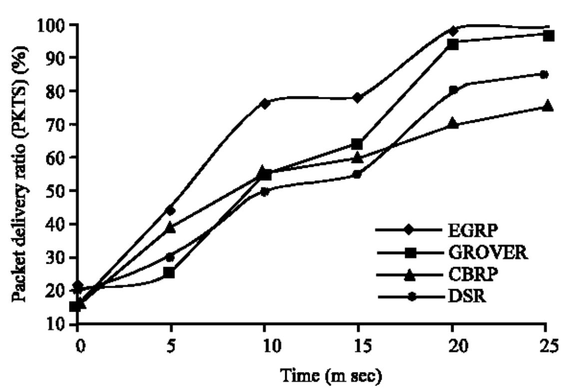

Fig. 5: Packet deliver ratio comparison between the protocols

Table 1: Performance analysis of EGRP ,GROVER, CBRP and DSR

Metrics	EGRP				GROVER				CBRP				DSR			
No of nodes	25	50	75	100	25	50	75	100	25	50	75	100	25	50	75	100
PDR (Packets/sec)	97.0	95.4	93.7	92.5	95.0	93.0	91.8	90.5	75.0	74.4	72.4	69.5	65.0	63.7	59.5	57.2
Tre (J)	99.0	98.3	97.5	92.5	97.3	96.8	95.3	91.5	95.3	93.2	91.3	89.6	87.0	81.6	81.8	81.5
N/W life time (J)	99.5	98.3	97.9	97.3	97.3	97.1	95.8	95.1	95.2	91.2	89.2	88.7	88.4	87.5	84.5	81.4
End To End Delay (m sec)	4.9	6.9	6.9	6.9	4.4	7.4	7.7	7.7	7.9	8.9	9.1	9.1	13.8	21.8	21.7	21.7
Total cluster energy (J)	2.7	3	3.3	3.4	2.9	3.4	3.5	3.8	4	4.1	4.1	4.1	4.5	4.8	4.9	4.9

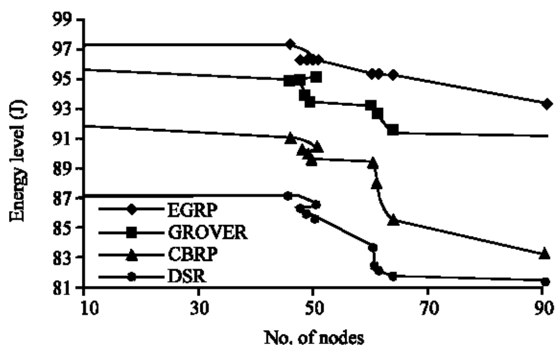

Fig. 6: Network lifetime comparison of various protocols

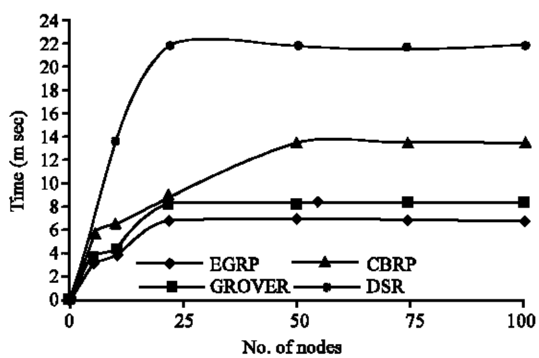

Fig. 7: End to end delay analysis

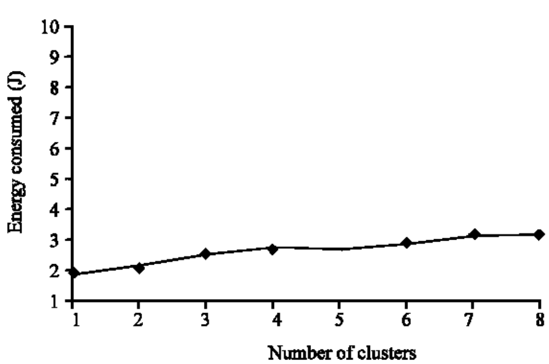

Fig. 8: Total energy consumption in clusters

Table 1 shows the performance analysis of EGRP, GROVER, CBRP and DSR in terms of PDR, energy network lifetime and end-end-deley. The simulations given the following results that is clear that the EGRP protocol provides higher efficiency in all compared scenarios.

CONCLUSION

The proposed system presents a distributed Grover's search hybrid ad-hoc routing protocol for quality of service support in mobile ad hoc networks, which mitigates disruption time under network mobility and also minimizes the packet loss and delay. This handles the nodes stability during data transmission and performs the reliable data transmission in efficient manner and also reduces the packet loss compared to other proactive and reactive routing protocols. Also, the use of energy efficient clustering provides way for optimum network paths for forwarding of data packets. The route searching process can converge quickly using this kind of unitary transformation. Simulation results showed that compared with DSR, in the case of limited node transmission power, the new routing protocol can effectively reduce the network delay, significantly reduce the number of routing hops and minimize the network BER to a certain extent.

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