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Energy Aware on Demand Routing for MANETs based on Intermediate Node Residual Status

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Abstract: MANETs (Mobile Ad-hoc Networks) are self-configuring network that comprised of mobile nodes having no fixed infrastructure. These devices are dynamic and move freely so that they form varying network topology. The challenge for successful communication is to form an appropriate route to maintain connectivity consistently between mobile nodes having limited battery power. Therefore, MANETs need to have improved network lifetime to perform a streamlined and dynamic routes between multiple mobile nodes. This research focuses on designing a protocol for MANETs which is energy efficient and congestion avoidance between mobile nodes. In this mechanism, two important attributes, i.e., link stability and network lifetime are addressed. We used NS-2 Network Simulator to analyze the performance. The outcome of this simulated demonstration that developed energy aware mechanism is better than the existing EDDSR, MDR and LEAR routing protocols.

Key words: MANETs, node, network lifetime, link stability, routing, LEAR

INTRODUCTION

MANETs (Muhammad *et al*., 2015) (Mobile Ad-hoc Networks) are self-configuring and infrastructure less networks that comprises of a set of mobile nodes forming peer-to-peer communications. The network topology of MANETs is autonomous, dynamic and consisting of number of intermediate mobile nodes between communicating peer nodes. Each node in a network has to act as a source, receiver and router to forward the packets. MANETs have many applications such as environment monitoring, wireless sensor network, military and law enforcement. These applications need to be cost and/or time effective. Communicating nodes in MANETs depends upon intermediate nodes for communication when they are not in radio range of each other. Moreover, forwarding packets by other nodes consume resources of node particularly energy. The primary issue in MANETs is availability of limited power as they are powered by batteries that have limited lifetime.

Mobile nodes are equipped with batteries that have a limited amount of power and lifetime. These batteries cannot be recharged or replaced during the mission and hence, energy management is considered as a necessary factor. The nodes consume the energy during data reception, data processing and data transmission. MANETs consist of single and multiple communicating entities have peer-to-peer connectivity and are required to route the traffic properly. To improve the performance of communication and lifetime of network, we need to design a routing mechanism in such a way that the packets are routed with minimum energy consumption and based on energy awareness of nodes. One of the important goal of routing in MANETs is to create a cost optimum as well as energy efficient path. Hence, we chose energy aware routing as the best procedure of managing the energy in Mobile Ad-hoc Networks. However, properties and resources of MANETs make this task more challenging. To solve the issues of energy management, in literature many routing protocols have been put forwarded. These protocols were broadly classified into three categories:

- Energy efficient routing path
- Reliable routing path and
- Routing path with higher energy nodes

The protocol designed based on energy efficient routing path concentrates on reduction of energy usage during transmission and reception to minimize the amount of energy required for communications by the mobile nodes present in a network. This goal is achieved either by reducing the energy consumption when the nodes are in idle state or by minimizing the amount of energy required for packet delivery. A routing path with higher energy nodes has the protocol that uses higher energy nodes to find the routes whereas a reliable routing path has the protocol that detects the route according to

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anticipated energy count. To recover from packet loss, this type of link routing used a concept of minimum amount of retransmission. Each protocol has its own merits and demerits and accordingly it is judged which protocol is suitable for a specified network condition.

In order to deep analyze the routing protocols performance, network condition is divided into categories and then the performance of different routing protocols is analyzed and compared. Researchers can have an effective use of the results produced in our project for their experimentations. Though in literature various researchers carried out a lot of analyses and research to contrast the routing protocols for energy management, this project has a new technical performance system such as forwarding packets from various sources through conversion of node into bottleneck intermediate node, which is one of the best procedure in assessing the multi-hop environment routing protocols for energy management. This system of performance analysis is an innovative feature of this study.

In the first part of our study, the state of the art analysis of proactive and reactive routing protocol performances such as DSDV (Moravejosharieh *et al*., 2013), AODV (Chaubey *et al*., 2015) and DSR are defined. For a particular network condition, it is difficult to judge which mechanism is suitable for routing protocols. Thus, we divided the network condition into broader categories and then compared the different performance systems by analyzing routing protocol performances with various network conditions with mobility considerations such as variable radio area, variable packet size and variable hop-count. The outcome of this analysis can be used by the researchers in their experiments. Ultimately, we considered DSR to be the best suited to develop a routing protocol in MANETs energy efficiency. Due to heterogeneous mobile nodes batteries with limited power, energy efficiency is a necessary issue in designing of MANETs. It is essential to have reduced amount of energy consumed during wireless communications. If the routing protocol does not consider the power required and relies upon shortest path, then the affect is caused on the lifetime of network by power failure of a node. The goal of energy efficient routing protocol is to find the route that consumes minimum amount of energy during end to end packet travelling as well as to make residual energy of a node and have reliable routing through links. This improves the network lifetime as well as the overall performance. Therefore, a routing protocol is still required to address these issues in MANETs.

In second part of our study, we designed "Energy aware routing for MANETs based on a current processing state of Node". In this protocol, we make use of DSR to achieve energy efficiency. DSR (Dynamic Source Routing) is a protocol that stores all nodes from source to destination. It is a source initiated protocol similar to "AODV" protocol. Proposed work enhances DSR protocol to improve network lifetime and to reduce routing cost upon mobile networks. Though the researchers carried out a lot of experiments and thesis for the development of energy efficient routing protocols with different performance analyses, our research has a new technical performance system which makes nodes possible to become a "Bottleneck node". It is the mediator condition for forwarding the traffic through intermediate node. Hence, we create a routing process to avoid the node to become "Bottleneck node" which results in improvement of performance and lifetime of a network.

Routing in manets: According to literature review of routing in MANETs, it seems more challenging over infra-structured networks. The literature shows a lot of routing protocols that were developed with extra attempts to manage the attributes of MANETs environment. The work of routing in MANETs is more taxing by the limiting factors such as mobility, heterogeneity and dynamic network topology. In most of the existing protocols, there are different patterns of designs that are followed by MANETs according to reactive and proactive approaches. In proactive routing protocols, the nodes are allowed to have a clear vision over the network topology. Therefore, all nodes in traffic can be routed quickly and properly. An extra overhead is made by periodic messages. DSDV, ABR and OSLR are the few examples of proactive routing (Mohammad *et al*., 2015; Varshney *et al*., 2016; Chaubey *et al*., 2015; Moravejosharieh *et al*., 2013; Dulman *et al*., 2003).

The reactive or source initiative routing follows on-demand approach and is an alternative to proactive routing mechanism. The establishment of route occurs only when there is a transmission or communication between a source and a destination. The route request function of source node follows a route reply function of a destination node to initiate the route. The route maintenance function maintains the initiated route till it is required. AODV and DSR are the examples of reactive source initiative routing protocol.

The DSR protocol is similar to AODV protocol which forms a route when it is requested by a transmitting node but instead of depending upon a routing table, DSR protocol uses source routing. In DSR protocol, the complete path is discovered by the sender of the packet through which the packets are forwarded. This route is listed in the packets by the sender which takes the address of next node to identify each hop to be forwarded through which the packets are transferred to the destination host. The performance of DSR routing protocol is better than that of AODV and DSDV protocol. Unlike table driven approach, DSR uses a reactive approach to avoid the need to flood the network periodically through the table update messages.

Need of energy awareness in MANETs: The battery power of mobile nodes is finite in MANETs. MANET's properties are highly suitable for various applications like disaster recovery and battlefield but recharging and changing of batteries looks very difficult. After losing the power completely, nodes cannot be used further for communication as they are removed from the network. In MANETs, it is necessary to manage the energy because it is difficult to change or substitute the battery, shortage of central coordination, peer to peer characteristics network and finite energy storage. The utilization of active energy in MANETs occurs through packet communication such as packet reception and packet transmission. Inactive utilization of energy occurs through rest state of node but as they are listening medium they can respond to any feasible communication requests by other nodes and it utilized the energy when the node is at rest. Most of the researchers developed the routing protocols such as correct path between source and destination, simply based on energy efficient beside this they are also developed the energy management as they can provide the network functions for a longer time.

Literature review: In the first stage of our research, we have done the analysis of performance of DSDV, AODV and DSR concerning radio area, traffic mobility and hop count regarding variable packet size. Performance of this routing protocol is analyzed based on reactive and proactive approach. The simulator used for calculating the performance of DSR, AODV and DSDV is NS-2 Network Simulator in terms of throughput, packet loss and end to end delay. The outcome of this simulation shows that DSR performance is slightly better than AODV and DSDV, which is shown in Fig. 1-5.

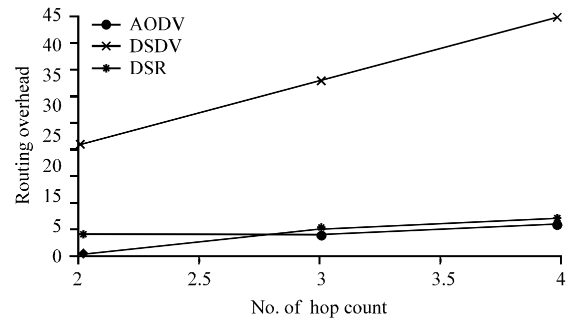

Fig. 1: Routing overhead comparison of routing protocols (AODV, DSDV, DSR)

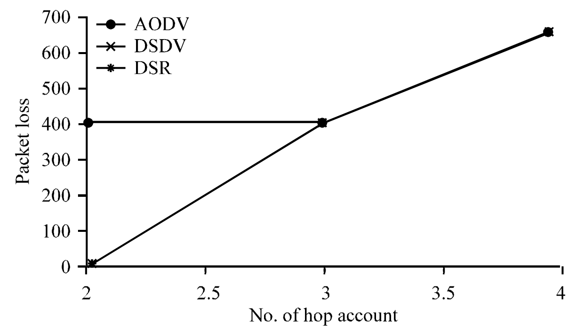

Fig. 2: Packet loss comparison of routing protocols (AODV, DSDV, DSR)

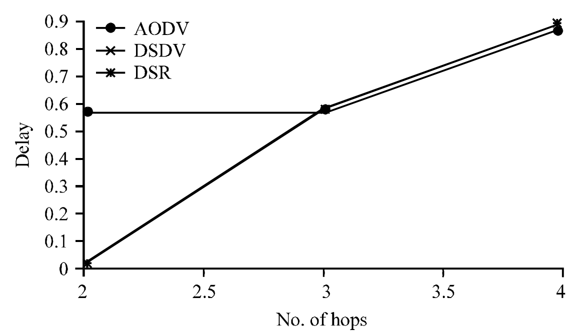

Fig. 3: End to end delay comparison of routing protocols (AODV, DSDV, DSR)

DSR based energy efficient routing: We have done literature review on DSR based energy management routing protocols as its performance is better than other routing protocols such as AODV and DSDV. In Dynamic Source Routing (DSR), the complete system of nodes is carried by each data packet which needs to be passed to reach the destination. DSR is based upon the process route discovery and route maintenance. A Route Request (RREQ) is broadcast by a node in the process of route discovery. After reaching the destination or intermediate node, RREQ process is terminated and Route Reply (RREP) is sent back to the source. The source node uses the route from RREP to transmit the packets towards the destination. A broken link or a link in disconnection is detected by route maintenance process which sends the Route Error packet (RERR) to the source. The source discovers a new route towards the destination and deletes the broken link from its cache.

To estimate the lifetime of a node, a new cost function is described by the Minimum Drain Rate (MDR)

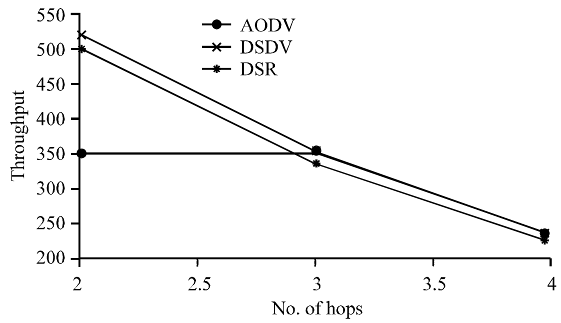

Fig. 4: Throughput comparison of routing protocols (AODV, DSDV, DSR)

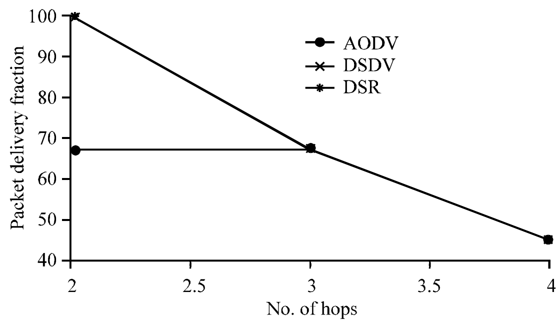

Fig. 5: Packet delivery fraction comparison of routing protocols (AODV, DSDV, DSR)

mechanism. The cost function is based upon the conditions of traffic load and battery power (Woo *et al*., 2001; Vazifehdan *et al*., 2014). MDR is fully based upon source-destination based mechanism. Only the source or destination makes decision during transmission and intermediate nodes can piggyback their current costs through the messages in routing.

To distribute the packets to all energy-rich nodes, the "Local Energy-Aware Routing" (LEAR) is introduced. A node discovers a node only when its current amount of energy exceeds a specific threshold. Otherwise, it creates a message known as Drop Route Request (DR- REQ) and drops Route Request (RREQ). RREQ reaches the destination node only when it passes through all intermediate nodes with sufficient amount of energy. If RREQ does not reach the destination, then the source does not receive RREP from the destination. It then starts a second attempt to discover a route towards destination.

A route cache is used in this protocol where an intermediate node generates a message known as Route Cache (RCAC) and sends towards a destination. The destination node responds either to first route request or to route cache and ignores all the other messages. Route cache will be replied only when power is above specific threshold. Otherwise Drop Route Cache (DR-CAC) or

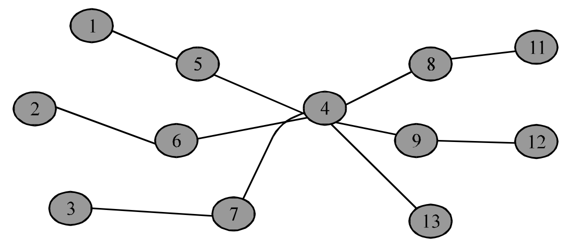

Fig. 6: Scenario of node to become bottleneck

Cancel Route Cache (CR-CAC) is replied to the node which sends route cache. The node then attempts to discover the other paths after getting next route request.

However, all the above discussed protocol does not concentrate the issue of node to become bottleneck. It is a situation in the network where multiple source node forwarding the packets through an identical intermediate node. If node receives the packets greater than its resource capacity of handling packets, then packets get drop from intermediate node and if this situation continue for some extend may cause complete network to congestion (Mohammad *et al*., 2016a, b). Bottleneck intermediate node is shown in Fig. 6.

MATERIALS AND METHODS

Proposed energy aware routing protocol: The Energy Dependent DSR (EDDSR) mechanism is proposed which can be used in the route discovery process of DSR. We devised a new mechanism whose aim is to increase the lifetime of node with low amount of energy stored. In this mechanism, each node shows its readiness to forward packets according to its current energy level. Each node in the medium calculates its Residual Battery Power known as "RBP_i". If RBP_i is lower than the specific threshold, then the rebroadcasting of RREQ by a node is delayed. If residual power of a node is enough, then it behaves as a DSR nodes and proceeds its network activities.

A predicted node lifetime n_i is described by the ratio RBP_{i}/, DR_i in which RBP_i represents residual battery power and Dr_i represents drain rate which described the amount of energy consumed per second.

In EDDSR mechanism, the nodes with shorter lifetime are prevented from route discovery process to increase their lifetime. Therefore, the route requests sent by a node having small lifetime will be cancelled by the nodes closer to destination. RERR packets are sent to the sourc to inform the source when the energy of a node is below critical levels. EDDSR mechanism finally uses RCAC as suggested by Local Energy-Aware Routing (LEAR) protocol. Hence, the behavior of intermediate nodes with RRCAC message is similar to RREQ.

We proposed a new mechanism called as "Energy Aware Proactive Routing for MANETs based on intermediate node current condition" to find the energy aware route from source to destination. We named it as EDDSR as it is extension of existing DSR routing protocol with energy awareness. In proposed algorithm, a route is selected according to "Contemporary Processing State" of an intermediate node to achieve extended network lifetime and link reliability in terms of node's input buffer and residual energy. A major handout over the work proposed is classified as follows:

- Energy required to process K Kilobytes of packets through an intermediate node
- Current Processing State (CPS) of node in terms of energy and its input buffer traffic
- Priority of node by describing value of threshold
- Selecting path of route according to priority of a node

When threshold condition is satisfied by a node in terms of energy, then it can participate in routing. The information processing capability optimizes the metric node based on residual energy and current traffic to prevent the node from becoming a bottleneck. In DSR protocol, it uses first priority message of a node to discover an optimistic route.

To calculate the CPS (Contemporary Processing State) of a node in terms of input buffer traffic and energy consumed, consider a node N_x having energy E_x in joules and B as buffer in kilobytes which must process the x kilobytes of packets in a present state.

Consider a packet termed as K_x which requires energy e_x joules of energy and buffer space b kilobytes to process from an intermediate node. To calculate the contemporary processing state, we need to calculate subset of packets so that firstly, all communication packets are combined with size in bytes at the most of energy E_x in joules. Secondly, a sufficient amount of packets must be processed by an intermediate node in a contemporary state and also, part of the packets must not be processed. To successfully process packet K_x, a node need to consume the energy $e(K_x)$ within multi-hop mobile ad-hoc network environment and it is computed by the equation given:

$$e(K_x) = T(K_x)+R(K_x)+D(K_x)$$

Where, $T(K_x)$, $R(K_x)$ and $D(K_x)$ send, receive and process node energy which needs to be sent, received and processed in K_x Kilobytes of packets through an intermediate node.

For calculation of the Contemporary Processing State (CPS) of a node according to energy and input buffer traffic, the data packets need to be processed through an intermediate node N_x in kilobytes (where x = 1, 2, 3, ...). The packets need to be processed completely because partial processing of packets impossible. N-Topples with positive values are considered as given below: number of packets for processing N_x from a given node is in K_x (Kilobytes where x = 1, 2, 3). E (K_x) is the energy required by a node for processing of packet K_x.

Now, we use Knapsack algorithm design in two-dimensional arrays to get optimal results. The equation is as follows:

$$S[0,..., n, 0...e_x] 1 \leq x \leq n \forall \text{ and } 0 \leq e(K_x) \leq e$$

Where, $SS[T(K_x), e_x]$ processes maximum number of packets with "K_x" Kilobits of data (where x = 1, 2, 3, ...,) (Algorithm 1).

Algorithm 1; the algorithm calculates contemporary processing state of a node:

```
S[0, e(kx)] = 0                                  0≤e(kx)≤ex
no packet process through the node
S[x, e(kx)] = ∀-∞e(kx)< 0, illegal condition
Optimization as:
 S[i,e(kx)] = max(S[x-1,e(kx)],      Sx+S[x-1,e(k)-e(kx)])  ∀  1≤I≤x  and
0≤e(kx)≤ex
```

We designed an algorithm for calculation of contemporary processing state of a node. Our protocol is based upon DSR but we use CPS as route selection metric instead of hop count. Each node has to calculate the value of CPS in a network and the rest of mechanism follows DSR protocol (Algorithm 2).

Algorithm 2; for proposed protocol:

```
    Step 1.: ( loop, initialization )
        for e(ky)←0 to ey till node energy
          set S[0,e(ky)]←0
    Step 2.: (loop)
for y←1 to m (set number of packets)
          set S[y,0]←0
Step 3.: (loop inspecting the packet to process or not)
        for i←1 to m
        for e(ky)←0 to ey
        if(e(ky))←0 to ey(then packets can be processed by a node)
    if (ky+S[Y-1,e(ky)-ey]>S[Y-1,ey]) then
        set S[Y, ey]←ky+s[Y-1, ey]-ey
        else
        set S[Y,ey]←s[Y-1,ey]+(e(ky)>ey)
    Step 4.: (finish)
        Exit
```

RESULTS AND DISCUSSION

Performance evaluation of proposed protocol (MDDSR): After calculating the EDDSR mechanism, we have compared this with LEAR, MDR and pure DSR in a

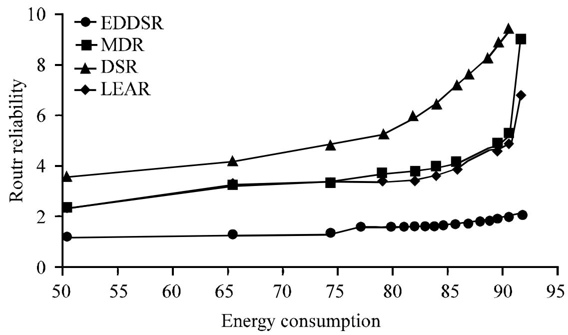

Fig. 7: Routing reliability comparison between proposed and existing mechanisms

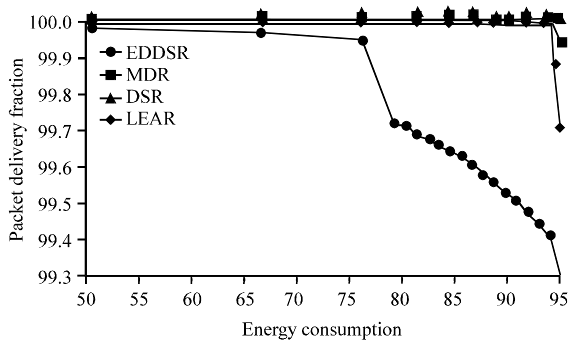

Fig. 8: Packet delivery fraction comparison between proposed and existing

Table 1: Simulation parameters

Parameters of network	Values
Time for simulation	300 (sec)
Total number of nodes	10-100
Type of link layer	Logical link
Type of MAC layer	802.11
Type of radio propagation	Two-ray ground
Type of queue	Drop tail
Node's initial enargy	15 Joules
Range of transmission	250 m
Antenna	OMNI antenna
Receiving and transmission power	350 and 650 MW
Routing protocol	DSR
Traffic	FTP, CBR
Network area	500×500 m
Type of mobility	Random wave propogation

scenario of sparse and dense network; we compared four mechanisms with respect to energy parameter. Moreover, our main focus is to compute node life time, i.e., due to lack of battery capacity it takes some time for a node to stop working. The network parameters consider in our simulation shown in Table 1. To investigate the overheating effects, we consider the energy cost and repeat all the simulations because of overheating activities.

Figure 7-9 compares number of nodes died over time after the capacity of a battery expires in a static network

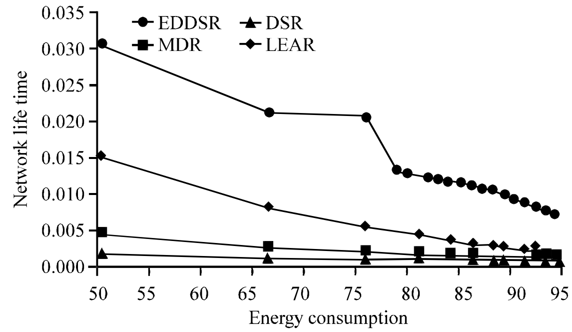

Fig. 9: Network lifetime comparison between proposed and existing mechanisms

environment. All protocols have a similar behavior but there is a slight amount of improvement found in EDDSR when simulation ends. This attitude is because of use of EDDSR rerouting techniques which helps us to avoid using a node with a weak battery.

When we consider overheating activity, balancing of energy consumption by the power aware algorithm fails because of large amount of energy consumed during overhearing activities.

In dynamic network scenario (Siddiqua *et al*., 2015), EDDSR and MDR outperform DSR. In addition, DSR consumes large amount of energy because of routing activities and the LEAR mechanism induces a large amount of energy consumption. This effect occurs due to frequent use of process of route discovery which uses DDREQ packets sent by broadcasting.

The perspective of MDR and EDDSR seems to have a better outcome from the mobility of a node which allows new routes after breakage of route. Therefore, EDDSR and MDR are able to balance the utilization of node and energy consumption accordingly. MDR is independent of the route cache and it has the capability to acquire fresh routes through periodical initiation of route discovery procedure. These routes reflect the node's residual power as well as the actual topology which removes the overhead caused due to route discovery. EDDSR does not allow an intermediate node to send RREP consisting an invalid route towards the source. In a manner of this appreciation, we also observed a small amount of expenditure of routing energy for both mechanisms.

CONCLUSION

In this research, we proposed a Energy Dependent DSR (EDDSR) method to improve energy efficiency in MANETs. Initially we compared the basic routing algorithms of MANETs designed based on hop count routing metric, through simulation we conclude that DSR is best suited protocol for achieving energy efficiency as it is designed based on demand source initiative mechanism. Thus, we developed a on demand reactive energy dependent routing based on DSR. Through simulation, we conclude that our proposed work out perform with respect to energy efficiency parameters.

LIMITATION

The proposed on-demand routing protocol considers only few parameters in routing like energy, congestion control and neglects other parameters of QOS.

SUGGESTION

In future another on-demand routing protocol can be designed which considers other parameters of QOS also.

REFERENCES

Chaubey, N., A. Aggarwal, S. Gandhi and K.A. Jani, 2015. Performance analysis of TSDRP and AODV routing protocol under black hole attacks in MANETs by varying network size. Proceedings of the 5th International Conference on Advanced Computing and Communication Technologies, February 21-22, 2015, Rohtak, India, pp: 320-324.

Dulman, S., J. Wu and P. Havinga, 2003. An energy efficient multipath routing algorithm for wireless sensor networks. Proceedings of the IEEE International Symposium on Autonomous Decentralized Systems, April 9-11, 2003, Pisa, Italy.

Mohammad, A.A.K., A. Mirza and M.A. Razzak, 2015. Reactive Energy Aware Routing Selection Based on Knapsack Algorithm (RER-SK). In: Emerging ICT for Bridging the Future-Proceedings of the 49th Annual Convention of the Computer Society of India CSI, Satapathy, S., A. Govardhan, K. Raju and J. Mandal (Eds.). Springer, Berlin, Germany, ISBN: 978-3-319-13730-8, pp: 289-298.

Mohammad, A.A.K., A. Mirza and S. Vemuru, 2016a. Analytical model for evaluating the bottleneck node in MANETs. Indian J. Sci. Technol., 9: 1-6.

Mohammad, A.A.K., A. Mirza and S. Vemuru, 2016b. Cluster based mutual authenticated key agreement based on chaotic maps for mobile ad hoc networks. Indian J. Sci. Technol., 9: 1-11.

Moravejosharieh, A., H. Modares, R. Salleh and E. Mostajeran, 2013. Performance analysis of AODV, AOMDV, DSR, DSDV routing protocols in vehicular ad hoc network. Res. J. Recent Sci., 2: 66-73.

Siddiqua, A., K. Sridevi and A.A.K. Mohammed, 2015. Preventing black hole attacks in MANETs using secure knowledge algorithm. Proceedings of the 2015 International Conference on Signal Processing and Communication Engineering Systems (SPACES), January 2-3, 2015, IEEE, Guntur, India, pp: 421-425.

Varshney, P.K., G.S. Agrawal and S.K. Sharma, 2016. Relative performance analysis of proactive routing protocols in wireless ad hoc networks using varying node density. Invertis J. Sci. Technol., 9: 161-169.

Vazifehdan, J., R.V. Prasad and I. Niemegeers, 2014. Energy-efficient reliable routing considering residual energy in wireless ad hoc networks. Mobile Comput. IEEE. Trans., 13: 434-447.

Woo, K., C. Yu, H.Y. Youn and B. Lee, 2001. Non-blocking, localized routing algorithm for balanced energy consumption in mobile ad hoc networks. Proceedings of 9th International Symposium on Modeling, Analysis and Simulation of Computer and Telecommunication Systems, August 15-18, 2001, Cincinnati, OH., USA., pp: 117-124.