An Energy Efficient Routing based on Route Segmentation in Mobile Ad Hoc Network

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Abstract

Mobile Ad hoc networks based communication is one of an essential form of today's technologies which is highly effective in an emergency need. The feature of infrastructure independence makes it highly useful and versatile all kind of wireless communications needs. But the insufficiency of resources availability degrades its performance and stability of the network. Energy is the vital resource in MANET, as it makes a node to live and retain in-network for longer, which provide better network stability, scalability, and throughput. In this paper, we propose an energy efficient routing based on route segmentation mechanism (EER-RS) for energy saving in the high scalable network. It presents a lightweight route segments energy prediction algorithm to predicts the optimal energy efficiency path for data routing. We evaluate this mechanism in a high scalable network and the obtained results show an improvisation with 40 to 60 percent less energy consumption than traditional AODV and other compared protocol.

Index terms — AD hoc network, energy efficiency, route segmentation, scalability.

1 I. Introduction

n the today's activities, rapid utilization of wireless communication is common. The availability of service like Wi-Fi, hotspots in public places makes it more efficient and scalable. These services are well stabilized for a fixed infrastructure based networks but in the case of a mobile ad hoc network (MANET), it is highly unstable due to its frequent changing network topology and absence of infrastructure. In MANET each node operates as routers to forward packets to other mobiles nodes which are in their transmission range. It creates a good amount of overload over the nodes and high and quicker energy loss. In a practical scenario, the batteries can be recharged or replaced but quicker exhaustion may lead to network partitioning due to poor connectivity range. To ensure a better energy efficient routing new routing mechanism is needed in a scalable environment.

MANET is a very dynamic and uncertain environment due to "frequent topology", "data traffic load", "bandwidth" and "energy resources" change often.

On the other hand, possible routing information is undecided and deficient because of MANET dynamic and distributed organization. To make certain highquality network performance, the routing protocol have to need to modify the routing strategy dynamically to account the transform in network situations. That is, the routing protocol for the MANET must adapt for different contexts such as mobility, traffic, energy utilization [1], [2], [3].

Routing at all times been one of MANET's key challenges and has become difficult as the size of the network grows. Various routing protocols for MANET have been proposed in [4], [5], [6], [7] and these protocols can be classified into dissimilar type according to diverse standard. Routing protocols can be cluster into "proactive" and "reactive" protocols if they are categorized in a manner that corresponds to network topology changes. The reactive routing protocol works well on small networks with hundreds of nodes. However, as the network develops due to "routing overhead" and "high energy consumption" its performance degrades rapidly. "Clusterhead-Gateway Switch Routing" (CGSR) [12] is a proactive routing protocol that separates the network into segments that are in rounded areas with a predefined number of hops. Later the network is partitioned into segments, the local route maintenance doings without affects the adjacent segment, but the other segments are not affected. Therefore, scalability is achieved.

However, as the network develops, the path among the source and target node happen to longer. When a route is interrupted because of "node mobility" or "node failure", reactive routing protocols such as "DSR" and "AODV" normally reject the main complete route and start one more route discovery to create a fresh route from the source to the target node. If the path is broken, only have some hops are usually corrupted, but the previous hops are not corrupted. Therefore, this methodology desecrates knowledge of the unique route and can result in considerable overhead and energy loss in discovering the new route.

In DSR, the source route transmits in data packets can source of considerable overhead in large networks with longer routes. The "Internet draft of DSR" [8] describes that DSR is appropriate for "MANET up to 200 nodes". In "DSR" [8] and "AODV" [9], if a path is lost due to "node mobility or node failure", then the failure path is deleted and a new path is found from the source to the target node. The "Scalability" and "performance" issues can arise in large networks. To defeat this problem in this paper, we propose an energy efficient routing solution based on route segment to support high scalability routing through effectively managing the energy consumption in route segments for active routes from source to the target node.

The following paper organized as follows. Related works are discussed in section-2, the proposed energy efficient routing based on route segment is presented in section-3, the experimental work and result in the analysis is presented in section-5 and section-6 presents the conclusion of the paper.

2 II. Related Works

This section illustrates the main tasks associated with energy efficient routing in MANET. Developing energy efficient routes is a challenge in mobile ad-hoc networks. The existence of an active route depends on the lifetime of each individual node in that route. If all nodes in the path die due to energy shortage, the path between all target node pairs is considered an invalid path [17]. To overcome the problem, the routing protocol must recognize the "residual energy". Making sure of the proper use of network resources throughout routing is a difficult assignment which needs to address [11], [13], [21].

Much research has been completed in the previous years, and the authors have attempted to extend an energy-efficient path based on "load balancing" [14], [15], [16], [27]. To enhance network life span, a "cross-layer load balancing algorithm" for DSR (CLB-DSR) has been proposed to stabilize the load among the "data link layer" and "the network layer". "CLB-DSR" can exchange information among this layer to properly handle the load, thus minimizing network energy consumption [25], [26].

The author [18] tailored the original DSR protocol and proposed a "Power-Aware Dynamic Source Routing" approach. When the energy level of a node exceeds a predefined threshold, the node broadcasts an individual packet. These packets notify the neighbouring nodes that the initiating node is not competent of sending any new request messages for the lack of outstanding energy. Therefore, the neighbouring node does not forward the message to this node. The difficulty with this protocol is that the broadcast of this particular control packet gets through a large quantity of energy from the mobile node. In addition, the overhead of the network enhances as more nodes attempt to deliver such control packets over time.

J. Zhu et. al. [10] proposed an important proposal to create an "energy-efficient routing protocol" for mobile ad hoc networks known as "PEER". However, without watchful intend, energy efficient routing protocols can outperform conventional routing protocols. In particular, energy-efficient routing protocols can result in significantly advanced control overhead and path setup delays as evidenced by simulation and can get through additional energy than a typical routing protocol in a mobile environment. The new link cost model allows for more accurate tracking of energy consumption and path maintenance issues related to path navigation and minimum energy routing protocols. "PEER protocol" with fast and small overhead path search and proficient path maintenance plan to reduce energy consumption in particular in a mobile environment.

J.E. Garcia et. al. [28] proposed ED-DSR is an energy-dependent DSR algorithm that prevents nodes from sharply dropping battery power consumption. ED-DSR provides better power usage compared to LEAR and MDR [7]. ED-DSR avoids the use of low-powered nodes and the outstanding energy information of the nodes is useful for path finding. The remaining battery power of every node is calculated by itself, and if it is higher than a certain threshold, the node cannot contribute in the routing activity. Otherwise, the node delays the rebroadcast of the "route request message" by a phase that is in reverse proportional to the expected duration.

Y. chen et. al. [29] proposed ECAODV, an "energy efficient routing protocol" that takes into relation the compactness of nodes affecting "energy consumption", valuable flooding mechanisms related to node steadiness and node remaining energy. "ALMEL-AODV" [30], "Alternate Link Maximum Energy Level The Ad-hoc On-Demand Distance Vector Routing Protocol" is also an enhancement of the existing "AODV routing" protocol. In this protocol, the residual energy sum of the nodes in the path acts as a metric for path selection. Highest energy path is opted for longer communication and network duration. The ESDSR ("Energy Saving Dynamic Source Routing") protocol is another modified DSR protocol for extending network life using two basic approaches to power consumption. One is the transmission power control method and the second is the load balancing method. The "Minimum Energy Dynamic Source Routing Protocol" (MEDSR) was one of the best attempts to make DSR an energy-aware routing protocol.

The above-mentioned routing protocols build up energy efficient routing in MANET using unexploited nodes with higher energy to balance the network load and thus reduce residual energy consumption [19], [20]. Finding high-energy nodes with ”overhead” and ”crosslayer load balancing” introduces an effective mechanism and necessitates additional overhead. Increasing the overhead of a critical baseline approach degrades network performance. To overwhelm this problem, we propose a mechanism to develop an energy efficient path among every source-target node pair that makes available a long life of network life by efficient and effective use of node energy [22], [23]. Considering node energy and current queue state, the mechanism can apply ”fuzzy-based rules” to expand the life of the node and develop a path that significantly improves network performance.

3 III. Energy Efficient Routing based on Route Segmentation

The proposed energy efficient routing based on route segmentation (EER-RS) provides a scalable and energy saving routing model for MANETs. This maintains small route segments for the active routes. The functionality of route discovery of EER-RS is comparable to DSR where multiple routes are discovered to reach the target node, and the shortest and optimal route is used for routing. In the case of longer routing, the shortest route might have a few hops to reach the target node. These hops, when segmented into w node, makes v route segments. The process of construction segmentation is described below.

4 a) Route Segmentation Mechanism

The intention of segmenting route is to make EER-RS scale for the bigger network. The distribution of network in MANET is into regions based on the node ranges as shown in Fig. 1. The two highlighted node in the figure makes a 2-hop segment. One can decide the number of hops based on the route hops length. If the segment length, w=2, then each route will be divided w segments having a segment head which maintain the segment path to reach segment end node as shown in Table -1

5 D

The advantage of these route segment supports in low energy utilization in maintenance in case of broken links. It can be present locally at the stage of a segment. Fixing a failure route within a segment broadens the life span of the route and accumulate energy through minimizing frequent route discoveries process. Thus, this mechanism will substantially help in reducing the routing overhead and energy consumption and improve the performance. Even varying segment length, w can support the adaptive routing scheme, which will be important for MANETs. Utilizing these segments we compute the minimum energy required to route data over it which will save the energy further.

6 b) Energy Saving Mechanism

Even though segmenting route save quite an amount of energy through minimizing routing overhead, but is essential to route data in an energy efficient route. As mention in Table-1 that each node in a route maintains its own segment path, eventually identifying the best energy sufficient path for routing can make the segment life longer and throughput efficiency can be achieved. To compute the energy level of each segment path we enhance the algorithm CMMBCR [24] (”Conditional Min-max Battery Capacity Routing”) which recognize the routes that have an adequate left over energy of a battery and then choose the routes with lowest total transmission power.

Let’s represent a routing structure by a graph V = (N, E), where, N is ”the set of nodes” and E is ”the set of communication edges”. Based on fig. 2, the node S has to send a packet to N6, which has two paths to reach and the energy needed to send a message to each hopping node is directly comparative to the square of its distance. If the first path distance, p1 have a distance is, p1=(d1+d2+d3) then the energy required for transmitting is, e1= (p1)2. Since, node S also have another path for transmitting and its distance is, p2 = (d1+d4+d5), and its energy required is, e2 = (p2)2. In this case, if e1 ? e2 then, S transmit data through p2 instead of p1 to save energy.

The minimum energy, B required between nodes S to next node n to send the message can be computed using the equation-1 as follows,?? ????? = ???? ??,?? ?? (1) © 2017 Global Journals Inc. (US) Year 2017 ( )

where, ???? ??,?? ?? is compute the required energy transmission between two nodes, and ? will be link loss exponent having minimum 2 and maximum 4, i.e., 2 ? ? ? 4, it depends based on the communication medium feature [15]. In such case the total transmitting energy required by node S to transmit to N6 is given by,?? (????????????????) = ?? (???????) + ?? (?????????) + ?? (?????????) + (?? × ??)**(2)**

where, ? is a constant amount of energy consumed by a receiver node, and l is the segment length excluding segment start and end node. A periodically monitoring of the node energy will be made after a configured time t, for each segment nodes to compute the remaining energy, ?? ???? (??) using the equation-3 as follows.?? ???? (??) = ?? ???? ? (?? ð ?”ð ?”ð ?”ð ?” + ?? ??ð ?”ð ?” + ?? ????????)**(3)**

where, ?? ???? -is the current battery energy status, ?? ð ?”ð ?”ð ?”ð ?” -total energy being consumed for transmitting packets,

?? ??ð ?"ð ?" -total energy being consumed for receiving packets, ?? ???????? -total energy being consumed being idle. Using equation-2 and 3 we can compute required energy and available energy in the path segment based on this we can select the energy efficient segment to save the energy and route for longer.

7 c) EER-RS Based Routing Mechanism

In EER-RS, the nodes in the primarily discovered path are selected as segment end point based on the configured segment length. The advantage of the proposal is that when a node-link fails or a routing node moves out it does not discard the entire path, only the segment has to discover a new path to reach segment end. This provides a clear energy saving and low overhead performance. Based on functionality it routes the data packets in energy efficient route as described in Alogorithm-1 below.

In the next section, we evaluate this work with varying different scale nodes.

8 IV. Experiment Evaluation a) Simulation Setup

We perform at widespread simulations to estimate the performance of EER-RS and contest with "DSR" [8], "AODV" [9] and "PEER" [10]. The simulation was executed over a scalable simulation background for wireless network structures. Traffic will be "constant bit rate" (CBR). The source and destinations of each "CBR flow" arbitrarily opt for but not the same. Every flow does not transform the source and target node during the life span of the simulation execution. Every source transmits data packets at the rate of "4pkts/sec" having size "512bytes" each. A "random waypoint" mobility model is utilized with variation speed from "0 -10 m/s" having a pause time of "30 seconds". We perform six nodes sets simulations to assessment the performance of EER-RS varying the terrain area and nodes as shown in Table-2. The performance of EER-RS being studied with the varying number of nodes from "100 nodes to 500 nodes". The dimension and the area were certain so that the node compactness was remain something like invariable, which would appropriately imitate the scalability of routing protocols. For every performance measure, we calculated the results of EER-RS with "DSR", "AODV" and "PEER". The computed results are shown in below section.

9 b) Result and Analysis

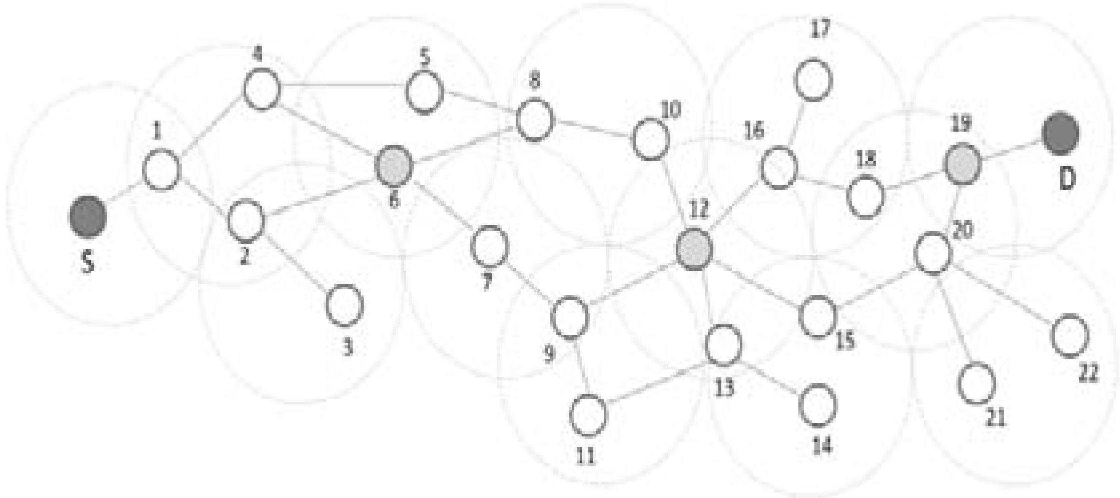
The simulation being performed with different nodes variation to assessment the performance of EER-RS in compared to DSR, AODV and PEER with respect to throughput, energy efficiency and routing overhead.

? Throughput: The throughput is measured based on the ratio of "the number of packets produced by the source" versus "the number of packets being delivered at the target node". The obtained results in Fig. 3 shows the throughput comparison between DSR, AODV, PEER and EER-RS. ? Energy Efficiency: It is defined as "total number of packets transmitted" / "total energy consumed". The higher the PE the better the energy efficiency will be considered. The comparison result is shown in Fig. 4. The main intention of the projected work is to reduce energy consumption and routing overhead, and also improve throughput. Fig. 3 presents a promising improvement in throughput in compare to DSR, AODV, and PEER. The analysis shows that DSR and AODV cannot extend to networks away from a few hundred nodes but PEER shows a good performance up to certain scale but it also degrades with high number nodes. The EER-SR achieve nearly 20% better throughput in compare to PEER and nearly 40% in compare to DSR and AODV.?? ?? = ?(?????? ð ?"ð ?"ð ?"ð ?" + ?????? ð ?"ð ?"ð ?"ð ?" + ???????? ð ?"ð ?"ð ?"ð ?" + ??ð ?"ð ?"?? ð ?"ð ?"ð ?"ð ?" + ???? ð ?"ð ?"ð ?"ð ?") ð ?"ð ?"ð ?"ð ?"??ð ?"ð ?"?? ???????????? ??ð ?"ð ?"???????????????ð ?"ð ?"??

Fig. 4 presents energy efficiency comparison between DSR, AODV, PEER and EER-RS. With increased number of nodes all shows falling off the efficiency, where DSR shows the lowest efficiency in comparing others. EER-RS shows an average of 20% efficiency improvisation in compare to others due to route segment based routing mechanism. Fig. 5 presents routing overhead of EER-RS in compare with DSR, AODV, and PEER, which shows drastically reduced since of the use of the segmented routing. But in the case of link loss between segment the node attained an additional overhead to rebuild the segment link. This creates a high routing overhead in compare to DSR, which can be crucial for EER-RS in the case of scale to large MANETs.

10 V. Conclusion

In this work, we point an attention on improvising the energy efficiency routing for a reactive routing protocol. The approach presents three mechanism to describe the functionality of the proposal. It initially discusses the mechanism and its advantage of route segment creation. It divides a primarily discovered route to few hop segments to minimize the routing overhead and energy consumption. Next, we discuss the mechanism for energy saving routing in a route segment and compute the energy required between two nodes for data transmission based on hops distance and node battery energy status. Based on the computed energy level we find the energy efficient route between segment start and end node. This contributes an energy saving and longer lifetime of the node and network with low overhead. An experiment evaluation in varying number of nodes shows promising improvisation in throughput and energy efficiency with low overhead. In future, it can be evaluated in different mobility scenarios and also in traffic load which causes frequent link loss and congestion. [1]



1

Figure 1: Figure 1 :

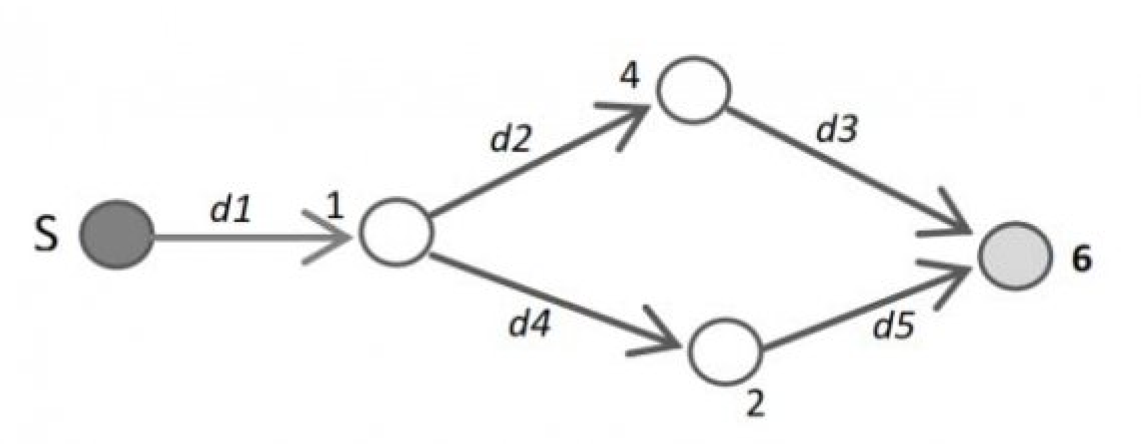


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Figure 2: Figure 2 :

Algorithm-1: EER-RS Based Routing Algorithm

Inputs:

$W(n) \rightarrow$ number of segments for nodes n.
$d_s \rightarrow$ segment end node.

//-- Before forwarding the packets
A source node S forwards a request packet

for each node $n \neq d_s$ that have received Request packet ***do***
Compute remaining energy $B_n(t)$;
$B_n(t) = B_n - (B_{Tx} + B_{Rx} + B_{Idle})$;
$B_n = B_n(t)$;
Node n send a reply packet with B_n;
for end;

//-- On receiving Reply packets
for each segment path p_i do
for each node n to destination node d_s ***do***
Compute energy efficient path, $E(p_i)$,
$E(p_i) = \sum B_n$;
for end;
for end;
Select the path having maximum $E(p_i)$;

3

Figure 3: Figure 3 :

Network Size	Nodes
1000 m × 1000 m	100
1200 m × 1200 m	200
1300 m × 1300 m	300
1400 m × 1000 m	400
1500 m × 1500 m	500
1600 m × 1600 m	600

4

Figure 4: Figure 4 :

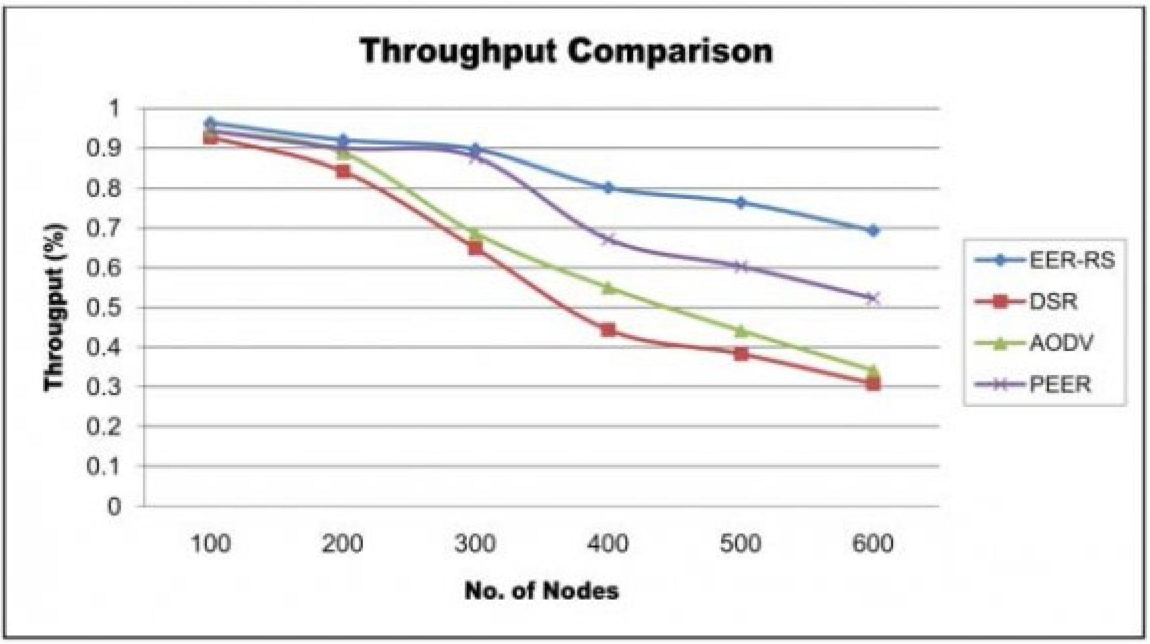

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Figure 5: Figure 5 :

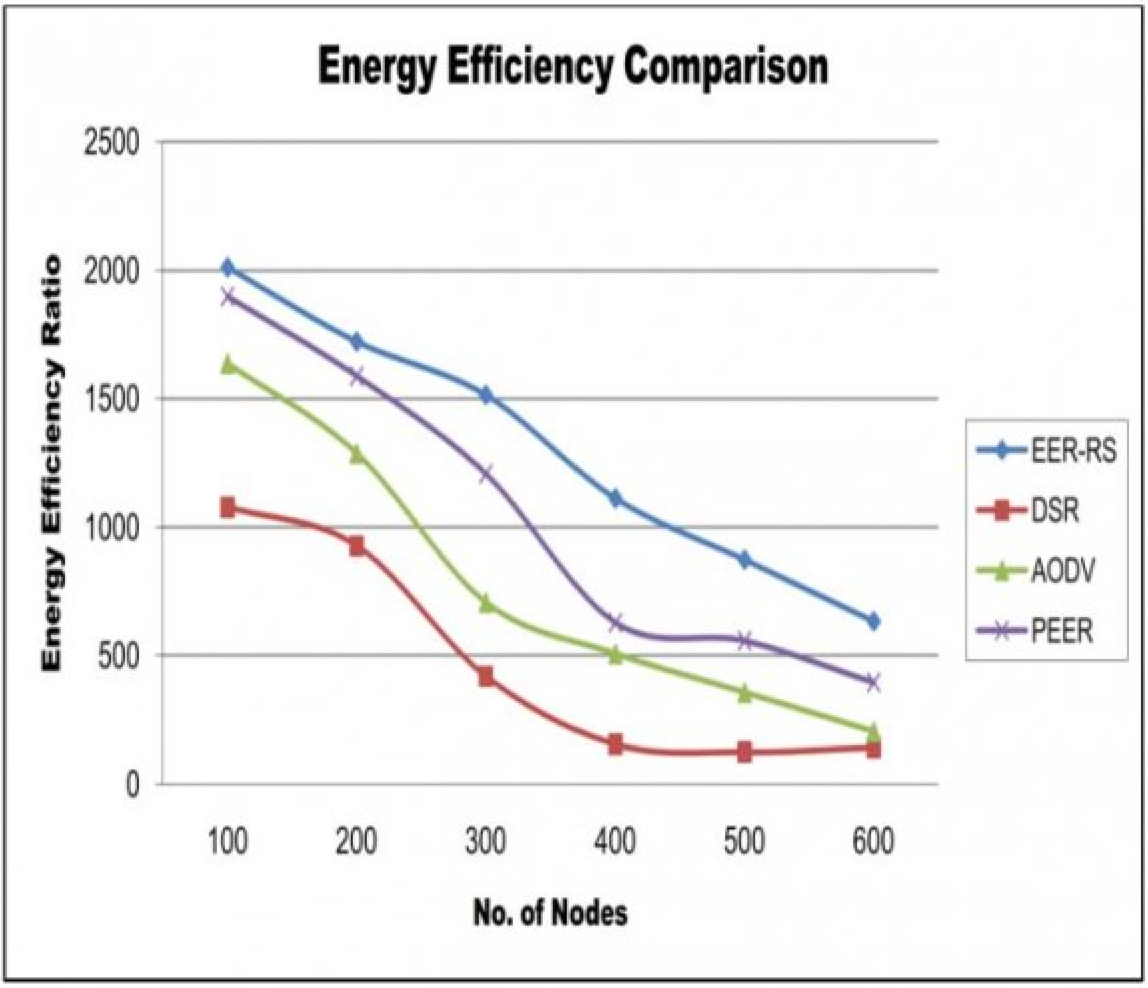

Figure 6:

1

S	6	12	19
1?4? 6	8?10? 12	16?18? 19	
1?2? 6	7?9? 12	15?20? 19	

Figure 7: Table 1 :

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Figure 8: Table 2 :

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