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Enhanced OLSR Routing Protocol Using Link-Break Prediction Mechanism for WSN

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ABSTRACT

In Wireless Sensor Network, various routing protocols were employed by our Research and Development community to improve the energy efficiency of a network as well as to control the traffic by considering the terms, i.e. Packet delivery rate, the average end-to-end delay, network routing load, average throughput, and total energy consumption. While maintaining network connectivity for a long-term duration, it's necessary that routing protocol must perform in an efficient way. As we discussed Optimized Link State Routing protocol between all of them, we find out that this protocol performs well in the large and dense networks, but with the decrease in network size then scalability of the network decreases. Whenever a link breakage is encountered, OLSR is not able to periodically update its routing table which may create a redundancy problem. To resolve this issue in the OLSR problem of redundancy and predict link breakage, an enhanced protocol, i.e. S-OLSR (More Scalable OLSR) protocol has been proposed. At the end, a comparison among different existing protocols, i.e. DSR, AODV, OLSR with the proposed protocol, i.e. S-OLSR is drawn by using the NS-2 simulator.

Keywords: Wireless Sensor Network, Scalability, Routing Protocol, OLSR, Link-Break, Energy Consumption

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1. INTRODUCTION

By managing connectivity in the distributed way wireless sensor network (WSN) (Sarkar *et al*., 2007), is illustrated as self-directing node, these node transfer data among them by using multi-hop radio network. In networks (Sohraby *et al*., 2007), each node has a radio transmission efficiency along with excellencies to network a data by signal processing. Maximum energy consumption occurs when sensors are communicating with each other. In sensor networks, energy is one of the most demanding resources where a lot of research has focused on energy utilization.

Due to an extreme energy pressure by a huge amount of deployed sensor nodes, that desire to implement different network routing protocols which help network to control and manage different tasks like node discovery, node synchronization, and network protection.

Routing protocols design can be altered, which is not only based on the energy conservation restraint, but it also depends on some other factors such as scalability. In WSN, scalability is a crucial element that helps to study the network performance. In networks, when a system has an intelligence to complete some appropriate job by increasing.

The size of the system or increase in network load, this can be termed as scalability (Snigdh and Gosain, 2016; Hong *et al*., 2002).

In network domain, it constitutes an extensive design argument as it determines the system's potential for holding some new nodes that are acceptable to some positive threshold rather than reconstructing the whole network again. Hence, various routing protocols are used in sensor networks that allow a network to support for scalability where these protocols should perform well when the network size rises along with the increase in network workload. Therefore, in the literature, various routing protocols are proven impractical for evaluating the scalability issue in each routing protocol. Performance related to scalability issues have been specified (Dhage *et al.*, 2014; Palaniammal and Lalli, 2014) which motives researchers for further research and development in wireless sensor network. Routing protocols (Patil, 2012) can be mostly categorized as reactive, proactive and hybrid. As mentioned in many literary works, the choice for research investigation in routing protocols can be done based on their characteristics, advantages, and disadvantages.

Therefore, the performance study of various routing protocols is considered under certain circumstances that are affecting the long-term performance of each protocol in a network. The various protocols have been briefly described below in section 3 (Figure 1).

This paper formulates as follow. Section 2, give a short literature survey of various routing protocols with its functioning and characteristics. In Section 3, various routing protocols are discussed and comparison among different routing protocols, i.e. reactive, proactive and hybrid is also made in this section. Section 4 gives a detailed information or working about OLSR routing protocol. Section 5 describes various parameters used and the simulation results. Section 6 defines scalability ranking of each protocol. Section 7 offers a conclusion and section 8 describes the future scope for further studies.

2. RELATED WORK

Many R and D attempts have been concerned with layout an efficient and scalable routing protocols for WSNs. Several papers associated we our simulation study which may involve the simulation performance estimation of AODV, DSR, and OLSR protocols.

Snigdh and Gosain (2016) we analyzed that the scalability issues of the various routing protocols. While including different metrics to measure the long-term achievements in the wireless network were done by delay, throughput, jitter, average carried load, average hop count, and energy consumption and concluded that DSR performs the best where a number of nodes to be deployed. Hong *et al.* (2002) survey different routing protocols that relates to the scalability issue and a comparison was done using the basic properties of scalability and useful features of the protocols. Patil (2012) a performance evaluation of both proactive and a reactive protocol was calculated and then a comparison was made between these two routing strategies. Kilinkaridis (1999) a general discussion and comparison between reactive and proactive routing schemes. Khandakar (2012) performance of AODV, DSR, and DSDV protocols was measured and in the comparison results shown that DSR performed well in all performance metrics. Simmy and Sona (2012) OLSR protocol was discussed in detailed and in this paper, it was concluded that this protocol performed strongly when the network dense.

3. ROUTING PROTOCOLS DESCRIPTION

3.1 Reactive Protocols

Reactive protocols (Kilinkaridis, 1999; Royer and Toh, 1999) are source-initiated routing protocols where a route is established individually by a starting node that wishes to forward a packet to the target node. Advantages of this type are that it has lower routing overhead and disadvantage is high latency in route setup. The most familiar examples of reactive routing are Ad hoc On-Demand Distance Vector (AODV), and Dynamic Source Routing (DSR) protocols, etc.

3.1.1 Ad hoc On-Demand Distance Vector (AODV)

AODV (Shivahare *et al.*, 2012; Rajeshkumar and Sivakumar, 2013; Khandakar, 2012) protocol depends on the distance-vector routing protocols where all nodes helps to manage its own distance vector table. This table contains distance-vector information for all the nodes, allowing them to know their neighboring nodes and costs to reach their destination. In AODV, a node that wishes to transmit the packet, but has no route to forward it to the destination, then the starting node will set up a route discovery process. Following two mechanisms are used in this protocol such as Route Discovery and Route Maintenance. In a mobile network environment, AODV attempts to use the Bellman-Ford distant vector algorithm. A ROUTE REQUEST message is required whenever a source node demands route to the destination. After the arrival of this request message at the destination node, it may further create a ROUTE REPLY message containing a number of hop counts require reaching a specific destination node. So, by this way AODV can also be termed as hop-by-hop routing. It can be adapted by both unicast and multicast routing. In order to attain a specific route, each network node provides a routing table containing neighboring information to reach the desired destination.

3.1.2 Dynamic Source Routing Protocol (DSR)

Dynamic Source Routing protocol (DSR) (Leanna and Rahmat, 2013; Bouhorma *et al.*, 2009) is one of the most efficient as well as simple protocols specifically constructed for the need of mobile nodes in multi-hop wireless networks. The source routing technique is used in this protocol rather than depending upon its routing table. In an ad hoc network, DSR progressively identifies a source route over numerous network hop counts to reach a destination node. In WSN specifications, there is no need for network infrastructure that may be allowed in DSR protocol, so it allows a network to fully self-configuring along with self-organizing capabilities.

This protocol operates on two systems (Leanna and Rahmat, 2013) i.e. Route Discovery and Route Maintenance process, which performs different tasks mutually to recognize and preserve route to different destination nodes. Hence, in this route discovery process, each transmitted packet must give a fully organized record of nodes for description that may assist to pass the packet. It ensures a loop-free routing by escaping the use of updated information in the central nodes by which the packet is redirected and enables nodes to either readdressing or eavesdropping of packets to hide away routing information for future reference. Different routing protocol forms are operating exclusively based on on-demand feature, granting each packet overhead to scale-up automatically and it desires to acknowledge any change in network routes which are currently in use.

3.2 Proactive Protocols

A proactive routing (Kilinkaridis, 1999; Royer and Toh, 1999) is table-driven protocols which accumulate information periodically inside its routing table that helps to provide updated routing information for each node within a network. Advantages of this routing are that it will lower route setup latency and interruption in such network are less and disadvantages are high routing overhead and highly dynamic topologies. Examples of these routing protocols are OLSR, etc.

An OLSR is a proactive protocol that is considered as a table-driven, i.e. in this routing type the topology information is exchanged with every node in the network frequently.

Hybrid routing (Jacquet *et al*., 2001) is a unification of the pair such as reactive (on-demand) and proactive (table-driven) routing features. It has various examples such as Zone Routing Protocol (ZRP) (Jacquet *et al*., 2001), etc.

This algorithm is based on a hybrid routing protocol having a combined attributes of reactive and proactive routing schemes. In this routing type, routing zone is defined by those nodes that proactively control routes to destinations inside its local neighborhood environment.

Following Figure 1 is displaying the underlying distribution of different routing protocols; here all these protocols are discussed in detail in this paper. Routing protocols (Rajeshkumar and Sivakumar, 2013) could be widely categorized as reactive, proactive and hybrid protocols.

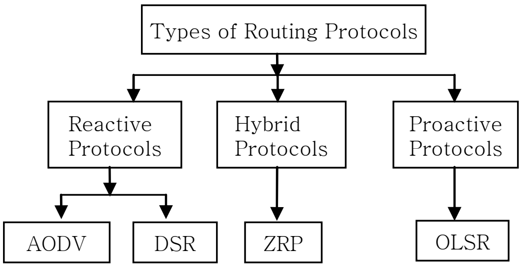

Figure 1. Description of routing protocols.

4. OPTIMIZED LINK-STATE ROUTING (OLSR) PROTOCOL

OLSR (Clausen Jacquet, 2003; Simmy and Sona, 2012) is a proactive protocol, which works as a table-driven, i.e. in this routing type the topology information is exchanged with every node in the network frequently. The main contribution to the proactive protocol is to preserve routing information as consistent and freshness for each node in a network. At least all nodes should maintain one routing table for preserving the routing information in it and however if the network topology changes, then the routing protocol need to update it at that time i.e. periodic updates are required during any change in the topology. This protocol is basically the extension of the link-state routing. In this routing algorithm, every node within the network transmits few messages, i.e. “Hello” message or some sort of information to their neighboring nodes, this process is called flooding. After some time, every node in the network will create its topology of the network, which is in the form of a graph. Hence, in link-state routing every router communicates with the other routers and exchanging their link-state information for either building a topology or the entire network. But the main issue related to this classical flooding mechanism include is that flooding causes encountering multiple copies of the same link-state information or link-state advertisement.

The main limitation in link-state routing is wastage

Table 1. Comparison of reactive, proactive, and hybrid routing protocol

Description	Reactive Routing	Proactive Routing	Hybrid Routing
Description	On-demand routing protocol provides a route demanded by a node to its destination	Table-driven routing technique where routing table consists of all the routes information	It correlates various features of on-demand and table-driven routing techniques together
Advantages	Lower routing overhead, no unnecessary control messages are required	In this case, Route setup latency is very lower	Having no route setup latency for short distance connection, reduces control overhead, minimizing delays
Limitations	High latency for finding routes, route discovery packet flooding	Maintaining cost for all topology information is very high, high routing overheads	Overlapping of routing zones are very large, large memory requirements

of network bandwidth as flooding causes high battery consumption.

So, to overcome these problems OLSR protocol is designed. A majority thought with this protocol is related to MPRs. Here, the MPRs are the elected nodes, which are leading to broadcast these messages in its flooding process. In comparison with classical methods, this technique truly decreases the message overhead. Here when a message is transmitted to a node that node will not go to receive another copy of the same message, i.e. it is used to avoid unnecessary transmission of the link-state packet. In OLSR, every node elects its set of neighbor nodes, which may act as MPRs and exclusively those selected nodes are liable to forward the traffic control messages by shortening the number of communications. This protocol is appropriate for those systems where traffic measures are arbitrary as well as isolated among the bigger and smaller set of nodes, i.e. OLSR protocol works well for a huge and opaque mobile network.

This routing protocol has the following different types of messages: HELLO, Mulitple Interface Declaration (MID), Topology Control (TC) messages, and Host and Network Announcement (HNA).

Advantages of OLSR protocol are as follows:

- OLSR is a form of flat routing protocol having no central policy-making system for governing different routing processes.
- This protocol does not depend on a reliable link for passing control messages, as messages are repeatedly transmitted over a constant medium.
- OLSR suite applications having a brief delay in sending data packets.
- It provides a user-friendly environment.
- For an ad-hoc network, the protocol suitability rises by including any active changes in the starting and ending node pairs.

Disadvantages of OLSR protocol are as follows:

- It involves huge delay dissemination.
- It takes lots of time to re-detect damaged links.
- Huge processing power is required to recognize an equivalent route.

4.1 Multipoint Relays (MPRs)

An idea behind MPRs (Clausen and Jacquet, 2003) is to play down the flooding mechanism for broadcasting messages through abbreviating retransmission of the same messages in the either network. In MPR, each node is elected by its one-hop neighbor in the network, which then retransmits all the broadcast messages acknowledged by the selected node. Example of MPR is given below in the following Figure 4.

In the following example, we can see that for node Q, 1-hop neighbors are node P, node S, and node R and its 2-hop neighbor nodes are node R, node U, and node V.

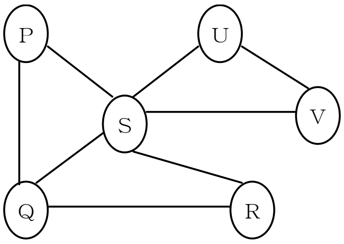

Figure 2. Multipoint relay example.

Table 2. Results of MPR (S)

Position	One-hop neighbors	Two-hop neighbors	MPR
Q	P, S, R	R, U, V	S

So from according to the MPR definition, it is stated that every node elector as a list of nodes from its one-hop neighbor nodes in that network, those set of selected nodes are termed as MPRs for that node.

Hence, MPR of node Q in the given example is node S as shown in the below-given Table 2.

Therefore, OLSR protocol is built on the election of multipoint relays and helps in calculating the routes to all familiar destinations over these MPR nodes and are elected as transiting nodes in that path.

4.2 Types of Packets in OLSR Protocol

There are basically three types of OLSR protocol (Simmy and Sona, 2012) which are described below in Figure 3:

4.2.1 HELLO Packets

These HELLO packets are used for hearing the links understand the state of the link. All nodes in the network are repeatedly exchanging these HELLO packets to their neighboring nodes so that every node in the network has complete information of their neighborhood or the topology used in that network. So for this purpose HELLO messages are used to send the link state information about their neighborhood in the entire network. This HELLO message follows these three tasks that are as given:

- Neighbor detection.
- Link is sensing.
- MPR selection.

These tasks are established for the periodic information exchange at their neighboring nodes, and also serving the function of "local topology discovery."

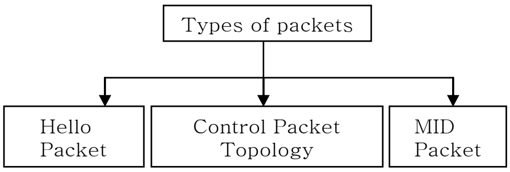

Figure 3. Types of packets in OLSR protocol.

4.2.2 Topology Control (TC) Packets

Topology Control messages together among MPR forwarding is used to advertise neighbor information throughout the entire network. In order to frame an intra-forwarding database or topology base information, all nodes that have been preferred just as an MPR in the entire network, will broadcast these TC messages. By taking the advantage of MPRs, these messages are flooded within the entire network.

Here MPRs facilitate a superior scalability for the dissemination of topology information.

4.2.3 Multiple Interface Declaration (MID) Packets

MID packets are used to inform multiple interfaces in the network by a node, these messages, including a list of the interface's addresses that are correlated to its main addresses. These messages are also used for multiple OLSR interface nodes where it is designed to define the relation between the OLSR interface addresses with the main addresses.

Every node in the entire network having multiple interfaces MUST declare information periodically defining its interface composition with other nodes in the network.

4.3 Link Breakage Algorithm in OLSR

The problem occurring with OLSR protocol according to the researcher's comprehension is that OLSR performs well in the large and dense network, but when the size of a network is tinier than the scalability of that network is very low. Hence, the OLSR routing protocol has the least scalability, as a dynamic state of this protocol is not compatible. If a node gets dead, OLSR does not periodically update its routing table which may create a redundancy problem, so link break predictions can be used to resolve this problem to dynamically update the routing table after a fixed interval of time.

This algorithm helps to estimate the time difference between two radio nodes during the existence of the link fails (Jaggi and Wasson, 2016). This indication time is represented as the time interval while these two nodes are withdrawn from their own transmission range.

In Ad Hoc Network, when data communicate between the starting and ending nodes in a wireless network, then the link break problem occurred most of the time over different specifications such as packet delivery rate, congestion in a network, end-to-end delay, and battery assistance problem.

The link break can be discovered with the use of Hello messages.

In OLSR (Jaggi and Wasson, 2016) generally, broadcasts the Hello messages at fixed time intervals. This Hello message helps to determine the availability of links between the first and last nodes. This protocol operates a feedback of MAC Layer which helps to quickly figure out a Link break in the neighboring nodes.

The route error message, i.e. RERR is generated by the initializing or final nodes, in the case of a link break. What this implies is that rather than restoring the broken links locally, the OLSR makes the end nodes detect other routes to the source. An initialization process of route discovery is also started due to the end nodes generating a link breakage. On receiving a RERR packet, cached entries of the intermediate nodes are discarded. If the destination is within the given number of hops, the host can try to retrieve the link in case of any link breakage in the network.

Method for reassembling the link is as follows:

The destination sequence number is increased by the host, which also broadcasts the RREQ to the host node. To avoid this local repair process, the Time-to-live (TTL) should be determined for each IP header which is then spread to all over the network. For a definite time, the host halts for the reply messages, i.e. RREP to its route request message known as RREQ and one of the below happens:

a) If a RREP is not recognized by the host node: It modifies the routing table position to an invalid entry.
b) If the RREP message is welcomed by the host: The hop count metric is correlated.

If the hop count is higher than the previous value, then 'N' is advertised in the RERR message field. This indicates that the link has been carefully repaired by the host and table entry should not be omitted. The acknowledged RREP is formulated as the actual RREP message. One of the improvements in proactive routing involves link substitution, even before a data is transferred to the inaccessible host. Proactive repairing can be avoided as it involves a risk of reconstructing the unused routes. So, it can be done according to the local traffic and the network load.

In the existing OLSR protocol, the degree is measured easily, but when the link-break exist the concept of node's orientation has not been found out or detected hence it is very difficult to obtain the next neighboring node. Therefore, in the proposed protocol, proper orientation of nodes is done using the link breakage prediction which is described in the following algorithm. So, our proposed protocol is able to calculate both degree and nodes orientation.

This algorithm is showing the basic working of link breakage in the OLSR routing protocol. As in the existing protocol, the only degree is measured and orientation of the node cannot be found hence, it is very difficult to detect the next neighboring node in the network. So, in this proposed algorithm the concept of orientation is covered and it can be easily calculated. Therefore, this can help to find out the next neighboring node in the network. So, by using this algorithm, our proposed protocol, i.e. S-OLSR (More Scalable OLSR) protocol is able to resolve the limitation of link breakage.

Algorithm for Link breakage in OLSR protocol

```
Notation:
nb: - neighboring node
Ɵ: - Orientation

BEGIN
while -> node moving
{
        Get-> node address
for
{
        Count -> nb-node
        Get co-ordinate X, Y
        Initialize degree = 0
        Find Orientation (Ɵ) = tan-1 X/Y
if
{
        Ɵ = +ve
then
    degree = degree ++
}
else
{
    degree = = Null
}
end if
    return degree;
end for
}
end while
}
FINISH
```

5. SIMULATION METRICS AND RESULTS DISCUSSION

5.1 Performance Parameters

Various simulation metrics can be used to evaluate the long-term performance of a wireless network. Some of them are taken in our proposed work, which is discussed as follows.

5.1.1 Average End to End Delay (ms):

It is basically a variation among simulation starting time and ending time as well. Network performance can be enhanced by minimizing this metric. It is measured in microseconds. The formula for the same is as follows:

Avg. End-to-end delay = simulation ending time
- simulation starting time.

5.1.2 Average Throughput (kbps):

It is addressed as the total quantity of TCP packets acknowledged by a server over the simulation duration. System performance can be improved by maximizing the throughput. It is measured in kbps. The formula for Avg. Throughput is as follows:

Avg. Throughput
= (no. of TCP packet acknowledged)
/(simulation time interval).

5.1.3 Packet Delivery Rate (PDR):

It is termed as the proportion of a total no. of TCP packets expected by a target node during the transmission of TCP packets from a starting node. The formula for this metric is as follows:

Packet delivery rate (PDR)
= (total no. of TCP packets expected)
/(total no. of TCP packets generated)×100.

5.1.4 Jitter:

In networks, it can be defined as a variation in the latency of a data packet flow that means some packets take more time to travel from one system to another. It comes out from congestion in a network, drift-time and also from route changes. The formula is given below:

Jitter = Routing packets/(received data packet×10).

5.1.5 Total Energy Consumption:

It can be measured by adding energy utilization while transmitting the data packets plus energy utilized while receiving the data packets in a network. To acquire the maximum lifetime of sensor nodes, minimize this parameter. Formula for total energy consumption is as follows:

Total energy consumption
= (transmission mode energy)
+(reception mode energy).

5.1.6 Network Routing Load (NRL):

It can be described as the overall transmission of data packets by source nodes over the received CBR traffic rate at the server end. The formula for the same is as follows:

Network Routing Load (NRL)
= Routing packets/received CBR traffic.

5.2 Performance Analysis and Results

The comprehensive objective of our analysis is to evaluate and correlate the simulation performances (Dhote *et al.*, 2010) of AODV, DSR, OLSR and S-OLSR protocols in a wireless network framework. This simulation has been accomplished by using the NS-2 simulator, software that provides network simulations over a windows platform because it works only with Linux platform so, we are using VMware Workstation as a platform to run NS-2 simulation tool. The simulations were run on Core™ i3-2350M CPU at 2.30GHz processor and having 3GB internal RAM memory. The NS-2 surroundings consist of complete implementation of the following routing protocols, namely DSR, AODV, and OLSR. All these protocols work under further improvement till now and the new improved versions of these protocols that can be directly added into the NS-2 simulation environment. So, improvement in the existing OLSR protocol is also done to the NS-2 environment by adding a link-breakage prediction, hence the S-OLSR protocol is developed with the help of this mechanism.

This graph is showing that the packet delivery rate (PDR) for S-OLSR protocol is higher than the other existing protocols, i.e. OLSR, DSR, and AODV as shown in the above Figure 4. From results, it is proved that our proposed protocol, i.e. S-OLSR work well with respect to PDR with contrast to other protocols.

Table 3. Simulation parameters for proposed work

Parameters	Values
Numbers of nodes	50, 75, 100, 125, 150
Area used	1,500×1,500 m
Simulation time period (in seconds)	10s
Data rate (in Mbps)	2Mbps
Radio transmission model	Two ray ground
Radio used	IEEE 802.11b
Traffic type	CBR
Source type	TCP,UDP
Routing protocols	AODV, DSR, OLSR
Simulator	NS-2

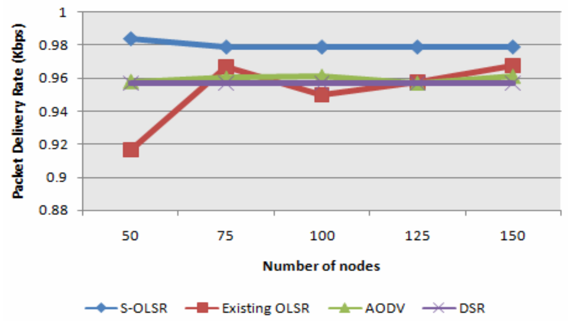

Figure 4. Packet Delivery Rate (PDR) of nodes.

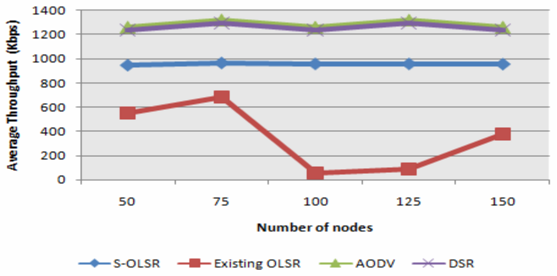

Figure 5. Average throughput of nodes.

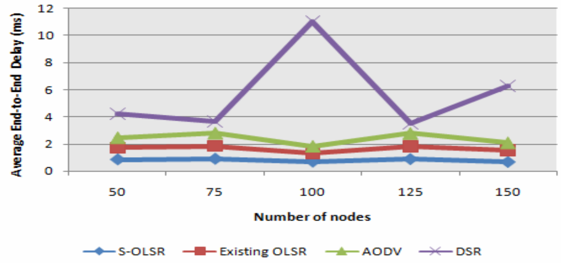

Figure 6. Average end-to-end delay in every node.

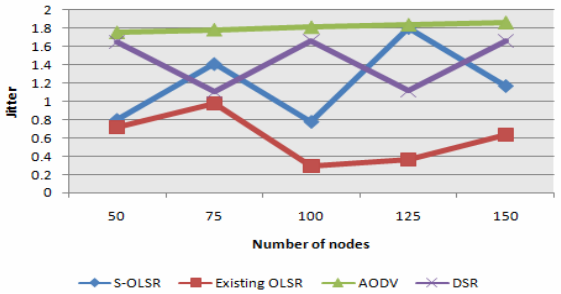

Figure 7. Network jitter of nodes.

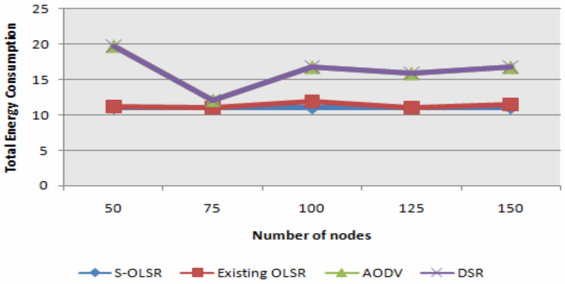

Figure 8. Total energy consumed by each node.

The throughput of our proposed work, i.e. S-OLSR is measured more than the existing OLSR protocol. But it is lower in comparison with AODV and DSR protocol. AODV having highest throughput value among the other protocols, so it is considered as the best protocol in terms of throughput.

In this work, our protocol, i.e. S-OLSR protocol calculated least delay during the transmission of packets. So, the S-OLSR protocol performs better than other protocols under certain conditions like average end-to-end delay. But DSR performs very poorly in this parameter as delay in this protocol comes out to be very high.

This graph is showing that the network jitter of the proposed protocol, i.e. S-OLSR comes out to be lower in comparison with the existing protocols, i.e. OLSR, AODV, and DSR protocol. But in the case of performance evaluation for AODV protocol, it measures very high variation in a network.

The proposed protocol (S-OLSR) performs well as it consumes lesser energy than all the other existing protocols for instance AODV, DSR, and OLSR as shown in the above Figure 8. The above graph shows that energy consumed by AODV and DSR protocols is very large in this case.

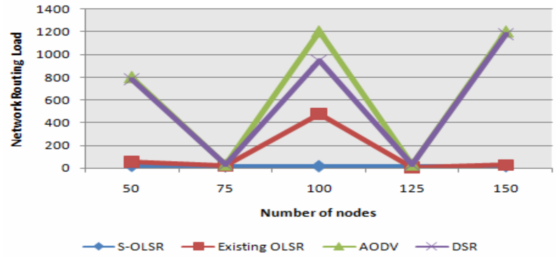

Figure 9. Network Routing Load (NRL) of nodes.

Figure 9 shows that the S-OLSR protocol performs well as it is having lesser routing loads in comparison with the other routing protocols. This graph is showing that the routing load in AODV protocol comes out very high. So, AODV carries more routing load, in this case as compared with other protocol.

The following Table 4 is showing performance analysis results of our proposed protocol based on some parameters which are already described above.

6. SCALABILITY PERFORMANCE ANALYSIS

See Table 5.

7. CONCLUSION

This paper introduced a fresh and innovative protocol, i.e. S-OLSR over the existing OLSR in WSN and finds out that S-OLSR outperforms in terms of some performance metrics, i.e. Packet delivery rate (PDR), Average throughput, Average end-to-end delay, Network routing load, and total energy consumption. This paper signified that the existing OLSR protocol has the limitation of link breakage, but S-OLSR performance is optimized by considering this particular issue for WSN which is shown in the simulation analysis results as mentioned above. It concluded that throughput of the existing OLSR protocol is lesser than the S-OLSR protocol. The S-OLSR protocol performs the best by obtaining lower network routing load, higher Packet delivery rate, higher average throughput value than other existing routing protocols and low energy consumption in comparison with other routing protocols. The average end-to-end delay of this protocol, i.e. S-OLSR is lower than DSR protocol, but it is higher than the AODV protocol which is analyzed in our proposed work. The obtained results proved the admirable performance of our S-OLSR protocol related to other routing protocols and existing OLSR protocol.

8. FURTHER STUDIES

In the future, this work can be implemented with ACO (Ant-Colony Optimization) and PSO (Particle Swarm Optimization) techniques with proposed protocol, i.e. S-OLSR routing protocol by working on some other metrics, i.e. Network jitter, number of data packet dropped, packet size, packet transmission rate, etc. and it can also be implemented by increasing the simulation time. Some modifications can be made in the future works wherein the traffic type may differ from CBR to VBR. Mobility model can also be changed in new research work for future use and then the result of future work can be compared with the existing one.

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Table 4. Performance Evaluation of S-OLSR protocol

No. of nodes	Packet Delivery Rate (PRD)	Average Throughput (Kbps)	Average End-to-End delay (ms)	Jitter	Total Energy Consumption	Network Routing Load (NRL)
50 nodes	97.9421	948.19	0.867096	0.796	11.0307	21.000
75 nodes	97.8819	967.69	0.912595	1.405	11.01	16.576
100 nodes	97.9434	959.43	0.699193	0.775	11.0208	18.173
125 nodes	97.8751	959.68	0.889868	1.798	11.0061	17.565
150 nodes	97.8778	957.42	0.668395	1.165	11.0081	18.355

Table 5. Scalability ranking of different routing protocols

Ranks	Avg. Throughput	Packet Delivery Rate (PDR)	Avg. End-to-End Delay	Jitter	Network Routing Load (NRL)	Total Energy Consumed
Rank 1	AODV	Enhanced OLSR	Enhanced OLSR	Existing OLSR	Enhanced OLSR	Enhanced OLSR
Rank 2	AODV/DSR	AODV	AODV	Enhanced OLSR	Existing OLSR	Existing OLSR
Rank 3	Enhanced OLSR	DSR	Existing OLSR	DSR	DSR	DSR/AODV
Rank 4	Existing OLSR	Existing OLSR	DSR	AODV	AODV	AODV

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