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Simulation Study of Optimization Techniques of OLSR Protocol in VANETs

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Abstract: *Optimized Link State Routing Protocol (OLSR) is one of a popular proactive protocol used in VANETs. This paper evaluates OLSR routing protocol to better performance. OLSR protocol performs well in networks having changing topology of nodes, as it can easily adapt in such environments and updated routing table is maintained by all nodes all the time. OLSR protocol is modified to increase its performance in a VANET scenario. For this an optimization problem is defined to do optimal parameter setting of OLSR. In this work it is done by implementing two algorithms i.e genetic algorithm and simulated annealing on OLSR to find automatically its optimal configurations. In the experiments, our tuned OLSR configurations results are more scalable due to better Quality of service (QoS) and communication efficiency than the standard results making it suitable for utilization in VANET configurations.*

Keywords: *Genetic Algorithm, VANETs, OLSR, MPR.*

1. INTRODUCTION

A VANET [1], is a form of Mobile ad-hoc network, to provide communications among nearby vehicles and between vehicles and nearby fixed equipment, usually described as roadside equipment. It is autonomous self-organizing wireless communication network, where nodes in VANET involve themselves as servers and/or clients for exchanging & sharing information [5]. VANET, a special case of MANET, has set of unique property. Highways, junctions, traffic lights, avenues restrict movements of nodes. It generates specific mobility patterns opposed to MANET. Vehicles move very faster than nodes in MANET gives shorter connection time between nodes. So network disconnection taken place frequently and route maintenance is harder compared to MANET [3]. Most of VANET applications critically rely on routing protocols. Thus, an optimal routing strategy, that makes better use of resources, is crucial to deploy efficient VANETs that actually work in volatile networks. Finding well-suited parameter configurations of existing mobile *ad hoc* network protocols is a way of improving their performance. In this work, we aim at defining and solving an off-line optimization problem in order to efficiently and automatically tune OLSR. Although specific routing protocols are emerging for VANET networks, a number of authors are currently using OLSR to deploy vehicular networks [6]. This protocol has been chosen mainly because it presents a series of features that make it well-suited for VANETs: it exhibits very competitive delays in the transmission of data packets in large networks (that is an important feature for VANET applications), it adapts well to the continuous topology changes, and OLSR has simple operation that allows it to be easily integrated into different kinds of systems.

2. OLSR PROTOCOL

The Optimized Link State Routing (OLSR) is proactive table driven protocol for mobile ad hoc networks. It facilitates efficient flooding of control messages throughout the network by using selected nodes called Multi-Point Relays (MPRs). MPRs are selected by each node and are used to forward control messages resulting in a distributed operation of the protocol. In addition to this, a node continuously maintains routes to all destinations in the network, thus making the protocol suited for traffic pattern that is random. Furthermore, the proactive nature makes OLSR suitable for networks where communicating pairs change over time [7] and it is suitable for networks which are dense like for vehicular adhoc networks.

2.1 OLSR Operation

The core functioning of OLSR can be divided into three processes namely:

1. Neighbor/Link Sensing

Each node periodically exchanges HELLO message with each other. A hello message mainly consists of link information and neighborhood information, i.e., two-hop neighbors, MPRs and MPR selector. A MPR selector set of a node is a set that has selected it as its MPR. The three important tasks performed by hello message exchange are namely link sensing, neighbor detection and MPR selection signaling.

2. Efficient Control Flooding Using MPRs

Due to the proactive nature of OLSR, each node maintains the partial topology graph of the network. This information is extracted from Topology Control (TC) messages and is then used for calculating the shortest paths to destinations. A MPR node broadcasts a TC message periodically that is disseminated across the network using the other MPR nodes. A TC message contains MPR selector set of the source of the message and is forwarded by MPR if and only if it received the message for the first time by that node and it is in the MPR set of the previous hop node. This controlled flooding results in minimized retransmissions [7].

3. Optimal Path Calculation Using Shortest Path Algorithm

A routing table is maintained by every node, which is then refreshed and updated whenever a change in the topology is detected. To populate a routing table, shortest path algorithm is used on the partial topology graph obtained from TC messages. It is important to note that OLSR is not involved in forwarding of data packets [7].

2.2 Multi point relay

The idea of multipoint relays is to minimize the overhead of flooding message in the network by reducing redundant retransmission in the same region. In MPR (Multi Point Relay) a node which is selected by its one hop neighbor to "re-transmit" all the broadcast messages that it receive from other node, provided that the message is not a duplicate, and that the time to live field of the message is greater than one [12]. In OLSR protocol, Multi Point Relays use of "HELLO" message to find its one hop neighbor and its two hop neighbors through their response. Each node has a Multi Point Relay selection set, which indicates, which node acts as a MPR. Message is forward after the node gets new broadcast message and message sender's interface address in the MPR Selector. Based upon its one hop and two hop neighborhoods a node selects one hop neighbors as Multipoint relays in such a way that each two hop neighbor can be reached by at least one member of the MPR set. The neighbor elected as MPR is marked MPR neighbor in the next HELLO message that is sent. The node being elected MPR upon receiving this HELLO message adds the node that selected it as MPR into its MPR selector set.

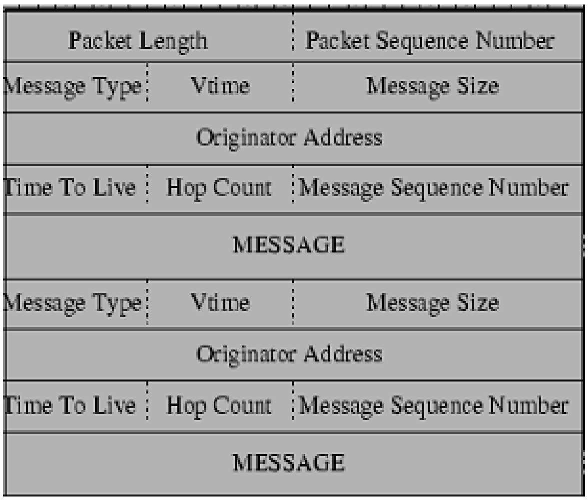

Figure 1: OLSR packet format

2.3 OLSR packet format

All OLSR control traffic is based upon OLSR packets. An OLSR packet has an OLSR packet header consisting of the packet length and a packet sequence number maintained independently by each interface of the OLSR node. The packet body consists of one or more OLSR messages which are preceded by a message header for each included message. The message header contains the message type, the validity time, the message size, the originator address, a time to live field, the hop count and a message sequence number. The originator address field contains the main address of the node that initially created the message, independently on which interface the message left this node [2].

Packet format: All OLSR traffic is sent in OLSR packets. These packets consist of an OLSR packet header and a body as displayed in figure 1.

3. EXISTING SOLUTIONS

Venkatesh et.al [1] reviewed the existing routing protocols for VANETs and categorise them into a taxonomy based on key attributes such as network architecture, applications supported routing strategies, forwarding strategies, mobility models and quality of service metrics. The performance of routing protocols depends on various internal factors such as mobility of nodes and external factors such as road topology and obstacles that block the signal. This demands a highly adaptive approach to deal with the dynamic scenarios by selecting the best routing and forwarding strategies and by using appropriate mobility and propagation models. The paper delivers important protocols belonging to unicast, multicast, geocast and broadcast categories. Strengths and weaknesses of various protocols using topology based, position based and cluster based approaches are analysed. Emphasis is given on the adaptive and context-aware routing protocols. Simulation of broadcast and unicast protocols is carried out and the results are presented.

B. Sahaya et.al [2] In this paper a new location based routing protocol is proposed which is used for vehicular ad-hoc networks. VANETs are more efficient for inter-vehicular communication when compared with other communication networks. But due to the vehicle mobility the link failures occur in more number so that the transmission of the data is not made successfully. In order to overcome the link failure problems, increase in routing overhead and degradation in network scalability a new protocol is proposed. A new hybrid location-based routing protocol which combines features of reactive routing with location-based geographic routing in a manner that efficiently uses all the location information available is to be proposed. The protocol is designed in a way such that as the location information of the vehicle degrades it automatically uses the reactive routing protocol. We show through analysis and simulation that our protocol is more efficient when compared with the existing protocols.

Mr. Bhagirath Patel et.al [3] Vehicular Ad hoc Networks (VANETs), a subclass of mobile ad hoc network (MANET), is a promising approach for the intelligent transport system (ITS). VANET allows vehicles to form a self-organized network without the need for a permanent infrastructure. As the VANET has a potential in improving road safety, real time traffic update and other travel comforts, it turns attention of the researcher. Though VANET and MANET shares some common characteristics like self-organized network, dynamic topology, ad hoc nature etc, VANET differs from MANET by challenges, application, architecture, power constraint and mobility patterns, so routing protocols used in MANET are not applicable with VANET. New routing strategy for VANET has been proposed by many researchers in recent year. This paper provides focus on the various aspects of VANET like

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architecture, characteristic, challen*ges*, glimpse of routing protocols, and simulation models used for VANET.

N.Lu et.al [4] Vehicular wireless communication should be able to provide vehicles with reliable and efficient data transmissions for various applications, especially safety applications. We present a dedicated multi- channel MAC protocol that has an adaptive broadcasting mechanism, specifically designed to provide collision-free and delay-bounded transmissions for safety applications under various traffic conditions. Besides defining the implementation of this protocol, we conducted simulation evaluations showing that it has promising performance on critical statistics.

Bijan Paul et.al [5] VANET (Vehicular Ad-hoc Network) is a new technology which has taken enormous attention in the recent years. Due to rapid topology changing and frequent disconnection makes it difficult to design an efficient routing protocol for routing data among vehicles, called V2V or vehicle to vehicle communication and vehicle to road side infrastructure, called V2I. The existing routing protocols for VANET are not efficient to meet every traffic scenarios. Thus design of an efficient routing protocol has taken significant attention. So, it is very necessary to identify the pros and cons of routing protocols which can be used for further improvement or development of any new routing protocol. This paper presents the pros and cons of VANET routing protocols for inter vehicle communication

J. Santa et.al [6] Experimental evaluation of Vehicular Ad-hoc Networks (VANETs) is still a remaining issue for most researchers. Some works carry out performance tests to evaluate the communication channel according to physical and MAC conditions. Only a few works deal with multi-hop experimentation, but practically none use routing protocols. In this paper an integral VANET test bed is evaluated, using 802.11b and a multi-hop network managed by the Optimised Link State Routing (OLSR) protocol. Up to four vehicles are used to study the VANET performance over different traffic environments and different metrics are considered to analyse the results, including a deeper analysis to track the routes followed by packets end to end. Results differ from traditional one-hop and static-route tests, presenting a more realistic study.

Tanuja Kumar et.al [7] Wireless mobile ad hoc network is a infrastructureless network where each network node not only acts as a host but also acts as a router. Since the nodes are mobile, the environment is highly dynamic. For these networks to function properly a routing protocol is required that can respond to the rapid changes in the topology. Many routing protocols have been developed for accomplishing this task. The paper presents the impact of mobility on the performance of two mobile routing protocols, AODV, which is reactive routing protocol and OLSR, which is proactive routing protocol.A basic framework to analyze the performance of routing protocols is developed. OLSR for discrete scenario when time snapshots were taken at a lower frequency i.e. every 30 seconds. On the other hand, OLSR performed better in pseudo-continuous scenario when time snapshots were taken at higher frequency i.e. every 5 seconds.

M. Gunasekar et.al [8] Vehicular adhoc network (VANET) provides wireless communication among vehicles without any underlying network infrastructure. In such Network, Quality-of-service (QoS) is difficult because the network topology may change constantly and the available state information for routing is inherently imprecise. However, due to the vehicle movement, limited wireless resources and the lossy characteristics of a wireless channel, providing a reliable multihop communication in VANETs is particularly challenging. Therefore, offering an efficient routing strategy is crucial to the deployment of VANETs. The paper proposes an Intelligent Water Drops (IWD) algorithm to optimize the parameter setting in optimized link state routing protocol (OLSR). IWD Algorithm harmonizes the parameters in OLSR for better Qos. The QoS versions of the IWD tuned OLSR routing protocol do improve the Packet Delivery Ratio, reduce the communication cost and network traffic load in the high speed movement scenarios.

Jamal Toutouh et.al [9] This paper discusses series of representative metaheuristic algorithms (PSO,DE,GA and SA) in order to find automatically optimal configurations of OLSR routing protocol. In addition, a set of realistic VANET scenarios (based in the city of M´alaga) have been defined to accurately evaluate the performance of the network under the automatically optimized OLSR. Experiments depict that the tuned OLSR configurations result in better QoS than the standard (RFC 3626) and than several human experts, making it amenable for utilization in VANETs configurations.

Padmavathi. K et.al [10] addresses some parameters of olsr that forces the inaccuracies in the energy level information of neighboring nodes and show the comparison between ideal and realistic version of olsr. Qos routing in mobile ad-hoc networks is challenging due to rapid change in network topology. The paper aims at providing a better quality of the package delivery rate and the throughput, that is in need of powerful routing protocol standards, which can guarantee delivering of the packages to destinations, and the throughput on a network. It primarily focuses on the inaccuracy of state information, more specifically the residual energy level of nodes that is collected by the control messages of olsr. Inaccurate information affects the efficiency of olsr protocol. Tuning of olsr is done which in turn improves the residual energy information of nodes.

Kunal Vikas Patil et.al [11] addressed a routing protocol which replaces the standard greedy approach with necessity first algorithm. The vehicular ad hoc network (VANET) is a superior new technology. Vehicular ad hoc network (VANET) is a subclass of MANET that is mobile ad hoc networks. The OLSR is best suitable for larger mobile network. It is having affecting factors like configuration, multipoint relays. Using proposed protocol the network traffic load of administrative packet is reduced. The proposed new routing protocols are best suitable for vehicular network which are highly dynamic in nature.

Kuldeep Vats et.al [12] discusses and evaluates "Optimized Link State Routing Protocol" OLSR routing protocol to better performance. Using OPNET simulator tools for the performance of OLSR routing protocol simulation, created in small network (30 nodes), medium size network (40 nodes)

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and large network (50 nodes) the complexity of the mobile ad-hoc network is analysed. The MPR count ”HELLO”message sent ,routing traffic sent and received, total TC message sent and forward, total hello message and TC traffic sent are studied.

B.A. Mohan et.al [13] In this paper, study of scalability issues in OLSR with respect to increased number of nodes in MANETs is presented. The Optimized Link State Routing Protocol (OLSR) is a routing protocol optimized for mobile ad-hoc networks, which can also be used on other wireless ad-hoc networks. OLSR is a proactive link state routing protocol, which uses hello and topology control (TC) messages to discover and then disseminate link state information throughout the mobile ad-hoc network. Individual nodes use this topology information to compute next hop destinations for all nodes in the network using shortest hop forwarding paths.

4. METHODOLOGY

The main contributions in this work done are:
[1] Simulation of OLSR protocol with standard value.
[2] Optimization framework to tune the OLSR configuration.
[3] Performance evaluation of optimized OLSR Protocol
We here evaluated two techniques first is Genetic Algorithm (GA) and the second is Simulated Annealing(SA).These algorithms are choosen because they represent a wide and varied range of solvers for real parameter optimization used in different search/optimization schemes and strategies. The popular network simulator ns-2 is used in the fitness function evaluation of the solutions (tentative OLSR parameters) generated by the optimization algorithms to simulate the search process.

4.1 Optimization Strategy

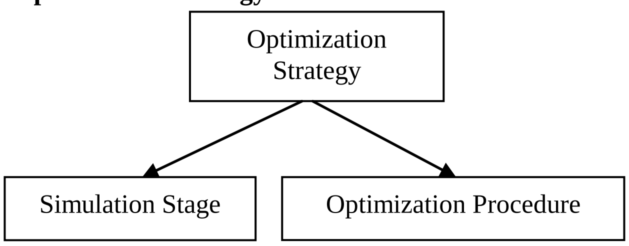

Figure 2: Optimization strategy used

The optimization strategy used to obtain automatically efficient OLSR parameter configurations is carried out by coupling two different stages: an optimization procedure and a simulation stage.

4.2 Optimization framework

As previously commented, the optimization strategy used to obtain automatically efficient OLSR parameter configurations is carried out by coupling two different stages: an optimization procedure and a simulation stage. The optimization block is carried out by a metaheuristic method Genetic Algorithm (GA), and Simulated Annealing(SA). These methods were conceived to find optimal solutions in continuos search spaces, We use a simulation procedure for assigning a quantitative quality value(fitness) to the OLSR performance of computed configurations in terms of communication cost. This procedure is carried out by means of the *ns-2* network simulator which has been modified in order to interact automatically with the optimization procedure with the aim of accepting new routing parameters, opening the way for similar future research.

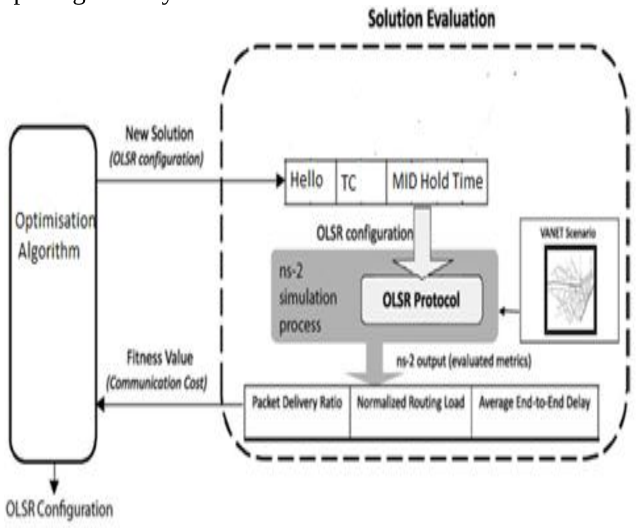

Figure 3: Optimization framework for automatic OLSR configuration

After the simulation returns global information about the PDR, the NRL, and the E2ED of the whole mobile vehicular network scenario, this information is used in turn to compute the communication cost (comm. cost) function as follows:

Comm.. cost = w2 · THROUGHPUT + w3 · E2ED − w1 · PDR

Where, the Packet Delivery Ratio (PDR) is the fraction of the data packets originated by an application that are completely and correctly delivered.

End-to-End Delay (E2ED**),** that is the difference between the time a data packet is originated by an application and the time this packet is received at its destination.

Throughput**:** No. of packet passing through the network in a unit of time. It is measure in kbps.

The communication cost function represents the fitness function of the optimization problem addressed. The objective here consists in maximizing PDR and Throughput and minimizing E2ED.

In this approach we used different biased weighs say, in the fitness function, being: w1 = 0.5, w2 = 0.2, and w3 = 0.3 and the communication cost can be evaluated using the fitness function defined above. This way, Packet Delivery Ratio and Throughput takes priority over End to End Delay since we first look for the routing effectiveness and second (but also important) for the communication efficiency.

4.3 Optimization techniques

Optimization is to improve the Quality of Service of the network scenario and to minimize the number of control messages in the network. Optimization means to find out the optimal route in terms of performance metrics. The basic principle behind optimizing is to control the flows in the

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network such that the flows must be better than previous. Here we are exploring two optimization techniques i.e Genetic Algorithm and Simulated Annealing explained as below:

a.) **Genetic Algorithm***:* Genetic Algorithm (GA) is a search and optimization technique which works on the principle "Select the best and Discard the rest". Genetic Algorithm is an iterative process that maintains a population of solutions that are candidate solutions to specific domain. At the beginning in case of VANET there are number of nodes. Some of the nodes are at better position and can be considered as best nodes to reach the destination. We start with the population of randomly generated solution and determine how fit it is. If solution is good, we stop, if not we optimize for a better. Now, as resources are limited, every node has to compete to another for resources. Ultimately only the strongest or fittest node survives and rest is discarded. Then this best node will be selected.

b.)**Simulated annealing:** is a probabilistic technique for approximating the global optimum of a given function. Specifically, it is a meta heuristic for approximate global optimization in a large search space. It is often used when the search space is discrete (e.g., all tours that visit a given set of cities). For problems where finding the precise global optimum is less important than finding an acceptable global optimum in a fixed amount of time, simulated annealing may be preferable to alternatives such as brute-force search or gradient descent. First, generate a random solution. The main point is that it's random - it doesn't need to be our best guess at the optimal solution. Calculate its cost using some cost function. Calculating the cost of each solution is often the most expensive part of the algorithm, so it pays to keep it simple. Generate a random neighboring solution "Neighboring" means there's only one thing that differs between the old solution and the new solution. Effectively, we can switch to two elements of our solution and re-calculate the cost. The main requirement is that it is to be done randomly. Calculate the new solution's cost using the same cost function as used above. If $c_{new} < c_{old}$: move to the new solution and if $c_{new} > c_{old}$: maybe move to the new solution accordingly and the corresponding best node will be selected.

4.3Tuning of Parameters

The standard configuration of OLSR offers a moderate QoS when is used in VANETs. Hence, taking into account the impact of the parameters configuration in the whole network performance, we tackled here the problem of the optimal OLSR parameter tuning in order to discover the best protocol configuration previously to the deployment of the VANET. The standard OLSR parameters are defined without clear values for their ranges. According to that , we can use the OLSR parameters to define a solution vector of real variables, each one representing a given OLSR parameter. This way, the solution vector can be fine-tuned automatically by an optimization technique, with the aim of obtaining efficient OLSR parameters configurations for VANETs hopefully outperforming the standard one defined in the RFC 3626.

Table 1: Simulation Parameters

SIMULATION PARAMETERS	VALUES
ENVIRONMENT SIZE	1000 * 1000
NUMBER OF NODES	10
ROUTING PROTOCOL	OLSR
NETWORK TYPE	ADHOC(VANET)
MAX SIMULATION TIME	50 SEC
SIMULATOR	Ns2
PROPAGATION	RADIO-PROPG. MODEL
Max PACKET	50
MAC PROTOCOLS	IEEE 802.11b
RADIO FREQUENCY	2.4 GHz
CHANNEL BANDWIDTH	11 Mb
HELLO_INTERVAL	2.0 sec
TC_INTERVAL	5.0 sec

5. SIMULATION RESULTS

We have used NS-2 Simulator for our work. Following figures represents the graph comparison of OLSR with default configuration and optimized OLSR with Genetic algorithm and OLSR with simulated annealing in terms of maximized Packet Delivery Ratio, minimized End to End Delay and Maximized Throughput at many simulation instances**.** Figure 4,5 and 6 shows the impact of PDR, End to End Dealy and throughput of OLSR with OLSR_GA and OLSR_SA.

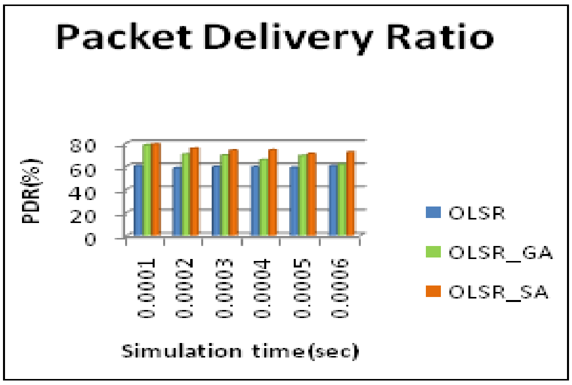

Figure 4: Comparison of Packet Delivery Ratio among OLSR, OLSR-GA and OLSR-SA

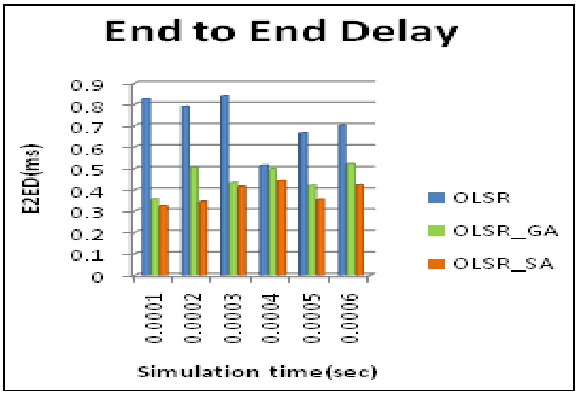

Figure 5: Comparison of End to End delay among OLSR, OLSR-GA and OLSR-SA

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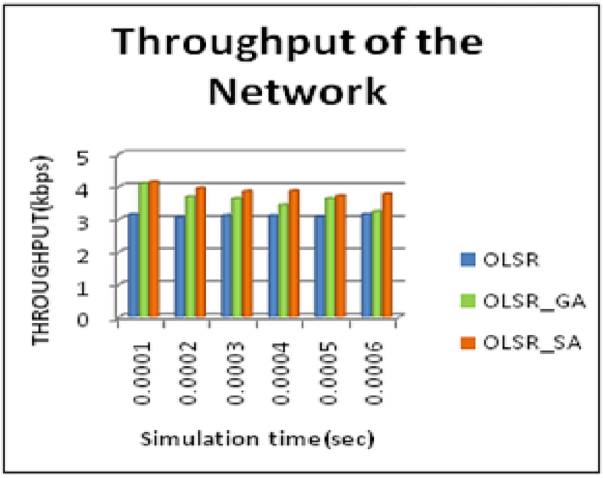

Figure 6: Comparison of Throughput among OLSR, OLSR-GA and OLSR-SA

Communication cost is calculated in terms of PDR, End to End delay and throughput of a network. The graph shows that the OLSR_SA outperforms the OLSR-GA and OLSR with default configuration.

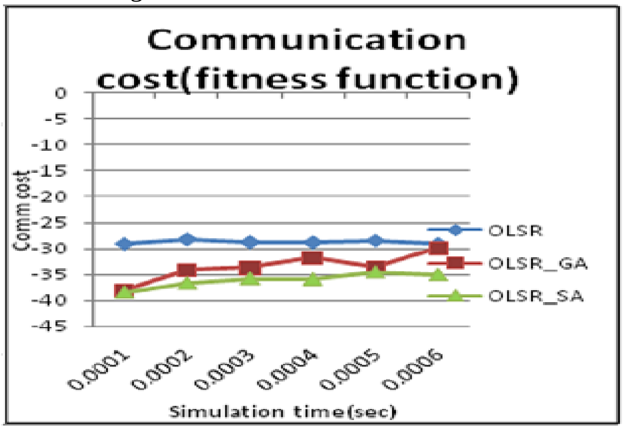

Figure 7: Comparison of Communication cost among OLSR, OLSR-GA and OLSR-SA

6. CONCLUSION

In this work, Optimization of OLSR protocol is done using genetic algorithm and simulated annealing and simulation of traffic is done using NS-2 Simulator. We achieved better results as OLSR with Simulated annealing outperformed the OLSR with GA and traditional OLSR .These results are compared and evaluated which indicate that performance gets improved in optimized OLSR (OLSR-SA) protocol in terms of increased PDR, throughput and decreased end to end delay at various simulation instances.

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