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Performance Evaluation of an Adaptive Gateway Discovery Algorithm for Mobile Ad hoc Networks

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Abstract— **An essential attribute of mobile ad hoc networks is the quality of service that makes an impact on the overall performance of the networks while connecting it to the internet. Many authors have faced the challenge to improve the performance in MANET-INERNET integration. To acquire efficient data services and high data rates this type of integration occurs.. The gateway acts as a bridge between the mobile ad hoc networks and internet. In this paper we are analytically proposing a model to evaluate the performance of an adaptive gateway discovery algorithm which improves the quality of service of transmitting the data and reduces the congestion overhead so that the advertisement messages are forwarded only up to the active sources in the network.**

Keywords— **MANET, Packet delivery Ratio ,Gateway , Adaptive Gateway Discovery, Gateway Selection, Time To Live**

I. INTRODUCTION

In MANET-INTERNET integration our objective is to provide an efficient data transmission. A mobile ad hoc network [1] is a network that is established and worked without any fixed infrastructure. All the nodes are equivalent in the mobile ad hoc networks .There is no governing entity like access point in the wired networks such as the internet. It is formed spontaneously in the areas where establishing an infrastructured network causes delay in the work as well as increases the cost of deployment. It is composed of portable mobile nodes such as notebooks, palmtops, PDAs and handheld mobile devices like cellulars

An important issue in mobile ad hoc networks is the flexible and the easy deployment and the self-configurability of the mobile ad hoc networks. These are the most essential attribute of a mobile ad hoc network. A hybrid MANET consists of those nodes that require connectivity to the infrastructure networks for the purpose of obtaining data and multimedia services like IP-telephony , VoIP and video over IP. The core of MANET-INTERNET integration is the gateway. A gateway provides means to connect mobile ad hoc networks with internet. So, it is important to choose an appropriate gateway in order to improve the transmission. The gateway translates the MANET address space to the Internet and vice-vera. The gateway acts as an intermediate device between the infrastructureless networks such as the mobile ad hoc networks and the internet. The following figure depicts the MANET-INTERNET integration.

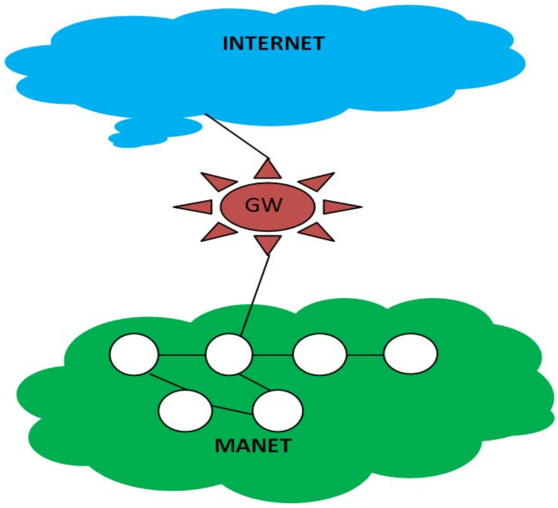

Fig 1 . MANET- INTERNET integration through the gateway.

II. GATEWAY DISCOVERY

Gateway discovery [2] is one of the basic process in integrating the mobile ad hoc networks with the internet. Gateways are special nodes. At one side they are connected with the MANET. On the other hand , they are connected with the internet. Both internet and MANET have different address spaces. So , there must be a technique to translate between these two address spaces which is known as address auto-configuration. In general there are three approaches for gateway discovery. In proactive approach [3], the gateway periodically sends the gateway advertisement message which are broadcasted in the whole network. Whereas in reactive approach [4], the node requiring connectivity to internet sends a gateway solicitation message to the gateway which consequently responds with the advertisement message. The hybrid approach [5] provides the balance between these two approaches. In hybrid technique the advertisement messages are sent by the gateway to a fixed range which is defined by TTL value of the advertisement message. The rest of the nodes connect with the gateway reactively .One more approach which is popular now a days is the adaptive gateway discovery approach [6]. The adaptive approach tries to optimize the TTL value of the advertisement message that is being sent in the hybrid approach. This optimization is quite essential in order to respond to the network changes. This approach improves the network throughput and reduces the congestion.

III. GATEWAY SELECTION

Gateway Selection [7] is the way through which a MANET node chooses a potential gateway node out of multiple discovered gateway nodes on the basis of network, link and other gateway selection parameters. Several authors have given various proposals on gateway selection .

IV. RELATED WORKS

In [15], Brannstrom et al. have proposed to measure the variance in the delay between successive GWADVs and use this as the metric for gateway selection. Both a higher number of hops between the mobile node and the gateway, and a higher amount of traffic along the path will lead to an increase in the variance of the arrival rate of the advertisements.

The gateway selection scheme in [8] attempts to choose a gateway node on the basis of hop count. A gateway discovery message is broadcasted by gateway and on the basis of that message each node estimates its distance metric to gateway. The gateway with least distance path in terms of hop count is selected for data transmission from MANET to the internet.

Ashish Bagwari et. al.[16] proposed a gateway selection scheme that is based on cluster head gateway candidates. This approach supports clustering in unstable networks, i.e. ones obeying a certain mobility rates. The goals are to provide more efficient information dissemination in clusters, to reduce the frequency of cluster head gateway re-elections due to the mobility. It is based on three different metrics which are transmission power, node mobility and quality of service. The Transmission power of cluster head gateway should be more in order to cover large area. Cluster Head Gateway should have low mobility. Due to this the CHG will stay in a network for the longer time period and will serve all the MANET nodes. The QoS deals with certain other parameters which are throughput, end-to-end delay, packet drop and queue size. One gateway selection scheme which is being proposed by bouk et al. [9] mainly considers three gateway selection parameters which are path availability period, residual load the capacity and the path latency. The path availability period between two nodes which are not immediate neighbors of each other, is equal to the minimum link availability period between intermediate nodes in that path. The path availability period of a path between a MANET node and a gateway node means the total time a gateway node is accessible by the MANET through that node.
Where L_i is the path availability period and l_u is the link availability period between intermediate nodes in that path.
The residual load capacity of a path is the minimum available load capacity at any node, including intermediate nodes and the gateway nodes, in that path. Latency of path *i*, *Yi*, is the additive measurement of latency at each link on the path between the gateway and mobile node. On the basis of these parameters an overall QoS value is being computed for all paths between a MANET node and gateway node(s). A gateway node is selected by the MANET node path with maximum *δi* is selected by the MANET node.

Mahmoud et. al[17] has proposed a gateway selection scheme which is based on combination of network mobility(NEMO) and ability to form the ad hoc connections which activates existence of complex, scalable, and auto-configured networking topologies. There is no standard method that can assure optimal gateway selection that maximizes internet connection performance and robustness. This scheme utilizes the presence of various internet gateways in a mobile ad-hoc network so as to increase the robustness of internet connectivity for the members of the mobile network, and improve the quality of the internet connection from inside the network.
In this section we discuss a multi-criteria gateway selection and multipath routing protocol proposed by Gargi et. al. [10] for hybrid MANET which considers mobility metric as one of the criteria for the gateway selection. For gateway selection, a combined weight value is computed based on some metrics mobility, inter and intra MANET load and residual energy using simple additive weighing (SAW) technique. Among the selected route from the multiple paths, the gateway with maximum weight is selected. If such a gateway does not exist, some other route is selected from the multi path set.
Felix Hoffmann et. al.[18] proposed a two step delay based gateway selection scheme for mobile ad hoc networks used in the space. The ad hoc networks are used as the means of providing internet access to passengers on board aircraft flying in oceanic or remote regions. The most of data packets in such networks is either destined for or originated at an internet gateway, that joins the ad hoc network to the internet. Hence, the distribution of aircraft to gateways plays a vital role for the overall network performance. It is a noble scheme for gateway selection based on calculation of certain parameters such as the path delay. The delay which is analyzed by the user depends on thetraffic along the path in the network, as well as the traffic load of the gateway itself. By considering not only the delay of the packets within the ad hoc network, but also the large delay that is caused by satellite access links, we aim to shift traffic away from the satellite links as long as possible that is when the overall traffic is sufficiently low.
P. Venkateswaran et al [11] has given a MAC protocol with cluster head and gateway selection algorithm. The gateway nodes are selected for inter-cluster communication. But they ensure that the maximum number of clusters that are connected with the help of the single gateway does not go above its allowable overhead during the gateway selection.
Quan Le -Trung et al [12] proposed a hybrid metric for selecting IGW for balancing the intra/inter-MANET traffic load between multiple IGWs on the similar MANET domain. This approach considers three components which are Euclidean distance, load balance of inter-MANET traffic and load balance of intra-MANET traffic. The shortcoming of this scheme is that it does not consider MANET""s node location along with the utilization of the location based ad hoc routing.
Huang et al. [14] proposed the Minimum Load Index (MLI) solution to choose the Internet gateway based on the current load of the gateways. The metric Li that is advertised by

gateway I , referred to as its Load Index, is calculated according to the equation $L_i = \sum_z \rho_{z,i*Tz}/C_i$. where Ci is the bandwidth of gateway i , and $\rho_{z,I}$ is the fraction of the total traffic Tx that host x sends to gateway i.

R. Hemaltha et. al [20] proposed a gateway selection scheme for improving the QoS performance in the gateway nodes. Various gateway selection schemes have been proposed to select gateway node based on single QOS and multiple non QoS path parameters. This scheme considers that has all QoS and multiple non-QOS parameters present in single gateway node connecting two networks. The QoS parameters are delay ,jitter, bandwidth, latecy, throughput and dropped packets. The algorithm proposed by the authors considers a connected graph with following values. Connected Graph is represented by G(V,E).G represents the MANET.$G^1(V,E)$ represents the cellular network M represents the gateway node. The packet are being delivered from G(V,E) to $G^1(V,E)$.The transmission of packets takes place via M. The algorithm attempts to integrate all the three networks which are MANET, cellular network and the distributed network. When a node in the MANET wants to send a packet to the distributed network or the cellular network it is being delivered through only the gateway M. The gateway node has all the parameters in built. The following figure depicts the situation.

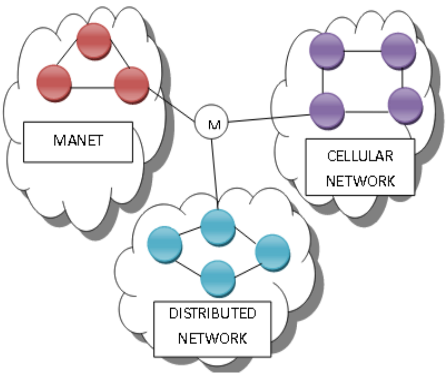

Fig2. Integration of three networks using the gateway node

Mary Wu. Et al.[19] proposed a gateway selection scheme using signal strength among clusters in ad hoc networks. Packet transmission among the cluster heads in a cluster based wireless ad hoc networks are carried out through gateway nodes, while nodes in a cluster communicate via the head node. Existence of multiple gateways between the cluster heads means multiple. path existence Multiple transmissions of packet though redundancy paths may not desire for efficient resource usage. Therefore, communications between cluster heads through the most stable gateway is a good solution. This scheme selects a stable gateway node which is called as the candidate gateway. Nodes receive signals from more than two cluster heads, then they broadcast their own beacon signals which include information the beacon signal strength from each cluster head.

V. PROPOSED WORK

In this section we present our work to give an efficient adaptive gateway discovery mechanism that reduces congestion and improves the network throughput. Uses an optimal gateway selection algorithm and an adaptive gateway discovery mechanism to optimize the Time To live Field of the gateway advertisement message. It also makes use of a table which is maintained by the intermediate nodes in the mobile ad hoc networks. The two networks mobile ad hoc network and the internet are being integrated through the gateway. An algorithm is executed to select the most appropriate gateway by a MANET node. The proposed work consists of a step by step mechanism which is as following.

STEP1: *Whenever any mobile node wants to deliver or receive the data traffic to the infrastructured network such as internet, it uses the gateway selection mechanism to select the appropriate gateway on the basis of the most optimal path .*

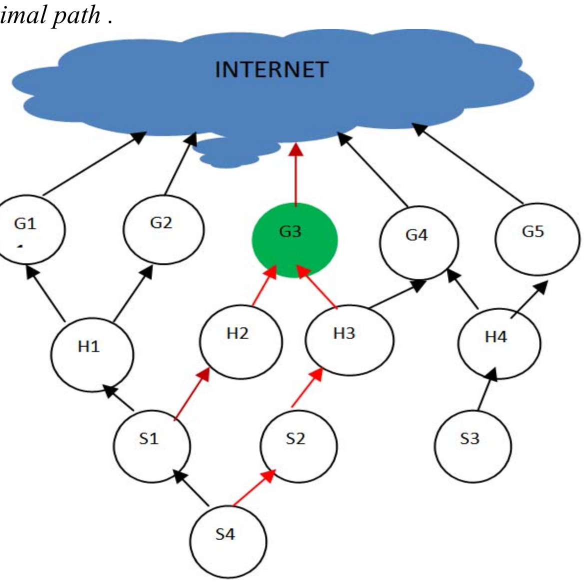

Fig 3. Gateway G3 is selected by the sources S1,S2 and S4 to connect to the internet. Here G1,G2,G3,G4,G5 are the gateways.H1,H2,H3,H4 are the intermediate nodes in the ad hoc networks.S1,S2,S3,S4 are the active sources.

STEP2: *The mobile nodes sends the data traffic to the internet node using the selected gateway.*

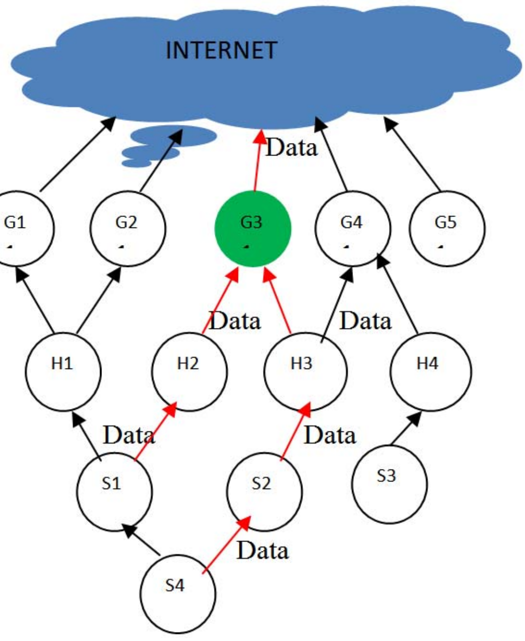

Fig 4. The Gateway G3 is selected by source S1.

STEP3: *The gateway obtains the required information i.e. the number of hops to the active sources which is needed for adaptation and stores it in its routing table. This information is obtained from the IP header of the data packet sent by the active sources .*

TABLE1

Table maintained by G3 to store the hops information.

IP address	No of Hops
172.20.5.1(S1)	2
172.20.5.2(S2) 172.20.5.3(S4)	2 3

STEP4: *Each intermediate node in the path from the active source towards the gateway gets the number of hops information too and stores it in its routing table. This node is distinguished from other node by the fact that it is used as the node to relay the traffic from active source. This node also gets the source address information as well.*

STEP5: *The gateway G3 sets the TTL value of the gateway advertisement message equal to 1.*

STEP6:*The gateway sends the advertisement message with TTL=1.*

STEP7:*Each intermediate node between the active source to gateway forwards the data packet with TTL=1.*

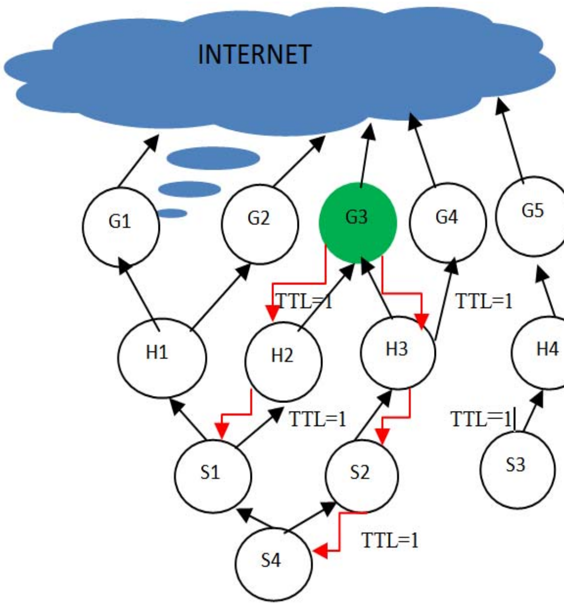

Fig5 .The advertisement message is forwarded up to S4.

VI. PROPOSED ALGORITHM

In this section we propose an adaptive gateway discovery algorithm that uses three gateway selection parameters which are path availability period, residual load capacity and path latency.

The algorithm[13] runs in 4 phases which are as following.

- Reactive gateway discovery phase
- Gateway Selection Phase
- Data Delivery Phase
- Proactive Gateway Discovery Phase

Phase 1: Reactive Gateway Discovery Phase

1. Each active source sends a GW-DISC message with parameters set as following for every available path to the gateway nodes

($L_{GW\text{-}DISC=null}$,TTL=0,$C_{GW\text{-}DISC}$= null, $Y_{GW\text{-}DISC}$=0)

2.For every available path i from active source to the gateway nodes.

2.1 mobile node j in path i computes L_J .
If($L_{GW\text{-}DISC}$=null or L_J<$L_{GW\text{-}DISC}$) then
$L_{GW\text{-}DISC}$=L_J
end if

2.2 Mobile node j computes C_J
If($C_{GW\text{-}DISC}$=null or C_J<$C_{GW\text{-}DISC}$)
Then, $C_{GW\text{-}DISC}$=C_J
End if

2.3 $Y_{GW\text{-}DISC}$ =$Y_{GW\text{-}DISC}$ + Y_J

2.4 Update path parameters (L,C,Y) in node j's routing table.

2.5 TTL=TTL+1

3.The GW-DISC message is forwarded till it reaches the gateway.

Phase 2: Gateway Selection Phase

1.Each active source computes the QoS value for every path to the gateway.

$\delta_i=(L_i/ L_{max})+(C_i / C_{max})+(Y_{min}/ Y_i)$

2.Each active source selects the best available gateway on the basis of most optimal path i.e. the path with maximum value of δ_i.

Phase 3: Data Delivery Phase

1. In this phase the active source delivers the data to the node in the infrastructured network such as the internet. The gateway finds out the necessary information from the IP-header of the data packets sent by the active source and stores it in a table. This information includes the number of hops from the source to the destination.

2. Each intermediate node j between the source and the gateway also captures the number of hops information the source is away from the gateway, from the IP header of the data packet and the source address and constructs a table.Phase 4: Proactive gateway Discovery Phase In this phase the TTL value of the GW-ADV message is adapted.

1.Initially gateway node sends the GW-ADV message towards the active sources with the TTL = 1.

2.Each node i on receiving the GW-ADV does the following.

2.1If it is an intermediate node. A node is an intermediate node if it is involved in relaying data packets from the source to the destination. Then it forwards the data packet with TTL=1.

2.2Othewise it does nothing

3.The GW-ADV message is forwarded until it reaches the active sources.

VII. PROTOCOL SIMULATION AND ANALYSIS

The protocol has been simulated and analyzed on ns2 2.35 simulator. The simulation parameters that have been taken are packet delivery ratio, throughput, end-to-end delay, routing overhead, traffic sent and traffic received. These are being plotted against the time duration.

TABLE 2
Table containing the simulation model parameters

Parameter	Value
Number Of MANET nodes	10
Number Of packet sources	5
Number of Gateways	5
Packet Size	512 Bytes
Size Of Area	(400*400) metres
Simulation Time	280 seconds
Traffic Type	Constant Bit Rate
Transmission Range	250m
Mobility Model	Random Waypoint
Maximum node speed	20 meteres /second

1. Packet Delivery Ratio: The packet delivery ratio is defined as the ration of total number of data packets received by the destination to the data packets sent by the source.

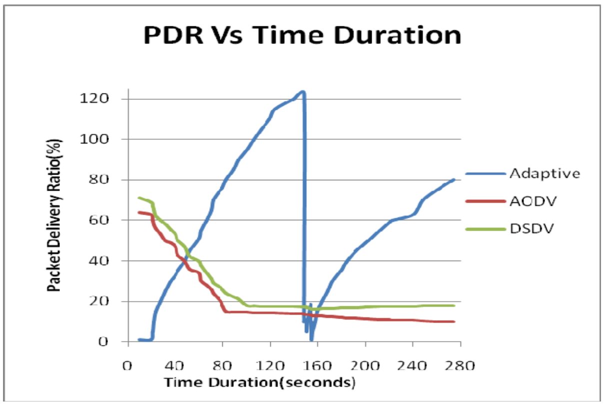

Fig 6. Packet Delivery Ratio Vs Time Duration

It can be observed from the figure that the proposed protocol has better packet delivery ratio initially when the simulation is carried out and it increases because the number of packets received through the selected gateway is large. After a certain time interval the packet delivery ratio drops of as the traffic source is temporarily disconnected from the selected gateway and attached to another gateway. As observed from the figure that the proposed adaptive protocol gives better packet delivery ratio than other two protocols.

2. End-To-End Delay: It is defined as the average time taken by the data packets to arrive at the destination.

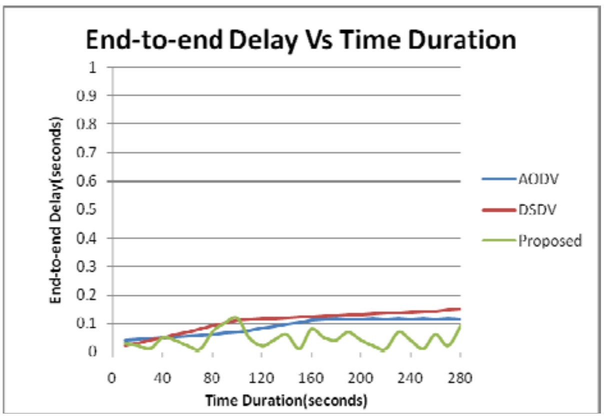

Fig 7. End-to-End Delay Vs time Duration

The proposed protocol has lesser end-to-end delay for packets to reach from source to the destination as compared to the AODV and DSDV gateway Discovery protocol. This is because once the gateway is being selected by a MANET node, all the traffic is delivered through the best available gateway and the path and hence the end-to-end delay is minimized .Moreover, the TTL value of the gateway advertisement message is adapted in the next gateway advertisement message transmission. Hence it gives better performance.

3. Throughput: It is defined as the average rate of successful messages delivered over communication channel.

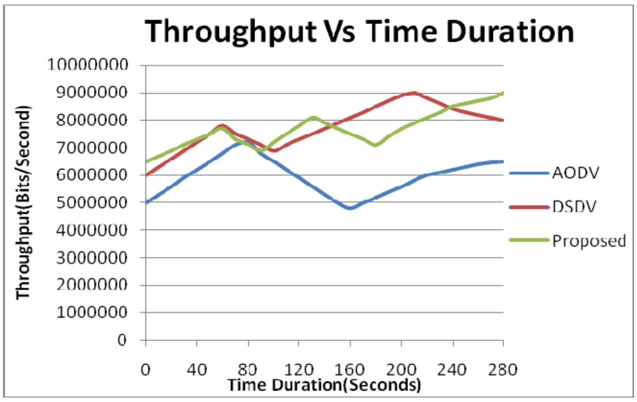

Fig 8. Throughput Vs Time Duration

It can be observed from the figure that the proposed protocol produces better throughput in terms of bits/second than other two protocols.

4. Routing Overhead: It is defined as the total number of control packets generated at every mobile node.

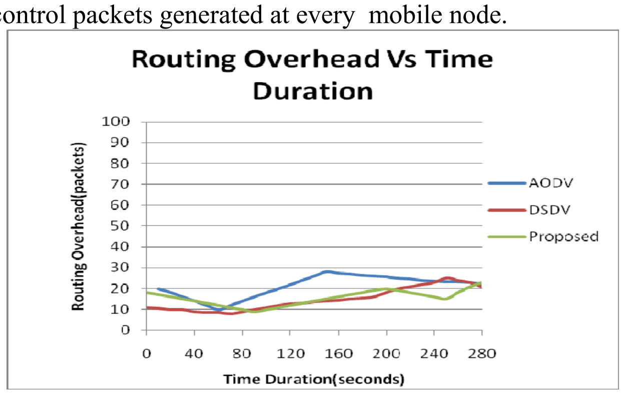

Fig 9.Routing Overhead Vs Time Duration

The overhead of the protocol is in between AODV and DSDV protocol. This is because the number of control packets generated for traffic delivery between source to destination is directly affected by the optimal gateway selection.

CONCLUSION

The proposed concept and algorithm aim to reduce the network congestion and increase the network throughput. The control overhead is also going to be decreased. As the TTL value of the gateway advertisement message is adapted .The gateway advertisement message will only be sent only to the active sources in the network and not to all the sources and hence causing lesser overhead and congestion and improving the network performance.

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