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SHWMP: Scalable Hybrid Wireless Mesh Protocol for Wireless Mesh Networks

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***Abstract*– Wireless Mesh Networks (WMN) is new concept of wireless networks which are interconnected without any wires and with full-fledged safety and dependable of a wired network. WMN brings the ease of simple installation and less expensive deployment costs. The standards which are met in Wireless Local Area Networks (WLAN) such as scalability, reliability and security has to be retained and maintained here. There are several issues exists with throughput, quality and security in a wireless mesh network and have largely been resolved. But scalable capacity issues remain as it and posses challenges for researchers to carry out work without compromising performance, Quality of Service (QoS) or availability across multiple hops in a mesh infrastructure. The increase in interest on wireless mesh architectures IEEE standard 802.11s has created lot of support for predominant mesh routing protocols. In this paper, we propose a scalable hybrid routing protocol for large scale Wireless Mesh Networks named as Scalable Hybrid Wireless Mesh Protocol (SHWMP). Specifically, performance analysis was simulated for ad hoc on demand distance vector (AODV), Optimized Link State Routing (OLSR), Hybrid Wireless Mesh Protocol (HWMP) and Scalable Hybrid Wireless Mesh Protocol (SHWMP). The impacts of traffic loads, number of sources and the network size on wireless mesh network have been investigated through the simulation. SHWMP has a clear advantage compare to AODV, OLSR, HWMP in terms of maximizing throughput and minimizing end to end delay.**

***Index Terms*— Hybrid Wireless Mesh Protocol, Routing, Scalability and Throughput**

I. INTRODUCTION

WIRELESS Mesh Networks transmits through multi-hops and consists of mesh client and mesh routers nodes. Researchers have considered Wireless Mesh Networks (WMNs) as a key technology for them to work on next generation wireless networks. WMN is a mesh network which is deployed over a wireless network system with low cost, high scalability, reliable services and easy maintenance. Another direction or alternative for last-mile broadband Internet access which has greatest potential to play a critical role is Wireless Mesh Networks. These networks are considered as a unique case of multi-hop mobile ad hoc networks where the nodes have fixed positions and talk to the internet via one or more routers/gateways. Mesh networks are classified by dynamic self-organization, self-configuration and self-healing.

In case of wireless mobile environment, the network layer and its routing operations must be made to support mobile nodes, dynamic topologies and changing link capacity [1]. Routing needs to be adapted to a specific application and also it must match radio environment. Cross-layered design techniques have been proposed for wireless networks to improve the system performance [2], [3], [4] and security [5].

The present 802.11 based wireless networks completely depend on wired infrastructure to transfer the traffic to end users. This makes wired infrastructure expensive and rigid for wireless local area networks (WLAN) as coverage cannot be scalable beyond the back-haul deployment. The performance of a WMN is mainly dependent on the design of the routing protocols and also associate metric used to measure it. The main goal of any routing protocols is to select the optimal path between the source and destination based on the suitable routing metric. Most of the existing protocols used in WMNs rely on the network layer (IP) and use hop count to allow multi-hop communication and do not provide a good solution for wireless networks.

The new standard IEEE 802.11s was developed by IEEE task group to design and develop a scalable integrated mesh networking solution. Even though, this group set hybrid wireless mesh protocol (HWMP) [6] as default routing protocol, but still there exists scope for extending scalable routing protocol for WMN. In addition this, airtime [7] metric was considered as default routing metric. We design and develop a new scalable routing protocol called SHWMP (Scalable Hybrid Wireless Mesh Routing Protocol) is suggested to measure the performance of scalable routing protocol. The airtime metric was only focus on consumption of resource by a packet on a link. This metric only cannot be used as standard, since there are so many parameters which mainly required to measure the overall performance of WMN.

The rest of the paper is organized as follows: In section II, related work carried out recently is discussed. The detailed descriptions about the routing protocol in WMN are discussed in Section III. The mathematical model suggested in Section IV for scalability in WMN. Section V proposes a new scalable routing protocol SHWMP. Section VII elaborates simulation environment and the simulation results are analyzed and discussed in Section VIII. The conclusion for this work is drawn in Section IX.

II. RELATED WORK

The IEEE 802.11s has been focusing on how to enhance the functionality of routing in order to achieve better efficiency and bandwidth utilization. It is built upon the existing IEEE 802.11a/b/g technologies and makes use of QoS features of IEEE 802.11e and security features of IEEE 802.11i. The extra forwarding features of IEEE 802.11s allow wireless Mesh Points (MPs) to know each other in network, authenticate and maintain connections and to find out the most optimal route for a particular task. The critical challenges for wireless mesh network are dynamic discovering and updating of routing information due to high mobility of nodes. The IEEE 802.11s working group is taken several MANET protocols for consideration. There are several research works carried out to evaluate the performance of routing protocols such as Ad Hoc On Demand Distance Vector (AODV) [8] and Optimized Link State Routing Protocol (OLSR) [9], which are based on on-demand and table-driven forwarding technique, respectively.

In previous years, many researchers have compared the popular protocols considering a standard wireless ad hoc network [10], [11], [12], [13]. However, wireless mesh networks are different from the traditional ad hoc network MPs are wireless and connected in ad hoc fashion. In order to improve the scalability of the routing performance in wireless mesh network, Jiwei Chen at. el. [14] analyze an extension of OLSR routing protocol, called Optimized Fisheye Link State Routing (OFLSR) to reduce routing overhead, then compare OFLSR with AODV in terms of packet delivery ratio, throughput, routing overhead and packet end-to-end delay.

Wireless mesh is a self organized network which has a mission been given in [15] and this paper contains information regarding how net work formation takes place. Issues related to multi hop net works such as degradation of mesh performance due to wireless devices and how to overcome the limitations of wireless mesh networks is also discussed in the case study.

The architecture of multi-channel wireless mesh net work which provides every mesh network node with number of 802.11net work inter face cards is presented in Raniwala et al [16]. Such kind of architecture is known as Hyacinth. In [16], it is also presented that intelligent assignment of channel is very critical to the performance of such multichannel wireless mesh net work architecture. The current distributed algorithms which make use of only information about local for the purpose of channel assignment with dynamism and to provide path for packets.

The authors also compared the performance of such distributive algorithm with centralized algorithm that does similar task in their simulation part of study.

The project for autonomic computing model presented in [17], clearly explains how in heterogeneous environment, the applications of autonomic computing are carried out in open system architecture and required initiatives for industry standards. Such model also shows that in an evolutionary manner how self managing autonomic abilities are achievable. Vandenberghe et al. [18] has presented an architecture for a system where he has explained how the system is capable of dealing with the restricted and contradictory requirements in building the wireless automation. Mobi Mesh is another architecture for wireless mesh network and is given [19] and this architecture has been implemented in a real life test bed and this architecture supports great mobility and offers integration abilities. Set of procedure that constitutes an intermediate layer between second and third layers support mobility. The performances and test results are highlighted and future works are described.

Making use the paradigm of autonomous computation, the authors in [20] suggested architecture for which WMN according to which the WMN are self managed. The various properties that are proposed for the networks include; the self-configuration, self-healing, self-optimization and self-protection and all these properties are adopted for these networks. In [21], the authors have presented a demonstrated system so called self-configuring and self-optimizing MANET's (SCOMAN) where it implements self configuration ability and self-optimization properties for ad-hoc networks. As it is discussed in [21], a WMN is regarded as very important candidate in providing the necessary solutions for the last line problem of high speed wireless networks. Scalability is one of the significant challenges that a conventional mesh net work encounters because of self–organization and multi-hop connection properties of WMN.

In [23], a self-organized architecture for the optimized Link State Routing Protocol (OLSR) and Ad hoc on demand distance vector (AODV) is developed for wireless mesh networks based on the agent based technology. The main idea is to adapt the self-organizing capabilities (self-configuration, self-optimization, self-healing, and self-protection) into the OLSR and AODV routing protocols to improve their routing performance.

The self-organization is a promising area for the next generations wireless networks, it still has drawback of the approaches towards self-organization of the network. By analyzing the related works, we arrive that some solutions in [14], [22], [16], [18], [20], [21], [23] partially emphasize the self organization problem and so allow us to work self organization through of the definition of an alternative architecture to provide a real experience in low cost of the main capacities: self-configuration, self-optimization, self-healing and self-protection in wireless mesh networks.

III. ROUTING PROTOCOLS FOR WIRELESS MESH NETWORKS

The popular three types of routing protocols have been considered for evaluation with newly proposed scalable protocols, namely AODV, OLSR and HWMP. In this section the mechanism of each routing protocols are explained briefly [24].

A) Ad hoc On-demand Distance Vector (AODV)

AODV [8], is basically source–initiated on demand protocol and is improved algorithm over Distance sequenced and Distanced Vector (DSDV) [4] algorithm, also AODV incorporates many features of Dynamic Source Routing (DSR). AODV only helps in the use of symmetric links. In AODV, the process of path discovery is initiated when ever source node needs to establish communication with any of the node in the network by sending route request packets. Unlike in DSR, AODV employs the usual routing tables; one entry for each destination while in DSR it holds many number of entries for each destination. The AODV offers loop-free in the event of link break. As it does not use the global periodic routing advertisements, the requirement for band with availability is reduced.

B) Optimized Link State Routing (OLSR)

This is basically a proactive type routing protocol [9] and it is optimization for MANET and it is inheritance of link state protocol. The central idea of optimization is realized by using multipoint relay concept, where the topological information is broad casted to the nodes present in the network and to establish the path quickly not considering the data load and node mobility causing the break in the links. Three important and fundamental activities that will play very vital role in providing the optimized paths and they are: Means for sensing neighbor nodes, Method for flooding and method for selection and disseminate topological message.

C) Hybrid Wireless Mesh Protocol (HWMP)

It is essentially a hybrid routing protocol and it combines the significant features of on demand protocol like flexibility and proactive protocol such as topology extension. The features of on demand routing are based on AODV routing protocol [8] and proactive essence is based on distance vector routing protocol. The IEEE 802.11s standard uses HWMP as default protocol in MAC layer. For route selection it uses air time link metric as default link metric calculation method in wireless mesh net works. The air time link metric is the radio-aware routing metric. In fact, it decides about the optimal path based on the channel resource consumption. The four important components that are contained in HWMP are: The root announcement (RANN), path request (PREQ), path reply (PREP) and path error (PERR).The other information of HWMP has three fields: distance sequence number (DSN), time to live (TTL) and metric. Here count to infinity problem is prevented by DSN and TTL and better routing path can found with the help of metric field.

IV. MATHEMATICAL MODEL FOR SCALABILITY IN WIRELESS MESH NETWORKS

Assume that the *N* nodes in WMN that can cover area *S*. Each node n_i has N_{ch} (i) independent sub channels with transmission capacity $C_{i\,j}$ and transmission radius r_i
The capacity of the nodes is calculated as

$$C = \sum_{j}^{Nch(i)} Cij \quad (1)$$

The scalability of the WMN is based on the capacity, traffic connectivity and coverage.

The traffic of multihop wireless network can be classified in to unicast traffic [2] and multicast traffic [3], [4]. The transmission traffic over the WMN must be exchanged between hop by hop. The efficiency of each node is determined by hops which are involved in exchange of packet. If C is the transmission capacity of the network and H is the number of relay hops then the pay load carried will be $\frac{W}{H}$. The connectivity model can be derived as follows. The spatial position of mesh nodes are assumed and modeled as Poisson distribution [28]. The positional information of the neighbors is detected using some mechanism by each node in the network.

The traffic is directly transmitted by each node to the neighbor closest to the termination. The probability for a node **n** have l forward node is:

$$P(l_j\ \lambda = n_f) = \frac{e^{-nf,}\ n_f^l}{l!} \quad (2)$$

Where n_f is the average of nodes that is near termination node in a transmission area.

The access of mesh nodes should be random and competitive. Let the $\mathbf{p_x}$ be the probability of a user x starts to packet at a given time step and (1- p_x) is the probability P_c of the channel is free when all the other n users in the transmission range are not sending will be:

$$P_c = (1 - p_x)^n \quad (3)$$

Let P_{col} - be the probability of at least one another user start to send simultaneously except the source
p_x - be the probability of pay load of the mesh users
P_c - be the probability of capacity of the mesh users
Based on Markov chain model for IEEE 802.11
DCF we get:

$$Pcol = \sum_{l=1}^{n} \binom{n}{l} P_x^l (1 - p_x)^{(n-l)} \quad (4)$$

$$Px = \sum_{i=1}^{m} Pc\ X\ B_{i,0} = \sum_{i=0}^{m} R_{i,0} \quad (5)$$

Where B is the bandwidth of the channel and R is the transmission coverage rage

$$P_c = Idlestate + \sum_{i=0}^{m} \sum_{j=1}^{c_i - 1} B_{i,j} + (1-f) \sum_{i=0}^{m} B_{i,0} \quad (6)$$

Now apply (3), since nodes spatial position accordingly the Poisson distribution:

$$E(Pc) = \sum_{l=1}^{n} \frac{e^{-nf}\ \ n_f^l}{l!} (1 - Px)^l \quad (7)$$

V. PROPOSED PROTOCOL SCALABLE HYBRID WIRELESS MESH PROTOCOL (SHWMP)

The design of the WMN is shown as unidirectional graph G = (V,E), where V is the set of wireless edges (p,q) between any two mesh nodes p and q and E is set of wireless connections that depicts any two mesh gateways p and q. Each mesh client can establish bi-directional connections to a certain mesh router by exchanging incoming and outgoing traffic patterns.

The Fig. 1 depicts the proposed scalable model for mesh router involving the agents and the interaction of the scalable capabilities modules with AODV, OLSR and HWMP protocols.

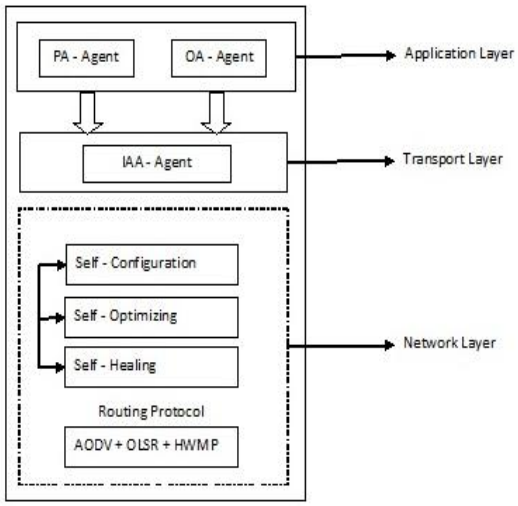

Fig. 1: Scalable model for Mesh Router

The agents in the application layers have got clear responsibility in self organization and self optimization.

PA-Agents: These mobile agents are added in the mesh router and also in each association of the client node of the mesh router. These agents have got specific functions in identifying the population or density of the network. The density of the network may vary between the small scale, medium scale and large scale. The group of PA-Agents forms the base ground of self configuration capability of AODV, OLSR and HWMP.

OA-Agents: These mobile agents are placed in the mesh router and also in each association of the client node of the mesh router. These agents are responsible for observing the network behavior such as drop packets rate, signal strength and range, throughput, delay, active and passive nodes, as well as information about the connection state. They are fixed agents in the mesh routers and allow self optimization capability of AODV, OLSR and HWMP.

The agent in the transport layer has got clear responsibility in self healing process during network formation.

HA-Agents: These mobile agents are added in the mesh router and also in each association of the client node of the mesh router. These agents have got specific functions in healing the mesh router when the population or density of the network increases suddenly. The density of the network may vary between the small scale, medium scale and large scale. The group of HA-Agents forms the base of self healing of AODV, OLSR and HWMP.

Scalable HWMP Algorithm: Scale of AODV, OLSR and HWMP Routing Control

1. *START*
2. *network_size* = [This is information collected from PA-AGENT]
3. *min_scale* = 50 [Node density in a small size WM*N]*
4. *avg_scale* = 100 [Node density in a medium size WMN]
5. *max_scale* = 200 [Node density in a large size WMN]
6. while there are nodes in the network do
7. if *network _size* is less than *min_scale* then
   [Initiate normal procedure with default values and configure parameters to work for a *min_scale*]
   CALL PA-AGENT
   RETURN
8. if *network _size* is less than *avg_scale* then
   [Initiate self-configuration procedure and configure parameters to work for a *avg_scale*]
   CALL PA-AGENT
   CALL OA-AGENT
   RETURN
9. if *network _size* is less than *max_scale* then
   [Initiate self-configuration and self-optimization procedure and configure parameters to work for a *max_scale*]
   CALL PA-AGENT
   CALL OA-AGENT
   RETURN
   if there disconnection of link due to coverage and connectivity problem due to increase in node density
   [Initiate self-healing procedure and configure parameters to work for a *max_scale*]
   CALL HA-AGENT
   RETURN
10. *END*

i) SELF-CONFIGURATION PROCEDURE

[This module is mainly takes care of configuring parameter values in the OLSR, AODV and HWMP protocols depending on the network density]

The performance of the OLSR, AODV and HWMP protocols is sensitive to the select values of some parameters that can be managed during increasing in the network size. The self-configuration process self-adapts the values deviate to changes in the network density, thus not avoiding the default values for these parameters in the networks.

Step 1: Depending on the *network_size* the self-configuration adopts OLSR protocol with *HELLO_INTERVAL* to value ranging from 1, 2, 5, 6, 10 and 15 seconds. In similar way other parameters such as *Refresh_interval, Tc_interval, neighbor_hold_time, top_hold_time, Dup_hold_time and Willingness* are dynamically adopted as per the scalability of the network takes place.

Step 2: Depending on the *network_size* the self-configuration adopts AODV protocol with *route_request_retries* value ranging from 1, 10 and 20. In similar way other parameters such as *route_request_rate*, *grat_rooute_reply_flag*, *dest_only_flag*, *ack_required*,*hello_interval*, *active_route_timeout etc* are dynamically adopted as per the scalability of the network takes place.

ii) SELF-OPTIMIZATION PROCEDURE

The information obtained through the PA-AGENT and OA-AGENT is used as feedback parameters for optimization of the AODV, OLSR and HWMP protocols. This will help in controlling message overhead, as well as to adopt itself to the optimized routing paths. The factors that affect the parameters of AODV, OLSR and HWMP are size of the network, signal strength, delay, jitter and overhead. When the network is small enough also medium enough to some extent default parameters works well with performance of the networks. This is not true in case we need to make routing protocol scalable for large network. Thus, it is necessary to find n method for self-optimization of parameters than can achieve better overall performance of the network.

iii) SELF-HEALING PROCEDURE

The self-healing procedure will be responsible for detecting, localizing and repairing breakups of the routing protocols. The Self-healing process is in the network layer and coupled together with the select the right routing protocol between OLSR, AODV and HWMP. OSLR is adopted when the networks has got high mobility and frequent changes. AODV is used for a large scale and dense networks and HWMP is used for a large scale and less delay is the major concern.

VI. SIMULATION ENVIRONMENT

The simulation experiments are conducted using QualNet Simulator [25]. The standard IEEE 802.11s radio is adopted with the channel rate as 2 Mbps. The scenario with mesh of wireless routers for the backbone client nodes (fixed and mobile) connected to the each mesh routers. The transmission range is 250m and the carrier sensing range is around 600m. The simulation area of 2000 x 2000 m^2 is deployed over a square geographical area. The client nodes have different mobility. These settings are maintained with real time wireless networks, in which the transmission range of a node is typically smaller than its interference range.

The Random Waypoint model [27] is adopted for driving mobile hosts. In this model, each host starts its movement from a random location to a random destination with a randomly chosen speed uniformly distributed between 0 and a maximum speed. Once after reaching the destination, node will choose targeted another destination is selected. In this simulation study, the maximum speed is varied from 0 m/s to 20 m/s. Traffic sources are CBR (constant bit rate) or TCP. For each TCP session, TCP-NewReno [26] is adopted and packet size is 1460 bytes. For each CBR session, the packet size is 512 bytes and packet rate is 4 packets per second. The number of session pairs is varied to change the traffic load transferred into the mesh network. Each scenario was simulated for 600 seconds. The collected data is averaged over those runs. Refer Appendix-A for simulation parameters used.

The performance of new developed SHWMP routing protocol in WMN were evaluated by using several routing metrics. The two different quantitative metrics were employed namely throughput and average end to end delay. Throughput is measured in terms of bits per second (bps). Average end to end delay is the average time needed for all data packets to be delivered from source to destination.

VII. RESULTS AND DISCUSSIONS

The performance of SHWMP protocol is evaluated with AODV, OLSR and HWMP was evaluated by varying traffic loads, number of nodes and number of sources. Simulations are discussed in detail.

A) Throughput and Delay against Traffic Loads

In this scenario, the number of nodes is fixed to 200 and traffic load is varied from 20 packets/s to 200 packets/s. The nodes are placed randomly within 2000 m x 2000 m area. The performance of the four routing protocols in terms average throughput with various number of traffic loads are depicted in the Fig. 2. The average throughputs of all four routing protocols are decreasing as the number of traffic loads increased.

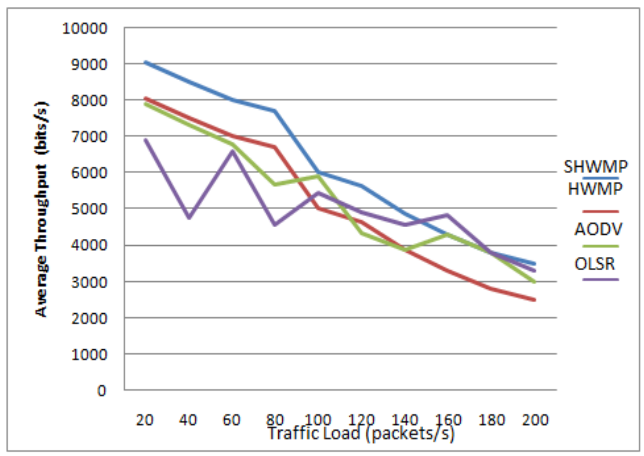

Fig. 2: Average Throughput versus Traffic Loads

Among all the four routing protocols, OLSR attained lowest throughput as the number of traffic loads increased. This is due to the OLSR protocol does not require reliable transmission of control messages. The nodes in the mesh networks simultaneously send control messages periodically and have got sustainability over loss of such control messages. It can be observed that SHWMP has got clear throughput higher than HWMP and AODV. This is because of the self-configuring capability of SHWMP over varying traffic loads.

In Fig. 3 the average end to end delay is added in the network. Here it can be seen that the SHWMP has lowest average end to end delay throughout simulation as compared to other routing protocols. It can seen clearly that, the average end to end delay for SHWMP is nearly

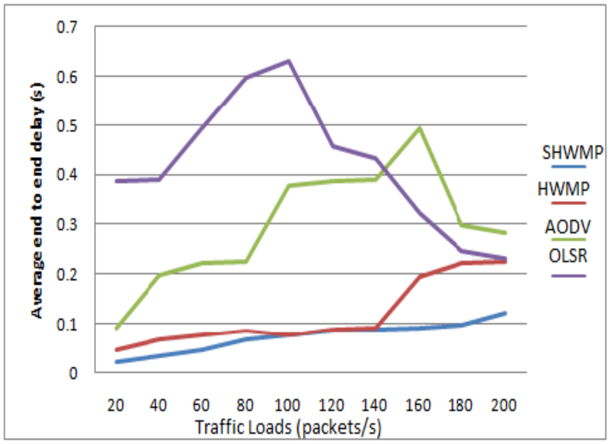

Fig. 3: Average end to end delay versus Traffic Loads

150 milliseconds and found to be consistent throughout the simulation as the traffic load is increased. HWMP recorded 50 to 230 milliseconds where as AODV shows the reasonable rise of delay up to 500 milliseconds and reduce to 280 milliseconds. OLSR takes highest end to end delay between 380 to 620 milliseconds and varies as the traffic loads gets increased. This is very high delay due to the required overhead to broadcast control signal throughout the mesh networks. This draws inference that, the change in traffic loads has got variation in the performance of the routing protocols in mesh networks.

B) Throughput and Delay against Network Density

The change in number nodes from 20 to 200 nodes keeping 10 sources of CBR traffic transmitting at the rate of 100 packets per seconds are placed randomly over a simulation area of 2000 m x 2000 m area. Initially all the four protocols demonstrate the more or less same value as shown in the Fig. 4. But when the number of nodes increases, the throughput of OLSR protocol is degraded drastically.

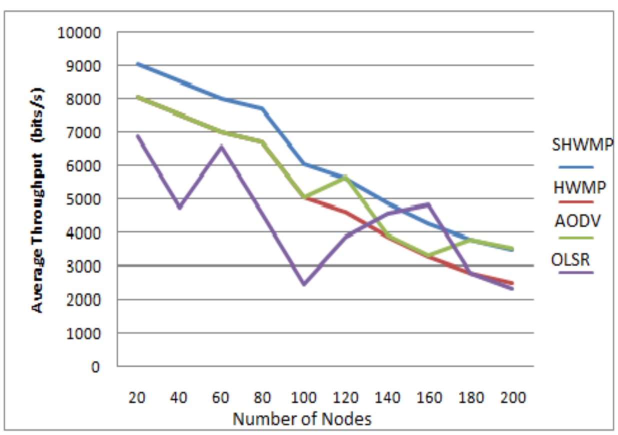

Fig. 4: Average Throughput vs Number of Nodes

This performance degradation is mainly due to increasing number nodes leads to increase in packet losses within the mesh networks. AODV and HWMP gives consistent throughout the simulations compared to OLSR. SHWMP is a clear winner among all the protocols. The main reason for degradation of OLSR protocol is due to non scalability nature of proactive protocol. OLSR fails in performing link state update efficiently in a large network.

The average end to end delay is measured from source to destination over a varying number of nodes as shown in Fig. 5. The increase in number of nodes will have direct effect on average end to end delay. This results in increase of end to end delay when network size grows as shown in Fig. 5.

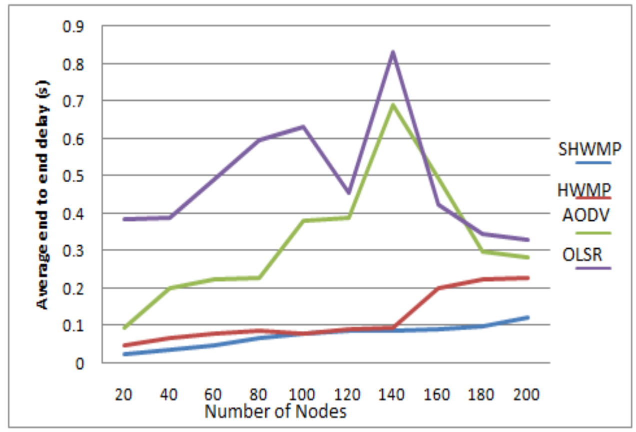

Fig. 5: Average Throughput versus Number of nodes

Both SHWMP and HWMP incur nearly 50 to 200 milliseconds of average end to end delay throughout this simulation. Whereas AODV and OLSR attained 100 milliseconds to 800 milliseconds due to large network size and fail in carry out the load efficiently. SHWMP shows a consistent lowest average end to end delay which indicates that protocol can be used for large scalable mesh networks.

C) Throughput and Delay against Number of Sources

In the next scenario, the number of CBR traffic sources with fixed number of packets sending at 200 packets/s. The Fig. 6 depicts the throughput pattern is varied from 10 to 50 CBR sources.

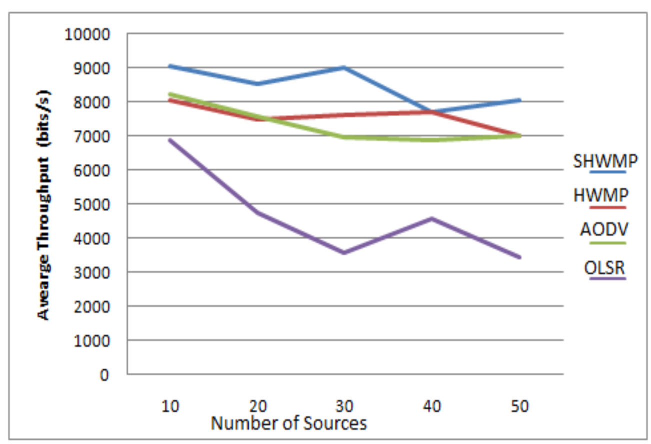

Fig. 6: Average throughput versus number of sources

The throughput is almost same for HWMP and AODV and SHWMP outperforms all the protocols. The OLSR shows very poor performance due to heavy packets loss that occur frequently in the wireless radio networks due to collisions or other retransmissions problems. SHWMP records highest throughput between 8200 to 9000 bits/s.

All the four routing protocols are tested for average end to end delay for variable number of sources as shown in the Fig. 7. As the delay gets increases with the increasing number of sources for the all protocols.

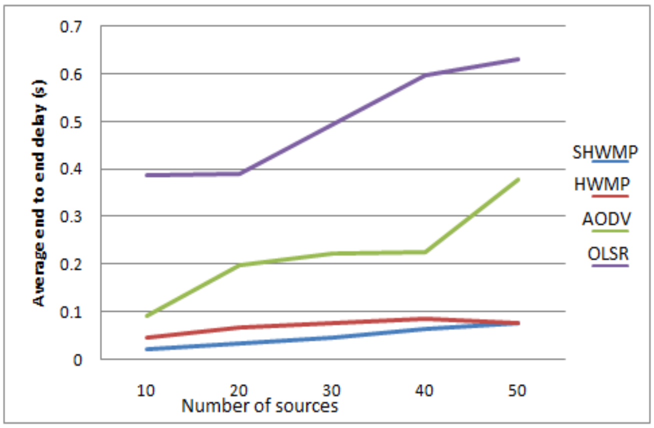

Fig. 7: Average end to end delay versus number of sources

The delay for SHWMP and HWMP are very closer and records between 20 to 60 milliseconds. As the number of sources increases the AODV and OLSR the delay gets increases drastically. OLSR records 380 to 630 milliseconds delay as the highest among all the other routing protocols. This is due the non adaptability nature of OLSR to sustain connectivity when the number of sources starts generating packets at high rate. But the self configuring capability of SHWMP and HWMP allows protocols to adapt to varying traffic due to increase in number of CBR sources.

VIII. CONCLUSION

In this paper, a scalable hybrid mesh protocol is proposed for wireless mesh networks based on the self-configuring agent technology. The basic idea is to adapt the self organization capabilities in to HWMP, AODV and OLSR protocols which in turn improves the scalability of the network and increases the routing performance. To study the behavior with reactive (AODV), proactive (OLSR), hybrid protocols (SHWMP and HWMP) which shows clear impact on performance when there is a change in network density, number of sources and different traffic loads. The self configuration module is implemented and evaluated under different network scenarios and traffic conditions. Through the self configuring process, dynamically certain parameters are tuned to the time intervals of HELLO message broadcasts depending on the density of the network. It was clearly observed through our simulations that SHWMP has clear advantage over HWMP, AODV and OLSR. The overall average throughput and lowest end to end delay recorded in SHWMP makes clear winner amongst other routing protocol used in this simulation. As future, we need to develop self organization capabilities such self healing and self optimizing modules for improved parameters for routing protocols used in the simulation.

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