SAMR: Swarm Adaptive Multipath Routing Topology for Load balancing and Congestion Endurance in Mobile Ad hoc Networks

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Abstract: **Ad hoc networks consist of independent self structured nodes. Nodes utilize a wireless medium for exchange their message or data, as a result two nodes can converse in a straight one to one connection if and only if they are within every other's transmit range. Swarm intelligence presents to intricate activities so as to happen as of each easy exclusive behavior and exchanges, which is often experienced in nature, particularly amongst social insects such as ants. Although every individual (an ant) has small intelligence and just tags on basic rules by means of confined information that gained from the network domain, for instance ant's pheromone track arranging and following activities, widespread best activities, such as determining a shortest route, appear when they work jointly as a group. In this regard in our previous work we proposed a biologically inspired metaphor based path finding in mobile ad hoc networks that referred as Swarm Adaptive Hybrid Routing (SAHR). . With the motivation gained from SAHR, here in this paper we propose a Swarm Adaptive Multiple paths routing (SAMR) topology. The aim is to perform the load balancing and congestion endurance. In this paper we utilize our previous proposed algorithm that inspired from Swarm Intelligence to get these characteristics. In a wide set of simulation tests, we evaluate our routing topology with SAHR, and show that it gets better performance over a wide range of diverse circumstances and for a number of various assessment evaluates. In particular, we demonstrate that it turns superior in load balancing and congestion endurance with dense networks.**

Keywords: Manet, Swarm intelligence, hybrid routing, unicast routing, "ACO"

I. INTRODUCTION

Multiple paths routing topologies are distinguish from uni-path routing by the details that they appear for and utilize some paths to deal out traffic from a source to a target in its place of transmitting entire traffic along the uni-path [1][2]. Conventional multiple paths routing have paying attention on the exploit of multiple paths first and foremost for load balancing and route breakdown tolerance. Load balancing trounces the issue of ability limitations of a single route by transfer data traffic on multiple routes and minimizing congestion by transmitting traffic from end to end fewer congested routes. As mentioned in [2], the application of multiple path strategies in mobile ad hoc networks shows natural, as it may help to weaken the result of defective wireless links, lessen end-to-end delay and attain load-balancing. Further, due to the energy and bandwidth limitations, a routing topology in ad hoc networks should quite share out the routing traffic between the mobile hosts. Though, most of the present routing topologies in this context are single-path topologies and have not caring the load-balancing issue. An unstable transfer of data traffic will not only direct to delay and congestion but also direct to energy resource excess use in heavily loaded hosts. Nasipuri et al [3] projected an on-demand multiple paths routing scheme that uses alternate routes, so that they can be exploited when the major one be ineffective. Though, the performance improvement of multiple paths routing in observe of load balancing wasn't been studied comprehensively. S.J. Lee et al [6] proposed a Split Multiple paths routing (SMR) that concentrated on the process of discover and maintain multiple paths that are at most disjoint.

In the perspective of ad hoc networks, the achievement of multiple paths routing relies on taking into account the effects of route mixture during route assortment. M. R. Pearlman et al [5] explored the effect of route coupling on Alternate Path Routing (APR) in mobile ad hoc networks. It was stand on that the network topology and channel characteristics such as, route coupling can sternly restricts the advantage accessible by APR tactics. Route combination is a visible fact of wireless medium that takes place when a couple of routes are identified close enough to impede by means of mutual during data correspondence. As a consequence, the nodes in multiple paths repeatedly compete for admittance to the medium they distribute and can end up with poorly scalable than a uni route topology. Therefore, detached routes are not at all an enough condition for scalability in this perspective.

This paper discussing the related work in section II that followed by the exploration of the proposed swarm adaptive multiple paths routing topology in section III. Section IV elaborates the considered basic routing topology SAHR and section V explores simulations and results analysis, which followed by the conclusion of the proposal and experiments.

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II. RELATED WORK:

Split Multiple paths routing (SMR) which is reactive scheme was anticipated by Sung-Ju Lee et al. [8] . This setups and makes use of manifold routes of maximally disjoint routes. The route recuperation process is reduced and the message operating cost is controlled by using manifold routes. The data packets are dispersed into multiple routes of dynamic sessions by means of a per packet allotment scheme.

A2OMDV is an extension to AOMDV, which was proposed by DUCKSOO SHIN et al. [9]. The static route switching of AOMDV is determined in A2OMDV. The finest route amongst the multiple paths can be chosen by the source node by sustaining the status of the node. In provisions of throughput and delay, the A2OMDV demonstrates an improved performance through profound loads. N. Jaisankar et al. [10] have projected an AODV protocol for multiple paths routing. For the upgrading of scalability, multiple routes were urbanized in this paper. The routing overhead obtained in sustaining the connection linking source and destination nodes can be compact by formative the multiple paths in a single route detection. Due to the node mobility or battery breakdown, the major path probably will fail. The secondary paths are used to pass on data packets so that extra overhead is produced by a new route discovery.

A “Link Optimization Ad-hoc On-demand Multipath Distance Vector Routing (LOAOMDV)” have projected by Bo Xue et al. [11]. In LOAOMDV, a novel route reply process can be located using 4 bits information of the RREP packet. The mislaid reverse path is located and the many general node in a number of paths is minimized. The end-to-end delay is minimized, network life span is improved, packet aptness can be domesticated, and the ratio of packet disordered progression is minimized in this topology.

A spatially disjoint multiple paths routing protocol without location information was proposed by Juan J. G´alvez et al. [12]. This protocol determines multiple paths among source and target nodes and it also measures the distance among the routes. The routes determined by this route detection model pass through all geographical regions.

Ash Mohammad Abbas et al. [13] have concluded that the path reduction is inescapable when a protocol finds out multiple node-disjoint routes in a single route discovery. Path reduction is alleviated using these methods. Here they have established that it is not possible to develop a capable algorithm which guarantees computation of all node disjoint routes between a given pair of nodes in a single route discovery.

Kun-Ming Yu et al. [14] have proposed a new protocol to develop existing on-demand routing protocols. When the network topology transforms, the routing protocols can transmit data packets animatedly through alternate support routes.

In the context of the routing topology SAHR [15], some thriving topologies for routing have been proposed taking insight on or after ant colony behavior and the associated structure of “Ant Colony Optimization (ACO)” [16]. Some instances of “ACO” routing topologies are “AntNet” [17] and “ABC” [18].

The “ACO” routing topologies refer to before were developed for wired networks. They work in a dispersed and limited way, and are able to study and adjust to transformations in traffic models. Though, alterations in MANETs are much more drastic: in addition to disparities in traffic, both topology and number of nodes can alter incessantly. Additional difficulties are caused by the partial realistic bandwidth of the communal wireless channel, even though the data transmission pace of ad hoc wireless correspondance can be rather elevated, algorithms in utilize for MAC, such as “IEEE 802.11 “DCF”” [19], create many overhead both in terms of control packets and delay, lessening the efficiently obtainable bandwidth. The adaptive control confronts are as a result much larger, and inventive proposes are necessary to promise even the essential network functionalities.

III. SWARM ADAPTIVE MULTIPLE PATHS ROUTING TOPOLOGY FOR LOAD BALANCING AND CONGESTION ENDURANCE FOR MOBILE AD HOC NETWORKS

1) When a route to a target node D is obligatory, but not known at source node S , S transmits a Rout Trace Swarm Agent RTSA to discover a route to D .
2) When D receives the RTSA from S , it initiates to transmit RTSA as Route Confirmation Swarm Agent RCSA , which transmits in backward manner through the route that traced by parent RTSA . The RCSA updates the routing table and emission table of all the nodes in the route from S to D , allowing for data transfer from S to D . Here emission table is maintained by each node n to store emission attribute value sav_{ni} of its each forwarding neighbor ni . The emission attribute value is similar to pheromone repository of the biological swarm agent.
3) When a route fall shorts at an intermediate node X then SAHR opts to alternate path to balance the load and endurance the congestion.

4) When a route at D is known to S, SAHR deterministically chooses the route by opting to best forwarding hop level neighbor ni based on their hop level delay and many hops to reach the destination.

IV. SWARM ADAPTIVE HYBRID ROUTING TOPOLOGY [15] USED IN SAMR

SAHR's style is stimulated by Swarm Agent Optimized routing topologies for wired networks. It employs swarm agents so as to go after and revise emission state in an indirect agent interaction for the modification of the surroundings learning method. Knowledge packets are routed adaptively with the learned tables. A vital distinction with alternative Swarm Agent Optimized routing topologies is that SAHR could be a hybrid algorithm, so as to deal higher with the precise confronts of mobile ad hoc structures. It's reactive within the sense that nodes solely gather routing info for destinations that they're currently communicating with, whereas it's proactive as a result of nodes try and maintain and improve routing info as long as communication goes on. we tend to build a distinction between the trail setup, that is that the reactive mechanism to get initial routing info a couple of destination at the beginning of a session, and route maintenance and development, that is that the traditional mode of operation throughout the course of a session to proactively adapt to network alteration. The routing info attained via indirect agent communication is unfolded among the nodes of the Manet in hop level neighbor info swap technique to supply secondary steerage for the swarm agents. Within the following we offer a broaden description of the SAHR.

SAHR's intend is stimulated by swarm agent optimized routing topologies for wired networks. It utilizes swarm agents which go after and modify emission state in an indirect agent interaction regarding the alteration of the situation knowledge progression. Data packets are transmitted orderly in accord to the learned emission state. An important divergence with other Swarm Agent Optimized routing topologies is that SAHR is a hybrid topology, in the process of dealing improved with the specific mobile ad hoc structure confronts. It is on-demand since that nodes only gather routing information for targets which they are at present corresponding with, while it is proactive because nodes try to preserve and get better routing information only if communication is going on. We make a distinction among the route setup, which is the on demand mechanism to obtain initial routing information regarding a destination at the begin of a session, and route maintenance and perfection, which is the common mode of process through the path of a session to table driven acclimatize to network changes. The routing information attained via indirect agent interaction erudition is broaden among the network nodes of the mobile ad hoc structure in a hop level neighbor information exchange process to present minor regulation for the swarm agents. In the following we make available a short description of every of these workings.

A. Pheromone Indicator for SAHR

Routes are implicitly outlined by the emission tables that are kept regionally at every node. An entry g_{ni} of the emission table ST_i at node i that consider as pheromone indicates about the goodness of the routing from node i to via immediate node ni contains a price signifying the predictable integrity of going as of i over neighbor ni to arrive at target d. This integrity is derived from the combination of route end-to-end delay and range of hops. These are commonly used quality measures in Manets. Combining the number of hops with complete delay between immediate node ni to current node i and destination node d is a way to swish out presumably giant oscillations within the time approximations congregated by the swarm agents. Since SAHR solely maintains info regarding destinations that are active during a session of correspondance, and due to continuous change at neighbor nodes, the updating of the emission states is dynamic.

B. Route Detection in SAHR

The source node s determines the route to node d via transmitting Route Trace Swarm Agent $RTSA$. At each neighbor hop that received $RTSA$, transmits the same to their neighbor hops. This mechanism is iterative till every $RTSA$ received by target node d. Upon receiving the $RTSA$, the destination node d initiates to transmit Routing-route Confirmation Swarm Agent $RCSA$ that derived from $RTSA$. $RCSA$ Transmits in backward manner through the route that traced by parent $RTSA$. Upon reaching each node i in the routing route, $RCSA$ updates pheromone indicator value g_{ni} of relay hop node ni of the current node i in the routing route opted by $RCSA$. The process of updating the pheromone indicator value is as follows:

During the transmission of swarm-agent $RCSA$, it collects the time $t_{ni \to i}$ taken to reach each node i from relay hop node ni the '$RCSA$'is coming from. The estimated time $t_{i \to d}$ to transmit a data packet from node i to destination node d via $\{ni, ni+1, ni+2 ... ni+n\}$ is measured using equation (1).

$$t_{i\to d}^{ni} = t_{(ni+n)\to d} + \sum_{k=n}^{1} t_{(ni+k-1)\to(ni+k)} \text{ ......}$$
(1)

And then pheromone indicator value will be measured using equation (2) and (3) that fallows

$$\left(t_{i\to d}^{ni}\right)' = \left[t_{i\to d}^{ni}\right]^{-1} * 100 \text{ ..... (2)}$$

$$g_{ni} = \frac{\left(t_{i\to d}^{ni}\right)'}{hc_{i\to d}^{ni}} \text{ .... (3)}$$

Here in equation (3), $hc_{i\to d}^{ni}$ indicates the hop count in route from the node i that is currently in action to transmit to target node d by the use of relay hop node ni.

The inverse value of the predictable point in time $t_{i\to d}^{ni}$ for a data packet to travel from node i to destination node d indicates the optimality of the route between nodes i to target node d by way of relay node ni. Hence the equation (2) is significant.

Upon receiving swarm agent $RCSA$, the source node s also updates its emission table with pheromone indicator value g_{ni} of each neighbor hop ni the $RCSA$ coming from.

C. Congestion Endurance Strategy

1. Alternative Route detection:

We change the table driven route detection of the SAHR. The n_s,which is aroute discovery intiator, finds the path to the target node n_d in a distribution way. The transmited route appeal $rreq$ packet will carry the transmit node information that can contribute in routing path. During the transmission of these route request $rreq$ packets, the transport layer recognize the overhearing nodes of every relay node and updates application layer and then the similar will be carried by route request $rreq$. formerly the target node obtains this route request $rreq$ then it prepares a route response $rrep$ packet so as to holds a list of relay nodes and their eavesdroping nodes. Hence upon receiving a route reply packet, every transmit node of the path updates its routing table with heir and ancestor node information, and the list of eavesdroping nodes to node that transmitting and descendant node in the transmission direction finding path. Upon the route reply $rrep$ packet acknowledged by the basis node n_s, best possible path will be chosen. Then the node n_s drives relay node individuality acknowledgement $ack(pn)_i$ for every relay node pn_i of routing path opted. Upon receiving relay node individuality acknowledgement $ack(pn)_i$, relay node pn_i attempts to recognize optimal paths among relay node pn_i and two hop level descendant relay node pn_{i+2}, in this phase relay node pn_i drives a $rreq$ to pn_{i+2}. This $rreq$ transmits merely through eavesdroping nodes of pn_i and pn_{i+1}. In receipt of the $rreq$ from pn_i, pn_{i+2} prepares route response $rrep$ and transmits to pn_i via the path opted by $rreq$. consequently ahead of receiving route reply $rrep$, pn_i selects an optimal path between relay nodes pn_i and pn_{i+2} ,finally stores in the routing table. The chosen best possible path will be employed for path restoration between nodes pn_i *and* pn_{i+2}, if congestion found at pn_{i+1} and not able to control, then path restoration occurs between pn_i *and* pn_{i+2}.

2. Congestion Endurance Route Discovery Algorithm (CERDA)

i. n_s categorize $rreq$ and transmit it to hop level nodes

ii. Ahead in receipt of $rreq_i$ a hop level node n_i verifies so as to retransmitting of $rreq_i$ previously done by itself or not.

iii. If retransmiting completed previously then rejects the $rreq_i$, otherwise n_i gather particulars of eavesdroping nodes from the "transport layer" and adds its distinctiveness and particulars of its eavesdroping nodes to '$rreq_i$', then retransmits . This progression is recurrent till $rreq$ obtained by the target node n_d

iv. Then n_d prepares a route response packet $rrep_i$ that have the details of the nodes be in the path, through which the route request $rreq_i$ traversed to reach n_d and their over hearing nodes. The $rrep_i$ sends back to the 'n_s' from end to end the path selected by $rreq_i$.

v. Every intermediate node pn_i of the path used by $rrep_i$ gathers particulars regarding its antecedent node pn_{i-1}, heir node pn_{i+1} and eavesdroping nodes of present relay node pn_i and pn_{i+1}

vi. pn_i revises its routing table with outcomes of the step iv.

vii. The process explained at vi and vii are recurrent till response packet obtained by the n_s

viii. n_s finds the best possible path by cells with high intensity of nodes.

ix. In a sequence of nodes of the path opted for, n_s drives $ack(pn)_i$ for $i = 1..n$.

x. Ahead in receipt of $ack(pn)_i$, pn_i begin finding substitute path from pn_i to pn_{i+2}, so as the substitute path should obliged to utilize merely eavesdroping nodes of the ' pn_i ' and ' pn_{i+1} '.

xi. pn_i after that preserves substitute path connecting pn_i *and* pn_{i+2} at routing cache.

D. Routing Route maintenance

Upon receiving a packet dp_i, the destination node d verifies the time $t(dp_i)$ taken by dp_i to travel from source node s to destination node d and then measures the routing delay for packet dp_i. If routing delay of dp_i is more than the delay threshold τ then it initiates a swarm agent $RCSA$ and transmits towards source node that opts to the route accessed by data packet dp_i. Hence the ' $RCSA$ ' performs the process of updating pheromone indicator value g_{ni} at each hop level relay node in the route. This process explored in equations (1), (2) and (3).

E. Handling link failures

The destination node d initiates swarm agents $RCSA$ to each neighbor relay hop nodes in fixed time gaps. Thus the pheromone indicator values in emission table of each node will be updated in fixed time interval ς.

The pheromone indicator value of any neighbor relay hop ni in emission table of any node i is not valid if time since last update of g_{ni} is greater than time interval ς. This shows the link failure among node i and destination node d.

V. EXPERIMENTAL RESULTS

The projected Swarm Adaptive Multiple paths routing (SAMR) topology for load balancing and Congestion Endurance is analyzed by simulation model that build using NS2[20]. In this simulation, the channel ability of mobile hosts is put to the value of 2 Mbps. In this simulation model, the MAC layer protocol is represented by "DCF (Distributed Coordination Function) of IEEE 802.11". This "DCF" is capable to alert the link failure during routing process.

To perform simulations, the number of nodes was used within the range of 30 to 110. For each sequence of simulation we incremented the number nodes by 10. The area of network considered in simulations is 1100 meter X 1100 meter and simulation time restricted to 60 seconds. As this simulation model is using Random Way Point mobility model, the divergence of node mobility direction not considered during this simulation model. The communication coverage range between any two hop level nodes is fixed as 200 meters. The node mobility speed is in the range of 10 to 60 m/s. The virtual traffic is Constant Bit Rate (CBR). The summary of parameters used in simulation model explored in table 1.

Table 1: Simulation parameters

No. of Nodes	30 to 110, with increment of 10 nodes for each sequence
Area	1100 X 1100
MAC	"DCF" of 802.11
Radio assortment	200 mtrs
Simulation time	60000 milli seconds
Traffic source	CBR
Rate	256 b/ms
Packet size	0.5 kb
Mobility Standard	RWP
Speed	10 to 60 m/s
Pause time	5000 milli seconds

A. Performance Parameters

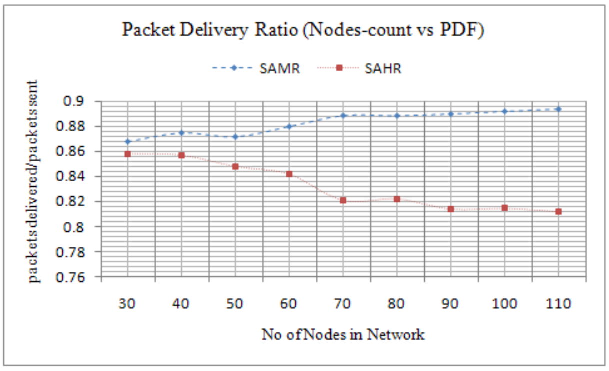
We compare the Swarm Adaptive Hybrid Routing Topology [15] with the proposed SAMR protocol. We evaluate performance of the SAMR fundamentally according to the subsequent parameters.

Control overhead: The normalization of the overall many routing control packets by the total number of received data packets.

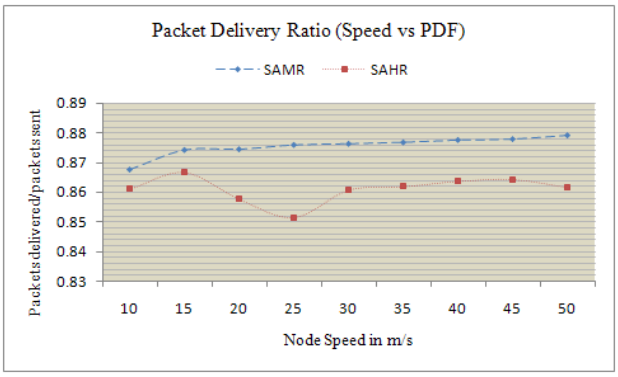
Average Packet Delivery Ratio: The ratio between overall number of packets routed and whole number of pckets delivered. The exploration of the simulation results follows.

Figure 1 illustrates Packet Delivery Ratio (PDR) for SAHR [15] and SAMR. By considering this output it is enough to prove that SAMR manages maximum failure of PDR than that of SAHR. Fairly accurate failure amount of PDR that is restored by the SAMR than SAHR is 1.47%. This is balanced amount between the pause intervals. The least amount of restoring examined is 0.12% and the highest id 3.04%.

Figure 2 proves that SAMR is having less control overhead than that SAHR. This benefit of the SAMR could be feasible as a reason of availability of multiple alternate paths with effective routing procedure. The control overhead experiential in SAHR be nearly 5.29% larger than packet overhead experiential in SAMR. The least and maximum packet overhead in SAHR than SAMR predicted as 4.61% and 9.29% correspondingly.

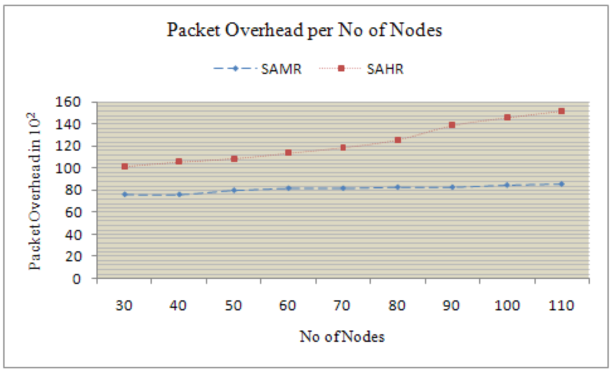


1(a) The Packet Delivery ratio by No Of Nodes

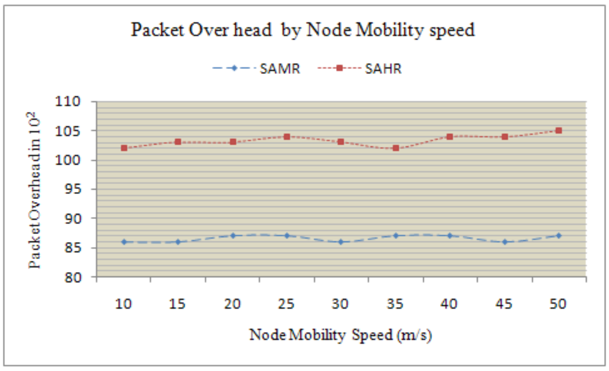


1(b) Packet Delivery Ratio by Node Mobility Speed

Figure 1: Packet Delivery Ratio comparison among SAHR[15] and SAMR



2(a): Packet Overhead by No of Nodes



2(b): Packet Overhead by Node Mobility Speed

Figure 2: Overhead comparison of SAMR with SAHR

VI. CONCLUSION

In this paper, we have proposed a Swarm Adaptive Multiple paths routing (SAMR) Topology for Load Balancing and Congestion Endurance in Mobile Ad Hoc Networks. Our previous proposed routing topology SAHR [15] is adapted for core level process of route search and establishment. During the process of route maintenance, we introduced a novel multipath model that considerably performed well to balance the load and endurance the congestion. After setting up the route, data packets are routed over chosen alternate paths according to load and congestion alerts observed from MAC layer. Then load balancing method is applied in this protocol to alleviate the congestion. Simulation results demonstrate that the proposed protocol performs enhanced, when contrasted with core level protocol SAHR. When the network size and the speed of the mobile are improved, it demonstrates superior performance in stipulations of PDR with reduced delay and control overhead.

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