GROUPING BASED COORDINATOR ELECTION FOR SERVICE PROVISIONING IN MOBILE AD HOC NETWORKS

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***ABSTRACT**:* Efficient routing and service provisioning in MANET is a big research challenge. In centralized directory-based schemes, some mobile nodes hold the service directory to assist the communications between service providers and clients. Although service co-ordination is easier, such centralized management is hard to scale and the centralized directories lead to bottlenecks. Later Hybrid and Distributed schemes constructed local directories which form the backbone of the network. But its topology-based scheme is still hard to scale to a larger network (e.g., with several hundreds of nodes). The existing service provisioning techniques makes use of hierarchical decomposition of the geographic area into zones and selects a core node in each of the zones to act as an agent for all the nodes in its zone. The existing techniques use node ID or hash value to select a core node. This paper deals with Adaptive service coordination, by a rendezvous node which delivers efficient tracking and coordination of services. This rendezvous node identifies services that can be grouped and maintains information about available services, and helps in reducing the overhead and network traffic.

***KEYWORDS**:* Hybrid and Distributed schemes, topology-based scheme, service provision, Mobile Ad Hoc Networks.

1. INTRODUCTION

A mobile ad hoc network (MANET), sometimes called a mobile mesh network, is a self-configuring network of mobile devices connected by wireless links. Each device in a MANET is free to move independently in any direction. The primary challenge in building a MANET is equipping each device to continuously maintain the information required to properly route traffic. Such networks may operate by themselves or may be connected to the larger Internet.

Many research papers evaluate protocols and their abilities assuming varying degrees of mobility within a bounded space. Different protocols are then evaluated based on the packet drop rate, the overhead introduced by the routing protocol, and other measures.

Service provisioning in MANET is essential due to the rapid proliferation of mobile nodes and the need for delivery of services to these mobile nodes. Any user with a mobile device would like to avail any service at his convenience. A service is a software component executed in one or more nodes that reacts to service requests from several clients. A user would like to hear to music or download a file or would like to know the traffic details or entertainment information in a particular location.

The goal of this research is to develop a scalable and efficient geographic service coordination scheme to harness the resources available from mobile devices. Service provision and routing will share the same infrastructure to track the membership, positions and service states of service nodes. The cross-layer design will significantly reduce the management redundancy and make different layers to work more closely.

The service provision framework [XW07] supports the following functions:

1) ***Service discovery***: locating the services based on user requests.

2) ***Service delivery***: delivering relevant service data and control messages. Unicast routing is needed for the delivery between peer devices, while multicast routing would be required to support efficient group communications.

3) ***Service coordination***: a service request may need to be satisfied by several service providers, or a service may have several candidate providers. To enable coordination, the service coordinator should be able to track a group of service providers and their services. Hence, efficient and scalable service and membership management is required to facilitate the selection of appropriate providers and the collaboration among multiple providers.

The Service Provider tells the available services and their attributes to the coordinator. The Service Requestor contacts the coordinator by sending a request message. This request is sent to the respective service provider which delivers the required service.

The design goals of Service Provision mechanism are:

1) *Scalability*: the protocol should be scalable to large network terrain and large number of service nodes.
2) *Efficiency*: the protocol should have relatively low control overhead.
3) *Robustness*: the service provision should be robust to possible failures.
4) *Adaptability*: the framework should be able to adapt its behavior based on the network environments to maximize its performance.

The scalable hierarchical structure and efficient membership management will facilitate the design of the scalable and efficient service discovery. The adaptive geographic unicast protocol and efficient multicast scheme will help provide robust and adaptive service coordination.

2. RELATED WORK

2.1 Centralized and Distributed Directory [XW07]

The distributed service discovery architecture proposed in [XW07], which relies on a flat topology. It consists of two independent components:

- Formation of a virtual backbone and
- Distribution of service registrations, requests, and replies.

The first component creates a mesh structure from a subset of a given network graph that includes the nodes acting as service brokers and a subset of paths (which we refer as virtual links) connecting them. The second component establishes sub-trees routed at service requesting nodes and registering.

In centralized directory-based schemes, some mobile nodes hold the service directory to assist the communications between service providers and clients. Although service co-ordination is easier, such centralized management is hard to scale and the centralized directories lead to bottlenecks.

In Distributed schemes, local directories are constructed which form the backbone of the network. A request will be searched in a local directory or multiple directories by distributed searching. Its topology-based scheme is still hard to scale to a larger network (e.g., with several hundreds of nodes).

2.2 Virtual Hierarchy Maintenance [XW07, XW06, K+07, SRS06]

Literature [XW07, XW06, K+07, SRS06] uses a virtual zone that makes use of the geographic location information, to divide the entire geographic area into zones that assists in hierarchical service provisioning. A core node for each zone is selected to assist in the service provisioning.

EGMP [XW06] uses a two tier architecture where every zone will select one node as a core node in the lower tier. These nodes collect membership information of all nodes in its zone and will act as a representative to the central core node in the upper tier.

SGSP has a flexible number of management layers based on the capability of coordinators, the density of service nodes and the service requirements. In each layer a service coordinator is elected.

HRPM has one access point for every zone and one rendezvous point for entire region. Service aggregation and management can be done by coordinators in various levels of hierarchy. The number of levels in the hierarchy and the number of coordinator nodes can be increased for scalability.

3. SERVICE COORDINATION

In Service Coordination, the Regional coordinator maintains the bit vector of all group members available in each zone. Initially when a source contacts Regional Coordinator responses with a bit vector, which specifies which cells have members (HRPM) [DPC06].

Source builds an overlay tree as,
Source -> Core Node tree,
Core Node -> Member tree.

3.1 Hierarchical Rendezvous Point Multicast (HRPM) [DPC06]

HRPM incorporates two key design concepts:
1) hierarchical decomposition of multicast groups and,
2) geographic hashing to efficiently construct and maintain a hierarchy.

The main design goal of HRPM is to limit the per-packet overhead to an application specified constant, irrespective of the group size G. This is achieved by geographically dividing the deployment area into smaller and smaller cells, the Core Node -> *Members* tree, whose vertexes are the members in that Core Node's cell and forwards the data along this tree, also using geographic forwarding. Both the source and the Core Node's use unicast to forward data packets.

3.2 Virtual zone construction

The given geographic area is divided into a number of zones. The length of a side of the zone square is defined as *zone size*. In [XW06], each virtual zone has a zone ID (zID) to help identify and locate a zone. Each node in every zone is provided with a node ID. zID for each node is denoted as (a,b) the value of (a,b) can be calculated from its position coordinates such that,

$$a = [\ x\text{¡}x0\ /(zone\ size)\ ] \qquad (1)$$
$$b = [\ y\text{¡}y0\ /(\ zone\ size)\ ] \qquad (2)$$

where ($x0; y0$) is the position of the virtual origin and (x,y) is its position coordinates. For simplicity, we assume that all zone IDs are positive. Each zone has a zone centre denoted by (xc,yc). For a zone with zID (a,b), the position of its center (xc,yc) is:

$$xc = x0 + (a + 0{:}5)\ /\ zone\ size \qquad (3)$$
$$yc = y0 + (b + 0{:}5)\ /\ zone\ size \qquad (4)$$

A packet destined to a zone will be forwarded towards its centre. When the number of nodes in a particular zone increases, the zone divides itself into two separate zones.

3.3 Leader [Local/Regional Coordinator] Election

For each zone (hierarchy level) the leader is elected to handle the service provisioning functions to all nodes in the respective zones. Regional coordinator is elected to coordinate all the local coordinators. Three types of leader elections schemes are compared:

3.3.1 Zone id based leader election[1] (SGSP): It is known that each node has a node ID and a Zone ID. The node with highest Zone ID is elected as Regional Coordinator and the node with highest Node ID is elected as Core Node.

3.3.2 Hash based leader election[3] (HRPM): Hash function is used that takes Group ID(GID), number of zones(d) and current position(myloc) of the node as the input and outputs a location.

$$H(GID,d,myloc) = (x,y)\ x,y\ £\ cell\ region \qquad (5)$$

The node present in the resulting location is made the leader.

3.3.3 Adaptive leader election: We suggest a voting based algorithm for selecting the coordinator based on an election scheme as in [SPS06]. Here node with the highest battery power(B), lowest average speed(v), and the node that is closest to the zone center(E) is considered as the leader. Analyzing the eligibility factor of each node using more parameters than the existing and elect the leader with highest eligibility factor [MQ09].

3.4 Group Management

The concept of rendezvous point group management (RPGM) [DPC06] assumes a flat geographic domain. A hierarchical decomposition of a multicast group that describes how to apply RPGM recursively in a hierarchy of subdomains.

3.4.1 Rendezvous Point Group Management: Rendezvous point group management allows multicast group members to leverage geographic hashing for efficient group management. Any node that wants to join a multicast group first hashes the group identifier to obtain the Leader's location in the physical domain of the network using a hash function:

$$H(GID) = \{\ x, y\ \}\ where\ x, y\ MANET\ region \qquad (6)$$

This hashing function takes as input the group identifier (GID) and outputs a location contained in the region.

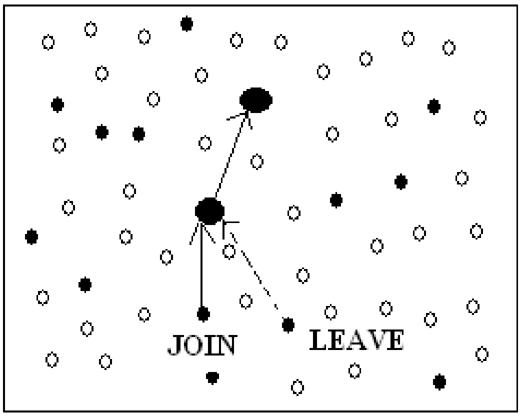

Fig.1. RPGM in HRPM (Group Management)

After obtaining the hashed leader location for the group it wants to join, the node sends a JOIN message addressed to this hashed. This JOIN message is routed by geographic forwarding to the node that is currently closest to the hashed location in the network. This node is the designated leader at this time. Since there is only one such node at any given time, the JOIN messages from all the group members converge at a single leader in a distributed fashion without global knowledge.Note that computing the hashed location assumes that all nodes know the approximate geographic boundaries of the network.

3.5 Rendezvous Based Service Coordination

In Rendezvous Based Service Coordination, information about services and the node that provides services are maintained and for efficient tracking and coordination of services, rendezvous node is created so as to reduce overhead and network traffic. Thus the services that can be grouped are identified and coordinated based on the source request.

Initially all the available services are advertised to all Core Node. When a service is needed the Service Requestor contacts Core Node by sending a request message, if the service is available the Core Node sends a hit message back to the requestor. If the service is not available within a Core Node then the Core Node contacts Regional Coordinator and the Regional Coordinator confirms the service availability by sending a Hit message to the requestor. If more than one Service Provider can provide service for the Service Requestor, using (SGSP) [XW07] the distance between the Core Node of Service Requestor and Core Node of all the Service Provider is calculated. After this Service Provider with least distance is chosen to provide the required service (i.e., the Service Provider closest to the Service Requestor).

4. PERFORMANCE EVALUATIONS

4.1. Simulation Overview

We implemented the proposed scheme using ns2 simulator [***08]. For performance reference, we also implemented the HRPM and SGSP protocols. In our hierarchical structure, each zone size is set as 800 m. The simulations were run with 50 nodes randomly distributed in the area of 2400m X 2400 m. The nodes movement follows the random waypoint model. The moving pause time was varied between 0 to 10 seconds, minimum speed was 0 m/s and maximum speed was varied between 10 to 200 m/s for different simulation runs.
We set the service distribution as follows. 25 % of the mobile nodes act as service providers. Total number of services provided is 75 % of mobile nodes. For simple update and beacon packets the CBR packet size is set as 100 bytes and for data and service information exchanges the CBR packet size is set as 512 bytes. Each simulation lasted 600 simulation seconds. A simulation result was got by averaging number of simulation runs. The following metrics were studied:
The following metrics were studied:
-Average Packet Delivery Ratio (PDR): The number of data packets delivered to destination to the number of data packets expected to receive.
-Delivery Overhead: The total number of bytes transmitted at the MAC layer including ACK in case of unicast transmissions
-Forwarding cost: The total number of data packets transmitted divided by the total number of packets received by all multicast members.

4.2 Simulation Results

In this section, we evaluate how the network size affects the protocol performance. We vary the network size from 10 to 60nodes. For each network size we consider 25 % of the nodes as service providers. For each simulation run we use different seed value and obtain the average values as result.
Fig. 3, Fig. 4, Fig. 5 shows that the packet delivery ratio, delay, overhead and forwarding cost of adaptive algorithm is better than the other two algorithms. It is found that the effect of all these parameters improves as the network size increases for all the algorithms because of the aggregation of messages by the core node of each zone.As the number of members for the same group within a zone increases, the overhead, forwarding cost and delay decreases. The adaptive algorithm performs better than the other algorithms because of the consistency in the core node selected for a longer period and the tree aggregation improves the comparative efficiency as the network size increases. Adaptive algorithm has 82 % PDR and 10 % less delay, 18 % less overhead, 18 % less forwarding cost on an average compared to other algorithms.

4.3 Performance Evaluations

The nodes are randomly distributed in the area of 1500m * 1000m and each simulation lasted for 900 simulation seconds. A simulation result was gained by averaging over several runs with different seeds. The performances of the three algorithms namely zone ID based, hash based and voting algorithm are evaluated based on the throughput and the data loss.
The throughput values are calculated by extracting the values of the packet sizes from the trace file. The throughput value of a node at different time intervals are recorded such as 0-7 seconds for the zone ID based leader, 7-14 seconds for the hash based leader and after that by the voting algorithm based leader.
The throughput values of a particular node when packets are routed through the different leaders elected by different algorithms are plotted in a graph wherein the throughput are marked along the Y axis and the time scale is marked along the X axis.
From the graph Fig.6 it is inferred that the throughput increases by time as the mode of selection of leader changes the efficiency of the leader.
At first the leader is elected by node ID based algorithm wherein no constraints. Secondly the leader elected through hash based algorithm is comparatively more efficient than the previous algorithm. The third algorithm is the voting algorithm which elects an efficient leader which has recorded the highest throughput of all the three in our analysis.
Due to higher battery power, lesser average speed and closer distance to the zone centre the leader elected

stays in the zone for longer, routes data effectively and receives data packets efficiently.

The value of data loss that occurs in the packets that are transferred are extracted from the trace file and similar to the throughput analysis, the data loss incurred on a node when three leaders are elected based on those three different algorithms are tabulated. The data loss is calculated by the difference in packet size of the sent and receiced packet. The Tabulated values are plotted in a graph.

From the graph Fig.7 it is inferred that the data loss occurring in the nodes decreases as the efficiency of the leader increases owing to the changes in their mode of selection.

In the first method efficiency becomes lesser and data loss is heavy.

The hash based method is comparatively better, this algorithm somehow returns a prominent value of a nodes position and a leader node is effectively functioning always and hence data loss becomes minimum.

The third method is the voting algorithm wherein the nodes transfer data packets efficiently because of their better battery power supporting competent data transfer, lesser average speed owing to their longer time of stay in the zone, and closer to the zone centre contributing to better routing of packets.

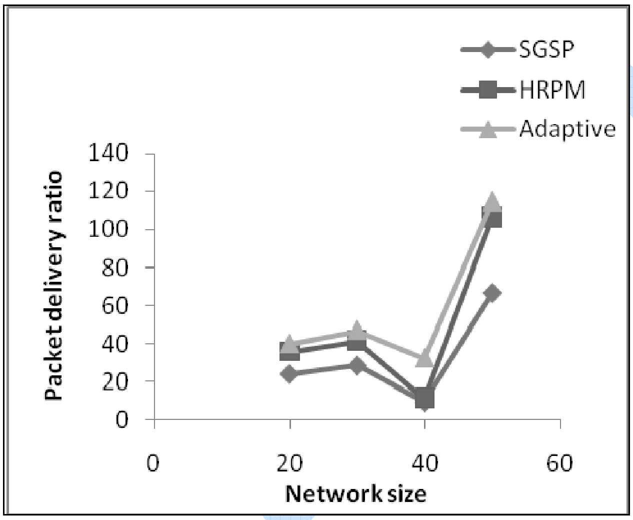

Fig. 2 PDR comparison

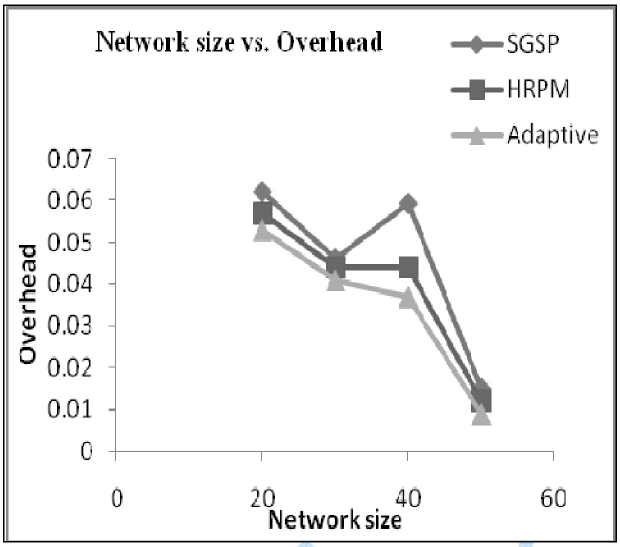

Fig. 3 Overhead Comparison

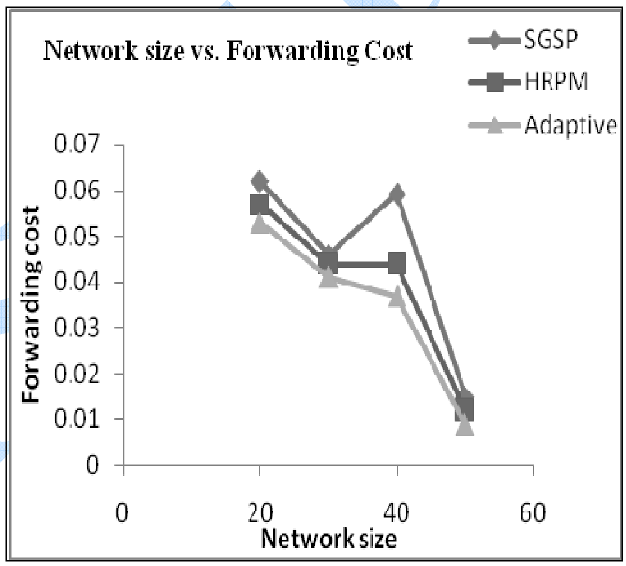

Fig. 4 Forwarding cost comparison

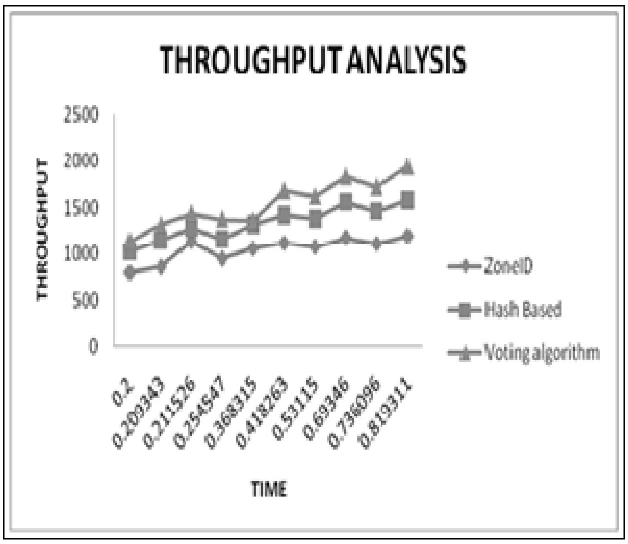

Fig. 5 Throughput Analysis

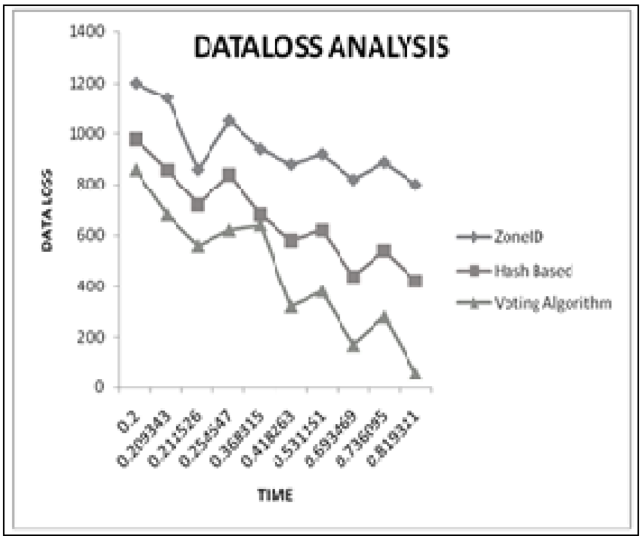

Fig. 6 Data Loss

CONCLUSION

In this paper, we proposed an adaptive service provisioning scheme that elects the best node within a group of nodes as a service coordinator, for performing all the service provisioning activities. The scheme is adaptable to the changing topology and management requirements of the network. This coordinator node is more stable because of the performance characteristic used for its election.
Hence it reduces the control overhead caused by the other election schemes. The performance evaluation shows that the voting algorithm's service delivery performance is better because of the reduced number of core nodes chosen and the tree aggregation scheme used.

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