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ADAPTIVE SERVICE PROVISIONING FOR MOBILE AD HOC NETWORKS

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Abstract
Providing efficient and scalable service provisioning in Mobile Ad Hoc Network (MANET) is a big research challenge. In adaptive service provisioning mechanism an adaptive election procedure is used to select a coordinator node. The role of a service coordinator is crucial in any distributed directory based service provisioning scheme. The existing coordinator election schemes use either the nodeID or a hash function to choose the coordinator. In these schemes, the leader changes are more frequent due to node mobility. We propose an adaptive scheme that makes use of an eligibility factor that is calculated based on the distance to the zone center, remaining battery power and average speed to elect a core node that change according to the network dynamics. We also retain the node with the second highest priority as a backup node. Our algorithm is compared with the existing solution by simulation and the result shows that the core node selected by us is more stable and hence reduces the number of handoffs. This in turn improves the service delivery performance by increasing the packet delivery ratio and decreasing the delay, the overhead and the forwarding cost.

Keywords:
Adaptive Algorithm, Leader Election, Mobile Ad Hoc Networks, Service Provisioning, Service Delivery.

1. INTRODUCTION

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.

A service provider may provide one or more service for a short or long duration. It is the responsibility of the service provider to advertise its services. Different approaches are followed for service provisioning in the literature. In the advertisement based approach, a node providing the service advertises the service to all the nodes. The service requestor searches its cache to find a suitable service provider and forwards a request. The service provider delivers the service to the requestor. In the discovery based approach, there is no prior service advertisement. Service discovery is done by the service requestor, to identify the node providing the service and then it makes a request to the service provider, which delivers the service to the requestor [1]. In the directory based service discovery approach, a service provider registers its service with an agreed upon core node, either in a centralized or distributed fashion [2]. A service requestor contacts the core node to acquire the information regarding the service. The request is forwarded to the service provider and the service provider provides the service to the service requestor.

A single service can be provided by different providers or a service request may need to be satisfied by several providers. All the available services and their providers must be coordinated. Centralized directory based schemes, [3] help in communication between the service provider and its clients, but is hard to scale and leads to bottlenecks. Local directory based scheme [4] search as request by distribution but is hard to scale for large networks.

Delivering the appropriate service to the service requestor is often done by multicasting, as it is an efficient method to implement group communication in MANET. For multicasting various tree based, mesh based and hybrid algorithms have been proposed [5]. Latest literature suggests geographic position based routing as the efficient way of delivering service in MANETs, as it reduces the overhead in state maintenance of multicast trees [6]. Using hierarchical service provisioning in MANETs reduces the encoding and state maintenance overhead [7].

In group communication protocols, leader election is necessary when a group leader crashes or leaves the system. In context of MANETs, the leader election algorithm should eventually elect a unique leader and the elected leader, must be the most valued node among all the nodes in terms of performance related characteristics [5]. We propose an adaptive election scheme that chooses a leader to act as a service coordinator.

2. RELATED WORK

2.1 ROLE OF A SERVICE COORDINATOR

The role of a service coordinator in service provisioning is vital. A service coordinator aids in service registration, discovery, coordination and delivery. Literatures [8]-[12], illustrate the role of coordinator in service provisioning.

2.1.1 Service Registration:

A service coordinator can act as a service directory, where all the service providers register their service descriptions. It is the service provider's responsibility to register and update the service information in the service directory. The service descriptions include information such as service providers identification, location, service identification, parameters describing the content of service and the life time of the service.

In SGSP [12], services are registered with local, global and regional coordinators selected at different management layers.

2.1.2 Service Discovery:

Mostly in mobile ad hoc network, the distributed approach of service discovery is preferred [1],[13]. The selection of a node, which acts as a coordinator node, maintaining the directory is a crucial issue for any directory-based service discovery approach. In directory less architectures, the service providers broadcast service advertisements and the service requestors will broadcast service requests. In this case the role of the coordinator is to act as a forwarder for a service request or the destination for a service provider.

To reduce the broadcast load in directory based architectures, service advertisements and requests can be multicast to a particular group acting as coordinator nodes. In the hybrid mode of service discovery, the servers can proactively advertise their services to service coordinators, and clients can issue requests to service coordinators reactively, which are then forwarded to an appropriate service provider [12].

2.1.3 Service Coordination:

It is the role of a coordinator to choose a service provider for the requestor and to track the group of service providers and their services. In most of the hierarchical architectures [8]-[10], the local coordinator in the zone communicates the service details to the coordinator which is higher in the hierarchy, and updates its service table in a soft state. The membership management of various nodes that has requested for a service is vital. The dynamic changes in membership and location information of the member nodes are maintained by the coordinator in each zone [9]. The use of hierarchy greatly reduces the encoding overhead in membership maintenance, as only the presence or absence of a member need to be sent from the coordinator in one level of hierarchy to other.

2.1.4 Service Delivery:

In general multicasting is the preferred mode of delivering a service to multiple nodes in MANET. In hierarchical service provisioning schemes service delivery is done by the service provider to the service requestor only through the coordinator of the respective zone. HRPM [9] shows how the coordinator can be used for efficient data delivery and for reducing encoding, state maintenance and computation overhead. The service provider constructs a overlay tree including all the destination core nodes and the requested services are sent to them using a unicast algorithm such as geographic forwarding. Most of the service delivery mechanisms such as PBM[6], SPBM[7], and GMR[8] use geographic position based routing protocol, where they share the location information of the nodes involved in service provisioning, update the location periodically and then forward the packet to the destination location.

2.2 VIRTUAL HIERARCHY MAINTENANCE

Literature [8]-[12] 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 [11] 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.

2.3 EXISTING CORE NODE SELECTION METHODS

2.3.1 ID Based Election:

EGMP elects a leader through a leader election process, in which a node checks its neighbor table. If the neighbor table has no other zone nodes, it announces itself as a leader. If no other node has been elected as leader and if the new node finds itself closer to the zone center it announces itself as the leader. If more than one node is willing to announce it as a leader, the one with the largest node ID is elected as leader. This is accomplished by having each node periodically broadcast beacon messages containing the ID and position of the node. SGSP selects a node with largest address when multiple coordinators exist.

2.3.2 Hash Function Based Election:

HRPM uses hierarchical rendezvous point multicast, where each cell is managed by an access point(AP) and the entire region is managed by a rendezvous point (RP). To avoid keeping track of AP and RP using some external location service, HRPM adopts the concept of mobile geographic hashing. The service provider or requestor can make use of an agreed upon hash function to hash the multicast group identifier (GID) and obtain the RP / AP location. Any node can get the position of AP / RP using a well-know hash function and its GID: H (GID) = (x, y) where x, y € MANET region. The node which is close to the location returned by the hashed location is chosen as a core node.

3. ADAPTIVE LEADER ELECTION

The objective of this algorithm is to choose a core node that changes adaptively and also lasts for a long time, reducing the maintenance and communication overhead. This core node can act as a local coordinator or leader within the zone and a global coordinator within the region.

3.1 DISADVANTAGES OF EXISTING METHODS:

In node ID based selection, the frequency of leader change and handoff is more because of the frequent change in topology of a mobile network. The hash value based election has got the following overhead [9]. The hash function must be made known to all nodes by some resource discovery process. The hash value must be computed by each node to communicate with the core node. The life time of the core node is short, as the core node keeps changing whenever a new node comes near the hashed location. This results in frequent hand off of the information maintained by the core node. It requires some convergence operation to prevent redundant core node. There is one core node per group per zone, which aggregates and sends the membership information to the rendezvous point of that group. All the service providers get the membership information from the regional coordinator and then deliver the service to the service requestor. This results in redundant service delivery and in turn increases the communication and control overhead.

3.2 CORE NODE ELECTION

We propose a vote based election algorithm that elects a core node dynamically. A node calculates its eligibility factor (EF), based on the distance to the zone center, remaining battery power and average speed. One core node called as local coordinator (LC), is selected for each of the zone and one core node called as global coordinator (GC), is selected for the entire region. A service node (SN) is a node providing or requesting for a service.

Adaptive Algorithm

1. When a new service provider or requestor enters a zone, it sends a hello message to learn about the core node to its neighbors.
2. All neighbor nodes reply with a beacon message, using which a neighbor table is constructed.
3. If there is no other core node, the new node announces itself as a leader and initiates an election procedure to elect a new core node.
4. To elect a core node, initially all the nodes in transmission range to the center of zone calculate their eligibility factor and send them to the leader.
5. The leader elects a node with the highest eligibility factor within a zone, as a new local coordinator and amongst all zones and within a radius of r/2 from the center of the geographical region, as a new global coordinator.
6. The node with the second highest ranking is stored as a backup node. If the core node fails or gets overloaded, the backup node becomes the core node.
7. Whenever the eligibility factor of the core node becomes less than the threshold, the election procedure is initiated to select a new core node.
8. All service records are transferred by the old core node to the new core node.

Fig.1. illustrates the flowchart for the leader election procedure. In order to preserve the battery power of the mobile nodes and to reduce the frequency of the handoffs, the election procedure is initiated only if there is any service node within a zone and when the EF becomes less than the threshold, instead of a periodical election.

3. 3 SERVICE PROVISIONING

Each local coordinator of a zone has information about all the service providers and requestors in its zone. Global coordinators have the information about all local coordinators and vice versa. All nodes within a zone must have updated the information about local and global coordinators. Every node maintains a neighbor table (node ID, Pos, Flag (CN/ not) and zone ID. The first three parameters are sent by beacon message from the neighbor node and the zone ID can be calculated [12]. Every core node maintains a service table, containing list of service provider coordinators and the service descriptions, a member table, containing list of members, their locations and

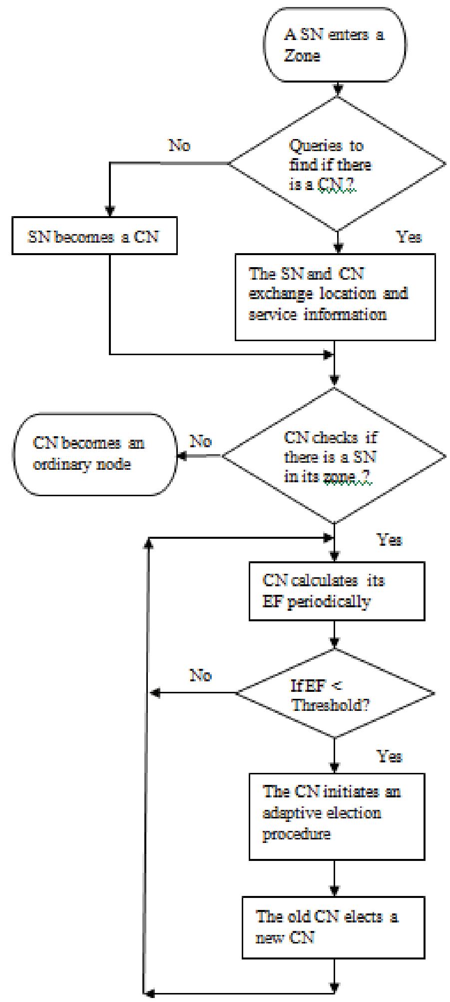


Fig.1. Flowchart for Core Node Election

services requested for and a core node table, containing list of coordinators and their locations.

Once a coordinator for a zone is elected all the service requests and delivery are forwarded through it. Every local coordinator sends the aggregated service information in its zone to the global coordinator and the aggregated membership information to the service provider. Only one bit is used to indicate whether a group member is present or not in that zone, thereby reducing the encoding overhead.

The service requests from all service requestors are forwarded by the respective zone leaders of that zone, to the service providers through their zone leaders. The service provider sends an HIT message back to the requestor and stores the details of the service requestor and the requested service. and delivers the service to all the requestors periodically or whenever there is any change in service information. The delivery trees from the same service provider providing different services are aggregated. This is possible because there is only one core node per zone unlike other algorithms where there is one core node per group in each of the zone.

4. PERFORMANCE EVALUATIONS

4.1 SIMULATION OVERVIEW

We implemented the proposed scheme using ns2 simulator [13]. For performance comparison, 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 model 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 strength of the adaptive algorithm is the reduced number of coordinator nodes and the consistency of the coordinator nodes. The ultimate aim of a service provisioning scheme is to deliver the service to the requestors. The following metrics are studied to measure the performance of the service delivery scheme, using the adaptive algorithm for coordinator election.

Average zone leader change: The average number of change in zone leaders, considering all the zones, over a period of time.

Average number of zone leaders: the average number of zone leaders within a zone, considering all the zones.

Control message overhead: It is the total number of control message transmissions. Each control message transfer, message forwarding, flooding and handoffs are counted.

Average Packet Delivery Ratio (PDR): The number of data packets delivered to destination to the number of data packets expected to be received.

Average Delivery Latency (Delay): The time at which a packet is sent to the average time at which the packets are received by all receivers.

Delivery Overhead: The total number of bytes transmitted at the MAC layer including ACK.

Forwarding cost: The total number of data packets transmitted to the total number of packets received by all the 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.2. shows that the average number of zone leader change in an adaptive algorithm is much less when compared to the other two algorithms. This is because of the eligibility factor used for leader election in an adaptive algorithm. Because of the reduction in the leader change, the number of handoffs from old to new core node is reduced. Fig.3. shows that the average number of zone leaders is less in an adaptive algorithm, because there is only one leader per zone when compared to other algorithms that has one leader per group. This performance will improve as the number of different groups in a zone increases. Fig.4. shows that the adaptive service discovery procedure has less number of control messages overhead. This is due to the reduced number of core node changes and handoffs. Fig.5. Shows that the packet delivery ratio, delay, overhead and forwarding cost of an 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 three 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 and the tree aggregation. An adaptive algorithm has 82 % PDR and 10 % less delay, 18 % less overhead, 18 % less forwarding cost on an average compared to other algorithms.

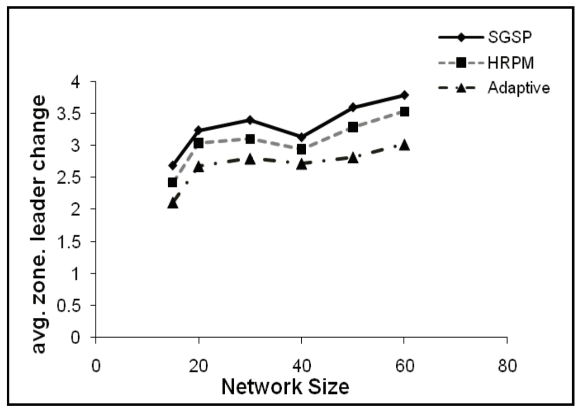


Fig.2.Effect of mobility for different network sizes on zone leader change

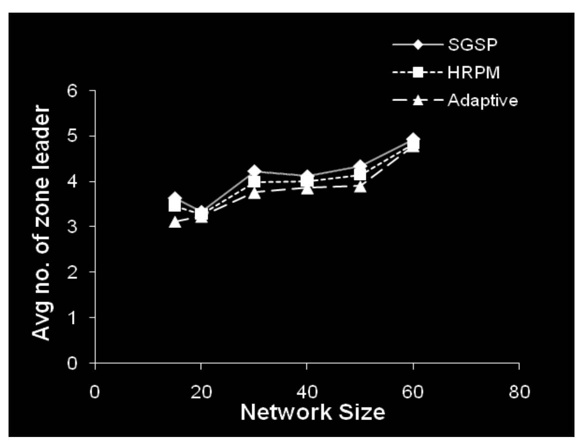


Fig.3.Effect of different network sizes on number of zone leaders

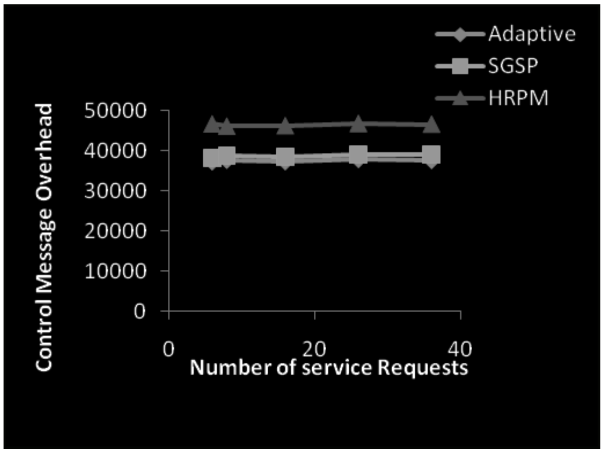
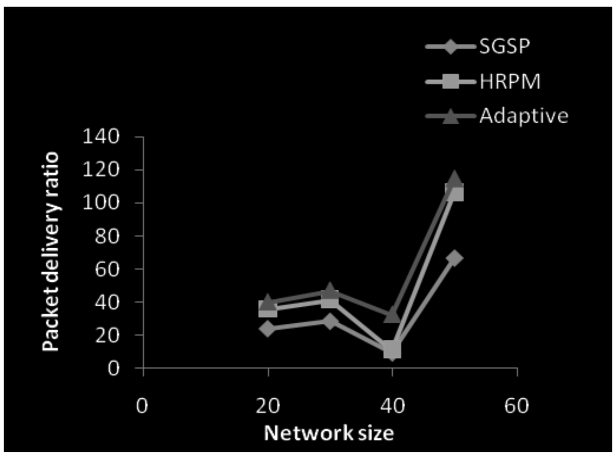
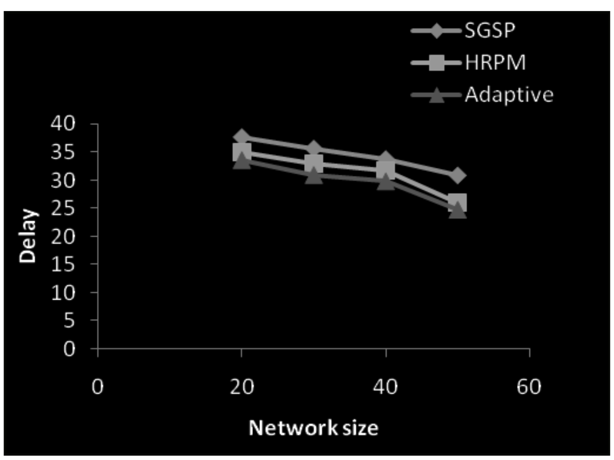


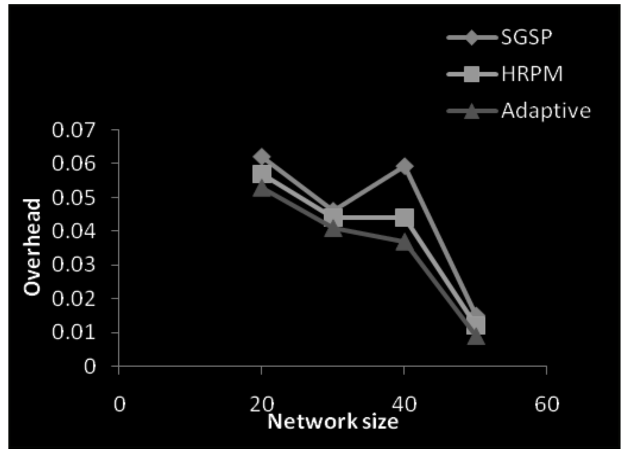
Fig.4. Effect of different network sizes on control message overhead.



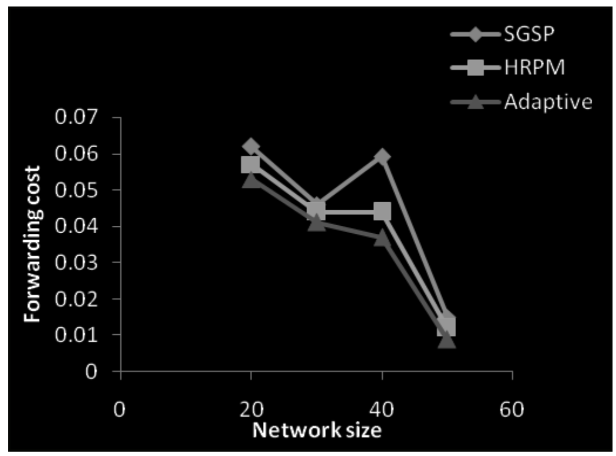
a) PDR comparison



b) Delay Comparison



c) Overhead Comparison



d) Forwarding cost comparison

Fig.5. Performance Comparison of Adaptive, HGMR and SGSP algorithms for different network sizes

5. 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. This coordinator node is more stable because of the parameters used to calculate the eligibility factor. Hence the control overhead and handoffs caused by the other election scheme is reduced in an adaptive algorithm. The performance evaluation shows that the adaptive 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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