A New Approach CBRP Based Resource Information Management in MANETs

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Abstract
One of the main characteristics of MANET (Mobile Ad-hoc NETworks) is the unpredictable movement of the nodes. Sometimes one or more nodes enter or exit from the network in an instance. In some other cases one or more nodes move from its own place to another place. Everything is influenced by these moving natures in the network which consequently cause some problems for the management of the networks. Thus, moving towards zero-configurations is difficult in these networks. The unique features of CBRP (Cluster Based Routing Protocol), on the one hand, and employing the cross layering technique on the other hand, are the main factors of our success in achieving our goal. This is particularly considered as a proper management of the sources in MANETs.

Keywords: CBRP, MANETs, Routing Protocol, Service Discovery, Service Information Accumulation Strategies.

1. Introduction

Making proper decision is one of the definitions of management. Mention should be made that decision making entails information on the same field. Obviously, lack of enough information causes the impossibility of decision making. Therefore we should try to gather and store resource information in the network in the best manner for a proper network management. On the other hand, one of the characteristics of MANETs is its unique features: for instance, the time of entering the node to the network and exiting from it is unpredictable due to lack of a fixed infrastructure. Based on what discussed going toward managing such network especially network resource management in the first view seems difficult, since everything should be considered dynamically. However, it is possible to apply some efficient methods to implement better resource management. In regard with the bandwidth of this networks and lake of static stability of the nodes to manage the network properly, extra overhead should not be imposed to the network.

One of the main and fundamental parts of the network resource management is advertising. The following part concerns the important process:

1- Decision making process in the selection of the features of the resources should be saved in the network: They are crucially applicable in the second phase, based on the resources which are selected.
2- Information saving process: The process involves the process of saving after the selection of the resources parameters, for example they are saved by employing XML method or any other methods.
3- The process of how and where to save information physically: It involves the place where the information resources are to be saved so that everybody can access to it easily and if a node containing information is deleted from the network, it does not have more expenses imposed.

Service Discovery (SD), as the other parts of resources management plays an important role in the network. The task of this part of resources management is defined as below.
We believed that the interaction of the two parts, 1 and 2, is crucially significant. Moreover, from information engineering point of view, the system throughput will not show its efficiency if the first part (advertisement) is not properly done.
The researcher’s intention is more on the first part of the resource management. The following key concepts are presented and defined to clarify the concept of the management of the resources.
Service: A service in the network can be any software or hardware entity that a user might be interested to utilize.
Information is defined as any characteristics of the resources of software and hardware which helps to proper selection in resource management.
Resource Management is referred to a set of processes which is used in introducing the service or resources, saving their information in the network and provides availability and right selective from the point of view of QoS. It is known as management protocol.

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Service Discovery (SD) is defined as one of the section of the management of the services in the network which automatically finds a service, either software or hardware offered by a network node on the basis of the request sent by a network node.
Service Advertisement (SA) is defined as one of the service management sections in the network which automatically distribute the service information, either software or hardware offered by a network node in the network in a way to access the information easily and fast.

2. Related Works

As mentioned before, many different methods are employed to save information in the network. It can be classified as:

- *Directory-less*
- *Centralized directory*
- *Distributed directory*

A directory is an entity that stores information about services available in the network to enable SD and invocation.

2.1. Directory less Architecture

In the directory-less architecture, nodes do not distribute their service descriptions onto other nodes in the network. A device interested in a special service typically sends its search message to all reachable nodes. If one or more of these nodes can satisfy the request, a response is sent back to the requestor.
There are many protocols which use this type of saving information architecture. See the following protocols as examples.

I) UPnP
The Universal Plug and Play (UPnP) is a simple extension of the Plug and Play peripheral model. It is designed to support zero configuration, "invisible" networking, and automatic discovery for a breadth of device categories from a wide range of vendors. With UPnP, a device can dynamically join a network, obtain an IP address, convey its capabilities, learn about the presence and capabilities of other devices, enabling zero configuration networks truly [1][2].

II) DEAPspace
DEAPspace provides a framework to connect devices over a wireless medium. It is a push-model-based approach to fast and resource efficient SD. All of services attributes are stored on service providers. DEAPspace services are specified as a data hierarchy. The root node of this hierarchy is the DSService class. Each service description has a field to keep expire time (time-to-live). Nodes advertise their services by a broadcast mechanism to their neighbors [3].

III) PDP
Pervasive Discovery Protocol (PDP) is a fully distributed protocol that merges the characteristics of both pull and push solutions for ad hoc networks. In this protocol, each device has a cache containing a list of the services that have been heard from the network. Each service has expire time and the service is removed from the cache when they timeout. PDP uses Generic Service Description Language (GSDL) for description services [4].

2.2. Centralized Directory Architecture

The centralized directory architecture rely on a central directory that stores the descriptions of all services available in the network so as to enable us to use SD and invocation. Service providers advertise their services to the central directory using a unicast message. To access a service, a client first contacts the central directory to obtain the service description, which is then used to interact with the service provider.
Centralized resource discovery is much suited to wireless infrastructure-based networks. However, this architecture makes the service SD process dependent upon the availability of the central directory, which further constitutes a bottleneck. In addition, a centralized directory limits its scope to devices within a local SD domain. The boundaries of a SD domain can be administratively defined such as an IP subnet, or they can be the result of a physical property such as the range of a wireless network.
SLP and JINI use the advantages of this type of architecture:

I) JINI
Java Intelligent Network Interface (JINI) is a protocol that has an environment for creating dynamically networked components, applications and services based on Java. There is a main protocol in JINI called Lookup Service (central directory) that registers devices and services available on the network. When a device connects to network, it locates the lookup service and registers its service there (SA), this device and its service are accessible by sending a query to lookup service [5].

II) SLP
The Service Location Protocol (SLP) provides a flexible and scalable framework for providing hosts with access to information about networked services. There are three main agents in the SLP framework: (i) User Agent (UA), issues a 'Service Request' on behalf of the client application, the User Agent will receive a Service Reply specifying the location of all services in the network

which satisfy the request. (ii) Service Agent (SA) advertises the location and attribute on behalf of services. After receiving a request for a service, it unicasts a reply message containing the service's location. (iii) Directory Agent (DA), there is one or more DAs in a large network. They act as a cache and store information about the service announced in the network. SLP has two different modes of operation: (1) when a DA is present, it collects all service information advertised by SAs, and UAs unicast their requests to the DA, and (2) when there is not a DA, UAs repeatedly multicast the request, SAs listen for these multicast requests and unicast responses to the UA [6].

2.3. Distributed Directory Architecture

The motivation that supports the use of the distributed directory architecture for SD is the scalability which can be achieved when the network size becomes larger. This architecture is quite suited to the mobile ad hoc network scenario. Directories are dynamically selected among mobile nodes which have suitable capability (e.g. battery power, memory, processing power, node coverage, etc) [1]. Protocols such as Sailhan use the distributed directory architecture:

I) Sailhan

Sailhan in [7] proposed a SD protocol aiming at large MANETs (i.e., comprising at least about 100 nodes). Its design is based on centralized discovery architecture, as it induces less traffic. Directories are further distributed and deployed dynamically for the sake of scalability. Specifically, its discovery architecture is structured as a virtual network. A virtual network is composed of a subset of MANET's nodes acting as directories. These directories represent a backbone of nodes responsible for performing SD. They are deployed at least one directory.

2.4. Comparison of the Various Directory Architectures

In directory-less architectures, broadcasting is generally used for SD and advertisement. These broadcasting mechanisms are not suited for mobile ad hoc networks due to their heavy consumption of bandwidth and energy, which are limited in mobile devices. Therefore, the network size supported by the directory-less architecture is very limited. Nevertheless, in regions with extremely high mobility, broadcasting could be the only possible technique.

In the central directory architecture, although centralized resource discovery is much suited to wireless networks, the central server further constitutes a bottleneck. In addition, a centralized directory limits its scope to devices within a local SD domain.

Distributed directory architectures are quite well suited to the mobile ad hoc network scenario, but when we have many nodes in the network, the overhead will increase exponentially.

In order to have an efficient SD and SA architecture, it is better to use the hierarchical distributed directory architecture.

2.5. Cluster Based Routing Protocol

1. CBRP is a routing protocol designed to be used in mobile ad hoc networks. The protocol divides the nodes of the ad hoc network into a number of overlapping or disjoint 2-hop- diameter clusters in a distributed manner. Each cluster chooses a head to retain cluster membership information. Based on cluster membership information kept at each cluster head, inter-cluster routes are dynamically discovered. The protocol efficiently minimizes the flooding traffic during route discovery and speeds up this process by clustering nodes into groups. Moreover, the existence of uni-directional links and the use of these links for both intra-cluster and inter-cluster routing are extremely considered by the protocol. An example of an ad hoc network is shown in Figure 1. Nodes are organized to five clusters and each of them has a cluster head.

Unlike the other on-demand routing protocols, in CBRP the nodes are organized in a hierarchy. Cluster-head coordinates the data transmission within the cluster to other clusters. The advantage of CBRP is that only cluster heads exchange routing information, therefore the number of control overhead transmitted through the network is less than the traditional flooding methods. However, as in any other hierarchical routing protocol, there are overheads associated with cluster formation and maintenance [8].

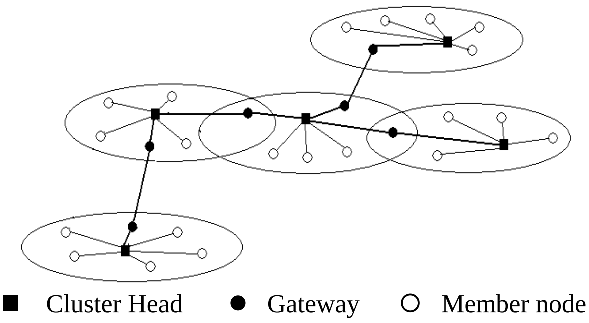


Figure 1: A cluster based ad hoc network

The information about link states (uni-directional or bi-directional) and its neighbors' states (retained by every node in CBRP) are presented in a neighbor table. A cluster head keeps information of its neighboring clusters, in addition to the information of all members in its cluster. The information includes the cluster heads of neighboring clusters and gateway nodes connecting it to neighboring clusters [9].

CBRP proposes the shortening route for performance optimization. Since CBRP uses a source routing scheme, a node gets all information about the route when receiving a packet. Nodes exploit route shortening to choose the most distant neighboring node in a route as next hop to minimize the hop number and adapt to network topology changes.

CBRP has the following features [9]:

- Fully distributed operation.
- Less flooding traffic during the dynamic route discovery process.
- Explicit exploitation of uni-directional links that would otherwise be unused.
- Broken routes could be repaired locally without rediscovery.
- Sub-optimal routes could be shortened as they are used.

In these protocols clusters are introduced to minimize updating overhead during topology change. However, the overhead for maintaining up-to-date information about the whole network's cluster membership and inter-cluster routing information at each and every node in order to route a packet is considerable.

3. Proposed Enhancement to SA Mechanisms for MANETs

SA is a basic component for SD. We propose a light weight manner to SA via:

(i) Using CBRP that supports clustering mechanism to combine distributed architecture for maintaining service information with centralized stores for each cluster to decrease delay for finding a service in the network [10].

(ii) Hybrid mechanisms for SA using network and application layers approaches to decrease connection overhead and power consumption. Network layer finds service based a request and application layer finds a well suitable service heuristically.

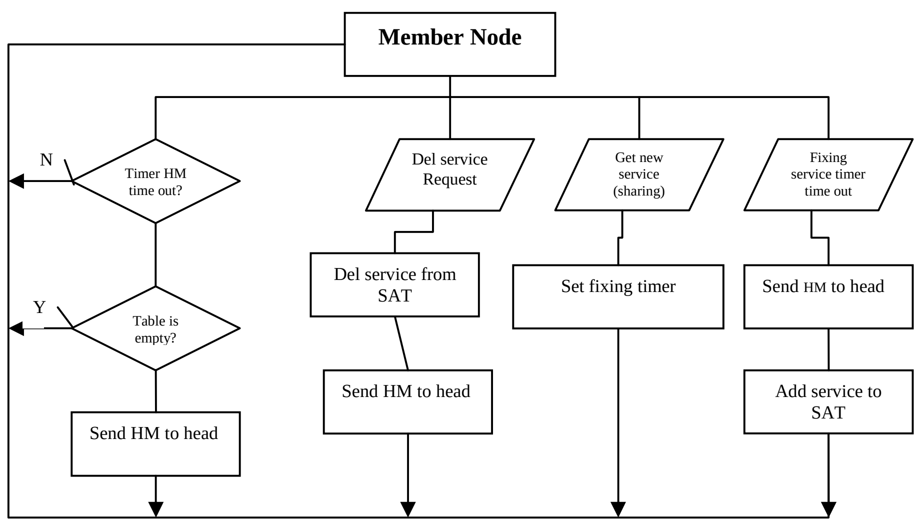
In order to add SA capability to CBRP, it needs to accomplish services attributes on the network. For this purpose a new table by the name of SAT (Service Access Table) has been added. Each node has a SAT to store all the available services. The SAT structure is shown in Table 1.

SA is started when a service is added to a machine located within the ad hoc network environment and the owner decides to share the service based on some criteria.

Table 1: SAT Structure

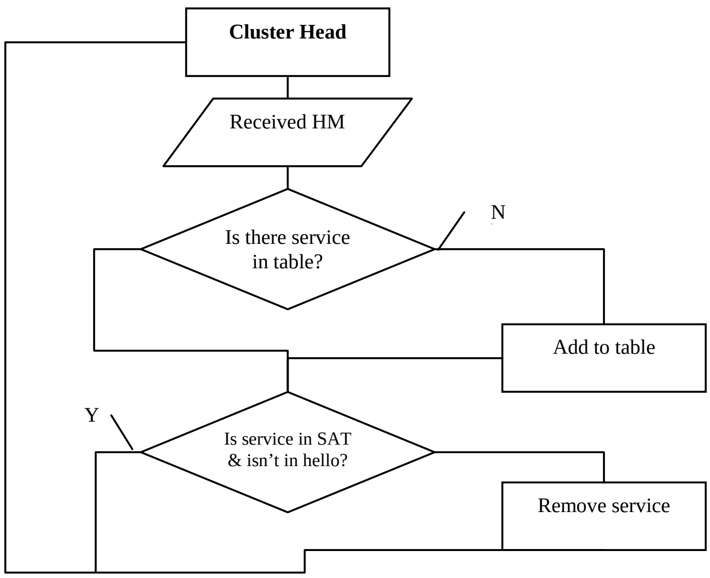
Service ID	Service type	Service Attributes	Service Owner
ID 1	T1	Att1	Owner Address
ID 2	T2	Att2	
…	…	…	…
ID n	Tn	Attn	Owner Address

Since the information of services kept in member node SAT and cluster head SAT, the state transition diagram for each of them is shown separately in Figure 2(a) and 2(b).



HM: Hello Message, SAT: Service Access Table

(a): Member Nodes State Transition Diagram



HM: Hello Message, SAT: Service Access Table
(b): Cluster Head State Transition Diagram

Figure2: State Transition Diagrams for SA

In contrast to existing clustered SA approach, service attribute information including static service attributes, service access models and the service physical location is sent to head cluster machine in the same cluster. In this way, all service information is stored at the cluster head node.

When a node shares a service, the node stores its service in its SAT and then sends the service to cluster head via making a packet which contains the SAT and sends it with a unicast service. Any change in this table causes the service packet to be sent to cluster head in addition to periodical hello message. For example, when we delete a service from SAT in member node we have to update the SAT of the cluster head, thus, based on figure 5 we proposed an UpDate Packet (UDP) and send it to CH directly.

A new Hello message packet has been organized for CBRP to advertise the services (See figure 4). In fact, we use the CBRP hello message with adding some fields for services. When the cluster head receives a packet containing one or more services, it should update its SAT without any overhead in this updating.

<table>
<tr><td>Status</td><td>Type of packet</td><td>No Neighbor Node (n)</td><td>No Neighbor Cluster (m)</td><td>No Service (k)</td></tr>
<tr><td colspan="3">Neighbor (1)</td><td colspan="2">Neighbor status (1)</td></tr>
<tr><td colspan="3">…</td><td colspan="2">…</td></tr>
<tr><td colspan="3">Neighbor (n)</td><td colspan="2">Neighbor status (n)</td></tr>
<tr><td colspan="5">Neighbor Cluster (1)</td></tr>
<tr><td colspan="5">…</td></tr>
<tr><td colspan="5">Neighbor Cluster (m)</td></tr>
<tr><td colspan="2">Service ID (1)</td><td>Service Type (1)</td><td colspan="2">Service Attributes (1)</td></tr>
<tr><td colspan="2">…</td><td>…</td><td colspan="2">…</td></tr>
<tr><td colspan="2">Service ID (k)</td><td>Service Type (k)</td><td colspan="2">Service Attributes (k)</td></tr>
</table>

Status: 0 = undecided, 1 = Member, 2 = Cluster Head
Type of packet: 8 = Reply to member
9 = Service Advertisement
10 = Service Discovery
11 = Request to Head in its cluster
12 = request to all cluster heads

Figure 4: Structure of new Hello Message

Upon a node in the network receiving a hello message packet or any packet containing one or more services; the cluster head modifies its own Service Table on the basis of the following algorithm:

1. It checks whether services in the hello message is already in the Services Table or not? If not, it adds some entry for them.
2. If there is a service in Services Table which has already been received, and it is not included in the Hello Message the service has to be deleted from Services Table in CH.

The pseudo code of the algorithm is as follows:

For *(all services in hello message) {*
Extract service parameters from packet;
If *(the service is in SAT of cluster head)*
Update the timeout event;

Else {*add it as a new record;*

}
If *(there is a service from B in SAT of cluster head but there isn't in hello message)*

Delete service from SAT;

Status	No Service (k)	
Service ID (1)	Service Type (1)	Service Attributes (1)
…	…	…
Service ID (k)	Service Type (k)	Service Attributes (k)

Figure 5: Structure of UDP

4. Simulation Result and Analysis

Our simulations were conducted in the Network Simulator 2 (NS2) [11].To facilitate the analysis of the results, we assume that there are 15 services in the network. The services are first distributed randomly to nodes so that each node cannot own more than one service to offer to other nodes. The scenario files are created by the SetDest tool of the NS2 and the traffic files are created by 'cbrgen.tcl' program. The simulation settings and parameters are shown in the following Table 2.

Table 2: Simulation setting

Simulation duration	900 sec
Broadcast interval	2 sec
Pause time	2 sec
Maximum Speed of the node	10 m/s
Area	Max x = 500 m max y= 500 m
Number Request service	300
Data stream	CBR
CBR Maxpkts	1100
Max connection	8
Sending rate	0.25
Seed	1.0
Number of nodes	15,20,30,40,50,60,70,80,90,100,130

Performance criteria are discussed in our simulations. The performance metric is the total mean of **control message overhead** of SA mechanism which measures the load of the algorithms on network resources in terms of the number of packets.
In the experiments, we intend to capture the effect of adding SA to the CBRP on control message overhead when we increase the number of nodes. We have captured the mean of control message overhead for various states in terms of the number of nodes in the network. Figure 6 shows the overheads versus number of nodes for SA and it illustrate that adding SA to the CBRP does not impose more overhead to the network.

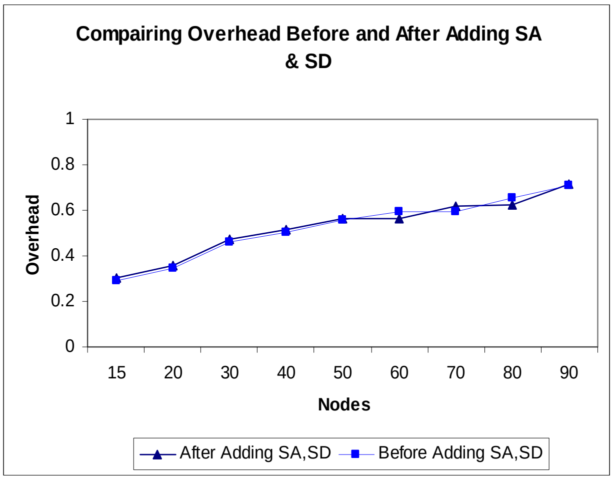


Figure 6: overhead before and after adding SD & SA to CBRP

5. Conclusion and future work

We propose a protocol for Cross Layers Resource Management in MANET. We optimize the resource management process in MANET by utilizing the routing mechanism (CBRP) for service advertisement and discovery as well as in layer 3. Since we put the process in Layer 3, it will speed up the processing time, and decrease overhead.

Based on our experiment, adding SA to CBRP does not have more overhead in various states, since increasing number of nodes do not have more effect on overhead, we have an acceptable and scalable Hierarchical Service Advertisement.

It seems that the better distributing of service information can improve SD. Thus, the researcher is currently studying on the feature of service information distribution on the network nodes to provide some improvement in case of access time in SD and SA.

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