Cluster Based Cross Layer Intelligent Service Discovery for Mobile Ad-Hoc Networks

Monire Norouzi
Department of Computer Engineering, Islamic Azad University, Ahar Branch, Ahar, Iran
E-mail: m-norouzi@iau-ahar.ac.ir

ABSTRACT

The ability to discover services in Mobile Ad hoc Network (MANET) is a major prerequisite. Cluster based cross layer intelligent service discovery for MANET (CBISD) is cluster based architecture, caching of semantic details of services and intelligent forwarding using network layer mechanisms. The cluster based architecture using semantic knowledge provides scalability and accuracy. Also, the minimum cluster forwarding (MCF) algorithm will find the remote services. It reduces network traffic and increases bandwidth utilization. The ability to discover services in Mobile Ad hoc Network (MANET) is a major prerequisite. Cluster based cross layer intelligent service discovery for MANET (CBISD) is cluster based architecture, caching of semantic details of services and intelligent forwarding using network layer mechanisms. The cluster based architecture using semantic knowledge provides scalability and accuracy. Also, the minimum cluster forwarding (MCF) algorithm will find the remote services. It reduces network traffic and increases bandwidth utilization.

KEYWORDS: MANET, Service Discovery, Cluster, semantic, MCF.

1. INTRODUCTION

Mobile Ad-Hoc networks are temporary infrastructure-less multi-hop wireless networks that consists of many autonomous wireless mobile nodes. Service discovery is a major building block of MANETs where flexibility and minimum user intervention are essential. SDP (Service Discovery Protocol) enables mobile nodes to advertise their own capabilities to the rest of the network and to automatically locate services with requested attributes. In the context of service discovery, service is any hardware or software feature that can be utilized or benefited by any node. Service description is the information that describes a service's characteristics, such as service type, attributes, access method, etc. The server node provides some services and the client node that requests services provided by other nodes.

When a service is needed, a client sends out a service request packet which will be forwarded by others. When receiving a service request packet, every node with matched services should respond with a service reply packet, which will be forwarded reversely to the source of the corresponding service request packet. Other nodes without matched services should forward the service request packet. All these corresponding packet transmissions, including service request packets and service reply packets, form a SDP session.

GSD is a Group-based Service Discovery in peer – peer network, uses semantic knowledge to find the service and provides redundant packet transmission.

GSD and its extended versions can be used for small networks. When the network is huge, network traffic is a bottleneck in these protocols.

Hence, our proposed work concentrates on huge networks and uses semantic information and clustered architecture to achieve scalability and accurate matching of services. Also, minimizes the number of packets exchanged and hence reduce the network traffic. The work uses two interesting mechanisms: (1) caching of service advertisement packets in cluster head and (2) group-based intelligent forwarding of service request packets.

In the cluster based approach, services are registered with the cluster head and uses uni-cast packet. The discovery of services provide low overhead and high throughput. Services are described using the Web ontology Language (OWL).We exploit the semantic class or sub-Class hierarchy of OWL to describe service groups and use this semantic information to selectively forward service requests.

The service discovery architecture based on clustering, which performs the cluster head selection by allotting a combined weight value based on the factors power level, connectivity and stability, intended for wireless mobile ad hoc networks. This method permits switch over of the service discovery messages only among the cluster members and considers the capabilities of the nodes for the distribution of workload, thus minimizing the cost of communication. We illustrate the minimized delay and overhead of the proposed architecture in addition to its accomplishment of good success ratio through the simulation results. The rest of the paper is organized as follows. Section 2 deals with literature review. In section 3, proposed work is explained. In section 4, simulation results are shown. Finally in section 5, conclusion is given.

2. RELATED WORK

In semantic service discovery scheme, the nodes intelligently forward requests based on its service description semantics. This approach is used in Group based service discovery(GSD)[7]. Its packet overhead is more due to flooding. PGPGSD, Gao, Z.G. et al used three mechanisms such as pruning of far candidate node(PFCN), combining of relay nodes(CRN) and piggybacking of relay nodes(PRN) are used to reduce the packet overhead[8]. In FNMGSDP(Forward Node Minimization enhanced Group-based Service Discovery Protocol) minimizes the number of next hop nodes when forwarding request packets by exhaustively utilize the information in Service Information Cache[6]. In CNPGSDP, Zhengao Gao et al has proposed two schemes to enhance GSD: Broadcast Simulated Unicast(BSU) and candidate node pruning (CNP). Several uni-cast packets are replaced with one request [9].

A representative clustering approach is service rings [10]. In service rings, a number of clusters are formed. Each cluster (called a ring) of service providers is formed based on physical proximity and semantic proximity of the descriptions of provided services. Every ring has its own service access point (SAP) that is responsible for handling service registrations and service requests (operating as a directory). SAPs also communicate with each other and exchange summaries about all the services about their own ring. These way higher-level rings are formed iteratively. Global discovery is possible because when a node request cannot be satisfied by its local SAP, then this SAP forwards the request to neighboring SAPs (and eventually to higher-level SAPs) that possibly are capable of satisfying the request, based on the service summaries they sent previously.

Gregor Schiele, et al, presented a service discovery algorithm based on node clustering. They presented SANDMAN, which is a protocol for energy efficient service discovery in Ubiquitous computing environment. Their simulations show high energy savings with large idle times. [5].

Seyed Amin Hosseini Seno et al, have used Cluster based routing protocol (CBRP). In order to reduce communication messages service advertisement was moved from application layer to network layer. The services are distributed in the network among clustered nodes [11].

3. PROPOSED WORK

3.1 CLUSTER INFORMATION

The nearby nodes are grouped together to form clusters in ad hoc network. Clusters are two hop in diameter and they are overlapping or disjoint. Each cluster chooses a cluster-head to retain cluster membership information. Each node maintains a neighbor table and a cluster adjacency table. The neighbor table is a data structure that tracks the link status sensing and cluster formation. It maintains neighbor information within one hop and is constructed using hello messages (HM). The cluster adjacency table maintains information regarding adjacent clusters for adjacent cluster discovery. These tables are updated periodically. Cluster structure is exploited to minimize flooding traffic during the service discovery phase. Cluster-head coordinates the cluster members and inter-cluster routes are dynamically discovered.

3.2 CLUSTERS-HEAD SELECTION

Cluster head is selected based on highest degree, energy level and stability. The weight based cluster head selection is done.

$W=w1A+w2B+w3C$

Where A,B and C are degree of a node, energy level and stability index. w1,w2, and w3 are weights. Each cluster head maintains the following tables with respect to service discovery.

Local Service Table (LST): When a node(CN) enters a cluster, it registers its service and group through service advertisement, at the CH. The service related information of a cluster are stored in LST and available at CH. LST contains the fields { member id, Service id, group id, service attributes,} Global Service Table(GST): The CH maintains GST , which consists of service details from other clusters.

It contains the fields { Neighbor CH id, service id of services available at neighbor CH, group id of Services seen by neighbors CHs }

3.3 ROUT DISCOVERY IN CLUSTER

Based on cluster membership information maintained by each CH, inter-cluster routes are dynamically discovered using underlying routing protocol. Essentially, during route discovery, only CHs are flooded with route request packets (RREQs) in search of a source route. Each CH node forwards an RREQ packet only once, and it never forwards it to a node that has already appeared in the recorded route. It proactively acquires intra cluster topology information by exchanging (HM) and, in response, acquires inter-cluster route information. As in almost all hierarchical protocols, the Cluster-heads coordinate the data transmission between clusters. The advantage is that only CHs exchange routing information; Therefore, the amount of control overhead over the network is far less than that in flooding methods. However, there is an overhead associated with cluster maintenance due to topology changes. In cluster based architecture, when a request packet is to be forwarded, the node will forward the request to its CH and the CH selects the forwarding nodes. CH uses the semantic knowledge to intelligently forward the request. Even though the cluster based architecture has more overhead for cluster maintenance, the scarce resource of bandwidth is saved due to minimum packet exchange. There are many redundant request packets belong to the same service. When a CH receives packets, it combines the packets and forwards a single request packet on behalf of multiple requests. The semantic comparison is done at CH.

3.4 SERVICE REGISTRATION

Each service provider broadcasts the service advertisement packet and the cluster head registers the service. The Hello packet is used for service advertisement.

Service advertisement packet:= { Packet type , Packet-id, Sender-id, Cluster head-id, Original hop, Service id, Service group id, Lifetime }

3.5 CLUSTER BASED SERVICE DISCOVERY

The cluster head maintains the services in LST as well as GST and this information are propagated to other cluster heads. The GST contains the details of other cluster heads within its neighborhood. Also it contains the details of all its cluster members in its LST. The information of cluster members and adjacent cluster heads are obtained by exchanging the HELLO message. LST and GST act as Service Information Cache to have the services from its cluster members and other cluster head.

When a CN requires a service, it forwards the query to its CH. If the service is available either in LST or GST, it sends a reply to CN. Otherwise, it forwards the query to other CHs to find the service.

3.5.1 SERVICE REQUEST

When a node requests a service, it forwards SREQ packet to its CH. If the service is available in LST, The CH sends reply back to the node. Otherwise, it constructs a request packet and forward to other clusters.

Service request packet :=(Packet type, Packet-id, Sender-id, Cluster head-id, Service id, group id, request description, receiver list}

3.5.2 SERVICE REPLY

When a node receives the service query, if it has the service, it constructs a reply packet and sends the reply to the source node.

Service reply packet: = { Packet-type,

Packet-id, Source-id, receiver-id, Original hop, service description}

3.6 MINIMUM CLUSTER FORWARDING (MCF)

If the node to be communicated is assumed to be present on another cluster, then cluster head of the source node transmits a SREQ message to the cluster heads of the remaining clusters using MCF algorithm. When a cluster is not able to find a service, it uses minimum cluster forwarding algorithm to find the service.

The forwarding request contains an empty list to store the cluster id. When a cluster head receives, checks for the service. If available, send the reply to the source cluster-head. Otherwise, it enters its CH ID in the check list and forwards the SREQ to other clusters.

Every CH combining the packets when it forwards a packet to next CH. And keeps track of the service. If the cluster head receives more than one request from its clients belonging to the same service, a single SREQ will be sent. As power energy is critical in MANET, the CH combines the requests. This reduces the network traffic also. CH maintains a table to store the corresponding CNs and service request id. When it receives reply, it checks the table and sends individual reply to the CNs.

We added three fields to the route request packet:

(i) service description, which contains a description of the service as advertised by the service provider along with group information,

(ii) service discovery flag,

(iii)Receiver list

In route reply packet, two fields are needed:

(i) service location, which contains the location of the service and

(ii) service metric, which contains additional metrics as advertised by a service provider.

Scenario 1:

There are nine clusters namely C1,C2 C3,C4 C5, C6,C7 C8 and C9 in Fig.1. For cluster C1, A1 is cluster head. When A2 wants service a_2, it sends a SREQ to A1. A1 has the address of service provider of a_2. It forwards the SREP to A2. Hereafter A2 can contact A3 using any underlying cluster based routing protocol.

Scenario 2:

When A2 wants the service c_2, it sends SREQ to A1. A1 checks the GST and finds that C2 has that service and provides address of the service c_2 to A2 in SREP.

Scenario 3:

When A2 wants the service d_2, it sends SREQ to A1. E checks the SIC and finds that C6 has that group of d_2 and not exactly d_2. It forwards SREQ to the candidate cluster C3. It uses the minimum cluster forwarding algorithm. Here, no of packets forwarded are reduced using cluster based architecture.

3.7 SERVICE DISCOVERY ALGORITHM

For *(all SD request) { Extract service-id and group-id from packet;*

If *(the service-id is in LST)*

Send reply to cluster member;

Else If ((*the service-id is in GST)*

Send reply to cluster member;

Else

{Construct a request packet and forward to other candidate cluster-heads *;*}

3.8 NETWORK LOAD ANALYSIS

Average Advertisement Frequency (number of advertisements/second) across all the cluster-heads N is SAf. The total number of messages generated in a single bounded advertisement from a single node is n. Thus, the total number of messages generated by advertisements in time T by all nodes is:

$$MAdv = n * N * SAf * T. \quad (1)$$

The average number of messages generated in the system due to a single discovery request is p. The total number of messages generated in a single bounded service request in time T is:

$$Mreq = p * N * T \quad (2)$$

The total network load is

$$M = MAdv + Mreq. \quad (3)$$

$$M = n * N * SAf * T + p * N * T \quad (4)$$

4. SIMULATION MODEL

We use NS2 to simulate our proposed algorithm. In our simulation, the channel capacity of mobile hosts is set to 2 Mbps. We use the distributed coordination function (DCF) of IEEE 802.11 for wireless LANs as the MAC layer protocol. It has the functionality to notify the network layer about link breakage. In our simulation, 100 mobile nodes move in a 1000 meter x 1000 meter A Cluster-Based Intelligent Service Discovery Protocol for Mobile Ad-hoc Networks for 100 seconds simulation time. Initial locations and movements of the nodes are obtained using the random waypoint (RWP) model of NS2. Each node moves independently with the same average speed. All nodes have the same transmission range of 250 meters. In our simulation, the minimal speed is 5 m/s and maximal speed is 20 m/s. The simulated traffic is constant Bit Rate (CBR). For each scenario, ten runs with different random seeds were conducted and the results were averaged. The nodes request rates are variable and fixed.

Table1. Simulation setting schedule

Parameters	Value
Number of service groups	4
Number of clusters	9
Valid Time of service in LST and GST	20s
Service advertisement interval	20s
Maximum hop of advertisement packets	2

4.1 SIMULATION RESULTS

The performance evaluation for cluster based intelligent service discovery (CBISD) architecture and FNMGSD schemes for the following performance metrics.

Packet overhead: The experiment is done for 10 minutes in which 20 nodes request service and 6 requests per minute. The average traffic at CH and SP are comparatively less than FNMGSDP.

Energy: Transmission, reception and computational part consumes energy. The energy consumption at cluster-heads is calculated. The simulation results are presented in this section.

5. CONCLUSION

Our proposed work is cluster based architecture, caching of semantic details of services and intelligent forwarding using cluster based routing protocol. The cluster based architecture using semantic knowledge provides scalability and accuracy. This work reduces network traffic and consumes less energy than previous work. A detailed traffic analysis and energy consumption analysis will be carried out in future work.

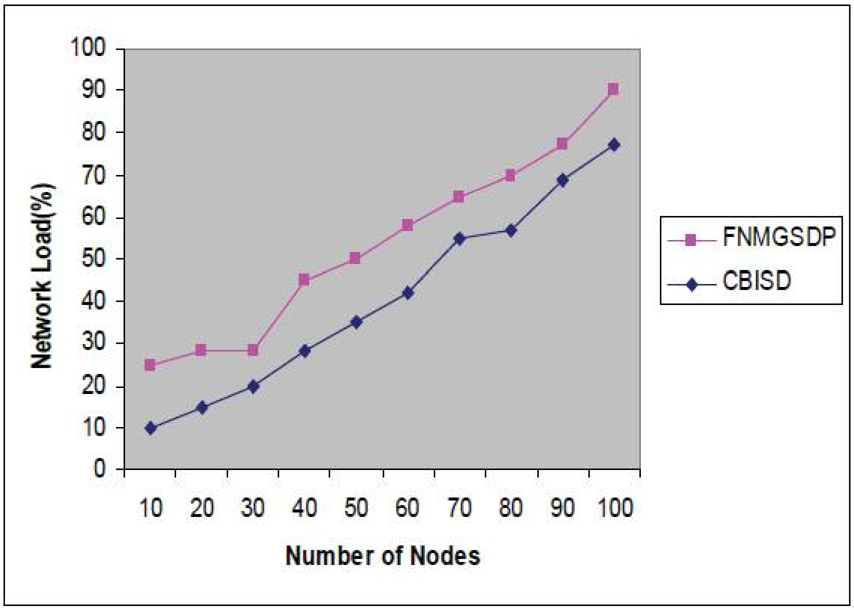

Fig.1. Service advertisement vs. Network load

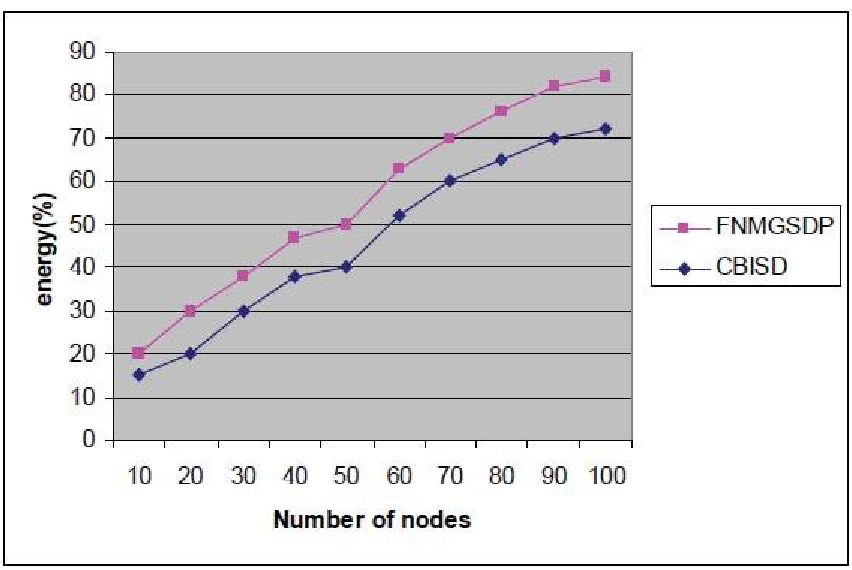

Fig.2. Number of nodes vs. Energy level

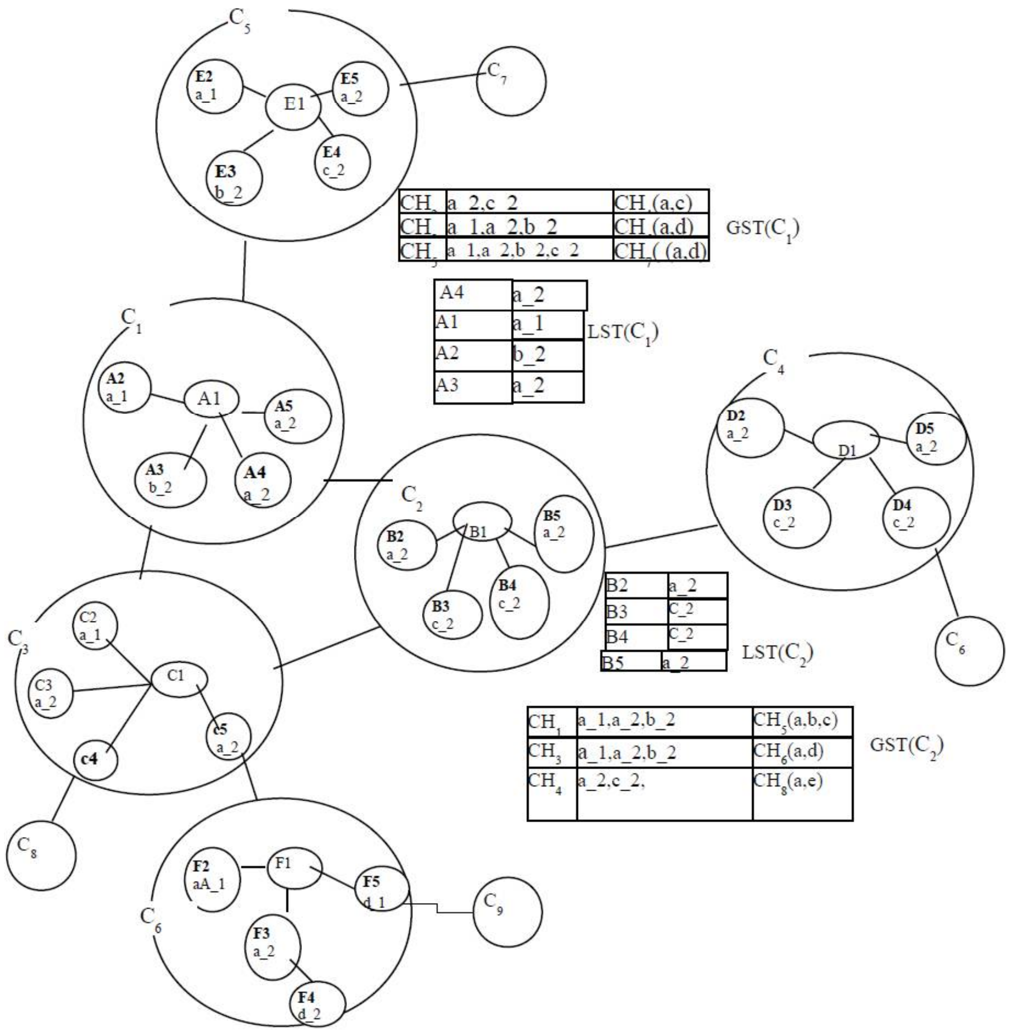

Fig.3. Cluster Formation

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