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Scalable Design of Service Discovery Mechanism For Ad-hoc Network Using Wireless Mesh Network

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Abstract - Wireless Mesh Network is an emerging technology that allow users to access information and services electronically using service discovery protocol. The seamless connectivity and mobility feature of WMN motivated us in the design of efficient and scalable service discovery scheme that assures certain level of quality of service. The proposed model uses routing clients which communicate with Service Caches to register for services. The gateway nodes discovers quality services by using backbone based distributed directory structure. The proposed model is scalable and reduces discovery overhead, duplicate information dissemination, and energy consumption.

Keywords- Wireless Mesh Network, Service Discovery, Service Directories, Service caches, OFLSR, routing daemon

I. INTRODUCTION

Wireless Mesh Networks (WMNs) provide flexibility in terms of mobility i.e. Mesh clients can be stationary or mobile and can form a client mesh network among themselves and with mesh routers. WMNs make use of multiple radios and multiple channels per radio for increased capacity, higher throughput and low interference.[1]. Service discovery is acclaimed as a crucial challenge in WMN [2], [3], [4]. Service discovery is the ability to discover and form an ad-hoc network without explicit user direction. It facilitates devices and services to properly discover, configure, and communicate with each other. Service discovery minimizes administrative overhead and increases usability [4]. So, Service discovery can be defined as a process that allows networked entities to broadcast their services, inquire about services provided by other clients, selecting the desired service and invoking it. In the literature, many service discovery schemes have been provided. Current approaches for service discovery uses different directory based architectures for flooding information into the network. In literature there are two architecture approaches to perform service discovery – (i) directory based and (ii) non directory based approaches. In later approach broadcasting or multicasting is performed for flooding messages in the

network.. The proposed scheme uses the mesh backbone approach and selects a set of nodes on the basis of stability constraints to coordinate the network. The nodes which have minimal mobility are elected as mesh backbone and gateways or routers. These nodes function as service caches. This paper proposes the design of an efficient and scalable service discovery scheme that optimizes discovery overhead by integrating discovery information in routing demon. We have also implemented the functionality of OFLSR routing protocol in the network layer this reduces the routing update overhead by using different exchange period for different entries in routing table. The advantage of this scheme is that it reduces message overhead, battery power consumption and maintenance messages for SC. The remainder of the paper is organized as follows: Section II presents related work and existing techniques for service discovery. Section III provides detail description of proposed model. Section IV discusses working of proposed architecture Section V discusses and evaluates scalability issues. Finally in section VI paper concludes with future work.

II. RELATED WORK

On the protocol level there are a lot of well-known protocols for service discovery like the Service Location

Protocol version 2 (SLPv2) [5], Simple Service Discovery Protocol as part of Universal Plug and Play (UPnP) [6] or the DNS based Service Discovery (DNS-SD) [7]. However, these protocols were originally designed for wired LANs or small single-hop ad-hoc network. mSLP [8] is one of many existing modifications to SLP where SLP Directory Agents form a mesh structure and exchange service registration states. However, this approach does not scale well in WMNs, because service registration states must be replicated between all servers.

A light-weight service discovery (LWSD) protocol for ad hoc networks was proposed by Mallah and Quintero [9]. This protocol deploys judiciously elected (stable) nodes in the environment for the service discovery to take place. Artail et. al describes a distributed service discovery model (DSDM) for MANETs [10]. This model is similar to the approach in [9]. Virtual backbone nodes act as service directories nodes. This model handles network partitioning. The intermediate nodes between the service provider and service requestor cache the service information. This model minimizes the use of packet flooding and broadcasting for service advertisement and discovery. This model achieves reasonable system response time and network traffic. This model uses proactive routing protocol to update the routing table for frequent disconnections and arrivals. This model does not consider high node mobility on system performance. The proposed model extends the work of [9] [11] [12] [13] to achieve quality of service(QoS) based service discovery on integrated directory-base architecture.

Figure 1. Back bone based directory architecture of WMN

III. PROPOSED WORK

The proposed system framework for QoS discovery in WMN is shown in figure 2. First, bootstrapping process is performed by node on application layer which helps in neighbor nodes and services identification. Then mesh network is organized using integrated directory-based architecture, backbone-based and cluster-based. After mesh backbone routers and clients discovery we have implemented Optimised Fisheye Link State Routing Protocol(OFLSR) which combines two routing protocols OLSR and FSR. It(OFLSR) divides the network into different scope levels for service advertisement and discovery. Implementation of this protocol significantly reduces duplicate packet retransmission. The service discovery component comprises of functional description and assigns QoS values dynamically. The service descriptions are registered by service providers to their clusters or zones or scopes. Then services are discovered within scopes either locally or globally. The network is reconfigured when either new mesh nodes join clusters or leave the network. Below are listed various components of proposed service discovery scheme in WMN using OFLSR protocol.

A. Service Discovery Scheme Components

1. *Clients:* are the entities that either provides services to other entities or expect to discover available services in an unknown environment with the help of node advertisement and neighborhood discovery.

a) Node Advertisement for Neighborhood Discovery: Initially in WMN there are no backbone nodes(BB) or clusterheads(CH). Every node in the network perform lightweight advertisement of HELLO messages to discover neighbor nodes. This message usually contains the following information fields

- SourceNet_id of node, node_id, BB, CH, packet_type)
- List of next hop neighbors (Network_id, node_id, BB,CH, latest Time stamp)
- Control information (Time To Live)

Initially the value of backbone (BB) nodes and cluster head (CH) nodes will be zero.

2) Directory

Directories are entities that are responsible for caching advertisements from available service provider nodes(SP) and carries out lookup to cater to discovery requests from clients. Explicit directory agents are used by in approaches. The proposed backbone based directory module consists of three types of nodes-Service Directories (SD) nodes, Service Provider (SP)

nodes and Regular non routing nodes. SD nodes are BB nodes and CH nodes and they act as service caches(SC).

Figure 2. Proposed Service Discovery Scheme design for WMN using OFLSR Protocol in Network Layer.

a) Backbone Nodes Identification

First BB nodes are randomly identified on the basis of stability constraints namely as Normalized Link Failure Frequency (NLFF) metric[9]. NLFF reflects the rapidity in which the neighborhood changes in comparison with its degree.

Then clustering technique or scope formation is applied according to Fisheye State routing to form integrated directory-based structure. This structure can be used to discover services among nodes.

b) CH identification or Proactive zone head formation

Only the BB nodes are eligible to be CH. CH node is a subset of BB node and form service caches. BB node sends chello message to the immediate minimal neighbor nodes with TTL field set to some value say x, this message will reach to local neighbor nodes only, they send this message to their local neighbors. These all nodes will then form a cluster.

3) Service

It abstracts a set of functionalities offered by a networked entity. Service description comprises of information like service name, service capabilities, non-functional attributes (QoS parameters). QoS parameters are reliability, security, response time, latency, throughput, correctness and availability. The Ontology Web Language for Services (OWL-S) [10] is used for functional description of services and WS-QoSOnto [14] is used for QoS description.

IV. WORKING OF SERVICE DISCOVERY SCHEME

A) Bootstrapping

It is the first step in service discovery and some a priori information is required. This process uses unicast and multicast communication techniques to declare its existence in the network and to avail the services of the WMN.

B) Service Registration

The mesh clients are service requestors (SRs). SR nodes requests for services from SD which are BB nodes and CH nodes. Each scope consists of one CH node, one or more BB nodes and other non routing nodes. Service Providers (SP) nodes register their services to one of nearest SD nodes in its scope. This SD node, performs lookup using service list, and is responsible to distribute the received services via unicast or multicast to other SD nodes in its zone. The service registration is done locally in its scope. Thus, this scheme limits the flooding of the service registration packets to local BB nodes by adopting OFLSR technique since a source only needs to know the approximate route towards the destination far away. In this way, all SD nodes in scope will maintain their list of services offered by their scope level members. The SP nodes must renew their registration periodically with any of SD node they can reach.

C) Service Discovery

The services can be discovered using routing deamon and QoS description shown in figure 2. When an application program installed at a mesh client wants to find an appropriate service, a unicast service discovery request is sent to the SD module in the local mesh router(CH). The mesh client is neither aware how many SD are in the network nor has any control over the decision to which SC the query is routed. OFLSR routes the unicast query to the best SD. Due to route switching it could happen that a client is directed to different SCs each time it queries. The decision of choosing an appropriate SC is made in the network layer. The SC verifies whether the requested service exists or not in the

service list. If this SD node finds the requested service description information, then it sends reply to the requesting node. This model optimizes the flooding of service request packets to reach only local SD nodes in a scope rather than all BB nodes in the WMN. If the requested service does not exist in the service list then the SC module requests the routing daemon to collaborate in order to find the requested service by generating the appropriate route request packet and by passing the application request to the integrated architecture that will generate the appropriate route discovery packet (RP). Routing daemon forwards this RP until on demand cache replication is performed in network, and CH sends service reply. A CH has two main tasks: Handling service queries and registrations from mesh clients and communication with other CHs in the backbone.

1) Registrations: When a CH receives a unicast service registration from a client, the CH stores the service record with a timestamp in its cache. If the timestamp has expired, the client has to re-register or the corresponding service record is deleted from the integrated architecture. Service records are not replicated to other CHs after a new registration until they are requested. If the CH receives new services from other CHs, it sends the new services to the client in route reply packet.

The advantage of this scheme is that services are only replicated on-demand, i.e. the information is pushed to all CH if another CH queries for the service. This prevents useless replications of services which are rarely or never used, but it increases request delay. It also increases packet efficiency, because multiple service records are aggregated into one.

D) Resiliency network

When new node approaches the network a topology control message (TCM) which contains topology information necessary to build routing table is sent to the routing daemon. The OFLSR protocol present in our design limits the flooding of the TCM by adopting FSR technique since a source only needs to know the approximate route towards the destination far away. When old mesh client leaves the network environment no TCM are flooded in WMN, since OFLSR does not triggers TC messages on broken links or link failure, thus reducing routing update traffic. Hence network is resilient on new nodes entry and old nodes exit.

V. PERFORMANCE EVALUATION

We performed simulations in ns2 to ensure that the proposed service discovery scheme design works and is feasible for wireless mesh networks. The first step was simulation of a WMN to demonstrate that networks with

different radio technologies can communicate with each other. In the next step, developed mechanism named as Integrated Discovery architecture was tested. This scheme is tested under various mobility conditions and different node topologies. The efficiency of this scheme can be evaluated with network load (in terms of number of packets), average time delay (between the time any successful request is sent from a client and the time a corresponding reply is received by the same client) and battery power consumption. The proposed scheme partitions the network into different scope levels. The scheme uses Optimized Fisheye Link State Routing protocol. In OFLSR, the reduction of routing update overhead is obtained by using different exchange periods for different entries in routing table [14]. More precisely, service request corresponding to nodes within the smaller scope are propagated to the neighbors with the highest frequency. OFLSR limits the flooding of the TC message hence is resilient to increasing traffic load, since it does not repair broken links hence provide better throughput. It exhibits a much better scalability of traffic load compared to the scheme proposed by [11][12][13].

VI. CONCLUSION AND FUTURE WORK

In this paper we provided a quality based service discovery scheme for wireless mesh networks. The proposed scheme implements OFLSR protocol which provides a better performance in terms of data packet delivery ratio throughput, packet latency and routing overhead, under different traffic and mobility instances. This scheme achieves reduced network load, reasonable mean time delay to the requests initiated by the clients, great average hit ratio of successful attempts, reduced battery power consumption. The scheme design uses service caches which optimizes the flooding of packets during service registration and discovery. Moreover, the cost (in time, control packets) to construct and maintain the clusters is almost negligible. Further, services are shared among SD nodes to reduce the overhead. The services are registered locally in zones and they are discovered with respect to QoS criteria across clusters. This model needs to address network maintenance. Moreover, our protocol outperforms existing protocols by reducing the network overhead. This makes our protocol efficient and scalable in WMNs.

Future direction of work will be to further study our scheme from other perspectives, such as reduced service response time and increased service availability for popular services.

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