A Hybrid Service Discovery for Improving Robustness in Mobile Ad Hoc Networks

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Abstract—***Recent research in mobile ad hoc networks has mainly concentrated on MAC, routing, and TCP protocols. However, service discovery is also an important issue for unreliable ad hoc networks, where the mobile nodes may join and leave the network at any time, causing the change of network topology. Although several protocols have been proposed to support service discovery in ad hoc networks, they generally assume that their service discovery function is separated or loosely coupled from route discovery, resulting in serious collision caused by unnecessarily redundant flooding and latency of service acquisition. In this paper, we propose a novel ad hoc service discovery protocol which is integrated with route discovery. Thus, in our service discovery protocol, a hybrid approach is utilized to improve the robustness of service acquisition.***

I. INTRODUCTION

Research on middleware for unreliable ad hoc networks is important for making the development and deployment of MANET applications more reliable [1]. Among various middleware services, service discovery and location play a critical role in ad hoc environments. Upon joining a network, mobile nodes should be able to automatically and efficiently discover the available network services. A variety of protocols have been proposed for service discovery in the context of wired networks [2, 3], but unfortunately these existing protocols may not work well in a MANET environment due to its dynamic nature and the scarce resources. Those service discovery protocols mostly rely on their assumption about the existence of centralized directory services, and hence have critical weakness of single node failure.

In recent years, some protocols have been presented to support service discovery specifically targeted at mobile ad hoc networks [4, 5]. These ad hoc service discovery protocols can be divided into two categories: centralized directory-based protocols and distributed directory-less protocols. In [4], some directory agents are involved as a logical entity in a service discovery process for a communication of clients and service providers. On the other hand, [5] can be thought as the distributed directory-less protocols in that there is no special directory server. Instead, every node discovers resources in a peer-to-peer manner to guarantee reliable service provision. Either service advertisements or service queries will be flooded in order to enable service discovery in ad hoc networks.

These schemes assume that some routing protocols may exist underneath for supporting request/service delivery from clients to service providers or vise versa. This can make them inefficient for use in wireless ad hoc networks due to a redundant control packet flooding problem, possibly causing extremely serious network collision and latency of service acquisition. It is important to observe that both protocols for service discovery and route discovery are all based on a network-wide flooding mechanism with different goals of discovery. Motivated by this interesting observation, we focus on the issue of combining these two different (but quite similar in some sense) discovery problems such that service discovery can be supported along with route search for those services.

II. HYBRID SCHEME FOR INTEGRATED DISCOVERY

This section describes our proposed scheme, HSID (Hybrid Scheme for Integrated Discovery), that efficiently integrates the service and route discovery components. The proposed HSID adapts between a pull-based advertisement and a push-based query by dynamically varying the region of advertisement information. It does so by defining an advertising region around a service provider. These two main characteristics are further elaborated below.

● *Integrated discovery of service and routing information*: In general, most of service discovery schemes proposed for ad hoc networks exploit an application level flooding to obtain appropriate service information. In this paper, we argue that such a flooding is not necessary because the generated request packets with a desired service ID will pass down through a routing layer anyway to be flooded to the outside network. A route discovery should use another broadcasting to find a path to the service provider. We focus on the fact that service information can be piggybacked in the route discovery. In our service discovery component, the corresponding service information, such as service type and service provider's ID is embedded within the routing control packet. Hence, service

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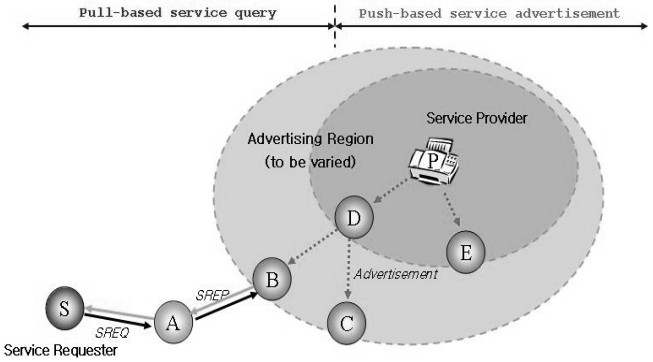
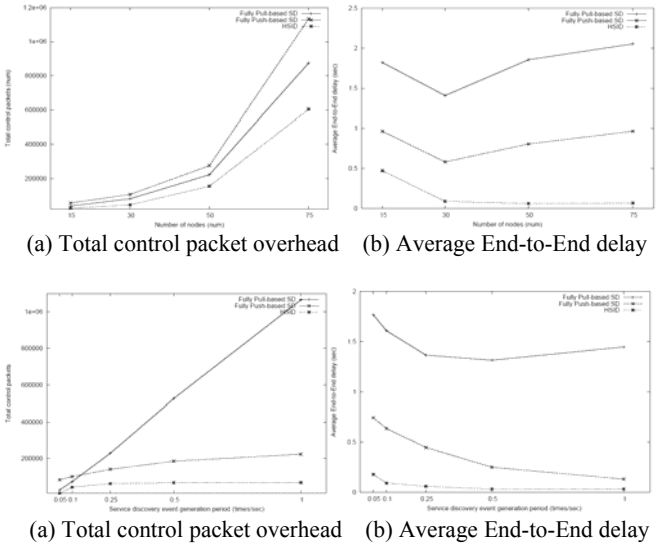


Fig 1. Overview of the proposed HSID

discovery and route discovery are performed at once, and we can avoid the network collision caused by unnecessary redundant broadcasting.

● *Hybrid scheme between push-based advertisement and pull-based query***:** The HSID utilizes a peer-to-peer caching of service advertisements in the limited vicinity of the service provider. It is designed as a hybrid approach combining push-based service advertisements with pull-based query methods. Generally, there is a trade-off between push-based and pull-based methods. While the push-based method used by service providers for advertising their service information is more reliable with relatively low latency, it is more expensive in terms of control packet overheads. Whereas, the pull-based method used by each service requester for querying any desired services minimizes control overhead and energy consumption, but it may suffer from long latency in service acquisition and large. This latency problem might be intolerable for some MANET applications requiring real-time communications. Given this comparison, the main design goal of our HSID is to combine these two different types of approaches for efficient service and routing discovery. As shown in Fig. 1, advertisements by service providers are performed using the push-based approach within some limited range (named "Advertising Region" and depicted as dark shadow in the figure). Note that this region can be adjusted dynamically (depicted as a light shadow region in Fig. 1), based on usage frequency of the particular service. Nodes within the advertising region are all assumed to cache the service information. Pull-based approach is utilized as well, by a service requester (here, node S) to send its query message (SREQ packet). This query message however, may not be replied from the service provider. In many cases, the reply message (SREP) will be issued by an intermediate node that receives the SREQ and currently caches the requested service (node B in Fig. 1), based on usage frequency of the particular service. Nodes within the advertising region are all assumed to cache the service information. Pull-based approach is utilized as well, by a service requester (here, node S) to send its query message (SREQ packet). This query message however, may not be replied from the service provider. In many cases, the reply message (SREP) will be issued by an intermediate node that



(a) Total control packet overhead (b) Average End-to-End delay

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Fig 2. Performance of HSID.((a),(b): by varying the number of nodes, (c),(d): by varying service discovery event generation period.)

receives the SREQ and currently caches the requested service (node B in Fig. 1). Therefore, our pull-based service query method is different from the traditional pull-based method, in that ours usually does not result in the network-wide flooding of query messages.

III. CONCLUSION

We have presented a novel scheme, HSID, for the integrated discovery of service and route information. It is a hybrid approach that combines push-based advertising and pull-based querying methods. HSID can automatically find the balancing point between these two approaches by dynamically adjusting the service advertising region size, in which all nodes are required to have knowledge about available services in their local caches. As seen in Fig 2, our preliminary simulation results show that our proposed scheme has better performance than the compared schemes (fully pull-based and fully push-based service discovery). As a future work, we will consider more intelligent ways of disseminating service advertisement messages. More complicated scenarios such as multiple service providers with different service types will also be considered for a performance evaluation in our future work.

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