

# Service Discovery for Support of Real-time Multimedia SIP Applications over OLSR MANETs

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**Abstract** — Support for real-time multimedia session services, such as real-time interactive voice-and-video-over-IP applications, is highly desirable in a mobile Ad Hoc Network (MANET). This paper presents a service discovery mechanism as an extension of the proactive OLSR (Optimized Link State Routing) protocol, enabling real-time interactive multimedia session applications using the Internet Engineering Task Force's (IETF) standard Session Initiation Protocol (SIP) in MANET. Effectively applying the cross-layer design between the networking and the application layer, a unified SIP service location distribution mechanism is proposed which can discover SIP service capabilities and server locations. Performance analysis and simulation results of the proposed scheme as applied to SIP MANETs running on OLSR are presented.

## I. INTRODUCTION

For many practical MANET deployments, session-based real-time applications such as voice and multimedia conversations and conferences are among those most highly desired. This paper studies service discovery mechanisms for supporting real-time multimedia session services, such as the voice-over-IP service in a proactive MANET using the OLSR [3] protocol. The proposed scheme supporting SIP services can be adapted straightforwardly into a generic service discovery mechanism for the OLSR MANET.

The standard protocol published by IETF [5] for setting up voice and multimedia session applications in a fixed-IP network is the Session Initiation Protocol (SIP) [5]. To place VOIP (Voice Over IP) or MOIP (Multimedia Over IP) calls using SIP in a fixed-IP network, an infrastructure of network hosts called "proxy servers" is usually deployed, to which the end-terminals called User Agents (UA) can send registrations, invitations and other session requests [5]. Specific considerations arise when this infrastructure of proxy servers is deployed in a MANET offering SIP-based services. In a fixed-SIP network, determining the location of the proxy server is achieved via the use of centralized servers, such as DNS (Domain Name Service) and ENUM (E.164 Telephone Number Mapping) servers. Under MANET, such centralized servers may not exist. Alternately a MANET may support SIP VOIP sessions without employing any SIP proxy servers (SIP

specifications [5] do in fact support SIP session services without benefit of proxy server). In both the proxy-based and proxy-less SIP networking architectures, a key issue towards providing support for the SIP application in a MANET is the one of service location discovery, i.e., determining the location of the SIP server node where SIP signaling messages can be sent.

This paper presents a service discovery mechanism for supporting SIP multimedia session services in an OLSR MANET. Differing from previous work on MANET service discovery [1][2][8][9] — where *reactive* routing protocols are assumed — the present work investigates options where a MANET is running on the *proactive* OLSR protocol proposed by IETF [3]. The reason for applying a proactive routing protocol is that such a protocol may improve call-setup latency and voice data transmission delay - factors which are critical to the performance of voice or video calls. Though OLSR is by its nature an advertising-only protocol, the service discovery scheme here proposed also leverages its forwarding mechanism to launch queries for service locations, which improves service discovery performance. Our analysis and simulation results demonstrate that the proposed approach delivers satisfactory voice performance while incurring very limited message-overhead on the OLSR protocol.

The remainder of this paper is organized as follows: Section 2 briefly describes the SIP application networking architecture and presents the distributed SIP service-discovery mechanisms over the OLSR protocol; Section 3 presents the results of our performance simulations; Section 4 concludes the paper.

## II. LOCATING SIP SERVERS IN PROACTIVE MANET

In SIP communications, a client-server architecture is applied [5], and communications can comprise more than one server. A SIP endpoint functions alternately as a User Agent Client (UAC), or as a User Agent Server (UAS). During a SIP session, the SIP UA of the caller functions as the UAC, while the called UA acts as a UAS in order to accept calls from the UAC. When a SIP proxy is employed to route a SIP call request from the caller to the called party, the call is sent from the caller UAC to the proxy server, and then from the proxy server to the called party's UAS.

Normally in a fixed network, before making and receiving

calls, a SIP UA registers itself with the registrar (often co-located with the proxy), providing both its AOR (Address of Record), which is a SIP URL (Uniform Resource Locator), e.g. “*sip:bob\_fisher@rescue\_canada.ca*” and its mapping contact information. A simple example of a contact is a SIP URL stipulating the Internet Protocol (IP) address of the SIP UA where the call can be routed, e.g. “*sip:bob@141.92.38.14*”. After registration of a SIP UA, the proxy is ready to route a call to the called UA using that UA’s registered location information. For example, when a caller intends to call Bob Fisher, the caller need only send the INVITE request with the AOR “*sip:bob\_fisher@rescue\_canada.ca*” to the proxy. The proxy server then routes the INVITE message to the callee at IP address 141.92.38.14, using the callee’s registered contact information. When no proxy server is deployed, the caller has to know that “*sip:bob\_fisher@rescue\_canada.ca*” is mapped to the location of IP address 141.92.38.14.

The proxy server is in fact a service location server which provides location information for the SIP applications. Therefore to make use of this function, the location of the proxy server first needs to be determined by the member nodes. To summarize, by way of contrast: in a proxy-based SIP MANET, determining the location of the *SIP proxy server* is required; in a proxy-less fully distributed SIP MANET, determining the location of the *SIP UAS* is required.

#### A. OLSR with Service Location Extension

Assume a MANET running on the standard proactive OLSR protocol [3]. We apply the OLSR MPR mechanism as the messaging infrastructure for SIP service location discovery, whereby SIP servers can advertise their location information, and SIP nodes can discover the servers.

The design principle of the OLSR protocol facilitates extension of the protocol functionality through the addition of new message types [3]. OLSR defines generic processing and forwarding mechanisms for the processing of all message types, plus additional procedures associated with each particular type. This provides the backward compatibility enabling nodes to properly handle all messages, regardless of whether a particular message type is recognized.

Therefore to implement the service location discovery, we have introduced a new message type into OLSR: Service Location Extension (SLE). In the SLE message, a service is advertised with a service-type field and one or more URL fields denoting server location(s). The main fields are as follows:

**Service sequence number:** used to identify updates to the service location information.

**Service-type:** for SIP service, the value is either “SIP Proxy” or “SIP UAS”.

**Weight:** this field yields improved robustness for use with multiple-proxy configurations. The weight parameter can be used to select from amongst multiple proxy servers, for example, by having the SIP UAs register with each of the known proxy servers (the mechanism used being discussed

under sub-section B) and, when making a call, to select the one having the highest weight, or to load-balance across all servers having the same weight.

**AOR URL:** the name of the service to be used by the SIP client in the SIP protocol, as defined in RFC 3261.

**Location URL:** identifies the service’s numeric IP address and port number, and where possible should specify the transport protocol used.

A few other fields further specifying the service attributes and the preferences are also included. The mechanism supports both the name/AOR-to-address mapping, and the service-type-to-address mapping where the host-name/AOR is not known (detailed below). Despite these service-specific parameters, the SLE is treated as an OLSR message, where OLSR’s default forwarding by means of MPR nodes is applied.

#### B. The Messaging Mechanism

Two messaging options are proposed whereby servers advertise their locations: the Automatic Server Advertising (ASA) scheme and the Client Query Server Advertising (CQSA) scheme.

##### 1) Automatic Server Advertising (ASA) Scheme

In this scheme, a SIP server, either a SIP proxy server or a SIP UAS, periodically advertises its location via MPR forwarding.

For a proxy-based SIP MANET, the proxy server(s) will be heard by all the SIP UA nodes. After listening for a defined period of time  $\Delta T$ , if no proxy node was heard a SIP UAS node concludes that no proxy server is present, upon which it begins advertising its location to the network; the UA stops advertising its own UAS immediately upon receiving a proxy server’s advertisement.

The ASA scheme is straightforward and cost-effective when implemented over the OLSR protocol. Yet one of the concerns arising with this scheme is that advertising of all the SIP UAS nodes may lead to scalability problems, in addition to which, a SIP server advertising itself to the network at large sends its messages also to non-SIP nodes. However, because the mapping of a service to its address usually does not change, messaging overhead can be significantly reduced by assigning a relatively large value for the refresh timer. Yet a longer refresh interval may require nodes recently arrived at the network to wait a lengthy period of time before the service can be accessed. Long refresh intervals also do not perform very well in instances where the messages become lost in the MANET OLSR environment.

##### 2) Client Query and Server Advertising (CQSA) Scheme

In this scheme, the SLE message can be used as a “query” message, via OLSR MPR forwarding, to request the location of the SIP proxy or of a wanted SIP UAS. A SIP endpoint wanting to make a call but which possesses no server location information can send a query, or (as is more commonly found in a proactive MANET) a SIP UA after being reset or one newly entering the MANET can send the query if no server was heard for a given time period. Having the UA nodes wait

a definite interval before the first query is sent reduces the number of queries generated when several UA nodes step into the network simultaneously (or nearly so). A proxy server always responds to a query, whereas a requested UAS responds to a query only if it has not yet identified any proxy server in the network. The “query” SLE message allocates one bit in the “Reserved” field flagging the message as a query. A query SLE message indicates that a server of “proxy” type is being requested, and may additionally indicate that a “UAS” type is acceptable when no proxy is available. The query message may carry the AOR of a particular UAS being requested, or it may omit the AOR, indicating that all servers of the requested type are sought. The location URL field in a query SLE is unassigned (size equals to zero) and the AOR URL may be unassigned as well.

Due to the flooding nature of the proactive network, a response message to a single query is heard by all nodes in the network. In some instances this response strategy can be excessive, but in other cases it reduces redundant queries for the same information, which would otherwise be generated by the other SIP nodes.

The query capability is most effective in preventing the delay in making calls when no server advertisement is heard in the network, such as is the case when a new node enters a MANET. To prevent message flooding caused by large numbers of queries in the network, the response advertisement is controlled by the minimum refresh timer and the limited maximum number of repeat queries, should no response be received on the initial query. After responding to a query, the refresh timer of the server is reset for the next advertisement. Though this response advertisement introduces extra traffic, the timer interval for the periodic refresh of the advertisement can be greatly increased if a reduction in traffic is desired. In fact, the refresh interval could conceivably be set to  $t_{refresh} = \infty$ .

### III. SIMULATION RESULTS

#### A. Simulation Environment

The proposed SIP MANET service discovery scheme is implemented in the OPNET simulators in order to evaluate the performance results. The performance metrics of interest include the control-message overhead, the call-setup delay, the success ratio of call-setup and of the overall data and voice application traffic delivery. In the simulations, each mobile node modifies its location within the subnet based on the “random waypoint” model [10]. For each caller, the inter-arrival time of SIP calls is exponentially distributed with a mean value of 600sec. The duration of the SIP call is also exponentially distributed with an average of 180sec. The OLSR timer intervals for the Hello and TC messages are assigned default values in accordance with RFC 3626 [3]. The SLE advertisement interval chosen is 300 seconds. The 802.11 WLAN (Wireless LAN) interface is set to a speed of 1Mbps.

#### B. Simulation Results

##### 1) OLSR Overhead with SLE for Service Discovery

The simulated network is comprised of 51 nodes. Of those, 40 are SIP UA nodes, in addition to one SIP proxy-server node in the proxy-based configuration. The ten remaining nodes are non-SIP nodes. There are 25 pairs of UDP transmissions in the network, distributed randomly between all the nodes. If selected, a SIP node performs UDP data communications in addition to voice calls. During the simulations, 31 of the 51 nodes are assumed to reside within the network, with another 20 SIP nodes coming into the network at an average of every 360 seconds. The “CQSA2” and “CQSA4” labels used in the diagrams below designate nodes newly entering the MANET in groups of two and four respectively. For example, in the “CQSA2” case, two nodes enter the network after approximately 360 seconds; after approximately 720 seconds, another two nodes arrive, etc.

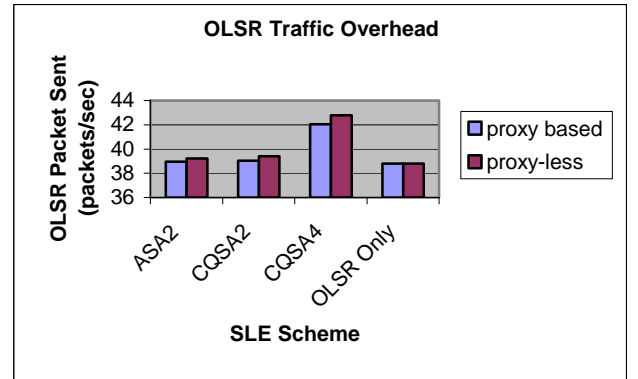


Figure 1 OLSR Traffic Overhead

The ASA and CQSA schemes are compared in Figure 1, which illustrates the OLSR traffic overhead generated in a SIP MANET network applying SLE messages embedded in the OLSR for service discovery; for sake of comparison, also shown is the same network without the SLE message. In the scenario without SLE messaging, the nodes enter the network in groups of two, separated by the defined interval.

Compared to the OLSR route advertisement traffic, the OLSR traffic overhead generated by the SLE messages is not significant, due to a much longer advertising timer interval for the SLE than those for Hello and TC messages. The proxy-based architecture generates lower OLSR traffic than does the fully distributed one, due to the smaller number of servers sending SLE messages. As larger numbers of nodes enter the network dynamically, more OLSR traffic is generated due to the increased updates of the network topology.

## 2) SIP Voice-Performance Results

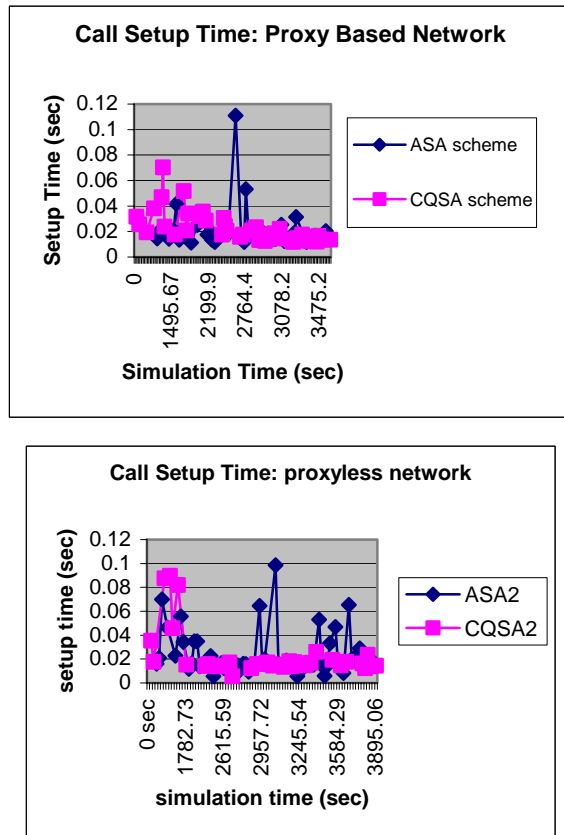


Figure 2 Average SIP Call-Setup Delays

Figure 2 plots the call-setup delays encountered in the different cases. The delay time shown in the diagram does not include the time spent waiting for the server to be heard. The average call-setup delay metrics are comparable for both the ASA and CQSA schemes, though they may be slightly better with CQSA. When the ASA scheme is applied, a new node arriving at the network may have to wait longer before making a call, thus the first call in the ASA case always begins late (this being reflected in the diagram). Though the first SIP UAC enters the network at approximately 360 sec., in both the proxy-based and proxy-less networks under the ASA scheme the first call seldom begins before 600 sec. have elapsed, whereas under the CQSA scheme the first call often is observed to start in the region of 400 sec.

Both mechanisms can provide satisfactory session service performance metrics, though it should be noted that, when the network is comprised of a single proxy server, performance quickly degrades if the network becomes partitioned, or when network mobility results in a too large number of hops encountered by the SIP nodes when attempting to contact the proxy server.

## IV. CONCLUSION

In this paper, we proposed a service discovery mechanism for MANET supporting SIP-based multimedia session services over a proactive OLSR routing protocol. The OLSR traffic overhead introduced into the MANET by the proposed

scheme was found to be insignificant. Based on the results of our simulations, the scheme here advanced can be adapted and applied as a generic service discovery mechanism for the OLSR MANET.

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