Solving the User-to-Host Binding Problem in Ad Hoc Networks Through Photo-IDs

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ABSTRACT

The practical use of a name as a more user-friendly abstraction of a machine's numerical address on a network is quite old. In fact, the basic functionality of the DNS (Domain Name System) service consists of translating hostnames into IP addresses. In this paper we present Visual DNS, which is an extension to the DNS service that meets the requirements of MANET environments. Visual DNS allows any node in the network to discover any other node in a transparent manner, and independently of its location. The proposed application makes use of a distributed user discovery protocol based on reliable data dissemination to share information about users. Information shared includes the user name and photo, along with the host's IP address, among other things. Once the discovery protocol starts, the application offers users the possibility to communicate with other known users through either a text based chat application, a VoIP session or a videoconference session. We present the architecture of the proposed application, along with some implementation details. Finally, experimental results show that, if properly tuned, the proposed data dissemination strategy allows user information to reach all the nodes in a MANET in just a few seconds.

Categories and Subject Descriptors

C.2.2 [**Computer-Communication Networks**]: Network Protocols—*Applications*; H.4.3 [**Information Systems Applications**]: Communications Applications; D.2.8 [**Software Engineering**]: Metrics—*complexity measures, performance measures*

General Terms

Performance, Reliability

Keywords

DNS, message dissemination, ad hoc networks

1. INTRODUCTION

Mobile and ubiquitous computing refers to an emerging computing paradigm that aims at providing user-friendly information and communication services, anywhere and at anytime [1]. In this area, communication plays a fundamental role. In particular, the characteristics of mobile adhoc networks [2] make them a highly flexible communications system. Mobile Ad Hoc Networks, or MANETs, are autonomous systems that do not require any fixed infrastructure of support neither centralized administration, being composed of independent mobile terminals which communicate among themselves using any sort of wireless technology. Each terminal operates not only as an end-system, but also cooperates on routing and packet forwarding tasks.

In a previous work [3] we proposed a solution that addresses the interface configuration of MANET nodes. Our solution makes the MANET initialization process fully automatic by relying on Bluetooth [4] technology, providing a fast and reliable solution to auto-configure MANET terminals. In this work we move one step forward by addressing the problem of discovering peer hosts in a MANET. Our proposal, Visual DNS, is an extension to the traditional DNS service that, besides mapping host names to IP addresses, goes one step further by identifying users themselves; such identification includes both the user's name and a picture of the user, so that other users can visually identify MANET participants. The proposed application relies on a distributed discovery protocol, offering the user the possibility to communicate with any other peer.

The rest of this paper is organized as follows: in the next section we discuss the adequacy of different data dissemination strategies. Section 3 describes the proposed Visual DNS service, including the discovery protocol and some implementation details. Some preliminary experimental results are presented in Section 4. Finally, section 5 presents our conclusions along with references to future work.

2. VISUAL DNS CONTEXT

Depending on its scope and purpose, data dissemination in mobile ad-hoc networks is made through a variety of techniques. Finding the optimal dissemination strategy for each purpose is extremely important to improve performance in terms of overhead, delay, and efficiency. We propose a basic taxonomy to discriminate among dissemination techniques that takes into account the amount of information to be disseminated and the number of target nodes (see table 1).

For category I partial information is distributed to a subset of the nodes in the MANET. Examples of applications

Data\Target	Subset of nodes	All nodes
Partial information	Category I	Category II
Complete information	Category III	Category IV

Table 1: Taxonomy for data dissemination in MANETs

or protocols that fit into this category are peer-to-peer data sharing and MPR diffusion in OLSR [5]. Category II applications and protocols must send partial information to all nodes. This is usually achieved through MANET casting techniques (broadcast propagation in MANETs), widely used by reactive routing protocols such as AODV [6], DSR [7] and DYMO [8]. An example of a category III application/protocol is neighborhood information exchange in OLSR, where only nearby nodes are able to receive the information, but the offered information about neighborhood is complete. Finally, for category IV, all nodes must receive all the information available in the scope of a service or protocol. Notice that this last category involves greater overhead than all the previous ones.

Visual DNS is an example of an application that requires a category IV dissemination technique, since all the information is expected to be disseminated to all MANET nodes. Our application has no real-time constrains, meaning that information can be disseminated at a slow pace. Yet, a relatively large amount of information must be disseminated reliably to all nodes. In order to avoid consuming excessive network resources, we propose a trade-off between delay and network overhead by avoiding communication with nodes more than one hop away. Therefore, we propose using a slow data dissemination technique based on the combined use of TCP and UDP functionality where available information is announced through UDP, and then reliably exchanged through TCP among neighbor nodes alone.

Finally notice that, in a MANET environments, users are usually not aware of the names of the machines participating on it, and so a visual identification of the user itself is perhaps the most effective option available.

3. THE VISUAL DNS PROPOSAL

Visual DNS runs upon a previously configured Mobile Ad hoc network by relying on some autoconfiguration system, and it offers users a visual identification of other peer members in the MANET. In particular it offers, for each discovered member, their photo, their name, and the corresponding IP identifier. Figure 1 presents the graphical interface that Visual DNS offers to a member of a previously established MANET. Notice that it shows all the peers in the MANET that have already been discovered. When the user selects any of the discovered peers, the application allows to start communication with that peer through either a text based chat application or a multimedia application supporting both VoIP and videoconference sessions.

Visual DNS uses a discovery protocol based on a combination of UDP and TCP functionality. Each node will periodically broadcast to its neighbors a UDP packet including a list with the IP addresses of all the known peers in the MANET. Upon receiving this message, all the neighbors will compare the list of advertised members with their

Figure 1: Screen-shot of the Visual DNS application.

own to find out if new members are listed. If new members are detected, the node will open a TCP connection to the neighbor advertising this information requesting all the data related to new member(s).

Figure 2 shows a small scenario which illustrates how the discovery protocol behaves. The main goal of the discovery protocol is to disseminate information about all MANET members to all the nodes in the network , independently of whether peers are directly reachable or not.

In our example scenario, although the node identified by IP address 192.168.1.3 does not receive the UDP packets disseminated by nodes 192.168.1.18 and 192.168.1.22, it will eventually receive an UDP packet from node 192.168.1.38 advertising information about these two nodes. Upon the reception of this UDP packet, node 192.168.1.3 will request information about these new nodes to node 192.168.1.38 us-

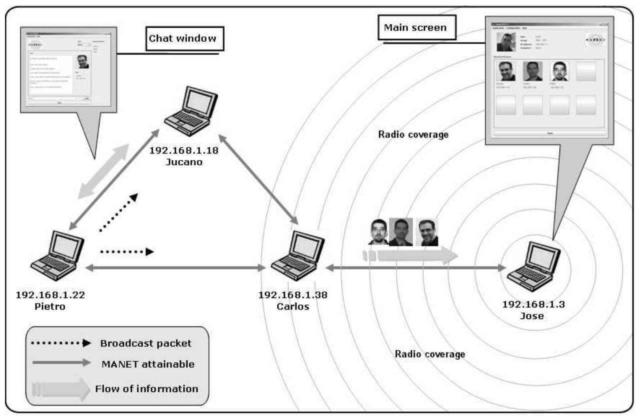

Figure 2: Information dissemination with Visual DNS.

ing a reliable TCP connection. This example evidences that, although a node cannot directly communicate with all the other nodes in the network, it will eventually receive information about other members, and so is able to maintain a complete list of MANET peers.

The period of time between consecutive UDP broadcast messages is a configurable parameter which could impact the efficiency and effectiveness of the protocol. However, since our approach limits broadcast communication to direct neighbors, we avoid the so called broadcast storm problem, typical of MANETs [9], caused by multiple re-propagations of broadcasted messages.

Algorithm 1 shows the steps followed by each node upon receiving a broadcast message on the appropriate UDP port.

Algorithm 1: OnReceivingaBroadcast()

```
for (every received message) do
    Detect unknown entries in the members list;
    if (New members are discovered) then
        Obtain new information through TCP
        Update my list of members
        Update Visual DNS' GUI;
    else
        Discard the packet;
```

3.1 Implementation details

We have implemented our application for both Windows and Linux operating systems using a Java like programming language (J2SE), under the NetBeans 5.5 IDE [10] platform, which offers a robust object-oriented multi-platform solution.

Before the application starts running the proposed discovery protocol, it is assumed that one of the wireless interfaces is already configured adequately for MANET communication to take place, which includes all the information required to configure the Wi-Fi interface (SSID, channel, etc.), setting the station's IP address and mask, and starting the appropriate MANET routing protocol (e.g. DSR, AODV, OLSR). Visual DNS delegates this task to our Autoconfiguration system.

Each of the MANET members must fill-in their personal information, including the user's name and photo, which will be used by other peers to visually recognize the user. Once the discovery protocol completes the information dissemination process, Visual DNS' graphical interface will show the photos and names of all the peers in the MANET.

From that point on users can interact with other peers by clicking with the mouse over any selected photo. Automatically, a chat window, a VoIP session or a videoconference session between peers may be started. Obviously, the success of these connections will depend on the right behavior of the underlying routing protocol, which is supposed to be running to offer support for mobile, multi-hop communication.

The discovery protocol requires the execution of three independent and simultaneous threads: (a) a thread in charge of periodically advertising to the one-hop neighbors the list of discovered peers, (b) a thread in charge of permanently listening and filtering information advertised by other neighbors. If new information is available it starts a TCP connection with its neighbor to download it; (c) a thread for the TCP server socket, which is responsible for handling all the incoming requests for user data.

Eventually, all the peers will have a Visual DNS screen resembling the picture presented in Figure 1, which includes information from the user itself, and also from other MANET users.

4. EXPERIMENTAL RESULTS

In this section we present some performance results for Visual DNS. Our purpose is to assess the overhead imposed by the proposed data dissemination strategy.

We firstly focus on the transference of user data. With Visual DNS, the set of descriptive information for each user occupies between 2.5 and 3.5 kilobytes. In Figure 3 we present the estimated and worst case values for the data transference time when varying the amount of information about new users. The values shown apply to the IEEE 802.11g technology, and worst case results are calculated for a physical data rate of 1 Mbit/s. As shown in Figure 3, when transferring information about a single user the total time is typically inferior to 30 ms. When transferring descriptive information about many new users the total transference time is usually below 300ms, a very low value, approaching 2 seconds under worst case conditions. Notice, however, that massive data transfers are infrequent, only applying to nodes that have recently joined the MANET.

To measure the time it takes for completing the data dissemination process to all nodes using different message advertising intervals, we used a simple topology where four nodes within radio range of each other conform a simple ad hoc network. Figure 4 shows the measured times, along with an interval whose range defines the standard deviation. From these results we observe that full configuration times increase almost linearly with the advertisement interval. We also see that, to achieve reasonable setup times, advertisement intervals above five seconds should be avoided.

To complete our analysis, we now study the impact of using different advertising intervals when the network diameter is greater than one hop. We test with network diameters of 1, 2, 4, 8 and 16 hops, forcing a chain configuration for nodes (worst case scenario). Figure 5 shows the expected data propagation times for a new user that has just joined

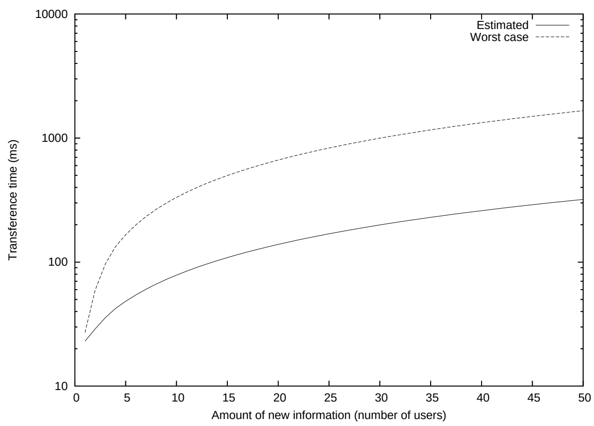

Figure 3: Data transmission overhead when varying the amount of new information.

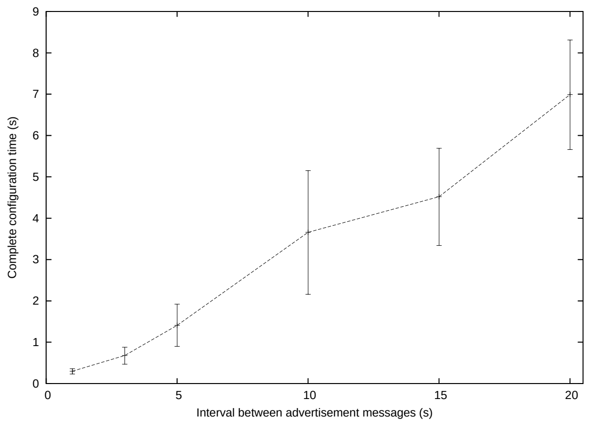

Figure 4: Total configuration time when varying the advertisement interval.

the MANET at one of the chain's edges. We see that, in order to avoid long data dissemination times, it is very important to keep advertisement intervals low. However, we must also take into account that the procotol's overhead is directly proportional to that interval, and so a trade-off must be sought. Based on the results here presented, we consider that an interval of three seconds could be a good candidate. However, simulation-based analysis is required in order to make a more in-depth analysis.

5. CONCLUSIONS AND FUTURE WORK

The idea of using mobile ad-hoc networks to support ubiquitous computing is becoming a reality, since they allow to develop pervasive applications that just a few years ago were non-viable. In this paper we present Visual DNS, an extension to the traditional DNS service optimized to MANET environments which allows users to identify each other directly through their photos and names. Our application provides MANET nodes a technique to discover any other node in a straightforward and simple manner, and independently of its location. Visual DNS is based on a distributed discovery protocol which combines the use of TCP and UDP to achieve slow data dissemination among neighbor nodes.

We presented a set of experiments were we evaluated the functionality and performance of the proposed application, and we conclude that it could encourage the use of MANET solutions in a wide variety of scenarios. As future work we plan to perform a complete performance evaluation of the proposed discovery protocol, which is the core of our Visual DNS application, through large-scale simulation experiments. Also, we plan to address the issue of service discovery, allowing any node using Visual DNS to be able not only to locate new peers, but also to discover which sort of network services they offer. Visual DNS is available as free software, and it can be downloaded at: http://www.grc.upv.es/.

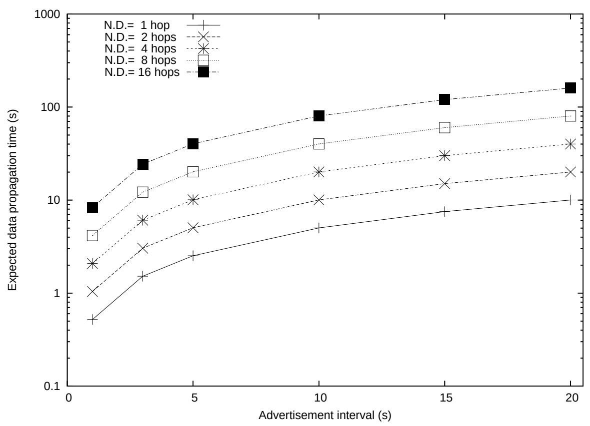

Figure 5: Data dissemination times for different network diameters.

Acknowledgments

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