Global Resolution Service for Mobility Support in the Internet

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***Abstract*—Resolution from identifiers to locators serves as a key component of mapping-based mobility solutions. In this paper we address the weakness of current resolution methods in supporting diverse mobility scenarios and propose a *Global Resolution Service* offered by *Resolution Service Providers*. We present a preliminary design and simulation, and results show that our approach is able to provide better resolution service compared to existing solutions in terms of performance.**

***Index Terms*—Mobility, identifier, resolution, overlay**

I. Introduction

Mobility support is an important feature in future Internet. Mapping-based mechanism is considered a feasible way to support mobility in the global Internet. [1] In such solutions, mobile nodes are named by identifiers instead of IP addresses, and mobility shows up as dynamic changes of identifier-locator (ID-LOC) mappings. Thus the key task to reach a mobile is to properly resolve its identifier to correspondent locations (normally IP addresses) during data transmission.

Some proposals (HIP, ILNP, etc.) rely on DNS to resolve directly from a mobile's identifier to its IP addresses. Since no extra network entities are used, mobility is managed mainly by end nodes. Though workable, such methods have drawbacks in handling several mobility scenarios, e.g. when both ends of a session move simultaneously, or when users demand location privacy, etc. Other proposals (MobileIP and its extensions, I3, etc.) employ rendezvous nodes to help resolving identifiers. But these newly introduced network entities are hard to get globally deployed, and partial deployment leads to some weakness such as routing inefficiency (triangle routing). Thus such methods are also not perfect for some scenarios, e.g. when the mobile roams far away from the rendezvous nodes, or when users are running some delay-sensitive applications, etc.

To address the above problems, we argue that one key point is to provide flexible resolution of identifiers according to different mobility scenarios. In this paper we propose a *Global Resolution Service (GRS)* to enrich the current resolution functions. To each mobile node, GRS relates its identifier to multiple IP addresses, which can be addresses the mobile owns or addresses belong to rendezvous nodes. When resolving an identifier, GRS compares among all the candidate ID-LOC bindings according to multiple factors such as application/user requirements, network condition, etc., to ensure the identifier is always resolved to the most proper address. Besides, GRS provides other mobility-related services such as packet redirection, buffering, etc. to assist its resolution service.

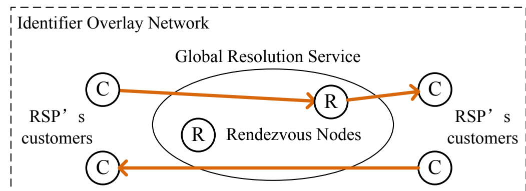

Fig. 1 RSP provides GRS by operating an overlay network

According to [1], mobility should be treated as services separated from network access control provided by ISPs, and multiple mobility protocols may coexist in the future Internet. Thus we consider GRS to be offered by third parties called *Resolution Service Providers (RSP)* in the future Internet, and provide a generalized service for both existing and emerging mobility protocols. RSPs attract customers by providing better resolution services that can help improving performance, reducing cost, and obtaining other features in privacy, security, etc. Except for mapping-based mobility solutions, RSPs can also offer services to other protocols that introduce an identifier namespace and require a global resolution system. But in this paper we only focus on the mobility support from RSPs.

II. Design

We propose a preliminary design of GRS in this section. To provide flexible resolution services, RSP has two main tasks: deploying rendezvous nodes in the network, and resolving identifiers to the most appropriate IP addresses.

A. Identifier Overlay Network

From the view of a RSP, all the resolution-related entities in the network consist of both its customers' hosts and deployed rendezvous nodes. They can be considered as forming an overlay network that we call *Identifier Overlay Network (ION)* as shown in Figure 1. And in this view, RSPs provide resolution services by operating overlay networks, which is similar to [2]. Since the resolution of identifiers can be regarded as overlay routing based on identifiers, the key task of RSP is to properly place the overlay nodes (rendezvous) and choose an optimal path from source towards destination in ION.

B. *Node Placement*

The introducing of rendezvous has several advantages such as localizing mobility, improving handoff efficiency, keeping location privacy and so on. But it also brings extra deployment cost. Besides, if a rendezvous node is located away from the optimal path from source towards destination in the network layer, it may cause a path-stretch (triangle routing) problem which degrades performance. Thus there exists an optimization problem of the rendezvous placement that aims to maximize the benefits of mobility support with constrains of acceptable path-stretch and deployment cost. The detailed analysis of the problem is within our future research plan.

C. *Path Selecting*

To each resolution request, GRS selects a path from source to destination directly or via rendezvous in the overlay. To get the most appropriate path, GRS make comparisons among candidate paths between both ends according to various factors. For example, GRS may resolve identifier of a mobile which moves in a limited range to a close rendezvous node for mobility localization and location privacy, or to its exact location for delay-sensitive apps, or to a specific address (for example, Wi-Fi address) for cost reduction. Besides in the initial of a connection, GRS is also responsible for re-selecting a better path when necessary during data transmission.

To make resolution decisions, GRS measures the cost of candidate paths in the overlay according to different metrics. Here we only take two examples due to the page limit. We use d_{link} to represent the *delay* of an overlay link, which indicates the latency between both ends of the link in the IP network. Thus the overall path delay is the sum: $D_{path} = \sum_{link \in path} d_{link}$. Similarly, we use r_{link} to represent link *reliability*, which represents the likelihood that packets will reach the destination via the link. Low reliability may be due to frequent location changes and will lead to more packet loss. The reliability of an overlay path can be calculated by $R_{path} = \prod_{link \in path} r_{link}$. We show the simulation results using the two metrics in Section III.

D. *Implementation Consideration*

We consider Openflow [3] as a possible way to realize GRS. Openflow switches can play the role of rendezvous by both collecting information from hosts and network and redirect data packets. A logically centralized controller gathers information from all switches to form a global view of the overlay network, which facilitates to provide optimized resolution services.

III. Simulation

We show performance improvements of using GRS by a simple simulation in this section. Other user/application specific simulations are left for future work.

We implemented three mobility protocols and compared their end-to-end performance measured by delay and packet loss using NS3. The first is an ILNP-like protocol (P1) that relies on DNS for resolution, the second is a MobileIP-like protocol (P2) that uses rendezvous to redirect packets, and the third protocol (P3) utilizes GRS. In this simulation, P3 monitors D_{path} and R_{path} of several paths for each source-destination pair. P3 selects a path to the mobile via its nearby rendezvous node if it both reduces R_{path} and keeps D_{path} in an acceptable range (20%). Otherwise P3 selects a direct end-to-end path.

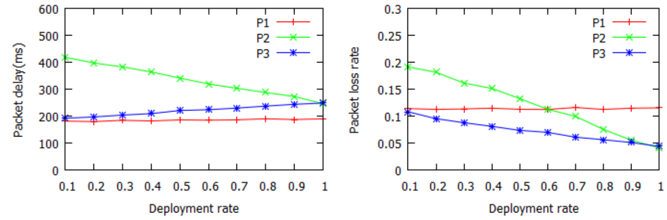

Fig. 2 Simulation results of (a) packet delay, and (b) packet loss rate

Since we only concern end-to-end properties, a simplified network topology consists of 10 domains is used without specify their connection relationships, but assign inter-domain latencies according to [4]. Rendezvous nodes are deployed at egress of each domain. We assume there exist 100 mobile nodes moving among the domains frequently (about 20 movements in each turn), with a higher probability for intra-domain mobility. The mobile nodes connect to each other randomly and each sends 10000 packets during the simulation.

Figure 2 shows the average simulation results. The X-axis represents the deployment rate of rendezvous, and the Y-axis represents packet delay and loss rate respectively. As we can see in Figure 2(a), P2 get a high delay because of severe triangle routing problems when there are few rendezvous deployed. While P1 keeps a low end-to-end delay by resolving identifiers to their exact locations. In Figure 2(b), P1 has a high packet loss rate since it does not rely on rendezvous nodes and the scenario that both ends move simultaneously makes a large contribution to the total packet loss. While the packet loss rate of P2 decreases along with the deployment rate of rendezvous nodes. In both figures, the results of P3 are approximate to the better one of P1 and P2, which proves that GRS combines the strength of existing solutions. We believe that the performance can get further improved if more GRS features are introduced such as rendezvous re-selection, packet buffering, etc.

IV. Conclusion

Resolution from identifiers to locators plays an important role in mapping-based mobility solutions, and we consider it necessary to enhance the resolution functions towards better mobility support in the future. Existing resolution methods have drawbacks in supporting diverse mobility scenarios, and to address the problem we propose a Global Resolution Service offered by third parties in the Internet, which can provide flexible and efficient resolution functions. Future work includes detailed design and analysis of GRS, further simulation and prototype implementation.

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