A Location Management-aware Mapping System for ID/Locator Separation to Support Mobility

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Abstract

In these days, Internet Default Free Zone (DFZ) is facing a scalability problem due to the double use of the current Internet Protocol (IP) name space. IP name space is used for both the location finding and identification of a host. Hence, scalability is not only affected but also mobility is difficult to achieve due to the dual use of IP. Therefore, Locator and identifier separation is proposed and discussed in the research community as a way to solve the above problem. However, this solution further creates a big challenging issue in designing a scalable mapping system to support efficient mobility of users while providing scalabilty. In this paper, we propose a hierarchical mapping system based on today IP allocation/assignment. We evaluate our mapping system and show that scalability, short lookup time can be achieved. However, to maintain the scalability in case mobility is a chalange. Therefore we provide a smooth location management scheme for mobility where the signaling cost is low compared to the approach using distributed hash table since the location updates is kept local.

1. Introduction.

In these days over the Internet, Internet Protocol (IP) represents not only the location of a host, but it also represents the Identity of the same host. The following use of IP has been a source of many problems in current routing and addressing system of the Internet. One of them being mobility support; that is whenever a host moves from one network to another its IP changes and all the previous established session interrupt causing the host to re-establish the connection.
However, mobility is not the only issue caused by the dual role of IP on the Internet; the routing table scalability is affected as well [1].
To solve these limitations, two roles have been separated into identifiers (ID) for the end-systems and Locators for routing for a new architecture commonly known as ID/Locator separation. This approach will not only allow a host to keep the ongoing session even when it has moved from its home network, but also will reduce the numbers of the routing table's entries considerably. In ID/locator separation, only the locators will be used during the routing process.
However, the separation of the IP role brings a very imperative concern which is how to map a node to its new location or to its locator in case of movement and in case of normal routing, respectively. And this crucial role is achieved by the mapping system. Hence, it can be act as the bottleneck of ID/locator separation approach if not well designated.
In this paper, we propose a hierarchical mapping system based on IP allocation/assignment hierarchy (HMS). HMS hierarchy is made of two component one in the IANA level and the second one in the registry level. The main assumption in HMS is that the allocation/assignment of EIDs would be done in the same way for IP, and Identifiers are aggregatable. We evaluate it in terms of scalability as well as in lookup resolution delay. However, the scalability of HMS is challenged by the mobility requirement in the future Internet. Therefore, we also proposed a location management scheme to enable mobility. It consists of a location manager server located at each network while the mapping system is in itself still using HMS two components for storing mapping information and not affected by any node movement. In addition to that this approach aims to reduce the signaling cost considerably while removing the need of any overlay network as which would be shown later in our work. We have evaluated our approach in terms of mobility using an analytical model. And with the numerical results we have shown that our proposal can support mobility better than the approach based on distributed Hash Tables (DHT) [8].
The rest of the paper is organized as follows, section 2 describe some of the related work. In section 3 we have introduced HMS for ID/locator separation Section 4 describes HMS performance evaluation Section 5 describes our proposal for mobility support. Section 6 discusses the analytical evaluation model for mobility and section 7shows the performance results, and finally we conclude our work in section 8.

2. Related Work.

Many proposals provide different ways of designing a mapping system. Here are some of them based on Locator and Identifier Separation Protocol (LISP) currently discussed in EITF [9].

In [3], V.Fuller et al propose LISP alternative topology (LISP-ALT), in which the mapping information EID-to-RLOC is stored in a distributed way in different ETR, which are interconnected using an overlay network of ALT-routers. Here, the scalability problem is removed at the cost of the complexity of the overlay network maintenance as well as the complexity of storage in multihoming. LISP-ALT overlay network uses BGP approach as used in the current Internet; but with a different kind of BGP. Moreover, whenever a host moves from one domain to another the resolver also changes, causing certain instability in LISP-ALT overlay network. LISP-CONS [4], LISP–NERD [5], LISP-DHT [6] are other proposals for LISP mapping system; each of them has its pros and cons.

With the objective to remove the burden of the cost using an overlay network in the design of mapping system, we have designed a hierarchical mapping system based on the recent IP allocation/assignment hierarchy. And we take the advantage of the LISP-NERD distribution process in our design. HMS aims to remove the overlay cost as well as providing scalability through a hierarchical mapping system approach to reduce the resolution time.

In the next section, we present an introduce HMS.

3. ID/locator Hierarchical mapping system

Fig.1 shows the overview of ID/locator separation. A packet is forwarded from one network to another after a locator for the routing has been well resolved by the mapping system.

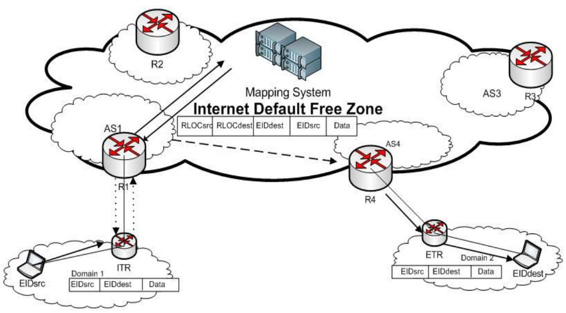

Fig1. ID/Locator Overview

We have designed a mapping system that will remove the overlay cost of the previously proposed mapping system by taking the advantage of the IP allocation/assignement hierarchy as well as LISP-NERD distribution approach.

The mapping system as shown in fig2 has two main components IANA Mapping Server (IMS) and Registry Mapping server (RMS).

IMS stores mapping information of EID prefixes which are allocated to registry. The mapping to the RMS points to the registry. IMS distributes its information to the tunnel router (TR) using LISP-NERD approach.

And the second component which stores the real mapping information is the RMS EIDpref-to-RLOC.

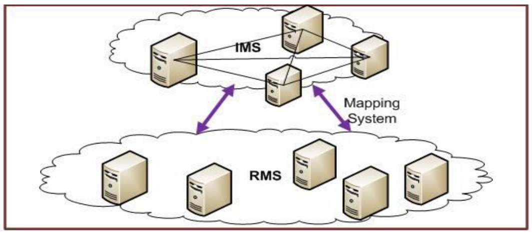

Fig2. HMS component hierarchy

3.1 Mapping rgeistration process

As depicted in the Fig.3 the mapping information from customer's networks is registerd following these steps

Step1. ITR/ETR receive the connection from the ISP

Step2. ITR/ETR downloads the IMS mapping information

Step3. Using longest prefix match in the downloaded IMS mapping table ITR/ETR determines to which RMS the mapping information should be sent.

Step4. After RMS has received the mapping information and it does not exist in the mapping table, the mapping information is stored. In case it already existing RMS just update the mapping table with the new mapping information.

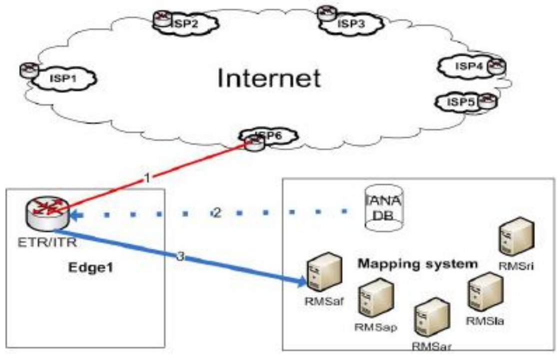

Fig.3 Mapping Information registration process

3.2 Mapping information retrieval process

To resolve EIDs locator, firstly, TR applies the longest prefix on the received information from IMS and directly sends the map-request to the concerned RMS. The last one will reply to the TR with the corresponding locator of the prefixe to which it belongs to. The steps are explained in details in fig4. Upon the reception of the mapping information the packet can be forwarded from one edge network to another using tunnel. Fig5 illustrate the packet forwarding process.

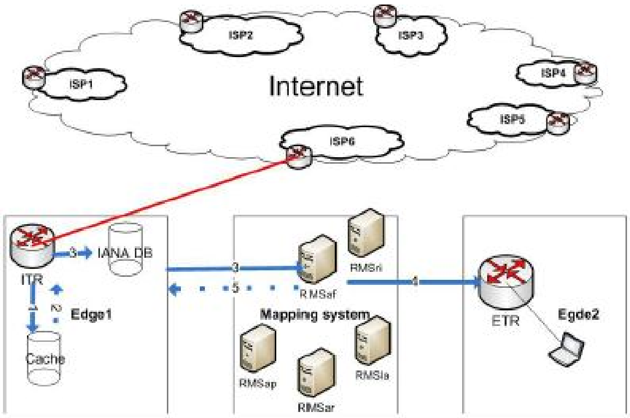

Fig4. Mapping ionformation retrival process

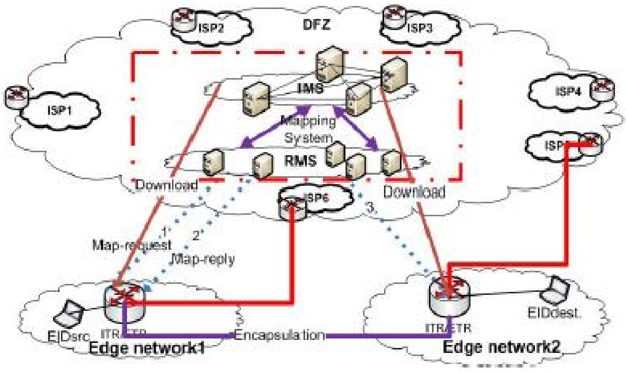

Fig5. Packet forwarding using HMS

4. HMS performance evaluation

4.1 Scalability:

It is one of the reasons ID/Locator separation architecture has been proposed. Our proposal has adopted LISP-NERD metric for the evaluation of it feasbility.

$$E * (30 + 20 * (R - 1)) \quad (1)$$

Where E is the number of EIDs and R the number of RLOCS attached to it.

During our evaluation we consider IPV6 as the space assigned to identifiers. Therefore, IMS is supposed to store 4096pools of /12 IPV6 allocated to registries. Based on our architecture TR will download also the same amount of entries. Using the formula above the space needed is around 122880Bytes.We can see that the space and the number of entries needed for IMS and TR and way much smaller compared to what routers and servers can support today.

However, for RMS to achieve scalabilty mapping information is stored into prefixes per network to which they are assigned to. Using one we approximate the space needed when EIDs are equally distributed among registries. The result is way much better then LISP-NERD which assume all mapping information in one database. And even if one registry has more pools assigned to it, it is clear that it will never hold all the mapping information. Therefore based on the figure below and on our analysis, scalability happens to not be an issue for our mapping system design as long as the mobilty is not considered. And moreover more than one server can be deploy in IANA or in registries to support robustness

4.2 Overhead analysis

Overhead can be caused by the frequency of request and updates.Updates is generated in IMS in case of new pool assignemet and from RMS is changed in case of provider change which also doesn't happen frequently. Therefore, the overhead is bearable. However, the request toward IMS from TR is evaluated in terms of processing time using a 1GB/s bandwidth under the assumption of 10 to 100servers deployed for IMS

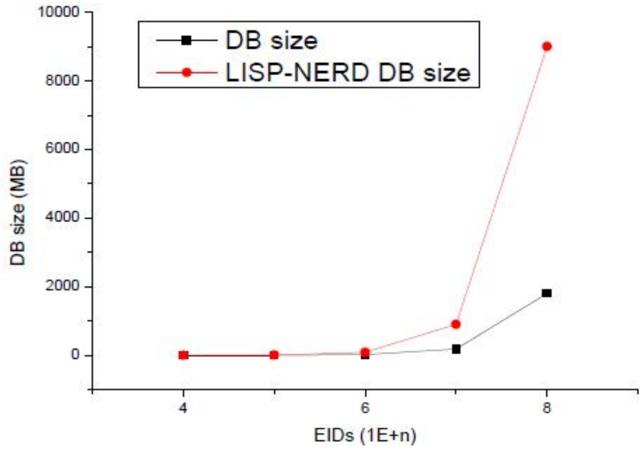

Fig3. Scalability performace

The results below shows that though the result is better than LISP-NERD the processing time still need to be improved. This is one of the challenges of our work, to provide the shortest processing time in case of simultaneous request.

Table1. Processing time in IMS

# simultaneous requests	10servers	100servers
100	9830.40	983.040
1000	98304	9830.40
10000	983040	98304
100000	9830400	983040
1000000	98304000	9830400

Through this approach thr resolution time is considreble reduced compared to approaches based on overlay network. We have evalauted the resolution delay as follow:

T_1 : Time a packet take from the PC to the ITR we assume T_1=1ms

T_2 : Time used by the ITR to process the request before generating or not a map request, we assume T_2 = 2ms

T_3 : the time map-request takes from the ITR to the RMS, we assume that this will depend on the RTT between the network and the RMS

T_4 : processing time in the RMS, we assume T_4 = 0,420ms based on [15] estimation with more than 25millions of search/second

T_5 : Time the map-reply takes from the RMS to the ITR is same as T_3
Therefore, the resolution delay
$T_{tot} = T_1 + T_2 + T_3 + T_4 + T_5 = 2RTT + 3.420ms$.
We can see that for our proposal the resolution delay depend on the RTT. If the RTT is low then T_{tot} is low but if high the T_{tot} will be high also. But based on the result on smokeping tool [11] of root DNS RTT, we assume that the results of RTT will allways be around 100ms for the highest RTT.
Therefore, the resolution delay T_{tot} = 103,420 which is better than the one proposed in [10]. Fig10 shows the variation of T_{tot} for different value of RTT. But mainly the resolution process burden is released by the caching process always implemented in TR.

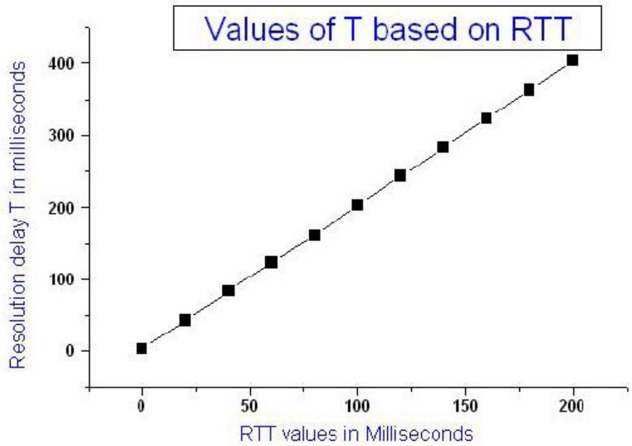

Fig4. Resolution Delat approximation

The evaluation of our proposal leads us to one of the most important challenge which is the mobility aspect. Whenever a node moves RMS will need to be updated by breaking the prefix of its original network and affect the scalability. Therefore, we have developped a scheme for mobility which will not affect the scalabilty. The rest of the work describes the proposed scheme.

5. Proposed Mobility support scheme.

To support mobility in HMS, we have added one more component called Mobility Mapping System (**MMS**), which will be specific to each network. For this work, we assume that each node in a given network is configured with its own MMS. The Fig3 below shows the overview architecture of the proposed mobility approach.
MMS: It is involved in the handover as well as in the mapping service of nodes, which have moved from the original TR to a new one. From the HMS, only TR is involved in the mobility support. The other elements are not affected by the user's mobility.
TR: Its main role is to encapsulate and decapsulate data packets as usual. However, TR also receives the new point of attachment of a node from MMS, which has moved out of the network. It maintains local identifiers mapped to it, as well as local identifiers mapped to new TR. It is also responsible of encapsulating the data packet designated to those nodes.
NODE N: It is responsible of informing the MMS about its new location through an update message sent from the visited TR.
Therefore, only two elements of the above architecture are crucial in case of our mobility approach, and the rest remains as showed in [2] with the same roles.

A. Location Update

The movement of nodes from one network to another need to be updated in the mapping system since the point of attachment changes while the identifier remains the same. Whenever a foreign network is visited, nodes need to inform their home network about their new location.

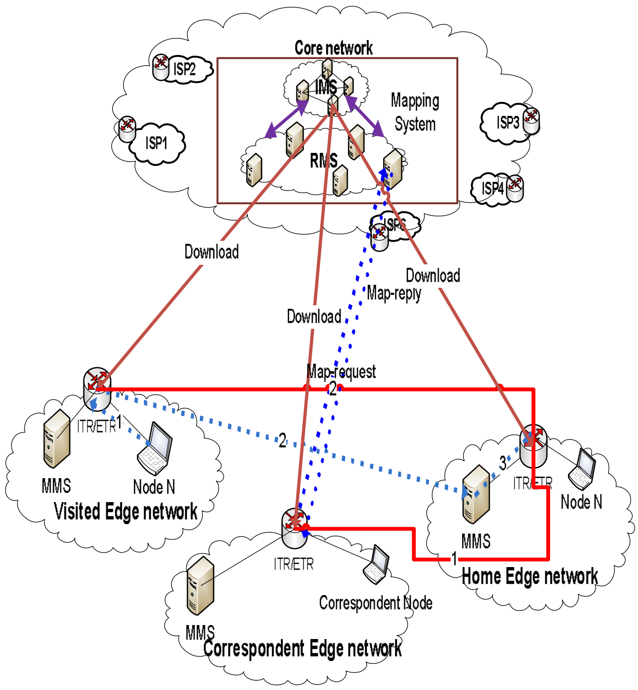

Fig5 Proposed mobility approach

As stated before each network has a location manager to assure mobility of its users. The location updates is performed as follows:
Step1: When a node moves to a new network, it issues a location update message to its own MMS via the visited TR. The update message includes the identifier mapped to the visited TR locator address.
Step2: Upon reception of this information, MMS will store it in a table and send an update to the TR. The TR will also information with EID-to–TR visited.
The location is updated inside the network owner of EIDs prefixes. Based on our mapping system design we avoid propagating the location update in the upper level to avoid any scalability problem as faced in the recent protocol's routing table due to the break of prefixes. And when the node comes back to its original network, MMS will discard that information about the movement and TR will keep only EID instead of EID-to-TRvisited.

B. Packet Forwarding with a mobile node

When a node wants to communicate with other nodes, the packet forwarding can be performed in the following steps:
Step1: When TR receives a packet with EIDdest, it first looks up in its local table. If the EIDdest is a home / visitor EID, the packet is forwarded directly to the destination. Else go to step2.
Step2: If EIDdest is not a local identifier/ visitor EID the TR will generate a map-request to find the locator of the network owner of EIDdest through HMS.
Step3: HMS will find the TR responsible for that specific EID and the RMS will send the map-reply to the requesting TR.
Step4: TR encapsulates the packet first and sends to TR of EIDdest. If the EIDdest is still in his network, the packet is decapsulated and sent to EIDdest. Otherwise go to step5.
Step5: TR of the destination receives the packet and re-encapsulates it into TR dest and visited TR. Once it received by the TR visited after decapsulation, EIDdest can receive the packet.
Note that when the EIDdest has visited the EIDsrc network no mapping retrieval is done, since both have the same point of attachment. Therefore, the resolution is faster.

6. Analytical performance evaluation.

In this section, we evaluate the cost of location signaling and also measured the cost of packet forwarding signals. We have adopted the idea of [7] from [8]. The following table describes the parameters considered in our evaluation.

Table1. System parameters

Notations	Description
C_{mt}	Transmission cost between TR and MMS
C_{tr}	Transmission cost between TR and RMS
α_t	Processing time at TR
α_m	Processing time at MMS
α_r	Processing time at RMS
T_f	Average time a MN stays in a visitor network
β_i	Packet arrival rate at the Node

In our proposal, assume N number of TR representing the networks. OneTR per network is considered for th is evaluation. Nodes can move randomly from a netw ork to a new one. A node moves to the new TR wit h a probability of 1/N-1. When a node moves from o ne TR to another, a location update is sent to the M MS. Let, U_m be the location updates cost.

$$U_m = 2\,c_{mt} + 2\,\alpha_t + \alpha_m$$

We assume that the average time a node stays in a given network before making a movement is equal to T_f. Thus, the average location update cost per unit of time is.

$$U_c = [1/N-1 \;*\; U_m]/T_f$$

We have not only evaluated the update cost but also the signaling cost introduced by the packet forwarding.
For that purpose, we have considered the following categories:
If the EIDdest needs to move in EIDsrc network, the communication will be done without any signaling cost.
Otherwise the signaling cost can be calculated on these terms when EIDdest would be away from its home network.

$$Pf_c = \beta_i * [2\,c_{tr} + 3\,\alpha_t + \alpha_r]$$

Where β is average packet arrival rate of each node.
Based on this calculation, we can say that the Total signaling cost will be the summation of the update cost and the packet forwarding cost.

$$T_c = U_c + Pf_c$$

7. Numerical evaluation.

The following numerical analysis will evaluate and give a result of the total cost. Since we have adopted the idea of [8], some part of the analysis is made to compare the numerical results using same the parameter as in [8]. $N=200$, $L=20$, $K=5$, $C_{mt}=6$, $C_{m}=10$, $C_{ii}=20$, $\alpha_t=5$, $\alpha_m=10$, $\alpha_r=\alpha_i=20$
The performance of our proposal is evaluated using these numerical data comparatively to DMS in terms of mobility support. We use the same definition of SMR as in [8] as the ratio of the packet arrival rate to the mobility rate, i.e., SMR= $\beta_i T_f$.

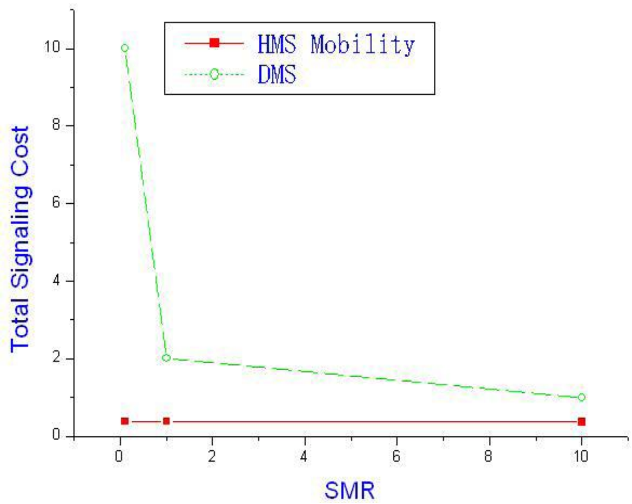

Fig6. Perfomance results

According to the Fig4, the total signaling cost decreases when the SMR increases. The three level DMS compared to our proposal achieves a better performance. This is because our proposal has only one level of update and therefore, the cost is very low compared to DMS, which has to update in different levels based on how the node has moved. Therefore, with our mapping system, the given mobility approach can maintain communication with a minimum signaling cost without affecting HMS scalability.

8. Conclusion

Identifier and Locator split aims to resolve the scalability problem that the Internet routing system is facing today as well as providing smooth mobility.
However, this approach requires a high consideration in the design of its mapping system, considered as a vital element of the inter domain packet routing process.
In this paper, we have focused on designing a Mobility support for hierarchical mapping system based on current IP assignment/allocation hierarchy for identifiers resolution.
We have added a component to each network to manage the location updates whenever a node moves from one network to another.
HMS mobility scheme aimed to remove the burden of overlay network while reducing the signaling cost.. Therefore, we have evaluated our approach comparatively to DMS, which uses a DHT overlay network for mapping information management in three levels.
The results and evaluation have shown that the three level approaches of DMS have higher cost than our approach, and this is mainly due to the removal of the overlay. Even the added component for location management and update doesn't really add any signaling cost because it does not intervene in the packet forwarding and influences only the TR in case of mobility.

8. References

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