Benefits on using H-P2PSIP in mobile environments

Isaias Martinez-Yelmo*, Alex Bikfalvi†, Carmen Guerrero*

*Departamento de Ingeniería Telemática
Universidad Carlos III de Madrid
Av. Universidad 30
28911 Leganés. Madrid (Spain)
Email: {imyelmo, guerrero}@it.uc3m.es

†IMDEA Networks
Av. del Mar Mediterráneo 22
28918 Leganés. Madrid (Spain)
Email: alex.bikfalvi@imdea.org

***Resumen*—The use of peer-to-peer technologies is increasing everyday and the improvement of mobility technologies is a reality. Now, it is expected that peer-to-peer applications run on mobile devices, but the conjunction of these two technologies is an open research issue. The user mobility impacts on the churn suffered by peer-to-peer networks and consequently it impacts on their performance. Therefore, some mechanisms are necessary to minimize this undesirable effect. Our proposal tries to solve this problem by using a Hierarchical P2PSIP architecture where different overlays are used for different peer mobility behaviours and they are interconnected between them through an interconnection overlay. In this way it is possible for peers that share the same behaviour to choose a certain protocol or to optimize some functionality that suits best with their mobility situation, while maintaining connectivity with all peers.**

***Palabras Clave*—H-P2PSIP, P2PSIP, DHT, Mobility, Performance**

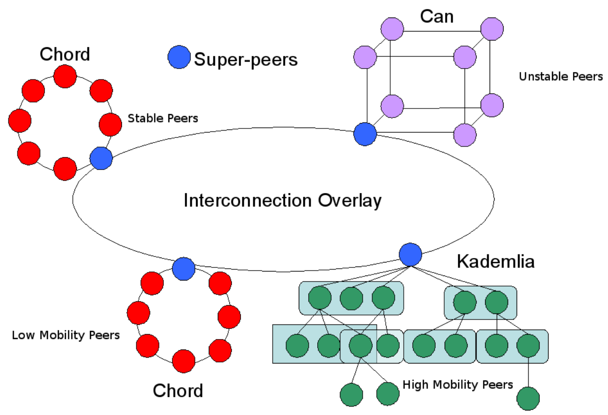


Fig. 1. Hierarchical DHT connecting domains with different peer behaviours

I. Introduction

Peer-to-peer technologies have had a great impact in the Internet in recent years. These peer-to-peer technologies present a scalable solution for distributed services such as file sharing, Voice over IP (VoIP), Video on Demand (VoD), Instant Messaging (IM), etc. Nowadays there are several peer-to-peer applications with great impact; Skype [1], [2] is one of the most successful. However, it is a proprietary solution that is not based on any standard. An open standard like Session Initation Protocol (SIP) would be desirable but in a decentralised fashion instead of the current server based solution.

The IETF P2PSIP[1] Working Group is working on a new protocol to offer an open standard in this field. P2PSIP [3] defines a peer-to-peer overlay-based solution that enables a decentralised architecture which is specially focused, but not only, in replacing SIP. It is expected to standardise a flexible protocol [4] which will be able to support most of the Distributed Hash Tables (DHTs) that can be found in the literature [5], [6], [7], ...

[1] http://www.p2psip.org

However, not only the evolution and deployment of peer-to-peer technologies is increasing everyday, the mobility based on 3G technologies and next 4G networks presents a more complex scenario. It must be taken into account the cross-effects among peer-to-peer overlay networks and mobility. If both technologies are used together, the continuous change in the devices location due to the itinerancy increases the churn and affects to the peer-to-peer performance [8]. Therefore, some optimisations and new proposals are needed for this type of mobile environments which would be a key factor in the near future. Our proposal takes advantage of the H-P2PSIP architecture in order to give a different treatment to peers with different mobility behaviours. In fact different overlays are created where the peers on an overlay have the same peer mobility behaviour (see Figure 1). This separation not only allows tuning the configuration parameters of each overlay network according the behaviour of its peers, it also allows to choose the most suitable overlay according to their behaviour under churn [8]. Therefore this approach opens a new dimension of research in the scenario of peer-to-peer networks deployed under mobile scenarios: which is the most suitable overlay and the best setup parameters to obtain the best performance in a specific scenario.

The paper is structured as follows. Section II explains how the mobility affects to the peer-to-peer networks. In section III, an overview of the state of the art of P2PSIP is given and in section IV a short overview of mobility in order to put in context our proposal. The different peer mobility behaviours that can be considered in this design and how to manage them are treated in section V. Finally, the proposal of interconnecting different P2PSIP domains with different peer mobility behaviours is explained in section VI. Section VII addresses the conclusions and the future work.

II. Problem Statement and Related Work

One of the main problems in peer-to-peer networks is the stabilisation of peer-to-peer routing tables in order to maintain an average number of hops towards a desired destination. The mechanisms to update these routing tables can be optimised [9] by taking into account the expected churn of the peers. A trade-off exists between complexity or traffic overhead and freshness of the routing tables. However, the evaluation of this trade-off is not a trivial issue. Works like [10], [11] and [12] have collected data from different peer-to-peer networks and have found that although many peers have a significant churn, there is also a set of peers which are really stable. Depending on the level of churn, different strategies can be adopted in order to maintain updated routing tables in the peers [9]. However, not all the peers present the same churn, thus it is difficult to obtain the optimal setup parameters. Other approach is [13] where the peers with high churn don't participate in the maintenance on the overlay because they cause more drawbacks than benefits. These peers can retrieve the information from the overlay as far as their instability let them to do it. With this approach fake routing entries are avoided and a better performance is obtained, although the peers that support the overlay have to increase their work load.

Furthermore, if we take into account the mobile environments and the disruptions caused by the mobility process [14], both the churn of peers and the maintenance overhead of the routing tables in the peer-to-peer networks increase. Therefore, the problem in mobile peer-to-peer networks is how to manage efficiently these peer-to-peer networks where different peer mobility behaviours exist. This efficient management consists in minimising the cost of maintaining the routing tables. This maintenance in mobile environments is not trivial because mobility has a great impact in the network conditions: new IP addresses, new topological points of attachment, different bandwidth conditions or different Round Trip Times (RTT's). Some proposals, like [13] as mentioned above, remove the peers with high churn in the maintenance tasks. However, in this paper we propose an architecture that provides a mechanism which allows dealing with this type of environments more efficiently with a higher flexibility.

Around this topic of peer-to-peer technologies in mobile environments, there is not very much work yet because of its high complexity. There are some works like [15] that establish the requirements needed for peer-to-peer networks in mobile environments. Basically, because of the problems associated with mobility, specially the increment in the churn, it is necessary to provide mechanisms that increase the traffic overhead, the churn itself, etc, All these requirements can be summarised in one: to increase the scalability as much as possible in order to reduce the drawbacks of a mobile scenario. Furthermore there are some solutions that take into account mobile ad-hoc networks like [16]. However this solution is very coupled to the routing infrastructure and to the movement patterns of nodes, which makes to look one of the advantages of overlay networks, applicability under a great variety of scenarios and conditions.

III. P2PSIP

The target of IETF P2PSIP WG is to develop a protocol that can support any DHT overlay network. The aim of this design is to allow an easy deployment of distributed services. The protocol allows to locating resources, services and users in a decentralised way. The first usage that can be used to this protocol is for obtaining a decentralised SIP service, although it can be used for other purposes.

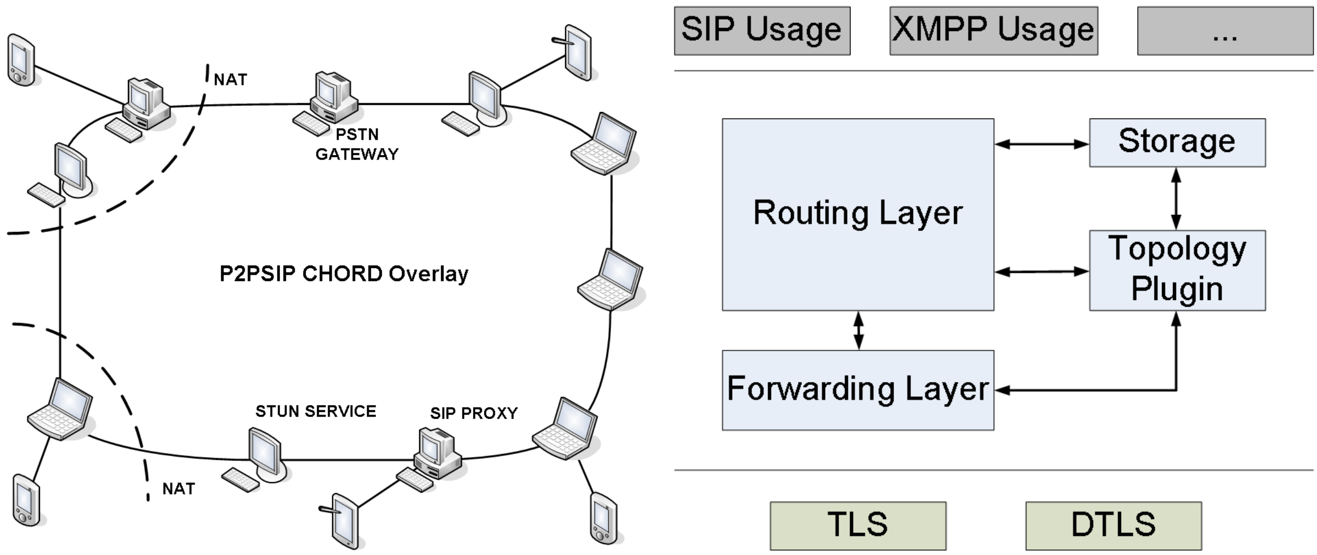
Figure 2(a) presents the P2PSIP Overlay Reference Model using the basic concepts from [3]. P2PSIP protocol is designed to support any type of DHT-based network. Each deployed overlay network is identified by an Overlay ID and the nodes in the overlay can be peers or clients. Peers are active node participants in the overlay network and they are uniquely identified by a Node ID (e.g. the computers and laptops in Fig.2(a)). On the other hand, clients are entities that use the resources offered by the peer-to-peer overlay network but they do not participate in its maintenance. This role should be only used by devices with very limited capabilities, such as the handheld devices shown in Fig. 2(a). The resources in the overlay are uniquely identified by a Resource ID. These resources can be composed by several items like data, files, service references, etc. Peers help to maintain all this information in the overlay and any peer or client in the overlay can retrieve this information. In order to fulfil the requirements, a set of primitives have been defined such as joining, bootstrapping, resource allocation and maintenance. The RELOAD protocol [4] is being defined to implement these tasks with a modular design supporting different overlays and applications (see Fig. 2(b)).

IV. Mobility

Mobility is a characteristic that is being more usual in user terminals and devices. This feature allows connectivity wherever and whenever some access technology is available for it. This feature can be summarised with the famous concept *always-on*. Although to provide mobility is common property nowadays, it is not a trivial functionality. Many studies have been performed to achieve seamless mobility; however this fact is impossible to obtain completely. It is usual to have some disruption in the communication availability of a terminal when is changing from one cell to another or from a technology to another.

A. Macro-mobility and Micro-mobility

A first classification of mobility support solutions that can be considered is the existence of macro-mobility and micro-mobility. Many definitions can be used to explain these terms, but in a simple way we consider them as follows.



(a) P2PSIP Overlay Reference Model (b) P2PSIP protocol reference model

Fig. 2. P2PSIP reference models

Macro-mobility is the mobility of terminals between different domains. The concept of domain here is quite wide. But in this context we mean a part of the network where mobility can be managed with a local solution, a micro-mobility solution.

Micro-mobility happens when the movement is performed inside a domain (i.e. adjacent cells of the same network). Thus, micro-mobility manages mobility closer to the terminal and implies a faster resolution of the connectivity disruption in the terminals. Several proposals have been studied to solve this problem [14], [17], [18]. These types of mobility are usually associated to the access technology used by the terminals. For instance, in UMTS, micro-mobility implies the management of changing from one cell to another, whereas macro-mobility implies the movement of a terminal from one operator network to another or changing from one access technology to another. The time needed for macro-mobility handovers is larger with respect to micro-mobility handovers.

B. Mobile IP

Mobility in IP networks imply the need to change the IP address of the moving terminal each time it moves to a new network. Micromobility solutions can hide or avoid this change of the IP address if the movement is within a micromobility domain. But in other cases, i.e. without a micromobility solution or when changing the micromobility domain, the terminal needs to change the IP address when moving. The reason is that IP addresses act as locators of the terminal, and must have a value according to where the terminal is connected to the network.

An additional problem is that IP addresses are not only locators, they also act as identifiers. This means that to keep ongoing communications, a moving terminal requires a permanent IP address as part of the identifier of its communications. The IETF[2] has standardised solutions to support IP mobility both for IPv4 [19] and IPv6 [20] that work by associating with the terminal a permanent address that acts as identifier (the home address, HoA), and temporal addresses that act as locators and that the terminal configures in the visited networks (Care of Addresses, CoA). A new entity, the Home Agent (HA) is introduced to act as rendezvous point for the communications of the terminal using the HoA. The HA is situated where the HoA is topologically valid and forwards packets to the mobile terminal. Furthermore, in order to accelerate the signalling with the HA, a strategy based on anchor points can be adopted [18]. It must be considered that these optimisations must be done per each flow that it was established before the movement.

V. Peer-to-Peer Overlays and Mobility

Once that the topic of mobility has been shortly reviewed in the previous section, we can consider how affects to DHT overlays which are supported by P2PSIP.

The mobility affects to the performance of peer-to-peer networks because of two facts. First of all we have the service disruption because of handovers. Depending on the type of handover, macro-mobility or micro-mobility based, this time will be different and will affect in a major or minor way to the performance of the overlay. Although mobility protocols try to minimise this effect, typically we will always have a certain level of impact of the handovers in the performance. Furthermore, we have to take into account another fact, depending on the mobility solution a change of IP address can be needed when the terminal moves. For example if a terminal uses Mobile IP but it wants to register the CoA instead of the HoA in the DHT peer-to-peer network to avoid routing inefficiencies of using the HoA. Therefore, a modification in the maintenance algorithm of the DHT needs to be considered. This implies that the overlay routing tables have to be updated more frequently, and the maintenance traffic needed to update these overlay routing tables will also increase. If in addition to this problem, we consider that mobile nodes usually have limited bandwidth capabilities, the increment in the maintenance traffic does not seem to be a good solution. Furthermore, the mobile IP handovers also

[2] http://www.ietf.org

introduce disruptions in the connectivity, these disruptions increment the churn suffered by the peer-to-peer overlay. Therefore, it would be desirable to minimize these effects as much as possible.

A. Management of routing tables in peer-to-peer overlay networks

Different methods to update the routing tables in DHTs have been proposed until this moment. In [9] two approaches are explained, they are proactive maintenance and reactive maintenance. In the first one, maintenance operations are run periodically in order to assure fresh routing entries and to avoid failures as much as possible. In the other approach called reactive maintenance, it fixes the errors once they are detected. Furthermore, many tweaks can be used on both approaches to improve the overall performance. The first approach is interesting for scenarios with high churn because the traffic generated to update the routing tables is limited by the periodicity that is used to refresh the entries. On the other hand, the second approach is suitable for scenarios where the churn is low. Only maintenance traffic is generated if necessary, and the errors caused are minimal because they don't occur frequently.

Finally, when some peers have a very high churn, it is better that they don't participate in the maintenance of the overlay. Its churn will produce more than drawbacks than the benefits of their resources to the overlay. The solution is to allow these peers to use the overlay but not to participate in its maintenance [13]. In P2PSIP this peers are called clients [4].

B. Management of peer-to-peer routing tables in mobile environments

The question that is discussed in this section is which is the most suitable strategy that must adopt a peer-to-peer overlay network if it is not desired to reduce the performance in a heterogeneous scenario with mobile peers. Several considerations can be done. One could consider using the approach of using the client profile for mobile nodes, so these peers wouldn't participate in the overlay [13]. However this approach cannot be applied in a scenario where only mobile peers exist. In this case it would be more suitable a proactive strategy in order to minimise the maintenance traffic of updating the overlay routing entries and avoiding as much as possible of the wireless interfaces of the peers. Nevertheless, in a heterogeneous scenario, stable peers will have to increase the costs of their maintenance traffic since mobile nodes exist, although a reactive strategy would be more suitable. Therefore, depending on the scenario one approach would be more suitable than other. Furthermore, we cannot predict how new services will evolve and which strategy would be the best.

We advocate for a flexible solution that can be adopted in any scenario. A classification of the different nodes participating in a peer-to-peer network can be done. One classification according to their mobility can be done as follows:

- **Fixed Nodes**
  - *Stable Nodes*: These nodes present large up-times and a stable connectivity. This fact usually implies a fixed available bandwidth and RTT in the access network.
  - *Unstable Peers*: These peers present small up-times. This behaviour is usually because of connectivity problems or own system instability. Bandwidth and RTT are usually stable but only available in short periods of time.
- **Mobile Nodes**
  - *Low Mobility Peers*: This profile considers those peers that have mobility support but they don't change their location very frequently. Although the bandwidth and RTT are given by the access network, they depend on the number of users that are connected in a cell or access point.
  - *High Mobility Peers*: These peers usually change their cell or visiting network since they change their location really fast. This pattern implies a lot of disruptions. Therefore, the RTT and bandwidth are heterogeneous and difficult to predict because of the continuous changes.

A different peer-to-peer overlay can be built according to the different groups listed before, and the most suitable strategy or DHT overlay [8] can be used. For fixed nodes we can use a reactive strategy, but for Unstable and Low Mobility Peers, both profiles with a higher churn, we can use a reactive algorithm tweaked to each of these profiles. Finally, high mobility peers can be configured as clients that are attached to the overlays maintained by the other profiles. Thus the problem that arises is how to allow the communication between the different overlays. This problem can be solved with H-P2PSIP [21] and [22] if we do an intelligent mapping of the different overlays in this architecture. Furthermore, this solution gives a great flexibility than can be really interesting for future deployments. The main drawback than can be related with this solution is the fact that probably is not a very good idea to have only mobility peers in an overlay network because their lifetimes probably would be short and the stability of super-peers peers could be affected in a dramatic way. This last statement depends on the strategies adopted for that profile and scalability of the solution but more stable peers can be also introduced but they will find drawbacks because they are not attached on their original overlay. Therefore some type of incentive mechanism is needed. Incentives in peer-to-peer systems is an open topic and it is out of scope with the topic of this paper, so it is not analysed but it will be probably be considered in an implementation.

VI. Hierarchical P2PSIP in mobile environments

The solution we propose is to change how resources are stored in H-P2PSIP ([21], [22]) in order to maintain different overlays of the same domain that manage peers with different mobility profiles. Using this approach, each peer-to-peer network can be optimised according to the specific node behaviour. Furthermore, in order to allow the connectivity between peers of different behaviours, a Hierarchical DHT based on P2PSIP [22] can be deployed to interconnect overlays with different peer behaviours; an example is in Figure 1. The peers in the same overlay share the same mobility profile and the connectivity between peers with different profiles is allowed through the interconnection overlay.

Prefix ID (n-bits)	Suffix ID(m-bits)

Fig. 3. Hierarchical ID

A. Hierarchical space domain of identifiers

In order to support the H-P2PSIP architecture, we define a hierarchical space of identifiers containing Hierarchical IDs (see Figure 3). Each Hierarchical ID is composed by two part IDs: a Prefix ID with n bits and a Suffix ID with m bits. The Prefix ID is used for the routing in the Interconnection Overlay between the different P2PSIP domains, whereas the Suffix ID is used for routing queries only in the own P2PSIP domain of a peer. This design advocates for a variable length for Node IDs in P2PSIP since any mapping function with independence of its length can be used to generate the Hierarchical ID. This Hierarchical ID can be used either as Node ID or Resource ID.

As Node ID identifies each node participating in the overlay network. The generation of the Node ID depends on the security level desired in the system. The simplest approach is to generate the Prefix Id of the node as `Prefix-ID=hash(domain_name.com)` and the Suffix ID as `Suffix-ID=hash(ip_address)`. However, if a more secured infrastructure wants to be provided, a central authority can be used to generate the certificates of a domain [23]. This central authority must define a mechanism to generate a Prefix ID per domain and a Suffix ID per peer in a domain, random numbers is a good approach to avoid some attacks to the overlay [23].

The generation of a Resource ID depends on the type of resource and how it is identified in the real world. This knowledge is necessary to accommodate its identification in the key space of a DHT. In our previous work [21] and [22], users and services are identified by URI's, like in a VoIP scenario based on SIP. The Prefix and Suffix IDs are generated with a hash of different parts of the URI. If we have a resource identified with the URI `resource@example.com`, we obtain:

- `Prefix-ID=hash(example.com)`
- `Suffix-ID=hash_a(resource@example.com)`

In this way all the resources of the same domain get the same Prefix ID and the Suffix ID identifies the resource. However, more complex and secured mapping functions can be used if necessary.

B. Peer mobility behaviours mapping

Considering our previous work [21] and [22], where users and services are identified by URI's, we have to incorporate the information of the peer mobility profiles in the URI format. The solution that has been adopted is to use a tag at the end of the URI that differentiates the mobility profile where is attached a peer according to its behaviour. The defined format is as follows: *user@example.org:**xx***. The *xx* tag defines where a user is attached and this tag can be *st* (**st**able peer), *un* (**un**stable peer), *lm* (**l**ow **m**obility peer) and *hm* (**h**igh **m**obility peer).

URI's are mapped to the Hierarchical ID in the following manner, the Prefix ID is obtained by applying a hash to the domain of the URI and the profile tag: `Prefix-ID=hash(example.com:xx)`. The Suffix ID is obtained from the hash of the URI without the profile tag: `Suffix-ID=hash_a(resource@example.com)`. The hash functions `hash` and `hash_a` can be identical or different. If something wants to be stored in the overlay network each Resource ID will have a Hierarchical ID format and it will have associated the original URI and the resource information. Each resource would be placed on the peer with the closest Node ID. Depending on the DHT protocol, this tuple can be replicated to other peers in some way. The content of the resource information can vary depending on the application scenario (i.e. location information in VoIP).

C. H-P2PSIP Basic Operation

Once the resources have been mapped to identifiers and how to storage them in the overlay, H-P2PSIP defines a method to locate these resources. This method is divided in two cases. In the first case, the search of a resource is bounded to the P2PSIP domain of the requester. This case is really simple since the search for resources is done inside the P2PSIP domain and it is identical to the flat peer-to-peer overlay using only the Suffix ID. In this situation, the Prefix ID of the resource must be equal to the hash of the associated URI domain. This hash is known by all the peers belonging to that P2PSIP domain. However, if a resource is stored in a different domain or in the same domain with a different mobility profile, the operation is more complex. For instance, this case can correspond to a VoIP call from a user in a P2PSIP domain to another user in a different P2PSIP domain. In order to obtain the resource (e.g. location) of the desired user, it is necessary to obtain the contact information published in the other P2PSIP domain. The first step in the search is to find a peer that can request information from other P2PSIP domains. These are the super-peers and there are several mechanisms [24], [25] that can be used to select them, which can be integrated in the maintenance protocol of the DHT used in the domain. Each P2PSIP domain has at least one super-peer, although it is desirable to have several super-peers for redundancy and performance.

Since all the peers in a domain know at least one super-peer, they can send a query to the super-peer in one hop. When the super-peer receives the query, it will search in the Interconnection Overlay for any of the super-peers that are responsible for the target Prefix ID, and once this information is retrieved, the query is forwarded to one of these super-peers. When the super-peer of the destination P2PSIP domain receives the query, it forwards the query inside its domain. If the query reaches a peer that has the desired resource, then the peer replies in a way that is compliant with the P2PSIP protocol [4].

An example of the signalling on the proposed hierarchical scenario is shown in Fig. 4, this example can be applied to a VoIP or an Instant Messaging service. Several aspects are taken into account in order to understand the signalling flow. First of all, when the peer in `domain.com:st` requests the information of `user1@domain.com:lm`, the query in the Fetch message is plain text. Plain text is used since a peer in a domain does not have to know what hash function is used in the Interconnection Overlay and what hash function is used in other P2PSIP domains. Thus, the super-peer

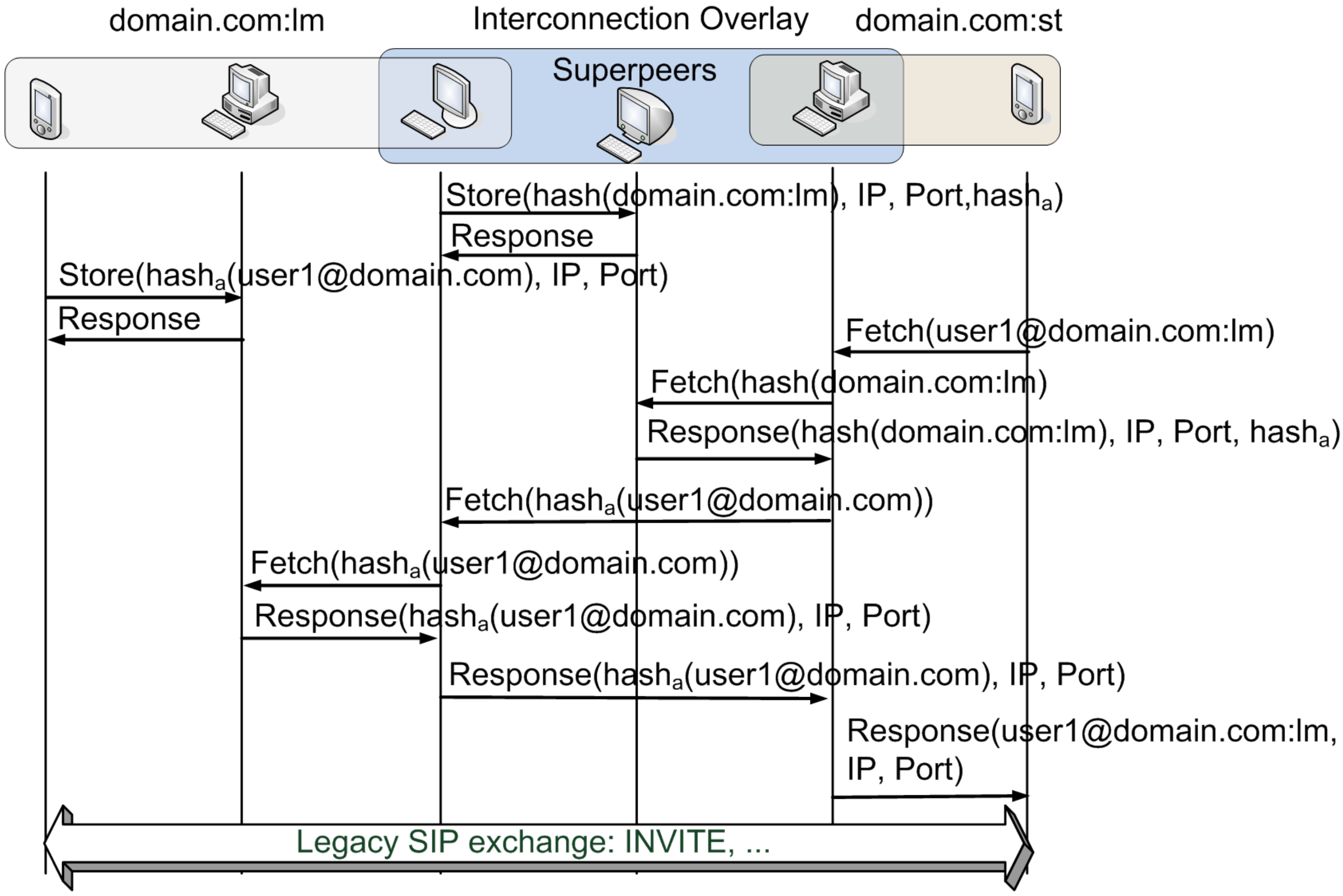


Fig. 4. H-P2PSIP Signalling

in `domain.com:st` performs `hash(domain.com:lm)` in order to obtain the information of the super-peers in `domain.com:lm` through the Interconnection Overlay. Inside this information, the hash used in the other domain ($hash_a$) is included and a request for the desired item can be built as `hash_a(user1@domain.com)`. Some of the peers taking care of the desired Resource ID answer to the super-peer from `domain.com:lm`, which then forwards this information to the super-peer from `domain.com:st`. Finally, the super-peer from `domain.com:st` sends the desired Resource ID to the peer from `domain.com:st`. Once this flow finishes, a SIP negotiation can be initiated for IM, VoIP or Video Conference. Figure 4 illustrates a subset of the real flow. The figure omits the intermediate hops in each overlay or Interactive Connectivity Establishment (ICE) exchanges for NAT traversal, if any is needed.

Therefore, the communication between different overlays is possible and different strategies can be adopted in each overlay. A different peer-to-peer overlay network can be used considering its robustness against churn or the stabilisation algorithm to update routing tables can be launched more frequently to compensate the churn effects.

D. Dynamic profile update

An important problem is how to contact with a peer with unknown mobility profile. One option could be to look in the last P2PSIP domain where it was contacted. If this information is not available, the first step is to look in the own domain where a peer is attached. Otherwise, each domain can be queried iteratively or in parallel. However, in order to avoid losing time and bandwidth with unnecessary queries, a peer can leave the information of its new position in the last visited domain. This information will be only available for a certain period of time. This solution is a compromise between looking for peers among all the domains and to store the location information in each one of the domains.

The way to proceed is as follows and it is illustrated on Figure 5. If a peer changes its location from the domain of low mobility to the domain of stable peers, it has to register this information in the new domain. Additionally, it has to register in the previous overlay domain a pointer to its new attachment point. In Figure 5, its URI with its new profile tag is stored on the original domain. If a peer looks for it in the old domain, it obtains the pointer of its new peer-to-peer location. Thus, it can start the same signalling exchange as explained in Figure 4 to get its contact location. Once these actions have been performed, a legacy SIP exchange can be done between the partners of the new session.

VII. Conclusions

In this paper, we propose an extension for P2PSIP domains that considers the mobility of peers. Due to the mobility environment, performance will be lower that the estimated in those references, but there are mechanisms to keep good

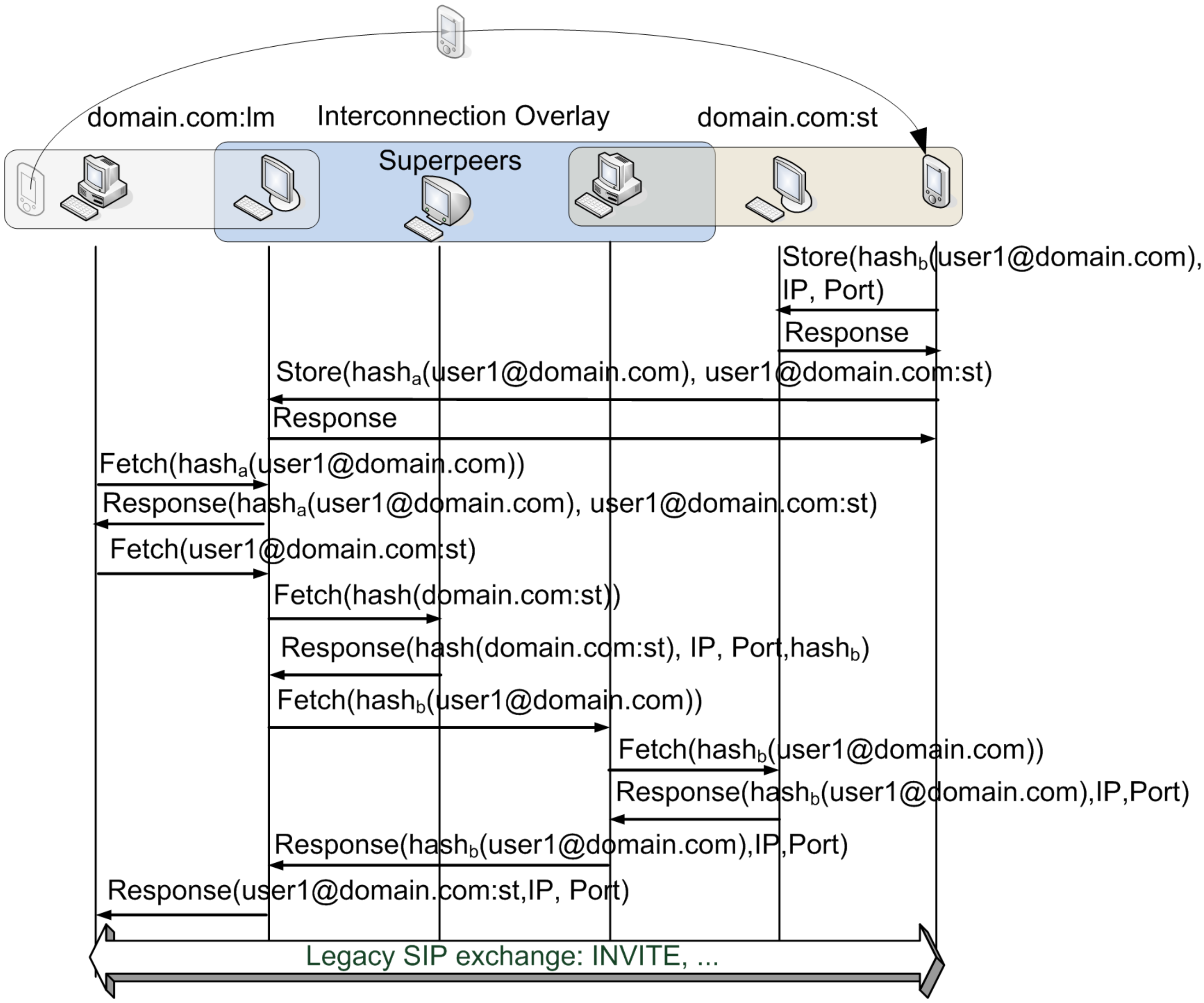


Fig. 5. Dynamic Update Signalling

levels of performance under mobility scenarios (i.e. [9], [13]). In this paper we argue that these should apply selectively only to the peers with high churn, in this way avoiding their negative impact on the rest of the peers and obtaining a better performance. Therefore, our proposal allows defining different domains for peers having different mobility behaviours. The connectivity between the different domains is realised through an interconnection overlay. In order to allow the routing between the different overlays through the interconnection overlay, a mapping function between the peers' URI and the tag that defines the mobility profile is defined to create the Hierarchical ID in a very simple way and with minor changes in comparison with our previous proposals [21], [22]. The Hierarchical ID is composed by a Prefix ID used for the routing in the interconnection overlay and a Suffix ID used in each overlay domain. The performance of this architecture without mobility considerations has been proved in [21] or [22].

The problem that arises under this architecture is to find the most suitable overlays and their setup parameters depending on the scenario and the mobile profile under study. A starting point can be [8] where the performance of different DHT's under churn is studied. Therefore, the next step in our research is to perform an evaluation of the benefits of this solution and its costs taking into account different type of mobility mechanisms, peer-to-peer networks, setup parameters and peer-to-peer maintenance solutions.

ACKNOWLEDGEMENT

We would like to acknowledge Ignacio Soto for their insightful comments to improve the readability and understanding of this paper.

This research work is being supported by the European Commission under the IST Content Network of Excellence[3] (FP6-2006-IST-038423), by the Regional Government of Madrid under the BioGridNet[4] project (CAM, S-0505/TIC-0101) and by the Ministry of Science and Innovation under the CONPARTE project (MEC, TEC2007-67966-C03-03/TCM).

[3]http://www.ist-content.eu

[4]http://www.biogridnet.org

REFERENCIAS

[1] S. A. Baset and H. G. Schulzrinne, "An analysis of the skype peer-to-peer internet telephony protocol," *INFOCOM 2006. 25th IEEE International Conference on Computer Communications. Proceedings*, April 2006.

[2] D. Rossi, M. Melia, and M. Meo, "A detailed measurment of skype network traffic," in *In IPTPS 2008*, 2008.

[3] D. Bryan, P. Matthews, E. Shim, and D. Willis, "Concepts and terminology for peer to peer sip," July 2008, internet Draft draft-ietf-p2psip-concepts-02.txt.

[4] C. Jennings, B. Lowekamp, E. Rescorla, S. Baset, and H. Schulzrinne, "Resource location and discovery (reload)," July 2008, internet Draft draft-ietf-p2psip-reload-00.txt.

[5] I. Stoica, R. Morris, D. Liben-Nowell, D. Karger, M. Kaashoek, F. Dabek, and H. Balakrishnan, "Chord: A Scalable Peer-to-Peer Lookup Protocol for Internet Applications," *IEEE/ACM TRANSACTIONS ON NETWORKING*, vol. 11, no. 1, 2003.

[6] P. Maymounkov and D. Mazieres, *IPTPS 2002 Cambridge, MA, USA, March 7-8, 2002. Revised Papers*, ser. Lecture Notes in Computer Science. Springer, 2002, vol. 2429/2002, ch. Kademlia: A peer-to-peer information system based on the XOR metric, pp. 53–65. [Online]. Available: http://www.springerlink.com/content/2ekx2a76ptwd24qt/?p=d9a88bd0609d4ac3902f147d1c183345&pi=0

[7] S. Ratnasamy, P. Francis, M. Handley, R. Karp, and S. Schenker, "A scalable content-addressable network," in *SIGCOMM '01*. New York, NY, USA: ACM Press, 2001, pp. 161–172.

[8] J. Li, J. Stribling, R. Morris, M. Kaashoek, and T. Gil, "A performance vs. cost framework for evaluating dht design tradeoffs under churn," *INFOCOM 2005. 24th Annual Joint Conference of the IEEE Computer and Communications Societies. Proceedings IEEE*, vol. 1, pp. 225–236 vol. 1, March 2005.

[9] S. Rhea, D. Geels, T. Roscoe, and J. Kubiatowicz, "Handling churn in a dht," in *ATEC '04: Proceedings of the annual conference on USENIX Annual Technical Conference*. Berkeley, CA, USA: USENIX Association, 2004, pp. 10–10.

[10] M. Steiner, T. En-Najjary, and E. W. Biersack, "Exploiting kad: possible uses and misuses," *SIGCOMM Comput. Commun. Rev.*, vol. 37, no. 5, pp. 65–70, 2007.

[11] M. Steiner, T. En Najjary, and E. W. Biersack, "Analyzing peer behavior in KAD," Institut Eurecom, France, Tech. Rep. EURECOM+2358, Oct 2007.

[12] D. Stutzbach and R. Rejaie, "Understanding churn in peer-to-peer networks," in *IMC '06: Proceedings of the 6th ACM SIGCOMM conference on Internet measurement*. New York, NY, USA: ACM, 2006.

[13] A. MacQuire, A. Brampton, I. Rai, and L. Mathy, "Performance analysis of stealth dht with mobile nodes," *Pervasive Computing and Communications Workshops, 2006. PerCom Workshops 2006. Fourth Annual IEEE International Conference on*, pp. 5 pp.–189, March 2006.

[14] R. Aguiar, S. Sargento, A. Banchs, C. Bernardo, M. Calderon, I. Soto, M. Liebsch, T. Melia, and P. Pacyna, "Scalable qos-aware mobility for future mobile operators," *Communications Magazine, IEEE*, vol. 44, no. 6, pp. 95–102, June 2006.

[15] W. Kellerer, Z. Despotovic, M. Michel, Q. Hofstatter, and S. Zols, "Towards a mobile peer-to-peer service platform," Jan. 2007, pp. 2–2.

[16] O. Landsiedel, S. Gotz, and K. Wehrle, "Towards scalable mobility in distributed hash tables," Sept. 2006, pp. 203–209.

[17] A. T. Campbell and J. Gomez-Castellanos, "Comparison of ip micromobility protocols," *SIGMOBILE Mob. Comput. Commun. Rev.*, vol. 4, no. 4, pp. 45–53, 2000.

[18] H. Soliman, C. Castelluccia, K. E. Malki, and L. Bellier, "Hierarchical Mobile IPv6 Mobility Management (HMIPv6)," Internet Engineering Task Force, RFC 4140, Aug. 2005. [Online]. Available: http://www.rfc-editor.org/rfc/rfc4140.txt

[19] C. Perkins, "IP Mobility Support for IPv4," Internet Engineering Task Force, RFC 3220, Jan. 2002. [Online]. Available: http://www.rfc-editor.org/rfc/rfc3220.txt

[20] D. Johnson, C. Perkins, and J. Arkko, "Mobility Support in IPv6," Internet Engineering Task Force, RFC 3775, Jun. 2004. [Online]. Available: http://www.rfc-editor.org/rfc/rfc3775.txt

[21] I. Martinez-Yelmo, A. Bikfalvi, C. Guerrero, R. Cuevas, and A. Mauthe, "Enabling global multimedia distributed services based on hierarchical dht overlay networks," in *NGMAST 2008. Future Multimedia Networking Workshop*. IEEE Computer Society, Sep. 2008, pp. 543–549.

[22] I. Martinez-Yelmo, A. Bikfalvi, R. Cuevas, C. Guerrero, and J. Garcia, "H-p2psip: Interconnection of p2psip domains for global multimedia services based on a hierarchical dht overlay network," *Computer Networks. (Accepted to Appear on March)*, vol. Special Issue on Content Distribution Infrastructures for Community Networks, 2009.

[23] G. Urdaneta, G. Pierre, and M. van Steen, "A survey of DHT security techniques," *ACM Computing Surveys*, 2009, http://www.globule.org/publi/SDST_acmcs2009.html, to appear.

[24] S.-H. Min, J. Holliday, and D.-S. Cho, "Optimal super-peer selection for large-scale p2p system," in *Hybrid Information Technology, 2006. ICHIT'06. Vol 2. International Conference on*, vol. 2, 2006.

[25] A. T. Mizrak, Y. Cheng, V. Kumar, and S. Savage, "Structured superpeers: leveraging heterogeneity to provide constant-time lookup," in *Internet Applications. WIAPP 2003. Proceedings.*, 2003, pp. 104–111.