

Multilayered Mobility Management in Next Generation Wireless Network: Home Networks Perspective

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Abstract

Multilayered approach is a significant trend in the field of mobility management. At the same time, home networking receives a growing interest in both research and industrial circles. This paper investigates the possible roles and advantages of applying the proposals of multilayered mobility management to home networking environments.

KEYWORDS: Mobility management, Multilayered mobility management, Home networking

1 Introduction

Mobility management (MM) is a key issue in next generation wireless networks. MM is mainly concerned with providing seamless connectivity to mobile hosts while they roam from one network to another. Several proposals have already been introduced to address the issue of MM. Mobile IPv4 (MIP) was the first proposal. It supports terminal mobility at the IP layer. MIP has the advantage of working at a lower layer to reduce the handoff delay. Another advantage of MIP is keeping the protocol stack without major changes. However, MIP has its own disadvantages viz. non seamless handoff and triangular routing. In contrast to MIP, Session Initiation protocol (SIP) mainly supports user mobility at the application layer. SIP has the advantage of the direct communication between a mobile node (MN) and a correspondence node (CN). However, working at the application layer introduces the problem of slow handoff. A third proposal is the experimental Host Identity Protocol (HIP). The major advantage of HIP is redefining the dual role of the IP addresses, viz. as a locator and as a host identity. Consequently, HIP is originally designed to support terminal mobility. However, HIP introduces a new layer to the protocol stack, which forms a major problem for its deployment.

A relatively new trend in mobility management is using a combination of single layered mobility management solutions, namely, multilayered mobility management. It is expected that multilayered mobility management introduces better performance by utilizing the advantages of the combined single layered solutions. Different combinations of protocols have already been proposed as multilayered mobility management solutions. A significant candidate multilayered solution is using SIP with MIP. Another interesting combination is using SIP with HIP. However, multilayered mobility management is still an open research area. More

proposals can still be introduced. Additionally, the already proposed solutions should be investigated more. Furthermore, multilayered mobility management solutions should be studied with considering the mobility management issues in the environments of the next generation wireless networks. Such studies should also consider home networks, which already receive an increasing interest in both scientific and research circles.

From the view point of the fields of communication and media, home networking is considered as a large step for the last mile connections. A bulk of applications are proposed, e.g. IP telephony, Digital TV, Multimedia Communication and even more. These types of applications may cover both the internal environment of a house and its connections to the outside world. At the same time, wireless networking is considered to be the most significant candidate as an enabling technology. Particularly, wireless networks provide the "no-wires" solution to home networks. So that, it solves the problems of the required rewiring for deploying home networks.

However, there may be different types of wireless enabled devices in a home environment. Consequently, different wireless technologies may work at the same time inside the same home or household. On the other hand, to connect to the outside world, a user terminal may roam between these home networks and the larger operator networks. In both sides, inside and outside a home, mobility management becomes a very essential issue as long as wireless technologies are involved.

In this paper, section 2 reviews and analyses the environment of home networks. It also investigates the possible mobility management considerations in such environment. Section 3 reviews the most significant solutions of single layered mobility management. It gives the basic background about mobility management. Section 4 reviews some of the already proposed multi-layered mobility management solutions. And finally, Section 5 combines both the background and the analysis parts from the previous sections to suggest some possible contributions of multilayered mobility management to home networks.

2 Home Environment And Mobility Issues

In this section, home networks are viewed from different perspectives. The first purpose of this section is to layout a background about home networks. The second purpose is to re-

view some of the most significant recent proposals for home networks. However, both the laying out of the background and the introduction of the review are done in a focused way to orient them to the analysis of the possible mobility management issues in home networks.

2.1 Home Network Applications Perspective

In [1, 2], a definition of a home network focuses on its function: Interconnecting electronic products and systems in a home to enable remote access and control to them. It also enables access to the content which is provided by these devices. Following this definition, a very important standard of home networking was defined, namely, the versatile home networking (VHN). By using VHN, different types of networks in a home can be interconnected. For example an A/V network, an Ethernet network, and even a lighting control network. VHN specifies standards like Universal Plug and Play (UPnP) for interoperability between devices, IEEE 1394 as a backbone for connecting the different types of networks, and network management using the Common Information model (CIM).

On the other hand, a home network can be connected to an outside network, i.e. Internet. So that, the above definition of a home network and the VHN standard extend the ability of controlling and accessing a diversity of home appliances remotely. For example, we can think about the ability to monitor homes and commanding home appliances from outside networks using PDAs or mobile phones. Such a view is confirmed by a proposed service architecture for home networks in [3]. The mobile devices play a very important role in accessing and controlling home appliances remotely in the future home. This is also supported by a user study in [3]. Consequently, the connectivity of such devices to the Internet is a very important issue. As users roam from a network to another, their mobile nodes should have a stable connectivity to their home networks. This issue may be critical when we talk about sending commands to home appliances or monitoring alarms at homes. This is a point where the mobility management outside home networks may indirectly affect the their functionality.

Additionally, if mobility management will be involved in the field of home networking applications, it must also consider the different types of traffic in a home network. Mainly two types of traffic exist in a home network, viz. real time traffic, for applications like VoIP, and non real time traffic for applications like file transfer [16]. The existence of both types of traffic at the same time imposes special considerations in both the internal and the external environments of a home network. Specially when we consider the wireless networks as an enabling technology. Because the wireless medium is considered as a limited resource with respect to the amount of data it can transfer and the error handling mechanisms. Mobility management has already paid a lot of attention to such considerations of wireless networks. Mobility management solutions can influence the "no-wires" solutions in home networks.

2.2 Home Services Architecture Perspective

Moreover, [4] proposes an architecture for a home network service environment which supports wide area communication. The important point in this proposal is the full dependency on Session Initiation Protocol (SIP) for providing such communication. SIP is widely discussed in the field of mobility management as a solution for different types of mobility. This can be another reason to consider the effect of mobility management outside home networks on home networking environments. For example, SIP can be considered as a meeting point for the integration of home networks and outside networks to form heterogeneous networks. Moreover, mobility management solutions using SIP can even influence the proposed solutions to the internal home environments. Similar solutions to similar problems can be a suggested approach to introduce such influence.

Moreover, [2] provides a service oriented study to simplify the concept of home networks. The proposed solution defines the concept of the ultimate device. This concept simply aggregates the duplicated functionalities in home appliances into one device per functionality. Then the solution introduces the room server. This entity receives synchronized content from a home server, and then it distributes it to the ultimate devices in the room when required. For that proposal in [2], WLAN is recommended as a solution for both inter-room (IEEE 802.11a/b/g) and intra-room (IEEE 802.15.3) connectivity. This means that wireless technologies are involved more and more inside home networks. And the learned lessons from mobility management with respect to wireless technologies can be applied to both the internal communication inside a home network and the interaction between a home network and the outside networks. For example, the handoff between a WLAN of a home network and an outside wireless network like UMTS is a problem of vertical handoff. This means that it is a handoff between two different wireless technologies. Such a problem was already been investigated by many mobility management studies.

2.3 Home Networking Enabling Technology Perspective

Another very interesting proposal for home networks is that of [5]. It is considered as a next generation wireless architecture for the home networks. It utilizes a newly emerging wireless technology, namely Multi-hop wireless mesh networks (WMN) [6]. It is considered as a next generation wireless network technology. WMN is a self configuring and a self organizing network, which makes it a very suitable option for home networks. However, WMN can be even used as backbone networks.

The proposal in [5] defines two classes of devices viz. home mesh backhauls (MeshBHs) and home mesh clients (Mesh-CLs). The MeshBHs include both mesh access points (MeshAPs) and mesh routers (MeshRTs). The mesh backhauls connect the various network devices among themselves and to the Internet. To connect to the Internet, the mesh backhauls use a broadband access technology like WLAN or DSL. The solution seems to be promising for home networking, specially with the feature of auto-configuration.

On the other hand, depending on WLAN to connect to the Internet causes some serious problems for the traffic in home networks [7]. The main cause of such problem is mechanism of medium access in IEEE 802.11. It uses CSMA/CA, a collision avoidance mechanism for the MAC layer. So that it is not suitable for transmitting constant rate A/V data. Because, for example if a file transfer occurs during an A/V transmission, they will interfere. Modifications to the MAC layer for the WLAN itself are required. So that, if we can avoid using WLAN with keeping the use of wireless connections to the Internet, this will be a better solution. WMN provides such a solution using the gateway/bridge feature of the MeshRTs.

In WMN, MeshRTs have a very important feature, namely, the gateway/bridge functionality [6]. This feature enables WMN to connect directly to various existing wireless networks such as cellular, wireless sensor, WiFi, WiMAX, and WiBro networks. Consequently, WMN can avoid depending on wired solutions or WLAN to connect to the larger wireless networks outside the home. However, as stated in [6], a wide range of research issues of WMN are being investigated nowadays. These issues even include a MAC layer design for communication in WMN. But at least, the communication among devices in a WMN will be very close to that communication among the nodes in ad hoc networks. An example of such communication in a WMN of a home network is illustrated by Fig. 1. In contrast to the case in IEEE 802.11, such a way of communication reduces the competition to a single wireless medium by all devices in a home network. As a result, less interference between different types of traffic inside the home network can be achieved. And this is very important for the QoS in a home network.

Additionally, the nodes in a WMN can be mobile nodes. For example, a user can roam in a home using a VoIP phone. If we see a WMN network of a home as an ad hoc network, then such roaming requires mobility management. In [6], mobility management is mentioned as a very important issue of research for WMN in general, regardless of the purpose of using WMN. Moreover, [6] suggests multilayered mobility management as more suitable solutions to WMN. Additionally, if we consider the previously mentioned home network proposal of [5], mobility management for WMN may lead to simplify the clients to work both inside and outside home networks without any special considerations. This is because of the very flexible integration of WMN with other wireless technologies, and because of the possibility to use WMN as a backbone technology in addition to using it for home networks.

In this section, different perspectives of the home networks were discussed. A background of the home networks along with a review of the recent home networks solution were introduced. Different possible mobility management issues related to home networks were introduced. The next section introduces a very concentrated background about single mobility management.

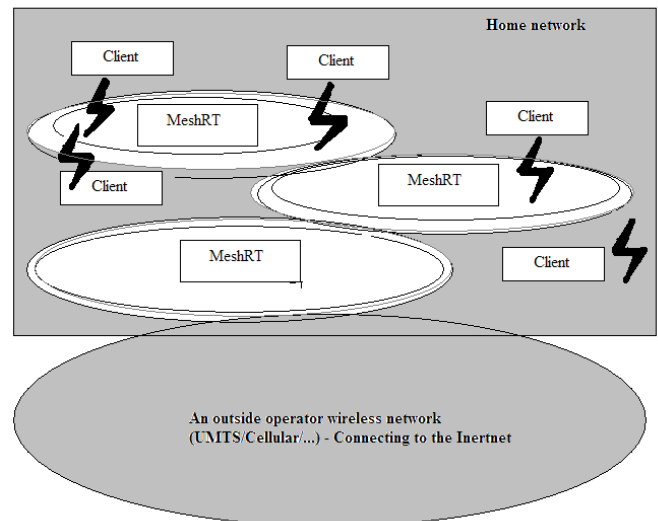


Figure 1: Communication in a WMN of a home network

3 Mobility Management: Single Layered Approaches

In this section, three single layered mobility management protocols are reviewed, viz. Mobile IP (MIP), Session Initiation Protocol (SIP), and Host Identify Protocol (HIP). This section is a basis for all the subsequent sections.

3.1 Mobile IP

Mobile IP (MIP), is considered as the first proposal for managing the mobility of mobile nodes. MIP focuses, in its original form, on keeping the traffic to a mobile node (MN) routable even when this node changes its connection point to the Internet [17]. MIP defines what is called a home network (HN) of a MN. It is the network where a MN was originally connected to the Internet. In other words, it is the network to which the IP of the MN belongs [17]. This should not be confused with the home network we discussed above. Through the rest of the paper, the abbreviation HN will be used to stand for the home network of a MN as defined by MIP, otherwise, home network will stand for what we have discussed before about the networks at homes. Additionally, MIP defines the concept of foreign networks (FN) [17]. It is the network which a MN may visit so that it changes its connection point to the Internet. As mentioned above, the main goal of MIP is to keep the traffic to the MN routable in such case.

The entities in MIP include home agents (HAs) and foreign agents (FAs) [17]. When a MN is in its own HN, it uses its home IP address. Also, the communication between it and a correspondence node (CN) is handled without any special considerations. However, when a mobile node moves to visit a FN, MIP takes care of the traffic. When it roams to a FN, a MN obtains an IP address from the FA to use it for the communication while it visits the FN. This IP address is referred

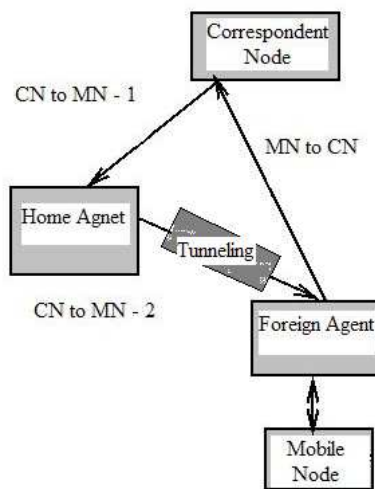


Figure 2: MIP

to as the care of address (CoA). The MN also registers itself to the FA of the FN. Then, the MN registers itself to its HA to inform it about its current CoA [17].

While a MN is visiting a FN, a CN sends the data packets to the home IP address of the MN. The HA of the MN intercepts this traffic. Then the HA tunnels the traffic to the FA of the currently visited network where the MN is. Then, the FA de-tunnels the traffic and forwards it to the MN. On the other hand, the traffic from the MN to the CN goes directly from the current location of the MN to the CN. This type of routing from the CN to the HA, then from the HA to the FA and finally from the MN to the CN is called triangular routing [17]. Fig. 2 illustrates the case when a MN visits a FN. This is considered as a very significant disadvantage of MIP. However, the performance study in [8] show the advantage of MIP with less hand off delay with high mobility compared to other macro mobility protocols which work at higher levels. Also, MIP is supported by a large number of micro-mobility protocols like Cellular IP. Additionally, the deployment of MIP involves less modifications in the network protocols layers stack than the required by other macro mobility solutions.

3.2 Session Initiation Protocol

Session Initiation Protocol (SIP) is an application layer signaling protocol that establishes, manages and tears down multimedia sessions [8, 9]. Mainly, SIP supports user mobility. A user has his own e-mail alike address. SIP keeps information about the current location of the user. I also provides information about his presence. In turn SIP can manage multimedia sessions to/from that user from/to other users [8, 9].

SIP entities include user agents, proxy servers, redirect servers and location servers [8, 9]. SIP user agents are responsible for sending SIP messages upon users actions and listening to incoming SIP messages. Both proxy servers and redirect servers accept registrations from users when they change their locations. Then these servers send updated in-

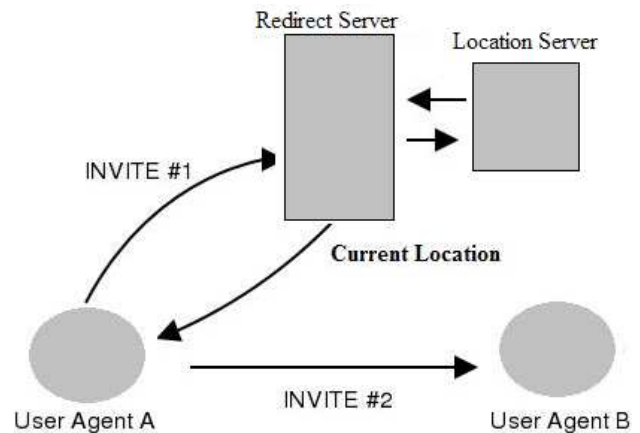


Figure 3: Redirection in SIP

formation to location servers. In this way, the current location of a user can be returned to any caller user agent which it sends a SIP invitation to another user agent to start a multimedia session. This is how SIP supports user mobility [9].

In an very identical way, SIP supports terminal mobility [8, 9]. When a MN moves from its HN to visit a FN. A SIP user agent of the MN sends a register message to the SIP server of its HN. So that, when a CN sends an invitation to start a SIP session with that MN, the SIP server of the HN replies with the current location of the MN in the FN. Then the CN sends an invitation to the MN to start a session. In turn the MN should responds with an OK message. Then the session begins starts. This process is illustrated by Fig. 3.

Special consideration occur when a MN is moving from one network to another while the SIP server of its HN receives an invitation message from a CN to that MN [8, 9]. The procedure in such situation is to inform the CN about the temporary unavailability of the MN. The SIP server of the HN of the MN does this. Then after it receives a register message from the MN, the SIP server can send the information about the new location of the MN to the CN. Another special case is the situation when a MN is moving from one network to another during an already established and running session. In this situation, the MN sends an invite message to the CN to inform it about its new location. Then the CN replies by an OK message, and then the SIP session is resumed.

The main advantage of the SIP mobility is the lower end to end delay compared to MIP. The reason is that SIP does not have the triangular routing of MIP, i.e. the session traffic from the CN to the MN does not pass through any servers in the HN of the MN. However, the performance study in [8], shows that SIP performs less than MIP when high frequency mobility exists. This is because SIP has a slower handoff mechanism. The study also shows that SIP can not support TCP traffic in an efficient way. It needs IP encapsulation to do such a job at both MN and CN.

3.3 Host Identity Protocol

Host Identity Protocol (HIP) [13, 18] is an experimental protocol. Its main goal is to separate the role of an IP address as

a host identity from its role as a host locator. In HIP, a host is identified by its Host Identity (HI). It is simply a public-private key pair which statically and uniquely identifies the host. Applications use only 128-bit hash form of the HI, called Host Identity Tag (HIT) [13, 18].

In HIP, a DNS server stores a mapping between the domain name of a node and its HIT [13, 18]. At the same time, the DNS server should be updated with current locations of the nodes. So that, when a node needs to communicate with another, it queries the DNS server using the domain name of the required destination node. Then the DNS replies with the IP address and the HIT of the required destination node. Then a process called HIP Base Exchange (HBE) is performed to authenticate the two communicating nodes and to establish a security association between them.

However, the update process of DNS servers is not rapid enough to adapt with cases like nodes mobility. This is the reason of introducing the Rendezvous servers (RVS) to HIP [13, 18]. In RVS, a direct mapping between the HIT of a node and its current IP address is stored. When a node changes its IP address, it sends an update message to its RVS about this new IP. Also, the node also needs to register the IP address of its RVS server to a DNS server. But since the RVS is less likely to be changed and it does not of course change its location, this registration lasts longer than a registration of the IP address of a mobile node to a DNS server.

With the introduction of RVS [13, 18], when a node wants to communicate with another node, it queries the DNS server to get the HIT of the required node and the IP address of its RVS. Then it queries the RVS about the current IP address of the required node. After the RVS replies with the required IP address, the HBE process starts between the two communicating nodes. This process is illustrated by Fig. 4. RVS is also important for the mid-session mobility. When a node moves from one network to another, as it updates its RVS about its new location, the RVS should update the node on the other side of the session about the updated location. This mechanism is preferred specially when two nodes are moving at the same time. This way RVS plays the role of the meeting point between the two nodes.

HIP has the advantage of isolating the upper layers from the mobility process [13, 18]. Simply because these upper layers continue to use HIT regardless of the underlying IP. However, if we consider that HIP is still an experimental protocol, then probably its most significant disadvantages is the deployment process. [14] mentions that another main disadvantage of HIP is not supporting micro-mobility. However, [15] provides a micro-mobility extension to HIP. It also proves that the proposed extension can reduce signaling overhead and handoff latency when it is used for micro-mobility with using HIP for macro-mobility.

This section introduced the single layered mobility protocols. This is the background for introducing the new trend in mobility management in the next section, namely, multilayered mobility management.

4 Multilayered Trend

In this section, multilayered mobility management is introduced. Mainly two combinations are considered viz. SIP-

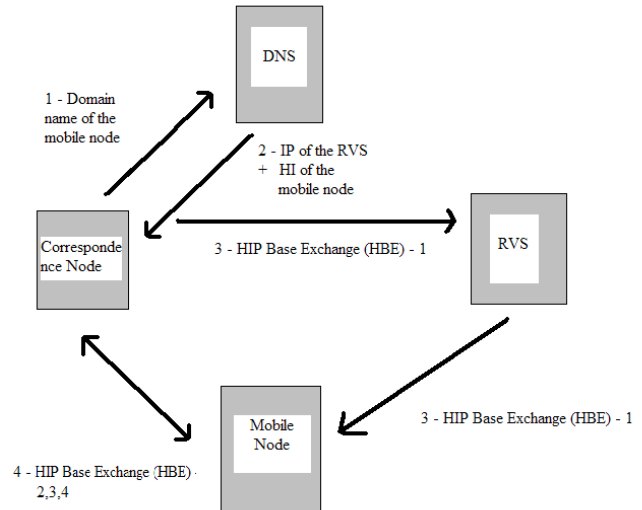


Figure 4: Using rendezvous server in HIP

MIP and SIP-HIP. However, other important multilayer mobility management concepts like cross layer interaction are also reviewed. Open questions and different considerations of different combinations finalizes the discussions.

4.1 SIP-MIP

In [8], a multilayered scheme is proposed such that both SIP and MIP can be used by the same node at the same time for the terminal mobility management. SIP-MIP combines the advantages of the two protocols. As mentioned above, SIP has less end to end delay between a MN and a CN. This is because SIP does not use this triangular routing from CN to MN as the case in MIP. So that SIP is considered to be better for handling mobility for real time traffic, RTP over UDP. On the other hand, MIP is used for non real time traffic over TCP. This is because MIP does not need a lot of modification in the protocol stack like that required by SIP to keep the ongoing TCP sessions. In particular, SIP requires IP encapsulation to keep such TCP sessions going on.

In [9], a complementary part to the above mentioned SIP-MIP approach is introduced, namely, the mobility policy table. By using such a table, applications can choose between a mobility management policy based on MIP and another one based on SIP. More specifically, applications can choose whether to use the care-of-address CoA of a MN for a SIP based mobility management or to use the home IP address of the MN for a MIP based mobility management. The first option connects a MN directly to a CN, which is better for real time traffic. The second option utilizes the triangular routing of MIP while keeping the ongoing TCP sessions flowing.

In the introduced SIP-MIP approach in [8], when a node moves from one network to another it may simply perform the previously described hand off mechanisms of both SIP and MIP separately. Suppose that a MN is communicating with two other nodes CN1 and CN2, with a real time traffic for CN1 and a non real time traffic for CN2. When this MN

roams from a network to another, it will of course perform the hand off mechanism of MIP. And the resulting triangular routing is used to communicate with CN2. Also, the MN must perform the SIP hand off mechanism for the real time traffic with CN1. This duplicates the signaling and consumes additional bandwidth by the two signaling and registering mechanisms of SIP and MIP. Because in SIP, the MN needs to register to its SIP home server to update the information about its current location. Also for MIP, the MN needs to register its new CoA to the HA of its HN.

In [10], an optimization mechanism is introduced to address this signaling overhead. The optimization mechanism keeps the signaling of MIP as it is. On the other hand, for the SIP signaling, the optimization starts from the call setup phase. A SIP server will always direct any caller CN to the HA of the HN of a called MN. Then the SIP response of the called MN to setup a call has two options. The first option is to send the home IP address of the called MN to the caller CN. Then the CN can use that IP to start the SIP session through the HA of the HN of the called MN. The second option is to send the CoA of the MN node. This way, the CN can start a direct SIP session with the called MN. Consequently, for any future hand off, the traditional MIP mechanism is used. However, for an ongoing SIP session, if the home IP address of the called MN was used to setup the SIP session, then no SIP signaling is required. Because the traffic already goes through the HA of the MN. But for the case of using the CoA to setup the SIP session, a minimal signaling is used. Simply the MN sends a re-invite message to the CN to use its new CoA for the resuming the session.

Actually, the SIP-MIP approach for multilayered mobility management has already received a lot of interest. But further studies should be considered for such an important approach. For example in [12], the cross layer approach of multilayered mobility management is proposed. The SIP-MIP proposal can be investigated from this point of view. Lets start by introducing the cross layer approach. This approach coordinates the work between different layers in the protocol stack to enable for example more seamless and rapid hand off. It gives higher layers a direct interaction with lower ones, e.g. the MAC layer. This is very close to the proposal in [11], where seamless handover of SIP is achieved by an assumed direct interaction between the wireless interfaces of a mobile node and SIP. This enables SIP to send re-invite messages at the same time as one of the antennas detects a new wireless network which it is about to be under its coverage. Such solutions may be even utilized for sending re-invite messages in the previously mentioned signaling optimizations of SIP-MIP.

In a very similar way to the proposals in [11, 12], the interaction between SIP and MIP can be considered as a cross layer interaction. Such an interaction needs to be investigated more to realize how the two layers can coordinate in a better way. Actually, the previously mentioned signaling optimization proposal can be considered as form of a coordination work of the two layers. Because in this proposal, SIP is aware of the home IP address and the CoA which are used by MIP. Moreover, issues like for example vertical hand over should also be considered. As we can see from [7] that different considerations for both SIP and MIP exist when a mobile

node roams between a WLAN and a UMTS networks. We may investigate issues about the already supported benefits for such protocols by such wireless technologies. We may also consider how to coordinate these protocols as they mobile nodes roam from one technology to another. The objective for such studies should be the efficient handoff process.

4.2 SHIP

Another proposed multilayered approach is using SIP with HIP, namely SHIP. [13]. In SHIP, when a CN needs to connect to a MN, it uses the DNS to get the Host Identity Tag (HIT) of the MN along with the IP address of the rendezvous server RVS of that MN. Then the CN queries the RVS for the current IP address of the MN. Then the previously described HIP Base Exchange HBE mechanism occurs between the two communicating nodes to authenticate them and to establish a security association between them. Then a SIP call setup process starts to start a SIP session.

When the MN moves from one network to another, it does not need to send a re-invite message to the CN. Because the CN still uses the HIT of the MN for the ongoing session. At the same time HIP takes care of the process of updating the IP address in a transparent manner to the upper layers. This is considered a very significant advantage of SHIP. However, the MN needs to send an address update message to the CN to inform it about the update in the IP address. The performance study in [13] shows that SHIP has less hand off signaling than that of the SIP-MIP proposal. However, the question of deploying HIP is the main criticism against SHIP. Because HIP is still an experimental protocol.

Finally, a significant issue about HIP in [14] is the lack of defined standards to work with it for the micro-mobility management. However [15] introduces what is called Local Rendezvous Server LRVS. By using LRVS inside local domains to handle micro-mobility, HIP may get closer to MIP which has already a large number of proposed micro-mobility protocols. However, still the problem of deployment for HIP, as the main issue which faces SHIP. This may be also the reason behind the limited number of studies for SHIP compared to those for the SIP-MIP approach.

This section reviewed two significant proposals of multilayered mobility management. It also investigated the advantages and disadvantages of each proposal along with the different considerations and open questions for each of them. The next section investigates the possible benefits of applying the discussed proposals and mechanisms above to home networks.

5 Home Networks Perspective

This section combines all the previously discussed reviews and analysis of both home networks and multilayer mobility management solutions. The objective of this section is to investigate and suggest possible benefits of multilayered mobility to home networking. The section views such possibilities from the same perspectives of the previous of home networks.

5.1 Home Network Applications Perspective

As mentioned before, the diversity of the devices in a home network allows the remote access and control of these devices [1]. Considering the worst case were the vendors of such devices assume the direct contact of the users with them for both monitoring and responding to the devices. From this perspective, stable connections can be a must. They may be even critical. Multilayered mobility management can be used to provide the required stable connections. Especially when a user need a seamless roaming from one network to another. For example, a cross-layer interaction between the MAC layer and higher layers can provide a seamless hand-off for a MN. An example of such multilayered solution is the seamless hand off of SIP with the help of direct interaction with MAC layer proposed in [11]. These networks may even be of different technologies. And this type of heterogeneous networking forms the main form of the next generation wireless networks. So that, by applying multilayered mobility management, users can have stable connections to their home networks while they are performing any significant remote control or access processes.

Another important issue here is security. Because such types of remote access and control of the home appliances and content should keep the privacy of a home. This issue must be considered even if the users are doing such job while they are moving and their mobile nodes are roaming from a network to another. A proposal like SHIP [13] introduces a multilayered mobility management mechanism which incorporates HIP. This gives the advantage of having security associations for any remote connection to the home network. However, still the different previously mentioned issues about using HIP.

Finally, for the home network there are two main types of traffic. The first is real time traffic and the second is non real time traffic [16]. The SIP-MIP approach of mobility management is mainly proposed to support the mobility for both types of traffic in a more efficient way than that when using single layered approaches. This extends the traffic inside the home to outside it with the support of multilayered mobility management. This is a very important advantage for home networking. Because is way, SIP-MIP is very adaptive with the nature of the traffic inside a home. And this makes home applications already suitable for the mobility even in the environment of heterogeneous next generation wireless networks.

5.2 Home Services Architecture Perspective

A very important aspect of many of the newly proposed service architectures of home networks is the high degree of utilizing SIP. For example the previously mentioned proposal of [4] uses SIP to enable wide area communication to home networks. The important point here is that such approaches follow a similar line to that followed by different multi-layered mobility solutions. SIP-MIP and SHIP, both utilize SIP. This means that home networks which applies such a service architecture can directly integrate to the world of multilayered mobility management which supports the different types of traffic at home.

As considered before, many different service architectures

for the home networks depend mainly on WLAN. So that roaming between WLAN and a networks technology like UMTS is a possible scenario for a home network user. For example this user may move between his home and outside it while having a VoIP call. At the same time he does not want to pause and restart the call just because he is going between the WLAN and the UMTS. Roaming between two different technologies is referred to as vertical hand over. A special focus is given in [7] to the vertical handover between WLAN and UMTS. It gives another reason for combining SIP and MIP to complement each other for a multilayered mobility architecture. More specifically, UMTS has its own special considerations with respect to MIP and SIP. Which again makes SIP suitable for a certain type of traffic, while MIP is suitable for another. In [7] SIP- MIP is proposed as a multilayered mobility management solution for the vertical handoff between WLAN and UMTS. This is absolutely what a home network needs in a scenario like the one mentioned above.

5.3 Home Networking Enabling Technology Perspective

As mentioned before wireless mesh networks (WMN) seem to be a very important candidate as a "no-wires" solution for the home network. And as [6] confirms, WMN still an open field for research in many fields including mobility management, and more specifically, multilayered mobility management. At this point many benefits for such networks can be achieved by applying multilayered mobility management schemes.

Lets consider such benefits from two different points of view. The first point is using WMN as the internal network of the home as proposed in [5]. And the second point is using it as a backbone for the next generation wireless networks [6]. For the first point, consider the example of using a VoIP phone while moving inside a home. The communication of the home network devices in this case is very similar to an ad-hoc network. So that, this VoIP phone is a client which continuously selects one of the devices in the WMN which function as routers to continue the ongoing session. A multilayered mobility scheme similar to that proposed in [11] can be used. For example, SIP on the VoIP phone can have a direct interaction with the MAC layer of the phone. So that, as the VoIP phone starts to listen to a different router form the current one, the SIP user agent on the VoIP is informed about the current change. Then it sends an update message to a SIP enabled home gateway ,like the one proposed in [4]. The update message traverses the new path to the SIP enabled home gateway carrying out the new path to which such gateway will forward the newly incoming traffic.

From the second point of view, if WMN will take a large part as a backbone technology for next generation wireless networks. Then, Multilayered mobility management schemes will be also proposed at least to handle the vertical handover issues. This way the WMN will be an in-home and out-home technology, which may then simplifies the requirements for the clients, or even unify them. This may lead to a more seamless integration of the home network to the outside ones.

This section introduced the possible benefits from applying the different multilayered mobility management solutions to home networks. It is pretty clear from this section there are numerous meeting points between the current proposals for home networking and those for multilayered mobility management. However, how practical is the utilization of such meeting points towards a better performance of home networks is still an open question.

6 Conclusion

Home networking receives an increasing interest in both research and industry circles. It is a corner stone in the world of the future networking. This paper reviewed home networking from the view points of both purpose and the recent proposals. It is pretty clear from these points of view that home networks require both ease of use and flexible deployment. Wireless networking is key to provide such features to home networks. It is also the enabling technology for many home networks services architectures and solutions. At the same time, multilayered mobility management is a trend in the field of next generation wireless networks. These were the reasons of investigating such multilayered mobility solutions for possible benefits for home networks. The paper reviewed and investigated two multilayered mobility management solutions, viz. SIP-MIP and SIP-HIP. Additionally, the cross layer interaction was analyzed for the same purpose. Finally, the paper suggested possible benefits of multilayered mobility management to home networks. .

At the end, we can conclude that wireless technologies have a major role in home networking. WLAN is a common suggestion for different home networking proposals. However, WMN is really an promising technology for home networks. Multilayer mobility management solutions like SIP-MIP and SIP-HIP may have different influences and benefits to home networking. However, cross layer interaction may be also considered as a trend which can benefit for example WMN as an enabling technology to home networks. However, the paper did not provide final answers for all of the considered issues. Open question about both the investigated multilayered mobility solutions and the possible benefits to home networks were also suggested. But at least, some meeting points have been suggested hoping this may influence home networking some how to flexibly adopt into next generation wireless networks.

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