MYHand: a Novel Architecture for Improving Handovers in NGNs

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***Abstract*—The on demand access, provided by Next Generation Networks (NGN), will allow users of mobile devices to choose from and connect to networks with no pre-established service contract. Besides signal strength, knowledge about different parameters of the available networks shall base the selection of the attachment point to use. No mechanism currently available provides the desired integrated support for network discovery and on demand access. This paper presents MYHand, an architecture for providing extended information in NGN scenarios. By using the IEEE 802.21 protocol Basic Schema and part of the Y-Comm architecture, MYHand improves the handover managed by mobile devices (user-centric management). This paper also presents an extension to the IEEE 802.21 Basic Schema, which is used by MYHand for extra information exchange between mobile devices and heterogeneous networks.**

***Keywords*-NGN; MIH; Y-Comm; Handover Management**

I. INTRODUCTION

Internet service providers currently share a relatively static market where a multitude of mobile devices send and receive data using different wireless technologies. Costs and different aspects of Quality of Service (QoS) are key factors for customer fidelity. Next Generation Networks (NGN) [1] will change this scenario by providing support for multimedia services and device mobility, accompanied by mechanisms for network discovery and selection. Other features of NGNs include the simultaneous support for different transmission technologies and overlapping network coverage.

NGNs will bring the user to the center of a handover decision process, which shall be done transparently, by matching pre-established desired QoS parameters with the characteristics of the available networks. Handover is defined as the switching of the Point of Attachment (PoA) of a mobile device [2]. A handover can be classified as a horizontal handover, which occurs when the new point of attachment is technologically identical to the previous one, or as a vertical handover, which occurs when the new PoA is technologically different to the previous one [3].

An advanced classification of handover divides it into two types: imperative or alternative [4]. Imperative handovers occur due to technological reasons such as signal strength, coverage and QoS, and it is called imperative because there may be a severe loss of performance if they are not performed. Alternative handovers occur due to reasons other than technical issues, such as, pricing, incentives, preferences, context, or available services.

Information about networks within reach includes SSIDs, signal strength and noise ratio, when using IEEE 802.11 interfaces, and network IDs, and frequency related parameters for different 3G networks. Network discovery, however, may imply switching different communication interfaces into a costly scanning procedure. Besides, several QoS parameters, and dynamic billing information cannot be observed by such mechanisms.

Authentication, authorization and accounting (AAA) also challenge the viability of NGNs since, in the envisioned on-demand service model for NGNs, no fixed contract will be required to allow an user access to the available network infrastructures. The use of multiple access technologies becomes an implication, because different terms can be used for the same information. For instance, parameter jitter is called ”jitter” in IEEE 802.11, ”tolerated jitter” in IEEE 802.16, and ”delay variation” in 3GPP networks.

No mechanism currently available provides the desired integrated support for network discovery and on demand access. Even if the support for IEEE 802.21 [5] services are available in a network, terminology issues make it difficult to correctly detect events and match the desired QoS with the offered services. Only a rich and coherent set of information will enable the envisioned dynamic and on demand service selection in NGNs. Dynamic handovers and the free competition among providers shall then benefit users in a virtuous cycle.

As the variety of wireless technologies and mobile devices is increasing, the discovery and selection of networks is becoming an important issue. This paper presents MYHand, an architecture for providing the mobile devices with additional information for dynamic handover decisions in Next Generation Networks. The name MYHand stands for ”MIH-based and Y-Comm-based Handover Management". In the MYHand architecture, network information is provided to the nodes via Y-Comm [4] [6], along with instances of the information service (MIIS), events service (MIES), and command services (MICS) of the IEEE 802.21 protocol [5]. An extension to the IEEE 802.21 Basic Schema (Extended Schema) was also introduced wherewith the provider can offer additional information to the mobile devices, including incentives, thus increasing competition among access providers. MYHand optimizes the handover process as it aids in the early and effective discovery of available networks. A flowchart is presented, which details an alternative handover procedure with minimum throughput requirement, using MYHand architecture. Simulation results based on this architecture show that the mobile user could prioritize a preference without loosing the access quality.

Unlike other works, the proposed extended schema focuses on alternative handover, although MYHand could also be used in imperative handovers. In addition, MYHand is user-centric, i. e., the handover if managed by the user device, as opposed to network-centric, offering greater freedom of choice.

As contributions of this work, we highlight the benefits for providers and mobile users. By adopting the proposed architecture, providers can disclose additional informations other than usual, for instance, incentive information, and thus attract new users. Besides, MYHand can be extended to offer any kind of information, including service offering. The information provided by the MYHand architecture will help the mobile in the discovery and selection of an access network.

The rest of the paper is organized as it follows. Section II presents some approaches to obtain information about available networks. Section III presents some related works. MYHand architecture is presented in Section IV. The last section concludes the paper and suggests some future work.

II. STRATEGIES FOR SELECTING TRANSMISSION INFRASTRUCTURE IN NGN

The choice of a network depends on the knowledge of the available options at each time. For this purpose, an operational entity running on the device in the form of a high-level process or something embedded inside the kernel should do a matching between the user desired features in terms of price and QoS parameters, for instance, and the available options.

There are different approaches to find out the available networks in the mobile device vicinity. At a lower level, it is possible to scan for the available access points of each network interface on the device. Using IEEE 802.11 networks, for instance, it is to know the available access points (APs) and their characteristics such as frequencies and signal strength. The same goes to Wimax and LTE networks. To this end, the decision-making entity should start a scanning process with the desired frequency. A consequence of this periodic scanning is the transmission interruption by the interface being queried, thus decreasing the throughput and increasing the power consumption.

The IEEE 802.21 protocol [5] introduces events that could minimize the need for periodic scanning for mapping available

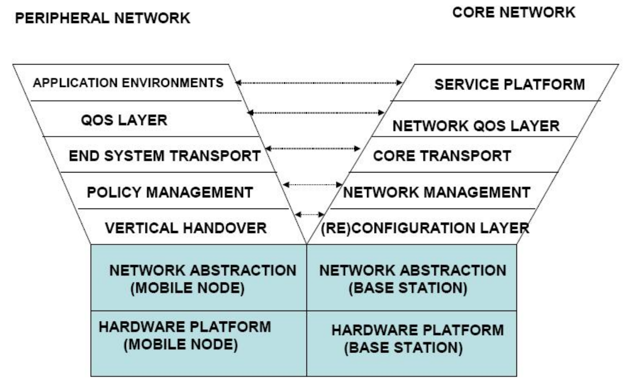

Fig. 1. Y-Comm Architecture, extracted from [6]

access points. If supported by a device, this standard foresees that the network interface itself, possibly using driver support in the operating system, performs a search for the desired network and generate notifications for a client entity that registers interest in such information. At a broader level, an element called MIIS (Media Independent Information Service) may be present in some device on the same network to collect information on the available access points and provide them later to probing customers. In this case, it avoids scanning on each mobile device. The communication between the client decision entities and the MIIS server occurs using application protocols over TCP/IP.

In the Y-Comm project [4] [6], an entity present in the Network Management layer performs equivalent functions to those provided by the MIIS, sending some information to the mobile, such as, network topology, resources, QoS parameters, etc. Obtaining such information also minimizes the need of scanning. The possibility of performing authentication on demand with a target network extends the functionality provided by the IEEE 802.21, but it is expected in Y-Comm, which communicates with several access providers.

The Y-Comm architecture is divided into layers and it is composed by two frameworks, as shown in Fig. 1. The Peripheral Framework, implemented in the Peripheral Network, deals with operations and functions on the mobile, and the Core Framework, implemented in the Core Network, which deals with the functionality required in the core network to support the Peripheral Framework. A detailed explanation about each layer can be found in [4] and [6]. In this paper, the terms Peripheral Framework and Peripheral Network are used interchangeably (the same to Core).

To understand how Y-Comm does handover, Fig. 2 shows a proactive handover procedure. The Network Management layer (NML) provides the AAA system, which is not provided by IEEE 802.21, and stores information about local networks. In the mobile, the Policy Management layer (PML) polls the Network Management layer (NML) to obtain information about all local wireless networks, their topologies and QoS characteristics. This information, along with others provided by higher layers such as, location, speed and direction are

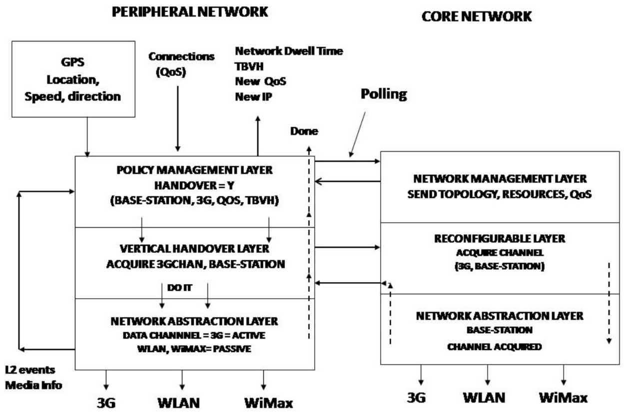

Fig. 2. Proactive handover using Y-Comm, extracted from [4]

used by the PML to evaluate the circumstances under which a handover should occur. The PML can be configured with some rules related to handover decision. The PML also calculates the Time Before Vertical Handover (TBVH) and communicates this information to the Vertical Handover layer (VHL), which requests resources to the Reconfiguration layer. In addition, once the PML decides to hand over, the new IP address, the new QoS, the TBVH and estimated Network Dwell Time are communicated to the upper layers. The Network Abstraction layer, both in the peripheral and core network, is responsible for providing a common interface to manage and control all the network links, and for sending L2 events to the PML.

MYHand is an application of the dynamic negotiation model trading under Y-Comm project, adding facilities of the MIHF (Media Independent Handover Function) services (event, information and command) supported by an extension of the Basic Schema. This extension provides a more efficient interaction between mobile and access network in terms of information exchange.

III. Related Work

There are several works related to network discovery and handover optimization using IEEE 802.21 protocol. In [7] the authors propose a multiple attributes decision making-based terminal controlled vertical handover decision schema using IEEE 802.21. The proposed schema is compared to RSS-based and cost function-based schema through simulations, which show that the proposed schema provides smaller handover times and lower dropping rate than the RSS-based and cost function-based vertical handover methods. But the authors focus on decision making in the integrated Wi-Fi and Wimax networks. MYHand architecture is designed to work with any network technology. In [8] the authors propose an architecture of MIIS server and the procedures for handover optimization, which avoid scanning and reduces energy consumption, but the management is network-controlled. Both works are aimed for imperative handover.

A lot of work focuses on handover optimization. Rizvi et. al. [9] presents an intelligent vertical handover decision algorithm and points out other works. In [10] the authors present an overview of the handover decision strategies, which are classified in categories, and present a new approach which considers context-aware and policies, aided by a Fuzzy Logic system. In [11] the authors present a multiservice vertical handover decision algorithm (MUSE-VDA) and a general cost function used to choose a target network. In [12] the authors describe a policy based handover decision algorithm (POLIMAND) and point several link layer parameters in heterogeneous networks used in the decision making. These works do not use IEEE 802.21, in a way that higher layers do not receive notifications from the lower layers when an important event occur.

The IEEE 802.21 protocol does not specify how the information of the available networks is filled in the databases. The authors in [13] propose a mechanism for this. Thus, this related work can be used as an adjunct to MYHand. In [14] the authors propose a new architecture for network discovery and a solution for the construction of the information database. Their work focuses in mobile-assisted and network-assisted proactive handover (when the mobile attempts to know the condition of the various networks at a specific location before the mobile node reaches that location) and pre-authentication. In this architecture, the information stored in the servers is restricted to the ones registered by the mobiles from visited networks and the information that Reporting Agents (RAs), present in each network, catch via SNMP and send it to the information server. In [15] the authors propose an Hierarchical IEEE 802.21 Information Service Management infrastructure, which places MIIS servers in three levels: Zone MIIS, Local MIIS, and Global MIIS, aiming to improve the response time. In the MYHand architecture, the Y-Comm information server obtains information from many different places as, for instance, its local database, MIIS servers, and other information services such as the WFP server [16].

The works related to network discovery found in the literature concerned with technological information, needed for imperative handover process. MYHand extends the network discovery by embedding additional information related, for instance, to incentives, required for alternative handover process [17]. The extended schema presented in this paper is focused on alternative handover, but MYHand can optimize both, imperative and alternative handovers.

IV. MYHand architecture

This section presents the extended schema and the MYHand architecture, as well as its validation.

A. IEEE 802.21 Information Service Schema

The Information Service Schema is an RDF/OWL ontology (Resource Description Framework / Web Ontology Language). The schema is used in the IEEE 802.21 Information Service to define the structure of each information element, as well as the relationship among the information elements. The IEEE 802.21 Information Service schema is supported by every MIHF that implements the MIIS to support flexible and efficient information queries.

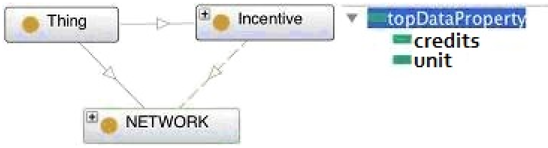

Fig. 3. Proposed Extended Schema Relationship

```
<owl:Class rdf:about="file:&mihextended;Incentive"/>

<owl:ObjectProperty rdf:about="file:&mihextended;incentive">
   <rdfs:range rdf:resource="file:&mihbasic;NETWORK"/>
   <rdfs:domain rdf:resource="file:&mihextended;Incentive"/>
</owl:ObjectProperty>

<owl:DatatypeProperty rdf:about="file:&mihextended;credits">
   <rdfs:comment>Credits to be assigned to user during the network
     usage. It is associated to property 'unit'.</rdfs:comment>
   <rdfs:range rdf:resource="&xsd;integer"/>
</owl:DatatypeProperty>

<owl:DatatypeProperty rdf:about="file:&mihextended;unit">
   <rdfs:comment>Amount of time, in seconds, that the user must keep
     connected for gaining the amount of credits. For instance, the incentive
     is 3 credits for each 60 seconds connected.</rdfs:comment>
<rdfs:range rdf:resource="&xsd;double"/>

</owl:DatatypeProperty>
```

Fig. 4. Proposed extended schema definition

The RDF/OWL schema definition for MIIS consists of two parts: the basic and the extended schema. The MIIS RDF/OWL representation method is extensible using an extended schema.

B. Proposed Extended Schema

Due to the independence of service-related functions from underlying transport technologies in NGNs, and appearance of new technologies, it is expected more concurrence among access providers. The proposed schema extends the selection of new networks, embedding information related to incentives, enriching the alternative handover, in which the device may choose the target network based on incentives.

Fig. 3 shows the proposed extended schema in the form of a new element, called Incentive, which is related to Thing and NETWORK. Thing is a generic element of RDF/ OWL language which defines the basic type for an element, from which all other elements inherit their properties. The element NETWORK aggregates information from other elements, related to a certain network, such as network type, Point of Attachment list, Operator ID, among others, and the Incentive element becomes another attribute of NETWORK.

The element Incentive is a simple example on how MYHand architecture can improve handovers. This element provides information about amount of credits offered to the user, who connects to a certain access provider. This amount of credits can be used for future connections, for gaining discounts for example, and thus be an attractive to the loyalty of the user. This element has two properties, according to Fig. 3:

Credits: credits to be assigned to the user during the network usage. It is associated to property 'unit';

Unit: amount of time, in seconds, that the user must keep connected for gaining that amount of credits. For instance, the incentive is 3 credits for each 60 seconds connected.

Part of the proposed extended schema definition is shown in Fig. 4 as an XML document. The extended schema is obtained through DHCP service by the same way that the Basic Schema [5].

C. MYHand architecture

Fig. 5 presents the MYHand architecture with four entities involved: the MobileNode (MN), the Serving Point of Attachment (PoA-S), with a co-located Serving Point of Service (PoS-S), a Candidate / Target Network and a MIIS Server, each of them with IEEE 802.21 modules properly inserted in the Y-Comm layers.

The Mobile Node (MN) can have more than one network interface. The MIHF module is located in the Network Abstraction Layer and it is responsible for the abstraction of the network interfaces to the higher layers. This module receives commands and sends events and information to the Handover Manager module, receives commands from Vertical Handover Manager and forwards commands from higher modules to remote MIHFs. The Service Access Points MIH_SAP, MIH_LINK_SAP and MIH_NET_SAP are the interfaces between the MIHF and the other modules. The Handover Manager module acquires information from the device, user and networks (MIH_Get_Information and MIH_MN_HO_Candidate_Query commands) and it decides when and to which antenna a handover should be done. The Vertical Handover Manager module receives commands from the Handover Manager module calling for a handover (do_handover), acquires target network resources and actually performs the handover (MIH_MN_HO_Commit). Both, the Handover Manager and Vertical Handover Manager modules are implemented as MIH Users. The Mobile IP protocol allows the user mobility at network level.

Still in Fig. 5, the PoA-S/PoS-S is the network point to which the MN is directly connected. In the PoS-S and other PoSs, the MIH-LINK-SAP is not necessary because the MIH Users do not need to communicate with modules below the MIHF. The MIHF module abstracts the network interface to the upper layers and forwards remote MIH commands to the respective modules. The Handover Manager module acts as an MIIS Server proxy and it is the responsible for providing information to the MN. This information can be gathered from a local database, a server information MIIS Server (MIH_Get_Information) or other possible sources. This module also verifies resource availability at candidate networks by means of the MIH_N2N_HO_Query_Resources message. The Resources Manager module (RM) requests resource allocation to the MN in the target network.

In the Candidate/Target Network, the MIHF module also abstracts the network interface to the upper layers and forwards

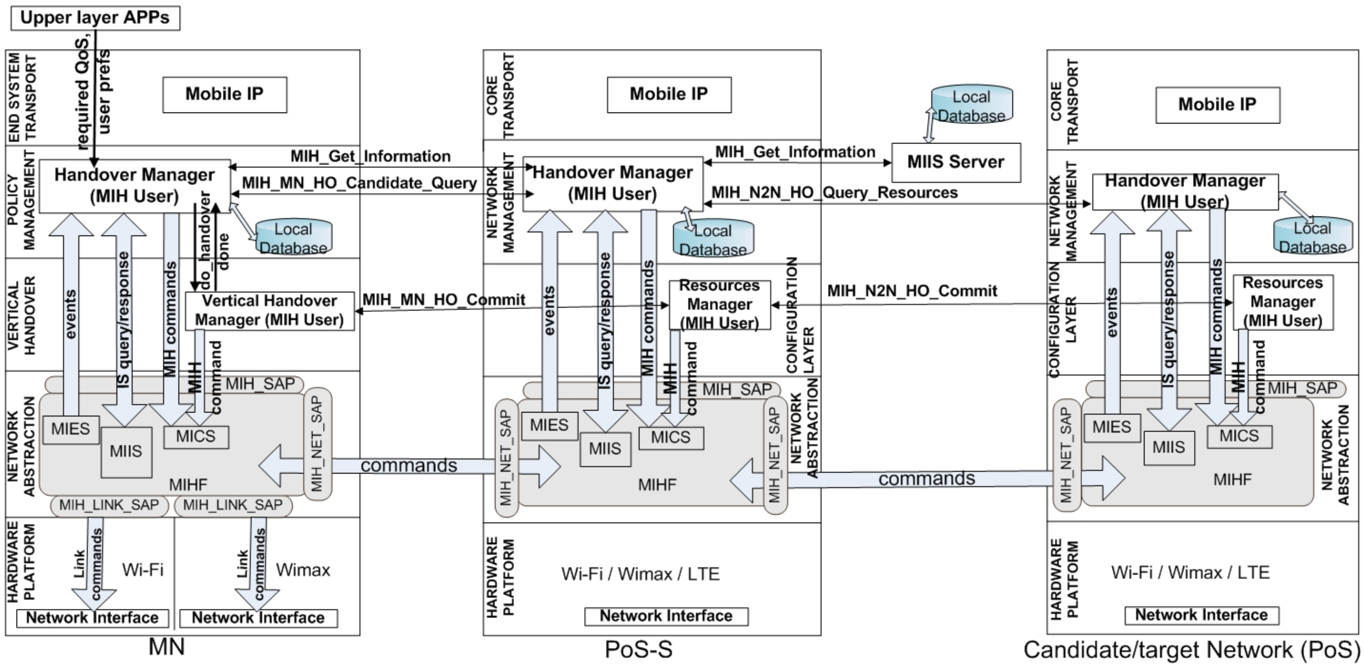

Fig. 5. MYHand architecture

remote MIH commands to the respective modules. The Handover Manager module checks and informs to the Handover Manager of the PoS-S about resource availability for new connections. The Resources Manager module (RM) allocates network resources to an user who will connect to this access point, when requested by the RM of the PoS-S.

In the MIIS Server, the module which implements the information server receives and responds to information requests about available networks in a given area.

For better understanding the architecture operation, Fig. 6 shows a flowchart which details an alternative handover procedure with minimum throughput requirement, which prioritizes the amount of credits that a provider offers, as explained in Section IV-B. IEEE 802.21 commands are started by ”MIH_”.

Before starting the handover, the MN is connected to network A by means of its Wi-Fi interface and it is running an application with a minimum throughput requirement. Higher layer applications in MN inform the Handover Manager module (with an appropriate frequency) on information about minimum QoS and user preferences (provider, access technology, price or minimum credits, for instance). In the case the MN is not yet connected to any network, a scanning is necessary, through the MIH_Link_Actions.request command, to search for an available network. This command reports information about AP address, network ID, signal strength, among others.

To enable an alternative handover, the Handover Manager module (HM) of the mobile node periodically requests information to the HM of the PoS-S on available networks in that area by means of the MIH_Get_Information.request message. In this message, the MN sends its location and desirable access technology (according to its available network interfaces and user preferences) and receives information (MIH_Get_Information.response) on each network as, for instance, provider SSID, roaming partners, access cost, maximum data rate, and credits to be gained (in the case of our extended ontology), and information about each available antenna as, for instance, MAC address, technology, geographic location, channel, and IP address. Eventually the HM of PoS-S can query the MIIS to update information. All remote MIH messages pass through the MIHF of the respective entities.

The MN can identify each network as belonging to a provider to which it has a contract or belonging to a partner of its home provider (through the roaming partners information of the IEEE 802.21 protocol).

If, after a query for available networks, the MN identifies a network offering more credits than the network currently being used, the HM module can decide to do a handover to that network. As the application requires a minimum throughput, the HM module sends an MIH_MN_HO_CandidateQuery.request message to the HM module of the PoS-S, requesting resources verification, stating which networks must be checked (candidate networks) and the minimal required resources. This module, in turn, queries the resources availability in each candidate network by sending an MIH_N2N_HO_QueryResources.request message to the HM module of each candidate network, advising which resources are required. So, the HM of the PoS-S joins the information about those networks and responds to the MN with an MIH_MN_HO_CandidateQuery.response message.

Having all the necessary information, the HM module of the MN decides if a handover should be done. If so, it sends the do_handover command to the Vertical Handover Manager (VHM) to proceed with the handover, stating the link type (Wi-Fi, LTE, etc) and to which network the handover should be

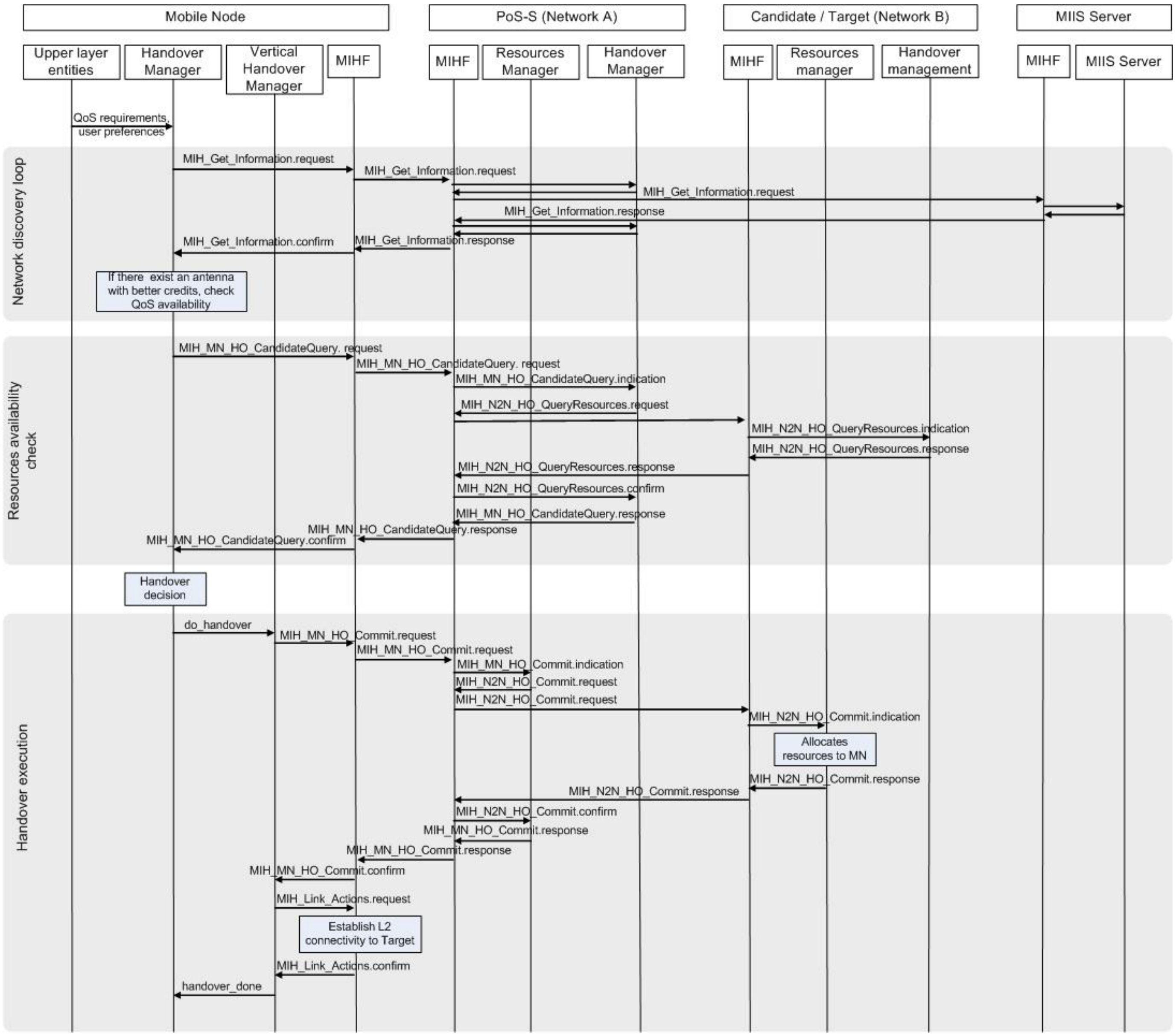

Fig. 6. Alternative handover flowchart

done. The VHM module notifies the Resources Manager (RM) of the PoS-S about the selected target network, by means of an MIH_MN_HO_Commit.request message. The RM module of the PoS-S sends the MIH_N2N_HO_Commit.request message to the RM module of the target network to advise that the mobile will connect to that network. Then the RM of the target network allocates the resources for the MN and replies sending a MIH_N2N_HO_Commit.response message advising on sucess or not. If so, the RM module of the PoS-S notifies the VHM of the mobile on the success of the operation by means of an MIH_MN_HO_Commit.response message.

Having the resources already allocated on the target network, the VHM module sends an MIH_Link_Actions.request command to the MIHF requesting that the interface is turned on to establish the connection at the link level to the target antenna in a given channel, or requesting that the current interface disconnects the current antenna and connects to the target antenna. Finally, the connection to the target is established and the VHM module informs the HM module that the handover is done (handover_done message).

After, Mobile IP is executed in the MN, Home Agent and Foreign Agent to keep the connection at transport layer.

D. Architecture Modelling Validation

For validating the modelling of the MYHand architecture, a scenario with 3 access providers (P1, P2 and P3) was simulated by using NS2 (Network Simulator 2) [18]. Although NGN networks foresees the usage of different technologies with signal overlay, the aim of this validation is focusing in

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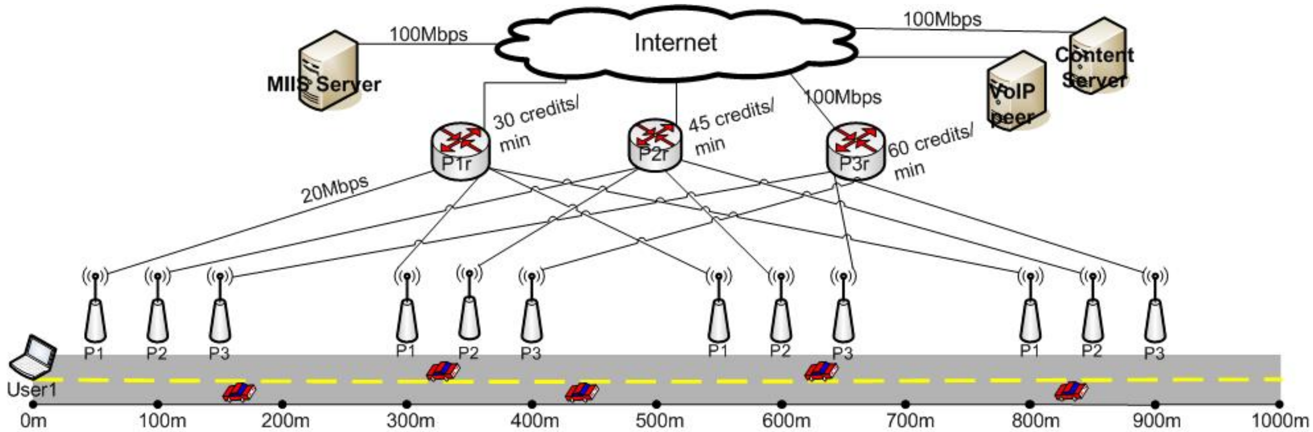

Fig. 7. Simulated scenario

the MYHand architecture with information about incentive. Because of this, only one wireless technology was simulated. Each provider has 4 Wi-Fi antennas positioned along an 1000 meters avenue, as showed in Fig. 7. Each antenna covers, approximately, 200 meters diameter. P1r, P2r and P3r are edge routers belonging to providers P1, P2 and P3, respectively. The link speed between each antenna and the edge router is 20Mbps, the delay is 10ms, and Droptail queue.

A mobile (User1) walks through the avenue handing over according to a specific handover decision policy, totalling a 15 minutes walk (common speed of 4 km/h, i.e., 1.11 m/s). Two decision policies were adopted. In the first policy, the mobile prioritized signal strength, as commonly simulated in the state-of-the-art, and in the second policy the mobile prioritized the amount of credits offered by each provider, using MYHand. Provider P1 offers 30 credits for each minute that the mobile stay connected, Provider P2 offers 45 credits and Provider P3 offers 60 credits. Three different amount of credits were simulated such that the mobile could gain more or less credits according to the policy (prioritizing credits or not).

To generate traffic in the scenario, each simulation had 3 fixed users in each antenna, at most 10 meters away from the antenna, downloading a 100 Kbps constant bit rate whose source was the host Content Provider. To verify the influence of the traffic in the total of credits gained, other simulations were realised with 6, 9, 12 and 15 users connected in each antenna. In the mobile a VoIP connection, whose peer was the host VoIP peer, was simulated. The link speed between hosts Content Provider and VoIP peer, and the core network is 100Mbps, the delay is 2ms, and Droptail queue. The total of received bytes and gained credits were measured in each simulation. Varying number of users and the policy, 10 different simulations were executed.

The propagation model used was shadowing. The loss exponent and the shadowing deviation parameters were, respectively, 3.2 and 4, characterizing an external environment of an urban area, according to [18]. The MAC layer was configured to the IEEE 802.11g standard by following the parameters used in [19]. The routing protocol used was NOAH

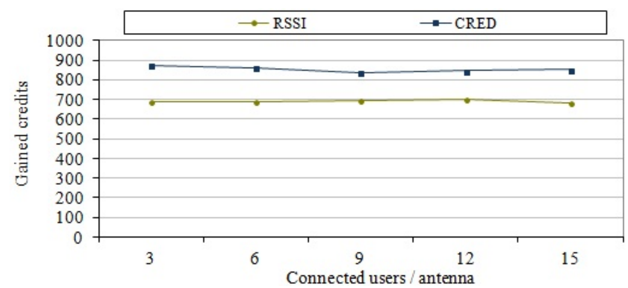

Fig. 8. Results of gained credits

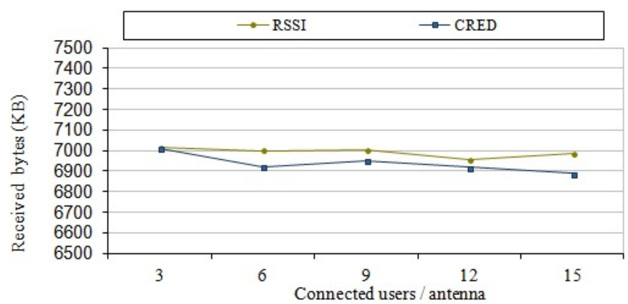

Fig. 9. Results of received bytes

[20], suitable for the infrastructure mode.

The results of gained credits by the User1 as a function of the number of connected users are shown in Fig. 8. In all simulations in which the amount of credits was prioritized, the mobile User1 gained more credits than RSSI prioritization (between 20.7% and 26.7% more). The increase in the number of users, and traffic, did not affected the amount of gained credits, because it was not verified a drop or an increase trend.

Fig. 9 shows the amount of received bytes as a function of the number of connected users. In the simulations prioritizing credits, the amount of received bytes decreased compared to RSSI prioritization but it was 1.38% in the worst case, not a significant loss.

The same 10 simulations were duplicated by changing the credits offered by providers P1, P2 and P3, respectively, 10,

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20 and 30 credits. The results were similar to the former.

The cost to the mobile for gathering incentive information was not measured because the architecture is not implemented, but it would be a few dozen of bytes. These informations will be received together to other basic schema informations, there being no need for scanning.

The handover process can be divided into three stages: decision, initiation and execution, and all these stages have dynamic features. These features do not affect MN ability to identify each network as belonging to a provider to which it has contract. The MN identifies the provider by means the SSID and roaming partners information, provided in the MIH_Get_Information.response message.

V. Conclusion and Future Work

Next Generation Networks (NGN) empower the users of mobile communication devices to opportunistically navigate through different access networks. Network selection can change according to the circumstances of offered services and required transmission parameters. An extended AAA mechanism provides on-demand connectivity to the devices even without a pre-established access plan. Specific information on the available networks and offered services must be provided to the handover decision mechanism on the mobile.

This paper presented the MYHand architecture, for providing the mobile devices with extended information for performing conscious alternative handover decisions. The architecture combines the use of the Y-Comm model and the IEEE 802.21 protocol, which is incremented with an extended schema. The MYHand architecture does not specify a decision algorithm, but assists in the decision-making process performed at the mobile device.

Validation results show an increase of 26.7% in the gained credits by using the MYHand architecture, compared to signal strength prioritization, as proposed by other works in the state-of-the-art. A decrease in the throughput using the new architecture was observed but it was less than 1.4%.

According to the MYHand architecture, different incentives and negotiation procedures can be used in the network selection mechanism, as exemplified by the rank-based model presented in this paper.

As future work, we intend to extend the architecture to include other informations, and to implement policy and access parameters negotiation between mobile and network.

Another possible future work is simulating a heterogeneous scenario with Wi-Fi and LTE antennas and evaluating the benefits of the new architecture in terms of amount of resources, robustness of RDF/OWL ontology, and the reliability if occurred changes in terms of territorial coverage area, speed of the user' moving, etc.

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