NIHO: Network Initiated Handovers for next generation ALL IP Networks

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I. INTRODUCTION

Several indicators point towards the co-existence of heterogeneous networks in the future. These relate to multiple types of access technologies ranging from the fixed network solutions, the 2G/3G networks to the IEEE 802.x, as well as the extension of the existing connection types to ad-hoc, multi-hop, sensor and moving networks. Operators and manufacturers have taken up the development and introduction of dual-mode and multi-mode handsets to permit connectivity across 3G and WLAN-based networks. Currently discussed standards still fall short of providing universal solutions that support seamless integration of these networks. Users on the move will experience service discontinuities, so such standardized solutions can only be regarded as a first step.

Tomorrow's customers will expect the network, and in particular its technological structure, to "disappear" and be of no concern. Along these lines, some solutions [1], [2], [3], [9] have been proposed to support seamless mobility based on the Internet Protocol version 6 (IPv6). While this previous work has shown that the basic concepts are viable, the Daidalos project [4] has moved to a comprehensive approach to provide seamless and pervasive end-to-end services across heterogeneous technologies, offering a broad range of services accessible anytime and anywhere regardless of the wireless or wired technology.

The focus of this demo is on one of the functions included in the Daidalos architecture - the Network Initiated Handover (NIHO) function. This function aims at solving a problem of existing IP based architectures. Specifically, in existing architectures handovers are typically initiated by terminals upon detecting that the quality of the signal received from the Access Point (AP) or Base Station (BS) degrades below a certain threshold. However, this can easily lead to non optimal distributions in which some APs are heavily loaded while neighbouring APs -that could take part of this load- are underutilized.

In order to address the above problem, the Daidalos architecture combines mobile-initiated handovers (MIHO) with network initiated handovers (NIHO). With NIHO [8], handovers are triggered by the network based on global information such as load distribution. In this way, it can be guaranteed that the load distribution among the various APs in the network is optimal. The NIHO function involves the decision of which handovers to trigger as well as their execution. The rest of this document is structured as follows: in sections II and III we explain, respectively, the operation of NIHO decision and NIHO execution processes. In Section IV we explain the demo setup.

II. NIHO DECISION FUNCTION

The NIHO operation is depicted in Figure 1. NIHO may be triggered either by the degradation of the quality of the signal received from the MT (Mobile Terminal) by the AP or when the load of an AP exceeds a predefined threshold. NIHO decisions are taken with the goal of optimizing global performance in a region. These decisions are taken by the PM (Performance Management) module in conjunction with the QoSB (QoS Broker) engine module. To this end, AP load data as well as data related to signal strength are sent to the PM module according to the process described in the following.

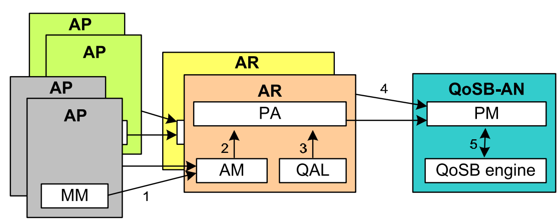

Figure 1 NIHO decision operation

Signal strength measurements are taken by MM (Measurement Modules) at the APs and from there they are transferred to the AM (Aggregation Modules) at the ARs (message 1), which aggregate all the information received and provide it to the PA (Performance Attendant) (message 2). By measuring the strength of the signal received from a given MT at all the APs of a region, it is possible to estimate all the candidate APs that provide good signal quality to this MT. In addition to signal strength data, the PA also collects load-related information from the QAL (QoS Abstraction Layer) modules (message 3). The data of all the PAs of a region is sent to their corresponding PM module (message 4).

With all the above information, the PM is aware (through the QoS related data) of the load of the various APs of the region, and is also aware (from the measurements taken) of the possible candidate APs that each MT may be handed over to while preserving a good signal quality. Based on these data, the PM can then decide the AP to which each MT should be attached to such that 1) load is optimally distributed among all the APs of a region, and 2) the signal strength of all connections is good. These decisions are checked against the QoSB engine in order to make sure that end-to-end QoS requirements are kept for the connections (message 5). At this point the handover execution process starts (see next section).

III. NIHO EXECUTION FUNCTION

The handover execution procedure is time critical, since it needs to be performed without users' awareness. The sessions need to be transferred from the old to the new network without noticeable disruptions. Our procedure is an extension and enhancement of the Fast Handovers for MIPv6 [6]. It includes Duplication and Merging (D&M) to minimize the data packet losses and delays during handover, Context Transfer (CT) to transfer mobility and security information to the new network, and integration with QoS modules to assure that the QoS requested by the MT is preserved after the handover.

Figure 2 presents an overview of the integrated FHO operation. The protocol operation involves the MT, the old and new ARs (oAR and nAR) and QoSB. When the PM initiates a NIHO, the QoSB informs both the nAR (message 1) of the QoS requirements and the oAR about the handover decision (message 2a and 2b).

After the oAR processes message 2, it triggers the CT, instructs the D&M to start duplication, and informs the MT that it SHOULD move to the network provided in the message ProxyRouterAdvertisement (messages 3a, 3b, 3c). When duplication is activated, the oAR forwards any data directed to the MT to the nAR for its delivery to the MT, in order to minimize data loss during the handover process. The context information to be transferred includes security related information; note that QoS-related context does not need to be transferred by CT since it was previously transferred directly through the QoSB.

As soon as the MT receives a ProxyRouterAdvertisement, it starts the merging process (messages 4a, 4b, 4c and 4d), whose function is to filter out the duplicated packets received from the oAR and the nAR and deliver only one copy of each packet to the applications. Then, the MT sends a FastBindingUpdate (FBU) message (message 5a) to the oAR, which informs the QoSB of the MT's decision (message 5b and 5c). This is followed by disconnection from the current link and attachment to the new one. Specifically, the FHO (Fast Handover) module in the MT notifies the MTC (Mobile Terminal Controller) of the decision to perform disconnection from the previous interface (message 6a), and the MTC notifies the MAL (Mobility Abstraction Layer) about the target AP the terminal should attach to (message 6b).

Upon connection to the nAR interface [10]the MT sends a *FastNeighbourAdvertisement* (FNA) message (message 7). By means of this message, the IPv6 neighbor cache is updated and packets are forwarded to the terminal. The nAR informs the QoSB that the MT is attached on the new link (message 8), and therefore this indication is then forwarded to the oAR (message 9) in order to delete reservations (messages 9a), and stop D&M (messages 9b, 9c and 9d). If this message is not received at the oAR within a time period, the oAR will nevertheless terminate the D&M process and release the QoS reservation. After this process, the oAR informs the QoSB (message 10) that the reservation release actions have been successfully performed

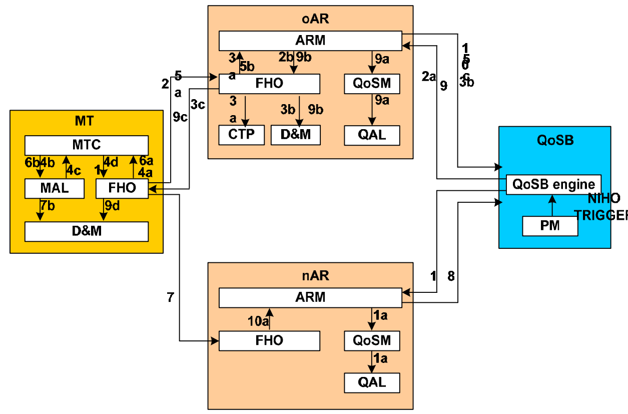

Figure 2 FHO Operation

IV. DEMO SETUP

The proposed demonstration is based on a prototype implemented on Linux 2.6.8.1 with MIPL basic Mobile IPv6 support for Wireless LAN technology [7]. In order to optimize the WLAN to WLAN handover latency we introduced modifications to the behaviour of the HostAP WLAN driver in the MTs and in the APs. A normal WLAN driver decides about handover and executes it only based on signal strength. The handover decision and execution can be done at firmware or driver level because all the information required is available in both places. In our architecture, the handover decision is influenced by other factors and therefore the decision cannot be taken at the firmware/driver level. Besides, in our architecture the decision must be separated from the execution. For this reason, the first modification we implemented was to disable automatic handovers and use a function to force handover execution when it is required.

In NIHO [8] APs are required to measure the signal strengths of the MTs connected (using different channels) to other APs. In order to make these measurements, we have installed a second WLAN card at the APs whose function is to scan all channels periodically and perform passive measurements on the signal strength detected from the MTs. QoS functions, required for NIHOs, have been developed based on the algorithm of [5] for admission control in WLAN.

The demo setup is illustrated in Figure 3 and described in the following†. Initially, the MT has requested 500 Kbps bandwidth and is connected to AR1. This bandwidth suffices for an audio application but not for a video one, as will be

† Space allocation: one table 1 x 2 meters. Extra equipment required (in addition to the equipment shown in the figure): one laptop and one or two standard VGA LCD screens.

shown by running the respective applications. If the MT wants to run a good quality video it will have to request for more bandwidth (2 Mbps). The problem is that AR1 is already loaded with other terminals (not shown in the figure) and therefore when increasing the bandwidth of the MT, AR1 becomes heavily loaded. This is why, upon detecting AR1 high load after the MT's request, the QoSB decides to trigger a NIHO. The execution of the NIHO will be shown by some graphical application in addition to some real captures of the signaling messages. Once connected to AR2, which is not loaded by other terminals, the MT experiences a larger bandwidth and can run video and audio applications. The Correspondent Node can be a node of a NEMO, which is another component of the Daidalos architecture that has also been submitted as an INFOCOM demo. This would show the interaction between these two components of the Daidalos architecture.

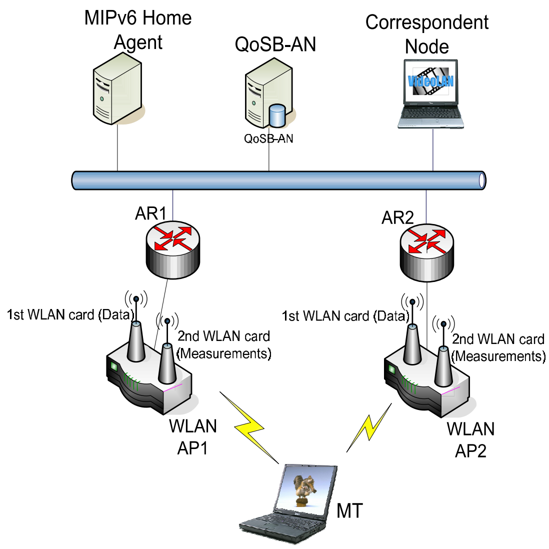

Figure 3 Test Network

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