NEMO: Network Mobility. Bringing ubiquity to the Internet access

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***Abstract*— The success of cellular communications networks shows the interest of users in mobility Terminal mobility support in IP networks is a first step in the adaptation of these networks to the needs of users in this field. But, there exists also the need of supporting the movement of a complete network that changes its point of attachment to the fixed infrastructure. This demo presents an implementation of the basic mobility support solution standardised by the IETF, as well as multicast extensions and some optimisation mechanisms proposed within the European DAIDALOS project.**

Keywords: Network Mobility, Route Optimisation, NEMO

I. Introduction

The success of cellular communications networks shows the interest of users in mobility. These networks are evolving to provide not only the traditional voice service but also data services. IP appears to be the base technology of future networks, to provide all kind of services and through different access technologies, both fixed and mobile. Nevertheless, IP was not designed taking into account mobility of users and terminals, and in fact, IP does not support it, neither in IPv4 nor in IPv6.

The IETF has defined some IP-layer protocols that enable terminal mobility in IPv4 [1] and IPv6 [2] networks. Nevertheless, these protocols do not support the movement of a complete network that moves as a whole changing its point of attachment to the fixed infrastructure, that is, network mobility. The IETF created a working group: NEMO (from Network Mobility), with the aim of extending existing host mobility solutions to enable the movement of networks in IPv6.

II. Network Mobility in IPv6

IP networks were not designed for mobile environments. Both in IPv4 and IPv6, IP addresses play two different roles. On the one hand, they are locators that specify, based on a routing system, how to reach the terminal that is using that address. On the other hand, IP addresses are also part of the end-point identifiers of a communication, and upper layers use the identifiers of the peers of a communication to identify it.

The problem of terminal mobility in IP networks has been studied for a long time within the IETF, and there exist IP-layer solutions for both IPv4 [1] and IPv6 [2] that enable the movement of terminals without stopping their ongoing sessions. Terminal mobility support in IP networks is a first step in the adaptation of these networks to the needs of users in this field. But, there exists also the need of supporting the movement of a complete network that changes its point of attachment to the fixed infrastructure, maintaining the sessions of every device of the network: what is known as network mobility in IP networks [4]. In this case, the mobile network will have at least a router that connects to the fixed infrastructure, and the devices of the mobile network will obtain connectivity to the exterior through this mobile router. The IP terminal mobility solution does not support, as is now defined, the movement of networks. Because of that, the IETF NEMO WG [5] was created to specify a solution, at the IP layer, to enable network mobility in IPv6.

The terminology used by the NEMO group names a router that provides connectivity to the mobile network as a Mobile Router (MR). Devices belonging to the mobile network – that obtain connectivity through the MR – are called Mobile Network Nodes (MNNs) and there are different types: Local Fixed Node (LFN), that is a node that has no mobility specific software; Local Mobile Node (LMN), that is a node that implements the Mobile IP protocol and whose home network is located in the mobile network; and Visiting Mobile Node (VMN) that is a node that implements the Mobile IP protocol, has its home network outside the mobile network, and it is visiting the mobile network.

The network mobility basic solution (see Figure 1) for IPv6 [6] [11] is conceptually similar to that of terminals. It is based in the set-up of a bidirectional tunnel between the MR and its Home Agent (HA). The HA is located in the home network of the mobile network, that is, in a location where the addressing of the mobile network is topologically correct. All the traffic addressed to the mobile network is delivered to its HA, that send it towards the MR through the tunnel. The MR removes the tunnel header and forwards the traffic to its

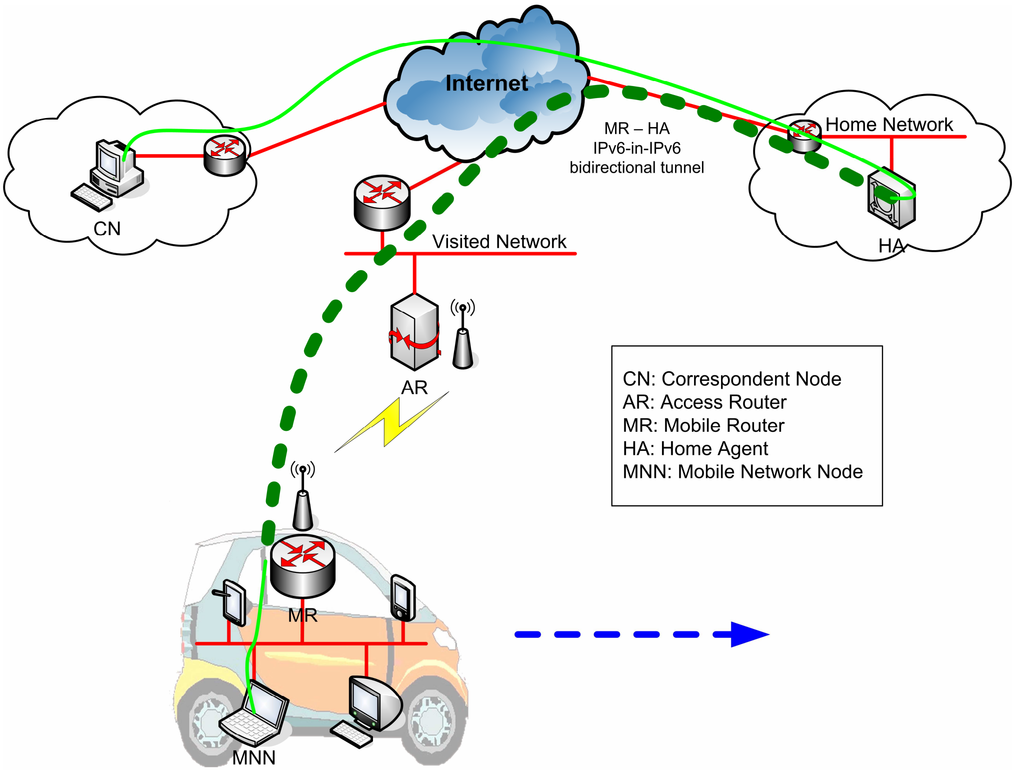

Figure 1 NEMO Basic Support protocol operation

destination within the mobile network. The traffic originated in the mobile network is sent by the MR towards the HA through the tunnel, the HA removes the tunnel header and forwards the packets to their destination.

III. MULTICAST SUPPORT

To support multicast traffic for mobile networks, the MR can use the bi-directional tunnel (BT) between the HA and the MR's CoA located in the visited network. Alternatively a remote subscription (RS) to a multicast group within the visited network as described in MIPv6 [2] is feasible. With respect to multicast traffic to and from mobile networks, the BT approach may prove inefficient in terms of non-optimal (triangular) routing, breech of the multicast nature of the flow, and limited scalability. The main disadvantage of applying RS for multicast services emerging or terminating within mobile networks is the required frequent re-construction of the multicast tree, especially if the traffic source is moving fast, resulting in high latency and network traffic overhead. The approach considered in project DAIDALOS consists of combining both methods depending on current environment and communication parameters. Upon subscription of a node within the mobile network to a multicast group or transmission of multicast traffic, the MR forwards the request or the traffic to the HA utilising the MLD (Multicast Listener Discovery) [7] protocol. Subsequently the corresponding data traffic or group control messages are forwarded by the HA back to the MR. This proxy functionality of the HA is described in [8]. In case of reduced mobility of the sub-network detected by means of low handover (CoA change) rate, the MR initiates routing of multicast traffic via the remote access point.

IV. ROUTE OPTIMISATION FOR UNICAST FLOWS

The DAIDALOS route optimisation solution for unicast flows is called MIRON [9], [10]. MIRON is a route optimisation protocol that mainly deals with two of the problems introduced by the use of the MR-HA bidirectional tunnel specified by the NEMO Basic Support protocol [6]: on the one hand the angular (also called "triangular") routing problem, and on the other hand, the multiple tunnels and the multi-angular (also called "pinball") routing present in nested networks (that is, mobile networks that get access for other mobile networks). In this demo, only the mechanism that avoids angular routing is shown.

The triangular routing problem is not specific to mobile networks. MIPv6 mobile hosts encounter the same issue. In order to solve such inefficiency, MIPv6 defines a route optimisation procedure, essentially based on the following: When a communication between a mobile node and any other end system (called Correspondent Node, CN) is established, all the traffic – in both directions - initially goes through the HA. But the mobile terminal can initiate a route optimisation process by sending location information (i.e., Binding Updates) directly to the CN. As it has been previously described, the BUs sent to the HA are protected with IPsec, but this operation does not seem viable in case of BUs sent to CNs, as it cannot be assumed that every mobile terminal has a trusting relationship with every potential CN in the IP network. Therefore, an alternative mechanism, called Return Routability (RR) is used. This mechanism is based on the verification that a node is reachable at the same time through its Home Address and also through its Care-of Address. In the approach followed by MIRON to avoid the triangular routing in the network mobility case, the MR acts as a proxy, performing the route optimisation procedure with the CN on behalf of the nodes of the mobile network. In this way, the MR sends to the CN location information that binds the MNN's address to the MR's CoA. The most important benefit of MIRON is that it allows a quick deployment of the route optimisation support in an IP network, like for example Internet. This is because of two main reasons: first, the route optimisation is transparent to the nodes of the mobile network, which is especially relevant for LFNs (i.e., nodes with no specific mobility software) and, second, it allows using the MIPv6 route optimisation support already available at the CNs.

V. DEMO SETUP

The proposed demonstration is based on a prototype implemented on Linux 2.6.8.1. As it has been described before, the NEMO Daidalos architecture basically deals with three different issues: the provision of Network Mobility support, by implementing part of the NEMO Basic Support protocol [6], the provision of Multicast support to mobile networks (since the aforementioned NEMO Basic Support protocol does not provide support for multicast traffic within a Mobile Network) and last, but not least, the route optimisation of unicast traffic (since the use of the bidirectional MR-HA tunnel introduced by the NEMO Basic Support protocol is clearly inefficient, in terms of delay, packet overhead and reliability).

The setup of the demo is shown in Figure 2 and consists of the following: a laptop/small PC that acts as Home Agent, two hardware Linksys routers that act as Access Routers, a laptop that acts as Mobile Router, two other laptops and a PDA, acting as Local Fixed Nodes and a laptop/small PC acting as Correspondent Node. All the machines run Linux, but the PDA, that runs MS Windows Pocket PC 2003.

To show the Basic Network Mobility Support, the Mobile Network is initially attached to Access Router (AR) 1. Then, any of the nodes of the Mobile Network starts a communication with the CN (a UDP video stream served by the CN), while the complete network moves from AR1 to AR2. To show the multicast support, two LFNs start playing a video stream multicast from the CN, while the network roams between the different access networks. The last part of the demo shows the route optimisation solution designed in Daidalos (MIRON) [10]. To illustrate this, a video is streamed from the CN to this PDA connected to the mobile network, showing that the traffic is no longer following the suboptimal LFN-MR=HA-CN path but the direct LFN-MR-CN path. Of course, as in the previous cases, the mobile network (the car) may move without breaking the communications.

In the demo, the Correspondent Node can be a node that is itself mobile, and belongs to a different Daidalos demonstrator (NIHO demo) that is also shown as an Infocom demo. This would show the interaction between these two components of the Daidalos architecture.

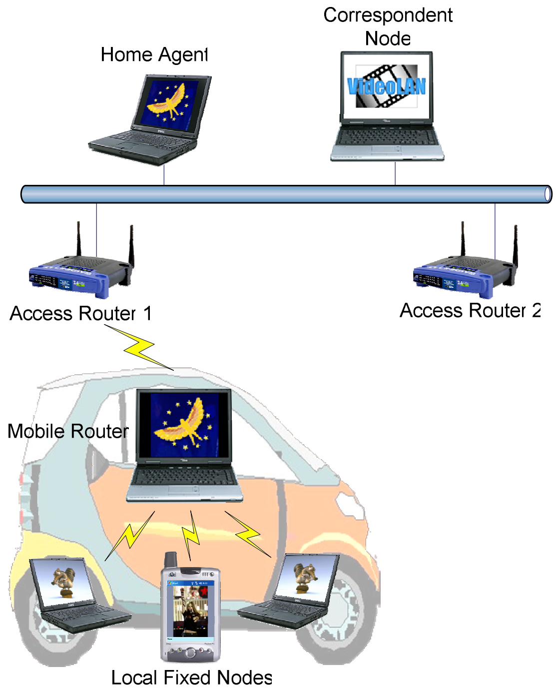

Figure 2 Test Network

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