Simulating Mobile IPv6 with ns-3

(Poster Abstract)

Fabian Mauchle
University of Applied Sciences Rapperswil
Oberseestrasse 10
CH-8640 Rapperswil, Switzerland
+41 (0) 55 222 46 30
fabian.mauchle@hsr.ch

Sandra Frei
University of Applied Sciences Rapperswil
Oberseestrasse 10
CH-8640 Rapperswil, Switzerland
+41 (0) 55 222 46 30
sandra.frei@hsr.ch

Prof. Dr. Andreas Rinkel
University of Applied Sciences Rapperswil
Oberseestrasse 10
CH-8640 Rapperswil, Switzerland
+41 (0) 55 222 46 30
andreas.rinkel@hsr.ch

ABSTRACT

Evolving mobile communication technologies like the Evolved Packet Core (EPC), specified by 3GPP, aim to incorporate more distinct access technologies. While mobility management and QoS aspects are consistently defined for 3GPP technologies, not all non-3GPP networks are integrated smoothly.

This work aims, using close to reality simulations with ns-3, to help understand the mechanisms used for the network aspect described above, identify its problems and develop new approaches in resolving them.

Categories and Subject Descriptors

C.2.1 [**Network Architecture and Design**]: Packet Switching Networks, Wireless Communication
C.2.2 [**Network Protocols**]: Protocol Verification

General Terms

Measurement, Documentation, Experimentation, Standardization, Verification.

Keywords

3GPP, EPC, ns-3, Mobile IPv6, Proxy Mobile IPv6.

1. INTRODUCTION

The Evolved Packet Core (EPC), specified by 3GPP, does not only support recent and current 3GPP access technologies such as UMTS and the new Long Term Evolution (LTE), it also allows the integration of non -3GPP access technologies including, amongst others, WiMAX and WLAN. While the 3GPP technologies use protocols also defined by 3GPP, most non-3GPP technologies rely almost entirely on protocols defined by the IETF. In order to study the protocols required for the EPC, some of them were implemented for ns-3 [10]. These include Mobile IPv6 (MIPv6) [5] and Generic Routing Encapsulation (GRE) [3].

In the following sections, we will quickly describe the use of ns-3 and the implementation of MIPv6. Afterwards we will also present some first result and the ongoing work.

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2. SIMULATION ENVIRONMENT

The use of ns-3 as the simulation environment has several advantages. Its close to reality protocol stacks, implemented in a similar way as it would be on real systems, show how protocols work. This not only forces a deep understanding of the protocol, but also assists in learning how to convert a protocol specification into a running implementation. This could go as far as having the simulated protocol communicate with existing, real life implementations.

Beyond that, ns-3 simulates always a full network stack, and thus can also reveal influences which were not considered initially and would have been overseen otherwise.

3. IMPLEMENTING MIPV6 IN NS-3

At the beginning of this project, the ns-3 main tree did not include IPv6 support, so we had to back up to the development done at the University of Strasbourg, and could also assist with some bug-fixes. At the time of writing, the inclusion of IPv6 in the ns-3 main tree is in progress.

With some future extensions like Proxy MIPv6 (PMIPv6) (see section 6) in mind, the implementation could be divided into three major parts. The first is the MIPv6 protocol itself, which is implemented as an extension of the IPv6 stack. It is mainly responsible for controlling the mobility and setting up the IP tunnel. It is often referred as the 'Control Plane'. The second part is the 'User Plane', represented mainly by an IP tunnel itself. To simplify its use, a tunneling framework, capable of setting up tunnels with different protocols, was implemented. The last part consists of some modifications and extensions of layer 2 related parts of IPv6 to handle the procedures required by MIPv6.

4. MOBILE IP IN EPC

For non-3GPP access networks, EPC requires the use of MIPv6 in most cases. Two variants of MIPv6 are allowed:

User equipments with support for Dual Stack MIPv6 are basically allowed to make use of it. Although, some features like Route Optimization are not supported by EPC [7]. In this scenario, all 3GPP networks are considered as the home network.

To support any other user equipments, the access gateway must use PMIPv6 [4] to provide the mobility features. This will most likely be the usual way non-3GPP networks are connected. Through the use of IPSec and IKEv2, this also allows integrating any IP network, even non wireless.

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In contrast to the 3GPP protocols, Mobile IP does not support QoS mechanisms. The only way to enforce QoS parameters is using Filters and traffic shaping at the Packet Data Network GW used as Home Agent (HA).

5. FIRST RESULTS

5.1 Handover Analysis

With the first prototype implementation of MIPv6, we could perform some delay analysis during handover, similar to the basic MIPv6 case in [8] and could also reproduce their results. In addition, we also considered situations with highly different network link delays and usage of Duplicate Address Discovery (DAD).

Figure 1 shows the flow graph just before and after a handover. One can see that downlink (green, left to right) latency, while no packets get to the Mobile Node is:

$$t_{down} = t_{cs} + t_{old} + t_{new} + t_{DAD}$$

The time t_{old} and t_{new} represent the network delays of the old (origin) and new (target) network. t_{DAD} is the DAD timeout to wait (usually 1s, but most scenarios try to bypass it), t_{cs} is the channel switch time, including authorization and address configuration for the new network.

Interestingly, in a worst case scenario requiring a fully complete DAD, also the uplink (blue, right to left) latency is significant. Resulting in:

$$t_{up} = t_{cs} + 2 \times t_{new} + t_{DAD}$$

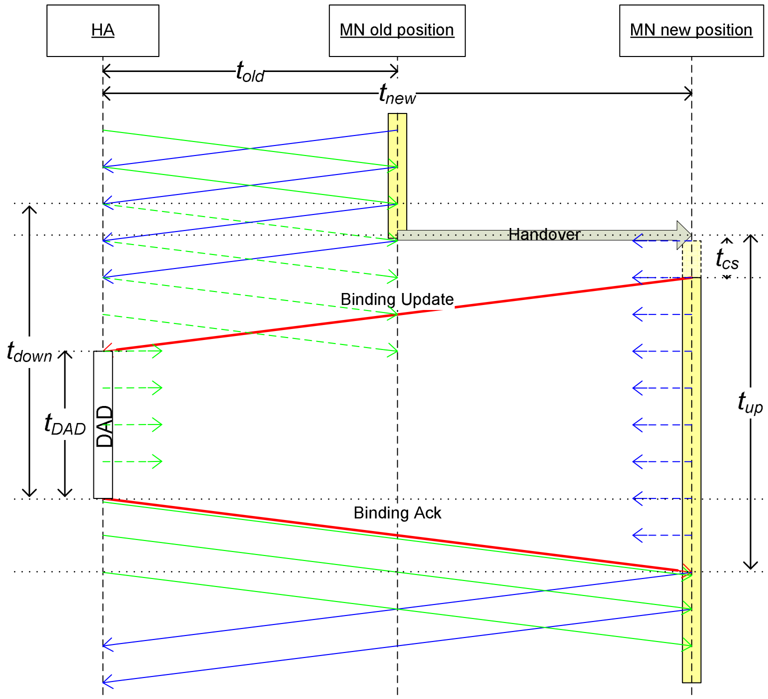

Figure 1. Handover including DAD

As can be seen from the formulas above, especially for the downlink, the network delays from both the new and the old access points have an influence on the handover latency. Considering real-time traffic like Voice over IP, this can be a critical value.

5.2 Conflicts in RFC 3775

During the implementation of MIPv6, we also noticed some conflicts and unspecified situations in the MIPv6 standard [5]. One conflict exists in the processing rules for Home Address options. The standard says that:

"*Packets containing a Home Address option MUST be dropped if there is no corresponding Binding Cache entry. (…) These tests MUST NOT be done for packets that contain a Home Address option and a Binding Update.*"

Beside that the paragraph is somewhat difficult to read, having the exception at the end, the evaluation of its condition requires a look-ahead in the packet. On the one hand this might be hard or even impossible to implement (if the packet is encrypted) and on the other hand, even worse, it is forbidden by IPv6 [2]. This condition can be replaced by a method which makes only use of the Next Header value, resulting in the same behavior.

The issues were reported to the MEXT work group [9] at IETF and the proposals were included in the most actual revision of the draft for refining the MIPv6 standard [6].

6. ONGOING WORK

The ongoing work in this project mainly concentrates on the implementation of PMIPv6 [4] and the extensions required for the use in EPC [1], as well as QoS procedures regarding the User Plane such as traffic shaping. This will provide the base for further studies regarding QoS aspects in non-3GPP networks connected to the EPC.

7. REFERENCES

[1] 3GPP, "Proxy Mobile IPv6 (PMIPv6) based Mobility and Tunneling protocols", TS 29.275, Release 8, June 2009

[2] S. Deering, R.Hinden, "Inetrnet Protocol, Version 6 (IPv6)", IETF, RFC 2460, December 1998

[3] D. Farinacci et al, "Generic Routing Encapsulation (GRE)", IETF, RFC 2784, March 2000

[4] S. Gundavelli et al, "Proxy Mobile IPv6", IETF, RFC 5213, August 2008

[5] D. Johnson, C. Perkins, J. Arkko, "Mobility Support in IPv6", IETF, RFC 3775, June 2004

[6] D. Johnson, C. Perkins, J. Arkko, "Mobility Support in IPv6", IETF, Internet-Draft draft-ietf-mext-rfc3775bis-05.txt, October 2009

[7] M. Olsson et al, "SAE and the Evovled Packet Core", Academic Press, 2009

[8] X. Pérez-Costa et al, "A MIPv6, FMIPv6 and HMIPv6 handover latency study: analytical approach", Proc. of IST Mobile &; Wireless Telecommunications Submit, 2002

[9] Mobility Extensions for IPv6 Working Group, IETF, http://tools.ietf.org/wg/mext/

[10] The ns-3 network simulator, http://nsnam.org

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