World Academy of Science, Engineering and Technology
International Journal of Electronics and Communication Engineering
Vol:1, No:6, 2007

Optimization of Multicast Transmissions in NC-HMIPv6 Environment

Souleymane Oumtanaga, Kadjo Tanon Lambert, Koné Tiémoman, Tety Pierre, and Kimou Kouadio Prosper

Open Science Index, Electronics and Communication Engineering Vol:1, No:6, 2007 publications.waset.org/1373/pdf

***Abstract*—**Multicast transmissions allow an host (the source) to send only one flow bound for a group of hosts (the receivers). Any equipment eager to belong to the group may explicitly register itself to that group via its multicast router. This router will be given the responsibility to convey all information relating to the group to all registered hosts. However in an environment in which the final receiver or the source frequently moves, the multicast flows need particular treatment. This constitutes one of the multicast transmissions problems around which several proposals were made in the Mobile IPv6 case in general.

In this article, we describe the problems involved in this IPv6 multicast mobility and the existing proposals for their resolution. Then architecture will be proposed aiming to satisfy and optimize these transmissions in the specific case of a mobile multicast receiver in NC-HMIPv6 environment.

***Keywords*—**Mobile IP, NC-HMIPv6, Multicast, MLD, PIM, SSM, Rendezvous Point.

I. Introduction

MOBILE IPv6 like its predecessor (Mobile IPv4) introduces mobility into the IP networks communication natively fixed. In order to perfect the mobility level with that observed in the GSM networks concerning the voice; several challenges are to be accepted. Among these, we mention the offer to the mobile Net surfer of all the basic services, services which the traditional Net surfer profits by.

Manuscript received September 6, 2007. This work was exclusively supported by the authors mentioned below.

Oumtanaga S. is with Laboratoire de Recherche en Informatique et Télécommunications (LARIT), Institut National Polytechnique Félix Houphouët Boigny, 08 BP 475 Abidjan 08, Côte d'Ivoire (phone: 225 07900231; e-mail: oumtana@nic.ci).

Kadjo T. L. is with Laboratoire de Recherche en Informatique et Télécommunications (LARIT), Institut National Polytechnique Félix Houphouët Boigny, 08 BP 475 Abidjan 08, Côte d'Ivoire (phone: 225 07620723 ; e-mail: nonatipv6@yahoo.fr).

Koné T. is with Institut de Recherches en Mathématiques (IRMA), University of Abidjan-Cocody, Côte d'Ivoire and with Laboratoire de Recherche en Informatique et Télécommunications (LARIT), Institut National Polytechnique Félix Houphouët Boigny, 08 BP 475 Abidjan 08, Côte d'Ivoire (e-mail: tkonet@yahoo.com).

Tety P. is with Laboratoire de Recherche en Informatique et Télécommunications (LARIT), Institut National Polytechnique Félix Houphouët Boigny, 08 BP 475 Abidjan 08, Côte d'Ivoire (phone : 225 05897919 ; e-mail : tety@nic.ci).

Kimou K. P. is with Laboratoire des Technologies de l'Information et de la Communication (LABTIC), Institut National Polytechnique Félix Houphouët Boigny, 08 BP 475 Abidjan 08, Côte d'Ivoire 07105326.

Some important emerging applications such as LAN TV, desktop conferencing, distance learning and collaborative computing require simultaneous communication between groups of computers.

Today, multicasting, introduced into the IPv4 networks, is perfectly deployed in the IPv6 fixed networks and includes all these services. However it constitutes a major problem for IPv6 mobile networks.

The success of this type of communications in the fixed networks is mainly due to their stability contrary to the mobile networks which still suffer from some shortcomings.

In this article, we describe some problems related to the implementation of this type of communication in the mobile networks, in section II. Section III mentions the efforts carried out in this direction. In section IV, we propose multicast communications architecture in a mobile environment governed by the NC-HMIPv6 (Network-Controlled Hierarchical Mobile Internet Protocol Version 6) protocol [8]. This architecture takes into account only the behavior of multicast receivers.

II. Multicast Transmissions in IP Mobile Networks

As IP fixed networks is completely dominated by the IP protocol, the mobility support in IP networks is incontestably Mobile IPv6 [15]. It represents the fundamental protocol used in the realization of several other protocols in order to improve it [8][17][23]. It therefore represents the building block of all these IP mobile networks protocols.

However, Mobile IPv6 is not exempt from any technical reproach. In spite of its clear improvement compared to Mobile IPv4 [21], there are still some problems:

- Mobile IPv6 suffers from a considerable latency time during the handovers.
- The recourse to the triangular routing for certain communications, e.g.: correspondent node can not implement the routing optimization.
- Quality of Service management

With the analysis of all these points, all new service to be implemented must adapt itself to existing mobile topology. It must also prevent itself, not to inject a considerable additional latency and wasted bandwidth.

However the multicast functions according to a particular routing mode and as a result, constitutes a particular service, unfortunately not explicitly taken into account by Mobile IPv6. That causes serious problems in this type of environment.

Indeed, according to the proposals of the multicast communications in the IPv6 networks, the flows routing of

Open Science Index, Electronics and Communication Engineering Vol:1, No:6, 2007 publications.waset.org/1373/pdf

multicast receivers is done according to an arborescent topology [3][5]. In this multicast distribution tree built using PIM (Protocol Independent multicast) protocol, the path chosen by the flow to serve the receivers is optimal (using SPT: Short Path Tree). Thus, when the mobile node is in its administrative network, multicast flows are delivered to him following this optimization of multicast routing.

During its movement in foreign networks, inducing the new address granting, two possibilities occur concerning its prior behavior multicast flows:

- Bi-directional multicast routing
- Optimization of the IPv6 routing or remote subscription.

A. Bi-Directional Tunneling Multicast

An IPv6 tunnel is implemented since the home network of the mobile node to deliver multicast flows [9]. If it is about a source, the same tunnel will make it possible to deliver flows with its multicast router of the home network. What is not very probable as for the optimization of multicast routing (the example of a multicast source in the same network as RP (Rendezvous Point) and remote from its home network or that of a mobile receiver finding itself in the same one as the source or RP). What also is not optimal for the IPv6 routing if the visited network possesses members of the multicast group.

B. Remote Subscription

If the visited network has a multicast router, these various cases appear:

- a local node is member of the multicast group. In this case, the mobile receiver is directly served without loss of traffic due to an unspecified adherence.
- no request is made for this flow. In this case, the mobile receiver joins the group via multicast access router of the visited network. From there, a new branch is added to the existing tree [25]. This generates a multicast latency higher than 1.5s, exceeded the maximum time tolerated (50ms) for real-time applications [20].
- required flow is unauthorized in the visited network or there is not any multicast router. The latency for the reception is related to the one that the mobile will put to reach a new network where this flow is authorized. By adding the delay time to join the group, the total latency is excessively long, if one limits oneself exclusively to an optimization of the IPv6 routing.

In addition, if the mobile is multicast source, multicast distribution tree will have to be completely rebuilt, and a new short path is selected with each rebuilding.

C. Evaluation of the Multicast Latency

The following table gives the identifiers of some temporary variables. These parameters are defined according to the Mobile IPv6 protocol.

TABLE I
SOME TEMPORARY VARIABLES

Variables	**Descriptions**
MHLD *(Mobility Handover Link layer Delay)*	maximum time of latency for a mobile to carry out a Link layer handover
MHND *(Mobility Handover Network layer Delay)*	Latency time necessary to the mobile to carry out a network layer handover (acquisition of a global temporary address)
MSD *(Mobility Signaling Delay)*	Time spent by localization binding updates
MMSD *(Multicast MLD Signaling Delay)*	Time spent by an host to join the multicast group
MPSD *(Multicast PIM Signaling Delay)*	Time spent by the access router to construct its multicast branch.
MoD *(Mobility Delay)*	ascribable latency time exclusively to mobility
MuD *(Multicast Delay)*	ascribable latency time exclusively to the multicast
ToD (Total Delay)	total latency time

By considering the mobility in an environment in which there is at least a multicast router by domain and where any multicast flow is authorized, the following relations are established:

- MoD = MHLD + MHND+ MSD

This time varies according to the mobility protocol. The micro-mobility protocols considerably reduce the mentioned quantity MHLD+MHND. Their main object is to make this time negligible. [8] gives a comparison of the time taken in various network under various protocols.

- MuD=MMSD+MPSD

This time is minimal if there is a member of the multicast group in the visited network. If the access multicast router of the visited network still has in its routing table, the line corresponding to the multicast group recently requested by a node of the network, then MuD is reduced to MMSD.

- ToD=MoD+MuD

Here, MuD can be taken as time necessary for the setting up of the IPv6 tunnel for the data transmissions of the multicast group by the home agent. It is the time spent between the validation of the principal CoA by the home agent and the reception of the first flow. This time can be zero by anticipation of the inter-domain handover.

It can also be regarded as the necessary time to the rebuilding of a multicast distributive branch for a receiver or multicast tree for a mobile source.

With the analysis of all these sizes thus defined, it is clear that the multicast in a mobile environment IP is effective if the multicast mobility protocol also is.

Open Science Index, Electronics and Communication Engineering Vol:1, No:6, 2007 publications.waset.org/1373/pdf

III. Some Approaches

Several proposals have been made. They were in majority on the Mobile IPv6 environment [2][6][7][11]-[14][16][29][31]. For the reduction of the multicast handoff latency, the opinions are based on macro-mobility protocols [2][13][30] but also on certain micro-mobility protocols such as HMIPv6 [26].

A. Solutions in the Macro-Mobility Environments

Several attempts to resolve the integration problems of multicast in the mobility environment ran up against the too long handoff latency for real-time applications.

Studies such as [18] and [30] related to the Fast MIPv6 environment improving macro mobility multicast [17].

Several other studies related to Mobile IPv6 in order to find a multicast mobility support effectively take into account the multicast management [2][6][7][12][13][16], etc.

Schmidt's recent study [25] gives some ideas of research and the rules to follow in order to solve the problem of the IPv6 mobile networks:

- optimal routing takes into account a better quality of service
- no modification of multicast protocols
- reducing disruption and communication delays.

It states in addition that among the various protocols of construction of multicast tree PIM-SM [5], PIM-DM [3], the most promising is the PIM-SSM. However this protocol involves certain problems such as the total rebuilding of multicast distribution tree for a mobile source using the routing optimization of Mobile IPv6 in a visited network.

B. Solutions in Micro Mobility Environments

Other researches were directed in the environment taking into account the fast and frequent handovers. Thus proposals of [25] were focused on the HMIPv6 protocol integrating the multicast [26].

All these solutions were carried out in environments offering themselves only little guarantee as far as optimization of handover is concerned [8]. By adding the latency time generated by the multicast, the losses of data become more persistent.

Our solution is based on a protocol of micro-mobility offering a better latency time and an effective quality of service management.

IV. Proposal for Architecture of Multicast Communications

The NC-HMIPv6 protocol (Network-Controlled Hierarchical Mobile IPv6) proposed by France Telecom is a micro-mobility protocol based on a hierarchical management of the mobility agents [8]. It constitutes an improvement of HMIPv6 [24].

Here we are interested in an integration of the multicasting in such an environment by treating the specific case of a mobile receiver.

This mobile host can join a multicast group since its home network and continued the communication until the visited network. It can also join or leave a new group in a visited network.

A. Functional Entities and Tools Used

The management of mobility will be based on the both but effective use of bi-directional tunnel mode [9] and the optimization of routing (rebuilding of under tree) as indicated in the mobility support [3]. The functional entities of NC-HMIPv6 will be more or less affected:

- the mobile node is a receiver (RM_MN).
- the home agent will be equipped with function of multicast access router (M_HA).
- the mobility manager will treat only transmissions multicast of mobile nodes of the network (M_GM).
- the access routers are multicast routers (MAR).

The protocols of management of multicast transmissions used are:

- MLDv2 [3][28] for the communication between receiver and multicast access router;
- PIM-SSM for the construction of multicast tree.

1. Management of the Multicast Mobility Concerning M_GM

The M_GM manages in the database of the correspondences (S, G)↔MAR, where S is multicast source and G the group [3].

It is regarded as local Rendezvous Point. It will be attached to multicast tree until there is no more multicast router of the domain likely to receive this flow. In this case correspondence multicast inherent to this flow and this RMA will be cancelled from the database.

A redundancy of M_GM proves to be necessary to avoid congestion and to better manage the scalability.

2. Mobility Management Concerning Home Agent (M_HA)

The home agent manages multicast mobile states of all its mobile nodes in displacements.

3. Mobility Management Concerning Multicast Access Router (MAR)

The Rendezvous Point of all the MAR of the domain is the M_GM. This makes it possible to better control multicast tree and reduces the process time of adhesions of the MAR to multicast group membership.

B. Functional Architecture

[8] Perfectly describes the NC-HMIPv6 handover phenomenon. Our study will not consist in describing the protocol then.

The architecture is described according to the state of the domain visited with respect to the multicast membership group of mobile node in visit.

1. Multicast Access Router (MAR) belongs to Tree Multicast

This case occurs when there is at least a node of the visited network belonging to the multicast group or the MAR is not pruned from the multicast tree yet.

Multicast handover is held jointly with the NC-HMIPv6 handover according to the diagram of Fig. 1.

Open Science Index, Electronics and Communication Engineering Vol:1, No:6, 2007 publications.waset.org/1373/pdf

The blue links are multicast traffic and the black ones are NC-HMIPv6 native traffic.

Step 0 and 0': the home agent (M_HA) conveys the multicast flow to its network node (future mobile node). During this time, in the next visited domain, the mobility manager (M_GM) disseminates information concerning his support of mobility to his access routers (step 0)[8].

Step 1: After configuration of its temporary addresses: LCoA (Local Care-of-Address) and RCoA (Regional Care-of-Address), the MR_MN informs its home agent and its correspondents of his new address (RCoA).

Steps 1' and 1'': The MR_MN also informs the M_GM about its addresses. This message by addressing it to the access router contains a multicast report option. This option allows the mobile receiver joining its previous multicast group.

Step 2: This multicast option is read by the MAR which answers MLD report message in order to convey the multicast flow.

Steps 2', 3 and 4: The reception of two identical copies (tunnel (2') and local distribution (2)) will make the MR_MN possible to suspend the tunneled flow by sending an indicating message (3), acknowledged by the home agent afterward (4).

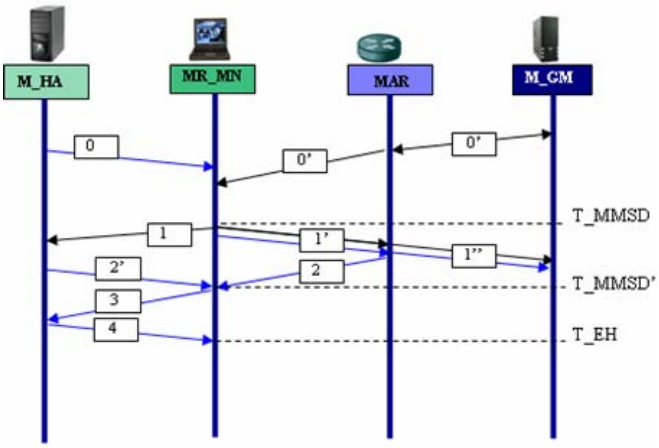


Fig. 1 Multicast Handover: case of a visited network with the MAR member of the group

The multicast latency is

$$MuD=T_MMSD' - T_MMSD$$

This time is null if there are members in the visited network. Otherwise, it is equivalent to the delay for MLD report.

2. Multicast Flow Delivered with an Unspecified Router of the Visited Domain

Here, the access router of the visited network does not belong to the multicast tree relating to the flow. However, the membership of a foreign router of the domain makes possible to maintain the M_GM in the group.

Steps 0, 0', 1 and 1' are similar to the previous case.

MAR constructs a new branch using PIM-SSM (Step 1''). The mobility manager (M_GM) represents the local Rendezvous Point. This last conveys the flow and records a correspondence

$$(S, G) \rightarrow RCoA$$

in the database (BD[8]) of the domain. This will enable to convey the multicast flow to the next visit router during the intra-domain handovers. Thus, the M_GM will pre-empt the multicast handover in order to minimize the multicast handoff latency.

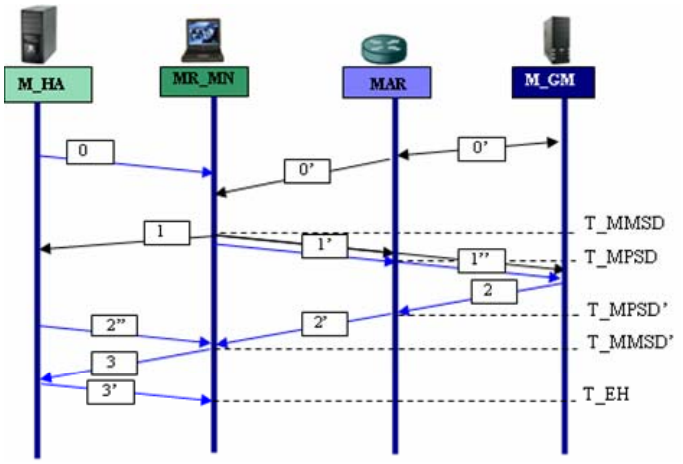


Fig. 2 Handover multicast: case of a network visited with the RAM member of the group

3. No Member Belonging to the Multicast Group in the Domain

This last case involves a global reconstruction of the multicast branch for this first handover.

The MR_MN request for adhesion (Step 1') will carry out successive PIM-SSM messages to the access router of the source or to the remote Rendezvous Point (Step 1", 2, 2', 3 and 3'). As in the previous case, a correspondence will be put into cache.

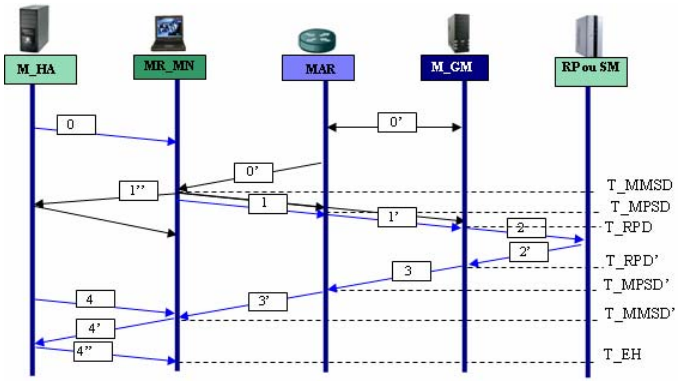


Fig. 3 Multicast handover: case of a network visited with the MAR member of the group

Open Science Index, Electronics and Communication Engineering Vol:1, No:6, 2007 publications.waset.org/1373/pdf

The delay time MuD=T_MMSD'-T_MMSD will be almost null for next handovers.

4. Handovers Multicast Inter-Domain

When a mobile host joins a new multicast group in the visited network, a MLD *Standby Report* (MSM) message is sent to the M_HA. This type of message introduced into this article allows the M_HA to establish the correspondence relating to this new multicast membership operated outside the administrative network.

The home agent will create a multicast branch if there is no member in the domain. It registers the correspondence (S, G)-RCoA in its routing table and maintains this branch until the reception of a Listener Hold multicast message [12].

This correspondence will permit the M_HA to answer more quickly the setting of the bidirectional tunnel by avoiding the installation of the branch at this moment of the movement.

C. Comparison with Existing Proposals

Our proposal depends on the following outstanding points:

- the mobility environment (NC-HMIPv6)
- the management mobility (GM) represents a local Rendezvous Point in order to reduce the multicast latency when creating new branches.
- the functionalities extension of the GM data in order to integrate data related to multicast handover
- the HA functionalities extension by the proxy MLD characteristics for the mobile nodes in visit.

V. Conclusion

Multicast mobility does not improve in any way traditional IPv6 mobility. It uses the latter as a support to convey the information group to the members whatever their connectivity mode. A perfect mobile environment thus constitutes an ideal support for its optimization. Our proposal gives an idea about what can be done in a mobile environment considered as improved in comparison with its peers. The current study was carried out for the receivers. This opens research ways to improve it and take into account the multicast mobile source. The security and QoS side can also be studied.

References

[1] S. Bhattacharyya, "An Overview of Source-Specific Multicast (SSM)", RFC 3569, July 2003.
[2] O. Christ, T. C. Schmidt, and M. Waehlisch, "A Light-Weight Implementation Scheme of the Tree Morphing Protocol for Mobile Multicast Sources", Proc. of 33rd Euromicro Conf., IEEE/CS, Sept. 2007.
[3] G. Cizault, "IPv6: Théorie et pratique", 4ème Edition, 2006.
[4] S. Deering, W. Fenner and B. Haberman, "Multicast Listener Discovery (MLD) for IPv6", RFC 2710, October 1999.
[5] B. Fenner, M. Handley, H. Holbrook, and I. Kouvelas, "Protocol Independent Multicast - Sparse Mode PIM-SM): Protocol Specification (Revised)", RFC 4601, August 2006.
[6] A. Garyfalos, and K. Almeroth, "A Flexible Overlay Architecture for Mobile IPv6 Multicast", IEEE Journ. on Selected Areas in Comm., 23 (11), pp. 2194-2205, November 2005.
[7] A. Garyfalos, K. Almeroth, and K. Sanzgiri, "Deployment Complexity Versus Performance Efficiency in Mobile Multicast", http://imj.ucsb.edu/papers/BROADWIM-04.pdf.gz
[8] K. Guillouard, Y. Khouaja, P. Bertin, and J. M. Bonnin, "Gestion Hiérarchique de la Mobilité IPv6 Contrôlée par le réseau", http://www-rp.lip6.fr/dnac/3.2-khouaja-article.pdf, 2002.
[9] M. Handley, I. Kouvelas, T. Speakman, and L. Vicisano, "Bi-directional Protocol Independent Multicast (BIDIR-PIM)", draft-ietf-pim-bidir-09.txt, February 2007.
[10] H. Holbrook and B. Cain, "Source-Specific Multicast for IP", RFC 4607, August 2006.
[11] C. Jannetau, Y. Tian,, S. Csaba, "Comparison of Three Approaches Towards Mobile Multicast", www.comnets.rwth- aachen.de/~o_drive/ publications/ist-summit-2003-IPMobile Multicast-paperv2.0.pdf.
[12] C. Jelger, "Multipoint et Mobilité: Optimsations pour IPv6", LSIIT-UMR 7005 – CNRS/ULP, Université Louis Pasteur, mai 2002.
[13] C. Jelger, T. Noel, "Multicast for Mobile Hosts in IP Networks: Progress and Challenges", IEEE Wireless Comm., pp 58-64, Oct. 2002.
[14] C. Jelger, and T. Noel, "Supporting Mobile SSM sources for IPv6 (MSSMSv6)", Internet Draft (work in progress, expired), January 2002.
[15] D.B. Johnson, C. Perkins and J. Arkko,"Mobility Support in IPv6", RFC 3775, June 2004.
[16] Kellil, M., Romdhani, Kellil, H.-Y. Lach, A. Bouabdallah, and H. Bettahar, "Multicast Receiver and Sender Access Control and its Applicability to Mobile IP Environments: A Survey", IEEE Comm. Surveys & Tutorials 7(2), pp. 46-70, 2005.
[17] R. Koodli, "Fast Handovers for Mobile IPv6", RFC 4068, July 2004.
[18] G. Leoleis, G. Prezerakos, and I. Venieris, "Seamless multicast mobility support using fast MIPv6 extensions", Computer Comm. 29, pp. 3745-3765, 2006.
[19] R.C. Lin and K. Cheng, "Scalable Multicast Protocol in IP-Based Mobile Networks", Wireless Networks and Applications, 5, pp. 259-271, 2000.
[20] T. Noel, N. Montavont, and P. Bertin, "Mobilité IPv6 et WLAN: Expérimentation et évaluation à l'échelle d'un campus", LSIIT. Université Louis Pasteur. Strasbourg, décembre 2002, http://www-rp.lip6.fr/dnac/7.1-noel-article.pdf
[21] C. Perkins, "IP Mobility Support for IPv4", RFC 3344, August 2002.
[22] I. Romdhani, M. Kellil, H.-Y. Lach et. al. "IP Mobile Multicast: Challenges and Solutions", IEEE Comm. Surveys, 6(1), 2004.
[23] Romdhani, I., Bettahar, H. and Bouabdallah, A. "Transparent handover for mobile multicast sources", in P. Lorenz and P. Dini, eds, 'Proceedings of the IEEE ICN'06', IEEE Press, 2006.
[24] H. Soliman, C. Castelluccia, K. El-Malki, and L. Bellier, "Hierarchical Mobile IPv6 mobility management", RFC 4140, August 2005.
[25] T.C. Schmidt, and M. Waehlisch, "Multicast Mobility in MIPv6: Problem Statement and Brief Survey", draft-irtf-mobopts-mmcastv6-ps-00.txt, May 2007.
[26] T.C. Schmidt, and M. Waehlisch, "Seamless Multicast Handover in a Hierarchical Mobile IPv6 Environment (M-HMIPv6)", draft-schmidt-waehlisch-mhmipv6-04.txt, December 2005.
[27] Thaler, D. "Supporting Mobile SSM Sources for IPv6", Proceedings of IETF meeting Dec. 2001, individual. URL:www.ietf.org/proceedings/01dec/slides/magma-2.pdf
[28] R. Vida and L. Costa (Eds.) "Multicast Listener Discovery Version 2 (MLDv2) for IPv6", RFC3810, June 2004.
[29] R. Vida, L. Costa, and S. Fdida, "M-HBH - Efficient Mobility Management in Multicast", Proc. of NGC '02, pp. 105-112, ACM Press 2002.
[30] F. Xia, and B. Sarikaya, "FMIPv6 extensions for Multicast Handover", draft-xia-mipshop-fmip-multicast-00.txt, September 2006.
[31] Zhang, H. et al "Mobile IPv6 Multicast with Dynamic Multicast Agent", draft-zhang-mipshop-multicast-dma-03.txt, (work in progress), January 2007.