Inter-Domain QoS Signaling under Mobility

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***Abstract*—This paper deals with the problem of QoS signaling across multiples domains in a context of topological changes due to mobility. Data path changes caused by mobility can degrade severely the service continuity to mobile terminals considering the end-to-end QoS inter-domain path reestablishment. We propose an efficient NSIS-based scheme to allow end-to-end QoS path maintenance under mobility. The domains are controlled by central resource managers acting as bandwidth brokers. The scheme addresses two open issues in the area: (a) the integration of NSIS with Hierarchical Mobile IP including anchor points collaboration to QoS signaling, and (b) the use of NSIS in an hybrid *on* and *off*-path context, exploring the common off-path points to improve signaling. The signaling procedure aims to reduce the impact of mobility in the time to setup new QoS paths and the time to tear down unused resources.**

***Index Terms*—QoS, inter-domain signaling, NSIS, mobility management**

I. Introduction

New distributed multimedia applications require QoS provision from IP-centric networks. As a consequence, new network services must provide guaranteed bandwidth, delay, and jitter. Some well known IETF QoS models like diffserv and intserv can be deployed inside domains to meet those requirements. However, the provisioning of inter-domain end-to-end QoS is still an open issue. Domains are managed independently with respect to QoS strategies. In this sense, an inter domain management must be implemented respecting domains idiosyncrasies. A signaling protocol is central to this management. IETF has been working on NSIS[1], a new generation signaling protocol, that incorporates a lot of learned lessons from RSVP protocol. NSIS was designed to be QoS model-independent, and it has mechanisms to inter-domain signaling and mobility.

Moreover, mobility management is another challenge imposed by advanced applications. In particular, service continuity implies the maintenance of network connectivity when a terminal moves from an access point to another. Original IP address fails, as topological identification when mobile nodes change of sub nets. This brings disruption in TCP and UDP communication. Those problems can be dealt with by mobility protocols in different layers (ex. Mobile IPv6[2] in the network layer).

Some well-known problems related to mobility and QoS were already pointed out in the literature [3]: (a) long delay for reservation re-establishment; (b) duplicate reservation of resources for a non-negligible time; (c) increased blocking probability of new session requests; and (d) increased cost for providing QoS-enabled services.

The coordination between a Mobility Management and a QoS Management is the focus of our work. We investigate the behavior of an inter domain Bandwidth Broker-based QoS architecture controlled by NSIS signaling protocol subject to topological changes due to local and global mobility of terminals. The architecture uses a hybrid on and off path signaling to enable signal Bandwidths Brokers in each domain.The mobility protocol considered is the HMIPv6 as it allows to confine path changes in a visited domain. We propose a schema to improve QoS signaling based on advance passive reservations on the neighbor access routers.

This paper is organized as follows. In section II, we review recent work in QoS and mobility. The inter domain QoS architecture investigated is described in section III. The integration of the QoS and Mobility Management is described in section V. Finally, a conclusion is presented in section VI.

II. Previous Work

A. QoS Signaling and Mobility

Most of the research contributions in the QoS signaling and mobility are extensions to the RSVP protocol [4]. In general, they explore the advance resource reservation in neighboring sub nets. Talukdar [5] has proposed MRSVP, the Mobile Resource Reservation Protocol, to make resource reservation at multiples locations. A mobile node can make active and passive reservations using a Mobile Specification object (MSPEC). An infrastructure of proxies is used to make reservation on behalf of mobiles hosts. HMRSVP[6] integrates RSVP with Mobile IP regional registration and it makes advanced reservations only in potential inter-regional movements. Benmammar [7] proposes the use of MSPEC object for advance reservations in a context of HMIPv6. MSPEC is computed trough a profile of network access. Extensions to this mobility protocol are also proposed to integrate it with the QoS management.

Some works explore the enhancement of QoS and mobility protocols. A RSVP proxy in the edge of access network is introduced in [3]. It collaborates with a mobility management authority like a MAP in HMIPv6 or GFA in Regional Mobile IP keeping track of the correspondence between the RCoAs and the LCoAs. The proxy makes dynamic address translation in signaling messages. The proxy must be on the edge router

[1]Sponsored by CAPES-MEC Government of Brazil

of the access network and the scheme can be complex if there are several such devices.

B. The NSIS Framework

IETF NSIS [1] is a protocol suite that overcomes shortcomings of RSVP. NSIS is presented as a two layer paradigm. The lower level layer (NSIS Transport Layer Protocol - NTLP) has a generic transport service. It manages associations between NSIS peers using TCP connections or UDP datagram messages. These associations allows signaling towards upstream and downstream direction. The signaling applications constitutes the upper layer (NSIS Signaling Layer Protocol-NSLP). QoS NSLP[8] is an IETF proposition for a QoS application layer. QoS NSLP messages are sent NSIS-peer to NSIS-peer and they can signal for any QoS model. NSIS incorporates a number of characteristics that makes it appropriate for inter domain scenarios: (a) route change detection; (b) support for reduced-state operation; (c) session binding, enforcing relations among sessions for use in aggregations; (d) use of QoS specification stacks.

Mobility is also a design concern of NSIS[9]. Each session has an identifier and a session can be bound to several flows. A flow also has an identifier. As consequence, a reservation for a new flow for the same session can be done simultaneously to an existing flow. At the next step, the states along the path can be updated.

C. Hierarchical Mobile IP Protocol - HMIPv6

The HMIPv6[10]) is an extension of MIPv6[2] to deal with mobility inside a domain. It is very attractive to deal with local mobility as it confines topological changes in a domain, avoiding long delays of registration with the Home Agent (HA) or Correspondents (CN). The Mobility Anchor points (MAPs) are components that can be seen as a local HAs in a visited network. They are located inside a domain but several MAPs can be associated to the same domain. When a MN moves to a network covered by a MAP, it uses a MAP-derived sub net address called Regional Care-of-Address (RCoA) to make a binding update with its HA or with its CN. MN also registers its new local IP address, LCoA, with the MAP. Packets from CN or HA are redirected to RCoA and captured by the MAP. When a new MN moves to an AR on the same MAP coverage then a new registration with the local MAP is done.

III. The Inter Domain QoS Signaling Architecture

We investigate an architecture that provides QoS guarantees to static and mobile applications by coupling the signaling with admission control and resource management in a multi domain context. Inside a domain, a Bandwidth Broker - BB knows the internal and external policies and resource availability. To ensure a successful end-to-end reservation across several domains, the BB must communicate with its adjacent peers to allocate resources on the end-to-end premises.

End-to-end QoS network signaling will be achieved only if signaling messages follow the same path as the user data and if all the BBs in the data path are signaled. We adopt a signaling architecture (Figure 1) based on [11] that couples a hybrid approach of on-path and off-path signaling in the NSIS framework. In order to signal the BB, the NSIS signaling packets are intercepted in a border router. The path decoupled signaling in NSIS was introduced in [12].

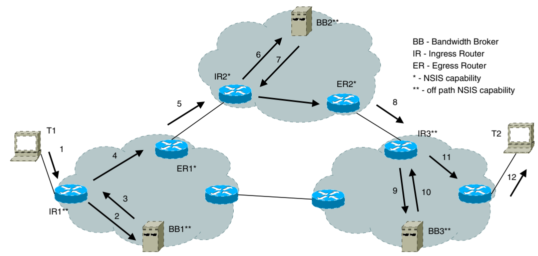

Fig.1 - Inter domain Signaling Architecture

In our approach, three nodes inside domain must be visited by signaling messages and therefore they must be QoS NSIS capable:

- ingress border router: they were incremented with a third thin layer between NTLP and NSLP to provide off path signaling. They should kbbl:now the BB domain IP address and forward NSIS signaling messages from client nodes. They must be signaled back to set local marking configuration related to the signaled flow. Finally, they must send signaling messages towards the destination;
- egress border router: in our QoS model, we assume the egress routers must be also visited as they have to make arrangements to measurement related to the flow. In the future, we expect them to make flow aggregation signaling on transit domains;
- BBs: as they are central authorities they should be always visited by signaling messages. In stub domains a per flow signaling is needed.

A typical signaling scenario showing the RESERVE message path for a flow from T1 to T2 is illustrated in the Figure 1. T1 acts as NSIS initiator. It sends a RESERVE QoS NSLP message (1) towards T2. The data path from T1 to T2 is IR1-ER1-IR2-ER2-IR3-ER3. All BBs on the domain path must be signaled. In this sense, ingress routers are configured with the address of each BB in the domain so that they can deviate messages to BBs. For example, IR1 knows BB1 address and it sends a NSIS message towards BB1 (message 2). BB1 processes the requested QoS and it signals back to IR1(message 3) so that, in the case of DiffServ, appropriate arrangements can be made. Note that we are not discussing details of QoS model as we are interested in the signaling architecture. This approach allows the use of on path signaling to configure border routers to the adopted QoS model. In the diffserv model, ingress routers can be instructed to make adequate marking.

IV. Signaling Architecture Behavior Under Mobility

A. Mobility Impacts on the Signaling Architecture

The Figure IV-A shows some possible scenarios of mobility applied to the Signaling Architecture discussed before. The QoS path is supposed to be already established for flow MN-CN with MN connected to AR1.1. As MN moves to another router (AR1.2) in the same domain (scenario 1) the data paths may change completely as BGP follows administrative policies specified for inter domain links. Once MN detects it is in new sub net, it sends a NSIS RESERVE message towards CN. In this case, router R2.4 clearly is the CRN, that is, the crossover router, the common point between the old and new path. NSIS takes advantage of CRN to tear down resource on the old path (AR1.1-AR2.4). A new state is established on the new sub path (AR1.2-R2.4).

The efforts related to scenario 1 (local domain mobility) and scenario 3 (local mobility in the visited network) are the same. The signaling efforts are very high (as NSIS end-to-end signaling is necessary) compared to the limited movement. It suggests to bound the path changes. As we will see in IV-C, HMIPv6 reduces the signaling load as it confines topological changes to the domain.

If we look to scenario 2 (inter domain mobility) the end-to-end signaling seems unavoidable. However, MIPv6 using HA inter-mediation could add some possibilities. As shown in scenario 2 in Figure 2 a tunnel can formed between HA-MN. The new data path is the old data path plus tunnel HA-MN(AR5.1). QoS managements in this case implies the QoS tunnel management. However, efforts to build a QoS path in the tunnel can be the same as for end-to-end signaling.

In accordance with previous works ([6],[7]) we have decided to use HMIPv6 as a mobility support. It reduces signaling load for scenarios 1 and 3. If some advance reservations are added and a properly NSIS integration is done, then scenario 2 can be also treated adequately.

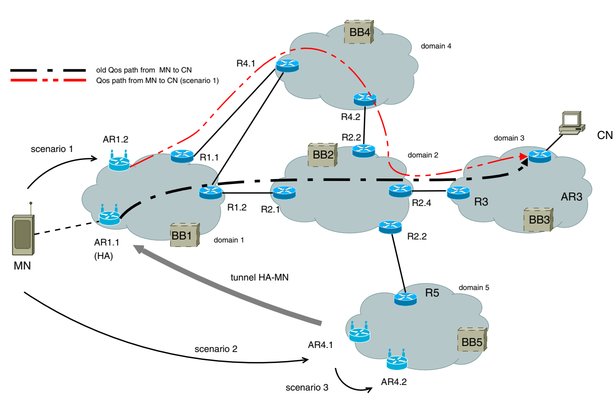

Fig.2 - Mobility Scenarios in a Inter domain Communication

B. Exploring Off Path Nodes to Tear Down Unused Resources

An efficient state update depends on finding the crossover node (CRN), that is, the merging point of two or more paths along which states are installed. In our work, we explore the existence of off-path nodes, the BB of the QoS model, to improve the process of tear down resources as they can act as crossovers nodes inside a domain. We call the domain managed by a such BB a crossover domain (Figure 3).

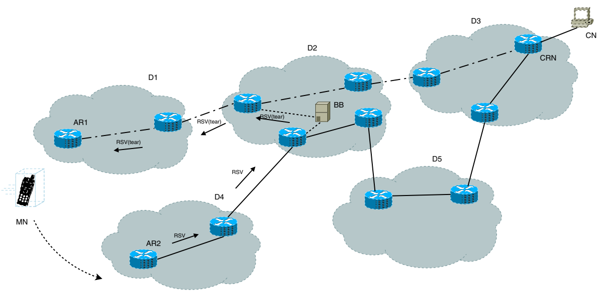

Fig.3 - Improved Signaling for Tear Down Resources

In on path signaling scenario, if MN is the signaling initiator, then the first crossover router will be the router labeled CRN in the figure. Resource releases will be initiated after CRN discovery so signaling messages after MN moves to AR2, will travel by domains 4,2,5 and 3. The off path signaling via BB is used to improve the signaling messages to tear down resources. Messages will travel by domains 4 and 2. In domain 2, BB self-detects as a CRN and start signaling to tear down resources in domains 2 and 3. When signaling reaches CRN router on domain 3, a new tear down message is sent on the old path to release resources in domain 3.

C. Architecture Behavior under Local Mobility

We propose a modified scheme of [7] to deal with local mobility. Alternatively, we do not built a mobility object but we assure the MAP knows the neighborhood of access routers under its coverage. MAP uses this information to make advance resource reservations[5]. The Figure 4 shows the establishment of a new QoS path and a handover procedure. AR1 is supposed to be neighbor of AR2. Note that from the point of view of service continuity, the key point is the handover procedure. A user can afford to wait some time to establish a QoS path but long QoS fluctuations on an ongoing communication are unacceptable. The behavior is as follows:

1) *AR1 periodically sends a RADV (Router Advertisement) to mobile nodes in its area. This message contains MAP global address used to form RCoA and AR1 sub net information.*
2) *MN registers its LCoA1 with its MAP through a BU-Binding Update. A tunnel is formed between MN and MAP (LCoA1,RCoA);*
3) *MN receives the Binding Update Acknowledgment from MAP;*
4) *MN will initiate a new flow with QoS requirements. It sends a RESERVE NSIS message related to SID(e2e), FID(HoA, CN) and SID(tunnel), FID(LCoA1,RCoA) . MAP deviates reservation towards BB1, beginning an off path signaling. MAP inform also BB about the neighbors of AR1 (in this case only AR2);*
5) *BB1 processes the new reservation request, does active reservations for AR1 and passive reservations for AR2. The RESERVE message is returned to MAP.*
6) *MAP continues the RESERVE signaling related to SID(e2e) towards MAP. Messages will follow paths as stated in Figure 1. RESPONSEs will be generated and returned to MAP;*

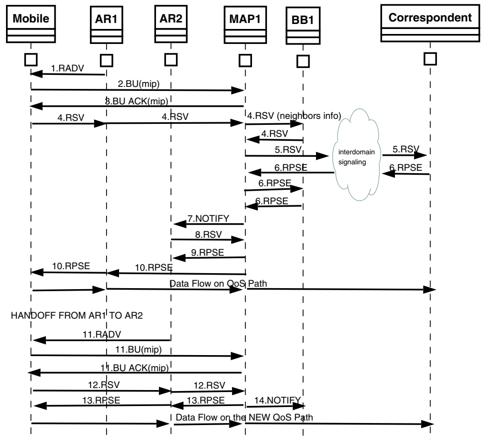

Fig.4 - Sequence Diagram for Local Mobility with HMIPv6

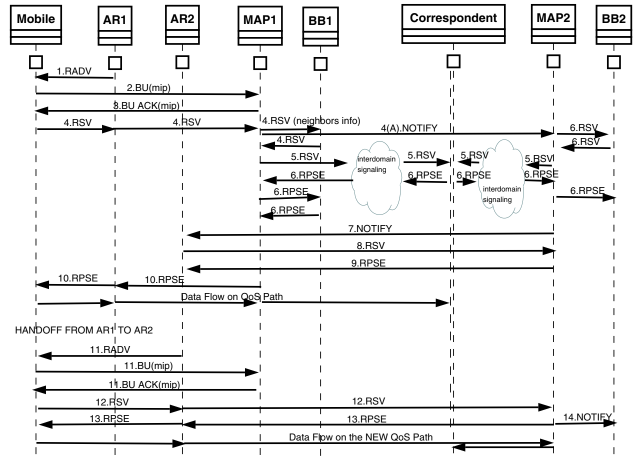

Fig.6 - Sequence Diagram for Global Mobility with HMIPv6

7) *MAP uses NOTIFY message to start a reservation process from AR2 for SID(tunnel), FLOW(AR2,CoA).*
8) *AR2 starts the RESERVE for SID(tunnel),FLOW(AR2,CoA);*
9) *AR2 receives a RESPONSE for the previous reservation;*
10) *MAP ends the process sending the final RESPONSE to MN.*
11) *From this point a handover is started . MN moves from AR1 to AR2. RADV and HMIP messages are exchanged as in 1,2 and 3.*
12) *Resources in AR2 are already reserved and path changes are confined to MAP coverage. MN starts a reservation towards MAP, related to SID(tunnel),FLOW(LCoA2,RCoA).*
13) *A RESPONSE message is sent from MAP to MN;*
14) *A NOTIFY message is sent to BB to register that AR2 is now using resources and AR1 is passive.*

D. Architecture Behavior under Global Mobility

We call global mobility the inter-domain handover, as shown in Figure 5. We will consider a message sequence illustrated in Figure 6, where a MN establishes a new QoS path from AR1 in a domain and then hands off to a AR2 in another domain. The messages are essentially the same as in the previous scenario but some additional signaling is needed. MAP1 is assumed to know that AR2 (and also MAP2) is an AR1 neighbor. Additionally to message 4, where MAP request BB1 to implement reservations to domain neighborhood, it must also inform MAP2 about advance passive reservations in its domain (message 4A). MAP2 also starts a inter-domain signaling similar to the one implemented in the new flow in MAP1. If the result of this process succeeds then MAP2 asks AR2 (message 7) to start the local reservation. When MN arrives in the new access router AR2, all the arrangements are done and MN only signals to activate the reservation.

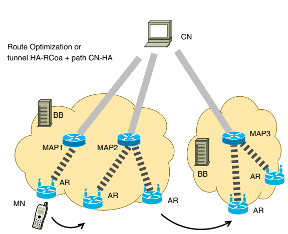

Fig.5 - Mobility between MAPs

V. Conclusions and Future Work

In this paper we have proposed an integration scheme of a QoS NSIS based Signaling Architecture in a HMIPv6 mobile environment. The architecture is based on bandwidth brokers and enforces the on and off path signaling. Advance reservations are done in inter and intra domains. We have shown that the approach of on-path and off-path signaling can boost the process of resource releases on unused paths. In order to evaluate the scenarios described above we have built a test bed using Linux virtual machines.

We are currently improving the scheme to reduce advance signaling. As a future work we will carry out detailed performance analysis of the proposed system.

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