IETF Mobile IP Working Group   Hemant Chaskar
INTERNET-DRAFT   Editor
Expires: November 2001   Nokia Research Center
                                                               June 2001

Requirements of a QoS Solution for Mobile IP

draft-chaskar-mobileip-qos-requirements-00.txt

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Abstract

Mobile IP protocol ensures correct routing of packets to mobile node as the mobile node changes its point of attachment with the Internet. However, it is also required to provide proper QoS forwarding treatment to mobile node's packet stream at the intermediate nodes in the network, so that QoS-sensitive IP services can be supported over Mobile IP. This document describes requirements of an IP QoS mechanism for its satisfactory operation with Mobile IP.

1.0 Introduction

Mobile IP is a technology that allows a "mobile node" (MN) to change its point of attachment to the Internet while communicating with the "correspondent node" (CN) using IP. The formal description of Mobile IP can be found in [1, 2]. Mobile IP primarily addresses the correct routing of packets to MN's current point of attachment with the Internet.

It is also essential to provide proper Quality of Service (QoS) forwarding treatment to the packets sent by or destined to MN as they propagate along different routes in the network due to node mobility. This document will identify the requirements that Mobile IP places on an IP QoS mechanism.

1.1 Problem statement

When a MN using Mobile IP undergoes handover from one access router to another, the path traversed by MN's packet stream in the network may change. Such a change may be limited to a small segment of the end-to-end path near the extremity, or it could also have an end-to-end impact. Further, the packets belonging to MN's ongoing session may start using the new care-of address after handover, and hence, may not be recognized by some forwarding functions along the old path that use IP address as a key. Finally, handover may occur between the subnets that are under different administrative control.

In the light of this scenario, it is essential to establish proper QoS support at the intermediate nodes in the new end-to-end path of the MN's packet stream.

1.2 An approach for solving QoS problem in Mobile IP

There are four important steps involved in solving the QoS problem for Mobile IP. They are as follows: (1) List the requirements that Mobile IP places on the QoS mechanism, (2) Evaluate current IP QoS solutions against the requirements, (3) Decide if current solutions need to be extended, or if new ones need to be defined, and (4) Depending on the result of step 3, define new solutions or fix the old ones.

Of these, the first step, i.e. the requirements step, is addressed in this draft. The last three steps are not dealt with here in detail. However, so as to create useful insight into the Mobile IP QoS problem, wherever relevant, this draft highlights the shortcomings of some popular current practices (proposals) for establishing QoS support along the packet path, in the light of the requirements imposed by Mobile IP.

2 0 Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119.

3 0 Requirements of a QoS solution for Mobile IP

This section describes the requirements of a QoS solution for Mobile IP. Conversely, note that only Mobile IP-specific requirements are described here. We do not assume any particular version (4 or 6) of IP while describing the requirements. Solutions can be designed for IPv4 and IPv6 independently, or a single solution can be designed to work with both versions.

3.1 Performance requirements

1. Minimize the interruption in QoS at the time of handover:

At the time of handover, interruption in QoS would occur if the packets sent by or destined to the MN arrive at the intermediate node in the new end-to-end packet path without that node having information about their QoS forwarding requirement. Then, those packets will receive default forwarding treatment. Such QoS interruption MUST be minimized. A good metric for this performance is the number of packets that get served with "default" QoS at the time of handover. The number of such packets MUST be minimized.

As an example, this performance metric is computed in [3] for the case of end-to-end RSVP signaling [4] with Mobile IPv6. It is shown there that when the end-to-end path of packets changes at large after handover or when the care-of address changes after handover, OPWA (One Pass With Advertisement) model of reservation used by RSVP causes the latency of about one round-trip time between the MN and the CN before QoS can be established along the new packet path. In other words, the packets using the new care-of address that would be released by the MN or the CN during one round-trip time, after these nodes are ready to use the new care-of address, may get default forwarding treatment at the intermediate nodes. Such a latency in QoS programming may be acceptable at the time of session initiation, but is not acceptable in the middle of an active session as would be the case with handover.

2. Localize the QoS (re)establishment to the affected parts of the packet path in the network:

In many cases, handover changes only a small segment of the end-to-end path of MN's packet stream near the extremity. Then, the QoS mechanism MUST limit the extent of QoS (re)establishment to the affected segment of the end-to-end path only. Of course, if the end-to-end path changes at large after handover, the QoS mechanism MUST be able to address that in a manner that is consistent with the QoS scheme(s) used along the new end-to-end packet path.

Note that the QoS signaling protocol such as RSVP [5] can localize the QoS signaling to the affected parts of the end-to-end path if the care-of address does not change upon handover. However, if the care-of address changes upon handover, RSVP as currently defined fails to localize the QoS signaling [see 6]. In addition, it will cause double reservations on the part of end-to-end path that remains unchanged after handover.

When the care-of address changes upon handover, it may be required to perform some signaling even over the unchanged part of the end-to-end path if the path contains any QoS mechanisms that use IP address as a key to forwarding functions. Examples are FILTER SPECs in the IntServ nodes or packet classifiers at the edges of DiffServ networks. However, double provisioning of resources over the unchanged part of the packet path MUST be avoided.

3. Releasing after handover the QoS state (if any) along the old packet path:

The QoS mechanism MUST provide some means (explicit or timer-based) to release any QoS state along the old packet path that is not required after handover. It is desirable that the unwarranted QoS states, if any, along the old path are released as quickly as possible at the time of handover. Note that, during handover, the MN may not always get a chance to send explicit tear down message along the old path because of the loss of link layer connectivity with the old access router.

3.2 Interoperability requirements

1. Interoperability with mobility protocols:

A number of mobility protocols that are complementary to Mobile IP are already defined or may be defined in future in IETF, particularly in Mobile IP and Seamless Mobility working groups. Examples are Fast Handover [7, 8], Regional Registrations [9], Hierarchical MIPv6 [10], Context Transfer [11] etc. The QoS mechanism for Mobile IP SHOULD take advantage of these mobility protocols for optimized operation. However, the QoS scheme MUST have provisions to accomplish its tasks even if one or more of these mobility protocols are not used.

2. Interoperability with heterogeneous end-to-end packet paths as regards QoS paradigms:

The new end-to-end path of MN's packet stream may encounter network domains employing a variety of QoS paradigms, such as IntServ, DiffServ and MPLS. Each of the networks/routers along this path may require a different kind of information about the MN's packet stream, so that proper QoS forwarding treatment can be established for the MN's packet stream. The QoS mechanism for Mobile IP MUST be able to establish proper QoS forwarding treatment for the MN's packet stream in these QoS-heterogeneous network domains in the new end-to-end path.

As an illustration, suppose that the MN is currently attached to an access router which is the edge router of a DiffServ network, and that the packet classifier and traffic policer for the MN's flows are somehow programmed in this access router. Further, assume that the QoS policy in this access network takes care of SLAs with other networks that it attaches to. Now, suppose that the MN needs to be handed over to the access router which is at the edge of an IntServ network. The new access network would expect the exchange of RSVP messages so that proper QoS forwarding treatment can be established for the MN's packet stream in that access network. Here is another example of cross-QoS-technology handover. Suppose that the MN is currently attached to an access router that is a part of access network X and is to be handed over to the access router that is a part of access network Y. In network X, the access router acts as a proxy (and possibly communicates with some QoS agent in the network) to program (possibly end-to-end) QoS forwarding treatment for the MN's packet stream. On the other hand, network Y expects the end hosts attached to it to send explicit QoS request messages along the data path.

The QoS solution for Mobile IP MUST be able to establish QoS support for MN's packet stream over the packet paths that use diverse (best current practices) end-to-end QoS mechanisms.

3.3 Miscellaneous requirements

1. QoS support along multiple paths:

After MN undergoes handover from one access router to another, potentially, there could be multiple paths over which MN's packet may propagate. Examples of these path are: route-optimized path between the MN and its CN, triangle route via Home Agent (HA), temporary tunnel between old and new access routers etc. A QoS mechanism SHOULD be able to support QoS along the different potential packet paths. However, whether all paths are supported or only a subset of them is supported will be determined by external mechanisms such as, say, mobility management, policy, location privacy requirement etc. Further, the same QoS mechanism may not be able to support all the three alternatives.

2. Interactions with link-layer support for QoS:

The QoS mechanism MAY provide some information to the link layers for them to support the required QoS. Since a vast number of devices using Mobile IP will be connected to the Internet via wireless links, wireless link significant QoS parameters such as error rate MAY have to be included in the set of QoS parameters to be possibly considered and supported by the underlying link layer.

An example scenario will be two UDP streams requiring different levels of error protection at the link layer. For such cases, an IP-layer QoS mechanism may indicate some generic parameters such as acceptable IP packet loss rate to link layers.

3.4. Obvious requirements

The QoS solution for Mobile IP SHOULD satisfy obvious requirements such as scalability, security, conservation of wireless bandwidth, low processing overhead on mobile terminals, providing hooks for authorization and accounting, and robustness against failures of any Mobile IP-specific QoS components in the network. While it is not possible to set quantitative targets for these desirable properties, the QoS solution MUST be evaluated against these criteria.

4.0 Concluding Remarks

In this document, we described the requirements of a QoS solution for Mobile IP. The expectation is that the appropriate working group will use this requirements document to provide a QoS solution for Mobile IP.

5.0 Acknowledgment

I would like to acknowledge the participants of the mailing list that was set up to discuss the above requirements. Their contributions and active participation in the discussion on the mailing list were very useful in the preparation of this document. Special thanks are due to, in alphabetical order, Marc Greis (Nokia), Glenn Morrow (Nortel), Phil Roberts and Michael Thomas (Cisco) for their comments during the preparation of this document.

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7.0 Addresses

The working group can be contacted via the current chairs:

Basavaraj Patil
Nokia Corporation
6000 Connection Drive
M/S M8-540
Irving, Texas 75039, USA
Phone: +1 972-894-6709
EMail: Basavaraj.Patil@nokia.com

Phil Roberts

20251 Century Blvd
Suite 120
Germantown, MD 20874
Phone: +1 847-202-9314
EMail: proberts@MEGISTO.com

Questions about this memo can be directed to the authors:

Hemant Chaskar
Nokia Research Center
5 Wayside Road
Burlington, MA 01803, USA
Phone: +1 781-993-3785
EMail: hemant.chaskar@nokia.com