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H. Chaskar, Ed.
Nokia Research Center

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Requirements of a Quality of Service (QoS) Solution for Mobile IP

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Abstract

Mobile IP ensures correct routing of packets to a mobile node as the mobile node changes its point of attachment to the Internet. However, it is also required to provide proper Quality of Service (QoS) forwarding treatment to the 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 for an IP QoS mechanism for its satisfactory operation with Mobile IP.

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1. 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, 6]. 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 an 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 a new care-of address after handover. Hence, they may not be recognized by some forwarding functions in the nodes even along that segment of the end-to-end path that remains unaltered after handover. 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 for the MN's packet stream along the new packet path.

1.2. An approach for solving the 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 these 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 document. The last three steps are not dealt with here in detail. However, so as to create useful insight into the Mobile IP QoS problem, at times this document highlights the shortcomings of some well known current proposals for establishing QoS support for the packet stream in the network, when directly used with Mobile IP.

2. 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 BCP 14, RFC 2119 [2].

3. Requirements of a QoS solution for Mobile IP

This section describes the requirements for a QoS solution for its satisfactory operation with 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.

In this document, we assume that the target access router for MN's handover is already pinned down by other protocols. For example, Seamoby working group has started work on the candidate access router discovery protocols [7]. Thus, any QoS-capability specific negotiations that may affect the handover decision are outside the scope of QoS solution as such, rather need to be performed by candidate and target access router selection protocols.

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 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 may potentially get served with the "default" QoS at the time of handover. The number of such packets MUST be minimized.

   As an example, this performance metric is computed in [8] for the case of end-to-end RSVP signaling [3] 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 it 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.

   However, note that handover may sometimes cause the end-to-end path of MN’s packet stream in the network to change at large. This may happen, for example, in the case of handover between different administrative domains. If the QoS mechanism used to establish QoS support for the MN’s packet stream along the new packet path in the network is based on the explicit end-to-end provisioning as such, it MUST perform so at the time of such 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.

Note that the QoS signaling protocol such as RSVP [9] 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 [4] fails to localize the QoS signaling. In addition, it will cause double reservations on the part of end-to-end path that remains unchanged after handover.

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 Seamoby working groups. Examples are fast handover [10, 11], localized mobility management [12, 13], context transfer [5] etc. The QoS mechanism for Mobile IP SHOULD take advantage of these mobility protocols for the 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 packet paths as regards QoS paradigms:

   The new path after handover, of the MN’s packet stream, may traverse network domains employing different QoS paradigms compared to those along the old path. The QoS mechanism for

Mobile IP SHOULD be able to establish proper QoS forwarding treatment for the MN's packet stream along the packet paths deploying different QoS paradigms (best current practices), in a manner consistent with the QoS mechanism deployed along those paths.

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 presently programmed in this access router. 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. QoS mechanism for Mobile IP SHOULD have provisions to handle such heterogeneity as regards the QoS mechanisms deployed along different packet paths.

3.3. Miscellaneous requirements

1. QoS support along multiple packet 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, reverse tunnel from the new access router (Foreign Agent) to HA 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 mobility management, policy, location privacy requirement and so on. Further, the same QoS mechanism may not be able to support all these paths.

2. Interactions with wireless link-layer support for QoS:

   Since a vast number of devices using Mobile IP will be connected to the Internet via wireless links, the QoS mechanism for Mobile IP MAY provide some information to the wireless link layers for them to support the required QoS.

   An example scenario that may benefit from such information is that of the two UDP streams associated with the same media, but requiring different levels of error protection at the wireless link layer due to certain characteristics of their respective encoding schemes. The packets of these two streams are equally delay sensitive (so as to maintain playout synchronization at the

receiver), and hence, may be treated equally (as regards queuing) by IP layer. But they may need to be transmitted on wireless channels of different error characteristics (say different FEC coding or power levels).

The QoS information included for the benefit of wireless link layers SHOULD be such that it is meaningful both ways: to applications that reside over IP so that they can choose the IP service of certain QoS characteristics and to wireless link QoS managers so that they can then map this information to the details of lower layer mechanisms and their parameters.

In the example scenario described above, such a QoS information could be expressed as the acceptable loss rate of IP packets in the UDP stream. This parameter enables the UDP application to choose the IP service having QoS that matches its requirements, and it also enables the wireless link QoS managers to choose the right wireless channel to transmit the packets of this UDP stream.

3.4. Standard requirements

The QoS solution for Mobile IP SHOULD satisfy standard 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. Security Considerations

The QoS (re)establishment triggered by node mobility MUST be guarded against security attacks. Such attacks could be launched by malicious nodes that spoof the QoS signaling to make it appear to the intermediate nodes that the MN has undergone handover. Such an attack could disrupt the QoS offered to MN’s ongoing sessions as the intermediate nodes may then tear down the QoS along some segments of the true packet paths between MN and CN. The malicious nodes may also request a reduced level of QoS or supply fake packet classifiers, thereby affecting QoS over some segments (e.g., that do not get affected by the spoofed handover) of the true packet paths between MN and CN. Further, network resources may be wasted or used in an unauthorized manner by the malicious nodes that spoof MN’s handover. To prevent this, QoS mechanism MUST provide means for intermediate nodes to verify the authenticity of handover-induced QoS (re)establishment.

5. Recommendation

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

6. Acknowledgment

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8. Authors' Addresses

The working group can be contacted via the current chair:

John Loughney
Nokia Research Center
11-13 Italahdenkatu
00180 Helsinki
Finland

EMail: john.loughney@nokia.com

Questions about this memo can be directed to the editor:

Hemant Chaskar
Nokia Research Center
5 Wayside Road
Burlington, MA 01803, USA

Phone: +1 781-993-3785
EMail: hemant.chaskar@nokia.com

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