# Design of Scalable QoS Peer to Peer Mobile Communication Using Traffic Engineered MPLS Path

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## 1. Introduction

In recent years, large scale mobile internets are being constructed in the 3rd generation cellular phone network and its all IP version. Mobile IP [1] standardized at IETF is used as the basic protocol in some of these networks [2]. Recently, the QoS guarantee is required in order to realize various mobile real time communications. So, we have been studying a new QoS Mobile IP communication scheme which has the same level of scalability as Mobile IP [3]. In our scheme, only the Mobile IP nodes, such as HA and FA, manage the resource management information on QoS communication of individual MNs, while intermediate backbone routers are not concerned about them. This paper describes the detailed procedures in which our proposal is applied to Peer to Peer communications among MNs.

## 2. Design Principles

(1) In this paper, we handle a QoS communication between an MN and another MN. The backbone comprises multiple MPLS routers (LSRs: Label Switching Routers), and these LSRs are not concerned with any movement information of MNs. It is just HAs and FAs that manage the information on MN's movement.

(2) We use CR-LDP (Constraint-based Routing Label Distribution Protocol) to establish the *thick* connections before the QoS communications. That is, LSPs (Label Swithched Paths) allocated with enough bandwidth are established beforehand, among HAs and FAs. Hereafter, this LSP is called a *CR-LSP*. The bandwidth of a CR-LSP is determined in the network design by taking account of estimated real-time traffic.

(3) When an MN starts QoS communication with another MN, the originating MN shall establish a *thin* connection with the accepting MN, within the CR-LSPs established beforehand, by the help of the corresponding HA and FA. Hereafter, we call this *thin* connection a *Pathlet*. The establishment of the Pathlet is performed with the coordination among HAs of the originating and accepting MNs, and individual FAs under which the communicating MNs are located.

(4) If the bandwidth of CR-LSP becomes insufficient while a Pathlet is being established, the HA/FA will establish a new CR-LSP according to the procedure of CR-LDP. The bandwidth of the new CR-LSP will be determined in advance according to the traffic conditions.

(5) Once a new CR-LSP is established, the bandwidth of individual links in the network backbone available for the Mobile QoS communications is changed. So, after a CR-LSP has been established, the LSR which is the transmitter of a link whose available bandwidth was changed, advertises the updated available bandwidth for this link to other LSRs. We use OSPF for this advertisement.

## 3. Detailed Communication Procedures

This section describes the communication procedures of our scheme using the network shown in Fig. 1. One MN (*MN1*) is located under *FAa* first and it moves to *FAb*. Another MN (*MN2*) is located under *FAc*. In this paper, we assume that MNs always connect with one of FAs and do not return back to the home network [2].

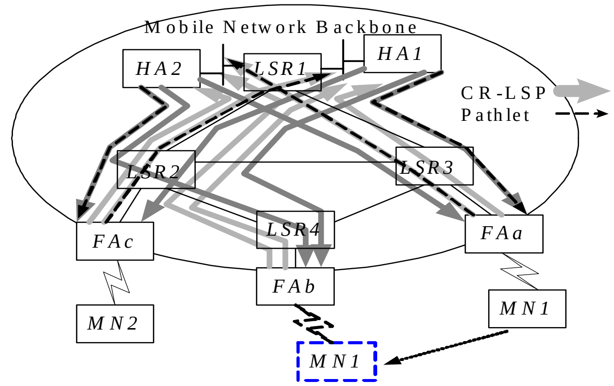


Figure 1. Network configuration

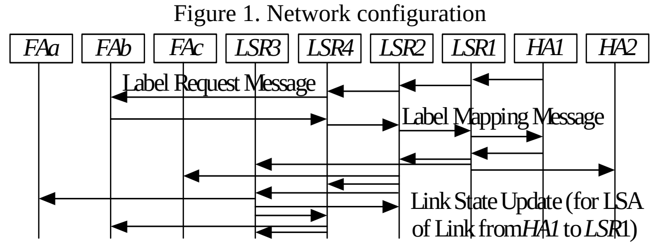


Figure 2. Sequence of establishing CR-LSP from HA1 to FAb

### 3.1. Procedures for CR-LSP Establishment

After an individual Mobile IP node becomes operational, it tries to establish CR-LSPs with other Mobile IP nodes in the following way.

(1) Every HA establishes CR-LSPs from itself to all of the FAs in the mobile network backbone. In our example, both of *HA1* and *HA2* establish CR-LSPs to *FAa*, *FAb* and *FAc*.

(2) Every FA in the network backbone establishes CR-LSPs to every home network where an HA resides. In our example, each of *FAa*, *FAb* and *FAc* establishes a CR-LSP to the sub networks of both *HA1* and *HA2*.

(3) A path of a CR-LDP is determined by considering the available bandwidth of the links which are included in the path.

Figure 2 shows the procedure for *HA1* to establish a CR-LSP to *FAb*. It is summarized as follows. As the result of the advertisement of the available bandwidth of individual links, all of the MPLS nodes (*HA1*/*HA2*/*Faa*/*Fab*/*Fac*/*LSR1* through *LSR4*) maintain the updated information.

It should be noted that the bandwidth of CR-LSPs is not necessarily reserved only for QoS communication, but can be used for best effort traffic when QoS traffic does not exist. When QoS traffic is generated, each CR-LSR uses the bandwidth for it in higher priority than best effort traffic.

### 3.2. Procedures for Pathlet Establishment between MNs

When an MN starts a Peer to Peer QoS communication with another MN, Pathlets are established between those MNs. The establishment and release procedures of Pathlets are designed according to the following principles.

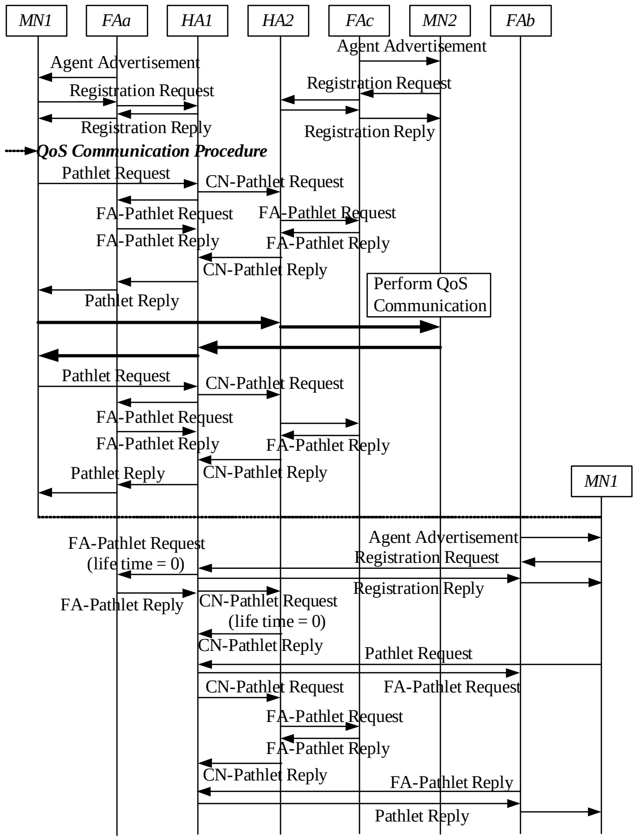


Figure 3. Sequence of establishing Pathlet between MNs

(1) A Pathlet is unidirectional similarly to CR-LSPs. A Pathlet is identified by five elements, MN IP address, CN IP address, protocol type, MN port and CN port. It should be noted that CN corresponds to the accepting MN, in this case.
(2) Since it is only HA and FA that maintain the information about Pathlets, a header for distinguishing a Pathlet is not introduced. The intermediate LSRs just forward these MPLS packets and are not conscious of Pathlets.
(3) Similarly to the registration procedure in Mobile IP, the lifetime is defined for a Pathlet. MN requests the establishment of a Pathlet periodically and keeps it effective. HA and FA will release a Pathlet implicitly if no request messages are received until its lifetime expires. It will release a Pathlet explicitly by setting the lifetime to zero.
(4) HA or FA will implicitly release all Pathlets related to a MN when the MN is deleted from the Mobility Binding List or the Visitor list, respectively.
(5) MN and HA use *Pathlet Request* and *Pathlet Reply* messages in order to establish and release Pathlets. HA uses *FA-Pathlet Request* and *FA-Pathlet Reply* messages, or *CN-Pathlet Request* and *CN-Pathlet Reply* messages, in order to ask FA or CN to establish and release Pathlets.
(6) In this case, a Pathlet is established between a sending MN and a receiving MN through the HA of a receiving MN, similarly with the data transfer between the sending and receiving MNs.

Figure 3 show the Peer to Peer QoS communication sequence with the configuration in Fig. 1. Here, *MN1* whose HA is *HA1* is located under *FAa*, and *MN1* starts QoS communication with *MN2*, whose HA is *HA2* and which is located under *FAc*, and then *MN1* moves to *FAb* network.

In the beginning, *MN1* and *MN2* register the care-of addresses of themselves to *HA1* and *HA2*, respectively. Then, *MN1* starts QoS communication with *MN2* and sends a Pathlet Request message to *HA1*. When *HA1* receives this message, it sends an FA-Pathlet Request message to *FAa*. This message contains the CN address and port as well as the required bandwidth. In this case, the CN address corresponds to the home address of *MN2*. *FAa* tries to establish a Pathlet with *MN2*, which results in the Pathlet establishment over a CR-LSP from *FAa* to the home network of *HA2*. This procedure establishes the FA to HA part of a Pathlet from *MN1* to *MN2*. After that, *FAa* sends an FA-Pathlet Reply message to *HA1*.

*HA1* also reserves the required bandwidth in the CR-LSP from *HA1* to *FAa* in order to establish the HA to FA part of a Pathlet from *MN2* to *MN1*.

At the same time, *HA1* sends a CN-Pathlet Request message to *MN2*, and this message is captured by *HA2*. *HA2* understands that *MN2* is selected as the target of QoS communication by *MN1*. So, *HA2* sends an FA-Pathlet Request message to *FAc*, to which *MN2* is belonging at this time. This message contains the home addresses of *MN1* and *MN2* (the home address of *MN2* is the CN address). Using this information, *FAc* tries to establish a Pathlet with *MN1*, which results in the establishment of the FA to HA part of a Pathlet from *MN2* to *MN1*. After that, *FAc* sends an FA-Pathlet Reply message to *HA2*.

In response to the CN-Pathlet Request message from *HA1*, *HA2* also establishes the HA to FA part of a Pathlet from *MN1* to *MN2*. After that, *HA2* sends a CN-Pathlet Reply message to *HA1*.

After all of those procedures have been finished, *HA1* sends a Pathlet Reply message to *MN1* via *FAa*. Then, *MN1* performs to Peer to Peer QoS communication with *MN2*. During the communication, Pathlet Request message is sent periodically to refresh the lifetime for maintaining the Pathlet. At this time, the above procedures among HA and FA are repeated.

In the sequence shown in Fig. 3, *MN1* then moves to the network of *FAb*. *MN1* detects its movement, obtains a care-of address and registers it to *HA1*. Since *HA1* has detected the movement of *MN1* by receiving the Registration Request message, it releases the HA to FA part of the Pathlet from *MN2* to *MN1*, sends an FA-Pathlet Request messages whose lifetime is zero to *FAa*, and releases the FA to HA part of the Pathlet from *MN1* to *MN2*.

After the registration is completed, *MN1* will send a Pathlet Request message to *HA1*, with the new care-of address, and *HA1* sends CN- and FA-Pathlet Request messages to request the establishment of new Pathlets for *MN1*. *HA1* returns a Pathlet Reply message to *MN1* if the establishment of Pathlets is completed.

## 4. Conclusion

This paper described the detailed communication procedures for maintaining CR-LSPs and Pathlets in the Mobile IP networks. The communication procedures are focusing on Peer to Peer communication between MNs, such as mobile VoIP communication.

## References

[1] C. Perkins, Ed., IP Mobility Support for IPv4, *RFC 3344*, Aug. 2002.
[2] 3rd Generation Partnership Project 2, Wireless IP Architecture Based on IETF Protocols, *3GPP2 P.R0001*, Ver.1.0.0, Jul. 2000.
[3] W. Liu, T. Kato, S. Ueno and S. Itoh, A Proposal of Scalable QoS Guaranteed Mobile IP Communication Using MPLS Path with Pre-allocated Bandwidth, *IEICE Trans. on Information and Systems*, Mar. 2004 (to be published).