Next Steps in Signaling (nsis)
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T. Sanda (Ed.)
Panasonic
X. Fu
University of Goettingen
S. Jeong
HUFS
J. Manner
TKK
H. Tschofenig
Nokia Siemens Networks

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NSIS Protocols operation in Mobile Environments
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Abstract

Mobility of an IP-based node affects routing paths, and as a result, can have a significant effect on the protocol operation and state management. This document discusses the effects mobility can cause to the Next Steps in Signaling (NSIS) protocol suite, and shows how the NSIS protocols operation can work in different scenarios, with mobility management protocols.

Status of this Memo

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1. Introduction

Mobility of IP-based nodes incurs route changes, usually at the edge of the network. Since IP addresses are usually part of flow identifiers, the change of IP addresses implies the change of flow identifiers (i.e., the General Internet Signalling Transport (GIST) message routing information or Message Routing Information (MRI) [draft-ietf-nsis-ntlp]). Local mobility usually does not cause the change of the global IP addresses, but affects the routing paths within the local access network

The NSIS protocol suite consists of two layers: NSIS Transport Layer Protocol (NTLP) and the NSIS Signaling Layer Protocol (NSLP). The General Internet Signaling Transport (GIST) [draft-ietf-nsis-ntlp] implements the NTLP, which is a signaling application independent protocol and transports service-related information between neighboring GIST nodes. Each specific service has its own NSLP protocol; currently there are two specified NSLP protocols, the QoS NSLP [draft-ietf-nsis-qos-nslp], and the NAT/Firewall NSLP [draft-ietf-nsis-nslp-natfw]

The goals of this document are to present the effects of mobility on

the NTLP/NSLPs and to provide guides on how such NSIS protocols work in basic mobility scenarios, including support for Mobile IPv4 and Mobile IPv6 scenarios. We also show how these protocols fulfil the requirements regarding mobility set forth in [RFC3726]. In general, the NSIS protocols work well in mobile environments. The Session ID (SID) used in NSIS signaling enables the separation of the signaling state and the IP addresses of the communicating hosts. This makes it possible to directly update a signaling state in the network due to mobility without being forced to first remove the old state and then re-establish a new one. This is the fundamental reason why NSIS signaling works well in mobile environments. As the additional information, mobility specific enhanced operations, e.g. operations with crossover node (CRN) are also introduced.

This document focuses on basic mobility scenarios. Key management related to handovers, multihoming and interactions between NSIS and other mobility management protocols than Mobile IP are out of scope of this document. Also, practical implementations typically need various APIs across components within a node. API issues, e.g., APIs from GIST to the various mobility and routing schemes, are also out of scope of this work. The generic GIST API towards NSLP is flexible enough to fulfill most mobility-related needs of the NSLP layer.

2. Requirements Notation and Terminology

The terminology in this documnet is based on [draft-ietf-nsis-ntlp] and [RFC3753]. In addition, the following terms are used. Note that in this document, a generic route change caused by regular IP routing is referred to as a 'route change', and the route change caused by mobility is referred to as 'mobility'.

(1) Downstream

The direction from a data sender towards the data receiver.

(2) Upstream

The direction from a data receiver towards the data sender.

(3) Crossover Node (CRN)

A Crossover Node is a node that for a given function is a merging point of two or more paths belonging to flows of the same session along which states are installed.

In the mobility scenarios, there are two different types of merging points in the network according to the direction of signaling flows followed by data flows, where we assume that the Mobile Node (MN) is the data sender.

Upstream CRN (UCRN): the node closest to the data sender from which the state information in the direction from data receiver to data sender begins to diverge after a handover.

Downstream CRN (DCRN): the node closest to the data sender from which the state information in the direction from the data sender to the data receiver begins to converge after a handover.

In general, the DCRN and the UCRN may be different due to the asymmetric characteristics of routing although the data receiver is the same.

(4) State Update

State Update is the procedure for the re-establishment of NSIS state on the new path, the teardown of NSIS state on the old path, and the update of NSIS state on the common path due to the mobility. The State Update procedure is used to address mobility for the affected flows.

Upstream State Update: State Update for the upstream signaling flow.

Downstream State Update: State Update for the downstream signaling flow.

3. Challenges with Mobility

This section identifies problems caused by mobility, which affect the operations of NSIS protocol suite.

1. Change of route and possibly change of the MN's IP address

Topology changes or network reconfiguration might lead to path changes for data packets sent to or from the MN and can cause an IP address change of the MN. Traditional route changes usually do not cause address changes of the flow endpoints. When an IP address changes due to mobility, information within the path-coupled MRI is affected (the source or destination address). Consequently, this concerns GIST as well as NSLPs, e.g., the packet classifier in QoS NSLP or some rules carried in NAT/FW NSLP. So already installed firewall rules, NAT bindings, and QoS reservations may become invalid, because the installed states refer to a non-existent flow. If the affected nodes are also on the new path, this information must be updated accordingly.

2. Double state problem

After a handover, packets may end up getting delivered through a new path. Since the state on the old path still remains as it was after re-establishing the state along the new path, we have two separate states for the same signaling session. Although the state on the old path will be deleted automatically based on the soft state timeout, the state timer value may be quite long (e.g., 90s as a default value). With the QoS NSLP, this problem might result in the waste of resources and lead to failure of admitting new reservations (due to lack of resources). With the NAT/FW NSLP, it is still possible to re-use this installed state although an MN roams to a new location; this means that another host can send data through a firewall without any prior NAT/FW NSLP signaling because the previous state did not yet expire.

3. End-to-end signaling and frequency of route changes

The change of route and IP addresses in mobile environments is typically much faster and more frequent than traditional route changes caused by node or link failure. This may result in a need to speed up the update procedure of NSLP states.

4. Identification of the crossover node

When a handover at the edge of a network has happened, in the typical case, only some parts of the end-to-end path used by the data packets changes. In this situation, the cross-over node (CRN) plays a

central role in managing the establishment of the new signaling application state, and removing any useless state, while localizing the signaling only to the affect part of the network.

5. Upstream State Update vs. Downstream State Update

Due to the asymmetric nature of Internet routing, the upstream and downstream paths are likely not to be exactly the same. Therefore, state update needs to be handled independently for upstream and downstream paths.

6. Upstream signaling

If the MN is receiver and moves to a new point of attachment, it is difficult to signal upstream towards the Correspondent Node (CN). New signaling states have to be established along the new path, but for a path-coupled Message Routing Method (MRM) this has to be initiated in downstream direction. So NTLP signaling state in upstream direction cannot be initiated by the MN, i.e., GIST cannot easily send a Query in upstream direction (there is an upstream Q-mode, but this is only applicable in a limited scope). The use of additional other protocols such as application level signaling (e.g, SIP) or mobility management signaling (e.g., Mobile IP) may help to trigger NSLP and NTLP signaling from the CN side in downstream direction though.

7. Authorization Issues

The procedure of State Update may be initiated by the MN, the CN, or even nodes within the network (e.g., crossover node, Mobility Anchor Point (MAP) in Hierarchical Mobile IP (HMIP)). This State Update on behalf of the MN raises authorization issues about the entity that is allowed to make these state modifications.

8. Dead peer and invalid NR problem

When the MN is on the path of a signaling exchange, after handover the old Access Router (AR) can not forward NSLP messages any further to the MN. In this case, the old AR's mobility or routing protocol, or even the NSLP may trigger an error message to indicate that the last node fails or is truncated. This error message is forwarded and may mistakenly cause the removal of the state on the existing common path, if the state is not updated before the error message is propagated through the signaling peers. This is called the 'invalid NSIS Receiver (NR) problem'.

9. IP-in-IP Encapsulation

Mobility protocols may use IP-in-IP encapsulation on the segment of the end-to-end path for routing traffic from the CN to the MN, and vice versa. Encapsulation harms any attempt to identify and filter data traffic belonging to, for example, a QoS reservation. Moreover, encapsulation of data traffic may lead to changes in the routing paths since the source and the destination IP addresses of the inner header differ from those of the outer header. Mobile IP uses tunneling mechanisms to forward data packets among end hosts. Traversing over the tunnel, NSIS signaling messages are transparent on the tunneling path due to the change of flow's addresses. In case of interworking with Mobile IP-tunneling, CRNs can be discovered on the tunneling path. It enables NSIS protocols to perform State Update procedure over the IP-tunnel. In this case, GIST needs to cope with the change of Message Routing Information (MRI) for the CRN discovery on the tunnel. Also, NSLP signaling needs to determine when to remove the tunneling segment on the signaling path and/or how to tear down the old state via interworking with the IP-tunneling operation. Furthermore, tunneling adds additional IP header as overhead that must be taken into account by QoS NSLP for example, when resources must be reserved accordingly. So an NSLP must usually be aware whether tunneling or route optimization is actually used for a flow [draft-ietf-nsis-tunnel].

4. Basic Operations for Mobility Support

This section presents the basic operations of the NSIS protocol suite after mobility related route changes. Detailed discussion of the operation of Mobile IP with respect to NSIS protocols are discussed in the subsequent section.

4.1. General functionality

The NSIS protocol suite decouples state and flow identification. A state is stored and referred by the Session ID (SID). Flows associated with a given NSLP state are defined by the Message Routing Information (MRI). GIST notices when a routing path associated with a SID changes, and provides a notification to the NSLP. It is then up to the NSLP to update the state information in the network. Thus, the effect is an update to the states, not a full new request. This decoupling effectively solves also a typical problem with certain signaling protocols, where protocol state is identified by flow endpoints, and when flow endpoint addresses change, the whole session state becomes invalid.

A further benefit of the decoupling is that if the MRI, i.e., the IP addresses associated with the data flow, remain the same after movement, the NSIS signaling will repair only the affected path of the end-to-end session. Thus, updating the session information in the network will be localized, and no end-to-end signaling will be needed. If the MRI changes, end-to-end signaling usually can not be avoided since new information for proper data flow identification must be provided all the way between the data sender and receiver, e.g., in order to update filters, QoS profiles, or other flow related session data.

GIST provides NSLPs with an identifier of the next signaling peer, the SII Handle. When this SII Handle changes, the NSLP knows a routing change has happened. Yet, the NSLP can also figure out whether it is also the crossover node for the session. Thus, CRN discovery is always done at the NSLP layer because only NSLPs have a notion of end-to-end signaling.

When a path changes, the session information on the old path needs to be removed. Normally, the information is released when the session timer is expired after a routing change. But the NSLP running on the end-host or the CRN, depending on the direction of the session, may use the SII Handle (provided by GIST) to explicitly remove states on the old path; new session information is simultaneously set up on the new path. Both current NSLPs use sequence numbers to identify the order of messages, and this information can be used by the protocols to recover from a routing change.

Since NSIS operates on a hop-by-hop basis, any peer can perform state updates. This is possible because a chain-of-trust is expected between NSIS nodes. If this weren't the case, e.g., true resource reservations would not be possible; one misbehaving or compromised node would effectively break everything. Thus, currently the NSIS protocols do not limit the roles of each NSIS signaling peer on a path, and any node can make updates. Yet, some updates are reflected back to the signaling end points, and they can decide whether the signaling actually succeeded, or not.

If the signaling packets are encapsulated in a tunnel, it is necessary to perform a separate signaling exchange for the tunneled region. Furthermore, a binding is needed to tie the end-to-end and tunneled session together.

Furthermore, in some cases the NSLP must be aware whether tunneling is used, since additional tunneling overhead must be taken into account, e.g., for resource reservations etc.

4.2. QoS NSLP

Figure 1 illustrates an example of QoS NSLP signaling in a Mobile IPv6 route optimization case, for a data flow from the MN to the CN, where sender-initiated reservation is used. Once a handover event is detected in the MN, the MN needs to acquire the new care-of-address

and update the path coupled MRI accordingly. Then the MN issues a QoS NSLP RESERVE message towards the CN, that carries the unique session ID and other identification information for the session, as well as the reservation requirements (step(1)~(4) in Figure 1). Upon receipt of the RESERVE message, the QoS NSLP nodes (which will be discovered by the underlying NTLP) establish the corresponding QoS NSLP state, and forward the message towards the CN. When there is already an existing NSLP state with the same session ID, the state will be updated. If all the QoS NSLP nodes along the path support the required QoS, the CN in turn responds with a RESPONSE message, to confirm the reservation (step(5)~(6) in Figure 1).

In a bi-directional tunneling case, the only difference is that the RESERVE message should be sent to the HA instead of the CN, and the node which responds with a RESPONSE should be the HA instead of the CN too. More details are discussed in Section 5

Therefore, for the basic operation there is no fundamental difference among different operation modes of Mobile IP, and the main issue of mobility support in NSIS is to trigger NSLP signaling appropriately when a handover event is detected, and the destination of the NSLP signaling shall follow the Mobile IP data path as being path-coupled signaling.

In this process, the obsoleted state in the old path is not explicitly released because the state can be released by timer expiration. To speed up the process, it may be possible to localize the signaling. When the RESERVE message reaches a node, depicted as CRN in this document (step(2) in Figure 1), where a state is determined for the first time to reflect the same session, the node may issue a NOTIFY message towards the MN's old care-of-address (CoA) (step(9) in Figure 1). The QNE adjacent to MN's old position stops the NOTIFY message (step(10) in Figure 1), and sends RESERVE message (with Teardown bit set) towards the CN, to release the obsoleted state (step(11) in Figure 1). This RESERVE with tear message is stopped by the CRN (step(12) in Figure 1). The Reservation Sequence Number (RSN) used in the messages is used to distinguish the order of the signaling. More details are described in Section 4.4

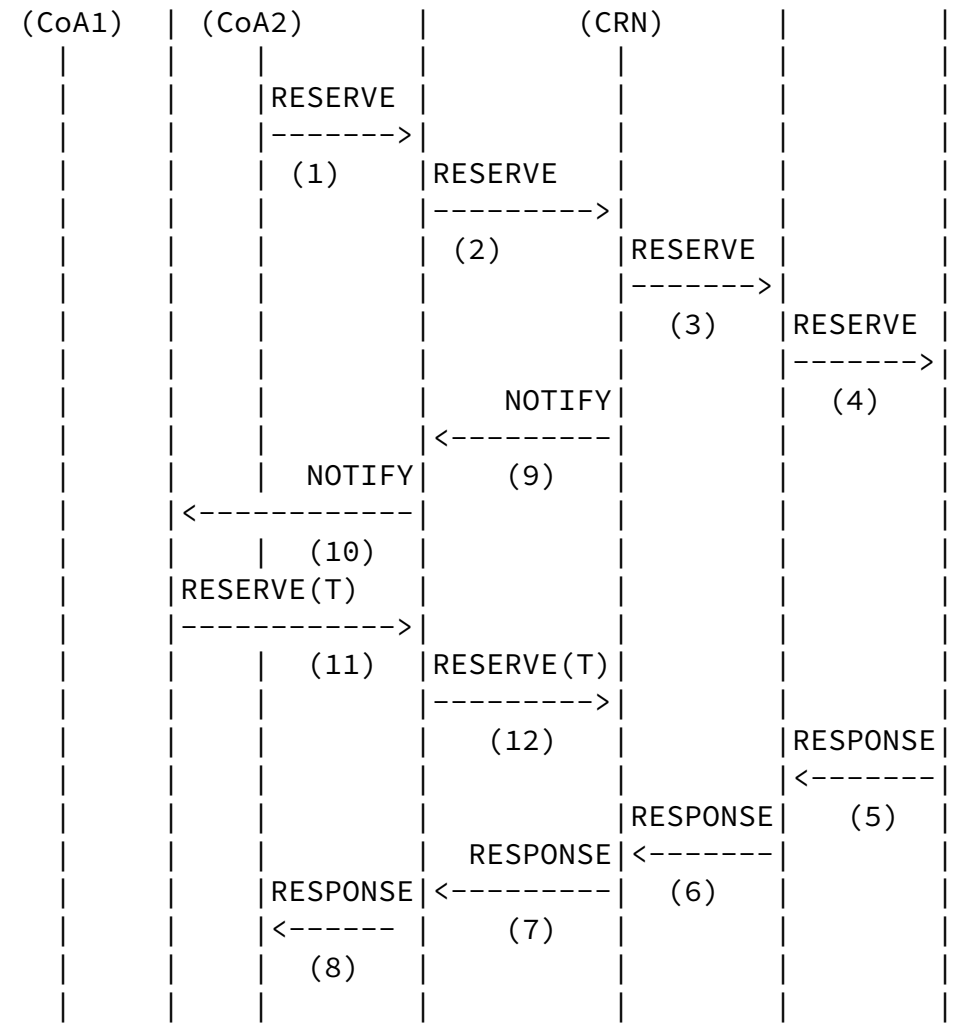


Figure 1: Basic operation example

Further cases to consider are:

* receiver-initiated reservation if MN is sender

* sender-initiated reservation if MN is receiver

* receiver-initiated reservation if MN is receiver

In the first case, the MN can easily initiate a new QUERY along the new path after movement, thereby installing signaling state and eventually eliciting a new RESERVE from the CN in upstream direction.

Similarly, the second and third cases require the CN to initiate a RESERVE or QUERY message respectively. The difficulty in both cases is, however, to let the CN know that the MN has moved. Because the MN is the receiver it cannot simply use an NSLP message to do so, because upstream signaling is not possible in this case (cf. Sec. 3, Upstream Signaling).

4.3. NATFW NSLP

Figure 2 illustrates an example of NATFW NSLP signaling in a Mobile IPv6 route optimization case, for a data flow from the MN to the CN. The difference to the QoS NSLP is that for the NATFW NSLP only the NSIS initiator (NI) can update the signalling session, in any case. Once a handover event is detected in the MN, the MN must get to know the new care-of-address and update the path coupled MRI accordingly. Then the MN issues a NATFW NSLP CREATE message towards the CN, that carries the unique session ID and other identification information for the session (step(1)~(4) in Figure 2). Upon receipt of the CREATE message, the NATFW NSLP nodes (which will be discovered by the underlying NTLP) establish the corresponding NATFW NSLP state, and forward the message towards the CN. When there is already an existing NSLP state with the same session ID, the state will be updated. If all the NATFW NSLP nodes along the path accept the required NAT/firewall configuration, the CN in turn responds with a RESPONSE message, to confirm the configuration (step(5)~(8) in Figure 2).

In a bi-directional tunneling case, the only difference is that the CREATE message should be sent to the HA instead of the CN, and the node which responds with a RESPONSE should be the HA instead of the CN too.

Therefore, for the basic operation there is no fundamental difference among different operation modes of Mobile IP, and the main issue of mobility support in NSIS is to trigger NSLP signaling appropriately when a handover event is detected, and the destination of the NSLP signaling shall follow the Mobile IP data path as being path-coupled

signaling.

In this process, the obsoleted state in the old path is not explicitly released because the state can be released by timer

expiration. To speed up the process, when the CREATE message reaches a node, depicted as CRN in this document (step(2) in Figure 2), where a state is determined for the first time to reflect the same session, the node may issue a NOTIFY message towards the MN's old CoA (step(9)~(10) in Figure 2) and when the NI notices this, it sends a CREATE message towards the CN to release the obsoleted state (step(11)~(12)) in Figure 2).

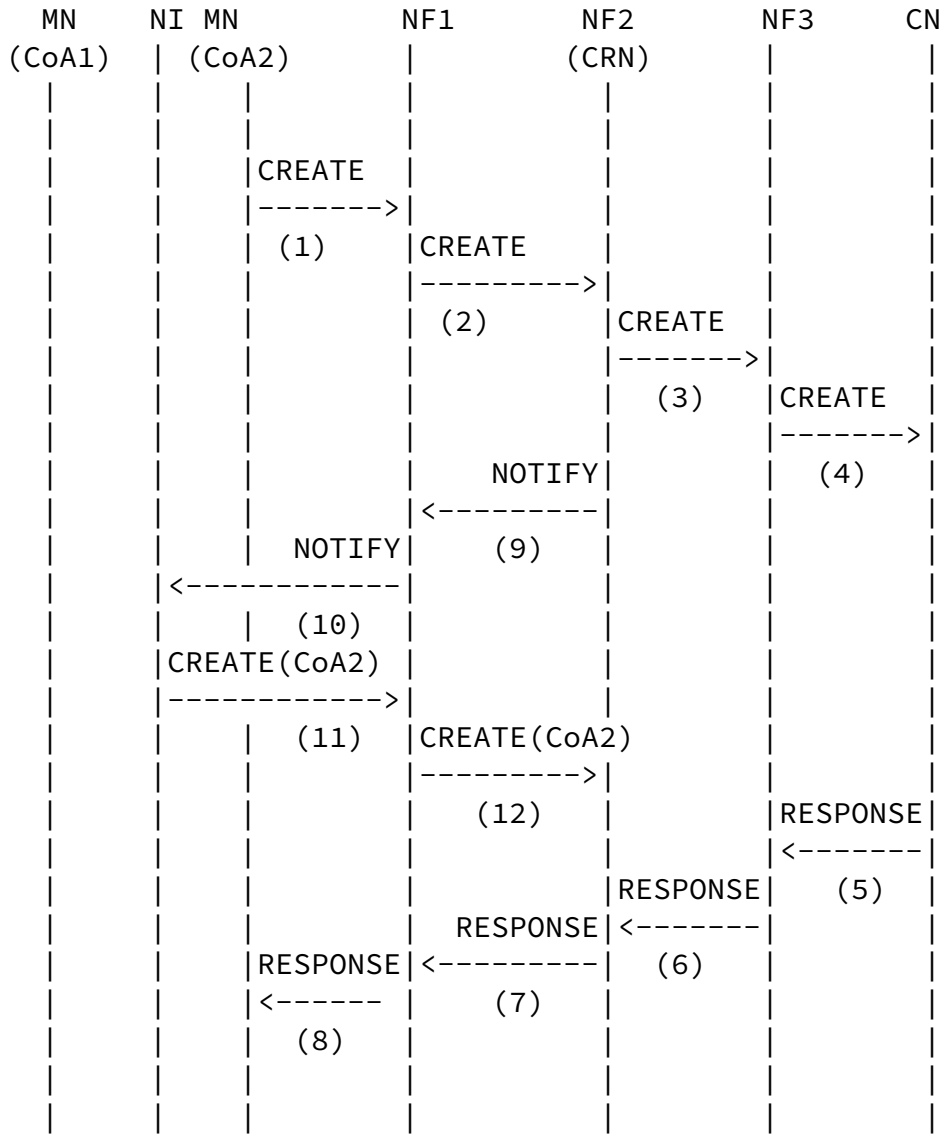
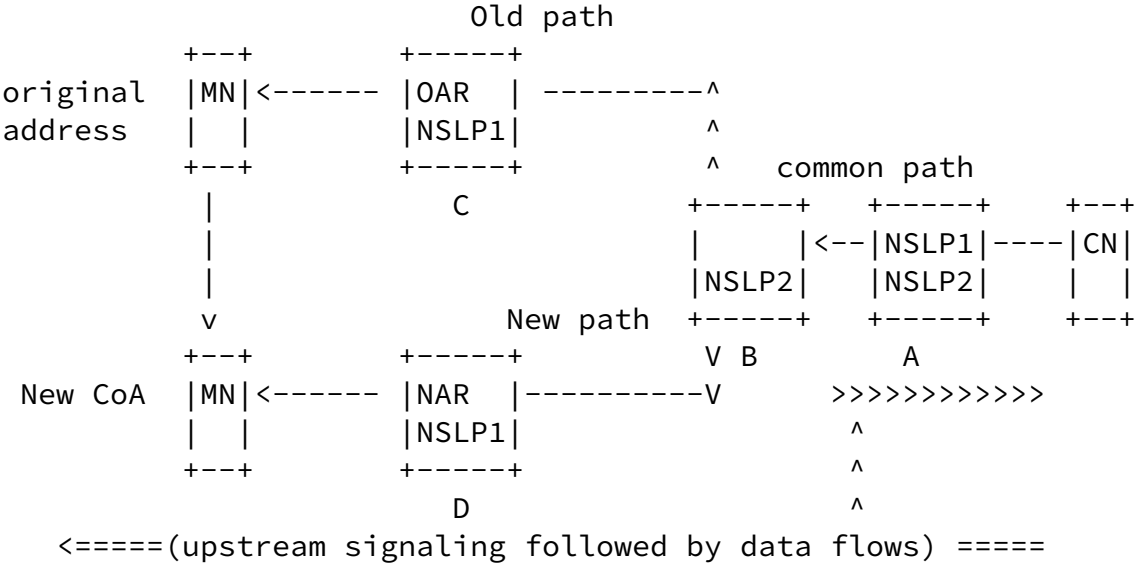


Figure 2: NATFW NSLP operation example

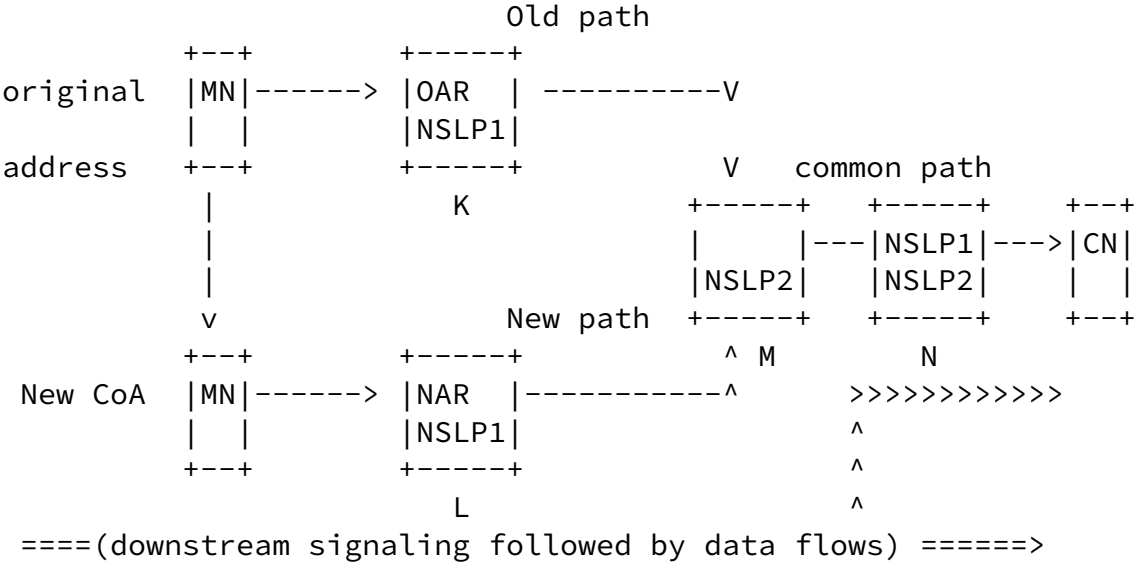
4.4. Localized signaling in mobile scenarios

This section describes detailed CRN operations. As described in previous sections, CRN operations are informational.

As shown in Figure 3, mobility generally causes signaling path to either converge or diverge depending on the direction of each signaling flow.



(a) The topology for upstream NSIS signaling flow due to mobility (in case the MN is a data sender)



(b) The topology for downstream NSIS signaling flow due to mobility (in case the MN is a data sender)

Figure 3: The topology for NSIS signaling caused by mobility

These topological changes due to mobility cause the NSIS state established in the old path to be useless. Such state may be removed as soon as possible. In addition, NSIS state needs to be established along the new path and be updated along the common path. The re-establishment of NSIS signaling may be localized when route changes (including mobility) occur to minimize the impact on the service and to avoid unnecessary signaling overhead. This localized signaling

procedure is referred to as State Update (refer to the terminology section). In mobile environments, for example, the NSLP/ NTLP needs to limit the scope of signaling information only to the affected portion of the signaling path because the signaling path in the wireless access network usually changes only partially.

4.4.1. CRN Discovery

The CRN is discovered at the NSLP layer. In case of QoS NSLP, when a RESERVE message with an existing SESSION_ID is received and its Source Identification Information (SII) and MRI are changed, the QNE knows its upstream or downstream peer has changed by the handover, for sender-oriented and receiver-oriented reservations, respectively. And realizes it is implicitly the CRN.

4.4.2. Localized State Update

In the downstream State Update, the MN initiates the RESERVE with a new RSN for state setup toward a CN and also the implicit DCRN discovery is performed by the procedure of signaling as described in Section 4.4.1. The MRI from the DCRN to the CN (i.e., common path) is updated by the RESERVE message. DCRN may also send NOTIFY with "Route change (0x02)" to previous upstream peer. The NOTIFY is forwarded hop-by-hop and reaches the edge QNE (i.e., QNE1 in Figure 1). After the QNE is aware that the MN as QNI has disappeard (how this is can be noticed is out of scope of NSIS, yet, e.g., GIST will eventually know this through undelivered messages), the QNE sends a tearing RESERVE towards downstream. When the tearing RESERVE reaches the DCRN, it stops forwarding and drops it. Note that, however, it is not necessary for GIST state to be explicitly removed because of the inexpensiveness of the state maintenance at the GIST layer [draft-ietf-nsis-ntlp]. Note that, the sender-initiated approach leads to faster setup than the receiver-initiated approach

as in RSVP [RFC2205].

In the scenario of an upstream State Update, there are two possible methods for state update. One is the CN (or a HA/ a Gateway Foreign Agent (GFA)/ a MAP) sends the refreshing RESERVE message toward the MN to perform State Update upon receiving trigger (e.g., Mobile IP (MIP) binding update). UCRN is discovered implicitly by the CN-initiated signaling along the common path as described in Section 4.4.1. When the refreshing RESERVE reaches to the adjacent QNE of UCRN, the QNE sends back a RESPONSE saying "full QoS Specification (QSPEC) required". Then the UCRN sends the RESERVE with full QSPEC towards the MN to set up a new reservation. The UCRN may also send tearing RESERVE to previous downstream peer. The tearing RESERVE is forwarded hop-by-hop and reaches to the edge QNE. After the QNE is aware that the MN as QNI has disappeard, the QNE

drops the tearing peer. Another method is, if GIST hop is already established on the new path (e.g. by QUERY from the CN, or the HA/ GFA/ MAP) when MN gets a hint from GIST that routing has changed, the MN sends a NOTIFY towards upstream saying "Route Change" 0x02. When the NOTIFY hits UCRN, the UCRN is aware that the NOTIFY is for a known session comes from a new SII-Handle. Then the UCRN sends a RESERVE with a new RSN and an RII towards the MN. By receiving the RESERVE, the MN replies RESPONSE. The UCRN may also send tearing RESERVE to previous downstream peer. The tearing RESERVE is forwarded hop-by-hop and reaches to the edge QNE. After the QNE is aware that the MN as QNI is disappeared, the QNE drops the tearing peer.

The State Update on the common path to reflect the changed MRI brings issues on the end-to-end signaling addressed in Section 3. Although the State Update over the common path does not give rise to re-processing of AAA and admission control, it may lead to the increased signaling overhead and latency.

One of the goals of the State Update is to avoid the double reservation on the common path as described in Section 3. The double reservation problem on the common path can be solved by establishing a signaling association using a unique SID and by updating packet classifier/MRI. In this case, even though the flows on the common path have different MRIs, it refers to the same NSLP state.

5. Interaction with Mobile IPv4/v6

Mobility management solutions like Mobile IP try to hide mobility effects from applications by providing stable addresses and avoiding address changes. On the other hand, the MRI [draft-ietf-nsis-ntlp] contains flow addresses and will change if the CoA changes. This makes impact on some NSLPs such as QoS NSLP and NAT/FW NSLP.

QoS NSLP must be mobility-aware because it needs to care about the resources on the actual current path, and sending a new RESERVE or QUERY for the new path. Applications on top of Mobile IP communicate along logical flows that use home addresses, whereas QoS NSLP has to be aware of the actual flow path, e.g., whether the flow is currently tunneled or route-optimized etc. QoS NSLP may have to obtain current link properties, especially additional overhead due to mobility header extensions that must be taken into account in QSPEC (e.g., the m parameter in the traffic model (TMOD)). Therefore, NSLPs must interact with mobility management implementations in order to request information about the current flow address (CoAs), source addresses,

tunneling, or, overhead. Furthermore, an implementation must select proper interface addresses in the natural language interface (NLI) in order to ensure that a corresponding Messaging Association is established along the same path as the flow in the MRI. Moreover, the home agent needs to perform additional actions (e.g., reservations) for the tunnel. If the home agent lacks support of a mobility-aware QoS NSLP a missing tunnel reservation is usually the result. Practical problems may occur in situations where a home agent needs to send a GIST query (with S-flag=1) towards the MN's Home Address and the query is not tunneled due to route optimization between HA and MN: the query will be wrongly intercepted by QNEs within the tunnel.

NAT/FW box needs to be configured before MIP signaling, hence NAT/FW signaling will have to be performed, to allow Return Routability Test (RRT) and Binding Update (BU)/Binding Acknowledgement (BA) messages to traverse the NAT/FWs in the path. After RRT and BU/BA are completed, another NAT/FW signaling needs to be performed for passing the data. Optimized version can include a combined NAT/FW message to cover both RRT and BU/BA messages pattern. However this may require NAT/FW NSLP to do a slight update to support carrying multiple NAT/FW rules in one signaling round trip.

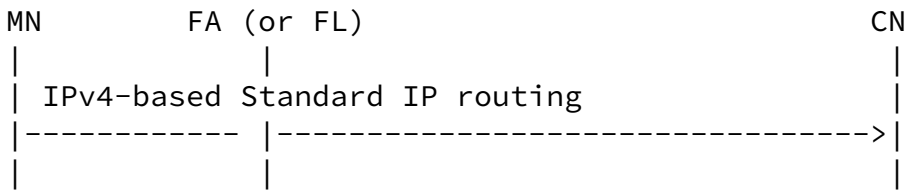
This section analyzes NSIS operation with tunneled route case especially for QoS NSLP.

5.1. Interaction with Mobile IPv4

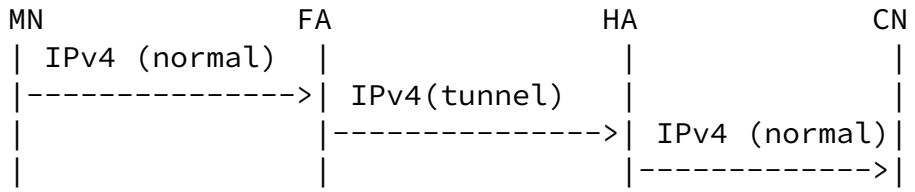
In Mobile IPv4 [RFC3344], the data flows are forwarded based on triangular routing, and an MN retains a new CoA from the Foreign Agent (FA) (or an external method such as DHCP) in the visited access network. When the MN acts as a data sender, the data and signaling flows sent from the MN are directly transferred to the CN not necessarily through the HA or indirectly through the HA using the reverse tunneling. On the other hand, when the MN act as a data receiver, the data and signaling flows sent from the CN are routed through the IP tunneling between the HA and the FA (or the HA and the MN in case of the Co-located CoA). With this approach, routing is

dependent on the HA, and therefore the NSIS protocols interact with the IP tunneling procedure of Mobile IP for signaling.

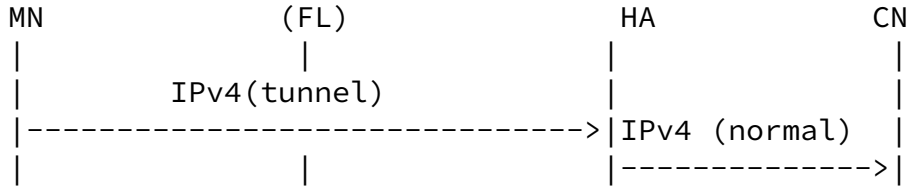
The Figure 4 (a) to (e) show the NSIS signaling flows depending on the direction of the data flows and the routing methods.



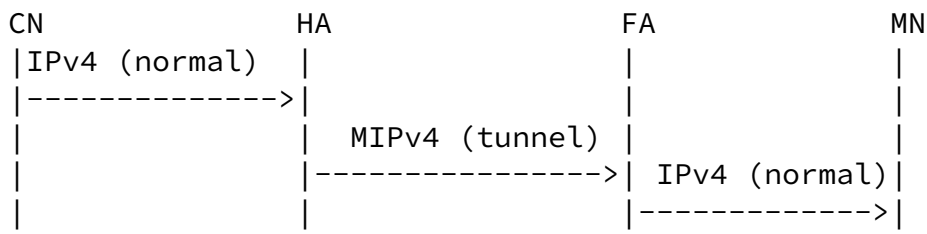
(a) MIPv4: MN-->CN, no reverse tunnel



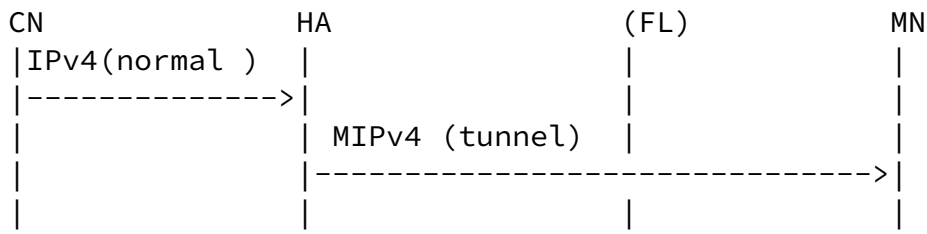
(b) MIPv4: MN-->CN, the reverse tunnel with FA CoA



(c) MIPv4: MN-->CN, the reverse tunnel with Co-located CoA



(d) MIPv4: CN-->MN, Foreign agent Care-of-address



(e) MIPv4: CN-->MN with Co-located Care-of-address

Figure 4: NSIS signaling flows under different Mobile IPv4 scenarios

When an MN (as a signaling sender) arrives at a new FA and the corresponding binding process is completed (Figure 4 (a), (b) and

(c)), the MN performs the CRN discovery (DCRN) and the State Update toward the CN (as described in Section 4) to establish the NSIS state along the new path between the MN and the CN. In case reverse tunnel is not used (Figure 4 (a)), a new NSIS state is established on direct path from the MN to the CN. If the reverse tunnel and FA CoA are used (Figure 4 (b)), a new NSIS state is established along a tunneling path from the FA to the HA separately from end-to-end path. CRN discovery and State Update in tunneling path is also separately performed if necessary. If the reverse tunnel and co-located CoA are used (Figure 4 (c)) the NSIS signaling for the DCRN discovery and the State Update is the same as the case of using FA CoA above except for the use of the reverse tunneling path from the MN to the HA. That is, in this case, one of tunnel end points is the MN, not the FA.

When an MN (as a signaling receiver) arrives at a new FA and the corresponding binding process is completed (Figure 4 (d) and (e)), the MN sends NOFITY message to the signaling sender, i.e., the CN. In case FA CoA is used (Figure 4 (d)), the CN initiates a NSIS signaling to update an existing state between the CN and the HA, and afterwards the NSIS signaling messages are forwarded to the FA and reaches to the MN. A new NSIS state is established along the tunneling path from the HA to the FA separately from end-to-end path. During this operation, a UCRN is discovered on the tunneling path, and a new MRI for the State Update on the tunnel may need to be created. CRN discovery and State Update in tunneling path is also separately performed if necessary. In case collocated CoA is used (Figure 4 (d)) the NSIS signaling for the UCRN discovery and the State Update is also the same as the case of using FA CoA above except for the end point of tunneling path from the HA to the MN.

Note that Mobile IPv4 optionally supports route optimization. In the case route optimization is supported, the signaling operation will be the same as Mobile IPv6 route optimization.

5.2. Interaction with Mobile IPv6

Unlike Mobile IPv4, with Mobile IPv6 [RFC3775], the FA is not required on the data path. If an MN moves to visited network, a CoA at the network is allocated like co-located CoA in Mobile IPv4. In addition, the route optimization process between the MN and CN can be used to avoid the triangular routing in the Mobile IPv4 scenarios.

If the route optimization is not used, data flow routing and NSIS signaling procedures (including the CRN discovery and the State Update) will be similar to the case of using the Mobile IPv4 with co-located CoA. However, if Route Optimization is used, signaling messages are sent directly from the MN to the CN, or from the CN to the MN. Therefore, route change procedures described in Section 4

are applicable to this case.

5.3. Interaction with Mobile IP tunneling

In this section, we assume that MN acts as an NI and CN acts as an NR in interworking between Mobile IP and NSIS signaling.

Scenarios for interaction with Mobile IP tunneling vary depending on:

- Whether a tunneling entry point (Tentry) is an MN or other node. In case Mobile IPv4 co-located CoA or Mobile IPv6, Tentry is an MN. In case Mobile IPv4 FA CoA case, Tentry is a FA. In both case, a HA is tunneling exit point (Texit).

- Whether the mode of QoS-NSLP signaling is sender-initiated or receiver initiated.

- Whether the operation mode over tunnel is with pre-configured QoS sessions or with dynamically created QoS sessions as described in [draft-ietf-nsis-tunnel].

The following subsection describes sender-initiated and receiver-initiated reservation with Mobile IP tunneling and CRN discovery and State Update with Mobile IP tunneling.

5.3.1. Sender-Initiated Reservation with Mobile IP tunnel

The following scenario assumes that a FA is a Tentry. However the procedure is the same for the case an MN is a Tentry if it is considered that the MN and the FA are the same node.

- When an MN moves into a new network attachment point, QoS- NSLP in the MN initiates RESERVE (end-to-end) message to start the State Update procedure. The GIST below the QoS-NSLP adds GIST header and then sends the encapsulated RESERVE message to peer GIST node with corresponding QoS-NSLP. In this case, the peer GIST node is a FA if the FA is an NSIS-aware node. The FA is one of the endpoints of Mobile IP tunneling: Tentry. For proper NSIS tunneling operation, a Mobile IP endpoint is required to be NSIS tunneling aware. In case of interaction with tunnel signaling originated from the FA, there can be two scenarios depending on whether the tunnel already has pre-configured QoS sessions or not.

In former case the FA map end-to-end QoS signaling requests directly to existing tunnel sessions. In latter case the FA dynamically initiate and maintain tunnel QoS sessions that are then associated with the corresponding end-to-end QoS sessions. [draft-ietf-nsis-tunnel].

- Figure 5 shows the typical NSIS operation over tunnels with pre-configured QoS sessions. Both the FA and the HA are configured with information about the Flow ID of the tunnel QoS session. Upon receiving a RESERVE message from the MN, the FA checks tunnel QoS configuration, determines whether and how this end-to-end session can be mapped to a pre-configured tunnel session. The FA then tunnels the RESERVE message to the HA. The CN replies with a RESPONSE message which arrives at the HA, the FA and the MN.

- Figure 6 shows the typical NSIS operation over tunnels with dynamically created QoS sessions. When the FA receives an end-to-end RESERVE message from the MN, the FA chooses the tunnel Flow ID, creates the tunnel session and associates the end-to-end session with the tunnel session. The FA then sends a tunnel RESERVE' message matching the request of the end-to-end session towards the HA to reserve tunnel resources. The tunnel RESERVE' message is processed hop-by-hop inside the tunnel for the flow identified by the chosen tunnel Flow ID, while the end-to-end RESERVE message passes through the tunnel intermediate nodes (Tmid). When these two messages arrive at the HA, the HA creates the reservation state for the tunnel session, and sends a tunnel RESPONSE' message to the FA. At the same time, the HA updates the end-to-end RESERVE message based on the result of the tunnel session reservation, and forwards the end-to-end RESERVE message along the path towards the CN. When the CN receives the end-to-end RESERVE message, it sends an end-to-end RESPONSE message back to the MN.

More detailed operations are specifid in [draft-ietf-nsis-tunnel].

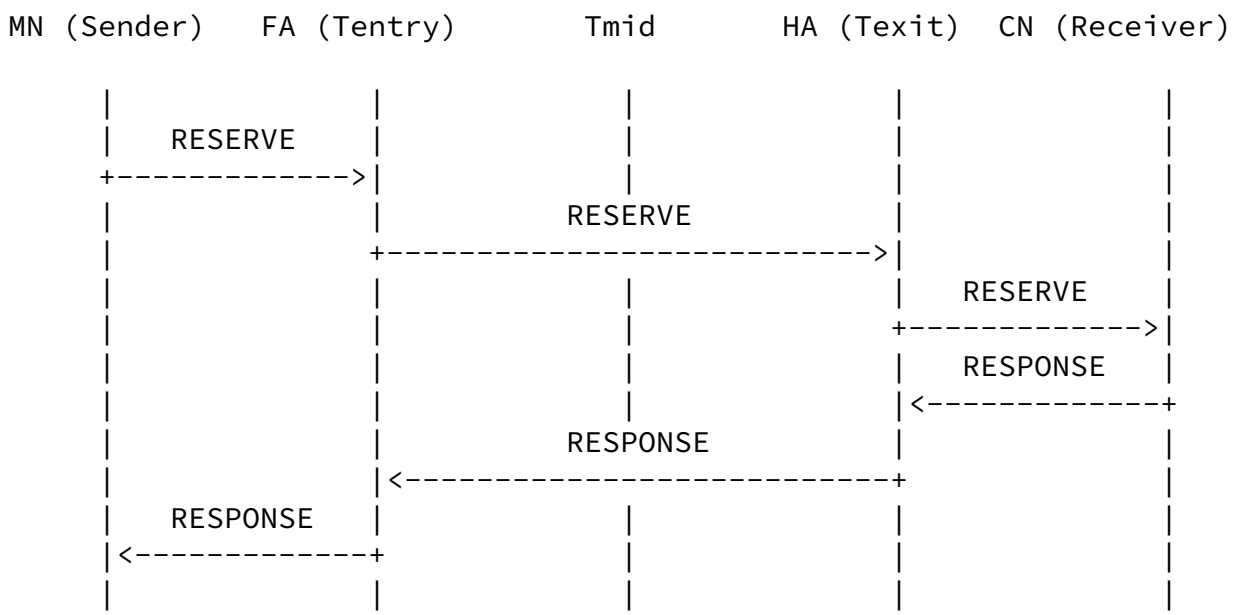
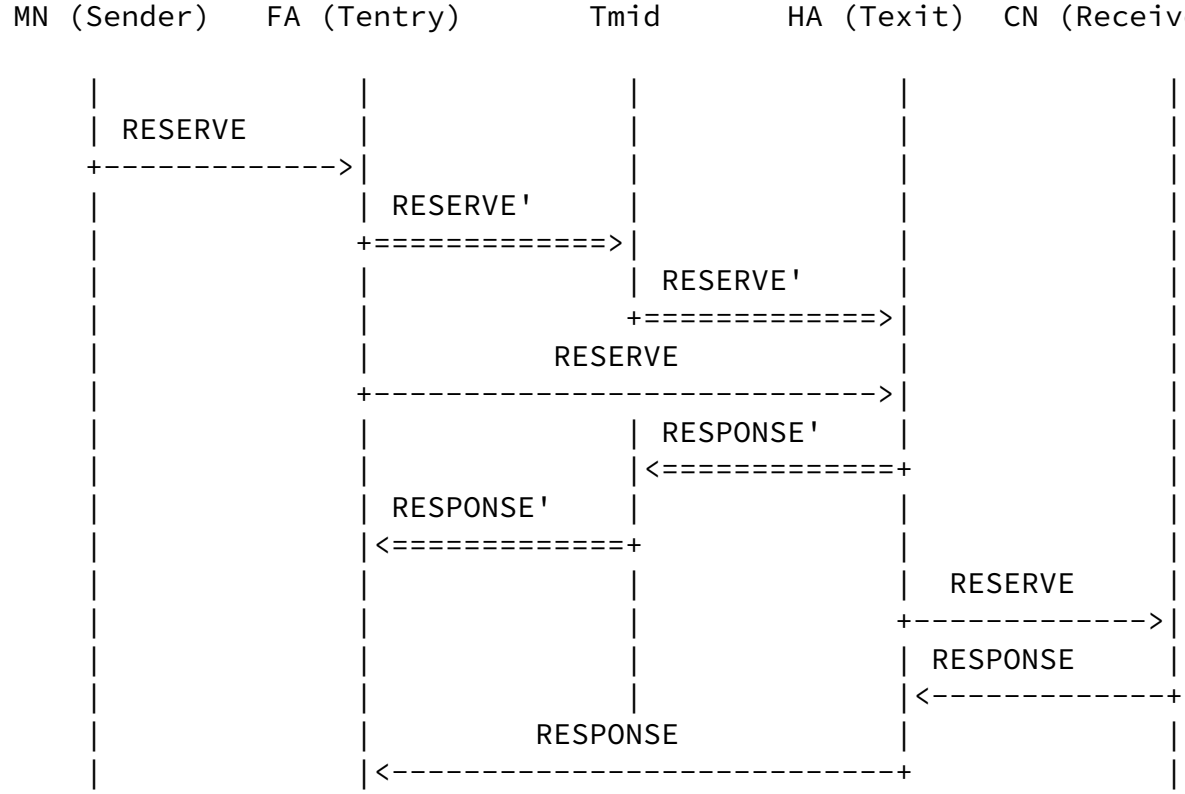


Figure 5: Sender-Initiated QoS-NSLP over Tunnel with Pre-configured QoS Sessions


MN (Sender)
FA (Tentry)
Tmid
HA (Texit)
CN (Receiver)
RESERVE
RESERVE'
RESERVE'
RESERVE
RESPONSE'
RESPONSE'
RESERVE
RESPONSE
RESPONSE

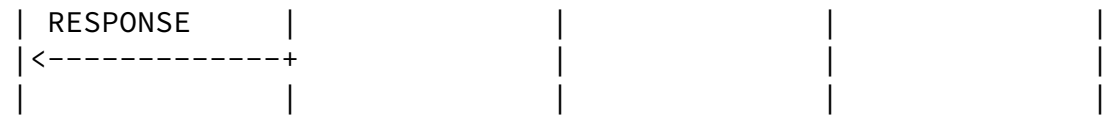
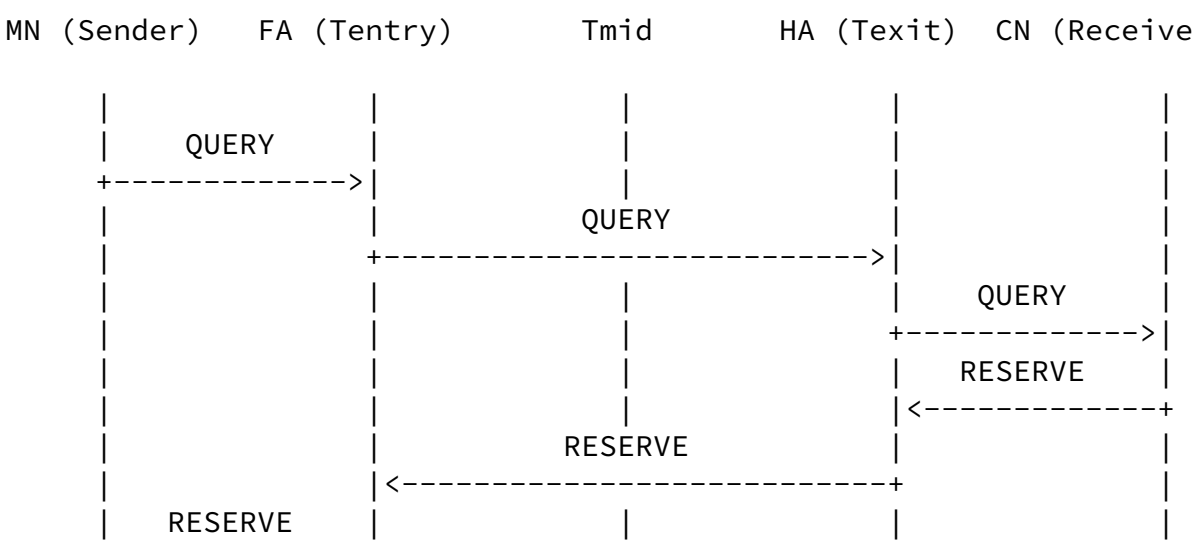


Figure 6: Sender-Initiated QoS NSLP over Tunnel with Dynamically Created QoS Sessions

5.3.2. Receiver-Initiated Reservation with Mobile IP tunnel

Figure 7 and Figure 8 show examples of receiver-initiated operation over Mobile IP tunnel with pre-configured and dynamically created QoS session, respectively. Basic Operation is the same as sender-initiated case.



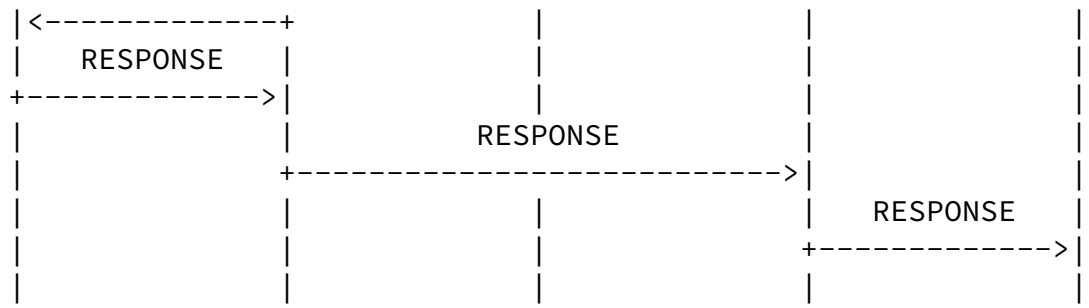
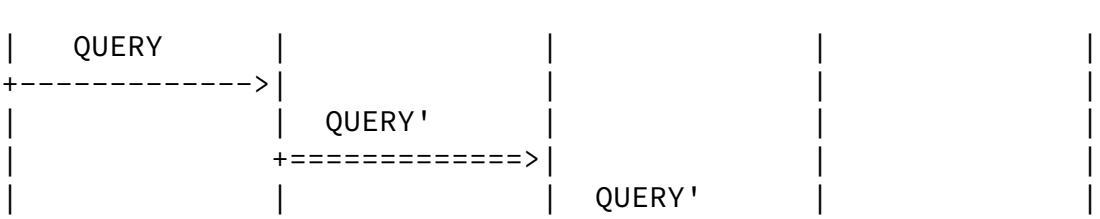


Figure 7: Receiver-Initiated QoS NSLP over Tunnel with Pre-Configured QoS Session



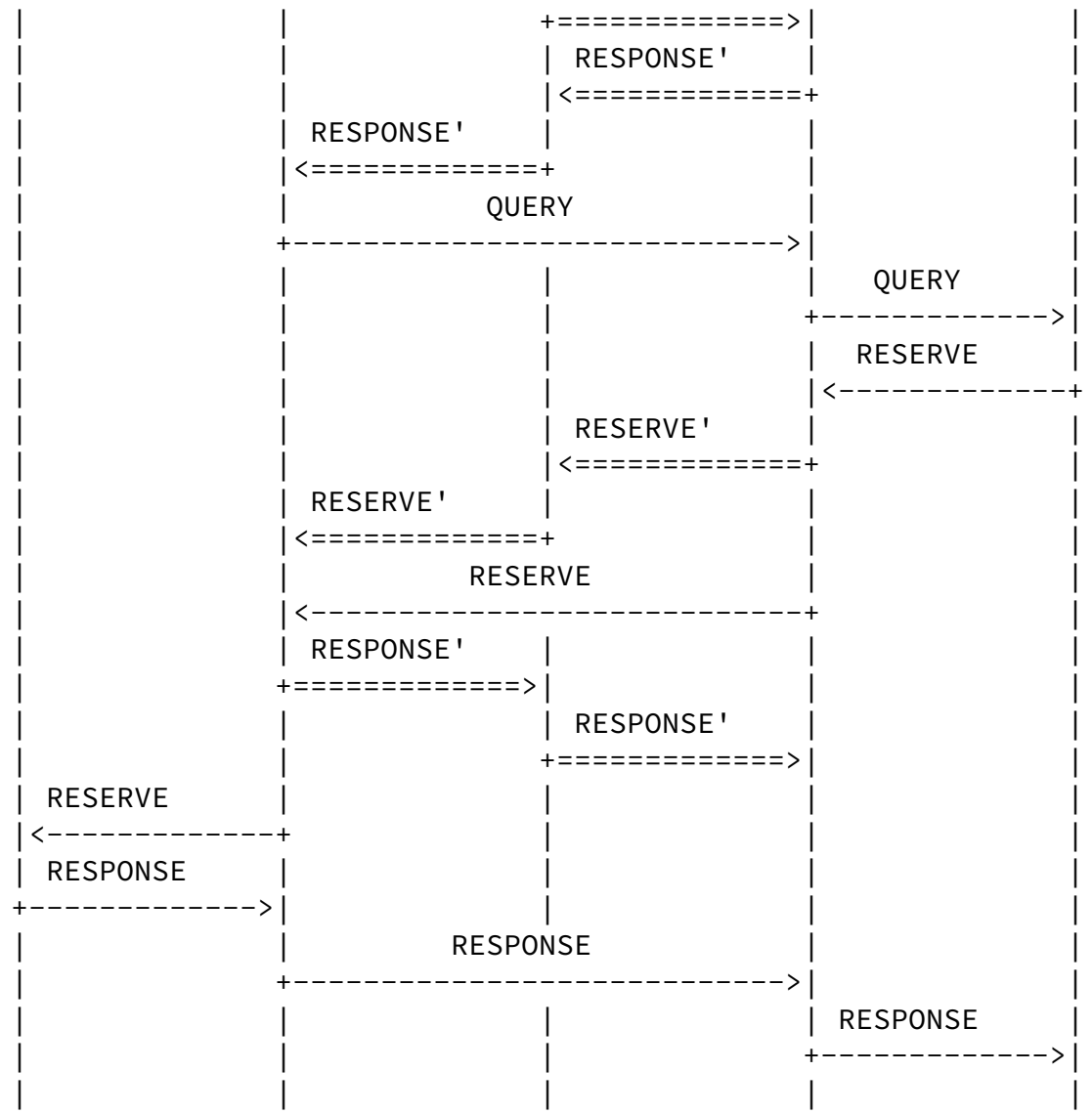


Figure 8: Receiver-Initiated QoS NSLP over Tunnel with Dynamically Created QoS Session

5.3.3. CRN discovery and State Update with Mobile IP tunneling

In case the tunnel is dynamically created mode, interaction with Mobile IP tunneling scenario can define two types of CRNs, i.e., a CRN on end-to-end path and a CRN on tunneling path while pre-configured mode only have the one on end-to-end. CRN discovery and

State Update for these two paths are operated independently.

CRN discovery for end-to-end path is initiated by the MN by sending RESERVE (sender-initiated case) or QUERY (receiver-initiated case) message. As MN uses HoA as source address even after handover, a CRN is found by normal route change process (i.e., the same SID and FID, but different SII handle). If a HA is QoS-NSLP aware, the HA is found as the CRN. The CRN initiate tearing process on the old path as described in [draft-ietf-nsis-qos-nslp]

CRN discovery for tunneling path is initiated by Tentry by sending RESERVE' (sender-initiated case) or QUERY' (receiver-initiated case) message. The route change procedures described in Section 4 are applicable to this case.

End-to-end state inside the tunnel should not be torn until all states inside the tunnel have been torn from impremention perspective. But detailed discussions are out-of-scope of this document.

6. Further Studies

All sections above dealt with basic issues on NSIS mobility support. This section introduces potential issues and possible approaches for complicated scenarios in the mobile environment, i.e., peer failure scenarios, multihomed scenarios, and interworking with other mobility protocols, which may need to be resolved in the future. Topics in this section are out-of-scope of this document. Detailed operations in this section are just for future references.

6.1. NSIS Operation in the multihomed mobile environment

In multihomed mobile environments, multiple interfaces and addresses (i.e., CoAs and HoAs) are available. This case, two major issues can be considered. One is how to select or acquire the most appropriate interface(s) and/or address(es) from end-to-end QoS point of view. The other is, when multiple paths are simultaneously used for load-balancing purpose, how to differentiate and manage two types of CRNs, i.e., CRN between two on-going Paths (LB-CRN: Load Balancing CRN) and CRN between the old and new paths caused by MN's handover (HO-CRN: Handover CRN). This section introduces possible approaches for these issues.

6.1.1. Selecting the best interface(s)/CoA(s)

In MIPv6 route optimization case, if multiple CoAs registration is provided [RFC5648], the contents of QUERYs sent by candidate CoAs can be used to select the best interface(s)/CoA(s).

Assume that an MN is a data sender and has multiple interfaces. Now the MN moves to a new location and acquires CoA(s) for multiple interfaces. After the MN performs the BU/BA procedure, it sends QUERY messages toward the CN through the interface(s) associated with the CoA(s). On receiving the QUERY messages, the CN or Gateway, determines the best (primary) CoA(s) by checking 'QoS available' field in the QUERY messages. Then a RESERVE message is sent toward the MN to reserve resources along the path the primary CoA takes. If the reservation is not successful, the CN transmits another RESERVE message using the CoA with the next highest priority. The CRN may initiate a teardown (RESERVE with the TEAR flag set) message toward old access router (OAR) to release the reserved resources on the old path.

In case of sender-initiated reservation, a similar approach is possible. That is, the QUERY and RESERVE messages are initiated by an MN, and the MN selects the Primary CoA based on the information delivered by the QUERY message.

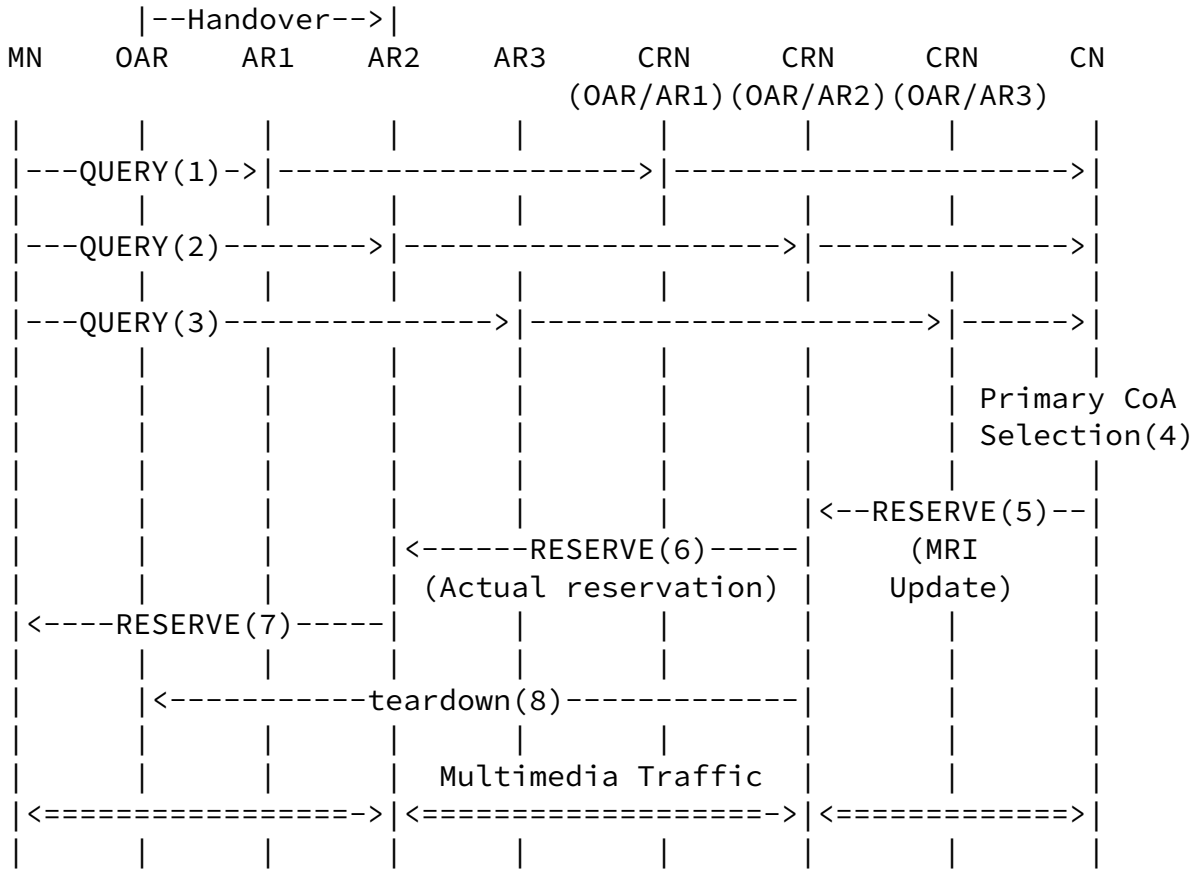


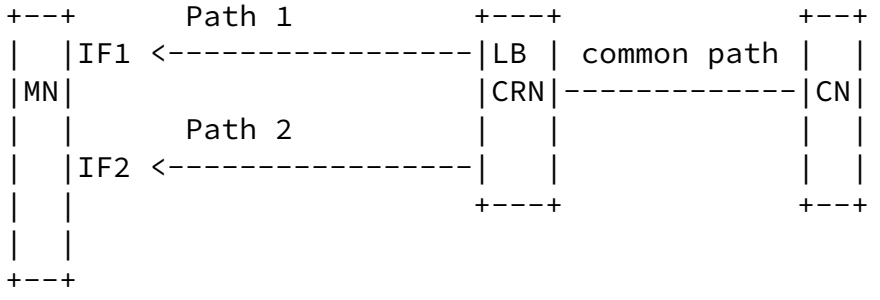
Figure 9: Receiver-initiated reservation in the multihomed environment

6.1.2. Differentiation of two types of CRNs

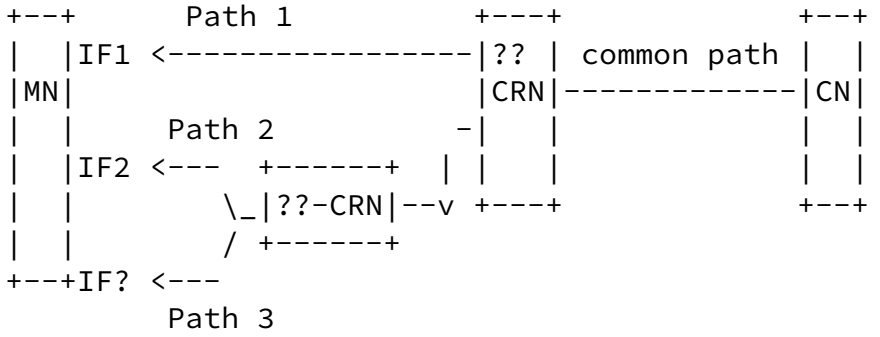
When multiple interfaces of the MN are simultaneously used for load-balancing purpose, a possible approach for distinguishing LB-CRN and HO-CRN will introduce an identifier to determine the relationship between interfaces and paths.

An MN uses interface 1 and interface 2 for the same session, where the paths (say path 1 and path 2) have the same SID but different FIDs as shown in (a) of Figure 10. Now one of the interfaces of MN performs a handover and obtains a new CoA, the MN will try to establish a new path (say Path 3) with the new FID, as shown in (b) of Figure 10. In this case the CRN between path 2 and path 3 cannot determine if it is LB-CRN or HO-CRN since for both cases, SID is the same but FIDs are different. Hence the CRN will not know if State Update is required. One possible solution to solve this issue will introduce path classification identifier which shows the relationship between interfaces and paths. For example, signaling messages and QNEs belong to paths from interface 1 and interface 2 carry the

identifier '00' and '02', respectively. By having this identifier, the CRN between path 2 and path 3 will be able to determine whether it is LB-CRN or HO-CRN. For example, if path 3 carries '00', the CRN is LB-CRN, and if '01', the CRN is HO-CRN.



(a) NSIS Path classification in multihomed environments



(b) NSIS Path classification after handover

Figure 10: The topology for NSIS signaling in multihomed mobile environments

6.2. Interworking with other mobility protocols

Unlike the generic route changes, in mobility scenarios, the end-to-end signaling problem by the State Update gives rise to the degradation of network performance, e.g., increased signaling overhead, service blackout, and so on. To reduce signaling latency in the Mobile IP-based scenarios, the NSIS protocol suite may need to interwork with localized mobility management (LMM). If the GIST/NSLP (QoS-NSLP or NAT/FW-NSLP) protocols interact with Hierarchical Mobile IPv6 and the CRN is discovered between an MN and an MAP, the State Update can be localized by address mapping. However, how the State Update is performed with scoped signaling messages within the access network under the MAP is for future study.

In the inter-domain handover, a possible way to mitigate the latency penalty is to use the multi-homed MN. It is also possible to allow the NSIS protocols to interact with mobility protocols such as Seamoby protocols (e.g., Candidate Access Router Discovery (CARD) [RFC4066] and Context Transfer Protocol (CXTP) [RFC4067]) and Fast Mobile IP (FMIP). Another scenario is to use peering agreement which allows aggregation authorization to be performed for aggregate reservation on an inter- domain link without authorizing each individual session. How these approaches can be used in NSIS signaling is for further study.

6.3. Intermediate node becomes a dead peer

The failure of a (potential) NSIS CRN may result in incomplete state re-establishment on the new path and incomplete teardown on the old path after handover. In this case, a new CRN should be re-discovered immediately by the CRN discovery procedure.

The failure of an AR may make the interactions with Seamoby protocols (such as CARD and CXTP) impossible. In this case, the neighboring peer closest to the dead AR may need to interact with such protocols. A more detailed analysis of interactions with Seamoby protocols is

left for future work.

In Mobile IP-based scenarios, the failures of NSIS functions at an FA and an HA may result in incomplete interaction with IP-tunneling. In this case, recovery for NSIS functions needs to be performed immediately. In addtion, a more detailed analysis of interactions with IP-tunneling is left for future work.

7. Security Considerations

This document does not introduce new security concerns. The security considerations pertaining to the standard NSIS protocol specifications [gist, qos-nslp, natfw-nslp] remain relevant. When deployed in service provider networks, it is mandatory to ensure that only authorized entities are permitted to initiate re-establishment and removal of NSIS states in mobile environments, including the use of NSIS proxies and CRN.

8. IANA Considerations

This memo includes no request to IANA.

9. Change History

[Note to the RFC editor: Please remove this section before publication]

9.1. Changes from -00 version

The major change made to the initial (-00) version of the draft is to re-arrange the issues addressed in the draft in order to clearly identify general issues caused by mobility itself and NSIS protocols-specific issues. The generic route changes-related text in Section 4 was moved into Appendix to make this draft more mobility-specific.

Specifically, the following changes have been made:

1. Removed the terminologies, 'uplink' and 'downlink' in Section 2.

2. Removed the terminology, 'local repair' in Sections 2 and 4.

3. Re-arranged all problems in Section 3 by merging the 'mobility-related issues with NSIS protocols' section and the 'problem statement and general considerations' section.

4. Removed the general considerations section in Section 3.

5. Modified the problem statement section and moved it into the general problem section in Section 3.1.

6. Added more problems including 'Identification of the crossover node', 'Key exchanges', and 'AA-related Issues' to Section 3.1

7. Added the 'Multihoming-related issues' to Section 3.2.4

8. Removed the issues on 'how to immediately delete the state on the old path' in Section 3.2.

9. Moved the generic route changes-related text in Section 4.1 into Appendix.

10. Removed the figure describing "NSIS signaling topology for downstream signaling flow after the route changes in the middle of the network" in Figure 2.

11. Added 'NSLP_IDs' to each node in Figure 1.

12. Removed the 'use cases of identifiers' section, and instead, added the 'support for ping-pong type handover' section to Section5.

13. Added this change history.

9.2. Changes from -01 version

Version -02 includes mainly a number of clarifications on the issues raised in this draft and more details in some specific areas. Specifically, the following changes have been made:

1. Defined the terminologies, 'route change' and 'mobility' in Section 2.

2. Clarified the terminology, 'Crossover node (CRN)' in Section 2.

3. Removed the terminology, 'mobility CRN' in Section 2.

4. The issue, 'Priority of signaling messages' in Section 3.2.2 was closed, and thus removed it.

5. Clarified the issue, 'CRN discovery and State Update on the IP-tunneling path in Section 3.2.4.

6. Added the pros and cons of two mechanisms on CRN discovery dependent on NSIS layers to Section 4.2.1.

7. Clarified the identifier, NSLP_Br_ID for CRN discovery in Section 4.2.2.

8. Added the scenario on interaction between NSIS and Mobile IP to Section 5.1.

9. Clarified interaction issues with IP-tunneling according to reservation initiation type (receiver-initiated or sender-initiated) in Mobile IPv4-based scenarios and added those to Section 5.1.1.1.

10. 1Clarified interaction issues between NSIS protocols and IP-tunneling in Mobile IPv6 and added those to Section 5.1.1.2.

11. Clarified the multihoming-related issues in Section 5.2.

12. Added the issues on usage of 'hint' information to trigger NSIS signaling in mobility to Section 5.5.

13. Identified the dead peer-related issues in Mobile IP-based scenario in Section 5.5.

9.3. Changes from -02 version

In version -03, tunneling-related and multihoming-related scenarios were newly added in Sections 5.1.3 and 5.2, respectively. Also, the terminology, 'Path Update' is changed into 'State Update' in Section 3.2.4.

9.4. Changes from -03 version

Version -04 includes mainly a number of clarifications on the issues raised in this draft and more details in some specific areas. Specifically, the following changes have been made:

1. The issue, 'Peering agreement issue' in Section 3.2.2 was closed, and thus removed it.

2. Clarified the issue, 'Interfaces between Mobile IP and NSIS protocols' in Section 3.2.1.

3. Clarified the issue, 'Authorization-related issues with teardown' in Section 3.2.2.

4. Clarified the issue, 'Dead peer discovery' in Section 3.2.2.

5. Clarified the issue, 'Invalid NR problem' in Section 3.2.2.

6. Clarified the issue, 'CRN discovery and State Update on the IP-tunneling path' in Section 3.2.4.

7. Clarified the issue, 'Multihoming-related issues' in Section 3.2.4.

8. Changed Figure 1 (a) into (b) in Section 4.1.

9. Changed Figure 1 (b) into (a) in Section 4.1.

10. Clarified the identifier, NSLP_Br_ID for CRN discovery in Section 4.2.2.

11. Clarified the identifier, Mobility identifier for CRN discovery in Section 4.2.2.

12. Added the text on 'CRN_DISCOVERY flag bit' in Section 4.2.3, and clarified the role of 'CD flag bit' in Section 4.3.1.

13. Clarified the issues on 'interaction with Mobile IP tunneling' and added those to Section 5.1.4.

14. Clarified the issues on 'load balancing in multihomed mobile environments' and added those to Section 5.2.5.

15. Changed Problems of the heading name in Section 3.2 into Challenges.

9.5. Changes from -04 version

Version -05 includes mainly a number of clarifications on the issues raised in this draft and more details in some specific areas. Specifically, the following changes have been made:

1. 'Explicit routes' in Section 3.1 (3) was removed.

2. Clarified the problem, 'Double reservation problem' in Section 3.1 (7).

3. Clarified the issue, 'CRN discovery-related issues' in Section 3.2.4 (1).

4. Clarified the issue, 'Issues on API between NTLP and NSLP' in Section 3.2.4 (3).

5. Clarified the issue, 'approaches for CRN discovery' in Section 4.2.1.

6. Changed NSLP_Br_ID (of identifiers for CRN discovery) into State_Br_ID in Section 4.2.2 for clarification.

7. Clarified the issue, 'double reservation problem on the common path' in Section 4.3.1.

8. Clarified the issue, 'Interfaces between Mobile IP and NSIS' in Section 5.1.1.

9. Removed the sencond paragraph on the issue, 'Explicit routes' in Section 4.1.

10. Clarified the issue, 'refresh timer value in mobility scenarios' in Section 5.3.

11. Removed the third paragraph on the issue, 'usage of Reservation Sequence Number (RSN) to support ping-pong type hanover' in Section 5.4.

12. Clarified the issues on 'peer failure' in Section 5.5.

13. Removed Figure 3 'Sender- vs. Receiver-initiated reservation' in Section 4.3.1.

9.6. Changes from -05 version

In Version -06, contents of this draft were re-selected and re-structured:

1. Section 4 and 5 of -05 were divided into two parts:

    1. 'Main' part, which is focusing on examples and describing how mobility is handled by the NSIS protocols. Topics here will be route change handling and NSIS interwork with MIP v4/v6 (Section 4 and Section 5 in -06)

    2. 'Further Study' part, which introduces summary of potential issues and possible approaches for other topics. These topics are out-of-scope for discussing details (Section 6 in -06)

2. Specific parameters and terms were removed from 'Main' part

3. Showing similar detailed operations were avoided in 'Interaction with MIP tunneling section (Section 5.3)'

4. In Further Study section Section 6:

    1. Detailed operations were removed

    2. Ping-pong issue was removed

5. Problem Statement (Section 3) was cleaned up

9.7. Changes from -06 version

Changes in Version -07 are:

1. 'Invalid NR problem' are moved from Further Study section

2. Figure 7 (Receiver-Initiated QoS NSLP over Tunnel -Parallel Mode) are changed

3. Terminologies 'NSLP CRN', 'NTLP CRN' 'NSIS CRN' 'Divergent-convergent UCRN' and 'Divergent-convergent DCRN' are removed from Terminology section.

4. 'Open Issues' section is added

9.8. Changes from -07 version

Changes in Version -08 are:

1. Figure 1 was updated (NOTIFY message from CRN is added)

2. Section 4.2.1 (CRN discovery) was updated to be synchronized with QoS-NSLP draft

3. Title of Section 4.2.2 was changed from "State setup and update" to "Localized State Update"

4. Section 4.2.2 (Localized State Update) was updated to be synchronized with QoS-NSLP draft

5. Section 4.2.3 (State teardown) was deleted because the issues was already solved

6. Title of Section 4.2.3 was changed to "State teardown consideration"

9.9. Changes from -08 version

Changes in Version -09 are:

1. Security Consideration Section (Section 7) was cleaned up.

2. Security Consideration issue was removed from Open Issue section (Section 8).

3. NAT traversal issues were removed from Open Issue section (Section 8).

9.10. Changes from -09 version

Changes in Version -10 are:

1. Introduction was updated accordingly.

2. Definition of RFC2119 terms were removed from Section 2

3. Definition of Upstream/Downstream State Update were cleaned up

4. Title of Section 3 was changed from "Problem Statement" to "Challenges with Mobility"

5. NSIS solutions are removed from Section 3

6. Section 4 was cleaned up

7. More detailed description was added to Section 5

9.11. Changes from -10 version

Change in Version -11 is:

1. Introduction part of Section 5 was updated.

9.12. Changes from -11 version

Change in Version -12 are:

1. Section 4.3 (NATFW section) was added.

2. Open Issue section was closed.

9.13. Changes from -12 version

Changes in Version -13 are:

1. "Upstream signaling" was added to Section 3

2. Three more cases were discussed in Section 4.2

3. Definition of Upstream/Downstream State Update were cleaned up

4. Figure 3 was removed because it was't really necessary for the discussion.

9.14. Changes from -13 version

Change in Version -14 is:

1. Figure 3 was re-added with appropriate changes.

9.15. Changes from -14 version

Change in Version -15 is:

1. Title was changed because this draft is not talking about AS.

9.16. Changes from -15 version

Changes in Version -16 are:

1. RFC2205, RFC3726, RFC3753 and draft-ietf-nsis-tunnel were changed from Normative references to Informative references.

2. IANA Consideration was added.

3. RFC4066 and RFC4067 was added to Informative References.

9.17. Changes from -16 version

Changes in Version -17 is:

1. Some editorial changes were made.

9.18. Changes from -17 version

Changes in Version -18 is:

1. Some editorial changes were made.

9.19. Changes from -18 version

Changes in Version -19 are:

1. Abstract and Introduction were changed to clearly say the NSIS protocols operations can work in mobility environments without particular operations, and additional operations such as CRN discovery are only for enhancement and informational.

2. Some texts were added to section 4 to say the state in old path can be torn by timer.

3. Consideration in tearing down end-to-end tunneling state was mentioned in section 5.

4. Authorization for CRN was briefly mentioned in security consideration.

5. Some editorial changes were made.

10. Contributors

Sung-Hyuck Lee was the first editor of the draft. Since version 06 of the draft, Takako Sanda has taken the editorship.

Many individuals have contributed to this draft. Since it was not possible to list them all in the authors section, this section was created to have a sincere respect for other authors, Paulo Mendes, Robert Hancock, Roland Bless, Shivanajay Marwaha and Martin Stiemerling. Separating authors into two groups was done without treating any one of them better (or worse) than others.

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Authors' Addresses

Takako Sanda
Panasonic Corporation
600 Saedo-cho, Tsuzuki-ku, Yokohama
Kanagawa 224-8539
Japan

Phone: +81 45 938 3056
Email: sanda.takako@jp.panasonic.com

Xiaoming Fu
Computer Networks Group, University of Goettingen
Lotzestr. 16-18
Goettingen 37083
Germany

Email: fu@cs.uni-goettingen.de

Seong-Ho Jeong
Hankuk University of FS
89 Wangsan Mohyun
Yongin-si, Gyeonggi-do 449-791
Korea

Phone: +82 31 330 4642
Email: shjeong@hufs.ac.kr

Jukka Manner
Helsinki University of Technology
P.O. Box 3000
Espoo FIN-02015
Finland

Phone: +358 9 451 2481
Email: jukka.manner@tkk.fi

Hannes Tschofenig
Nokia Siemens Networks
Linnoitustie 6
Espoo
02600
Finland

Phone: +358 50 4871445
Email: Hannes.Tschofenig@nsn.com