Network-Based Mobility Extensions
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J. Korhonen
Renesas Mobile
T. Savolainen
Nokia
S. Gundavelli
Cisco

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Local Prefix Lifetime Management for Proxy Mobile IPv6
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Abstract

This specification defines a protocol extension to Proxy Mobile IPv6 that enables prefix lifetime management for locally assigned prefixes within a Proxy Mobile IPv6 domain. A locally assigned prefix is managed by a Mobile Access Gateway and is always topologically anchored to the Mobile Access Gateway within the Proxy Mobile IPv6 domain.

Requirements Language

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 [RFC2119].

Status of this Memo

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1. Introduction

This specification defines a protocol extension to Proxy Mobile IPv6 (PMIPv6) [RFC5213] that enables prefix/address lifetime management for locally assigned prefixes/addresses within a PMIPv6 domain. A prefix/address locally assigned to the mobile node (MN) is managed by a specific Mobile Access Gateway (MAG) and is always topologically anchored to that MAG within the PMIPv6 domain. The protocol extension essentially defines a context transfer mechanism that allows for a source MAG to inform a target MAG about locally assigned prefixes/addresses during the handover.

After a handover, the prefixes/addresses from the source MAG are topologically in an incorrect location when the mobile node (MN) is attached to the target MAG. The context transfer mechanism defined in this specification can implicitly serve as a trigger to create a temporary tunneling (read, localized routing) between MAGs for the period prefixes/addresses from the source MAG are used under the target MAG.

Additionally, using the context transfer information the target MAG can take required actions to deprecate those prefixes/addresses that belong to the source MAG. The specified mechanism is a complementary for Simple Procedures for Detecting Network Attachment in IPv6 (DNA) [RFC6059]. Explicit network side prefix/address deprecation is useful in situations, for instance, when the MN does not implement DNA or there is a need to trigger DHCPv6 Reconfigure procedure [RFC3315] when the MN attaches to the target MAG.

> [Discussion: it is to be verified whether the existing PMIPv6 Localized Routing protocol [RFC6705] with small enhancements is appropriate for the temporary tunneling between MAGs for the purpose this specification has.]

Locally assigned prefixes/addresses that are topologically anchored to the MAG allow for optimized access to local resources near the MAG. This, of course, assumes the MAG is able to route certain traffic locally bypassing the PMIPv6 tunnel, and the MN is able to detect which prefixes/addresses are local or have mobility [I-D.korhonen-6man-prefix-properties][I-D.bhandari-dhc-class-based-prefix].

2. Solution Overview

The protocol solution in this specification is targeted to the following use case and illustrated in Figure 1. Additional use cases outside the IP mobility domain are discussed extensively in

[I-D.lepape-6man-prefix-metadata].

- A MN is assigned with multiple prefixes that it uses to configure multiple IPv6 addresses.

- Some of the prefixes/addresses assigned to the MN are anchored at the Local Mobility Anchor (LMA) and provide mobility within the PMIPv6 domain.

- Some of the prefixes/addresses assigned to the MN are local to the MAG the MN is currently attached to. These prefixes/addresses provide mobility only in a limited area, for example, within the layer-2 domain under the MAG control.

- When the MN moves from a MAG (i.e., a source MAG) to another MAG (i.e., a target MAG), the prefixes/addresses anchored to the LMA remain but the prefixes/addresses anchored to a MAG will change. The prefixes/addresses are topologically only valid under the MAG they are anchored to.

- If DHCPv6 is used for configuring addresses to the MN, then the DHCPv6 server is collocated in the LMA.

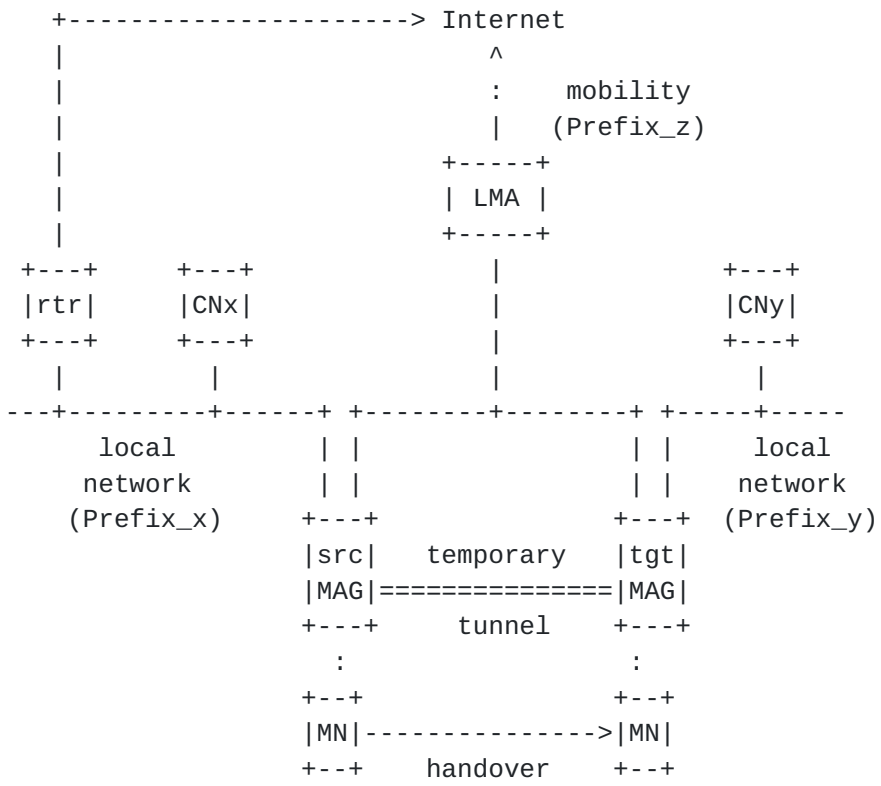

Figure 1: Local services provided topologically close to a MAG

In order to provide a mechanism for a source MAG to inform the target MAG about prefixes the MN might have configured and that are topologically valid only under the source MAG, there is a need for a context transfer of locally assigned prefix/address information between MAGs. This specification extends both the PMIPv6 signaling and the Binding Cache in the LMA with a local prefix/address information.

During the Proxy Binding Update (PBU) and the Proxy Binding Acknowledgement (PBA) exchange, MAGs and the LMA inform each other about locally assigned prefixes/addresses. Using that information, a target MAG can do the following two things:

- Make sure the prefixes/addresses from the source MAG get deprecated and eventually invalidated using some mechanism (that essentially does not require end host stack changes).

- Optionally create of a temporary tunnel between the source and the target MAG, and setting up the required host routes for routing addresses belonging to the source MAG back and forth until the addresses become invalid.

3. Mobility Options

A MAG uses the Local Prefix mobility option (LPO) to inform the LMA of the IPv6 prefix/address and its valid lifetime (see [RFC4861] and [RFC3315]) that shall be locally assigned to a MN. After a handover an LMA uses the option to inform a target MAG of the IPv6 prefix/address that was assigned to a MN by the previous MAG. The Local Prefix option has an alignment of 4n. There can be zero or more LPOs in a PUB and in a PBA.

Figure 2: Local Prefix Mobility Option

Type:

Set to TBD1.

Length:

The length of the Local Prefix mobility option in octets, excluding the Option Type and Length fields. The length is set to 22.

Prefix Length:

The prefix length of the local IPv6 prefix. Valid prefix lengths are between 1 and 128. In case of an IPv6 address the prefix length is 128.

'R':

Set to 1 if the sender of the LPO wants the receiver to deprecate/ invalidate/remove the prefix/address. Otherwise set to 0.

Reserved:

This field is reserved for future use. MUST be set to zero by the sender and ignored by the receiver.

Valid Lifetime:

The valid lifetime of the IPv6 prefix/address. The value follows the valid lifetime semantics of Prefix Information Option [RFC4861] and OPTION_IAADDR option [RFC3315].

Local Prefix/address:

The locally assigned IPv6 prefix/address.

4. Mobile Access Gateway Operation

4.1. Extensions to Binding Update List Entry Data Structure

The Binding Update List Entry (BULE) data structure for each MN's mobility binding with its LMA is extended with zero or more locally assigned IPv6 prefix/address, and its lifetime information.

4.2. Local Prefix/Address Assignment

A MAG maintains a pool of locally usable prefixes/addresses. If the 'EnableLocalPrefixManagement' configuration object is set to TRUE, then the MAG assigns one or more local prefixes/addresses to the MN during the initial attach. Essentially the MAG adds new Local Prefix Mobility Options into the Proxy Binding Update (PBU) message, and eventually advertises those prefixes to the MN when using Stateless Address AutoConfiguration (SLAAC).

4.3. Local Use of Prefixes/Addresses

The local prefixes/addresses are topologically anchored to the MAG, and do not really provide mobility in a same level as PMIPv6 provides for Home Network Prefixes (HNP) anchored to the LMA. This specification also requires the MAG is provided with a functionality that certain traffic can bypass the PMIPv6 tunnel in the MAG. Such functionality is already hinted in [RFC5213] Section 6.10.3. However, this specification further assumes the local corresponded nodes do not need to be directly on the access link connected to the MAG. They can be any number of IP hops away.

There is no restriction on the scope of the local prefixes/addresses. A MN could use local addresses to the MAG as its source address to access the Internet, assuming local addresses have a global scope. Similarly, the MN could use the home address anchored to the LMA to reach local destinations around the MAG.

4.4. Local Prefixes/Addresses Management

After a MN has moved from a source MAG to a target MAG as a result of a handover, the MN might be configured with prefixes/addresses that topologically belong to the source MAG. In this case, the target MAG may purposely need to deprecate and invalidate or otherwise handle prefixes/addresses that are topologically in a wrong place (i.e., are anchored to the source MAG). We could assume that the DNA [RFC6059] handles this but explicit actions by the target MAG make sure that MNs without DNA support are also covered.

4.4.1. Deprecating Prefixes/Addresses

A target MAG receives information of prefixes/addresses that are not valid under the target MAG in LPOs included in a PBA from a LMA. If SLAAC is used to configure addresses to a MN, then the target MAG SHOULD deprecate prefixes from the source MAG by sending a Router Advertisement with a Prefix Information Option (PIO) and set at least the preferred lifetime to zero (0). The valid lifetime is set to value received in the corresponding LPO. If e.g. SeND [RFC3971] is

used, then the valid lifetime can also be set to zero (0).

4.4.2. Temporary Tunneling Between Mobile Access Gateways

During the handover from a source MAG to a target MAG, it might not be possible to make the MN to discard all addresses in use that belong to the source MAG. This is the case, for example, when the MN does not implement the DNA functionality and the valid lifetime of the prefixes is still greater than zero. In this case, it would be beneficial to establish a temporary tunnel for the local addresses from the source MAG to the target MAG for the period the valid lifetime of the prefixes expires. The temporary tunnel would be removed immediately when valid lifetime of the local prefix from the source MAG expires. Whether the target MAG initiates the creation of the temporary tunnel between MAGs is controlled by the 'EnableTemporaryLocalizedRouting' configuration object.

[Discussion: it is to be verified whether [RFC6705] is usable for this purpose and whether it has to be extended to cover the above use case or do we need to develop a new one.]

4.4.3. Informing a Mobile Node of an Inoperable Prefix/Address

If tunneling between MAGs as described in Section 4.4.2 is not an option, then the target MAG SHOULD respond to all IP packets a MN originates with an address belonging to the source MAG with an ICMPv6 error Destination Unreachable Message and set the Code to 5 (Source address failed ingress/egress policy) [RFC4443]. The configuration SHOULD remain active until the valid lifetime received from the corresponding LPO expires.

5. Local Mobility Anchor Operation

5.1. Extensions to Binding Cache Entry Data Structure

The Binding Cache Entry (BCE) data structure for each currently registered MN is extended with zero or more locally assigned IPv6 prefix/address and its valid lifetime pairs. The prefix/address in the Local Prefix mobility option MUST NOT be used as a BCE look up key.

5.2. Local Prefix/Address Context Transfer

The operation of the LMA is fairly simple. When the LMA received a PBU and the BCE for the MN has no prior knowledge of a local prefix/address information learned from the received LPO option, then the LMA:

- Records the prefix/address into the BCE.
- Records the valid lifetime of the prefix/address into the BCE.
- Echoes the prefix/address, the valid lifetime and 'R' set to 0 information back to the MAG in the LPO option included in the PBA.

If the BCE for the MN has existing local prefix/address information learned from the received LPO option, then the LMA:

- Records the new prefix/address into the BCE.
- Records the new valid lifetime of the prefix/address into the BCE.
- Returns the old prefix/address, the valid lifetime and 'R' set to 1 information back to the MAG in the LPO option included in the PBA.

5.3. Local Prefixes/Addresses Management

After a MN has moved from a source MAG to a target MAG as a result of a handover, the MN might be configured with prefixes/addresses that topologically belong to the source MAG. If DHCPv6 was used to configure addresses to the MN, then the LMA SHOULD initiate the DHCPv6 Reconfigure procedure towards the MN immediately after sending the PBA to the target MAG. If SLAAC was used to configure addresses to the MN, then the LMA does not need to do anything beyond what has already been done in Section 5.2.

6. Signaling Flow Examples

6.1. Stateless Address AutoConfiguration Example

Figure 3 shows example PMIPv6 signaling for the initial attachment to the PMIPv6 domain and a handover with locally assigned prefixes and when the stateless autoconfiguration (SLAAC) [RFC4862] is used for configuring addresses.

In the following figure 'PIO' stands for Prefix Information Option [RFC4861] in a Router Advertisement, 'p' means the preferred lifetime in a PIO, and 'v' means the valid lifetime in a PIO. 'lp1' stands for local prefix 1 and 'lt1' for its valid lifetime. Similarly 'lp2' stands for local prefix 2 and 'lt2" for its valid lifetime. 'lp1' is different from 'lp2'.

Figure 3: Local prefix assignment and lifetime management example using SLAAC

6.2. Stateful Address Configuration Example

Figure 4 shows example PMIPv6 signaling for the initial attachment to the PMIPv6 domain with locally assigned prefixes and when the stateful address configuration (DHCPv6) is used for configuring addresses.

In the following figures 'p' means the preferred lifetime in an IA_TA or IA_NA, and 'v' means the valid lifetime in an IA_TA or IA_NA respectively. Also, 'la1' stands for local address 1 and 'lt1' for its valid lifetime. Similarly 'la2' stands for local address 2 and 'lt2" for its valid lifetime. 'la1' is different from 'la2'. The 'IA_xA' stands for either IA_TA or IA_NA.

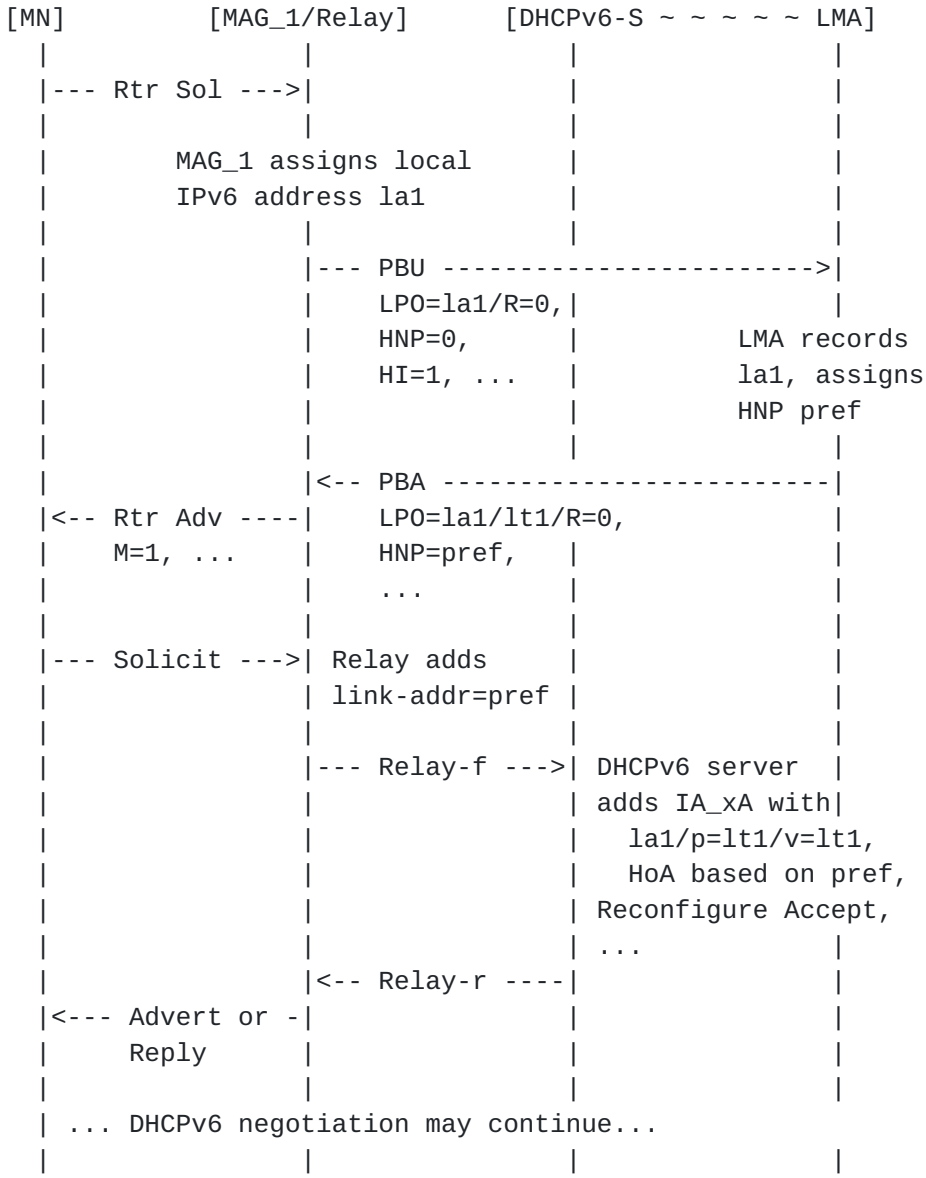

Figure 4: Local prefix assignment example using stateful DHCPv6

Figure 5 shows example PMIPv6 signaling for a handover with locally assigned prefixes and when the stateful address configuration (DHCPv6) is used for configuring addresses.

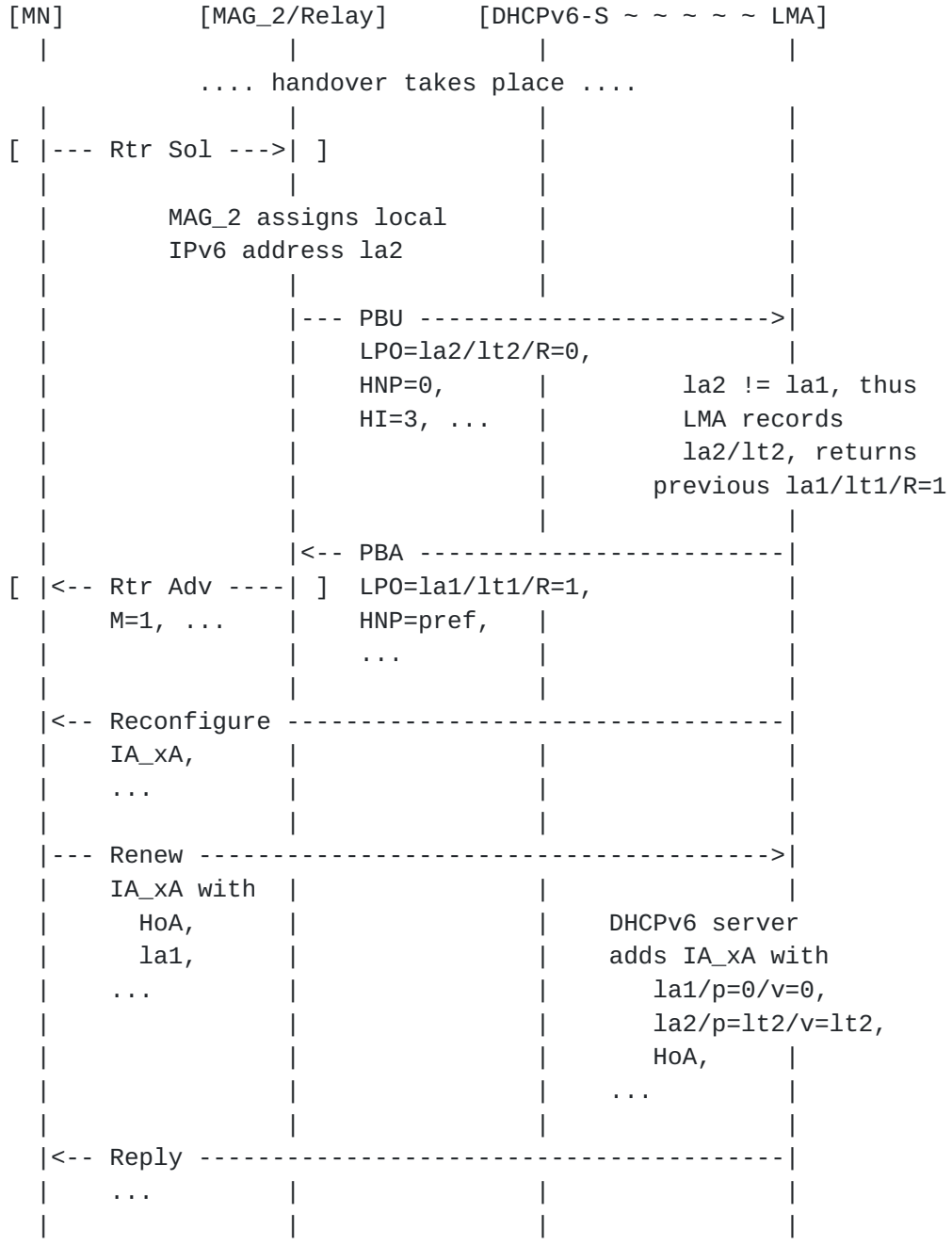

Figure 5: Local prefix change example using stateful DHCPv6 during a handover

7. Configuration Objects

This specification defines two configuration objects.

EnableLocalPrefixManagement

This configuration object is available in both a MAG and in a LMA. When set to TRUE (i.e., enabled), the PMIPv6 node enables the local IPv6 prefix/address lifetime management functionality. The default value is FALSE (i.e., disabled).

EnableTemporaryLocalizedRouting

This configuration object is available in both a MAG and in a LMA. When set to TRUE (i.e., enabled), the MAG or the LMA MAY initiate the localized routing (tunnel) [RFC6705] for the period locally meaningful prefixes from the previous MAG are still valid. The default value is FALSE (i.e., disabled).

8. Security Considerations

The security considerationf for the Proxy Mobile IPv6 [RFC5213] apply. Furthermore, generic security threats regarding the address/ prefix ownership also apply [RFC3971]. An attacker can make use of unprotected Router Advertisements to interfere the address selection the MN does and in that way hijact traffic. This requires that the attacker is albe to gain access to the same link the victim host is.

[Editor's Note: security considerations to be imporved.]

9. IANA Considerations

One new mobility options for the use with PMIPv6 is defined in the [RFC6275] "Mobility Options" registry. The mobility option is defined in Section 3:

Local Prefix Mobility Option is set to TBD1

10. Acknowledgements

We ack.

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Authors' Addresses

Jouni Korhonen
Renesas Mobile
Porkkalankatu 24
FIN-00180 Helsinki
Finland

Email: jouni.nospam@gmail.com

Teemu Savolainen
Nokia
Hermiankatu 12 D
FI-33720 Tampere
FINLAND

Email: teemu.savolainen@nokia.com

Sri Gundavelli
Cisco
170 West Tasman Drive
San Jose, CA 95134
USA

Email: sgundave@cisco.com