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       InterDomain-QOSM: The NSIS QOS Model for Inter-domain Signaling to
   Enable End-to-End QoS Provisioning Over Heterogeneous Network Domains
                 <draft-zhang-nsis-interdomain-qosm-02.txt>

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Abstract

   This document describes a NSIS Inter-domain QoS Model
   (InterDomain-QOSM) for realizing automatic inter-domain QoS
   interactions between adjacent network domains in a standardized and
   dynamic way to facilitate the end-to-end QoS provisioning over
   a chain of heterogeneous network domains. Specifically, it adopts the
   idea of distinct separation between the intra-domain QoS control
   plane and the inter-domain QoS control plane at each administrative
   domain and aims at standardizing the interface between the
   intra-domain and inter-domain QoS control planes within a domain and

implementing the inter-domain QoS control plane as well as the
inter-domain interface between peer inter-domain control planes by
specifying the InterDomain-QOSM. Furthermore, the interactions
between the intra-domain and inter-domain control planes via the
standardized interface are also described in detail when the NSIS
(e.g., the RMD-QOSM or Y.1541-QOSM) is deployed as the intra-domain
QoS control solution.

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1. Introduction

   Although lots of efforts (e.g., IntServ [RFC2210] and Diffserv
   [RFC2475], [RFC2638]) have been made by the Internet community to
   address efficient Quality-of-Service (QoS) support in IP networks,
   there are still some barriers to overcome before the end-to-end QoS
   provisioning can be truly realized over heterogeneous IP network
   domains. Among them, one major barrier to the achievement of
   end-to-end QoS over heterogeneous environments is the lack of a
   standardized and automatic approach to perform inter-domain QoS
   interactions between adjacent administrative domains. To fully
   address this barrier, we believe that a distinct separation between
   the intra-domain QoS control plane and the inter-domain QoS control
   plane within an administrative domain must be made, an interface
   between the intra-domain and inter-domain QoS control planes in the
   domain must be clarified and standardized, and an interface between
   the peer inter-domain QoS control planes at adjacent domains must be
   standardized and implemented in a way that the network operator's
   internal confidentials don't need to be exposed. With the above
   separation and interfaces, the automatic QoS negotiation and setup of
   inter-domain traffic streams over a chain of heterogeneous network
   domains will be enabled in a standardized and dynamic way, fully
   independent from the intra-domain QoS mechanisms in use at each
   domain.

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   The Next Steps in Signaling (NSIS) Working Group proposed a flexible
   IP signaling solution [RFC4080] for the Internet, where the NSIS
   protocol suite is structured in two layers: a generic (lower) layer,
   termed NSIS Transport Layer Protocol (NTLP), which is responsible for
   moving upper-layer signaling messages between NSIS entities and is
   independent of any particular signaling applications on top of it;
   and an upper layer, termed NSIS Signaling Layer Protocol (NSLP),
   which contains functionality such as upper-layer message formats and
   sequences, specific to a particular signaling application. Currently,
   the General Internet Signaling Transport (GIST) protocol [GIST]
   provides a concrete solution for the NTLP. Moreover, the QoS NSIS
   Signaling Layer Protocol (QoS-NSLP) [QoS-NSLP] defines message types
   and generic QoS control information for supporting the QoS signaling
   application together with a class of QoS Models (QOSM). A QOSM
   defines the detailed QoS-related procedures and operations (e.g.,
   negotiation, setup, update and release of network resources) to
   achieve the requested QoS target in a manner that is consistent with
   either the QoS control technology in use at a network domain
   (intra-domain QOSM) or between adjacent domains (inter-domain QOSM).
   The RMD-QOSM [RMD-QOSM] and Y.1541-QOSM [Y.1541-QOSM] are examples of
   the NSIS based intra-domain QOSMs.

   This document adopts the idea of distinct separation between the
   intra-domain QoS control plane and the inter-domain QoS control plane
   at each administrative domain and aims at standardizing the interface
   between the intra-domain and inter-domain QoS control planes within a
   domain and at implementing the inter-domain QoS control plane as well
   as the related inter-domain interface between peer inter-domain QoS
   control planes at adjacent domains by specifying a NSIS Inter-domain
   QoS Model (InterDomain-QOSM). Furthermore, the interactions between
   the intra-domain and the inter-domain control planes via the
   standardized interface are also described in detail when the NSIS
   (e.g., the RMD-QOSM or Y.1541-QOSM) is deployed as the intra-domain
   QoS control solution. For the case that non-NSIS solutions are used
   as the intra-domain QoS control mechanism, an additional intra-domain
   signaling protocol will be needed to implement the standardized
   interface between the intra-domain and inter-domain QoS control

planes within an administrative domain, and we leave it to other
drafts to address.

The structure of this specification is as follows. Section 2 defines
terminology, and Section 3 gives an overview of inter-domain
signaling requirements for end-to-end QoS provisioning over
heterogeneous network domains and then describes the aims and scopes
of the InterDomain-QOSM draft. The basic features of the
InterDomain-QOSM are summarized in Section 4 including the high-level
view of inter-domain signaling operations with the InterDomain-QOSM
via the standardized interfaces. The detailed descriptions of the
InterDomain-QOSM, such as the QSPEC [NSIS-QSPEC] parameters, the
operation modes and the signaling procedures and operations for

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    realizing the inter-domain control plane, etc, are presented in
    Section 5. In addition, Section 6 discusses the security
    consideration raised by the InterDomain-QOSM and the IANA
    considerations are given in Section 7. Finally, Appendix A provides
    the examples of discovering the peer inter-domain QNE with the
    path-decoupled MRM of GIST when the NSIS is used as the intra-domain
    QoS control solution.

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 RFC 2119
    [RFC2119].

    The terminology defined by GIST [GIST] and QoS-NSLP [QoS-NSLP]
    applies to this draft.

    In addition, the following terms are used:

    Edge node: Node on the boundary of an administrative domain.

    Ingress node: Edge node that handles the traffic as it enters the
    domain.

    Egress node: Edge node that handles the traffic as it leaves the
    domain.

    Inter-domain QoS controller: Abstract entity which is responsible for
    the inter-domain control mechanisms within its administrative domain,
    in cooperation with its logically adjacent domains via a common
    inter-domain interface. Depending on the kind of domain (size,
    network technology, method used to assure the intra-domain QOS,
    etc.), the inter-domain QoS controller can be implemented in a
    fully centralized, fully distributed or hybrid (i.e. an intermediate
    approach between fully centralized and fully distributed) mode.
    Please refer to Section 4.1 for the details of the implementation
    modes.

    Intra-domain QoS controller: An abstract entity which is responsible
    for performing all intra-domain control mechanisms in a manner
    appropriate to the specific network technology in use at an
    administrative domain. As happens with the inter-domain control
    agent, it can be implemented in a centralized, decentralized or
    hybrid mode.

    Customer: Business entity which has the ability to subscribe to the
    services offered by providers.

    Provider: Business entity which owns an administrative domain and is

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responsible for its operation, especially for the provision of
Internet connectivity.

Service Level Agreement (SLA): Contract between a customer, which can
be an end-user or an administrative domain, and an administrative
domain, which acts as a provider, where the provider guarantees that
traffic offered by a customer meeting certain stated conditions, will
receive one or more particular service levels. The guarantees may be
hard or soft, may carry certain tariffs, and may also carry certain
monetary or legal consequences if they are not met.

Service Level Specification (SLS): Technical details of the agreement
specified by a SLA. A SLS has, as its scope, the acceptance and
treatment of traffic meeting certain conditions and arriving from a
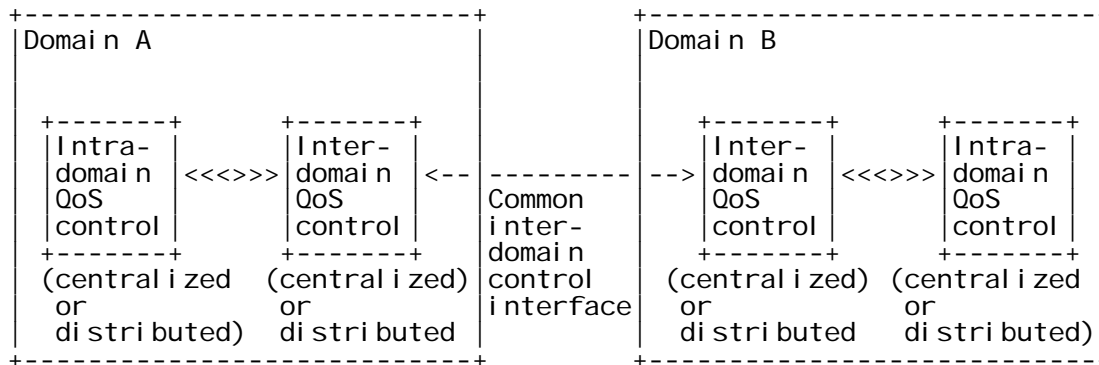certain customer.

3. The Overview of Inter-domain Signaling for End-to-End QoS
   Provisioning Over Heterogeneous Network Domains

There are scenarios that can increase their data forwarding
performance by separating the control plane heavy processing from the
data forwarding processing. Such scenarios are for example, described
in [draft-hancock-nsis-pds-problem-03], which achieve this separation
by implementing outsourcing. The outsourcing takes place when nodes
located on the data forwarding give over either the complete or a
part of their control plane responsibilities, such as resource
management, to one or more central controlling entities. Such
scenarios are able to use signaling that can propagate off path
towards the central controlling entities.

Several off path signaling scenarios can be distinguished, but in
this draft we mainly concentrate on the path decoupled type of
signaling, where signaling messages can travel on path but they might
also be transferred to nodes off the data path. Off path signaling
can be realized by using GIST, which can support path decoupled
signaling, see [draft-hancock-nsis-pds-problem-03] and an
inter-domain QOSM that in combination with the QoS-NSLP realizes a
distinct separation between the intra-domain control plane and the
inter-domain control plane at each administrative domain.
Furthermore, the inter-domain QOSM can specify, by using a QSPEC, a
common inter-domain interface between adjacent domains so that the
inter-domain interactions will be fulfilled in a standardized and
dynamic way to facilitate the realization of end-to-end QoS
provisioning over heterogeneous network domains.

Figure 1 shows a high-level view of such distinct separation made at
two adjacent domains. More specific, at each administrative domain,
the intra-domain QoS controller is responsible for performing all
intra-domain control mechanisms in a manner appropriate to the
network technology in use at the domain and the inter-domain QoS

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controller implements a common inter-domain control interface and
is responsible for the inter-domain interactions with its peer via
the common inter-domain interface. Note that both the intra-domain
and inter-domain QoS controllers shown in Figure 1 are the abstract
entity, which can be implemented in a centralized or distributed
mode (see Section 5.1). Moreover, the interface between the
intra-domain and inter-domain QoS controller within a domain is
standardized in this document.

```
+----------------------------+        +----------------------------+
|Domain A                    |        |Domain B                    |
|                            |        |                            |
|                            |        |                            |
| +-------+    +-------+     |        | +-------+    +-------+      |
| |Intra- |    |Inter- |     |        | |Inter- |    |Intra- |      |
| |domain |<<<>>>|domain |<-- --------- -->|domain |<<<>>>|domain |      |
| |QoS    |    |QoS    |     |Common  | |QoS    |    |QoS    |      |
| |control|    |control|     |inter-  | |control|    |control|      |
| +-------+    +-------+     |domain  | +-------+    +-------+      |
| (centralized (centralized)|control  | (centralized) (centralized |
|  or           or          |interface|  or            or         |
|  distributed) distributed |        |  distributed   distributed)|
+----------------------------+        +----------------------------+
```

     <<<>>> = standardized interface between the intra-domain and
              inter-domain QoS controller within an administrative domain
     <----> = common inter-domain interface between peer inter-domain QoS
              controllers at adjacent domains

     Figure 1: The high-level view of the inter-domain interactions
                between two adjacent domains where the distinct separation
                between the intra-domain and inter-domain control planes is
                made and a common inter-domain control interface exists.

3.1 The Requirements of the Inter-domain Control Plane

     The requirements of the inter-domain control plane (i.e., the
     functions provided by the inter-domain control agent in Figure 1)
     which is required to implement a common inter-domain control
     interface to facilitate the support of end-to-end QoS provisioning
     over heterogeneous network domains are summarized below. Note that
     they are derived closely based on the ones outlined by the proposed
     Diffserv Control Plane Elements (DCPEL) BOF in its document
     [DCPEL-requirements] and from some of the requirements provided in
     [Y-RACF].

     The Requirements of the Inter-domain Control Plane:

     o A common inter-domain control interface, which allows the QoS
        negotiation and set-up of inter-domain traffic streams while

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        hiding intra-domain characteristics from inter-domain
        interactions (i.e., independent from the specifics of the
        intra-domain control plane), must be implemented by the
        inter-domain control plane.

     o Signaling communications over the common inter-domain interface
        must be made based on a well-understood information model for
        SLSs. This model should allow the definition of different degrees
        of SLSs, from per-flow, more suitable for end-hosts or small
        networks, to per-aggregate, more suitable for large networks. It
        should also allow the identification of the SLS validity and a set
        of time periods over each the SLS must be available (activated),
        besides the information about the QoS characteristics.

     o The inter-domain control plane at each domain must be able to keep
        established and/or available/offered SLSs. The SLS is associated
        with the identity of the network domain offering or requesting the
        SLS.

     o The inter-domain control plane must allow network domains
        negotiate and set up SLSs between adjacent domains. Policy

   information specific to the requester, or other general policies
   must be checked to determine if the requested SLS can the
   accepted.

   o The inter-domain control plane at each domain must be able to
      ensure that the traffic streams its domain sends are in conformity
      with the established agreement. Packets might need to be re-marked
      from one internal traffic class identifier to the inter-domain SLS
      identifier, which then might need to be re-marked from the
      inter-domain SLS identifier to another internal traffic class
      identifier used at its adjacent domain.

   o The inter-domain control plane should be able to:

      * support the QoS query, request, response and monitor operations
         in a chain of heterogeneous network domains on a per-flow or
         per-aggregate basis via the common inter-domain control
         interface;

      * support the automatic inter-domain adjustment in the scenario
         of mobile end customers;

      * support bothrelative QoS control and absolute QoS control;

      * verify resource availability within its purview;

      * support QoS differentiation over various categories of packet
         traffic including flows and user designations;

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      * operate only on authorized requests for QoS;

      * make use of the service priority information for priority
         handling;

      * support the following QoS resource control modes:

         a) Push mode: the policy and resource management decisions are
             pushed towards the intra-domain control plane

         b) Pull mode: the policy and resource management decisions are
             requested by the intra-domain control plane upon receiving
             path coupled signaling.

   o The inter-domain QoS resource control process should consists of
      three logical states:

      * Authorization: QoS resource is authorized based on operator
         specific policy rules

      * Reservation: QoS resource is reserved based on authorized
         resource and resource availability

      * Commitment: QoS resource is committed for the requested
         real time flows

3.2 The Aims and Scope of the InterDomain-QOSM Draft

   The aims of the InterDomain-QOSM draft are to standardize the
   interface between the intra-domain and inter-domain QoS control
   planes within an administrative domain and to specify and implement
   the inter-domain QoS control plane as well as the related
   inter-domain interface between the peer inter-domain control planes
   at adjacent domains by specifying a NSIS Inter-domain QoS Model
   (InterDomain-QOSM) so that the automatic inter-domain QoS

interactions can be realized in a standardized and dynamic way to
facilitate end-to-end QoS provisioning over heterogeneous network
domains.

The scope of the draft covers the definition of the interface between
the intra-domain and inter-domain QoS control planes within a domain
and the definition and implementation of the inter-domain interface
between peer inter-domain QoS control planes at adjacent domains by
specifying the InterDomain-QOSM. Moreover, the interactions between
the intra-domain and the inter-domain control planes via the
standardized interface are also described in detail when the NSIS
(e.g., the RMD-QOSM or Y.1541-QOSM) is deployed as the intra-domain
QoS control solution. For the case that non-NSIS solutions are used
as the intra-domain QoS control mechanism, an additional intra-domain
signaling protocol will be needed to implement the standardized
interface between the intra-domain and inter-domain QoS control

planes within an administrative domain, and we leave it to other
drafts to address.

4. The Assumptions about NSIS

This section provides the first analysis of how to include the
InterDomain-QoSM in the NSIS protocol stack, by describing a set of
assumptions about NSIS that are central to the development of the
proposed model. This section introduces section 6.6, which allows us
to go back to NSIS with some proposals for adjustments in order to
fulfill all the requirements of the described InterDomain-QoSM.

This section analysis the potential requirements of the
InterDomain-QOSM on the GIST [GIST] and QoS-NSLP [QoS-NSLP]:

i)   We analyze the possible impact of the InterDomain-QoSM on GIST,
     namely its support for message association between edge devices
     and the inter-domain QoS controller, between the inter-domain QoS
     controller and the edge devices, and between two inter-domain QoS
     controllers (in the case of a distributed operation mode of the
     InterDomain-QoSM.

ii) We analyze until what extend can QoS-NSLP signaling and the
     defined QSpec be re-used.

As referred in this section, the inter-domain QoS controller
responsible for the InterDomain-QoSM is involved in the NSIS
signaling framework. Hence we'll call it from now on, Inter-domain
QoS NSIS Entity (Inter-Domain QNE).

4.1 GIST Analysis

The NSIS working group is currently developing a protocol suite in
which the signaling messages will be processed on the nodes which
also handle the data flows themselves ("path-coupled signaling").
Complementary to this method, a complementary routing method
partially decoupled from the data path is being analyzed. This new
off-path Message Routing Method (MRM) allows the signaling and data
paths to be partially decoupled, without sacrificing the integration
with routing.

The major assumption that the InterDomain-QoSM makes of NSIS is the
support of an off-path MRM.

The current proposal for an off-path MRM
[draft-hancock-nsis-pds-problem-03] defines two discovery mechanisms,
one starting in one off-path node and finishing in one on-path node,

and another starting in one on-path node and finishing in one
off-path node. Figure 2 illustrates these two methods.

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```
                                                +----------+
                                                |   NSLP   |
                   Messaging association        +----------+
                   #########################>>| GIST     |
                   #         .....................| C/D-mode |
                   #         .      GIST-Response  +----------+
  +----------+     #         .                      ^       *
  |   NSLP   |     #         .                       .      *
  +----------+     #         .                       .      *
  |          |<<##########   .                       .      V
  | GIST     |  <.................     GIST-Query  +-.-------+
  | C/D-mode |  |...........................................| GIST    |
  |          |  |.................................. | D-mode|
  +----------+  +----------+    +----------+      +----------+
  |          |  |RAO bypass|    |RAO bypass|      |          |
  |    IP    |  |   IP     |    |   IP     |      |    IP    |
  |Forwarding|  |Forwarding|    |Forwarding|      |Forwarding|
  -----------------------------------------------------------------------> 
  +----------+    +----------+    +----------+      +----------+


  +----------+
  |   NSLP   |
  +----------+       Messaging Association
  | GIST     |<<#########################
  | C/D-mode |                          #
  +----------+                          #
    *     .  ^                          #
    *     .  .                          #                  +----------+
    *     .  .                          #                  |Signalling|
    V     .  .                          #                  | Appl.    |
  +-------.-.-+                          #                  +----------+
  |       . .|      GIST-Response      ##########>>|        |          |
  | GIST  ...........................................|      | GIST    |
  | D-mode .  |        GIST-Query                    | C/D-mode |
  |       ... |.............................>|        |          |
  +----------+    +----------+    +----------+      +----------+
  |          |  |RAO bypass|    |RAO bypass|      |          |
  |    IP    |  |   IP     |    |   IP     |      |    IP    |
  |Forwarding|  |Forwarding|    |Forwarding|      |Forwarding|
  -----------------------------------------------------------------------> 
  +----------+    +----------+    +----------+      +----------+


          ---------> = Data flow (and direction)
          .........> = GIST D-mode messages (and direction)
          <<######>> = GIST C-mode messages (bidirectional)
          *********> = Control (off-path node to router)
```

    Figure 2: discovering a downstream off-path node from a on-path node
              (top figure) and discovering a downstream on-path node from
              an off-path node (bottom figure).

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   These two methods are of use to discover a inter-domain QNE from an
   edge device by which flows enter a domain (ingress device), and for
   an inter-domain QNE to discover an edge device by which flows exit a
   domain (egress device). However, these two discovery mechanism do not
   support the discovery of one QoS controller by its peers. This is a

kind of off-path to off-path discovery mechanism.

The off-path MRM proposal mention "Off-path 'server' discovery from
another off-path node" in section 3.1, but does not describe that
mechanism. Nevertheless, this off-path to off-path discovery
mechanism may be build by using the two methods (on-path to off-path
discovery and vice-versa) described in the off-path MRM proposal by
allowing the configuration of an on-path node for selecting a
specific off-path device. This is one downstream on-path node (i.e.,
the edge routers in the case of the InterDomain-QoSM) should be
configured to select an off-path QoS controller to which its received
GIST-QUERY message should be forwarded.

Figure 3 illustrates the setup of an association between two
off-path inter-domain QNEs located in two different domains. After
the edge QNE1 at Domain A processes the QoS-NSLP message from its
upstream interior QNE, it will connect to the inter-domain QNE1 in
its domain which is configured to serve it (via GIST D-mode or C-mode
depending on the configuration or requirement). Next, the
inter-domain QNE1 sends a GIST-Query message, which is forwarded by
the Edge QNE1 in its domain and intercepted by the Edge QNE3 in
Domain B. Then, this intercepted Query message is forwarded to the
inter-domain QNE2 in Domain B, which is configured to serve Edge
QNE3. To this end, the inter-domain QNE2 at Domain B knows the
necessary info of its peer at Domain A and can send the GIST-Response
message directly to its peer (here, i.e., inter-domain QNE1 at Domain
A). Finally, a message association is set up between them.

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```
   Domain A                             Domain B

 Inter-domain QNE1                    Inter-domain QNE2
   +----------+                         +----------+
   |Inter-QOSM|      Message Association |Inter-QOSM|
   +----------+<<###########################>>+----------+
   |  GIST    |<..............................|  GIST    |
   | C/D-mode |<.-.       GIST-Response        | C/D-mode |
   +----------+  |                         +----------+
       .         |                            ^
       .         |                            .
   +-----.----+  .                         +-----.----+
   |Intra.QOSM|  |                         |Intra.QOSM|
   +-----.----+  .                         +-----.----+
   |     .    |  |                         |GIST .    |
   |GIST .    | -.-.                        |C/D- .    |
   |C/D- .    |  .                         |mode .    |
   |mode .....|..........................  |.....     |
   +----------+       GIST-Query            +----------+
   |    IP    |                             |    IP    |
   |Forwarding|      Data path              |Forwarding|
   ---------------------------------------------------------------->
   +----------+                             +----------+
     Edge QNE1                                Edge QNE3


          ---------> = Data flow (and direction)
          .........> = GIST D-mode messages (and direction)
          <<######>> = GIST C-mode messages (bidirectional)
```
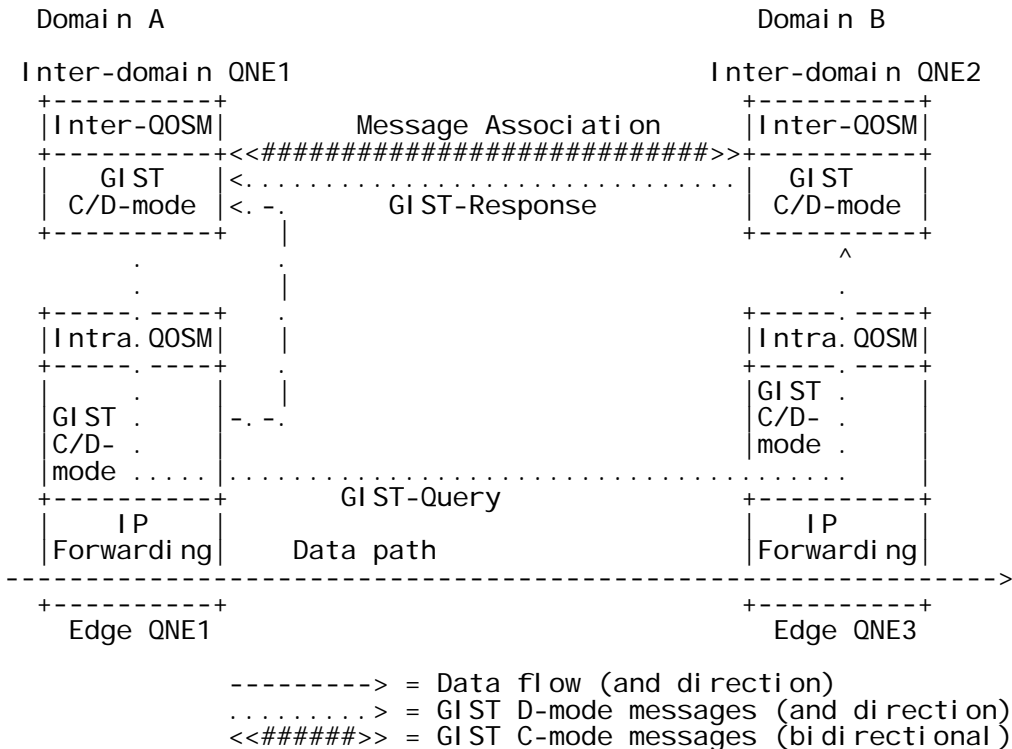
Figure 3: discovering a downstream off-path node from an upstream
          off-path node.

This off-path discovery mechanism can be applied to discover peer
off-path devices in different networks, as illustrated in Figure 3,
and to discover peer off-path devices inside the same network. The
later may be used in a scenario in which a domain uses distributed

inter-domain QNEs -- a set of inter-domain QNEs each controlling a
subset of edge nodes. The configuration of the inter-domain QNE as
centralized or distributed is introduced in Section 5.1 of this
document.

4.2 QoS-NSLP Analysis

   In the example illustrated in Section 4.1, the inter-domain QNEs
   implement the InterDomain-QoSM by signaling QoS between domains,
   while QoS-NSLP [QoS-NSLP] is used to support an IntraDomain-QoSM.
   This is, the inter-domain QNE may trigger a specific ingress device,
   which may use QoS-NSLP to signal the needed QoS among all QoS-NSLP
   aware routers inside the domain from the triggered ingress device
   until the indicated egress device.

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   However, the use of QoS-NSLP to signal between ingress and egress
   devices is not mandatory for the InterDomain-QoSM. Actually, the
   InterDomain-QOSM makes no assumptions about the implementation
   mechanisms of the IntraDomain-QoSM. That is to say intra-domain
   resources may be controlled in a centralized or distributed way,
   based on NSIS protocols or not. Nevertheless, a distributed
   implementation of the IntraDomain-QoSM based on QoS-NSLP signalling
   over several intra-domain QNEs is more close to the work being done
   in NSIS (independent from if the intra-domain signalling is done
   on-path or off-path based on the use of a new off-path MRM also
   inside a domain).

   In any case, the InterDomain-QoSM makes use of the messages, objects
   and procedures defined by QoS-NSLP for signaling exchanges between
   inter-domain QNEs. However, the InterDomain-QoSM depends on the GIST
   to discover the peer inter-domain QNEs in adjacent domains. This
   means that QoS-NSLP is used to signal between inter-domain QNEs, over
   a set of NSIS message associations, as described in section 5.1.

   Moreover, the SLS parameters and QoS control information required for
   the inter-domain QoS interactions are specified by using/extending
   the QSPEC template in [NSIS-QSPEC].

5. The Basic Features of Inter-domainQoSM

   The InterDomain-QOSM described in this document assumes the distinct
   separation between the intra-domain QoS control plane and
   the inter-domain QoS control plane at each administrative domain by
   implementing an inter-domain controller through specifying a NSIS
   based Inter-domain QoSM (InterDomain-QOSM).

5.1 Role of the Inter-domain QNE

   This section provides an introduction to the three possible
   implementation methods for the InterDomain QNE and to the type of
   message associations they might use. It also gives some insight about
   the impact that the IntraDomain-QoSM can have on the setting of the
   above mentioned message associations.

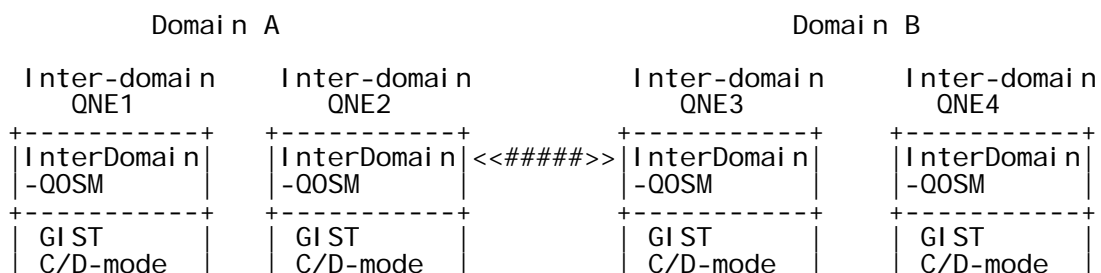   There are three possible ways to implement an Inter-domain QNE:

   i) Fully centralized, which means that the Inter-domain QNE
       functionality is implemented in an interior network node.

   ii) Fully distributed, which means that the Inter-domain QNE
       functionality is implemented in all edge network nodes.

   iii) A hybrid approach of i) and ii), in which the Inter-domain QNE
        is co-located with interior network nodes close to edge devices.

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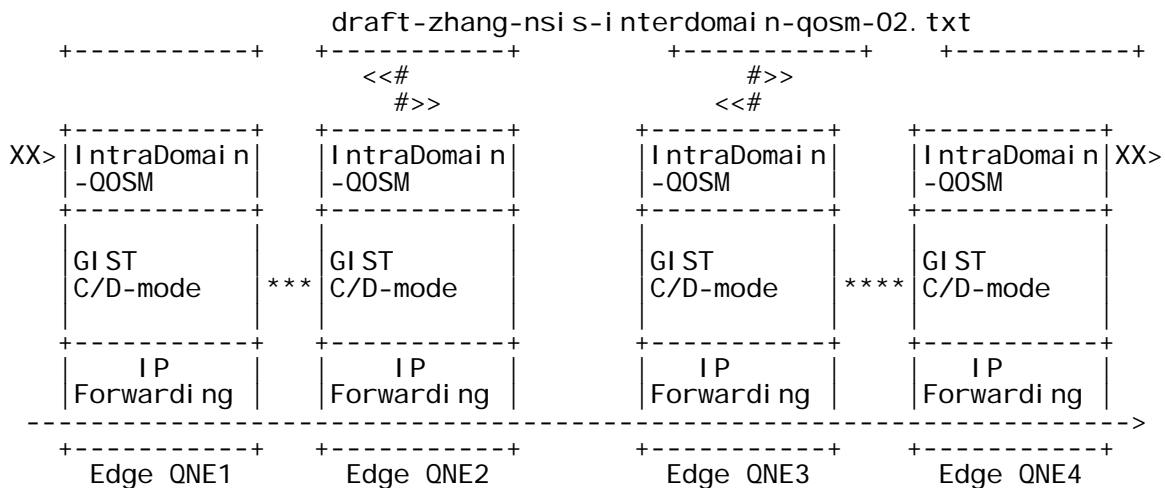
       implemented in each edge router (which does not separate data
       and control plane), in this option we have one Inter-domain QNE
       controlling a subset of edge devices and we separated the data
       from the control plane.

   Each of these approaches has advantages and disadvantages. For
   instance:

   -   The centralized option does not need the synchronization between
       several Inter-domain QNEs in the same network, but has scalability
       and resilience problems. In terms of signaling, it needs an
       off-path inter-domain QoS signaling.

   -   The fully distributed option presents the highest scalability and
       resilience properties, but it incorporates the constraint that the
       signaling will be processed on the nodes which also handle the
       data flows themselves. From the signaling point of view, there is
       no need for a new off-path QoS signaling, since the signaling can
       be done by using QoS-NSLP in two steps, inter-domain and
       intra-domain.

   -   The hybrid option seems to provide a good compromise between the
       de-coupling of signaling and data and the needed scalability and
       resilience. In terms of signaling, it needs an off-path
       inter-domain QoS signaling. It may also need an off-path NSLP
       intra-domain signaling to synchronize the set of Inter-domain
       QNEs.

   Figure 4 illustrates the usage of message associations for the
   operation of inter-domain QNE in a hybrid approach, when considering
   a distributed NSIS intra-domain controller at each on-path node. This
   is, in this example the end-hosts (attached to Edge QNE1 and QNE4)
   signal the network via the QoS-NSLP message. However this
   intra-domain QoS-NSLP message is only forwarded until the egress
   router (Edge QNE2). Then, this egress router (Edge QNE2) will
   transfer the communication to the inter-domain QNE that serves it (in
   this example, inter-domain QNE2), over the pre-established message
   association. Next, the inter-domain QNE2 interacts with its peer (in
   this example, inter-domain QNE3) via inter-domain QoS-NSLP messages
   over a pre-established associations between them. In the neigbour
   domain, the inter-domain QNE3 transfers the communication signal to
   the suitable ingress device (in this case, the Edge QNE3) also over a
   pre-established message association. At this point, the edge QNE3
   uses the intra-domain QoS-NSLP messages again to signal all on-path
   routers until the next egress router (Edge QNE4). In this example,
   the edge QNE4 will not pass the communication signal to the
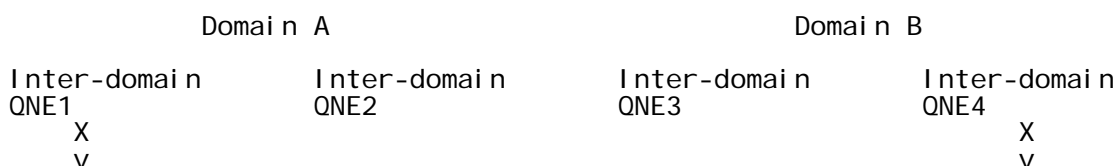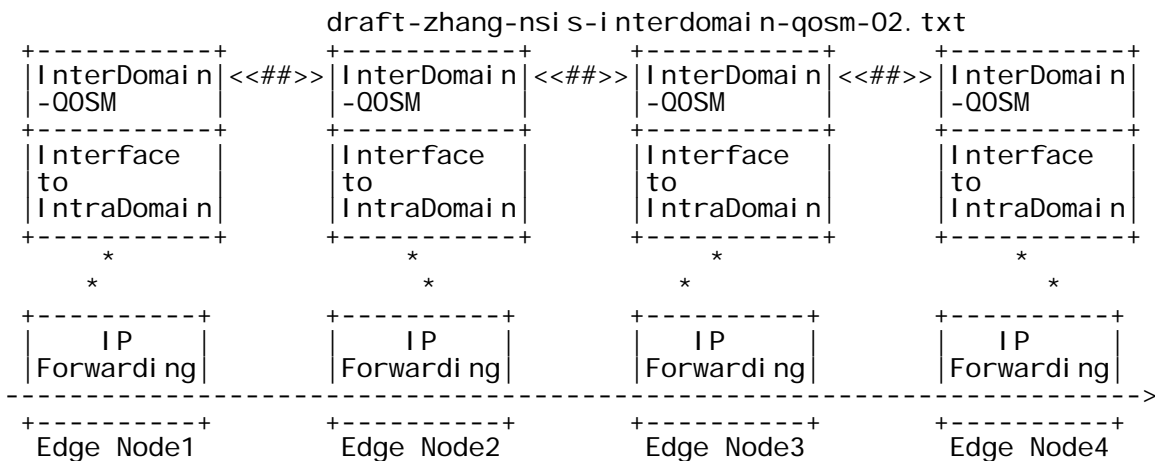   inter-domain QNE4, since the destination host is attached to it.

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         Domain A   Domain B

     Inter-domain   Inter-domain   Inter-domain   Inter-domain
        QNE1   QNE2   QNE3   QNE4

    +-----------+   +-----------+   +-----------+   +-----------+
    |InterDomain| |InterDomain|<<#####>>|InterDomain| |InterDomain|
    |-QOSM | |-QOSM | |-QOSM | |-QOSM |
    +-----------+   +-----------+   +-----------+   +-----------+
    | GIST | | GIST | | GIST | | GIST |
    | C/D-mode | | C/D-mode | | C/D-mode | | C/D-mode |

```
        +-----------+  +-----------+      +-----------+  +-----------+
        |           |      <<#          #>>         |           |
        |           |      #>>          <<#         |           |
        +-----------+  +-----------+      +-----------+  +-----------+
XX>|IntraDomain|  |IntraDomain|      |IntraDomain|  |IntraDomain|XX>
   |-QOSM      |  |-QOSM      |      |-QOSM      |  |-QOSM      |
   +-----------+  +-----------+      +-----------+  +-----------+
   |           |  |           |      |           |  |           |
   |GIST       |  |GIST       |      |GIST       |  |GIST       |
   |C/D-mode   |***|C/D-mode  |      |C/D-mode   |****|C/D-mode  |
   |           |  |           |      |           |  |           |
   +-----------+  +-----------+      +-----------+  +-----------+
   |    IP     |  |    IP     |      |    IP     |  |    IP     |
   |Forwarding |  |Forwarding |      |Forwarding |  |Forwarding |
   -------------------------------------------------------------------->
   +-----------+  +-----------+      +-----------+  +-----------+
     Edge QNE1      Edge QNE2          Edge QNE3      Edge QNE4
```

```
----------> = Data flow (and direction)
<<######>> = InterDomain-QOSM signalling via the GIST C-mode messages
***** = IntraDomain-QoSM signalling based on QoS-NSLP
XXX> = end-host interface
```

Figure 4: message associations for the operation of the inter-domain
          QNE in a hybrid approach

If we consider always a distributed NSIS IntraDomain-QoSM as the
intra-domain QoS solution, the interDomain-QoSM follows an approach
similar to the ITU-T RACF pull mode, independently of the way the
inter-domain QNE is implemented. In fact, the message associations
needed to implement the other two approaches of the InterDomain-QoSM
are similar to the one presented in Figure 4, with the following
differences:

   a. Fully centralized approach: message associations between
      ingress/egress and the central inter-domain QNE and between peer
      inter-domain QNEs in adjacent networks.

   b. Fully distributed approach: message associations between peer
      inter-domain QNEs.

If fact, the most suitable solution (fully centralized, fully
distributed or hybrid) will strongly depend on the characteristics of
the domain, such size, network technology, and method used to assure
QoS. Moreover, it also depends on the used IntraDomain-QoSM. In the
previous examples we always consider the use of a distributed
NSIS-based IntraDomain-QoSM. However, we may also consider the use of
a generalized distributed InterDomain-QoSM, i.e., leave the
definition of the IntraDomain-QoSM open. In this operational mode,
similar to the ITU-T RACF push mode, the message associations for
inter-domain interactions may be as follows: between peer
inter-domain QNEs. Note that a generic interface between the
IntraDomain-QoSM (i.e., the intra-domain QoS control plane) and the
interDomain-QoSM (i.e., the inter-domain QoS control plane) has to be
specified, since the IntraDomain-QoSM is not specified. Figure 5
illustrates the possible message associations and router
configurations.

```
          Domain A                              Domain B

Inter-domain      Inter-domain        Inter-domain      Inter-domain
QNE1              QNE2                QNE3              QNE4
   X                                                      X
   v                                                      v
```

```
+----------+         +----------+         +----------+         +----------+
|InterDomain|<<##>>|InterDomain|<<##>>|InterDomain|<<##>>|InterDomain|
|-QOSM     |         |-QOSM     |         |-QOSM     |         |-QOSM     |
+----------+         +----------+         +----------+         +----------+
|Interface |         |Interface |         |Interface |         |Interface |
|to        |         |to        |         |to        |         |to        |
|IntraDomain|        |IntraDomain|        |IntraDomain|        |IntraDomain|
+----------+         +----------+         +----------+         +----------+
     *                    *                    *                    *
     *                    *                    *                    *
+----------+         +----------+         +----------+         +----------+
|    IP    |         |    IP    |         |    IP    |         |    IP    |
|Forwarding|         |Forwarding|         |Forwarding|         |Forwarding|
-------------------------------------------------------------------------->
+----------+         +----------+         +----------+         +----------+
  Edge Node1           Edge Node2           Edge Node3           Edge Node4
```

    ---------> = Data flow (and direction)
    <<######>> = InterDomain-QOSM signalling via the GIST C-mode messages
    ****** = Direct Router configuration
    XXX> = end-host interface

    Figure 5: Examples of the message associations for the operation of
             distributed inter-domain QNEs, with generic
             IntraDomain-QoSM

5.2 High-level View of InterDomain-QoSM Signaling and Operations

    This section provides an overall view about the interfaces used by
    the InterDomain-QoSM to interact with peers in neighbour network
    domains, with the IntraDomain-QoSM present in the same network
    domain, and with a local manager of Service Level Specifications
    (SLS).

    The definition of these signalling interfaces is independent from
    the way the inter-domain QNE is implemented inside a domain (either
    fully centralized, fully distributed, or hybrid), but assume a
    distributed IntraDomain-QoSM, as the one that can be implemented
    based on QoS-NSLP. Moreover, the InterDomain-QoSM assumes that the
    SLSs between adjacent domains have been established by some other
    mechanism and those SLSs are maintained at the inter-domain QNE.
    Hence it is assumed that there is also one interface between the
    InterDomain-QoSM and the SLS manager to allow the former to receive
    from the latter information about the available SLSs at each moment
    in time.

    Since the interaction between the InterDomain-QoSM and the SLS
    manager happens before the occurrence of any flow (aggregated or not)
    request, the interface between these two components do not show any
    time-related numeration on Figure 6. In the Figure 6, the
    intra-domain QoS controller represents and implements the
    IntraDomain-QoSM in use at a network domain. Although the
    InterDomain-QoSM does not need to make any assumption about the way
    the IntraDomain-QoSM is implemented, Figure 6 exemplifies an
    IntraDomain-QoSM based on QoS-NSLP, in which the latter is used to
    configure network resources on on-path router between edge devices of
    the same domain.

```
     Source Domain    |    Transit Domain    |    Sink Domain
                      |                      |
```

draft-zhang-nsis-interdomain-qosm-02.txt

```
                +-------+ +-------+          +-------+
                | SLS   | | SLS   |          | SLS   |
                |Manager| |Manager|          |Manager|
                +-------+ +-------+          +-------+
                    |         |                  |
                    V         V                  V
 QoS Trigger +-------+ 3  +-------+     6     +-------+
      |   ^   |Inter  | -- ->|Inter  |-----------> |Inter  |
    1 |   |12 |Domain |10    |Domain |     9       |Domain |
      V   |   |QoSM   | <- --|QoSM   |<----------- |QoSMin |
  +-------+ 2 |       |      +-------+   4 +-------+|       |
  |Intra  | -->|Inter- |      |Inter- | -->|Intra  ||Inter- | -->|Intra  |
  |Domain-|11  |domain |      |domain | 5  |Domain-||domain | 8  |Domain-|
  |QoSM1  | <--|QNE    |      |QNE    | <--|QoSM2  ||QNE    | <--|QoSM3  |
  |       |    |------ |      |------ |    |       ||------ |    |       |
  |Intra- |    |QoS-   |      |QoS-   |    |Intra- ||QoS-   |    |Intra- |
  |domain | <->|NSLP   |      |NSLP   | <->|domain ||NSLP   | <->|domain |
  |QNE    |    |------ |      |------ |    |QNE    ||------ |    |QNE    |
  +-------+    |GIST   |      |GIST   |    +-------+|GIST   |    +-------+
  +-------+    +-------+      +-------+             +-------+    +-------+
```
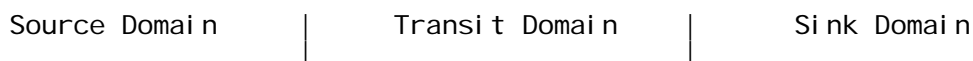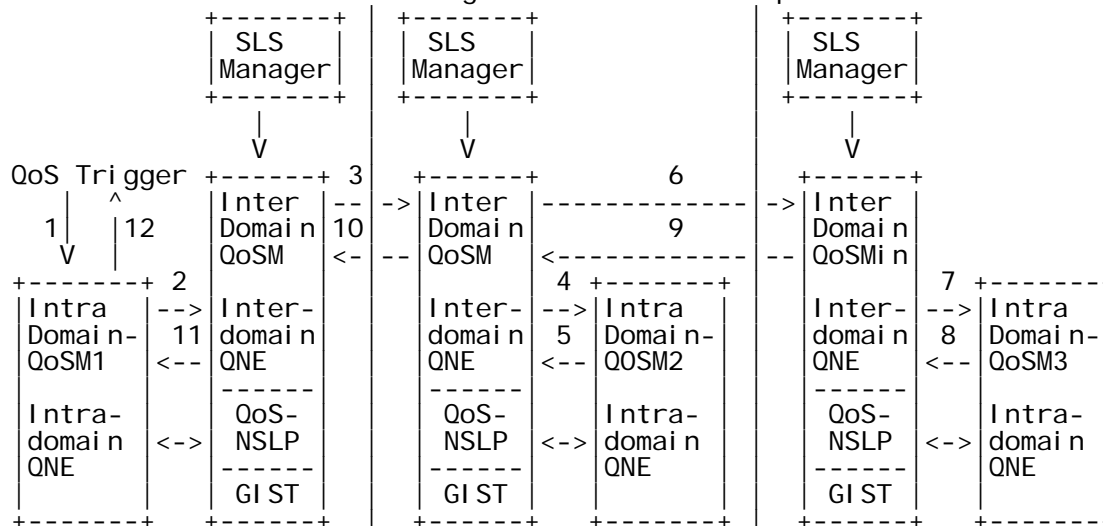
GIST: with on-path and off-path MRM

Figure 6: InterDomain-QOSM signalling interfaces

In the InterDomain-QoSM, it is assumed that hosts communicate with the nearest intra-domain QNE in the attached network to request or query resources for a set of SLSs (step 1) and will get from the same intra-domain QNE a response to that action (step 12). It is assumed that the SLS request made by a host can have a single flow scope or can have a scope to reach a certain network prefix.

Besides the IntraDomain-QoSM signalling used in steps 1 and 12, all the other signalling messages illustrated in Figure 6 refer to the following InterDomain-QoSM interfaces:

a. Inter-Domain QNE / SLS Manager:
   - The SLS Manager provides/updates/removes a set of available SLSs in the InterDomain-QNE. This means, SLSs that were negotiated between neighbout network domains. Each of these SLSs can have different scopes, from a specific network prefix until any reachable prefix (wildcard scope)

b. Inter-Domain QNE / Intra-Domain QNE:
   - A intra-domain QNE (e.g. a QoS-NSLP aware edge router) forward to an inter-domain QNE which serves it (e.g. preconfigured) the SLS request or query with an indication of the egress node of the local domain to which the request or query was locally

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     assigned --- inter-domain QoS interactions are requested
     (step 2).

   - As a result of a previous request to an inter-domain QNE, an
     intra-domain QNE will receive a response with information about
     the sucess or not of the inter-domain signalling (step 11)

   - After an interDomain signalling, the receptor inter-domain QNE
     will have to discover the local ingress node for the received
     SLSs, after which it will trigger the intra-domain QNE at that
     place (steps 4 and 7)

   - As a result of a previous request to an intra-domain QNE, an
     inter-domain QNE will receive a response with information about
     the sucess or not of the intra-domain signalling (steps 5 and 8)

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c. InterDomain-QNE / InterDomain-QNE:

- Based on the information collected in a signalled SLS and on the
  knowledge about the ingress node in the adjacent domain, an
  inter-domain QNE is able to select its peer inter-domain QNE at
  the neighbour domain (inter-domain association) to communicate
  with (steps 3 and 6)

- As a result of a previous request to its peer inter-domain QNE,
  the initiating inter-domain QNE will receive a response with
  information about the sucess or not of the inter-domain
  signalling request (steps 9 and 10).

The remainder of this subsection provides an example an end-to-end
operation performed based on the described interfaces.

When a SLS request or query is received by the intra-domain QNE at
the source domain (step 1), the intra-domain QNE authenticates the
request or query and then trigger the intra-domain QoS mechanisms to
reserve the requested resources from the ingress point where the
intra-domain QNE rests until the egrees point provided by the routing
mechanism. In case of a successful reservation, the egress QNE will
forward the SLS request/query to the inter-domain QNE which is
assigned to serve this egress QNE together with the IP address of the
egress node of the source domain (step 2).

The inter-domain QNE at the source domain will then discover the IP
address of the ingress node in the transit network for the request
(e.g. by querying the inter-domain routing protocol at each border
router that it controls about the IP prefix included in the signalled
SLS). After this, the inter-domain QNE will check whether the
received SLS fit in some SLS established between the egress node of
the source domain and the identified ingress node of the transmit
domain. After a successful checkup, the inter-domain QNE constructs a

new QoS-NSLP RESERVE or QUERY message with the QSPEC object
containing all received SLSs, egress and ingress node parameters as
well as the POLICY_DATA object containing its ID and authentication
information, and send the message to its peer at the transit domain
(step 3).

When the inter-domain QNE at the transit domain receives a QoS-NSLP
RESERVE or QUERY message from its peer, it will take the following
actions:

a. Authenticate that the RESERVE or QUERY message is indeed from a
   peer by using the information containing in the POLICY_DATA object
   of the received message.

b. Check that the SLS parameters containing in the QSPEC object of
   the received message fall within the SLS established between the
   egress and ingress nodes indicated in the QSPEC object.

c. Determine whether the QoS request or query may be accepted
   according to the policies of the domain.

In case of a successful SLS admission control, the inter-domain QNE
at the transit domain sends the SLS parameters to the intra-domain
QNE located at the edge devices which IP address was received in the
SLS (step 4). At this moment, the transit domain performs
intra-domain operations identical to the ones described before and
the result of the intra-domain signaling is sent back in step 5.
After step 5, the transit domain performs similar inter-domain

operations with the sink domain (step 6) as the ones described before
between the source and transit domains.

   At the sink domain, the same operations will be performed by the
   inter-domain QNE and the intra-domain QNE inside it (steps 7 and 8),
   as the ones described before for the transit domain. After step 8,
   and as a result of a successfull intra-domain operation, the
   inter-domain QNE will exchange QoS-NSLP RESPONSE message (steps 9 and
   10), leading to a sucessful reply on steps 11 and 12.

   In case of an unsuccessfull QoS request, each inter-domain QNE should
   notify the intra-domain QNE that it serves so that the reserved
   resources at this domain can be teared down (this step is not
   reflected in Figure 6 due to limited space).

6. InterDomain-QOSM, Detailed Description

6.1 Additional QSPEC Parameters for InterDomain-QOSM

   First of all, two new QoS control parameters <Egress ID> and
   <Ingress ID> need to be added to the QSPEC Control Information of
   the InterDomain-QOSM, which describes the IP interfaces of the

   egress and ingress nodes to which the signaled traffic stream is
   assigned respectively.

   Secondly, to describe the time periods over which a SLS will be
   available or requested, the following <Time Interval Specification>
   parameters are added to the <QoS Desired>, <QoS Available>,
   <QoS Reserved> and <Minimum QoS> QSPEC objects of the
   InterDomain-QOSM:

   <Time Interval Specification> =
   <Absolute Time Interval Specification> |
   <Relative Time Interval Specification>

   where the <Absolute Time Interval Specification> defines a time
   period by specifying its starting and ending time points whereas
   the <Relative Time Interval Specification> specifies only the length
   of a time period. Note that the format of all the additional
   parameters follows the one defined in [NSIS-QSPEC].

6.1.1 <Egress ID> parameter

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |O|E|N|T|     Parameter ID      | IP-Ver|         Length        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   //               Ingress Interface IP Prefix                   //
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   //               Ingress Interface IP Mask                     //
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   //               Ingress Interface IP Prefix                   //
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   //               Ingress Interface IP Mask                     //
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   //                          ...                                //
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
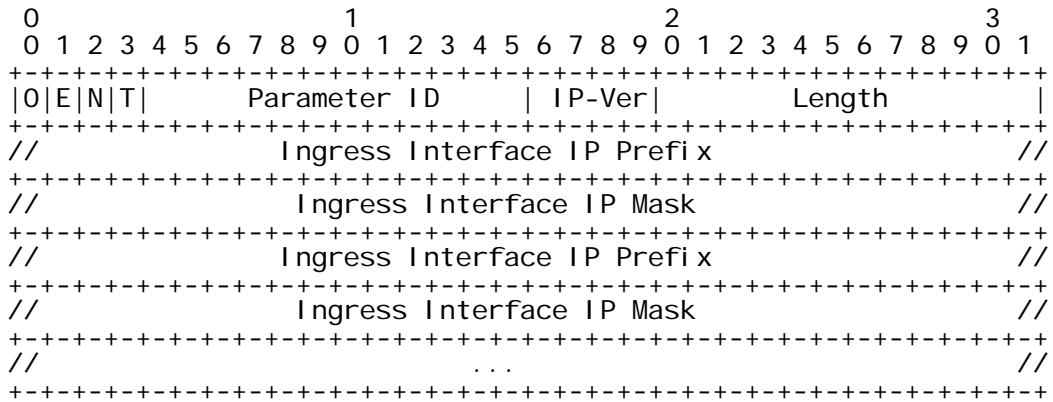
   In order to allow for more than one ingress interface for which the
   QSPEC applies, IP prefixes are used to describe the ingress
   interfaces instead of IP addresses. In this way, the fields Ingress
   Interface IP Prefix specify IP prefixes of the ingress nodes to which

the signaled traffic stream is assigned, while the fields Ingress
Interface IP Mask specify the mask for those prefixes. The four
reserved bits after the Parameter ID field include the IP version
used in the fields Ingress Interface IP Prefix and Ingress Interface
IP Mask. Depending on the IP version used, the length of this field
will vary. All other fields remain the same meanings as defined in
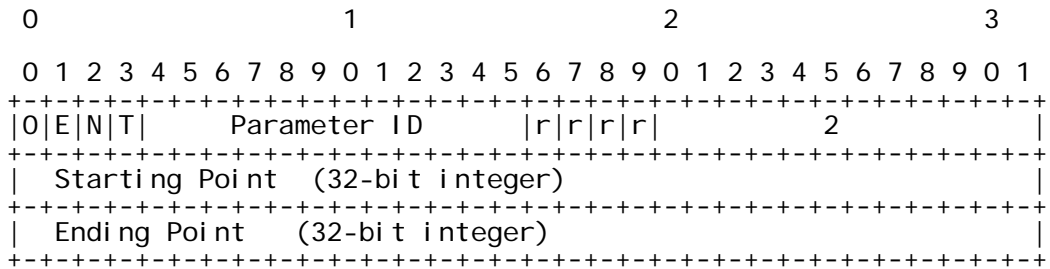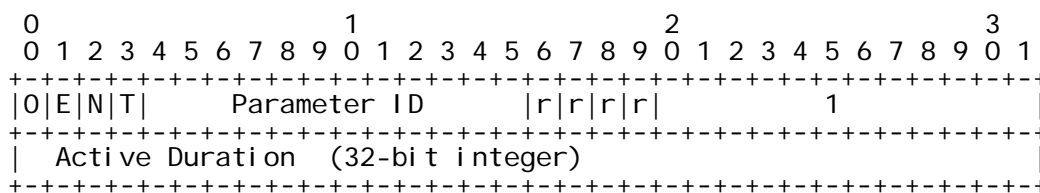[NSIS-QSPEC].

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6.1.2 <Ingress ID> parameter

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |O|E|N|T|     Parameter ID      | IP-Ver|         Length        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   //                 Egress Interface IP Prefix                  //
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   //                  Egress Interface IP Mask                   //
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   //                 Egress Interface IP Prefix                  //
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   //                  Egress Interface IP Mask                   //
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   //                            ...                              //
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
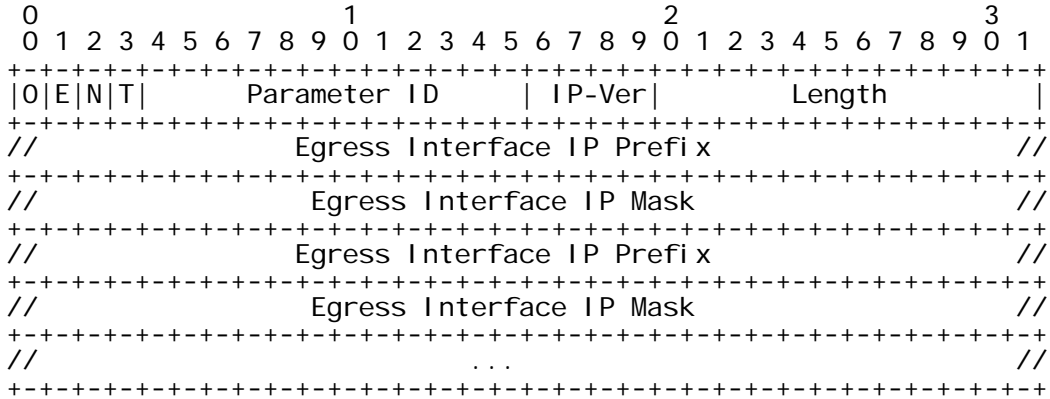
In order to allow for more than one egress interface for which the
QSPEC applies, IP prefixes are used to describe the egress interfaces
instead of IP addresses. In this way, the fields Egress Interface IP
Prefix specify IP prefixes of the egress nodes to which the signaled
traffic stream is assigned, while the fields Egress Interface IP Mask
specify the mask for those prefixes. The four reserved bits after the
Parameter ID field include the IP version used in the fields Egress
Interface IP Prefix and Egress Interface IP Mask. Depending on the IP
version used, the length of this field will vary. All other fields
remain the same meanings as defined in [NSIS-QSPEC].

6.1.3 <Absolute Time Interval Specification> parameter

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |O|E|N|T|      Parameter ID       |r|r|r|r|          2         |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |  Starting Point  (32-bit integer)                            |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |  Ending Point   (32-bit integer)                             |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The fields Starting Point and Ending Point specify the absolute time
values of the starting and ending points of a time period
respectively. The format of the absolute time values follow the one
defined by the IETF Network Time Protocol [NTP]. Both of them must be
nonnegative and are measured in microseconds. Now they are
represented as a 32-bit integer and can be changed afterwards if
necessary. All other fields than the Starting Point and Ending Point
remain the same meanings as defined in [NSIS-QSPEC].

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6.1.4 <Relative Time Interval Specification> parameter

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|O|E|N|T|     Parameter ID      |r|r|r|r|           1          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Active Duration  (32-bit integer)                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The field Active Duration specifies the length of a time period
during which a SLS described by other QSPEC parameters will be
available or need to be activated. It must also be nonnegative and
is measured in microseconds. Now it is represented as a 32-bit
integer and can be changed afterwards if necessary. All other fields
than the Active Duration remain the same meanings as defined in
[NSIS-QSPEC].

6.2 The Operation Modes of InterDomain-QOSM

To address the scalability issue for deploying the InterDomain-QOSM
in real IP network domains, three possible ways to implement the
Inter-domain QNE (see Section 5.1) are provided. Moreover, one aim of
this draft is that the inter-domain QoS control plane implemented by
the InterDomain-QOSM should be able to interact with any intra-domain
QoS solution (no matter NSIS based or not) via the standardized
interface between the intra-domain and inter-domain QoS control
planes. With this in mind, four operation modes of the
InterDomain-QOSM have been specified: fully centralized, fully
distributed, hybrid and generalized modes, where the first three
modes are dedicated to the case that the NSIS is deployed as both the
intra-domain QoS control solution (via IntraDomain-QOSM) and
inter-domain QoS control mechanism (i.e., the InterDomain-QOSM) while
the last mode is for the case that the NSIS InterDomain-QOSM is
deployed for the inter-domain control plane and the intra-domain
control mechanism in use is left open. Note that the implementation
details of the first three operation modes are presented in this
document and the last mode is just briefly discussed and its
implementation is left to other drafts to address.

6.2.1 Operation mode 1: fully centralized

In this operation mode, a single off-path NSIS inter-domain QoS
controller that deploys the InterDomain-QOSM will exist at an
administrative domain, which is responsible for all the
inter-domain QoS interaction requests from/to the domain, and the
NSIS intra-domain QoS controller is distributed at each on-path QNE
and deal with the intra-domain QoS control with an IntraDomain-QOSM
in use at the domain. The NSIS message associations necessary for the
inter-domain interactions will exist between the edge QNEs

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(ingress/egress) and the inter-domain QoS controller and between peer
inter-domain QoS controllers at adjacent domains.

6.2.2 Operation mode 2: fully distributed

In this operation mode, the InterDomain-QOSM and an IntraDomain-QOSM
in use will co-exist at each edge QNE of an administrative domain and
the InterDomain-QOSM will be responsible only for the inter-domain
QoS interaction requests from/to the edge QNE where it resides. The
NSIS intra-domain QoS controller is also distributed at each on-path
QNE and manage the intra-domain QoS via an IntraDomain-QOSM in use at
the domain. The NSIS message associations necessary for the
inter-domain interactions will exist only between peer edge QNEs at
adjacent domains.

6.2.3 Operation mode 3: hybrid

   In this operation mode, a number of off-path NSIS inter-domain QoS
   controller will exist at an administrative domain, and each of them
   will deploy the InterDomain-QOSM and be responsible for handling the
   inter-domain QoS interaction requests from/to a set of edge QNEs.
   Normally the set of edge QNEs assigned to different inter-domain QoS
   controller should be disjoint to reduce the synchronization
   requirement between different inter-domain QoS controllers. The NSIS
   intra-domain QoS controller is also distributed at each on-path QNE
   and handle the intra-domain QoS via an IntraDomain-QOSM in use at the
   domain. The NSIS message associations necessary for the inter-domain
   interactions will exist between the edge QNEs (ingress/egress) and
   the inter-domain QoS controller and between peer inter-domain QoS
   controllers at adjacent domains.

6.2.4 Operation mode 4: generalized mode

   In this operation mode, a number of off-path NSIS inter-domain QoS
   controller will exist at an administrative domain, and each of them
   will deploy the InterDomain-QOSM and be responsible for handling the
   inter-domain QoS interactions made through a set of edge nodes in the
   domain. Moreover, the intra-domain QoS control plane can deploy any
   intra-domain control mechanisms and the interactions between the
   intra-domain and inter-domain QoS control planes will be performed
   via the standardized interface between them. The NSIS message
   associations for the inter-domain interactions will exist only
   between peer inter-domain QoS controllers at adjacent domains. Note
   that this mode can be applied to effectively support the ITU-T RACF
   push mode [Y-RACF]. Due to the fact that an additional intra-domain
   signaling protocol is needed to implement the interface between the
   intra-domain and inter-domain QoS control planes, we leave the
   implementation details of this operation mode to other draft to
   address.

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6.3 Message Format

   TBD

6.4 InterDomain-QOSM Node State Management

   TBD

6.5 InterDomain-QOSM Operations and Sequences of Events

   TBD

6.5.1 Basic unidirectional operation

   TBD

6.5.1.1 Successful reservation

   TBD

6.5.1.2 Unsuccessful reservation

   TBD

6.5.1.3 Refresh reservation

   TBD

6.5.1.4 Modification of reservation

TBD

6.5.1.5 InterDomain release procedure

TBD

6.6 Inter-domain QNE Discovery and Transport of InterDomain-QOSM Messages

TBD

6.6.1 Requirements of InterDomain-QOSM to the Underlying Path-coupled NTLP

TBD

6.6.2 Requirements of InterDomain-QOSM to the Underlying path-decoupled NTLP

TBD

6.7 Handling of Additional Errors

TBD

7. Security Consideration

The operation mode of the InterDomain-QOSM might produce some security concerns and this will be discussed and clarified later.

8. IANA Considerations

This section provides guidance to the Internet Assigned Numbers Authority (IANA) regarding registration of values related to the QSPEC template, in accordance with BCP 26 RFC 2434 [RFC2434].

InterDomain-QOSM requires a new IANA registry. In addition, this document also defines 3 new QSPEC parameters for the QSPEC Template, as detailed in Section 4. Values are to be assigned for them from the QSPEC Parameter ID registry.

9. Open Issues

This section includes the issues that we will do or we think should be analysed in the next version of the draft. Currently, the open issues include:

o All the missing subsections in Section 6 will be done in the next version of the draft.

o Multiple paths: one border router may have more than one interface that a signaled SLS may apply to.

o IntraDomain-QoSM: currently, the InterDomain-QOSM in this draft makes no assumption about the implementation of the IntraDomain-QOSM, i.e., it can support any intra-domain QoS control solutions (NSIS based or non-NSIS based) by standardizing the interface between the intra-domain and inter-domain QoS control planes in an administrative domain. However, the authors are not sure that if the NSIS people will like the idea of an IntraDomain-QoSM that is not based on NSIS (e.g.: direct configuration of all router by using SNMP or COPS).

o The interface between the inter-domain QoS control plane and the intra-domain QoS control plane need to be refined based on more studies and discussions.

o More QSPEC parameters may be needed for the InterDomain-QOSM.

o The support of the automatic inter-domain adjustment in the scenario of mobile end customers.

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Appendix A. Examples of Discovering Peer Inter-domain QNE with the
Path-decoupled MRM of GIST

    A.1 Under InterDomain-QOSM operation mode 1

        TBD

    A.2 Under InterDomain-QOSM operation mode 2

        TBD

    A.3 Under InterDomain-QOSM operation mode 3

        TBD

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