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Two-plane and Three-tier Framework Structure for NSIS

Status of this Memo

Abstract

This document proposes a "two-plane three-tier" framework structure for NSIS signaling. In this framework the Access Networks are connected with wired backbone through default routers. It is assumed that one can do a competent job of network configuration & provisioning in the backbone network, and just keeps backbone

networks stupid simple.Resource policies which are implemented in inter-NSIS Domains and intra-NSIS Domain, NSIS Signaling and NSIS negotiations are in the control plane. User data is transported in the transport plane. COPS/Diameter is used for exchanging resource policies.

Three-Tier NSIS signalings mean that NSIS signaling should be done in three levels. The first level is Inter-NSIS Domain NSIS signaling across neighboring NSIS Domains, and the second level is Intra-NSIS Domain NSIS signaling inside each NSIS Domain while the third level is end-to-edge NSIS signaling and end-to-end NSIS signaling. The aggregate traffic crossing NSIS Domain borders is served according to relatively stable, long-lived bilateral agreements. End-to-end QoS support is achieved through the concatenation of such bilateral agreements.

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1. Introduction

The current wisdom is that the existing circuit switched and 2G (second generation) wireless systems will eventually evolve/morph into an end-to-end IP platform that provides ubiquitous real-time as well as non-real-time services based on 3G (third generation) wireless IPv6 mobile networks. A NSIS framework that provides the end-to-end QoS guarantees for the future network is worth studying. The intention of NSIS framework structure is to provide a framework for the integration of NSIS entities, NSIS signalings, NSIS negotiations with the existing network infrastructures, and we try to identify what NSIS should do in which part of the network, and what NSIS entities should be added.

Although we donÆt consider exactly for what NSIS should signal currently, and resource is a broad sence concept, anyway NSIS should achieve end-to-end QoS guarantee to end users and achieve resource management signaling mechanisms to network operators.

In the proposed NSIS framework there is a central server which has global resource information of the whole NSIS domain, and several local nodes which feed the local information to the central server; and the NSIS signaling and user traffic transport are separated in control plane and transport plane.

We assume that the existing QoS mechanisms can guarantee the traffic transported to the right destination. The aggregate traffic crossing NSIS Domain borders is served according to relatively stable, long-lived bilateral agreements. End-to-end QoS support is achieved through the concatenation of such bilateral agreements.Things about transport plane is out of the scope of this draft.

NSIS signaling should be done in three levels. The first level is Inter-NSIS Domain NSIS signaling across neighboring NSIS Domains, and the second level is Intra-NSIS Domain NSIS signaling inside each NSIS Domain while the third level is end-to-edge NSIS signaling and end-to-end NSIS signaling. The first two levels are mainly about resource policies, so they can almost be done based on existing protocols such as COPS, DIAMETER, etc..

End-to-edge and end-to-end NSIS signaling are considered as the focus areas in this draft. These two types of singalings should provide flexibility for different QoS session management that can be either based on existing reservation or provisioning mechanisms.

In order to have the common definitions with other drafts, some terms are adopted from some drafts. Section 3 describes the two-plane framework and its components. Section 4 explains three-tier NSIS signalings. How the framework guarantees the end-to-end QoS and the three-tier NSIS signalings are presented in Section 5.

1.1 Conventions used in this document

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.

2. Terminology

Administration Domain (AD)
: An AD has the same management methods, pricing policies and so on. An AD belongs to an administrative organization and an administrative organization may have one or more ADs. An AD includes a backbone and some ANs that directly connect to the backbone.

Access Network (AN)
: The AN represents the wireless and back-haul infrastructure that provides MNs with wireless access to the wired infrastructure. An AN usually comprises a set of base stations and base station controllers.

Backbone Network (BN)
: The networks can be controlled and manageable so the configuration and provision can be done well in it.

Control Plane (CP)
: Aggregate of network functionalities including entities such as resource management mechanisms, routing protocols, admission control, NSIS signaling, and NSIS negotiation.

Default Router (DR)
: A router through which the AN connects directly to the backbone network and the traffic from AN to backbone.

Mobile Node (MN)

MN is the device that allows users to communicate, and also provides means of interaction between users and the networks. Traffic is generated/received by MN and may be

queued in the MN while waiting for transmission/reception.

NSIS Domain (ND)

Administrative domain where an NSIS protocol signals for a resource or set of resources.

NSIS Entity (NE)

the function within a node which implements an NSIS protocol.

NSIS Initiator (NI)

NSIS Entity that initiates NSIS signaling for a network resource.

NSIS Responder (NR)

NSIS Entity that terminates NSIS signaling and can optionally interact with applications as well.

NSIS Forwarder (NF)

NSIS Entity on the path between a NI and NR which may interact with local resource management function (RMF) for this purpose. NSIS Forwarder also propagates NSIS signaling further through the network.

Resource

something of value in a network infrastructure to which rules or policy criteria are first applied before access is granted. Examples of resources include the buffers in a router and bandwidth on an interface.QoS can be considered a special example of resource.

Resource Management Function (RMF)

An abstract concept, representing the management of resources in a domain or a node.

NSIS Domain Resource Management Agent(NDRM Agent)

There is one logical NDRM Agent in each ND. The

NDRM Agent has the global information about the resources available in the whole ND. The communications between the NDRM Agents is through the COPS [RFC2748] protocol or Diameter protocol. The NDRM Agent is responsible for resource management mechanisms between the neighboring NDs and responsible for resource control mechanisms between the ANRM Agents.

Access Network Resource Management Agent(ANRM Agent)

ANRM Agent is a separate logical entity and maybe incorporated with the default router. ANRM Agent has the local information about the AN. The default router interacts with ANRM Agent, if necessary, when the MN requests certain degrees of resources in this AN. The ANRM Agent is the entity for NSIS negotiation and NSIS signaling between MN and the network control system. The ANRM Agent decides what resources are available for each default router. Thus, the ANRM Agent is an intelligent entity residing in the control plane. ANRM Agents provide the local resource information to NDRM Agent periodically. ANRM Agent maintains a table that is then updated by NDRM Agent periodically too. Based on this table, ANRM Agent will tell the default routers how to mark, police, shape, map, etc. the traffic going through the default router.

The communications between the NDRM Agent and ANRM Agents can be through the COPS protocol or Diameter protocol, and the communications between the ANRM Agent and the default router can be through the COPS protocol or Diameter protocol too.

Transport Plane (TP)

Aggregate of network functionalities where per-packet activities such as packet forwarding, queuing, conditioning and header editing occur (Per-flow packet conditioning may require interaction with control plane).

3. Two-plane framework

The separation principle for the design of a generalized NSIS framework states that media transfer, control and management are functionally distinct architectural activities [A92]. The principle states that these tasks should be separated in architectural frameworks; one aspect of separation is the distinction between signalling and media-transfer; flows (which are isochronous in nature) generally require a wide variety of high bandwidth, low latency, non-assured services with some form of jitter correction; on the other hand, signalling (which is full duplex and asynchronous in nature) generally requires low bandwidth, assured-type services with no jitter constraint.

In the proposed framework the resource management mechanisms and NSIS Signaling and NSIS negotiations are in the control plane, and media-transfer is in the transport plane

In this draft we assume that one can do a competent job of network configuration & provisioning in the backbone network, and per-class flow QoS can be guaranteed perfectly by DiffServ, MPLS, whatever. This may be enough in many cases. Just keeps backbone network stupid simple. The most important parts of an NSIS domain would be the ingress & egress nodes which are NSIS-ware, so an Intelligent Edge should be formed between backbone network and access networks. NDRM Agent is responsible for the resource management in each ND. COPS or other protocols can be used for communications between NDRM Agent and ingress & egress nodes.

Per-flow QoS can be grarанteed in access network especiall Radio Access Networks, so the intermediate routers and default routers should be NSIS-ware.

3.1 Control Plane

The basic entities in control plane include NDRM Agents, ANRM Agent, and NSIS entities which may be co-located with ingress & egress routers, default routers. The tasks of control plane is to manage reousrce and signal resource. How to manage resource is out of the scope of this draft.

In the proposed framework, there is at least one NDRM Agents and several ANRM Agents in a ND. ANRM Agents reside generally in the edge of wired backbone networks that connect to wireless network through default router, and ANRM Agent can work as a server or co-loated with the default router.

The NDRM Agent retains the global resource information of the ND, and informs ANRM Agents what to do for resource management. The MN has the QoS signaling with ANRM Agent, and ANRM Agent has the QoS signaling with NDRM Agent. The actual traffic generated by MN goes through the default router. The NDRM Agent and ANRM Agents are in control plane while the default routers are in transport plane. By retaining the global resource information in NDRM Agent and separating control plane and transport plane, the framework is flexible, easy to add new services, and more efficient for mobile environment.

Three-tier NSIS signaling means that NSIS signaling should be done in three levels. The first level is Inter-NDRM Agent NSIS signaling across neighboring NDRM Agents, and the second level is Intra-NDRM Agent NSIS Signaling inside each ND, while the third level is End-to-Edge NSIS signaling and End-to-end NSIS signaling.

The signaling protocol can be COPS or Diameter or whatever between NDRM Agents, between NDRM Agents and ANRM Agents.

Figure 1 is the overall picture of the control plane in the framework. There are 2 NDs in this figure and ND1 has 2 ANs each of which connects to the backbone and has a ANRM Agent.

```
          +-------------------------------------------+
         +               +------------+               +
        +  ND2           | NDRM Agent |                +
         +               +------------+               +
          +-------------------- A ----------- -------+
                                |
                            COPS|Diameter                    First Tier
                                |
          +-------------------- V -------------------+
         +               +------------+               +
        +  ND1 +--------->| NDRM Agent |<---------+      +
         +     |         +------------+         |     +
          +--- | ----------------------------- | ---+
               |                                |         Second Tier
           COPS|Diameter                    COPS|Diameter
               |                                |
        +----- V ----------------------------- V --------+
       +    +------------+               +------------+    +
      +     | ANRM Agent |               | ANRM Agent |     +
       +    +------------+               +------------+    +
        +----- A ------------------------------ A -------+
               |                                 |        Third Tier
           COPS|Diameter                     COPS|Diameter
```

```
            |                                 |
  +-------+ |        +===============+        | +-------+
  | +--+  | |       +  +---+   +---+  +       | |  +--+ |
  | |BS|  | V      + +-| ER|---| ER|-+ +      V |  |BS| |
  | +--+ +---+    +  | +---+   +---+ |  +    +---+ +--+ |
  |      |DR |-------+   |       |   +-------| DR|      |
  | +--+ +---+    +    +---+   +---+    +    +---+ +--+ |
  | |BS|  | A      +    | R |---| R |   +      A |  |BS| |
  | +--+  | |       +  +---+   +---+  +       | |  +--+ |
  +-------+ |        +===============+        | +-------+
            |                                 |
End-to-Edge | Signaling          End-to-Edge | Signaling
            V                                 V
          +--+                              +--+
          |NI| <-------------------------> |NR|
          +--+   End-to-end QoS Signaling  +--+
```

Figure 1: Control Plane of the framework

3.2 Transport Plane

User traffic is transported in transport plane. The user data enter the backbone network from AN through default router. How about the backbone network in the transport plane?

As we know, for controlling the traffic there are two types of Internet QoS: Integrated Services [IntServ] and Differentiated Services. Integrated Services is based on resource reservation and network resources are apportioned according to an application's QoS requests, and subject to bandwidth management policy. Integrated Services can guarantee QoS for per-flow traffic. Differentiated Services is based on prioritization and network traffic is classified and apportioned network resources according to bandwidth management policy criteria. To enable QoS, classifications give preferential treatment to applications identified as having more demanding requirements. Differentiated Services can guarantee QoS for per-aggregate traffic.

While the aggregated behavior state of the Differentiated Services architecture does offer excellent scaling properties, the lack of end-to-end signaling facilities makes such an approach one that cannot operate in isolation within any environment. What appears to be required within the Differentiated Services model is both resource availability signaling from the core of the network to the Differentiated Service boundary and some form of signaling from the boundary to the client application [RFC2990].

In the proposed framework a kind of resource allocation protocol for the per-flow traffic in the AN. When the traffic leaves the AN, per-flow traffic is aggregated to form aggregate-flows in the default router. Moreover Differentiated Service is selected in the backbone network and the QoS for aggregate flows between NDs is guaranteed by the other mechanisms [RFC2996], [FCFB99] and [RFC2998]. Other QoS protocols such as MPLS [MPLS] can be selected in the backbone network too.

Figure 2 is a picture about transport plane for end-to-end QoS guarantee.

There are two mapping mechanisms in transport plane: Intra-ND mapping and Inter-ND mapping. Because of different QoS mechanisms in ANs and the backbone network, Intra-ND mapping mechanisms can guarantee the traffic between ANs and backbone network with QoS consistency. Inter-ND mapping mechanisms can guarantee the traffic between ADs with QoS consistency.


```
                +-----------------------+        -------    -------
       +--+     | +--+            +--+  |           A          A
       |CN|<----->|BS|            |BS|  |           |          |
       +--+ per | +--+   +-----+  +--+  |       per-flow       |
           flow +--------| DR |---------+         QoS          |
                         +-A -+                 guarantee      |
                           |  Intra-ND              |          |
     AN                    | Aggregate-flow         |          |
                           |  & Mapping             V          |
                        += V ===========+        -------       |
                       +  +---+   +---+  +          A          |
                      +   | R |---| R |   +         |          |
                     +    +---+   +---+    +        |          |
    BackBone        + ND2   |       |       +       |          |
                     +    +---+   +---+    +        |
                      +   | R |---| R |   +         |         End
                       +  +---+   +---+  +          |          |
                        +== A ==========+           |          to
                            |                       |          |
                            |  Inter-ND             |         End
                            | Aggregate-flow        |
```

```
                            |  & Mapping            |         QoS
                            |                       |
                        +== V ==========+           |
                       +  +---+   +---+  +       Aggregate     G
                      +   | R |---| R |   +        flow        u
                     +    +---+   +---+    +        QoS        a
    BackBone        + ND1   |       |       +    guarantee     r
                     +    +---+   +---+    +        |          a
                      +   | R |---| R |   +         |          n
                       +  +---+   +---+  +          |          t
                        +== A ==========+           |          e
                            |  Intra-ND             |          e
                            | Aggregate-flow        |
                            |  & Mapping            V          |
                         +- V-+                  -------       |
                +--------| DR |---------+           A          |
                | +--+   +-----+  +--+  |           |          |
     AN         | |BS|            |BS|  |        per-flow      |
                | +--+            +--+  |          QoS         |
                +--A---------------A----+        guarantee     |
         Per-flow  |      Per-flow |                |          |
                   V               V                |          |
                  +--+            +--+              |          |
                  |MN|            |MN|              V          V
                  +--+            +--+           ------      ------
```

Figure 2: Transport Plane of the framework

4. Three-tier NSIS signalings in control plane

In [TWOZ99] a two-tier resource management model for the Internet is proposed. The solution resembles the current two-tier routing hierarchy and allows individual administrative domains to independently make their own decisions on strategies and protocols to use for internal resource management. We borrowed some ideas from this paper and the three-tier NSIS signalings are proposed in the framework.

The tenet of our design is what we call three-tier NSIS signalings. By this term we mean that NSIS signalings should be done in three levels. The first level is Inter-ND NSIS signalings across neighboring NDs, and the second level is Intra-ND NSIS signalings inside each ND, while the third level includes End-to-Edge NSIS signalings and End-to-end NSIS signalings. Following the paradigm of Internet Routing, each ND is free to choose whatever NSIS signalings it deems proper for internal NSIS signalings as long as its bilateral SLA with neighboring NDs are met.

These three NSIS signalings have different time cycle for signaling actions. The first tier has the longer time cycle than the other tiers. The third tier is based on per-flow time cycle.

4.1 The first tier NSIS signalings

While AN QoS can be fined grained (per flow), we require that Inter-ND QoS agreements such as SLAs are made for the aggregate traffic crossing NDs. Furthermore, Inter-ND agreements should change infrequently at a larger time-cycle than that of individual applications. These two requirements on Inter-ND agreements provide substantial scaling characteristics by decoupling Inter-ND QoS mechanisms from individual end-to-end flows. So the first tier NSIS signalings occur between neighboring NDRM Agents in different NDs. COPS or Diameter can be used for NSIS protocol, and actually SLAs are signaled in this tier.

Note that the NBRM Agent contacts only its immediate neighbor for all its traffic, although the traffic may head toward various final destinations far away. It is the responsibility of the downstream domain, after agreeing to carry the client traffic, to both guarantee QoS internally as well as request QoS from the downstream neighbors for the portions of the traffic that exit the domain.

As we know, end-to-end QoS is provided by the concatenation of Intra-ND QoS mechanisms and bilateral SLAs between neighboring NDs.

These agreements specify the amount of traffic belonging to different classes that crosses links connecting adjacent NDs. To ensure that the level of actual traffic is always lower than the negotiated limit, the receiving domain polices incoming traffic, dropping or demoting excess traffic. Knowing that offending traffic will be policed, the sending domain in turn, shapes traffic so that it always remains in profile.

4.2 The second tier NSIS signalings

The second tier NSIS signalings occur between NDRM Agent and ANRM Agents in the same ND. COPS or Diameter can be used for NSIS protocol, and actually the resources for aggregate flows from/to AN are signaled in this tier.

ANRM Agents contact NBRM Agent to request certain about of resources to cover for the aggregate high quality traffic leaving the AN. Once the agreement is in place, ANRM Agent will tell default router how to do the configuration, and individual applications can request and use portions of the aggregate allocated amount from the default router. When and if the allocated resources are exhausted, the ANRM Agents may be able to re-negotiate the agreement with its NBRM Agent, allocating a larger amount of resources.

For example one of the purposes of Intra-ND resource provisioning mechanisms is to check whether sufficient network resources are available for traffic flowing through each AN and if so to allocate domain resources for this traffic. Each ANRM Agent is responsible for resource provisioning internally.

4.3 The third tier NSIS signalings

The third tier NSIS signalings includes End-to-Edge NSIS signaling between MN and the default router which is NSIS-ware, and End-to-End NSIS Signaling between MN and CN.

5. NSIS negotiation

Meeting resource guarantees in network systems is fundamentally an end-to-end issue, that is, from application to application. In our framework there is a NBRM Agent acts as the resource controller for each NSIS domain. Neighboring NBRM Agents communicate with each other to establish Inter-domain resources agreements such as SLAs. The aggregate traffic crossing domain borders is served according to relatively stable, long lived bilateral agreements. End-to-End

NSIS signaling support is achieved through the concatenation of such bilateral agreements.

NSIS negotiation includes End-to-Edge NSIS negotiation based on End-to-Edge NSIS signaling and end-to-end QoS negotiation End-to-End NSIS signaling. End-to-Edge QoS negotiation happens between the MN/CN and default routers. End-to-end QoS negotiation happens between MN and CN.

When a MN moves to a foreign network and wants to communicate with other nodes, it will negotiate with the foreign network through the End-to-Edng NSIS signalings to guarantee some necessary resources for its applications. If the foreign network cannot meet MN's resource requirements, MN can decide whether or not enter this network or re-negotiate with the network with degrading its resource requirements. Moreover, the foreign network can decide whether or not allow the MN to enter based on the current resource conditions. The foreign network must inform MN the NSIS negotiation results and this is called the response of NSIS.

If the foreign network allows the MN to enter, it will inform MN the successful results through the End-to-edge NSIS signalings and reserve required resources for MN based on some resource management mechanisms. When MN leaves the network, the resources used by MN will be released by MN itself or the network.

After MN is admitted to enter the foreign network, it will inform CN of its resource requirements for an application through End-to-End NSIS signalings. The CN will decide whether or not communicate with this MN, and CN will inform MN the unsuccessful negotiation result if CN cannot meet MN's NSIS requirements. Otherwise the CN will negotiate with the network in which CN is locating based on the MN's NSIS requirements. In some cases CN can meet MN's requirements but network cannot. If the CN and the CN's located network all can meet MN's QoS requirements, MN may communicate with CN. Moreover CN and the CNÆs located network can modify the resource requirements.

The procedures of NSIS negotiation has three phases: 1) the negotiation between MN and its located network, 2) the negotiation between MN and CN, 3) the negotiation between CN and its located network. Phase 1 and phase 3 are called End-to-Edge NSIS negotiation, and Phase 2 is called end-to-end NSIS negotiation.

The procedures of NSIS negotiation are dependent on what type of NSIS Signaling protocols are used.

6. NSIS Signalings

6.1 In-Band and Out-of-Band Signaling

In-band signaling means that the path followed by the user data packets is the same as the path followed by signaling messages. In other words, the signaling and data paths are identical. In AN, in-band signaling should be used.

Out-of-band signaling means that the path followed by signaling messages might be different from the path used by the user data packets. In the backbone network, out-of-band sigangling should be used.

6.2 End-to-edge and End-to-end Signaling

End-to-edge signaling is initiated by a MN/CN, and is terminated by the default router, or is initiated by the default router and is terminated by a MN/CN. End-to-edge is a kind of in-band signaling, and is used to reserve resource, state management.

End-to-end signaling is initiated by a MN/CN, and is terminiated by a CN/MN. End-to-end signaling is a kind of out-of-band signaling, and is used to take the resource request to the correspondent nodes.

6.3 An example NSIS Signaling protocol

A suite of NSIS signalings protocol is necessary for NSIS negotiation in order to guarantee per-flow end-to-end QoS. Although RSVP is a popular QoS signaling, we build a new suite of QoS signaling by extending the existing Moible IPv6 signalings other than selecting RSVP based on the following factors:

1) the limitations of RSVP;

2) the existing Moible IPv6 mobility management signalings can be extended for QoS negotiation, and doing so can integrate mobility management within QoS negotiation.

The extended Mobile IPv6 signalings for QoS negotiation is divided into two parts: edge QoS signalings and end-to-end QoS signalings. Figure 2 shows the QoS signalings.

The stateless-based Differentiated Services [DiffServ] lack of QoS response and there is no explicit negotiation between the application's signaling of the service request and the network's

capability to deliver a particular service response. If the network is incapable of meeting the service request, then the request simply will not be honored. In such a situation there is no requirement for the network to inform the application that the request cannot be honored, and it is left to the application to determine if the service has not been delivered. So our QoS signaling can be a complement for DS.

The detailed design of the QoS signaling and the procedures of QoS negotiation will be appeared in other draft.

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