# NSIS Signaling Protocol Simulator for Heterogeneous Quality of Service Inter-domain Negotiation

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**Abstract.** This paper presents an IP domain Simulator whose local Quality of Service (QoS) provision rules follow ITU-T specifications. The Simulator inter-operates with a multi-domain, non QoS-homogeneous environment. By means of the NSIS signaling protocol, the local IP domain negotiates QoS agreements with "foreign" domains, effects performance parameters exchange, QoS adaptation in the local domain, route resource reservation, issues the data transmission initiation command and performs session termination. Since the adaptation policies from external to local QoS specifications is left open by the NSIS documentation, the Simulator sets the framework to interchangeably test and compare diverse QoS-adaptation approaches.

## 1 Introduction

With no regard to what type of application is to be transported by the Internet Protocol (IP), it will only provide the best effort service, which is insufficient for most of today's multimedia applications. In order that proper Quality of Service is provisioned, it has been necessary to add higher level protocols. In the context of a single IP domain, IntServ (Integrated Services), and DiffServ (Differentiated Services) have been widely used. When two or more domains are comprised, consistent end-to-end QoS has to be provided. With this objective, a host of protocols have been substantiated, among them: RSVP [1], YESSIR [2], Boomerang [3], BGRP and others [4, 5]. The diverse and at the same time stringent performance demands of the ever growing multimedia applications have outrun these solutions. The Next Steps in Signalling (NSIS) group of the Internet Engineering Task Force (IETF) is the most ambitious and relevant effort for inter-domain QoS provisioning at the time. NSIS started in 2002 releasing the NSIS Threats draft [6]. IP domains working under NSIS maintain their local QoS models (UMTS, DiffServ, etc.), while NSIS provides procedures and formats for QoS information exchange between domains, strategies to homogenize dissimilar QoS classes, IP and routing support and interaction [7].

NSIS has two layer architecture (Fig. 1). The upper layer (NSLP: NSIS Signalling Level Protocol) defines fields and message formats, and messages interchange [8]; while the second layer (NTLP: NSIS Transport Level Protocol) interworks with IP and lower layer protocols to deliver user data and NSLP messages [8].

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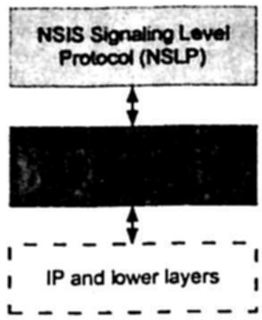



**Fig. 1.** NSIS layer architecture.

In this paper, a Simulator implementing the NSL Protocol in a local domain governed by ITU-T QoS specifications [9] is presented.

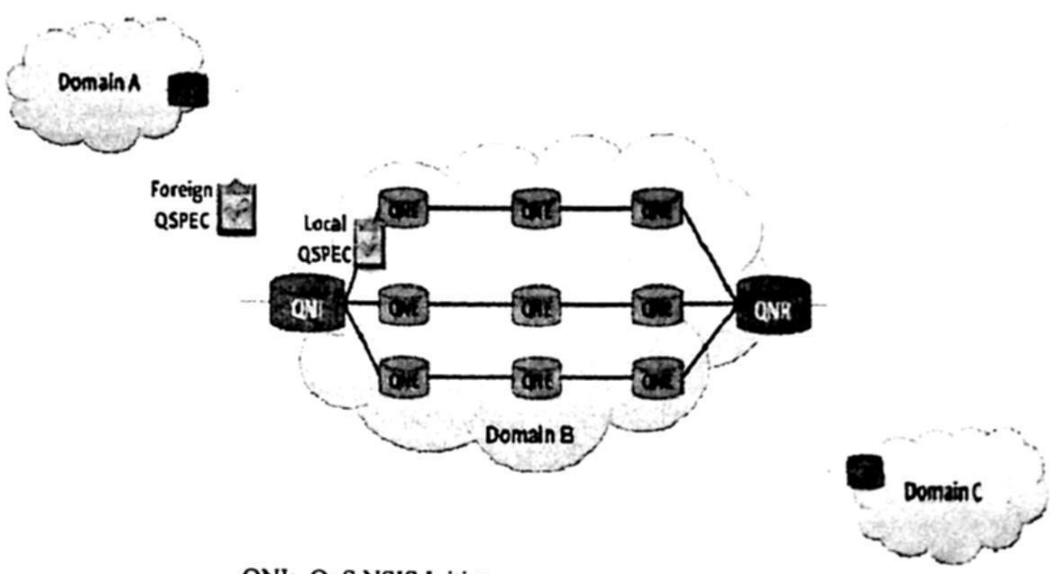
The rest of the paper is organized as follows. Section 2 explains the NSLP, including packet control information, network entities definition, types of messages and their utilization. Section 3 presents the NSLP Simulator development, NSIS entities implementation, QoS class/subclass definitions and signalling procedures for session establishment. Section 4 shows Simulator test scenarios and discusses on the outcomes of the QoS level assignments and their validity. Finally some conclusions on the Simulator features and future work are stated.

## 2 NSIS Signaling Level Protocol

NSLP establishes and maintains signalling among network entities of a session path, in order to reserve resources for the transmission of a data stream [10]. It interprets foreign QoS specifications (QSPECs) and adapts them to local QSPECs (Fig. 2).

### 2.1 QoS Specification

NSLP organizes in a QSPEC all QoS parameters, formats, and processing rules of the domain from which the session establishment comes. The adaptation procedure of a foreign QSPEC to a local QSPEC is not specified by the NSLP, and therefore is open to interpretation and/or definition by the Domain Administrator. Our implementation is explained in section 3. The local QSPEC is composed of four objects (see Fig. 3). (a) Desired QoS. Describes the best fit of a local-to-an-external QSPEC. (b) Available QoS. Is the available resource of an entity equal or nearest to the QoS level requested an entity can assign. (c) Minimum QoS. The minimum QoS level an Entity can offer to a session. (d) Reserved QoS. Resources reserved by a specific entity for a session [11]. Listed in the QSPEC objects, the QoS parameters are the QoS descriptors that specify the expected performance of a session. Restrictions parameters {Delay (ms), Delay variation (ms), Packet loss rate (packets/sec) and Packet error rate (%)} are preferred for NSLP performance description.




QNI: QoS NSIS Initiator
QNE: QoS NSIS Entity
QNR:QoS NSIS Receptor

**Fig 2.** Foreign and local QSPECs.

| QoSDesired | QoSAvailable | QoSMinimum | QoSReserved |
|---|---|---|---|
| Parameter1 | Parameter 1 | Parameter 1 | Parameter 1 |
| : | : | : | : |
| : | : | : | : |
| Parameter n | Parameter n | Parameter n | Parameter n |

**Fig. 3.** QSPEC structure.

## 2.2 NSLP Entities

Each node (router) in an NSIS domain is called an entity. According to their position in the network topology there are three types.

- QoS NSIS Initiator (QNI): Edge router capable of receiving and processing incoming sessions. Starting with a foreign QSPEC whose values can be expressed in numeric or descriptive form. If the values are descriptive, the QNI translates them to a numeric equivalent. The numeric foreign QSPEC is the reference to compare and find the most fitted local parameters. The QNI can now go through its resource table, to see if it has the required or similar QoS available. If it does, QoS class is reserved and diminished from the resource table.
- QoS NSIS Entity (QNE): Operates in the intermediate routers of an NSIS domain. Receives the local QSPEC and seeks through its resource table for the QoS requested. If available it is reserved, discharged from the resource table, and loaded in a message to the next entity in the path.
- QoS NSIS Receptor (QNR): Edge router in the receiving end of a domain. On receiving a QSPEC, the QNR performs the same tasks described for the QNE. Additionally builds a RESPONSE message for the QNI, which collects the reservation

status of all entities participating in the session [7], [12]. If the QNR is not the final destination of the session, it will pass on the original foreign QSPEC to the next domain (Fig. 4).

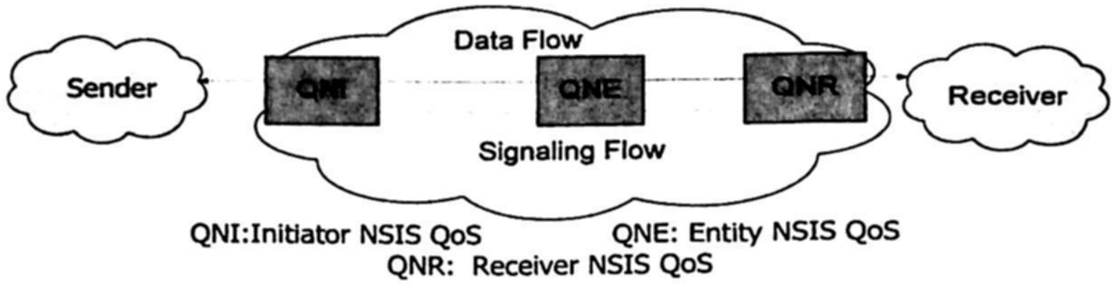



**Fig. 4.** Shows the entities that compose a domain NSIS.

### 2.2 NSLP Messages

QSPECs are carried within various types of messages throughout the NSIS domain [11]. There are three main messages:

- RESERVE: Travels from QNI to QNR. Signals the entities to manipulate its reservation states (creation, update and modification).
- QUERY: Goes from QNR to QNI. Collects information about the available resources in the entities of a path, which allows the QNI to decide on whether to accept or reject a session request.
- RESPONSE: Its direction is from QNR to QNI. Provides information in reply to previous messages like RESERVE or QUERY. Advices the QNI that a path reservation has been successful, and delivers the reservation values assigned by each entity in the path. Is used in reply to a QUERY when a reservation error has appeared.

## 3 NSLP Simulator

The Simulator replicates the *modus operandi* of the NSL Protocol in an IP network. The local domain's QoS classes are those of the Y.1540 and Y.1541 (ITU-T) [9], which together define packet delivery performance parameters (Table 1). In order that the QoS ITU-T framework be adapted to the NSIS objects, a modification to the ITU-T table was introduced, consisting of a subdivision of each class into three subclasses (Premium, Regular and Basic), to correspond respectively with desired, available and minimum QoS.

**Table 1.** ITU-T QoS specification.

| PARAMETERS OF OPERATION OF A NETWORK | CLASS 0 | CLASS 1 | CLASS 2 | CLASS 3 | CLASS 4 | CLASS 5 |
|---|---|---|---|---|---|---|
| IPTD | 100 ms | 400 ms | 100 ms | 400 ms | 1 s | I* |
| IPDV | 50 ms | 50 ms | I* | I* | I* | I* |
| IPLR | $1X10^{-3}$ | $1X10^{-3}$ | $1X10^{-3}$ | $1X10^{-3}$ | $1X10^{-3}$ | I* |
| IPER | $1X10^{-4}$ | $1X10^{-4}$ | $1X10^{-4}$ | $1X10^{-4}$ | $1X10^{-4}$ | I* |
| Application\| | Voice, VoIP, Videoconferences | | Data transactions | | Video Streaming | Traditional uses of IP networks |

IPTD: IP Packet transfer delay IPDV: IP packet delay variation
IPLR: IP packet loss ratio IPER: IP packet error ratio

## 3.1 Simulator's Operation

The control flow chart of Fig. 5 depicts all functions needed to be performed by the Simulator for a session to be completed, initiating with the request arrival until the user-data transmission ceases and the session is terminated. Since the diagram intends to be self-explanatory, additional clarification is given only to the QNI's processes, which require more "intelligence" then the rest of the entities.

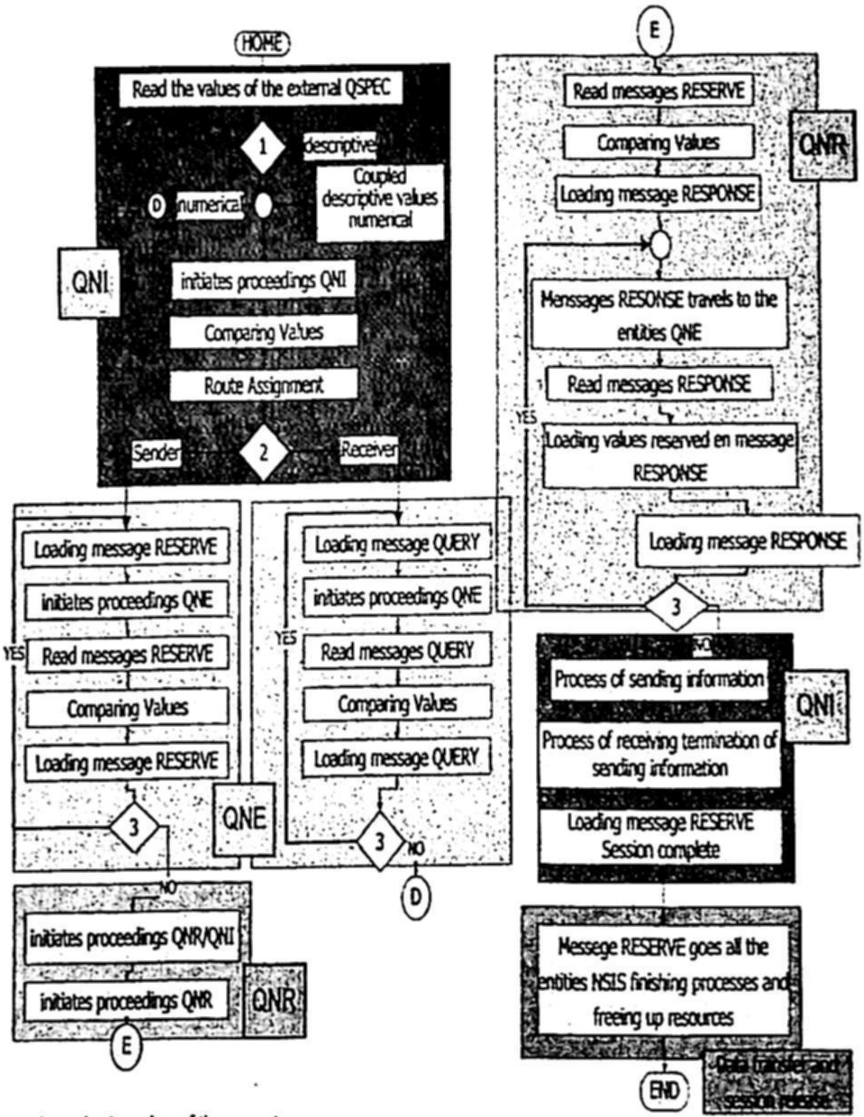
On the arrival of a foreign QSPEC, the QNI determines if there are descriptive parameters. All descriptive values are fitted to a corresponding numeric. Once all values are numeric the QNI performs the QoS level adaptation, to obtain a QSPEC with local values from an external QSPEC that follows a different value reference. This is an unspecified issue in NSIS, bequeathed to the network Administrator. We implemented a straightforward comparison to match the foreign QSPEC values with those of our modified ITU-T QoS specification, first by individual parameter, then by group with majority of hits. This way a class and subclass is assigned as a best fit to the external QSPEC. Other approaches can be tried in this stage [13].

The QNI then inquires in its resource table, to look for the QoS level required. If available, the QoS level is reserved and diminished from the resource table. Then a predefined route to the QNR is designated for the RESERVE message. Finally the role of the edge router as QNI or QNR is defined.

## 3.2 Programming Tools

The Simulator was developed in Visual Basic, using the Visual Studio 2005 platform. The rationales for this are as follows:

- Visual Studio supports several programming languages, so it would ease the workload in case a migration might be needed.
- Object oriented architecture. One of the main functions of the Simulator is to load QoS objects, which can be performed straightforward with Visual Basic. [14].
- A future version might be done and transported to XML (Extensible Markup Language), which is a de facto standard for networks device management [15].
- Visual Studio allows working in console mode, which could facilitate a future NSLP learning environment.




1.- evaluation values of the parameters

2.- assess whether the reservation is initiated by the sender or receiver

3.-Is there another QNE?

**Fig 5.** Diagram shows the operation of the simulator based on NSLP.

## 4 Simulation Scenarios and Results

Over 150 simulations were made, each one representing a session. For the sake of comparison, two of them are selected to highlight different conditions of the network entities, which lead to a differentiated processing for each one. In the first case, the

QoS required is maximum, and the QoS assigned ends up degraded one level. For the second case, the Desired QoS is regular, and is also assigned a lesser level..

The main premises for the Simulator operation are:

- Topology. A simple network topology was adopted (Fig. 2, Domain B). It provides three alternative routes with three QNEs each, enough to test all NTLP functions.
- Foreign QSPECs. Twenty QSPECs were formulated (Table 2). The QSPECs are fed in sequential order, and upon getting to the 19th the process is repeated iteratively. These QSPECs cover the whole spectrum of characteristics a Domain could encounter, mainly: (a) Parameters are descriptive and numeric. (b) Signaling initiated by the QNI and QNR. (c) Range of values. The two instances to be analyzed are QSPEC 3 and 19.
- Entity´s Resource Table. Each entity contains a table to manage a limited pool of resources. Each class has 10 premium instances, 10 regular and 10 basic. This list is updated according to the incoming demands, and the sessions being finished.

**Table 2.** List of external QSPEC-sessions fed to the Simulator.

| No. QSPEC | Message Sequence | QoS Class | Packet Transfer Delay (ms) | Packet Delay Variation (ms) | Packet Loss Ratio (paq/s) | Packet Error Ratio (%) |
|---|---|---|---|---|---|---|
| 0 | 0 | 5 | 2000 | 300 | 0.0002 | 0.00002 |
| 1 | 0 | 4 | 350 | 100 | 0.0003 | 0.00003 |
| 2 | 0 | 3 | 300 | 70 | 0.0007 | 0.00007 |
| 3 | 0 | 0 | 58 | 30 | 0.0002 | 0.00002 |
| 4 | 0 | 5 | 3000 | 500 | 0.0005 | 0.00005 |
| 5 | 0 | 4 | LOW | LOW | LOW | LOW |
| 6 | 0 | 3 | HIGH | HIGH | HIGH | HIGH |
| 7 | 0 | 0 | MEDIUM | MEDIUM | MEDIUM | MEDIUM |
| 8 | 0 | 5 | LOW | LOW | LOW | LOW |
| 9 | 0 | 4 | HIGH | HIGH | HIGH | HIGH |
| 10 | 1 | 3 | 250 | 98 | 0.0003 | 0.00003 |
| 11 | 1 | 0 | 300 | 47 | 0.0007 | 0.00007 |
| 12 | 1 | 5 | 2000 | 300 | 0.0002 | 0.00002 |
| 13 | 1 | 4 | 350 | 100 | 0.0003 | 0.00003 |
| 14 | 1 | 3 | 300 | 70 | 0.0007 | 0.00007 |
| 15 | 1 | 0 | HIGH | HIGH | HIGH | HIGH |
| 16 | 1 | 5 | MEDIUM | MEDIUM | MEDIUM | MEDIUM |
| 17 | 1 | 4 | LOW | LOW | LOW | LOW |
| 18 | 1 | 3 | HIGH | HIGH | HIGH | HIGH |
| 19 | 1 | 0 | MEDIUM | MEDIUM | MEDIUM | MEDIUM |

## 4.1 Test Outcomes Analysis

Table 3 records the QNI sessions information in 16 items. Columns 7-10 carry the Desired QoS values. Columns 13-16 hold the actual resources the QNI had available to match the request.

Sessions 61 and 77 are processed by the QNI on request of external QSPECs 3 and 19 respectively. As can be seen, in session 61 the values of Desired and Reserved objects belong to the same QoS level.

**Table 3.** Data excerpt from the QNI log.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : |
| 61 | 3 | 1 | 0 | 1 | 4 | 100 | 28 | 0.0003 | 0.00003 | 0 | 1 | 200 | 38 | 0.0007 | 0.00007 |
| : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : |
| 77 | 19 | 1 | 1 | 1 | 4 | 200 | 50 | 0.001 | 0.0001 | 0 | 3 | 400 | 50 | 0.001 | 0.0001 |
| : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : |
| 130 | 15 | 1 | 1 | 1 | 1 | 100 | 50 | 0.001 | 0.0001 | 0 | 3 | 400 | 50 | 0.001 | 0.0001 |
| 131 | 16 | 1 | 1 | 1 | 3 | 10000 | 10000 | 0.001 | 0.0001 | 5 | 3 | 10000 | 10000 | 0.001 | 0.0001 |
| 132 | 17 | 1 | 1 | 1 | 0 | 1000 | 10000 | 0.001 | 0.0001 | 4 | 3 | 10000 | 10000 | 0.001 | 0.0001 |
| 133 | 18 | 1 | 1 | 1 | 2 | 100 | 10000 | 0.001 | 0.0001 | 3 | 3 | 400 | 10000 | 0.001 | 0.0001 |
| 134 | 19 | 1 | 1 | 1 | 2 | 200 | 50 | 0.001 | 0.0001 | 0 | 3 | 400 | 50 | 0.001 | 0.0001 |
| 135 | 1 | 1 | 0 | 0 | 3 | 400 | 10000 | 0.0003 | 0.00003 | 4 | 1 | 100 | 10000 | 0.0003 | 0.00003 |
| 136 | 2 | 1 | 0 | 0 | 1 | 400 | 10000 | 0.0007 | 0.00007 | 3 | 2 | 200 | 10000 | 0.0007 | 0.00007 |
| : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : |

1. ID_Iteration. 2. ID_QSPEC 3. Scoreboard_Local / External.
4 Type_parameter. 5 Message_Sequence. 6 Route.
7 IPTD_QoSDesired(ms). 8 IPDV_QoSDesired(ms) 9 IPLR_QoSDesired(paq/seg)
10 IPER_QoSDesired(%). 11 QoS_Class. 12 Level_QOS
13 IPTD_QoSReserved (ms). 14 IPDV_QoSReserved(ms). 15 IPLR_QoSReserved.
16. IPER_QoSReserved.

Columns 7-10 of session 77 display the descriptive-to-numeric conversion of the Desired QoS, while the Available QoS assigned values stated in columns 13-16 are of a lesser level. The QNI loads the Desired QoS values in the RESERVE message (Table 4), and sends it to the next QNE in the route. Entities QNE 4, QNE5 QNE6 launch the process of comparing, adapting, and assigning QoS values in relation to the RESERVE message bore values (see Table 4).

**Table 4.** RESERVE message registry.

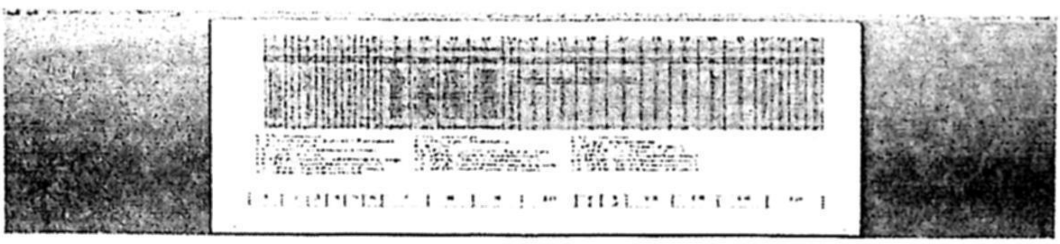
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : |
| 61 | 1 | 3 | 1 | 1 | 0 | 1 | 4 | 100 | 28 | 0.0003 | 0.00003 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : |
| 77 | 1 | 19 | 1 | 1 | 1 | 3 | 4 | 200 | 50 | 0.001 | 0.0001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : |
| 130 | 1 | 15 | 1 | 1 | 1 | 3 | 1 | 100 | 50 | 0.001 | 0.0001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 131 | 1 | 16 | 1 | 1 | 1 | 3 | 3 | 10000 | 10000 | 0.001 | 0.0001 | 5 | 10000 | 10000 | 0.001 | 0.0001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 132 | 1 | 17 | 1 | 1 | 1 | 3 | 0 | 1000 | 10000 | 0.001 | 0.0001 | 4 | 1000 | 10000 | 0.001 | 0.0001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 133 | 1 | 18 | 1 | 1 | 1 | 3 | 2 | 100 | 10000 | 0.001 | 0.0001 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 134 | 1 | 19 | 1 | 1 | 1 | 3 | 2 | 200 | 50 | 0.001 | 0.0001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 135 | 1 | 1 | 1 | 0 | 0 | 1 | 3 | 400 | 10000 | 0.0003 | 0.00003 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 136 | 1 | 2 | 1 | 0 | 0 | 2 | 1 | 400 | 10000 | 0.0007 | 0.00007 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : |

Upon the RESERVE message arrival, the QNR repeats the reservations operations in like manner as the QNEs. Now the QNR ready a RESPONSE message to inform the QNI that the reservation process was successfully completed (see Table 5). The RESPONSE message gathers the Desired QoS and Reserved QoS objects of all the QNEs in its trajectory to deliver to the QNI.

The rest of the messages, and data generated during the initiation, follow-up, and tear-down of a session can also be observed.

**Table 5.** RESPONSE message registry.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : |
| 61 | 1 | 3 | 1 | 1 | 0 | 1 | 4 | 100 | 38 | 0.0003 | 0.00003 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 200 | 38 | 0.0007 | 0.00007 |
| : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : |
| 77 | 2 | 19 | 1 | 1 | 1 | 3 | 4 | 200 | 50 | 0.001 | 0.0001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 200 | 50 | 0.001 | 0.0001 |
| : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : |
| 130 | 2 | 15 | 1 | 1 | 1 | 1 | 1 | 100 | 50 | 0.001 | 0.0001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 28 | 0.0003 | 0.00003 |
| 131 | 2 | 16 | 1 | 1 | 1 | 2 | 3 | 10000 | 10000 | 0.001 | 0.0001 | 5 | 10000 | 10000 | 0.001 | 0.0001 | 0 | 0 | 0 | 0 | 10000 | 10000 | 0.001 | 0.0001 |
| 132 | 2 | 17 | 1 | 1 | 1 | 1 | 0 | 1000 | 10000 | 0.001 | 0.0001 | 4 | 1000 | 10000 | 0.001 | 0.0001 | 0 | 0 | 0 | 0 | 100 | 10000 | 0.0003 | 0.00003 |
| 133 | 2 | 18 | 1 | 1 | 1 | 1 | 2 | 100 | 10000 | 0.001 | 0.0001 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 10000 | 0.0003 | 0.00003 |
| 134 | 2 | 19 | 1 | 1 | 1 | 2 | 2 | 200 | 50 | 0.001 | 0.0001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 200 | 38 | 0.0007 | 0.00007 |
| 135 | 2 | 1 | 1 | 0 | 0 | 1 | 3 | 400 | 10000 | 0.0003 | 0.00003 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 136 | 2 | 2 | 1 | 0 | 0 | 2 | 1 | 400 | 10000 | 0.0007 | 0.00007 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : | : |



## 5 Conclusions

The Simulator presented follows NSIS signaling layer protocol specifications. Its prominent operative characteristics are: (a) Parameters value fitting mechanism. (b) Assign numeric equivalents to descriptive, or a combination of descriptive-numeric values. (c) NSIS entities construct and issue messages with parametric values derived from the entity's particular state.

Simulator's QoS policies follow ITU-T (Y.1540 and Y.1541) specifications. An adaptation was introduced to the QoS Classes table to allow for the use of the three NSIS QoS containers (desired, available and minimum).

The tests carried on the Simulator yielded a heuristic validation of its operation. Sessions 61 and 77 having external QSPEC with numerical and descriptive values and also different QoS level requirements were analyzed, to contrast the differences in processing. In both instances the QoS levels assigned were of inferior qualification, in accordance to the available resources at the Entities at the time of the local QSPEC arrival.

What appears to be a weakness in the reservation strategy of NSIS was detected. It comes out when an NSIS entity assigns a lower QoS level then requested, then this QoS is transported as a request to following entities, and depending on resources, the process can repeat, lowering furthermore the QoS level. This will be a drawback in large chains.

Continuation of this work is envisioned using the Simulator as a framework to test known and novel QoS-adaptation strategies, subject not specified by NSIS, but which constitutes the core of the heterogeneous to equivalent QoS-level conversion. Implementations of other QoS models (UMTS, IntServ, etc.) are also envisaged.

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