The ATM Forum

Technical Committee

# Signalling Congestion Control
# Version 1.0

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# Preface

During preparation of this addendum, the Control Signalling working group was chaired by Gert Öster. The minutes at related working group meetings were recorded by Thomas Cornély and Dave Paw. The editor of this addendum was Shawn McAllister. The editor would like to thank the following contributors for their help with this addendum as well as all participants of the Control Signalling working group for the many days and evenings spent discussing this addendum:

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This specification uses three levels for indicating the degree of compliance necessary for specific functions, procedures, or coding. They are indicated by the use of key words as follows:

- **Requirement:** "Shall" indicates a required function, procedure, or coding necessary for compliance. The word "shall" used in text indicates a conditional requirement when the operation described is dependent on whether or not an objective or option is chosen.
- **Objective:** "Should" indicates an objective which is not required for compliance, but which is considered desirable.
- **Option:** "May" indicates an optional operation without implying a desirability of one operation over another. That is, it identifies an operation that is allowed while still maintaining compliance.

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# 1 Introduction

## 1.1 Scope

### [Normative]

This document is an Addendum to UNI Signalling 4.1 [1], PNNI 1.1 [2] and AINI [3]. It contains the signalling and routing extensions for the support of Signalling Congestion Control.

This addendum specifies signalling congestion control support across public and private UNI interfaces, PNNI interfaces, and AINI interfaces.

Signalling Congestion Control is an optional feature of UNI Signalling 4.1, PNNI 1.1, and AINI.

A device supporting the Signalling Congestion Control feature shall implement these procedures for point-to-point calls/connections, and shall implement these procedures for point-to-multipoint calls/connections if point-to-multipoint calls/connections are supported.

### 1.1.1 Support of Signalling Congestion Control by PNNI 1.0 Nodes

A device supporting PNNI 1.0 may implement the functionality defined in this addendum by treating this addendum as if it were an optional addendum to PNNI 1.0 [5], and PNNI 1.0 Errata and PICS [6]. No new PNNI 1.1 features are required by Signalling Congestion Control.

### 1.1.2 Support of Signalling Congestion Control by UNI 4.0 Nodes

A device supporting UNI 4.0 may implement the functionality defined in this addendum by treating this addendum as if it were an optional addendum to UNI 4.0 [8]. No new UNI 4.1 features are required by Signalling Congestion Control.

## 1.2 Background

### [Informative]

Congestion in signalling networks is a well-known phenomenon. Congestion can occur due to many real life situations such as radio promotional offers in the PSTN and call re-establishments after a failure in an ATM network. Congestion results from the fact that the offered signalling load cannot be serviced with the resources available - be these resources signalling bandwidth, call processing capacity, etc. Sustained, uncontrolled congestion can have a crippling impact on the ability of the network to serve its users.

In this document, the term "signalling congestion" is used to mean insufficient control plane resources to process the offered signalling and call processing load in a timely manner. This includes signalling transmission bandwidth, internal switch message queues, CPU realtime, memory resources, etc. Signalling congestion specifically does not address the issue of insufficient user plane resources to accept new calls.

## 1.3 Overview

### [Informative]

The functions required to perform signalling congestion control are summarized as follows:

1. Detection of signalling congestion by a node.

2. Notification of congestion to other nodes in the network. In general, notification must be provided to the node(s) immediately adjacent to the congested node or signalling link. In PNNI networks, notification of congestion must also be provided to nodes building DTLs that transit the congested point. Since DTL originators and entry border nodes are the nodes deciding to route new calls into the congested point, it is the behavior of these nodes that must be altered during signalling congestion.

3. Actions by nodes receiving notification of congestion to limit signalling congestion to acceptable levels

While all these functions must be present in the solution, not all aspects of each function are subject to standardization.

### 1.3.1 Detection of Signalling Congestion

There are many points within call processing where congestion can occur. One important point at which signalling congestion can be detected and which is discussed in this document occurs as a result of layer 2 flow control. Under signalling congestion, a receiving node R can exert layer 2 flow control toward an adjacent node S which is sending signalling traffic at a faster rate than R can process. In this case, the transmit queue on S for this signalling link will increase in length. This is an example of a node S detecting signalling congestion on a signalling link toward another node R.

Congestion can occur at other points within call processing. It is expected that implementations will detect congestion at these points and react as described in this specification.

### 1.3.2 Notification of Signalling Congestion

For PNNI and AINI, notification to other nodes of signalling congestion occurs using crankback. When congestion occurs on a link or within a node, this condition is indicated by cranking back call establishment requests with a Crankback cause explicitly specifying signalling congestion as the reason for clearing. Use of this mechanism is defined in this addendum.

### 1.3.3 Actions Upon Receiving Notification of Signalling Congestion

Upon receiving notification of congestion, DTL originator and entry border nodes use this information to influence routing of calls in such a manner as to allow congestion within the signalling network to subside. This is accomplished by controlling the rate at which DTL originator and entry border nodes route calls toward the congested resource. This rate control mechanism is adaptive to different congestion conditions within the network.

## 1.4 Example Applications of Signalling Congestion Control

### 1.4.1 Controlling Signalling Congestion Within a PNNI Network

Figure 1-1 depicts a sample network topology where signalling congestion can occur. This example is a single PNNI peer group.

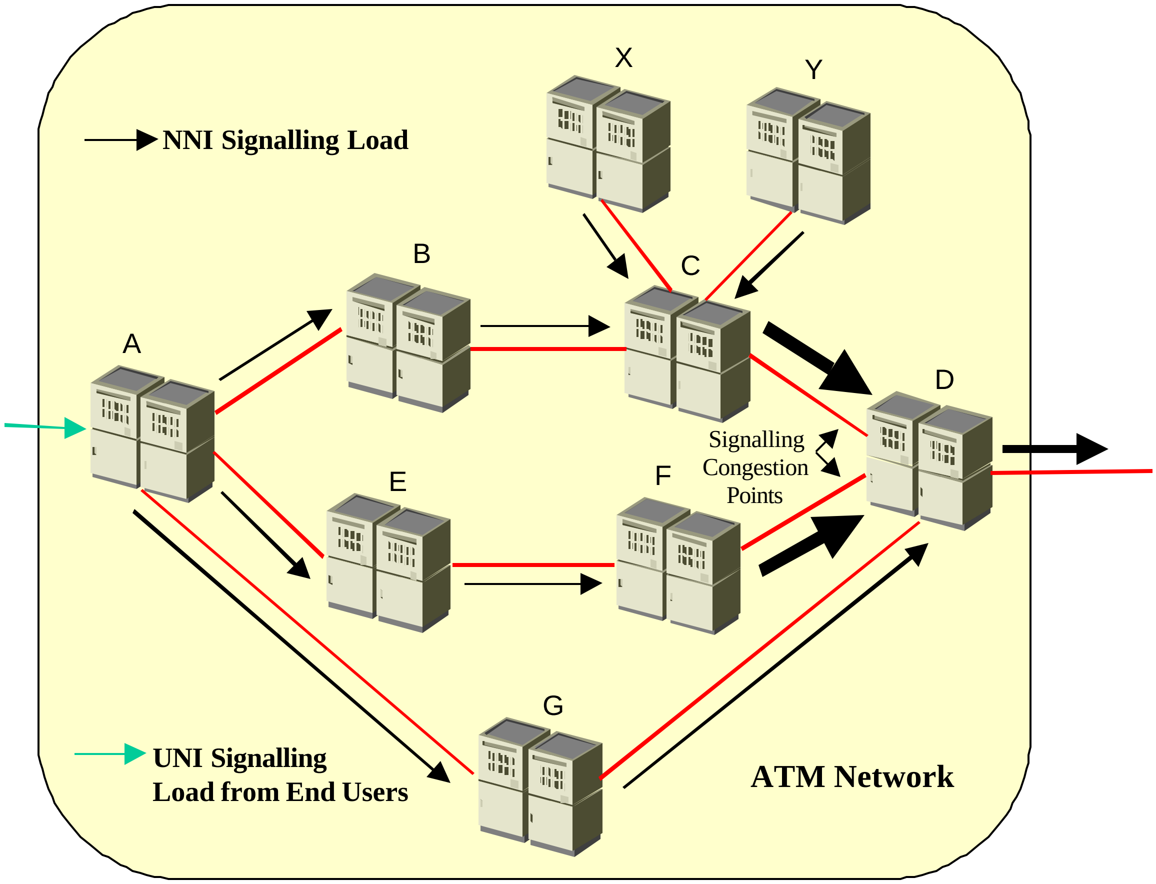


Figure 1-1 Signaling Congestion within a Network

In this scenario, Node A is capable of processing 2000 calls per second. It is being presented with a sustained offered load of 1000 calls per second directed to Node D. The preferred path (A,B,C,D) has a signalling bottleneck between Node C and Node D of 200 calls per second. A second signalling bottleneck exists on link F-D with a capacity of 400 calls per second.

Assuming the link from Node C to Node D is only capable of 200 calls per second, in the absence of the procedures defined in this addendum, the behavior of the system could be as follows:

- The call load of 1000 calls per second arriving at Node A is directed by Node A toward link C-D which is only capable of 200 calls per second.

- Since there is finite queueing capacity at Node C, it will eventually not be able to queue all arriving calls. At this point, Node C will either discard SETUP messages for link C-D, or it may send RELEASE messages in response - PNNI 1.1 provides no guidance on this subject.

- Either way, calls will eventually be released back to the source and, if they are re-attempted, they are likely to be routed along the same (A,B,C,D) path, thereby increasing network congestion.

In effect, the network's goodput call rate in this case is limited by the smallest capacity element along the preferred path. This behavior results in lengthy call setup delays and is wasteful of network resources since other paths such as A,E,F,D and A,G,D exist and could potentially be used to establish calls.

The Signalling Congestion Control feature dramatically increases network efficiency during such periods of signalling congestion, helps to decrease call setup latency and protects congested equipment from undue overload. The remainder of this section provides an overview of how the network will behave if the nodes implement Signalling Congestion Control as defined in this specification.

As signalling congestion occurs on link C-D, Node C begins to crankback calls indicating signalling congestion on link C-D. The DTL originator (Node A) then initiates a control mechanism to adaptively restrict the offered call load to link C-D. Since Node A does not know the call capacity of link C-D, it must dynamically infer this rate using the signalling congestion crankbacks it receives as feedback. The combined behavior of Node A and Node C results in a feedback control mechanism.

As the stream of new calls destined for Node D is received at Node A, the actual stream sent by Node A to link C-D is "thinned" by Node A in an adaptive manner in order to converge to a steady state rate that is slightly above the call capacity of link C-D. In this case, the thinned rate would be slightly higher than 200 calls per second. The thinned rate must exceed the call capacity of the congestion point in order for Node A to continue to receive some level of signalling congestion crankbacks as feedback and adapt its restriction level to meet the (changing) capacity of the congestion point. The goal is to maximize the use of the congested resource while minimizing the number of crankbacks due to signalling congestion from the congested resource.

Assume a new source of calls from Node X destined for Node D becomes active. Node A will begin receiving a higher rate of crankbacks indicating signalling congestion (due to the new calls from Node X) and will dynamically decrease the call rate offered to link C-D. This allows calls from Node X to also be admitted through the link. Likewise Node X will receive signalling congestion crankbacks and will control the rate of calls it directs toward link C-D.

As Node A applies rate control restrictions in directing new calls over link C-D, the call load arriving at Node A in excess of the restriction level is routed around the congestion point by Node A. In this example, assuming Node A had settled on a restriction level of 110 calls per second toward link C-D, the excess calls (1000 - 110 = 890 calls per second) will be initially routed along the second best path, namely (A,E,F,D).

Assume further that link F-D is capable of 400 calls per second. Crankbacks indicating signalling congestion for link F-D will begin to be received at Node A which will reduce the offered load from 890 calls per second to slightly more than the 400 calls per second capacity of link F-D. The remainder of the call load will be directed along the next best path A,G,D.

The routing behavior mandated by this specification is that the call rate directed toward signalling congestion points be adaptively and fairly "thinned" to the capacity of the congestion point. Specific actions to be performed on the arriving call load that is in excess of the restriction level are not mandated by this specification.

As a result, the functionality of this Addendum allows the full 1000 calls per second arriving at Node A to be accommodated by the network using multiple parallel paths, thereby decreasing call setup latency, increasing call completion likelihood and protecting congested network elements from undue signalling load.

### 1.4.2 Controlling Signalling Congestion at DTL Terminator – Single Homed User

Figure 1-2 depicts a sample network topology where signalling congestion occurs at the DTL terminator. This condition can arise when there is high demand for a particular destination or called party due to, for example, radio station like “phone ins” or a Video on Demand (VoD) Service Provider announcing that a popular movie/re-run of a TV program is now available to view on line.

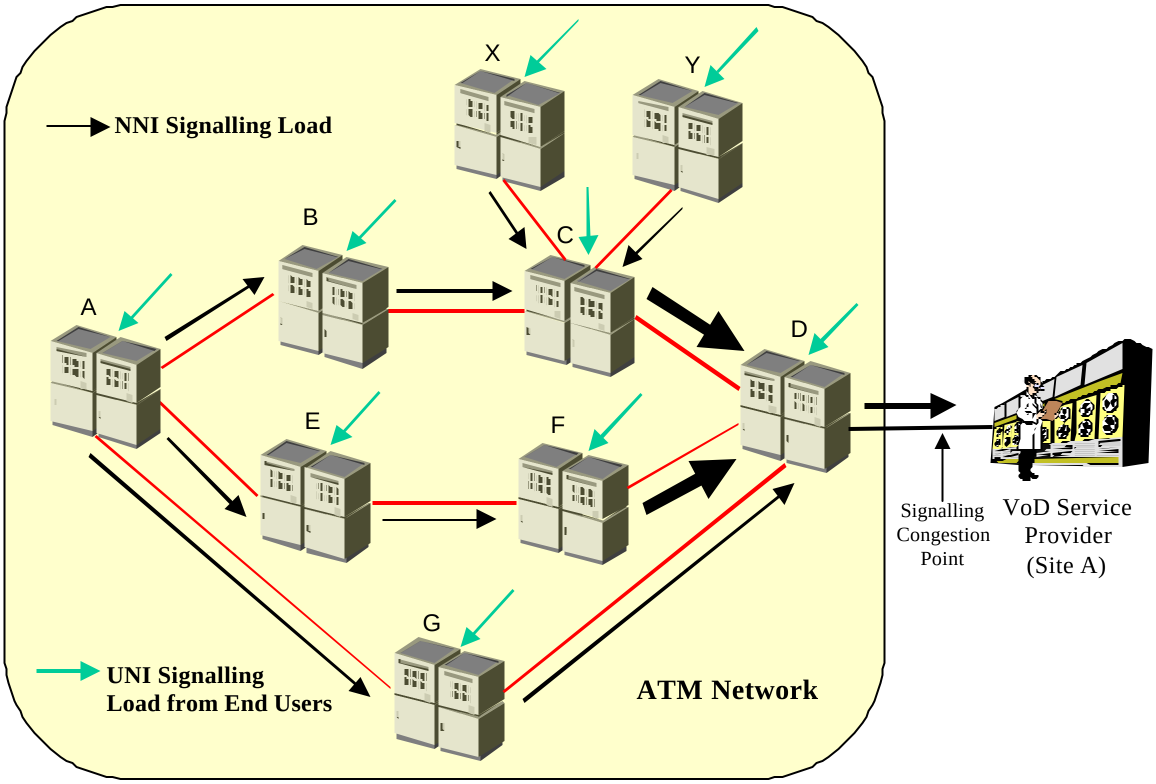


Figure 1-2 Signalling Congestion at a DTL Terminator

In this scenario, end users connected to all switches in Figure 1-2 want to contact the VoD Service Provider that is connected to Node D. The sustained calling rates that arrive at Node D from nodes C, F and G are assumed to be 200, 400 and 250 calls per second respectively and lie within the engineered capacity of links C-D, F-D and G-D and nodes C, F, G and D. It is also assumed that no signalling congestion exists within nodes or links further back towards the DTL originators, i.e. in nodes A, B, E, X or Y or in links A-B, A-E, A-G, B-C, E-F, X-C or Y-C. If congestion did occur anywhere in the network prior to Node D, the offered signalling load would be effectively thinned down to just above the engineered capacity of the nodes or links where the signalling congestion occurs as described in s 1.4.1.

Assuming the link from Node D to the VoD Service Provider is only capable of 100 calls per second in the absence of the procedures defined in this addendum, the behavior of the system could be as follows:

- The call load of 850 calls per second arriving at Node D is directed by Node D toward the VoD Service Provider (with the link from Node D to the VoD Service Provider only being capable of 100 calls per second).
- Since there is finite queueing capacity at Node D, it will eventually not be able to queue all arriving calls for the VoD Service Provider. At this point, Node D will either discard SETUP messages for the UNI link to the VoD Service Provider or it may send RELEASE messages in response - PNNI 1.1 provides no guidance on this subject.
- Either way, calls will eventually be released back to the respective DTL originators and hence end users. If end users re-attempt any rejected calls, they are likely to be routed along the same path to Node D thereby increasing or sustaining the load on Node D and on the link to the VoD Service Provider. Furthermore, the available call processing capacity for other Service Providers or Customers connected to Node D will decrease unnecessarily as Node D processes calls destined for the VoD Service provider in excess of the capacity of the link to that provider.

The Signalling Congestion Control feature increases network efficiency and call completion rates during periods of heavy demand. Call setup latency is reduced and Node D's call processing resources can be freed up to complete calls to other customers connected to Node D, instead of being tied up rejecting calls to a Service Provider which arrive at a rate above what the Service Provider can handle. The remainder of this section provides an overview of how the network will behave if the nodes implement Signalling Congestion Control as defined in this specification.

As signalling congestion occurs at the link between Node D and the VoD Service Provider, Node D begins to crankback calls indicating signalling congestion at the VoD Service Provider's UNI. The DTL originators (Nodes A, B, C, E, F, G, X and Y) then initiate a control mechanism to adaptively restrict the offered call load to the VoD Service Provider.

As calls from end users are received at Nodes A, B, C, E, F, G, X and Y destined for the VoD Service Provider at Node D, the actual call rate sent by each node to the VoD Service Provider is "thinned" in an adaptive and fair manner in order to converge to a steady state aggregate rate that is slightly above the call capacity of the link to the VoD Service Provider. In this case, the aggregate thinned rate would be slightly higher than 100 calls per second. The aggregate thinned rate must exceed the call capacity of the link to the VoD Service Provider in order for each node to continue to receive some level of signalling congestion crankbacks as feedback and adapt its restriction level to meet the (changing) offered load and capacity of VoD Service Provider.

In addition, calls from users local to node D destined for the VoD Service Provider will be thinned by node D when the link to the VoD Service Provider experiences signalling congestion. This is done in order to ensure that Node D shares in a fair manner the call processing capacity of the VoD Service Provider between calls originating from directly connected end users and calls originating at other nodes within the network.

### 1.4.3 Controlling Signalling Congestion at DTL Terminator – Multi Homed User

Figure 1-3 depicts a multi-homed subscriber, the VoD Service Provider, homed off Node D and Node Y.

Assuming the link from Node D to the VoD Service Provider is only capable of 100 calls per second, in the absence of the procedures defined in this addendum, the behavior of the system could be as follows:

- The call load of 850 calls per second arriving at Node D is directed by Node D toward the VoD Service Provider (with the link from Node D to the VoD Service Provider only being capable of 100 calls per second).
- Since there is finite queueing capacity at Node D, it will eventually not be able to queue all arriving calls for the VoD Service Provider. At this point, Node D will either discard SETUP messages for the UNI link to the VoD Service Provider or it may send RELEASE messages in response - PNNI 1.1 provides no guidance on this subject.
- Either way, calls will eventually be released back to the respective DTL originators and hence end users. If end users re-attempt any rejected calls, they are likely to be routed along the same path to Node D thereby increasing or sustaining the load on Node D and on the link to the VoD Service Provider. The available call processing capacity for other Service Providers or Customers connected to Node D will decrease unnecessarily as Node D processes calls destined for the VoD Service Provider in excess of the capacity of the link to that provider. Furthermore, calls that fail at the interface from Node D to the VoD Service Provider may not be alternate routed to Node Y. In this case, having dual homing of the VoD Service Provider has not helped increase call completion rates.

DTL originators implementing the procedures defined in this addendum can route new calls in an adaptive manner to the multiple access points. Each UNI access point can be kept at its maximum signalling capacity while reducing (wasted) signalling traffic within the network. The remainder of this section provides an overview of how the network will behave if the nodes implement Signalling Congestion Control as defined in this specification.

In this example, calls for the VoD Service Provider that arrive at DTL originators (Nodes A, B, C, E, F, G, Y and X) are thinned by the DTL originators to a rate slightly higher than can be handled by the link from Node D to the VoD Service Provider. Calls in excess of this thinned rate are then directly routed to Node Y since the DTL originators know that the link from Node D to the VoD Service Provider is experiencing signalling congestion. In addition, any calls cranked back by Node D to the DTL originators (as the aggregate offered load to the link from Node D to the VoD Service Provider needs to be slightly higher than 100 calls/s) can be re-routed by DTL originators to Node Y. If the demand from end users continues to increase for the VoD Service Provider above 200 calls per second, further signalling congestion could occur at Node Y (assuming that its link to the VoD Service Provider can only handle 100 calls per second). If this happens, Node Y would then start to crankback calls indicating congestion to the VoD Service Provider. The DTL originators would then also automatically "thin" the offered load to the link from Node Y to the VoD Service Provider to around 100 calls per second.

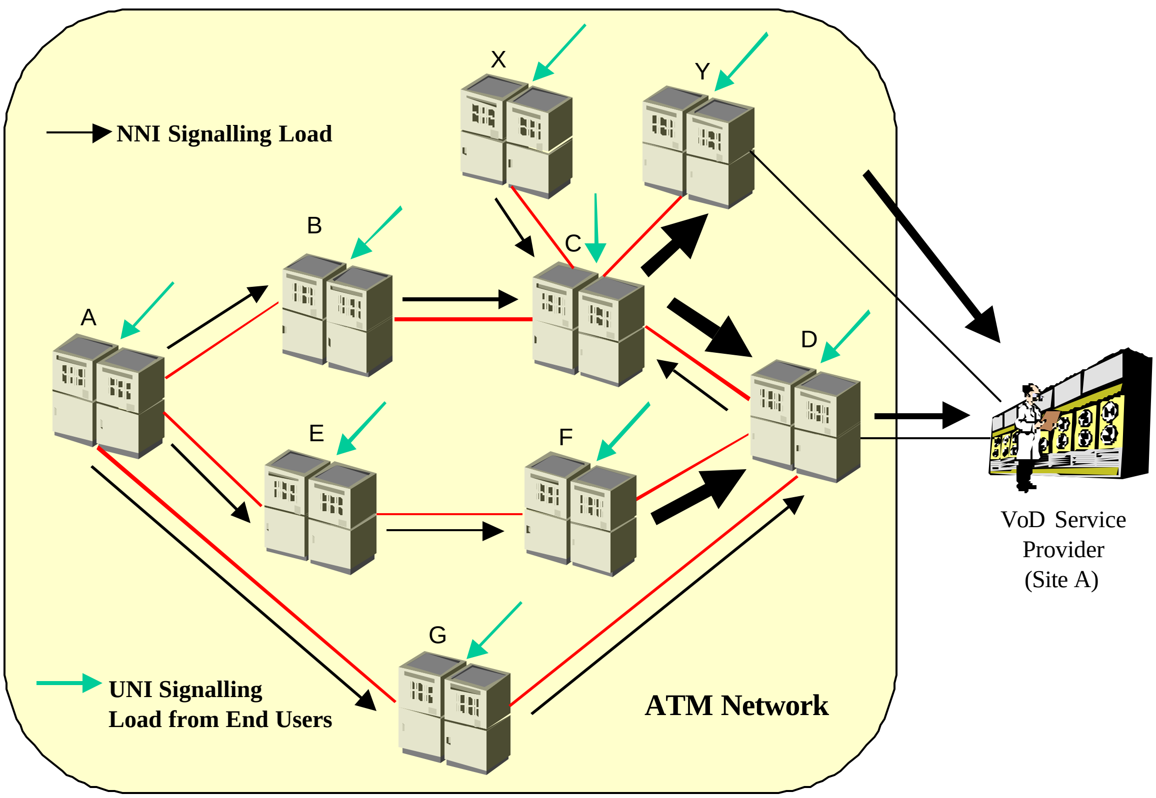


Figure 1-3 Signalling Congestion Behaviour with Multi-homed UNIs

# 2 Terminology

## [NORMATIVE]

### 2.1 Acronyms

| | |
|---|---|
| AINI | ATM Inter-Network Interface |
| ATM | Asynchronous Transfer Mode |
| DTL | Designated Transit List |
| IUT | Implementation Under Test |
| PICS | Protocol Implementation Conformance Statement |
| PNNI | Private Network-Network Interface |
| Soft PVC | Soft Permanent Virtual Connection |
| SUT | System Under Test |
| SVC | Switched Virtual Connection |
| UNI | User-Network Interface |

### 2.2 Definitions

| | |
|---|---|
| Signalling Congestion | A condition characterized by insufficient control plane resources to process the offered signalling and call processing load in a timely manner. This includes signalling link transmission bandwidth, internal switch message queues, CPU realtime, memory resources, etc. Signalling congestion specifically does not address the issue of insufficient user plane resources to accept new calls. |
| Restrictor | A Restrictor is a mechanism for reducing the aggregate rate at which calls are routed from a node to a congested resource. |

# 3 Information Element Coding

## [Normative]

When a device supporting UNI Signalling 4.0, PNNI 1.0 or AINI implements the functionality defined in this addendum as if it were an optional addendum to those specifications, the following extension shall apply.

*Add the following cause value from Q.850 [4] to the Cause information element in Section 2 §4.5.15/Q.2931 of UNI Signalling Specification 4.0:*

| Bits<br>8 7 6 5 4 3 2 1 | Number | Meaning | Diagnostics |
|---|---|---|---|
| 0 0 1 0 1 0 1 0 | 42 | Switching Equipment Congestion | |

Note - These changes are not necessary when this specification is considered as an addendum to UNI Signalling 4.1 or PNNI 1.1 because Section 2 §4.5.15/Q.2931 of UNI Signalling 4.1 references the latest version of ITU-T Recommendation Q.2610 which itself points to the latest version of ITU-T Recommendation Q.850. As a result, this extension is implicitly already covered in UNI Signalling 4.1 and PNNI 1.1.

# 4 UNI Support of Signalling Congestion Control

## [Normative]

No changes are required to UNI signaling procedures.

# 5 PNNI Support of Signalling Congestion Control

**[Normative]**

## 5.1 Additions to PNNI Signalling Messages

No changes are required to existing PNNI signalling messages.

## 5.2 Additions to PNNI Information Elements

*Add the following Crankback cause value from Q.850 [4] to the Crankback information element in Section 6.4.6.3/PNNI 1.1:*

| Bits<br>8 7 6 5 4 3 2 1 | Number | Meaning | Diagnostics |
|---|---|---|---|
| 0 0 1 0 1 0 1 0 | 42 | Switching Equipment Congestion | Note 3 |

Note 3 - The following coding is used:

| 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Octet |
|---|---|---|---|---|---|---|---|---|
| Congested called party number address prefix length | | | | | | | | 7.1* |

Congested called party number address prefix length (octet 7.1)

Defines the number of bits of the called party number address of the associated call or party that are to be used to create an address prefix. This diagnostic may optionally be included only when the blocked transit type is "blocked link" and the Blocked link's succeeding node identifier is set to all zeroes. Refer to section 5.3, §8.6/PNNI 1.1 for further details.

The address prefix composed of the high order Congested called party number address prefix length bits of the called party address together with the Blocked link's preceding node identifier identify a topological entity which is experiencing signalling congestion.

## 5.3 Signalling Procedures For PNNI Signalling Congestion Control

This section describes the procedures used for generating, interpreting and modifying crankback information when signalling congestion is detected by a node. These procedures are in addition to the procedures of Section 8/PNNI 1.1.

**8.1/PNNI 1.1 Scope of Crankback Procedures:**

*Modify the fourth paragraph as follows:*

The cases where crankback is used in PNNI fall into ~~three~~ four categories:

Reachability errors
Resource errors
DTL processing errors
Signalling Congestion errors

*Add the following subsection to Section 8.2/PNNI 1.1 Crankback Cause*

**8.2.4/PNNI 1.1 Signalling Congestion Errors**

Various signalling and call processing resources are required to support the establishment of a new call or party when processing a SETUP or ADD PARTY message. Signalling Congestion Errors are used to indicate that signalling congestion encountered along the path of a SETUP or ADD PARTY message has prevented the establishment of the call or party.

Inability to establish a call or party due to signalling congestion can occur because of a lack of resources internal to a node such as queuing resources, memory and CPU realtime. Mechanisms to detect signalling congestion internal to a node are implementation specific.

In addition, congestion can be detected at the preceding side of a signalling link. Congestion can occur on a signalling link for several reasons, including:

- the call rate capacity of the sending node is greater than that of the receiving node,
- the receiver proactively closes the Layer 2 window, and
- the SCR on the signalling link is too low for the offered load.

In such cases, the queue of Layer 2 sequenced data PDUs to be transmitted on that signalling link will grow. Nodes shall monitor the length of this transmission queue and detect the condition where the queue has grown sufficiently long that it is expected that newly-enqueued Layer 3 SETUP or ADD PARTY messages will not be transmitted in a timely manner. This condition indicates signalling link congestion. Mechanisms to detect this signalling link congestion are implementation specific.

If a node detects that signalling congestion will prevent the timely establishment of a call or party, the call or party shall be cranked back with cause and crankback cause #42, "Switching Equipment Congestion". When blocking due to signalling congestion occurs, it must be determined whether blocking was due to insufficient resources at the succeeding end of the previous link (calls on other ports might be accepted), insufficient resources at the preceding end of the following link (calls on other ports might be accepted), or insufficient resources within the node itself (all calls to this node are likely to be blocked). Depending on the answer, the procedures in Section 8.3.1.3/PNNI 1.1, 8.3.1.2/PNNI 1.1, or 8.3.1.1/PNNI 1.1, respectively, shall apply.

**8.3/PNNI 1.1 Procedures for Crankback Level and Blocked Transit**

*Add the following sentence to the end of the second paragraph:*

In addition, if the crankback cause is #42 "Switching Equipment Congestion", then the blocked node or link may need to be avoided for newly arriving calls or parties. Refer to Section 8.3.2.2.3/PNNI 1.1.

**8.3.1.1/PNNI 1.1 Blocking at a node**

*Add the following paragraph in front of the first paragraph of this section:*

Node blocking can be determined when connection admission control (CAC) within the node determines that insufficient node resources are available or when signalling congestion is detected which prevents the timely establishment of a connection at a node level.

**8.3.1.2/PNNI 1.1 Blocking at the preceding end of a link**

*Modify the first sentence of the first paragraph as follows:*

Link blocking can be determined at the preceding end of a link when connection admission control (CAC) within the node at the preceding end of the link determines that insufficient resources are available or when signalling congestion is detected which prevents the timely establishment of a connection at the preceding end of the link.

*Add the following to the end of the last paragraph:*

In the case where signalling congestion is detected at the DTL terminator, the procedures of section 8.6/PNNI 1.1 Carrying Signalling Congestion Diagnostics in Crankback information element shall also apply.

**8.3.1.3/PNNI 1.1 Blocking at the succeeding end of a link**

*Modify the first sentence of the first paragraph as follows:*

Link blocking can be determined at the succeeding end of a link when CAC within the node at the succeeding end of the link determines that insufficient resources are available or when signalling congestion is detected which prevents the timely establishment of a connection at the succeeding end of the link.

**8.3.2.2.2/PNNI 1.1 Crankback to next higher level**

*Add the following paragraph to the end of section 8.3.2.2.2/PNNI 1.1 Crankback to next higher level*

If signalling congestion was detected in the first attempt to route the call across the peer group, either as a result of local path selection (where a Restrictor rejected admission of this call as described in section 8.3.2.2.3/PNNI 1.1 "Routing considerations in the presence of signalling congestion") or as a result of receiving a crankback with crankback cause #42, "Switching Equipment Congestion", then it is recommended that cause and crankback cause #42, " Switching Equipment Congestion" be returned toward the calling party. If a Congested called party number address prefix length field was included in the received crankback, then this value shall be included in the crankback sent toward the calling party.

*Add the following section after section 8.3.2.2.2/PNNI 1.1 Crankback to next higher level*

**8.3.2.2.3/PNNI 1.1 Routing considerations in the presence of signalling congestion**

This section applies when a crankback is received with crankback cause #42 "Switching Equipment Congestion" and when routing new calls in a network that is experiencing signalling congestion.

In most cases, when a crankback is received, the information in the crankback is used to influence alternate routing of the particular call being cranked back as described in Section 8.3.2.2.1/PNNI 1.1. In addition to this, when a crankback is received with crankback cause #42, "Switching Equipment Congestion", the location of call blocking shall be used to influence path selection for other newly arriving calls. The call routing algorithm shall attempt to maximize use of the congested resource while minimizing the number of crankbacks due to signalling congestion from the congested resource. Ideally, the algorithm implemented should satisfy the properties of a "good" solution as outlined in Appendix I. Since many algorithms exist which satisfy these requirements, no specific algorithm is mandated by this specification. However, in order to provide consistent behavior in a multi-vendor network and also satisfy the properties of a "good" solution, conformant algorithms shall satisfy the following requirements:

1. One instance of a Restrictor shall be created for each topological entity (node or link) experiencing signalling congestion. The topological entity is identified either by the blocked transit identifier field of the received Crankback information element with a crankback cause #42, "Switching Equipment Congestion" or, in the case of call blocking at the DTL terminator, as described in section 8.3.2.2.3.1/PNNI 1.1. If the maximum number of Restrictors has already been allocated, then the node should indicate to network management the failure to allocate another Restrictor.

2. When a Restrictor is first created, it shall initially restrict calls into the signalling congestion point at a rate of InitialMaximumCallAdmissionRate. InitialMaximumCallAdmissionRate shall be user-configurable. The actual admission rate will depend upon both the call arrival rate and the InitialMaximumCallAdmissionRate.

3. The Restrictor shall dynamically adjust its rate of admitted calls into the signalling congestion point being monitored in such a manner as to cause the rate of all calls cranked back from the signalling congestion point to this node to converge to a configurable value called TargetRejectRate. The TargetRejectRate is measured in units of calls per second for calls that are cranked back with crankback cause #42 "Switching Equipment Congestion".

4. A Restrictor instance shall be terminated only when the reject rate measured at the controlling node has been zero for sufficient time to indicate that congestion has abated. Implementations shall avoid premature termination of control and subsequent reactivation of it, at the initial (potentially low) InitialMaximumCallAdmissionRate for borderline overload events.

5. When a Restrictor rejects admission of a call through a particular topological entity, the path selection algorithm shall either find another path to the destination avoiding this topological entity, or crankback the call toward the calling party using cause and crankback cause #42 "Switching Equipment Congestion". If the call is cranked back and this Restrictor is associated with a Congested Address Prefix as described in section 8.3.2.2.3.1/PNNI 1.1, then the Congested called party number address prefix length in the crankback diagnostics shall be set to the prefix length of the Congested Address Prefix (see section 8.6/PNNI 1.1 for more information regarding the crankback diagnostics).

6. If a path is selected that contains multiple signalling congestion points, the Restrictor of each congestion point must admit the call in order for this path to be used to progress the call.

#### 8.3.2.2.3.1/PNNI 1.1 Receiving a Link Blocked Crankback from DTL Terminator

As described in section 8.3.1.2/PNNI 1.1 “Blocking at the preceding end of a link”, when a call blocks between the DTL terminator and the called party address, the blocked transit type of the Crankback information element is set to blocked link and the blocked transit identifier contains a valid Blocked link’s preceding node identifier value, a valid Blocked link’s port identifier value and a Blocked link’s succeeding node identifier set to all zeroes.

Upon receiving such a crankback, if the crankback cause is #42 "Switching Equipment Congestion" and if this node generated any DTLs for this call of equal or higher level than the crankback level, then the procedures of this section shall apply in addition to normal crankback procedures.

A Restrictor as described in Section 8.3.2.2.3/PNNI 1.1 shall be created for the topological entity defined by:

- the Blocked link’s preceding node identifier (from the received Crankback information element) and
- the Congested Address Prefix determined as follows:

- if the received Crankback information element contains a Congested called party number address prefix length field, then the Congested Address Prefix shall be set to the first Congested called party number address prefix length bits of the called party address for the call or party.

  Otherwise

- the Congested Address Prefix shall be set to the reachable address prefix, advertised by the node identified by the Blocked link's preceding node identifier, which was used as the routing target for this call or party.

If the destination node to which a call or party is to be routed has a Restrictor associated with a Congested Address Prefix that matches the Called party address, then this Restrictor shall be consulted to admit the call as described in section 8.3.2.2.3/PNNI 1.1. If more than one Congested Address Prefix matches the Called party address, then the Restrictor associated with the longest matching Congested Address Prefix shall be used.

This implies that the rate control provided by this Restrictor will limit the rate of calls offered to this Congested Address Prefix from the Blocked link's preceding node identifier.

*Add the following section:*

**8.6/PNNI 1.1 Carrying Signalling Congestion Diagnostics in Crankback information element**

When signalling congestion occurs at a DTL Terminator's interface to a called party, it is desirable that other nodes control the rate at which they offer calls to this DTL Terminator destined for the congested interface through which this called party is reachable. Conversely, it is desirable that this rate control not be applied to calls destined to other interfaces off this same DTL Terminator node, or that a separate control be applied if signalling congestion exists on those interfaces.

In most cases, the address prefix summarizing the addresses reachable over the (congested) interface to the called party will be longer (more precise) than the address prefix advertised by the DTL Terminator via PNNI to the rest of the peer group. It is even more likely that the address prefix summarizing the addresses reachable over the (congested) interface to the called party is longer (more precise) than the address prefix advertised by the parent LGN at higher levels of the hierarchy to nodes in other peer groups. Therefore, using the advertised prefix as the Congested Address Prefix as described in section 8.3.2.2.3.1/PNNI 1.1 could cause the rate control to be applied to more destination interfaces than it should.

To avoid this situation, the following procedures shall be followed.

When a call blocks due to signalling congestion at the DTL Terminator toward the called party, a link blocked crankback shall be generated with crankback cause #42 "Switching Equipment Congestion". The Congested called party number address prefix length field of the Crankback information element should be set to the prefix length to be applied to the called party address to form the longest (most precise) address prefix possible summarizing the addresses reachable over the (congested) interface to the called party. This address prefix is then used by DTL Originators and entry border nodes as described in section 8.3.2.2.3.1/PNNI 1.1 to rate control calls to this interface.

*Add the following variables to section 11/PNNI 1.1 Annex E: Architectural Variables*

InitialMaximumCallAdmissionRate: default value 100 calls per second.

> The initial maximum call rate that a Signalling Congestion Control Restrictor will offer to a signalling congestion point when the Restrictor is first created. After initial creation, the actual call rate that the Restrictor will allow into a signalling congestion point may increase or decrease in order to cause the rate of calls cranked back by the signalling congestion point to converge to the TargetRejectRate.

TargetRejectRate: default value 4 calls per second.

> The target rate of calls cranked back due to signalling congestion that a Restrictor is attempting to achieve. When the actual rate of calls cranked back due to signalling congestion exceeds this rate, the Restrictor's call admission rate is decreased. When the actual rate of calls cranked back due to signalling congestion falls below this rate, the Restrictor's call admission rate is increased.

## 5.4 Compatibility with nodes not supporting Signalling Congestion Control

## [Informative]

This specification introduces a new crankback cause codepoint to the existing Crankback information element. If an implementation that does not support this specification receives a Crankback information element with a crankback cause #42 "Switching Equipment Congestion", then its behavior will depend upon whether it performs validation of crankback cause values.

If the implementation validates crankback cause values, then it will perform the procedures for Non-mandatory information element content error. In this case, the Crankback information element will be discarded (changing the crankback into a release) and the call will be released back to its originator.

If the implementation does not validate crankback cause values, then it will perform normal crankback procedures as specified in section 8.3.2/PNNI 1.1 Receiving a clearing message with a Crankback information element. This crankback will not be used to influence the routing of newly-arriving calls. As such, new calls will be routed freely toward the point of signalling congestion, just to be cranked back and potentially alternatively routed.

In addition to relying on new codepoints within the Crankback information element, the Signalling Congestion Control scheme specified in this document defines two roles: the role of the node where congestion is occurring to provide information that other nodes can react to, and the role of nodes receiving congestion indications to thin their offered call load (section 5.3 §8.3.2.2.3/PNNI 1.1). With all traffic sources capable of providing and reacting to congestion indications, fairness between nodes competing for the resources of that congested entity will be achieved, where no node is “forced” to disproportionately thin its offered call load compared to other traffic sources.

It is worth pointing out that a traffic source that simply ignores the congestion indications and does not reduce the rate at which it forwards calls to the congested entity (i.e. a node which does not comply with this specification) affects the fairness of the Signalling Congestion Control scheme. When competing with such a “misbehaving” node, compliant nodes will have a tendency to disproportionately thin their offered call load.

However, benefits can still be achieved in case of partial deployment of this feature within the network. Compliant nodes will decrease the load on the congested entity and, in case of alternate routing possibilities, also provide better call setup performance of the immediately alternate routed calls, as they need not first be cranked back by the congested entity.

## 5.5 Feature Interactions with Transported Address Stack and AINI

## [Normative]

This section shall apply to nodes implementing this addendum as well as AINI [3] and PNNI Transported Address Stack, Version 1.0 [7].

### 5.5.1 Crankback from AINI to PNNI

When

- a call arrives at a DTL terminator and exits the PNNI network at an AINI and
- the called party number sent over the AINI is different than the called party number received over the PNNI (i.e. this node is a Transport Termination Point or a Transport Origination Point) and
- an AINI crankback indicating congestion is received by the DTL terminator and
- this AINI crankback contains a Congested called party number address prefix length field and
- the crankback is to be progressed backward toward the calling party,

then the Congested called party number address prefix length field from the received AINI crankback shall not be propagated backward into the PNNI network as indicated in section 6.3 §4.2.2.3.1/AINI. This is because the called party number used by the PNNI network is different than the one used in the network beyond the AINI link where signalling congestion really occurred.

In this case, the procedures of section 8.6/PNNI 1.1 Carrying Signalling Congestion Diagnostics in Crankback information element shall apply. The called party number to be used in setting the value of the Congested called party number address prefix length field of the Crankback information element is the called party number received in the original SETUP message before popping the transported address stack.

### 5.5.2 Crankback from PNNI to AINI

When

- the called party number sent over the PNNI is different than the called party number received over the AINI (i.e. this node is a Transport Termination Point or a Transport Origination Point) and
- a PNNI crankback indicating congestion is received by the DTL originator and
- this PNNI crankback contains a Congested called party number address prefix length field and
- the crankback is to be progressed backward toward the calling party,

then the Congested called party number address prefix length field from the received PNNI crankback shall not be propagated backward into the AINI network as indicated in section 6.3 §4.2.2.3.2/AINI.

## 5.6 Feature Interactions with Call Processing Priority

## [Normative]

This section shall apply to nodes implementing this addendum as well as Call Processing Priority Version 1.0 [9].

*Add the following new item to the end of section 5.3 §8.3.2.2.3/PNNI 1.1:*

7. A Restrictor should give preference to calls with higher Call Processing Priority level compared to calls with lower Call Processing Priority level when admitting them towards the signalling congestion point. This shall be done while still converging to the target reject rate for all calls cranked back from the congestion point, regardless of their Call Processing Priority level, as required by point 3 above.

# 6 AINI Support of Signalling Congestion Control

**[Normative]**

## 6.1 AINI Signalling

### 6.1.1 Additions to AINI Signalling Messages

The message coding defined in section 5.1 shall apply.

### 6.1.2 Additions to AINI Information Elements

The additions described in section 5.2 shall apply with the following change:

Significant Called Party Number Address Prefix Length (octets 7.1 to 7.2)

> Defines the number of bits of the called party number address of the associated call that are to be used to create an address prefix. This diagnostic may optionally be included only when the blocked transit type is "call or party has been blocked at or beyond the succeeding node" ~~"blocked link" and the Blocked link's succeeding node identifier is set to all zeroes. Refer to Annex B Section 8.5 for further details~~.

### 6.1.3 Signalling Procedures for AINI Signalling Congestion Control

This section describes the procedures used for generating, interpreting and modifying crankback information when signalling congestion is detected by a node. These procedures are in addition to the procedures of section 6 Annex A/AINI.

**6.1/AINI Scope of Crankback procedures**

*Modify the fourth paragraph as follows:*

The cases where crankback is used in AINI fall into ~~two~~ three categories:

1. Reachability errors
2. Resource errors
3. Signalling Congestion errors

*Add the following subsection to Section 6.2/AINI Crankback Cause*

**6.2.3/AINI Signalling Congestion Errors**

Section 8.2.4/PNNI 1.1 Signalling Congestion Errors, as created in this specification, shall apply with the following modifications:

*Modify the last sentence of the last paragraph of Section 8.2.4 as follows:*

Depending on the answer, the procedures in Section 6~~8~~.3.1.3/AINI, 6~~8~~.3.1.2/AINI, or 6~~8~~.3.1.1AINI, respectively, shall apply.

**6.3.1.1/AINI Blocking at a node**

*Add the following paragraph in front of the first paragraph of this section:*

Node blocking can be determined when connection admission control (CAC) within the node determines that insufficient node resources are available or when signalling congestion is detected which prevents the establishment of a connection at a node level.

**6.3.1.2/AINI Blocking at the preceding end of a link**

*Modify the first sentence of the first paragraph as follows:*

Link blocking can be determined at the preceding end of a link when connection admission control (CAC) within the node at the preceding end of the link determines that insufficient resources are available or when signalling congestion is detected which prevents the establishment of a connection at the preceding end of the link.

**6.3.1.3/AINI Blocking at the succeeding end of a link**

*Modify the first sentence of the first paragraph as follows:*

Link blocking can be determined at the succeeding end of a link when CAC within the node at the succeeding end of the link determines that insufficient resources are available or when signalling congestion is detected which prevents the establishment of a connection at the succeeding end of the link.

### 6.1.4 Compatibility with nodes not supporting Signalling Congestion Control [INFORMATIVE]

This specification introduces a new crankback cause codepoint to the existing Crankback information element.

If an implementation which does not support this specification receives a Crankback information element with a crankback cause #42 "Switching Equipment Congestion", then its behavior will depend upon whether it performs validation of crankback cause values.

If the implementation validates crankback cause values, then it will perform the procedures for Non-mandatory information element content error. In this case, the Crankback information element will be discarded (changing the crankback into a release) and the call will be released back to its originator.

If the implementation does not validate crankback cause values, then it will perform normal crankback procedures as specified in section 6.3.2/AINI Receiving a clearing message with a Crankback information element.

## 6.2 Interworking between AINI and B-ISUP

No changes are required to AINI [3].

## 6.3 Interworking between AINI and PNNI

*Modify the last row of the table in section 4.2.2.3.1/AINI as follows*

| | | |
|---|---|---|
| Crankback cause diagnostics | 7.1 etc. | If crankback cause is other than #42, then omitted<br><br>If crankback cause equals #42, then:<br><br>If the Congested called party number address prefix length field of the AINI Crankback information element is either not present or its value is less than the value computed using the procedures in section 8.6/PNNI 1.1, then the (more precise) value as computed in section 8.6/PNNI 1.1 shall be |

| | | |
|---|---|---|
| | | returned in the PNNI Crankback information element. Otherwise, the received Congested called party number address prefix length field shall be returned. |

*Modify the last row of the table in section 4.2.2.3.2/AINI as follows:*

| | | |
|---|---|---|
| Crankback cause diagnostics | 7.1 etc. | If crankback cause is other than #42, then omitted<br>If crankback cause equals #42, then<br>The Congested called party number address prefix length field of the PNNI Crankback information element if present, omitted otherwise |

# 7 References

[1] af-sig-0061.002, ATM User-Network Interface (UNI) Signalling Specification Version 4.1 (April, 2002)

[2] af-pnni-0055.002, Private Network-Network Interface Specification Version 1.1 (PNNI 1.1) (April, 2002)

[3] af-cs-0125.000, ATM Inter-Network Interface (AINI) Specification (July 1999).

[4] ITU-T Recommendation Q.850, Use of cause and location in the digital Subscriber Signalling System No. 1 and the Signalling System No. 7 ISDN user part (May 1998)

[5] af-pnni-0055.000, Private Network-Network Interface Specification Version 1.0 (PNNI 1.0) (April 1996)

[6] af-pnni-0081.000, PNNI v1.0 Errata and PICS (May 1997)

[7] af-cs-0115.000, PNNI Transported Address Stack, Version 1.0 (May 1999)

[8] af-cs-0061.000, ATM User-Network Interface (UNI) Signalling Specification, Version 4.0 (July 1996)

[9] af-cs-0182.000, Call Processing Priority Version 1.0, (April 2002)

# 8 Appendix I - Properties of a Good Solution

**[INFORMATIVE]**

This section is an informative appendix that discusses feedback control mechanisms. The intent of this section is to provide education and guidance to implementers on the types of decisions that must be made in designing a feedback control.

Many call processing congestion points can exist within a switch implementation and as such it is expected that many implementation-specific issues will need to be considered in order to support this addendum. The intent in listing the goals of a "good" solution is to promote a common view which implementers can use as a guide when making decisions in order to foster "good" system behavior.

The properties of a "good" signalling congestion control solution are:

1. The mechanism must rapidly and automatically limit the load offered to a point of congestion (node or signalling link) to a level that it can sustain without risk of collapse.

   Property 1 aims to keep congested resources busy without the danger of the signalling element failing.

2. The mechanism must not starve a node or signalling element of load.

   Property 2 aims to keep to a minimum the effect of this congested condition on new calls during overload. Call rejection or sub-optimal routing of new calls should be kept to a minimum.

3. The mechanism must maximize the successful call completion rate subject to points 1 and 2 above and ensure "acceptable" call completion latency.

   Property 3 clarifies that the "goodput" of call establishment is the optimization goal, not signalling message forwarding throughput. There is no point in forwarding signalling messages at high rates if in the end the rate of successful call completion is low. This particular goal is important since it leads to many "don't do" mechanisms such as silently dropping messages during overload, or queueing messages for a period that exceeds their useful life where a node will start to process a call after the upstream node has released it, for example.

4. The congestion control mechanism must not add to the level of signalling congestion.

5. The call admission rate updating process for the Restrictor needs to be able to make small changes to the maximum admission rate if the reject rate is close to the configured target reject rate. This is to ensure convergence to the steady-state. Also it needs to make progressively larger changes to the maximum admission rate as the reject rate departs further from the configured target reject rate. This is to respond rapidly to sudden changes (increases or decreases):

   a) Either to the call capacity at the congested node or

   b) To the offered calling rates from source nodes as they become active/inactive or as their demand load changes

Each of these properties should be achievable in all known application uses, for example SPVC reroutes, SVC call setup storms, etc.

# Annex A Protocol Implementation Conformance Statement (PICS) for the PNNI 1.1 Component of Signalling Congestion Control Version 1.0

## A.1 Introduction

To evaluate conformance of a particular implementation, it is necessary to have a statement of which capabilities and options have been implemented. Such a statement is called a Protocol Implementation Conformance Statement (PICS).

### A.1.1 Scope

This document provides the PICS proforma for the PNNI 1.1 component of the Signalling Congestion Control Version 1.0 defined in [1] in compliance with the relevant requirements, and in accordance with the relevant guidelines, given in ISO/IEC 9646-7. In most cases, statements contained in notes in the specification, which were intended as information, are not included in the PICS.

This document provides the PICS proforma for the PNNI 1.1 component of the Signalling Congestion Control Version 1.0 defined in [1] in compliance with the relevant requirements, and in accordance with the relevant guidelines, given in ISO/IEC 9646-7. In most cases, statements contained in notes in the specification, which were intended as information, are not included in the PICS.

### A.1.2 Normative References

[1] af-cs-0181.000, Signalling Congestion Control Version 1.0 (April, 2002)

[2] ISO/IEC 9646-1: 1994, Information technology – Open systems interconnection – Conformance testing methodology and framework – Part 1: General Concepts (See also ITU Recommendation X.290 (1995)).

[3] ISO/IEC 9646-7: 1995, Information technology – Open systems interconnection – Conformance testing methodology and framework – Part 7: Implementation Conformance Statements (See also ITU Recommendation X.296 (1995)).

[4] ISO/IEC 9646-3:1998, Information technology – Open systems interconnection – Conformance testing methodology and interconnection – Part 3: The Tree and Tabular Combined Notation (TTCN) (See also ITU telecommunication X.292 (1998)).

### A.1.3 Definitions

Terms defined in [1]

Terms defined in ISO/IEC 9646-1 and in ISO/IEC 9646-7

In particular, the following terms defined in ISO/IEC 9646-1 apply:

**Protocol Implementation Conformance Statement (PICS):** A statement made by the supplier of an implementation or system, stating which capabilities have been implemented for a given protocol.

**PICS proforma:** A document, in the form of a questionnaire, designed by the protocol specifier or conformance test suite specifier, which when completed for an implementation or system becomes the PICS.

### A.1.4 Acronyms

ASN.1 Abstract Syntax Notation One

ATS Abstract Test Suite

IUT Implementation Under Test

PICS Protocol Implementation Conformance Statement

SUT System Under Test

### A.1.5 Conformance

The PICS does not modify any of the requirements detailed in Signalling Congestion Control Version 1.0. In case of apparent conflict between the statements in the base specification and in the annotations of “M” (mandatory) and “O” (optional) in the PICS, the text of the base specification takes precedence.

The supplier of a protocol implementation, which is claimed to conform to the PNNI 1.0 component of the ATM Forum Signalling Congestion Control Version 1.0, is required to complete a copy of the PICS proforma provided in this document and is required to provide the information necessary to identify both the supplier and the implementation.

## A.2 Identification of the Implementation

Identification of the Implementation Under Test (IUT) and system in which it resides (the System Under Test (SUT)) should be filled in so as to provide as much detail as possible regarding version numbers and configuration options.

The product supplier information and client information should both be filled in if they are different.

A person who can answer queries regarding information supplied in the PICS should be named as the contact person.

### A.2.1 Date of Statement

### A.2.2 Implementation Under Test (IUT) Identification

**IUT Name:** ____________________________________________________________________________

______________________________________________________________________________________

______________________________________________________________________________________

**IUT Version:** __________________________________________________________________________

### A.2.3 System Under Test (SUT) Identification

**SUT Name:** ____________________________________________________________________________

______________________________________________________________________________________

**Hardware Configuration:** _________________________________________________________________

______________________________________________________________________________________

______________________________________________________________________________________

**Operating System:** ______________________________________________________________________

### A.2.4 Product Supplier

**Name:** ________________________________________________________________________________

**Address:** ______________________________________________________________________________

______________________________________________________________________________________

______________________________________________________________________________________

**Telephone Number:** ____________________________________________________________

**Facsimile Number:** ____________________________________________________________

**Email Address:** ____________________________________________________________

**Additional Information:** ____________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

### A.2.5 Client

**Name:** ____________________________________________________________

**Address:** ____________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

**Telephone Number:** ____________________________________________________________

**Facsimile Number:** ____________________________________________________________

**Email Address:** ____________________________________________________________

**Additional Information:** ____________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

### A.2.6 PICS Contact Person

(A person to contact if there are any queries concerning the content of the PICS)

**Name:** ______________________________________________________________________________

**Telephone Number:** ______________________________________________________________________

**Facsimile Number:** ______________________________________________________________________

**Email Address:** ________________________________________________________________________

**Additional Information:** __________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

### Identification of the Protocol Specification

This PICS proforma applies to the following specification:

[1] af-cs-0181.000, Signalling Congestion Control Version 1.0 (April, 2002)

## A.3 PICS Proforma

### A.3.1 Global statement of conformance

The implementation described in this PICS meets all of the mandatory requirements of the reference protocol.

[ ] YES

[ ] NO

Note: Answering "No" indicates non-conformance to the specified protocol. Non-supported mandatory capabilities are to be identified in the following tables, with an explanation by the implementor explaining why the implementation is non-conforming.

### A.3.2 Instructions for Completing the PICS Proforma

The PICS Proforma is a fixed-format questionnaire. Answers to the questionnaire should be provided in the rightmost columns, either by simply indicating a restricted choice (such as Yes or No), or by entering a value or a set of range of values.

The following notations, defined in ISO/IEC 9647-7, are used for the support column:

Yes supported by the implementation

No not supported by the implementation

The following notations, defined in ISO/IEC 9647-7, are used for the status column:

M mandatory – the capability is required to be supported.

O optional – the capability may be supported or not.

O.i qualified optional – for mutually exclusive or selectable options from a set. “i” is an integer which identifies a unique group of related optional items and the logic of their selection is defined immediately following the table.

A supplier may also provide additional information, categorised as exceptional or supplementary information. These additional information should be provided as items labeled X<i> for exceptional information, or S.<i> for supplemental information, respectively, for cross reference purposes, where <i> is any unambiguous identification for the item. The exception and supplementary information are not mandatory and the PICS is complete without such information. The presence of optional supplementary or exception information should not affect test execution, and will in no way affect interoperability verification. The column labeled ‘Reference’ gives a pointer to sections of the protocol specification for which the PICS Proforma is being written.

## A.4 PICS for the support of Signalling Congestion Control at the PNNI interface

### A.4.1 Major Capability at PNNI interface (MCP)

| Item Number | Item Description | Status | Condition for status | Reference | Support |
|---|---|---|---|---|---|
| MCP1 | Does the IUT support the signalling congestion control feature at the PNNI interface? | M | | | Yes__ No__ |
| Comments: | | | | | |

### A.4.2 Subsidiary Capabilities at PNNI interface (SCP)

| Item Number | Item Description | Status | Condition for status | Reference | Support |
|---|---|---|---|---|---|
| SCP1 | Does the IUT support signalling congestion control for the establishment of point-to-point calls/connections? | M | | | Yes__ No__ |
| SCP2 | Does the IUT support signalling congestion control for the establishment of point-to-multipoint calls/connections? | M | | 1.1 | Yes__ No__ |
| SCP3 | Is the IUT capable of acting as an entry border node? | O | | PNNI/1.1 Annex G | Yes__ No__ |
| Comments: | | | | | |

### A.4.3 Information Element Encoding at PNNI (IEEP)

| Item Number | Item Description | Status | Condition for status | Reference | Support |
|---|---|---|---|---|---|
| IEEP1 | Does the IUT support cause #42 “Switching Equipment Congestion” for the Cause information element? | M | | 3 | Yes__ No__ |
| IEEP2 | Does the IUT support crankback cause #42 “Switching Equipment Congestion” for the Crankback information element? | M | | 5.2 | Yes__ No__ |
| Comments: | | | | | |

### A.4.4 Signalling Procedures at the PNNI interface (SPP)

| Item Number | Item Description | Status | Condition for status | Reference | Support |
|---|---|---|---|---|---|
| SPP1 | Does the IUT apply the crankback procedure when a SETUP or ADD PARTY message is received and the call/connection cannot be progressed due to signalling congestion errors? | M | | 5.3 | Yes__ No__ |
| SPP2 | Does the IUT crank back a call/party with Cause and Crankback information element cause value #42 “Switching Equipment Congestion”, when signalling congestion is encountered which prevents the timely establishment of the call/party? | M | SCP1, SCP2 | 5.3 | Yes__ No__ |
| SPP3 | Does the IUT apply the procedure in section 8.3.1.1/PNNI 1.1 “Blocking at a node”, when signalling congestion is detected within the node, which prevents the establishment of a connection/party at a node level ? | M | SCP1,SCP2 | 5.3 | Yes__ No__ |
| SPP4 | Does the IUT apply the procedures in section 8.3.1.2/PNNI 1.1 “Blocking at the preceding end of a link”, when signalling congestion is detected at the preceding end of the link, which prevents the establishment of a connection/party? | M | SCP1,SCP2 | 5.3 | Yes__ No__ |
| SPP5 | Does the IUT apply the procedures in section 8.3.1.3/PNNI 1.1 “Blocking at the succeeding end of a link”, when signalling congestion is detected at the | M | SCP1,SCP2 | 5.3 | Yes__ No__ |

| Item Number | Item Description | Status | Condition for status | Reference | Support |
|---|---|---|---|---|---|
| | succeeding end of the link, which prevents the establishment of a connection/party? | | | | |
| SPP6 | If a crankback is received with crankback cause #42 “Switching Equipment Congestion” and if alternate routing is attempted, does the IUT, when acting as the DTL originator, use the information in the crankback to influence alternate routing of the particular call/party being cranked back, as described in section 8.3.2.2.1/PNNI 1.1? | M | SCP1,SCP2 | 5.3 | Yes__ No__ |
| SPP7 | If a crankback is received with crankback cause #42 “Switching Equipment Congestion”, does the IUT, when acting as the DTL originator, use the location of call blocking to influence path selection for other newly arriving calls? | M | SCP1,SCP2 | 5.3 | Yes__ No__ |
| SPP8 | If a crankback is received with crankback cause #42 “Switching Equipment Congestion” and if alternate routing is attempted, does the IUT, when acting as an entry border node, use the information in the crankback to influence alternate routing of the particular call/party being cranked back, as described in section 8.3.2.2.1/PNNI 1.1? | M | SCP1,SCP2, SCP3 | 5.3 | Yes__ No__ |
| SPP9 | If a crankback is received with crankback cause #42 “Switching Equipment Congestion”, does the IUT, when acting as an entry border node, use the location of call blocking to influence path selection for other newly arriving calls? | M | SCP1,SCP2, SCP3 | 5.3 | Yes__ No__ |
| SPP10 | Is one instance of a Restrictor created for each topological entity (node or link) experiencing signalling congestion, where the topological entity is identified by the blocked transit identifier field of the received Crankback information element having a crankback cause #42 "Switching Equipment Congestion" or, in the case of call blocking at the DTL terminator, as described in section 8.3.2.2.3.1/PNNI 1.1? | M | SCP1,SCP2 | 5.3 | Yes__ No__ |

| Item Number | Item Description | Status | Condition for status | Reference | Support |
|---|---|---|---|---|---|
| SPP11 | When a Restrictor is first created, does it initially restrict calls into the signalling congestion point at a rate of InitialMaximumCallAdmissionRate? | M | SCP1,SCP2 | 5.3 | Yes__ No__ |
| SPP12 | Does the Restrictor dynamically adjust its rate of admitted calls into the signalling congestion point it is monitoring in such a manner as to cause the rate of calls cranked back from the signalling congestion point to converge to a configurable value called TargetRejectRate? | M | SCP1,SCP2 | 5.3 | Yes__ No__ |
| SPP13 | Is a Restrictor instance terminated only when the reject rate measured at the controlling node has been zero for sufficient time to indicate that congestion has abated. | M | SCP1,SCP2 | 5.3 | Yes__ No__ |
| SPP13 | When a Restrictor rejects admission of a call through a particular topological entity, does the path selection algorithm find another path to the destination avoiding this topological entity? | O.1 | SCP1,SCP2 | 5.3 | Yes__ No__ |
| SPP14 | When a Restrictor rejects admission of a call through a particular topological entity, does the path selection algorithm crankback the call further toward the calling party using cause and crankback cause #42 "Switching Equipment Congestion"? | O.1 | SCP1,SCP2 | 5.3 | Yes__ No__ |
| SPP15 | If a path is selected that contains multiple signalling congestion points, does the Restrictor of each congestion point admit the call in order for this path to be used to progress the call? | M | SCP1,SCP2 | 5.3 | Yes__ No__ |
| SPP16 | When a call blocks due to signalling congestion at the DTL Terminator toward the called party, is a link blocked crankback generated with crankback cause is #42 "Switching Equipment Congestion"? | M | SCP1,SCP2 | 5.3 | Yes__ No__ |
| SPP17 | When a call blocks due to signalling congestion at the DTL Terminator toward the called party, is a link blocked crankback generated containing a Significant Called Party Number Address Prefix Length field set to the prefix length to be applied to the called | O | SCP1,SCP2 | 5.3 | Yes__ No__ |

| Item Number | Item Description | Status | Condition for status | Reference | Support |
|---|---|---|---|---|---|
| | party address to form the longest (most precise) address prefix possible summarizing the addresses reachable over the (congested) interface to the called party? | | | | |

Comments:

O.1 The IUT must support at least one of these capabilities.

# Annex B Protocol Implementation Conformance Statement (PICS) for the AINI 1.0 Component of the Signalling Congestion Control Version 1.0

## B.1 Introduction

To evaluate conformance of a particular implementation, it is necessary to have a statement of which capabilities and options have been implemented. Such a statement is called a Protocol Implementation Conformance Statement (PICS).

### B.1.1 Scope

This document provides the PICS proforma for the AINI 1.0 component of the Signalling Congestion Control Version 1.0 defined in [1] in compliance with the relevant requirements, and in accordance with the relevant guidelines, given in ISO/IEC 9646-7. In most cases, statements contained in notes in the specification, which were intended as information, are not included in the PICS.

This document provides the PICS proforma for the AINI 1.0 component of the Signalling Congestion Control Version 1.0 defined in [1] in compliance with the relevant requirements, and in accordance with the relevant guidelines, given in ISO/IEC 9646-7. In most cases, statements contained in notes in the specification, which were intended as information, are not included in the PICS.

### B.1.2 Normative References

[1] af-cs-0181.000, Signalling Congestion Control Version 1.0 (April, 2002)

[2] ISO/IEC 9646-1: 1994, Information technology – Open systems interconnection – Conformance testing methodology and framework – Part 1: General Concepts (See also ITU Recommendation X.290 (1995)).

[3] ISO/IEC 9646-7: 1995, Information technology – Open systems interconnection – Conformance testing methodology and framework – Part 7: Implementation Conformance Statements (See also ITU Recommendation X.296 (1995)).

[4] ISO/IEC 9646-3:1998, Information technology – Open systems interconnection – Conformance testing methodology and interconnection – Part 3: The Tree and Tabular Combined Notation (TTCN) (See also ITU telecommunication X.292 (1998)).

### B.1.3 Definitions

Terms defined in [1]

Terms defined in ISO/IEC 9646-1 and in ISO/IEC 9646-7

In particular, the following terms defined in ISO/IEC 9646-1 apply:

**Protocol Implementation Conformance Statement (PICS):** A statement made by the supplier of an implementation or system, stating which capabilities have been implemented for a given protocol.

**PICS proforma:** A document, in the form of a questionnaire, designed by the protocol specifier or conformance test suite specifier, which when completed for an implementation or system becomes the PICS.

### B.1.4 Acronyms

| | |
|---|---|
| ASN.1 | Abstract Syntax Notation One |
| ATS | Abstract Test Suite |
| IUT | Implementation Under Test |
| PICS | Protocol Implementation Conformance Statement |
| SUT | System Under Test |

### B.1.5 Conformance

The PICS does not modify any of the requirements detailed in the Signalling Congestion Control Version 1.0. In case of apparent conflict between the statements in the base specification and in the annotations of "M" (mandatory) and "O" (optional) in the PICS, the text of the base specification takes precedence.

The supplier of a protocol implementation, which is claimed to conform to the AINI 1.0 component of the ATM Forum Signalling Congestion Control Version 1.0, is required to complete a copy of the PICS proforma provided in this document and is required to provide the information necessary to identify both the supplier and the implementation.

## B.2 Identification of the Implementation

Identification of the Implementation Under Test (IUT) and system in which it resides (the System Under Test (SUT)) should be filled in so as to provide as much detail as possible regarding version numbers and configuration options.

The product supplier information and client information should both be filled in if they are different.

A person who can answer queries regarding information supplied in the PICS should be named as the contact person.

### B.2.1 Date of Statement

### B.2.2 Implementation Under Test (IUT) Identification

**IUT Name:** ________________________________________________________________________________

________________________________________________________________________________

________________________________________________________________________________

**IUT Version:** ________________________________________________________________________________

### B.2.3 System Under Test (SUT) Identification

**SUT Name:**________________________________________________________________________________

________________________________________________________________________________

**Hardware Configuration:** ________________________________________________________________________________

________________________________________________________________________________

________________________________________________________________________________

**Operating System:** ________________________________________________________________________________

### B.2.4 Product Supplier

**Name:** ________________________________________________________________________________

**Address:** ________________________________________________________________________________

________________________________________________________________________________

________________________________________________________________________________

**Telephone Number:** ______________________________________________________________

**Facsimile Number:** ______________________________________________________________

**Email Address:** ______________________________________________________________

**Additional Information:** ______________________________________________________________

______________________________________________________________

______________________________________________________________

### B.2.5 Client

**Name:** ______________________________________________________________

**Address:** ______________________________________________________________

______________________________________________________________

______________________________________________________________

**Telephone Number:** ______________________________________________________________

**Facsimile Number:** ______________________________________________________________

**Email Address:** ______________________________________________________________

**Additional Information:** ______________________________________________________________

______________________________________________________________

### B.2.6 PICS Contact Person

(A person to contact if there are any queries concerning the content of the PICS)

**Name:** ______________________________________________________________

**Telephone Number:** ______________________________________________________

**Facsimile Number:** ______________________________________________________

**Email Address:** ________________________________________________________

**Additional Information:** __________________________________________________

______________________________________________________________________

______________________________________________________________________

### Identification of the Protocol Specification

This PICS proforma applies to the following specification:

[1] af-cs-0181.000, Signalling Congestion Control Version 1.0 (April, 2002)

## B.3 PICS Proforma

### B.3.1 Global statement of conformance

The implementation described in this PICS meets all of the mandatory requirements of the reference protocol.

[ ] YES

[ ] NO

Note: Answering "No" indicates non-conformance to the specified protocol. Non-supported mandatory capabilities are to be identified in the following tables, with an explanation by the implementor explaining why the implementation is non-conforming.

### B.3.2 Instructions for Completing the PICS Proforma

The PICS Proforma is a fixed-format questionnaire. Answers to the questionnaire should be provided in the rightmost columns, either by simply indicating a restricted choice (such as Yes or No), or by entering a value or a set of range of values.

The following notations, defined in ISO/IEC 9647-7, are used for the support column:

Yes supported by the implementation

No not supported by the implementation

The following notations, defined in ISO/IEC 9647-7, are used for the status column:

M mandatory – the capability is required to be supported.

O optional – the capability may be supported or not.

O.i qualified optional – for mutually exclusive or selectable options from a set. "i" is an integer which identifies a unique group of related optional items and the logic of their selection is defined immediately following the table.

A supplier may also provide additional information, categorised as exceptional or supplementary information. These additional information should be provided as items labeled X<i> for exceptional information, or S.<i> for supplemental information, respectively, for cross reference purposes, where <i> is any unambiguous identification for the item. The exception and supplementary information are not mandatory and the PICS is complete without such information. The presence of optional supplementary or exception information should not affect test execution, and will in no way affect interoperability verification. The column labeled 'Reference' gives a pointer to sections of the protocol specification for which the PICS Proforma is being written.

## B.4 PICS for the support of BCS at the AINI interface

### B.4.1 Major Capability at the AINI interface (MCA)

| Item Number | Item Description | Status | Condition for status | Reference | Support |
|---|---|---|---|---|---|
| MCA1 | Does the IUT support the signalling congestion control feature at the AINI interface? | M | | | Yes__ No__ |
| Comments: | | | | | |

### B.4.2 Subsidiary Capabilities at the AINI interface (SCA)

| Item Number | Item Description | Status | Condition for status | Reference | Support |
|---|---|---|---|---|---|
| SCA1 | Does the IUT support signalling congestion control for the establishment of point-to-point calls/connections? | M | | 1.1 | Yes__ No__ |
| SCA2 | Does the IUT support signalling congestion control for the establishment of point-to-multipoint calls/connections? | O | | 1.1 | Yes__ No__ |
| Comments: | | | | | |

### B.4.3 Information Element Encoding at AINI (IEEA)

| Item | Item Description | Status | Condition for status | Reference | Support |
|---|---|---|---|---|---|
| IEEA1 | Does the IUT support cause #42 “Switching Equipment Congestion” for the Cause information element? | M | | 3 | Yes__ No__ |
| IEEA2 | Does the IUT support crankback cause #42 “Switching Equipment Congestion” for the Crankback information element? | M | | 5.2 | Yes__ No__ |
| Comments: | | | | | |

### B.4.4 Signalling Procedures at the AINI interface (SPA)

| Item | Item Description | Status | Condition for status | Reference | Support |
|---|---|---|---|---|---|
| SPA1 | Does the IUT apply the crankback procedure when a SETUP message is received and the call/connection cannot be progressed due to signalling congestion errors? | M | | 6.1.3 | Yes__ No__ |
| SPA2 | Does the IUT apply the crankback procedure when an ADD PARTY message is received and the call/connection cannot be progressed due to signalling congestion errors? | M | SCA2 | 6.1.3 | Yes__ No__ |
| SPA3 | Does the IUT crank back a call/party with Cause and Crankback information element cause value #42 "Switching Equipment Congestion", when signalling congestion is encountered which prevents the timely establishment of the call/party? | M | SCA1, SCA2 | 6.1.3 | Yes__ No__ |
| SPA4 | Does the IUT apply the procedure in section 6.3.1.1/AINI "Blocking at a node", when signalling congestion is detected within the node, which prevents the establishment of a call/party? | M | SCA1, SCA2 | 6.1.3 | Yes__ No__ |
| SPA5 | Does the IUT apply the procedures in section 6.3.1.2/AINI "Blocking at the preceding end of a link", when signalling congestion is detected at the preceding end of the link, which prevents the timely establishment of a call/party? | M | SCA1, SCA2 | 6.1.3 | Yes__ No__ |
| SPA7 | Does the IUT apply the procedures in section 6.3.1.3/AINI "Blocking at the succeeding end of a link", when signalling congestion is detected at the succeeding end of the link, which prevents the timely establishment of a call/party? | M | SCA1, SCA2 | 6.1.3 | Yes__ No__ |
| Comments: | | | | | |