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ATIS-1000652.1996(R2011)

B-ISDN Signaling ATM Adaptation Layer – Layer Management for the SAAL at the NNI

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B-ISDN Signaling ATM Adaptation Layer – Layer Management for the SAAL at the NNI

Secretariat

Alliance for Telecommunications Industry Solutions

Approved March 8, 1996

American National Standards Institute, Inc.

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Contents

Foreword (This foreword is not part of American National Standard T1.652-1996.)

This standard specifies the Layer Management functions for the Signaling ATM Adaptation Layer (SAAL) at the Network Node Interface (NNI). These include the interfaces to the Service Specific Connection Oriented Protocol (SSCOP), (ANSI T1.637), to the Service Specific Coordination Function (SSCF) at the NNI (ANSI T1.645), and to systems management. Layer Management provides, or supports, the following functions for the Service Specific Convergence Sublayer (SSCS) at the NNI:

– error processing;

– measurements;

– notification of processor outage status;

– determination of link quality during proving; and

– determination of link quality during normal operation.

There are 5 annexes in this standard. Annexes A through C are normative and are considered part of this standard. Annexes D and E are informative and are not considered part of this standard.

Suggestions for improvement of this standard will be welcome. They should be sent to the Alliance for Telecommunications Solutions, 1200 G Street, NW, Suite 500, Washington, DC 20005.

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American National Standard for Telecommunications –

B-ISDN Signaling ATM Adaptation Layer – Layer Management for the SAAL at the NNI

1 Scope, purpose, and application

This standard specifies the Layer Management functions for the Signaling ATM Adaptation Layer (SAAL) at the Network Node Interface (NNI). These include the interfaces to the Service Specific Connection Oriented Protocol (SSCOP), (ANSI T1.637), to the Service Specific Coordination Function (SSCF) at the NNI (ANSI T1.645), and to systems management. Layer Management provides, or supports, the following functions for the Service Specific Convergence Sublayer (SSCS) at the NNI:

– error processing;

– measurements;

– notification of processor outage status;

– determination of link quality during proving; and

– determination of link quality during normal operation.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this American National Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

ANSI T1.635-1994, *Telecommunications – Broadband ISDN – ATM adaptation layer type 5 common part functions and specification*[1)]

ANSI T1.637-1994, *Telecommunications – B-ISDN ATM Adaptation Layer – Service Specific Connection Oriented Protocol (SSCOP)*

ANSI T1.645-1995, *Telecommunications – B-ISDN Signaling ATM Adaptation Layer – Service Specific Coordination Function for Support of Signaling at the Network Node Interface (SSCF at NNI)*

ITU-T Recommendation Q.2144 (1995), *B-ISDN Signaling Adaptation Layer - Layer Management for the SAAL at the NNI* [2)]

[1)] ANSI T1.635-1994 refers to ITU-T Recommendation I.363 (1993), *B-ISDN ATM Adaptation Layer (AAL) specification,* for all requirements. ITU-T Recommendation I.363 is available from the American National Standards Institute, 11 West 42nd Street, New York, NY 10036.

[2)] Available from the American National Standards Institute, 11 West 42nd Street, New York, NY 10036.

3 Abbreviations and acronyms

AA	ATM Adaptation
AAL	ATM Adaptation Layer
ALN	Alignment
ANS	Alignment Not Successful
ATM	Asynchronous Transfer Mode
BER	Bit Error Ratio
BGAK	Begin Acknowledge (SSCOP PDU)
BGN	Begin (SSCOP PDU)
BGREJ	Begin Reject (SSCOP PDU)
B-ISDN	Broadband Integrated Services Digital Network
CC	Congestion Ceased
CD	Congestion Detected
END	End (SSCOP PDU)
ENDAK	End Acknowledge (SSCOP PDU)
ER	Error Recovery (SSCOP PDU)
ERAK	Error Recovery Acknowledge (SSCOP PDU)
INS	IN Service
LM	Layer Management
LPO	Local Processor Outage
LR	Local Release
MAA	Management ATM Adaptation
MAAL	Management ATM Adaptation Layer
MD	Management Data (SSCOP PDU)
MPS	Management Proving State
MTP	Message Transfer Part
MTP-2	Message Transfer Part Level 2
MTP-3	Message Transfer Part Level 3
MU	Message Unit
NC	NO CREDIT
NNI	Network Node Interface
NRP	Number of Retransmitted SSCOP PDUs
OOS	Out Of Service
OSI	Open Systems Interconnection
PDU	Protocol Data Unit
PDUT	SSCOP PDU Transmitted

PE	Protocol Error
PNS	Proving Not Successful
PO	Processor Outage
POLL	Poll (SSCOP PDU)
QoS	Quality of Service
RR	Remote Release
RS	Resynchronization (SSCOP PDU)
RSAK	Resynchronization Acknowledge (SSCOP PDU)
RSREC	Timer_REPEAT-SREC
SAAL	Signaling ATM Adaptation Layer
SAR	Segmentation And Reassembly
SD	Sequenced Data (SSCOP PDU)
SR	SSCOP Release
SREC	SSCOP RECover
SSCF	Service Specific Coordination Function
SSCOP	Service Specific Connection Oriented Protocol
SSCOP-UU	SSCOP User-to-User Information
SSCS	Service Specific Convergence Sublayer
STAT	Solicited STATus (SSCOP PDU)
UD	Unnumbered Data (SSCOP PDU)
UDR	UNITDATA Received
USTAT	Unsolicited STATus (SSCOP PDU)

4 Model for interactions with Layer Management

Figure 1 shows the relationship of Layer Management to other protocols and management entities. In the figure, solid lines connect Layer Management to entities with which it interacts directly. Clauses 5, 6, and 7 provide more information on these interfaces.

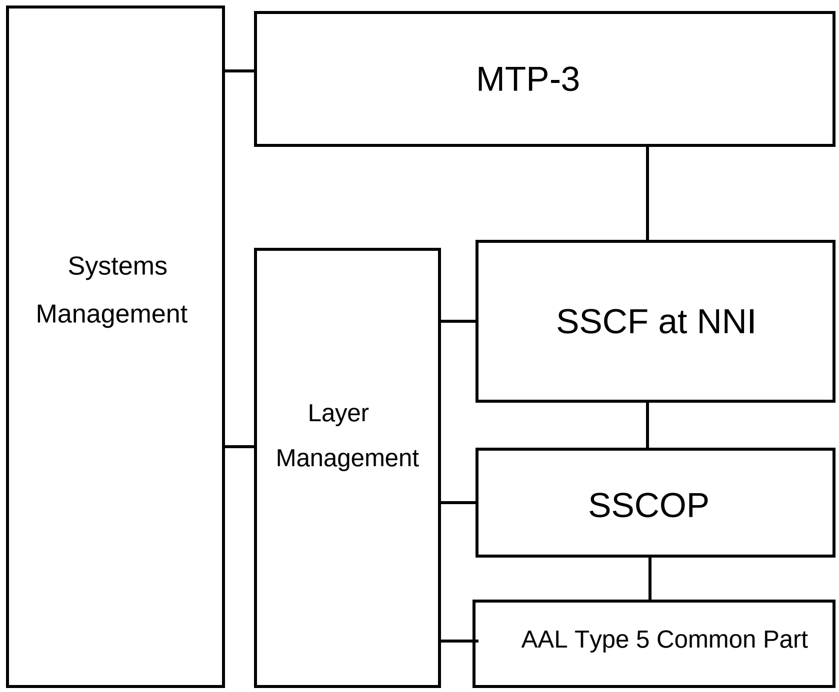


Figure 1 – Relationships of Layer Management with other entities

5 Interface between Layer Management and the SAAL at the NNI

This section defines the signals between the Layer Management entity for the SAAL at the NNI and the SSCF at the NNI and the signals between the Layer Management entity for the SAAL at the NNI and the SSCOP. Subclause 5.1 defines the interface to SSCOP. Subclause 5.2 defines the interface to the SSCF at the NNI. For information concerning the interface of AAL Type 5 Common Part to Layer Management, consult ANSI T1.635.

NOTE – Currently there are no interactions between the AAL Type 5 Common Part and Layer Management specified in ANSI T1.635.

5.1 Interface between Layer Management and SSCOP

Between Layer Management and the SSCOP the signals contained in table 1 are defined:

Table 1 – Signals and parameters between SSCOP and Layer Management

Generic Name	Type			
	Request	**Indication**	**Response**	**Confirm**
MAA-ERROR	Not Defined	Code, Count	Not Defined	Not Defined
MAA-UNITDATA	MU	MU	Not Defined	Not Defined

The definitions of these signals are found in ANSI T1.637. They are shown here for ease of reference.

– The MAA-ERROR signal is used by SSCOP to report the occurrence of various error events to Layer Management;

– The MAA-UNITDATA signals are used for the non-assured transfer of information between peer Layer Management entities.

NOTE – Thus far, no procedures using the MAA-UNITDATA signal have been defined for the Layer Management for the SAAL at the NNI.

The parameters in these signals are defined as follows:

– The Message Unit (MU) parameter contains the service data unit that is transferred from Layer Management to SSCOP in the MAA-UNITDATA.request and from SSCOP to Layer Management in the MAA-UNITDATA.indication;

– The Code parameter indicates the type of error that occurred. A table of errors that can be reported and the corresponding Code values are given in ANSI T1.637 and are replicated for convenience in annex D;

– The Count parameter indicates the number of SD PDU retransmissions that occurred.

5.2 Interface between Layer Management and the SSCF at the NNI

Between Layer Management and the NNI SSCF the signals contained in table 2 are defined in ANSI T1.645. These definitions are repeated below for the convenience of the reader.

Table 2 – Signals between SSCF at the NNI and Layer Management

Signals	Direction
MAAL-PROVING.indication	SSCF to LM
MAAL-CLEAR_FORCE_MODES.request	LM to SSCF
MAAL-FORCE_EMERGENCY.request	LM to SSCF
MAAL-FORCE_PROVING.request	LM to SSCF
MAAL-STOP_PROVING.indication	SSCF to LM
MAAL-PROVING_UNSUCCESSFUL.response	LM to SSCF
MAAL-RELEASE.request	LM to SSCF
MAAL-LOCAL_PROCESSOR_OUTAGE.request	LM to SSCF
MAAL-LOCAL_PROCESSOR_RECOVERED.request	LM to SSCF
MAAL-REPORT.indication	SSCF to LM

These signals are defined as follows:

"MAAL-PROVING.indication"

is used by SSCF to initiate the error monitoring within Layer Management for connection proving.

"MAAL-FORCE_PROVING.request"

is used to instruct SSCF to implement forced proving.

"MAAL-FORCE_EMERGENCY.request"

is used to instruct SSCF to omit proving.

"MAAL-CLEAR_FORCE_MODES.request"

is used to notify SSCF that Layer Management is indifferent to which proving mode is used.

"MAAL-RELEASE.request"

is used to instruct SSCF to release the connection.

"MAAL-STOP_PROVING.indication"

is used to indicate that the proving procedure has terminated.

"MAAL-PROVING_UNSUCCESSFUL.response"

is used to notify SSCF that the proving was not successful.

"MAAL-LOCAL_PROCESSOR_OUTAGE.request"

is used to notify SSCF of local processor outage.

"MAAL_LOCAL_PROCESSOR-RECOVERED.request"

is used to notify SSCF that the local processor has recovered.

"MAAL-REPORT.indication"

is used to notify Layer Management of events detected by SSCF.

The generic structure for the MAAL-REPORT.indication is:

MAAL-REPORT.indication ("lower boundary conditions," "upper boundary conditions," "reasons in case of exceptional situations")

The "lower boundary conditions" parameter reports whether the SSCOP connection was released by the remote or local SSCF or by SSCOP itself if the event being reported involves release of the SSCOP connection; it can take values RR, LR, SR, or -.

The "upper boundary conditions" parameter reports the interface state at the upper boundary of the SSCF into which a transition was made if the event being reported involves a transition at this boundary; it can take values OOS, INS, ALN, or -.

The "reasons in case of exceptional situations" parameter reports the reason for transitions reported in the lower boundary conditions or upper boundary conditions parameters or the type of event being reported when the boundary conditions parameters are empty; it can take values ANS, SREC, SSCOP-UU, PE, CD, CC, PDUT, UDR, or -.

Key:

ALN	Alignment
ANS	Alignment Not Successful
CC	Congestion Ceased
CD	Congestion Detected
INS	IN Service
LR	Local Release
OOS	Out Of Service
PDUT	PDU Transmitted
PE	Protocol Error
RR	Remote Release
SR	SSCOP Release
SREC	SSCOP RECover
SSCOP-UU	SSCOP User-to-User Information
UDR	UNITDATA Received
-	empty

These parameter values of the MAAL-REPORT.indication and other MAAL-signals provide the Layer Management with an unambiguous view of the status of SSCF (see table 6 of ANSI T1.645 for applicability of notifications).

In the state transition diagram, figure 2:

a) the signal MAAL-REPORT.indication (-,-,UDR) is possible in any state. This is not shown;

b) any other signal which is not shown as resulting in a transition (from one state to the same state, or from one state to a different state) is not permitted in that state;

c) it is assumed that the signals passed between LM and an SSCF are coordinated so that collisions do not occur;

d) the following abbreviations are used:

MAAL-PROVING_UNS = MAAL-PROVING_UNSUCCESSFUL,

MAAL-LOC_PROC_OUT = MAAL-LOCAL_PROCESSOR_OUTAGE,

MAAL-LOC_PROC_REC = MAAL-LOCAL_PROCESSOR_RECOVERED.

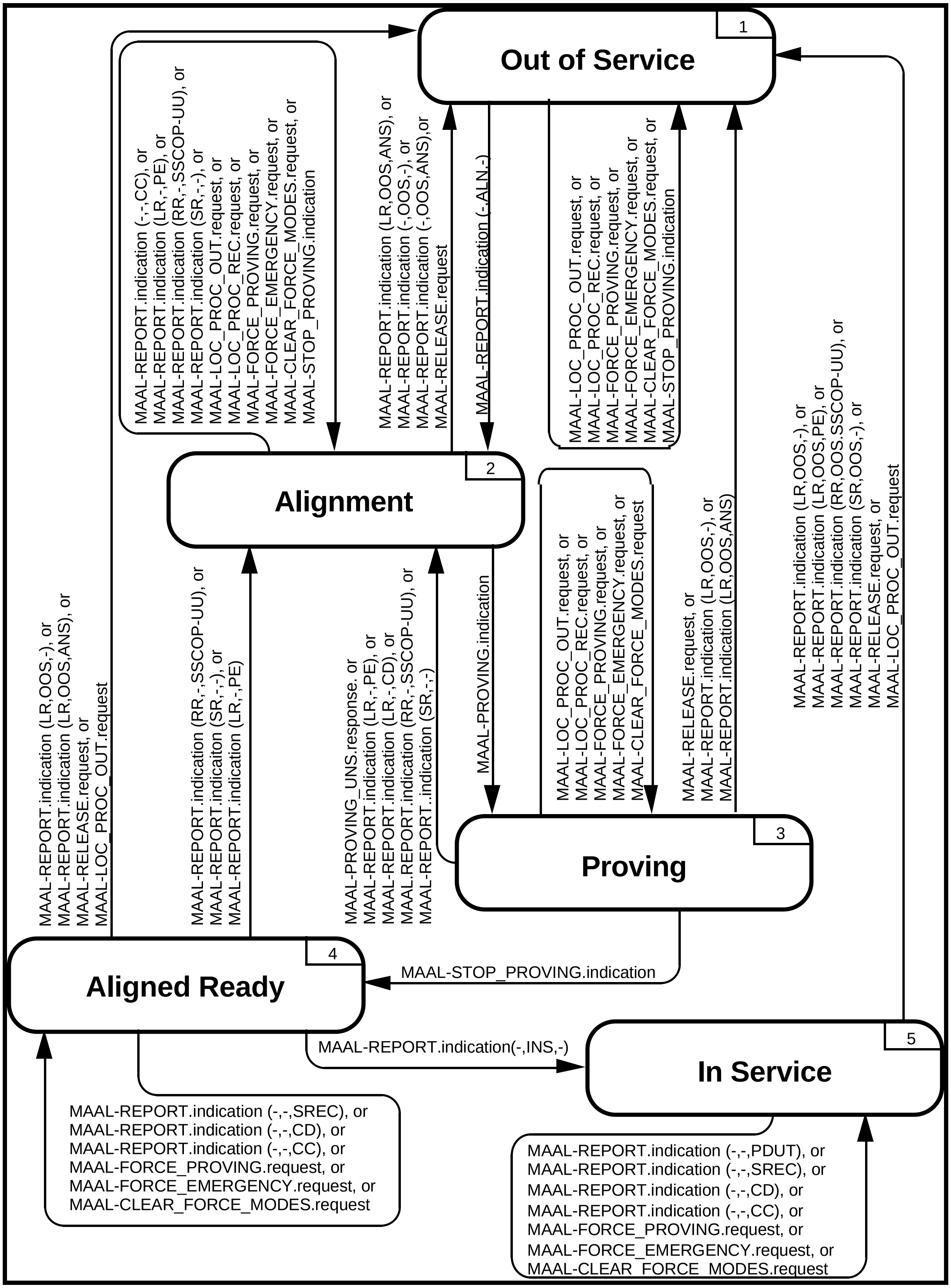


Figure 2 – State transition diagram at the SSCF to LM boundary for sequences of MAAL-signals

6 State transition table of LM for the management of SAAL at the NNI

This clause contains the state transition table, table 3, of the LM for the management of SAAL at NNI in support of an SAAL service which is provided at an AAL connection endpoint. It makes use of sequences of MAA-, and MAAL-signals as defined in 5.1 and 5.2.

The events shown in table 3 are signals at the boundary between LM and SSCF or SSCOP, LM-internal events, or management status information e.g., Local Management Proving Status. Some of the events identified in table 3 as illegal and associated with a state, are the result of collisions at the boundary between LM and SSCF or SSCOP which, as assumed here, do not occur.

The state of Layer Management is determined by its perception of the state of the SSCF. The following states are defined:

1. *Out Of Service:* In this state no signaling connection exists and SSCF waits for an AAL-START.request from the SSCF user;

2. *Alignment:* In this state the SSCF has received an AAL-START.request and is either in the process of establishing an SSCOP connection or waiting between connection establishment attempts;

3. *Proving:* In this state the SSCF has established an SSCOP connection. Layer Management has been notified of the establishment and conducts alignment error rate monitoring;

4. *Aligned Ready:* In this state the SSCF has completed proving and awaits an indication from its peer that the signaling link can be put into service. Layer Management conducts In-Service error rate monitoring;

5. *In Service:* In this state, the signaling connection may be used by the SSCF user to transfer messages. Layer Management conducts In-Service error rate monitoring.

The LM has an internal state variable Number of Retransmitted PDUs (NRP) which keeps track of SSCOP retransmission of SD PDUs during proving, based on MAA-ERROR.indication (V,Count). The LM parameter Max_NRP determines the maximum permissible such retransmissions.

The LM has an internal Timer_NO-CREDIT (NC) which supervises the unavailability of credit, if PDUs are available to be transmitted. The value of this timer is an LM parameter. On expiry of this timer, LM issues an MAAL-RELEASE.request signal which causes the release of the signaling connection.

The LM has an internal Timer_REPEAT-SREC which is set whenever a report of an SSCOP recovery is received from the SSCF. If the timer is already active when the report of recovery is received, LM issues an MAAL-RELEASE.request signal which causes release of the signaling connection.

Some of the events result in an Error logging. The accumulation of these error reports and comparison with thresholds is beyond the scope of this standard.

Key to the contents of a cell in table 3

|	Impossible by the definition of the boundary condition
/	Impossible by the definition of LM internal events
MAAL-PROVING_UNS	MAAL-PROVING_UNSUCCESSFUL
MAAL-LOC_PROC_OUT	MAAL-LOCAL_PROCESSOR_OUTAGE
MAAL-LOC_PROC_REC	MAAL-LOCAL_PROCESSOR_RECOVERED
RSREC	Timer_REPEAT-SREC
NC	Timer_NO-CREDIT

Table 3 – State transition table for the LM at the NNI (sheet 1 of 4)

State / Event	Out Of Service 1	Alignment 2	Proving 3	Aligned Ready 4	In Service 5
MAAL-REPORT. indication (-,ALN,-)	2	I	I	I	I
MAAL-PROVING. indication	illegal	NRP:=0 3	I	I	I
MAAL-STOP_PROVING. indication	1	2	4	I	I
MAAL-REPORT. indication (-,INS,-)	illegal	I	I	5	I
MAAL-REPORT. indication (-,OOS,-)	illegal	1	I	I	I
MAAL-REPORT. indication (-,OOS,ANS)	illegal	1	I	I	I
MAAL-REPORT. indication (LR,OOS,-)	illegal	I	1	Stop timers NC and RSREC 1	Stop timers NC and RSREC 1
MAAL-REPORT. indication (LR,OOS,ANS)	illegal	1	1	Stop timers NC and RSREC 1	I
MAAL-REPORT. indication (LR,OOS,PE)	illegal	I	I	I	Stop timers NC and RSREC 1
MAAL-REPORT. indication (LR,-,PE)	illegal	2	2	Stop timers NC and RSREC 2	I
MAAL-REPORT. indication (LR,-,CD)	illegal	I	2	I	I
MAAL-REPORT. indication (RR, OOS,SSCOP-UU)	illegal	I	I	I	Stop timers NC and RSREC 1
MAAL-REPORT. indication (RR,-,SSCOP-UU)	illegal	2	2	Stop timers NC and RSREC 2	I
MAAL-REPORT. indication (SR,OOS,-)	illegal	I	I	I	Stop timers NC and RSREC 1
MAAL-REPORT. indication (SR,-,-)	illegal	2	2	Stop timers NC and RSREC 2	I

Table 3 – State transition table for the LM at the NNI (sheet 2 of 4)

State Event	Out Of Service 1	Alignment 2	Proving 3	Aligned Ready 4	In Service 5
MAAL-REPORT. indication (-,-,SREC)	illegal	I	I	If timer RSREC active THEN MAAL-RELEASE. request MAAL-FORCE_ PROVING.request stop timer NC stop timer RSREC (Note 1) 1 ELSE start timer RSREC 4	If timer RSREC active THEN MAAL-RELEASE. request MAAL-FORCE_ PROVING.request stop timer NC stop timer RSREC (Note 1) 1 ELSE start timer RSREC 5
MAAL-REPORT. indication (-,-,CD)	illegal	I	I	4	5
MAAL-REPORT. indication (-,-,CC)	illegal	2	I	4	5
MAAL-REPORT. indication (-,-,PDUT)	illegal	I	I	I	5
MAAL-REPORT. indication (-,-,UDR)	Error logging 1	Error logging 2	MAAL-PROVING _UNS.response 2	Error logging 4	Error logging 5
MAA-ERROR. indication (A - M)	Error logging 1	Error logging 2	MAAL-PROVING _UNS.response 2	Error logging 4	Error logging 5
MAA-ERROR. indication (O)	Error logging 1	Error logging 2	I	I	I
MAA-ERROR. indication (P)	illegal	illegal	Error logging 3	Error logging 4	Error logging 5
MAA-ERROR. indication (Q - T)	illegal	illegal	Error logging 3	Error logging 4	Error logging 5
MAA-ERROR. indication (U)	Error logging 1	Error logging 2	MAAL-PROVING _UNS.response 2	Error logging 4	Error logging 5

Table 3 – State transition table for the LM at the NNI (sheet 3 of 4)

State Event	Out Of Service 1	Alignment 2	Proving 3	Aligned Ready 4	In Service 5

MAA-ERROR. indication (V,Count)	illegal	illegal	NRP:= NRP+count
			IF NRP>Max_NRP THEN
			MAAL-PROVING_UNS.response
			2
			ELSE
			3
				Error logging
				4
					Error logging
					5

MAA-ERROR. indication (W)	illegal	illegal	MAAL-PROVING_UNS.response 2	Start timer NC	Start timer NC
MAA-ERROR. indication (X)	illegal	illegal	I	Stop timer NC	Stop timer NC
MAA-UNITDATA. indication {MU}	Management communication Protocol Error	Management communication Protocol Error	Management communication Protocol Error	Management communication Protocol Error	Management communication Protocol Error
Local Management Proving Status NORMAL (Note 2)	MAAL-FORCE_PROVING. request 1	MAAL-FORCE_PROVING. request 2	MAAL-FORCE_PROVING. request 3	MAAL-FORCE_PROVING. request 4	MAAL-FORCE_PROVING. request 5
Local Management Proving Status EMERGENCY (Note 2)	MAAL-FORCE_EMERGENCY. request 1	MAAL-FORCE_EMERGENCY. request 2	MAAL-FORCE_EMERGENCY. request 3	MAAL-FORCE_EMERGENCY. request 4	MAAL-FORCE_EMERGENCY. request 5
Local Management Proving Status NEUTRAL (Note 2)	MAAL-CLEAR_FORCE_MODES .request 1	MAAL-CLEAR_FORCE_MODES .request 2	MAAL-CLEAR_FORCE_MODES .request 3	MAAL-CLEAR_FORCE_MODES .request 4	MAAL-CLEAR_FORCE_MODES .request 5
Expiry timer NC	/	/	/	MAAL-RELEASE. request stop timer RSREC 1	MAAL-RELEASE. request stop timer RSREC 1

Table 3 – State transition table for the LM at the NNI (sheet 4 of 4)

State / Event	Out Of Service 1	Alignment 2	Proving 3	Aligned Ready 4	In Service 5
Local Processor Outage (Note 3)	MAAL-LOC_ PROC_OUT. request 1	MAAL-LOC_ PROC_OUT. request 2	MAAL-LOC_ PROC_OUT. request 3	MAAL-LOC_ PROC_OUT. request Stop timers NC and RSREC 1	MAAL-LOC_ PROC_OUT. request Stop timers NC and RSREC 1
Local Processor Recovered (Note 3)	MAAL-LOC_ PROC_REC. request 1	MAAL-LOC_ PROC_REC. request 2	MAAL-LOC_ PROC_REC. request 3	I	I
Expiry timer RSREC	/	/	/	4	5
Signaling Link below acceptable performance level (Note 4)	/	/	MAAL-RELEASE. request (Note 5) 1	MAAL-RELEASE. request Stop timers NC and RSREC 1	MAAL-RELEASE. request Stop timers NC and RSREC 1

NOTES

1 The Local Management proving status is set to "NORMAL" by implementation dependent means.

2 This event is implementation specific.

3 The detection of local processor outage is implementation dependent.

4 See 9.1.1

5 As the error monitor of annex B is started upon entry to the Proving state, it can notify Layer Management of unacceptable link performance in the Proving state. ITU-T Recommendation Q.2144 does not reflect this possibility.

7 Interface to systems management

The interface to systems management is for further study. The real system resources that may be managed by this interface are listed in annex A.

8 Peer-to-peer Layer Management communication

The use of peer-to-peer Layer Management messages is for further study. SSCOP has provided the MAA-UNITDATA signal type for such communication should the need for it arise.

9 Procedures of Layer Management

9.1 Error processing

The various protocol errors reported by SSCOP to Layer Management are found in annex D. The actions taken, beyond those specified in table 3, upon receipt of these error notifications may be network specific.

9.1.1 Error monitoring for In-Service links

Layer Management determines when the performance of an In-Service link has deteriorated to the point where the link should be taken out of service. Information contained in MAA-ERROR.indication signals from SSCOP and in MAAL-REPORT.indication signals from the SSCF can be used for this purpose. When a determination is made that performance is unsatisfactory, the MAAL-RELEASE.request signal is issued from Layer Management to the SSCF.

Error monitoring is a mandatory feature on the transmitting side of NNI signaling links. The ideal error monitoring algorithm would satisfy simultaneously the following criteria:

1) **Burst tolerance:** To avoid unnecessary changeovers, the error monitor should tolerate all error bursts of duration less than 300 ms and should tolerate error bursts of duration 400 ms with probability 0.9.

2) **Limit data to be retrieved:** If cell error ratios approaching 1.0 persist on the link, the error monitor should take the link out of service quickly enough that at the time the error monitor determines that the link is to be taken out of service, the amount of traffic that must be retrieved does not exceed twice the traffic that arrives from the upper layer in TE1.

TE1 is the maximum time between the beginning of an error burst of length 400 ms and the arrival at the transmitter of the STAT triggered by the first POLL sent after the error burst terminates; it is equal to the sum of 400 ms plus the SSCOP Timer_POLL and the delay between the sending of a POLL and the receipt of the resulting STAT, including the round trip propagation delay and the possible queueing delays for the POLL and STAT, which are limited by the implementation dependent "lower layer busy" mechanism within SSCOP.

3) **Avoidance of excessive delays:** The error monitor should prevent signaling traffic from experiencing excessive delays for an extended period of time. Characterization of "excessive delays" and "extended period of time" is for further study.

4) **Limit of buffer:** The amount of traffic in the buffer at link failure at any cell error ratio should not exceed 1.4 times the amount in the buffer at link failure when the cell error ratio approaches 1.0.

5) **No unnecessary Out-of-Service events:** If the effective BER of the signaling link is less than 10^{-7} for links of speed up to 4 Mbits/s, the mean time between link failures declared by the error monitor should exceed 10^{6} s.

6) **Effectiveness under small load conditions:** If the effective BER is 10^{-4} or greater and the user load is at least 0.01 erlang, the error monitor should take the link out of service within 600 s with probability 0.9.

7) **Administrative ease:** It is desirable that the error monitor not require manual adjustments of its parameters to meet the preceding criteria for links of different speeds, lengths and traffic characteristics (e.g., load or message size distributions). At a minimum, an error monitor designed to meet the criteria on a link of a given speed and TE1, should continue to meet the criteria for all link lengths and traffic characteristics yielding a smaller TE1, provided criterion 2 is interpreted as limiting the retrieved traffic to the amount of traffic that arrives in 2 times $TE1^*$, where $TE1^*$ is the TE1 of the original link.

The algorithm to be used for error monitoring is not specified in this standard. The algorithm used shall provide performance with respect to the above criteria that is equivalent (but not necessarily identical) to that provided by the reference algorithm in annex B.

NOTES

1 Simulation studies indicate that the error monitor in annex B meets the above criteria for a wide range of link speeds, link loads, and traffic characteristics, although not all possibilities were studied.

2 The error monitor in annex B requires information from SSCOP and SSCF at the NNI beyond that provided by the MAA-ERROR and MAAL-REPORT signals defined in ANSI T1.637 and ANSI T1.645, respectively. It is a local matter how this information is provided.

9.1.2 Detection of excessive time with no credit

SSCOP notifies Layer Management (using the MAA-ERROR.indication signal) when it has message(s) to send to its peer but cannot do so because it has not been given credit to do so. SSCOP also notifies Layer Management (using the MAA-ERROR.indication signal) when it again has credit to send at least one message. Layer Management shall issue an MAAL-RELEASE.request when the length of a period of no credit exceeds a threshold.

NOTE – A similar function is performed in MTP-2 via timer T6, as described in clause 9 of chapter 3 of ANSI T1.111.

9.1.3 Detection of closely spaced SSCOP recoveries

SSCF notifies Layer Management (using MAAL-REPORT.indication) when an SSCOP recovery takes place. Layer Management ensures that the link does not remain in service if closely spaced SSCOP recoveries take place. If Layer Management receives an MAAL-REPORT.indication indicating an SSCOP recovery, it checks to see if Timer_REPEAT-SREC is active. If it is active, Layer Management issues an MAAL-RELEASE.request and sets the local management proving status to NORMAL, ensuring that the link must successfully pass proving before it can be put in service. Whether the timer is active or not, Layer Management then sets it so a subsequent closely spaced recovery can be detected. When Timer_REPEAT-SREC expires, no action is taken.

9.2 Measurements

The Layer Management shall maintain various counters for interrogation by systems management and report specified events autonomously to systems management. The set of measurements that should be supported includes the contents of table 4.

Table 4 – Signaling link faults and performance

#	Description of measurements	Units	Support required	Usage	Duration (Note)
1	Duration of link in the In Service state	secs/SL	M	F, P, N	30 min
2	SL failure - all reasons	event/SL	M	F, R, P	on occurrence
3	SL failure - No_RESPONSE Timer expiration	event/SL	O	F, R, P	on occurrence
4	SL failure - excessive error rate	event/SL	O	F, R, P	on occurrence
5	SL failure - excessive duration of congestion	event/SL	O	F, R, P	on occurrence
6	SL alignment failure	event/SL	O	F, R F, P	5 min 30 min
7	Number of MAA-ERROR.indications with Error Type SD loss	events/SL	O	F, R, P F, P	5 min 30 min

NOTE – Entities in this column specify the measurement interval applicable for each measurement.

Key to Table:

F Fault

M Mandatory

N Network planning and administration

O Optional

P Performance

R Near real time measurements

SL Signaling Link

The usage of the measurements identified in table 4 has been categorized to correspond to OSI management categories of ITU-T Recommendation Q.750 and the "administration" category of ITU-T Recommendation Q.752. These measurements may be used singly or in conjunction with other measurements by the network administration for management, administration or planning purposes.

The applicable usage categories are defined as follows:

– **Fault (F)** – This category utilizes on occurrence events and measurements to report and detect faults, and monitor the signaling network response to abnormal conditions. Measurements made for this purpose are usually made for use in near real time, but resources performing to "just acceptable" limits might require long measurement intervals.

– **Network planning and administration (N)** – This category involves measurements that are used on a long term basis and are generally retained external to the signaling network resources. The activities include planning and dimensioning (engineering) the signaling network resources, including determination of the resource quantities, e.g., number of link sets, and resource configuration, e.g., routing.

– **Performance (P)** – This category is used for near real time, medium term and long term control. The purpose is to sustain network performance, over both the short and long terms.

– **Near real time measurements (R**) – This classification is applied, in addition to the categories defined above, for those measurements which are for use in near real time. Usually, it is applied to those measurements which are marked as "on occurrence," or "1st & interval," or "5 minute" duration. These measurements include all alarms that might require immediate attention.

9.2.1 Duration of presence in *In Service* state

The SAAL Layer Management can determine when a signaling link goes into the *In Service* state based upon the receipt of an MAAL-REPORT.indication signal from the SSCF indicating "Link In Service." Similarly, it can determine when a link is taken out of service based upon receipt of an MAAL-REPORT.indication from the SSCF indicating "Out of Service." The difference in time of arrival of these signals represents the duration of that link being in the *In Service* state.

9.2.2 Signaling link failures

Failure events and the reasons for them can be obtained through MAAL-REPORT.indication signals from the SSCF and through MAA-ERROR.indication signals from SSCOP. In particular, signaling link failures caused by the expiry of the SSCOP Timer_NO-RESPONSE can be detected by receiving an MAA-ERROR.indication with the Code parameter set to P.

Excessive error rate failures may be determined by the SAAL Layer Management through its error monitoring function for In-Service links. This function is described in 9.1.1.

Excessive duration of congestion can be determined by the SAAL Layer Management through the Layer Management function for detection of excessive time with no credit. This function is described in 9.1.2.

Signaling link alignment failures can be determined by the SAAL Layer Management based upon receipt of MAAL-REPORT.indication signals indicating "Alignment Not Successful."

The SAAL Layer Management may utilize an internal counter for accumulating the number of MAA-ERROR.indications that it receives for each signaling link from SSCOP.

9.2.3 Signaling link restoration

The SAAL Layer Management can only determine when the signaling link goes into the *In Service* state. This is based upon the receipt of MAAL-REPORT.indication signals from the SSCF indicating "Link In Service." Only MTP-3 can determine when it considers the signaling link to be restored, i.e. after successful completion of signaling link test (see clause 12 of chapter 4, ANSI T1.111. Therefore, specification of signaling link restoration measurements are beyond the scope of this recommendation.

9.3 Handling of processor outage conditions

Implementation dependent functions determine when factors at a functional level higher than SAAL (e.g., when received messages cannot be transferred to functional levels higher than SAAL) preclude the use of the link and cause the Layer Management entity to issue the MAAL-LOCAL_PROCESSOR_OUTAGE.request signal to the SSCF. When the use of the link is again possible the Layer Management entity issues the MAAL-LOCAL_PROCESSOR_RECOVERED.request signal to the SSCF.

The SSCF notifies SAAL Layer Management of a condition of remote processor outage via an MAAL-REPORT.indication signal indicating "Remote Release" and "Processor Outage." This information is useful in trouble sectionalization of difficulties and in network performance measurements. The actions taken upon receipt of these error notifications may be network specific.

9.4 Management of signaling link proving

While the SSCF is sending proving messages over the link, the Layer Management entity must make a determination of whether the link performance is satisfactory. It uses the MAA-ERROR.indication signals it receives from SSCOP and MAAL-REPORT.indication signals it receives from SSCF to make this determination. The number of messages sent during normal proving (parameter n1 in ANSI T1.645) and the maximum permissible retransmissions during a successful proving attempt (Max_NRP) should be such that the probability of proving the link successfully within

8 minutes does not exceed 0.05 when the error ratio is such that the mean time for which the In-Service error monitor will leave the link in service is less than 1 day.

The SSCF notifies Layer Management of the beginning of proving with the MAAL-PROVING.indication. Layer Management notifies the SSCF that proving is unsuccessful with the MAAL-PROVING_UNSUCCESSFUL.response. If an MAAL-STOP_PROVING.indication is received from the SSCF, then procedures related to proving in the Layer Management entity are stopped.

The ability for Layer Management to override the decision of whether to perform normal or emergency proving, usually made by the user of the SSCF, is possible by using the MAAL-FORCE_PROVING.request to notify the SSCF to use forced proving and by using the MAAL-FORCE_EMERGENCY.request. Layer Management informs the SSCF to cancel forced normal proving or forced emergency proving through the use of an MAAL-CLEAR_FORCE_MODES. request. The algorithm used to decide when to force any mode of proving and when to cancel such force modes may be network specific.

Annex A
(normative)

Real system resources

Besides the Layer Management states (Out Of Service, Alignment, Proving, Aligned Ready, In Service) that are described in clause 6 and the measurements that are described in 9.2, the following real system resources, i.e., timers and parameters may be managed via the interface between Layer Management and system management.

Parameter or timer	Default value
SSCOP parameters and timers (Note 1)	
k	4096 octet
j	4 octet
MaxCC	4
MaxPD	500
Timer_CC	200 milliseconds
Timer_KEEP-ALIVE	100 milliseconds
Timer_NO-RESPONSE	1.5 seconds
Timer_POLL	100 milliseconds
Timer_IDLE	100 milliseconds
MaxSTAT	67
SSCF parameter and timers (Note 2)	
Timer T1	5 seconds
Timer T2	30 seconds
Timer T3	Such that loading of the signaling link is approximately 50 % of its nominal cell rate
n1	1000
Layer Management parameters and timers	
Max_NRP	0
Timer_REPEAT-SREC	1 hour
Timer_NO-CREDIT	1.5 seconds

NOTES

1 These are defined in 7.6 and 7.7 of ANSI T1.637 and repeated here for convenience.

2 These are defined in ANSI T1.645 and repeated here for convenience.

Furthermore, the internal flags LPO (Local Processor Outage) and MPS (Management Proving State) of the SSCF at the NNI are real system resources. The use of these flags, their sets of values, and their initial values are described in clause 12 of ANSI T1.645.

Annex B
(normative)

Reference error monitor for In-Service links

B.1 Overview

This annex provides the reference monitor that is used in 9.1.1 to define the minimum performance of an In-Service error monitor.

This error monitor comprises three algorithms.

High error rates: Algorithm 1 removes the link from service whenever the queue of untransmitted and unacknowledged messages, i.e., the sum of the SSCOP transmission queue and transmission buffer, exceeds the maximum queue that could be caused by an error burst of length 400 ms, given the input traffic and link capacity. This algorithm responds accurately to extreme traffic conditions (e.g., overload) as well as expected traffic conditions.

Intermediate error rates: Algorithm 2 removes the link from service when retransmissions occur too frequently within the monitoring intervals. This algorithm removes a link from service when errors are sufficient to cause unacceptable delays, but not so severe as to cause sufficient queue build-up to trigger the first algorithm.

Low error rates and low traffic: Algorithm 3 removes the link from service when the number of POLLs within a large block, termed a superblock, that fail to be acknowledged with a STAT exceeds a threshold. This algorithm discovers problems on links when they are carrying little or no user traffic.

B.2 Detailed description

The error monitor periodically (every τ seconds) makes a determination of whether the link should be taken out of service. The following information is assumed to be available at the end of each monitoring interval:

1. NA: The length of the PDUs that arrived from the upper layer during the last τ seconds (the monitoring interval). This value is obtained from the SSCF via an implementation specific mechanism.

2. MCR: The maximum number of PDU cells that are allowed to pass to the lower layer during the interval (this value is available to the SSCF as part of the requirement that the AAL not overrun the ATM layer (see 6.1.3 of ANSI T1.645).

3. NF: The length of the PDUs freed from the retransmit buffer during the interval. (This value is computed during the SSCOP processing of STATs and USTATs via an implementation specific mechanism.)

4. CRED: An indication that credit was denied at any time during the preceding interval. CRED=1 if credit was denied, CRED=0 otherwise. (This information is obtained from SSCOP via an implementation dependent mechanism. Note that MAA-ERROR.indication with code W [see ANSI T1.637] only reports no credit conditions that exist immediately after the updating of credit upon receipt of a STAT PDU.)

5. ROLLBACK: An indication that window has been rolled back in the preceding interval. Rollback occurs whenever the receiver has closed the transmission window so that previously transmitted PDUs will not be accepted by the receiver. ROLLBACK=1 if rollback has occurred, ROLLBACK=0 otherwise. (ROLLBACK can be detected during the SSCOP processing of STATs and USTATs via an implementation specific mechanism.)

6. rexmit_flag: A flag that indicates PDUs were put in the retransmission queue in the preceding interval and the retransmissions were not caused by a credit rollback by the remote receiver. (This information can be determined from MAA-ERROR indications (code V) and indications of credit rollback and advancing VT(S).)

7. PI-count: A count of the number of POLLs that have been sent since the beginning of the current superblock. (Layer Management could accumulate this count if SSCOP simply gives an indication every time a POLL is sent.)

8. ct_stats: A count of the number of STATs that have been received since the beginning of the current superblock. (Layer Management could accumulate this count if SSCOP simply gives an indication every time it receives a STAT.)

A flow chart of the algorithm is given in figure B.1. This flow chart also uses the following variables:

9. seqno: VT(S) at the time of the most recent sending of a POLL. This value is obtained from SSCOP via an implementation specific mechanism.

10. prev_seqno: VT(S) value from the previous polling interval.

11. rollback: A boolean to indicate credit has been withdrawn by the remote receiver for those already transmitted SD PDUs, and VT(S) has not advanced since the credit rollback.

12. stat_received: A boolean to indicate that a STAT has been received since the most recent SSCOP connection establishment or recovery.

13. tot_penalty: Running total of the penalty factors for the polling intervals within a block.

14. block_qos: QoS value for the current block.

15. tot_qos: Overall running QoS value.

16. I_count: A count of successive error monitoring intervals.

17. NAVECT: A vector that stores the most recent N values of NA, where N is the number of error monitoring intervals required to span the time when data may not be acknowledged because of an error event of duration 400 ms.

18. MCVECT: A vector which stores the most recent N values of MCR.

19. IX: An index used to access the appropriate entry in MCVECT or NAVECT.

20. Q: The total length of PDUs currently in the SSCOP transmission queue and transmission buffer.

21. TTH: See definition in third paragraph following.

22. FTH: See definition in third paragraph following.

23. I: An index used to access the appropriate entry in MCVECT or NAVECT during computation of the effects of a credit rollback.

24. Y: A temporary variable used to store the minimum of Q and TTH during computation of the effects of a credit rollback.

25. QT: A temporary variable used to sum entries of NAVECT during computation of the effects of a credit rollback.

Algorithm 1 computes Q, the queue length, by simply maintaining a cumulative sum of NA minus NF. It takes the link out of service if Q exceeds a threshold T, which is the total length of PDUs that could be in the transmit and retransmit buffers due to any error event with Bit Error Ratio (BER) of 1 that has occurred in the recent past for a duration of 400 ms, the value based on Criterion 1 in 9.1.1.

This length T includes PDUs in the buffers just prior to the onset of the error event, the PDUs added to the buffers during the event and the PDUs added to the buffers after the event has abated up to the point where messages are released from the transmit buffer. T is computed by maintaining a history of the NA's (in NAVECT) and MCRs (in MCVECT) over the last N intervals. N is the number of τ second intervals needed to span the time when messages are not released from the buffers as a result of a 400 ms second error event. IX, an index that is incremented modulo N to address the oldest (N intervals prior) elements of NAVECT and MCVECT, is used to update efficiently T, NAVECT and MCVECT.

T has two components:

a) TTH – the amount of data that would be held in the transmit buffer as the result of a 400 ms error event (including the necessary POLL and round trip delay times). This is the sum of the elements of NAVECT after all updates have been completed;

b) FTH – the length of the PDUs in the buffer due to the arrivals (NA) that exceed the VC's capacity (MCR) for N or more intervals back in time. FTH is computed by cumulative summation of the NAVECT[IX] – MCVECT[IX] prior to the updating of NAVECT and MCVECT. FTH is allowed to be a minimum of 0 (no overload need be accounted for).

Algorithm 1 periodically updates Q, TTH, and FTH and tests to determine whether T is exceeded.

Algorithm 1 responds appropriately to denial of credit and rollback. In either case, the error monitor assumes that no cells were allowed to be transmitted in the affected intervals. If credit is denied at any time during the preceding interval (CRED=1) then MCVECT[IX] is set to 0. If the window is rolled back during the preceding interval (ROLLBACK=1), then elements of MCVECT corresponding to intervals when PDUs currently in the transmit queues arrived are set to 0. In both instances FTH will increase at the appropriate time to account for the window closings. This may present a slightly pessimistic estimate of the impact of credit denial and rollback. However, it has the side effect of forcing the error monitor to tolerate congestion. In this case as in overload, the congestion, which is due to the network elements themselves and not VC error phenomena, is expected and should be tolerated.

At the end of each monitoring interval, Algorithm 2 sets a penalty factor for the interval to either 1 or 0 depending on whether any reports of retransmissions have been received from SSCOP during the interval. At the end of every N_blk intervals, a quality of service (QoS) measure for the block is computed as the arithmetic average of the penalty factors and an overall (or running) QoS is computed by using exponential smoothing over consecutive block QoSs. That is, if Q denotes the running QoS and Q_b denotes the QoS from the current block, Q is updated as follows:

$$Q = (1 - \alpha) * Q + \alpha * Q\_b$$

where α is the exponential smoothing factor in the range (0,1). Whenever the running QoS exceeds a threshold "thres", the link is taken out of service. To prevent the error monitor from taking the link out of service because of retransmissions caused by a rollback in credit by the remote SSCOP receiver, the error monitor ignores all retransmission reports from SSCOP from the time it receives an indication of a credit rollback until after it receives the indication of a sending of a POLL by SSCOP with a VT(S) value that is higher than the VT(S) value when the credit rollback indication was received. Note that excessive time with lack of credit is independently supervised by the Layer Management, so the error monitor does not need to monitor such time also.

In the absence of user PDUs, Algorithms 1 and 2 are ineffective. The only monitoring on such a link is that the no-response timer will cause a link failure for severe errors or complete loss of connectivity. Some signaling links may be used predominately in alternate routes and have nearly no traffic under normal conditions, but it is best not to find out that the link has an excessive error rate only when the normal routes become unusable and traffic is placed on the alternate route. Therefore Algorithm 3 uses traffic that is always on the link, the POLLs and STATs. Over a superblock of N_sup polling intervals (on the order of 1000) the number of received STATs is accumulated. If the number of received STATs is less than the number of transmitted POLLs by more than a threshold N_loss, the link is taken out of service. Otherwise accumulation of STATs over another superblock is begun. To prevent the algorithm from being influenced by the delay in receiving an initial STAT upon SSCOP connection establishment or recovery on a high delay link, the algorithm behaves as if STATs are received in every polling interval until the first STAT is actually received. Timer_NO-RESPONSE will fail the link if the first STAT is not received in an acceptable amount of time. Although Algorithm 3 is most conveniently described using the counts N_sup and N_loss, the values of these counts must change if the SSCOP Timer_POLL is changed. Therefore it is best to consider the primary parameters of the algorithm to be the amount of time that corresponds to these counts when Timer_POLL is at its default value. These time parameters are denoted T_sup and T_loss. Then the counts are set as follows where T_poll is the actual value of Timer_POLL: N_sup := T_sup/T_poll; N_loss := T_loss/T_poll.

When SSCOP recovery takes place, all three algorithms are reinitialized. For Algorithm 1, the initial value of NA is set to the number of cells in messages in the transmission queue after the transmission buffer is cleared. This value is obtained from SSCOP in an implementation dependent manner.

All the primary parameters of the algorithms and their recommended default values are listed below:

T_sup: Superblock size in seconds. (Default value: 120 s)

T_loss: STAT loss limit in seconds. (Default value: 1.3 s)

α: Exponential smoothing factor. (Default value: 0.1)

thres: Threshold for comparing the running QoS. (Default value: 0.244)

τ: Error Monitoring Interval (Default value: 0.1 s)

N: Monitoring intervals needed to span the time when messages are not released from buffers as a result of a 400 ms error event. (Default value: 9)

N_blk: Number of monitoring intervals in a block for Algorithm 2. (Default value: 3)

B.3 Rationale for Default Parameters

N*τ must be chosen to span the time when messages are not positively acknowledged because of a 400 ms error event. The default design is for a link of 100 ms round trip delay and 100 ms Timer_POLL, and up to 100 ms queuing delay for a POLL and STAT pair. Thus TE1, i.e., the maximum time until arrival of a STAT calling for the retransmission of the first PDU affected by the error burst, for the default design is 600 ms. After this STAT arrives, the SD PDU can be retransmitted, but a subsequent STAT that acknowledges the retransmitted SD PDU may not arrive until after another Timer_POLL plus the round trip delay plus the possible queuing delays. Therefore, the total time between the initial transmission of an SD PDU and receipt of an acknowledgment may be as much as 900 ms. To minimize the amount of buffered traffic at changeover a value of N of the order of 10 is desirable. Default values of N = 9 and τ = 100 ms are chosen. A smaller τ will reduce retrieved traffic somewhat at the expense of more computation.

Grouping the monitoring intervals into blocks of 3 (N_blk) improves the burst tolerance of Algorithm 2.

The parameters α and thres are chosen together to give good burst tolerance and to ensure that link is removed from service quickly whenever the error ratio on the link is below the sustainable BER, i.e., the highest BER at which delays are considered acceptable. The default values are chosen so that the second algorithm will tolerate 8 consecutive intervals of penalty equal to 1. This means the Algorithm 2 will tolerate nearly all 500 ms bursts and more than 90% of 600 ms bursts. (Thus, the combination of Algorithms 1 and 2 will have a burst tolerance very similar to that of Algorithm 1 acting alone.) Minimizing α and thres subject to this constraint, and the constraint that a 4 Mb/s link (at arbitrary load) remain in service for 10^6 seconds at BER of 10^{-7} gives a design that minimizes link mean time to failure at moderate error rates, better limiting the persistence of unacceptable delays for signaling traffic. This gives the defaults of α = 0.1 and thres = 0.244.

The parameter T_loss can be chosen to allow for STAT deficiency due to one error burst of length t_b seconds, 2 random errors, and queuing delays suffered by POLLs or STATs at the edges of a superblock. Thus a T_loss of 1.3 sec is sufficient. T_sup is chosen to enforce a given link quality, denoted θ, under random errors and zero offered load. It suffices to choose θ as the sustainable

BER of a 4 Mb/sec link at normal engineered load. This gives θ of approximately $5*10^{-6}$, which, in turn, gives T_sup equal approximately 120 sec. (A very precise calculation of T_sup is unnecessary.)

B.4 Proving

When the default values given above are used for the In-Service error monitor and Timer_POLL is 100 ms, the following default values for proving parameters will satisfy the criterion given in 9.4:

Max_NRP = 1

n1/ANSI T1.645 = 4200 + 41*(Y-64) where Y is nominal link speed in Kb/s

T3/ANSI T1.645 = such that n1 cells are generated in 1 minute

T2/ANSI T1.645 = 120 seconds

The effective BER at which a link will fail to prove in within 8 minutes ranges from $4*10^{-6}$ for a 64 Kb/s link to $1*10^{-7}$ for a 4 Mb/s link.

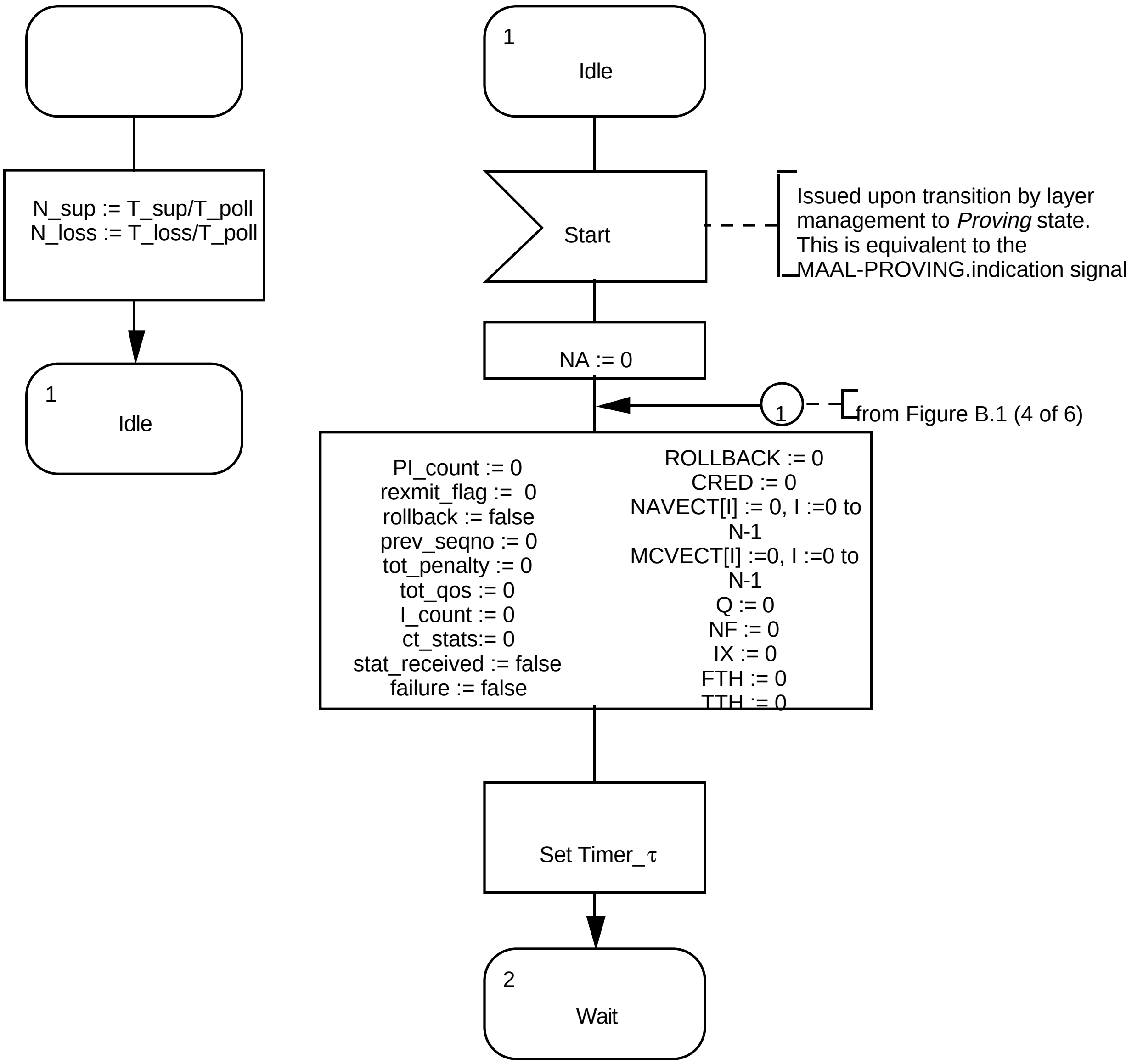


Figure B.1 – Error Monitor (sheet 1 of 6)

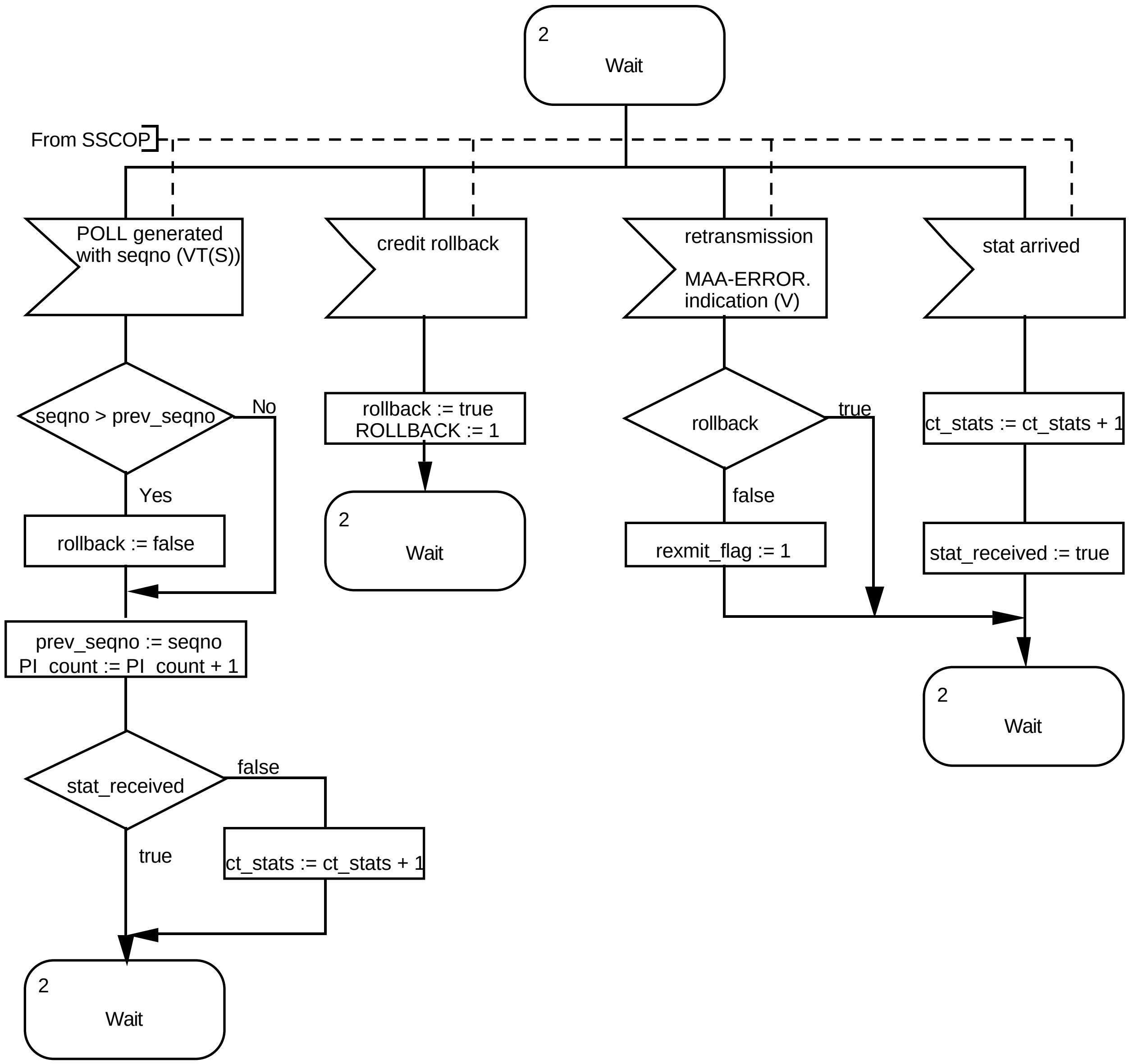


Figure B.1 – Error Monitor (sheet 2 of 6)

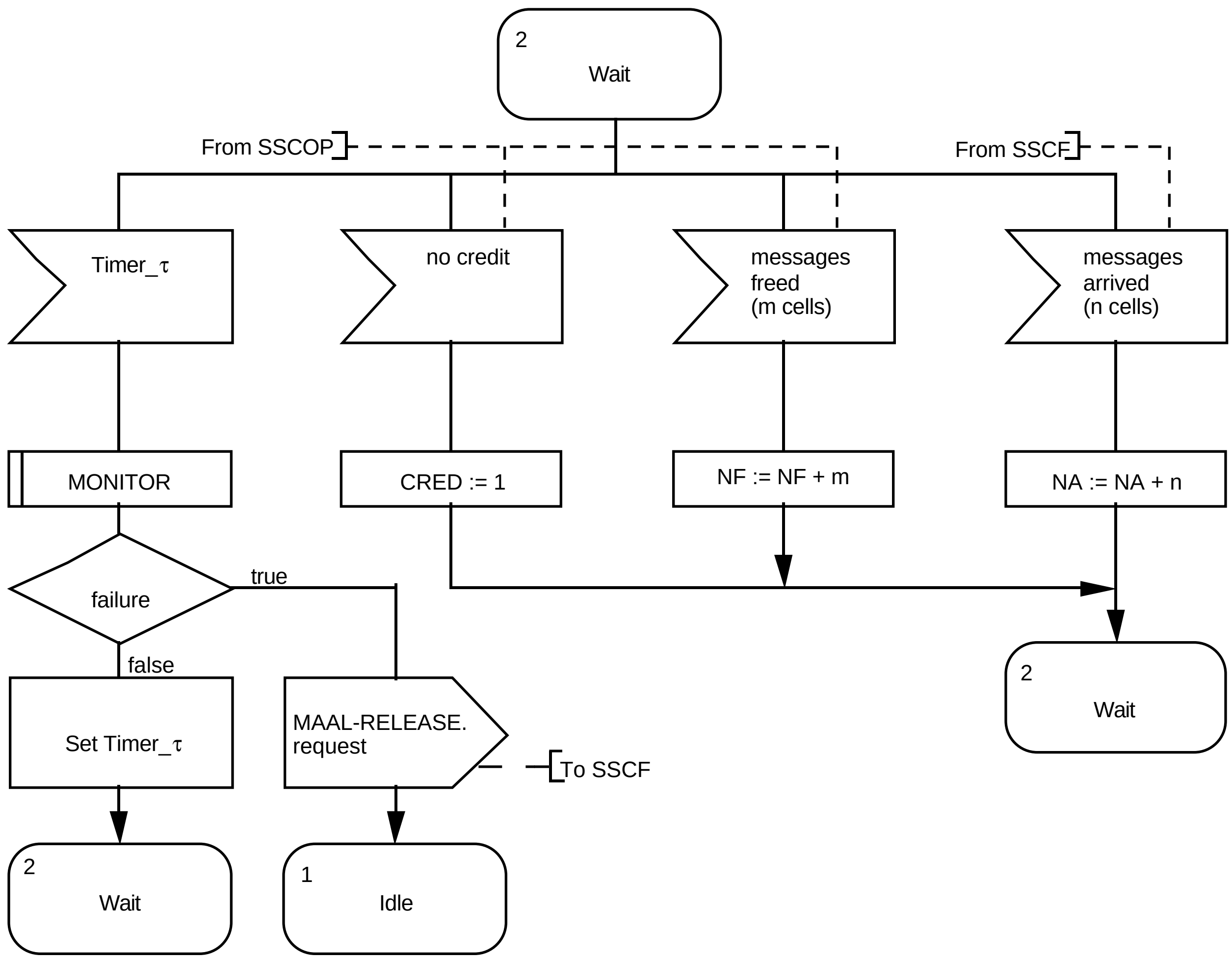
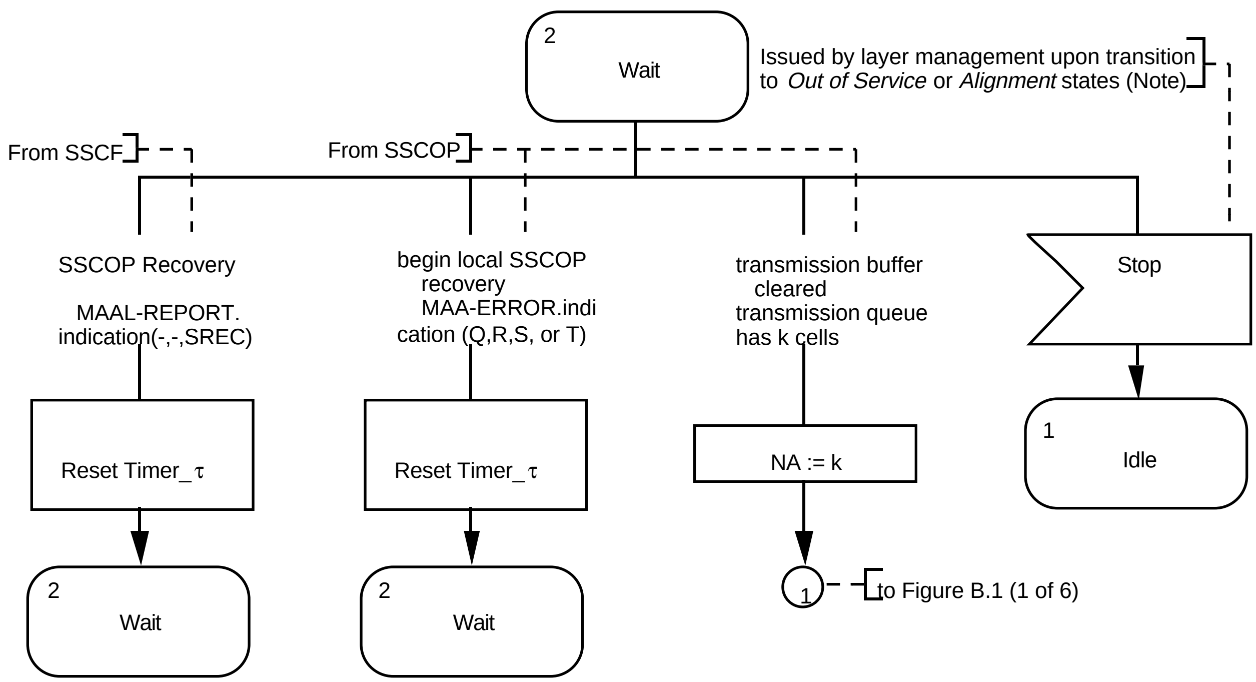


Figure B.1 – Error Monitor (sheet 3 of 6)



Note:
This signal is equivalent to any of the following events:

MAAL-REPORT.indication(LR, OOS, -)
MAAL-REPORT.indication (RR, OOS, SSCOP-UU)
MAAL-REPORT.indication (LR, OOS, ANS)
MAAL-REPORT.indication (LR, -, CD)
MAAL-REPORT.indication (SR,-, -)
MAAL-PROVING_UNSUCCESSFUL.response
MAAL-REPORT.indication (LR, OOS, PE)
MAAL-REPORT.indication (SR, OOS, -)
MAAL-REPORT.indication (LR, -, PE)
MAAL-REPORT.indication (RR, -, SSCOP-UU)
MAAL-LOCAL_PROCESSOR_OUTAGE.request

In addition, an MAAL-RELEASE.request generated outside this monitor is also equivalent to this signal.

Figure B.1 – Error Monitor (sheet 4 of 6)

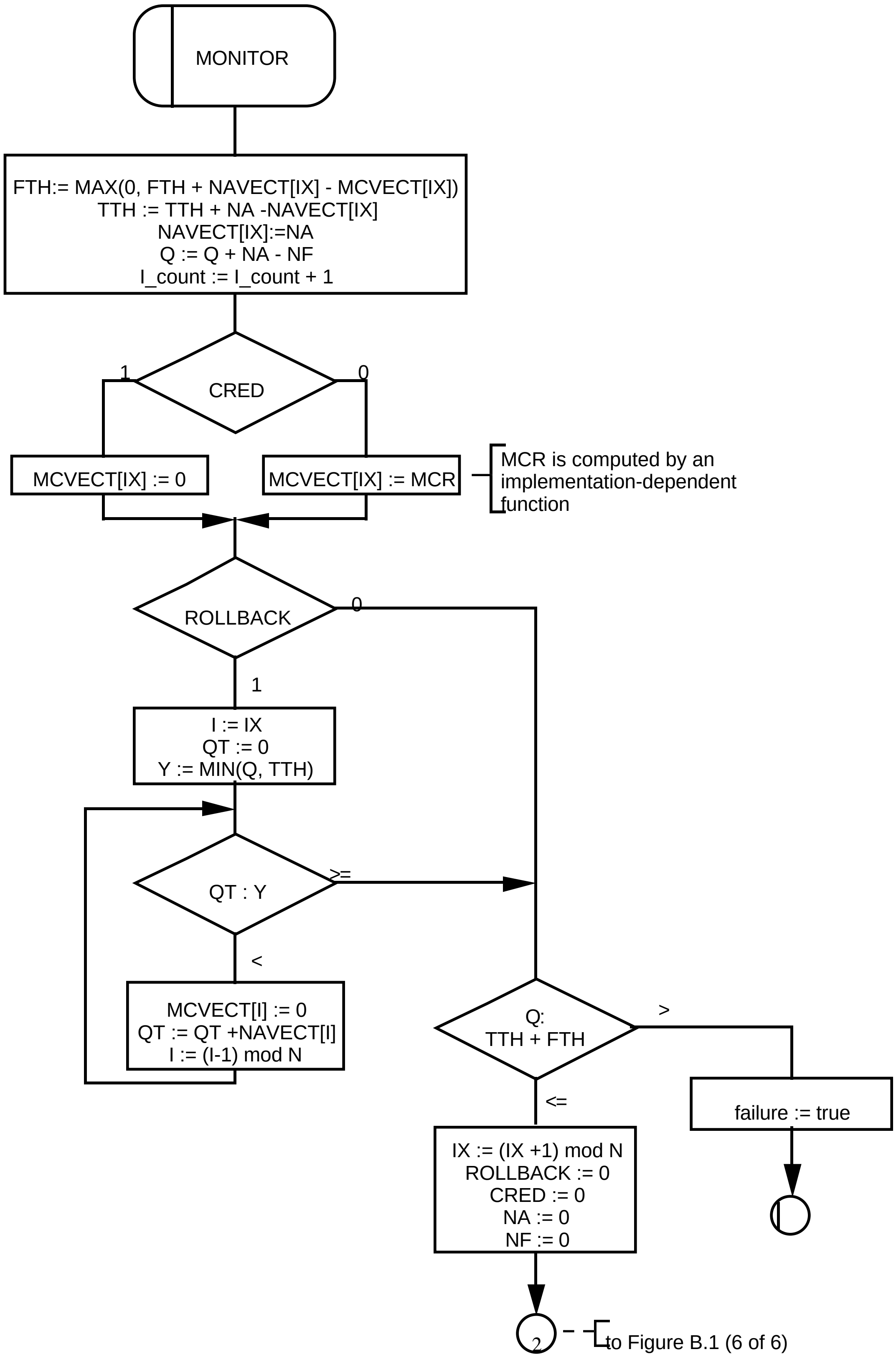


Figure B.1 – Error Monitor (sheet 5 of 6)

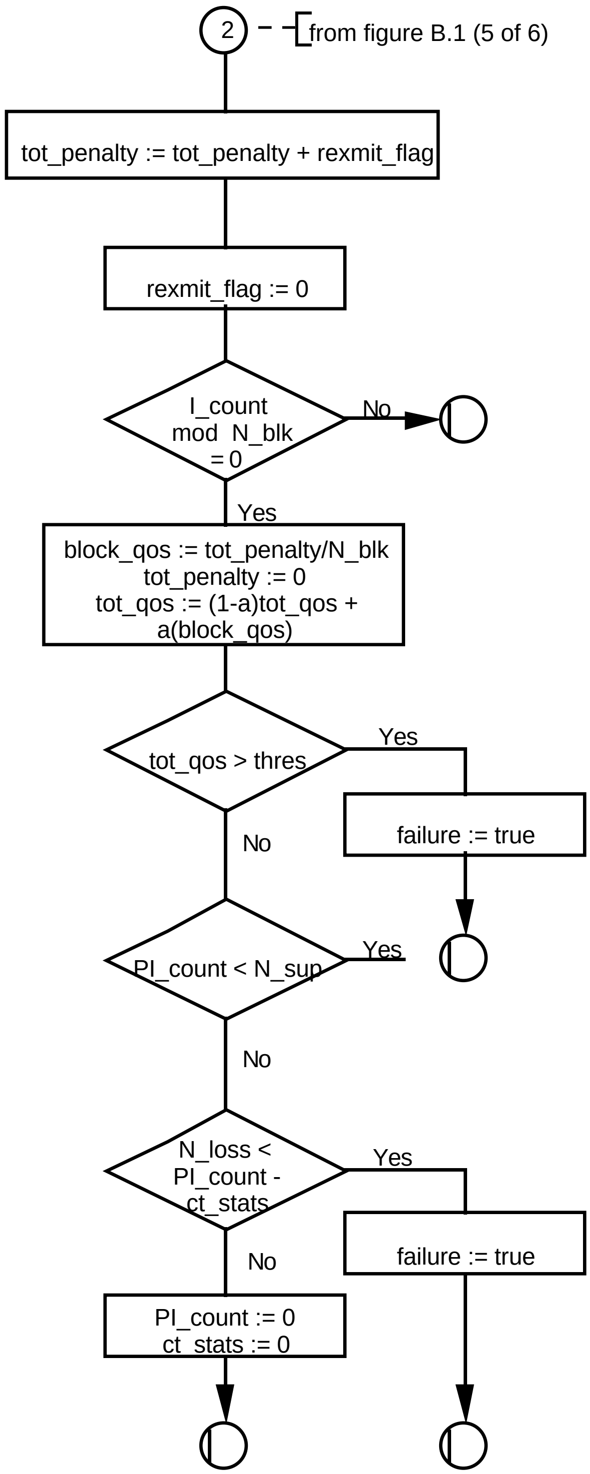


Figure B.1 – Error Monitor (sheet 6 of 6)

Annex C
(normative)

Differences between this standard and ITU-T Recommendation Q.2144

This standard is aligned with ITU-T Recommendation Q.2144 except that the example error monitor of Q.2144 is specified as a reference algorithm in annex B of this standard. The possibility of the event "Signaling link performance below the acceptable level" occurring while Layer Management is in the Proving state is clearly stated in table 3. Although the error monitor variable "CRED" is the same in this standard as in ITU-T Recommendation Q.2144, its description in annex B is updated to say that information beyond that provided in MAA-ERROR.indications is needed to maintain this variable.

In addition, wherever ITU-T Recommendation Q.2144 refers to other ITU-T recommendations, this standard instead refers to appropriate American National Standards when such standards exist with the equivalent information. References to American National Standards rather than to ITU-T recommendations do not cause any changes to the procedures of layer management.

Annex D
(informative)

Management error indications

A number of events will cause errors to be submitted to the layer management entity. The associated error parameter contains the error code that describes the specific error conditions.

The column entitled “Error condition” describes specific protocol error events when the MAA-ERROR.indication primitive is generated. Should differences be detected between this description of the management error indications and the specification comprised in annex A of ANSI T1.637, the specification of ANSI T1.637 takes precedence.

Error type	Error code	Error condition
Receipt of unsolicited or inappropriate PDU	A	SD PDU
	B	BGN PDU
	C	BGAK PDU
	D	BGREJ PDU
	E	END PDU
	F	ENDAK PDU
	G	POLL PDU
	H	STAT PDU
	I	USTAT PDU
	J	RS
	K	RSAK PDU
	L	ER
	M	ERAK
Unsuccessful retransmission	O	VT(CC) >= MaxCC
	P	Timer_NO-RESPONSE expiry
Other list elements error type	Q	SD or POLL, N(S) error
	R	STAT N(PS) error
	S	STAT N(R) or list elements error
	T	USTAT N(R) or list elements error
	U	PDU length violation
SD loss	V	SD PDUs must be retransmitted
Credit condition	W	Lack of credit
	X	Credit obtained

Annex E
(informative)

Bibliography

The following standards and ITU-T recommendations contain provisions which assist in the proper understanding of this American National Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

ANSI T1.111-1996, *American National Standard for Telecommunications – Signaling System Number 7 (SS7) – Message Transfer Part*

ITU-T Recommendation Q.750 (1993), *Overview of Signaling System No. 7 Management*

ITU-T Recommendation Q.752 (1993), *Monitoring and Measurements for Signaling System No. 7*