EN 301 167 V1.1.1 (1998-08)

European Standard (Telecommunications series)

Transmission and Multiplexing (TM);
Management of Synchronous Digital Hierarchy (SDH) transmission equipment;
Fault management and performance monitoring;
Functional description

Reference

DEN/NA-042137 (at000ico.PDF)

Keywords

management, SDH, TMN, transmission, transport

ETSI

Postal address

F-06921 Sophia Antipolis Cedex - FRANCE

Office address

650 Route des Lucioles - Sophia Antipolis
Valbonne - FRANCE
Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16
Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Internet

secretariat@etsi.fr
http://www.etsi.fr
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Foreword

This European Standard (Telecommunications series) has been produced by ETSI Technical Committee Network Aspects (NA).

The present document specifies the fault management and performance monitoring aspects of the Synchronous Digital Hierarchy (SDH) transmission equipments.

National transposition dates	
Date of adoption of this EN:	7 August 1998
Date of latest announcement of this EN (doa):	30 November 1998
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	31 May 1999
Date of withdrawal of any conflicting National Standard (dow):	31 May 1999

1 Scope

The present document specifies the functional requirements for fault management and performance monitoring aspects of SDH equipments.

The Telecommunications Management Network (TMN) provides management functions which cover the planning, installation, operations, administration, maintenance and provisioning of telecommunications networks and services. ITU-T Recommendation M.3010 [1] proposes five management functional areas identified as follows:

- Fault management;
- Performance management;
- Configuration management;
- Security management;
- Accounting management.

The present document provides guidance and supporting information for the functional specification for the first two of these management areas.

The TMN functionality is realized by means of processes in Equipment Management Function (EMF) in Network Elements (NE), Element Management Systems (EMS) and Network Management Systems (NMS) or Operation Systems (OS).

The present document fully specifies the EMF functionalities. NMS/OS functionalities are described only if needed for clarification.

2 Normative references

References may be made to:

a) specific versions of publications (identified by date of publication, edition number, version number, etc.), in which case, subsequent revisions to the referenced document do not apply; or

b) all versions up to and including the identified version (identified by "up to and including" before the version identity); or

c) all versions subsequent to and including the identified version (identified by "onwards" following the version identity); or

d) publications without mention of a specific version, in which case the latest version applies.

A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

[1] ITU-T Recommendation M.3010: "Principles for a Telecommunications management network".

[2] ITU-T Recommendation M.20: "Maintenance philosophy for telecommunications networks".

[3] ETS 300 417: "Generic functional requirements for Synchronous Digital Hierarchy (SDH) equipment".

[4] ITU-T Recommendation M.3100: "Generic network information model".

[5] ITU-T Recommendation X.733: "Data networks and open system communications OSI management. Information technology – Open Systems Interconnection – Systems Management: Alarm reporting function".

[6] ITU-T Recommendation X.734: "Data networks and open system communications OSI management. Information technology – Open Systems Interconnection – Systems Management: Event report management function".

[7] ITU-T Recommendation X.735: "Data networks and open system communications OSI management. Information technology – Open Systems Interconnection – Systems Management: Log control function".

[8] ITU-T Recommendation G.826: "Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate".

[9] ETS 300 416: "Availability performance of path elements of international paths".

[10] ITU-T Recommendation M.2120: "PDH path, section and transmission system and SDH path and multiplex section fault detection and localization procedures".

[11] ITU-T Recommendation M.2101: "Performance limits for bringing-into-service and maintenance of international SDH paths, sections and transmission systems".

[12] EN 301 129: "Transmission and Multiplexing (TM); Digital Radio Relay Systems (DRRS); Synchronous Digital Hierarchy (SDH); System performance monitoring parameters of SDH DRRS".

[13] ITU-T Recommendation G.707: "Network node interface for the synchronous digital hierarchy (SDH)".

[14] ITU-T Recommendation M.2110: "Bringing-into-service of international PDH paths, sections and transmission systems and SDH paths and multiplex sections".

[15] ITU-T Recommendation G.783: "Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks".

[16] ITU-T Recommendation G.784: "Synchronous digital hierarchy (SDH) management".

3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AIS	Alarm Indication Signal
AR	Availability Ratio
AU	Administrative Unit
BBE	Background Block Error
BBER	Background Block Error Ratio
BIP	Bit Interleaved Parity
CSES	Consecutive SES
EB	Errored Block
EDC	Error Detection Code
EMF	Equipment Management Function
EN	European Norme
ES	Errored Second
ESR	Errored Second Ratio
FE BBE	Far-End Background Block Error
FE ES	Far-End Errored Second
FE SES	Far-End Severely Errored Second
FFS	For Further Study
HP	High order Path
LOF	Loss Of Frame
LOM	Loss Of Multiframe
LOP	Loss Of Pointer
LOS	Loss Of Signal
LP	Low order Path

MO	Mean time between digital path Outage
MP	Management Point
MS	Multiplex Section
NE	Network Element
NE BBE	Near-End Background Block Error
NE ES	Near-End Errored Second
NE SES	Near-End Severely Errored Second
NMS	Network Management System
OI	Outage Intensity
OS	Operation System
PJE	Pointer Justification Event
PLM	Path Label Mismatch
PS	Protection Switch
PSC	Protection Switch Count
PSD	Protection Switch Duration
RDI	Remote Defect Indication
REI	Remote Error Indication
RS	Regenerator Section
SDH	Synchronous Digital Hierarchy
SEMF	Synchronous Equipment Management Function
SES	Severely Errored Second
SESR	Severely Errored Second Ratio
STM-n	Synchronous Transfer Module n
TMN	Telecommunication Management Network
VC	Virtual Container
UNEQ	Unequipped
UTC	Universal Time Co-ordinated

4 Fault management

Fault management is a set of functions which enables the detection, isolation and correction of abnormal operation of the telecommunication network and its environment.

4.1 Purpose

This subclause describes the generic process of alarm handling in SDH network element.

4.2 Additional definitions

These definitions have been derived from ITU-T Recommendation M.20 [2].

fault: A fault is the inability of a function to perform a required action. This does not include an inability due to preventive maintenance, lack of external resources, or planned actions.

anomaly: The smallest discrepancy which can be observed between the actual and desired characteristics of an item. The occurrence of a single anomaly does not constitute an interruption in the ability to perform a required function. Anomalies are used as the input for the performance monitoring process and for the detection of defects.

defect: The density of anomalies has reached a level where the ability to perform a required function has been interrupted. Defects are used as input for performance monitoring, the control of consequent actions, and the determination of Fault Cause (FC).

fault cause: A single disturbance or fault may lead to the detection of multiple defects. A FC is the result of a correlation process which is intended to pinpoint the defect that is representative of the disturbance or fault that is causing the problem.

failure: The FC persisted long enough to consider the ability of an item to perform a required function to be terminated. The item may be considered as failed; a fault has now been detected.

alarm: A human observable indication that draws attention to a failure (detected fault) usually giving an indication of the severity of the fault.

4.2.1 Functional architecture

The functional architecture is depicted in figure 1.

Anomaly processing, defect filtering, consequent action functional blocks are defined in ETS 300 417 [3].

Fault cause persistency, which allows the NE to wait a certain amount of time before to entering in the failure state and therefore it conditions the generation of alarms. The persistency time needed to declare a failure is settable in dependence of defect characteristics (toggling, stable, ...). Only a defect which passes that filter could be subsequently reported as an alarm.

A failure shall be declared if the fault cause persists continuously for X seconds. The failure shall be cleared if the fault cause is absent continuously for Y seconds. X and Y shall be within the range between 100 ms and 30 s in steps of Z ms. The incremental value Z shall follow a logarithmic scale (for further study). It is recommended that X < = Y.

Severity assignment, which is used to assign the management perception of the severity of a Fault which could depend on the service dependency of the fault, a non service affecting Fault will be alarmed with a severity of Warning or Minor, while a service affecting fault will be reported with a severity of Major or Critical. A service independent fault will be alarmed with any value of the severity. This is an information that is provided by the OS (refer to ITU-T Recommendation. M.3100 [4]).

Station alarm, represents the synthesis of alarm for purpose of audible and visual indication to a human operator in the station. Station alarms can be suppressed by management operations.

Unit alarm represents the synthesis of alarm on replaceable unit basis, the unit could be a board, sub-rack, etc.

Alarm notification, represents the ability to generate alarm. For more details refer to ITU-T Recommendation. X.733 [5].

Alarm filtering, which is used to filter the alarm depending on the contents of the alarm such as the type and cause of the alarm, the source of the alarm, the severity, the correlation information etc. prior to report and/or log alarms. Alarm filtering is different for logging and reporting.

Alarm logging and **alarm reporting**. alarm reporting allows the reporting of those alarms which have passed the alarm filtering process to a single or multiple destinations. for more details refer to ITU-T Recommendation.X.734 [6] and ITU-T Recommendation. X.735 [7].

4.2.2 Alarm information description and management

This subclause aims to classify alarms in terms of severity, type, probable cause, etc. Furthermore, basic principles of alarm management should be identified.

The above issues need further study.

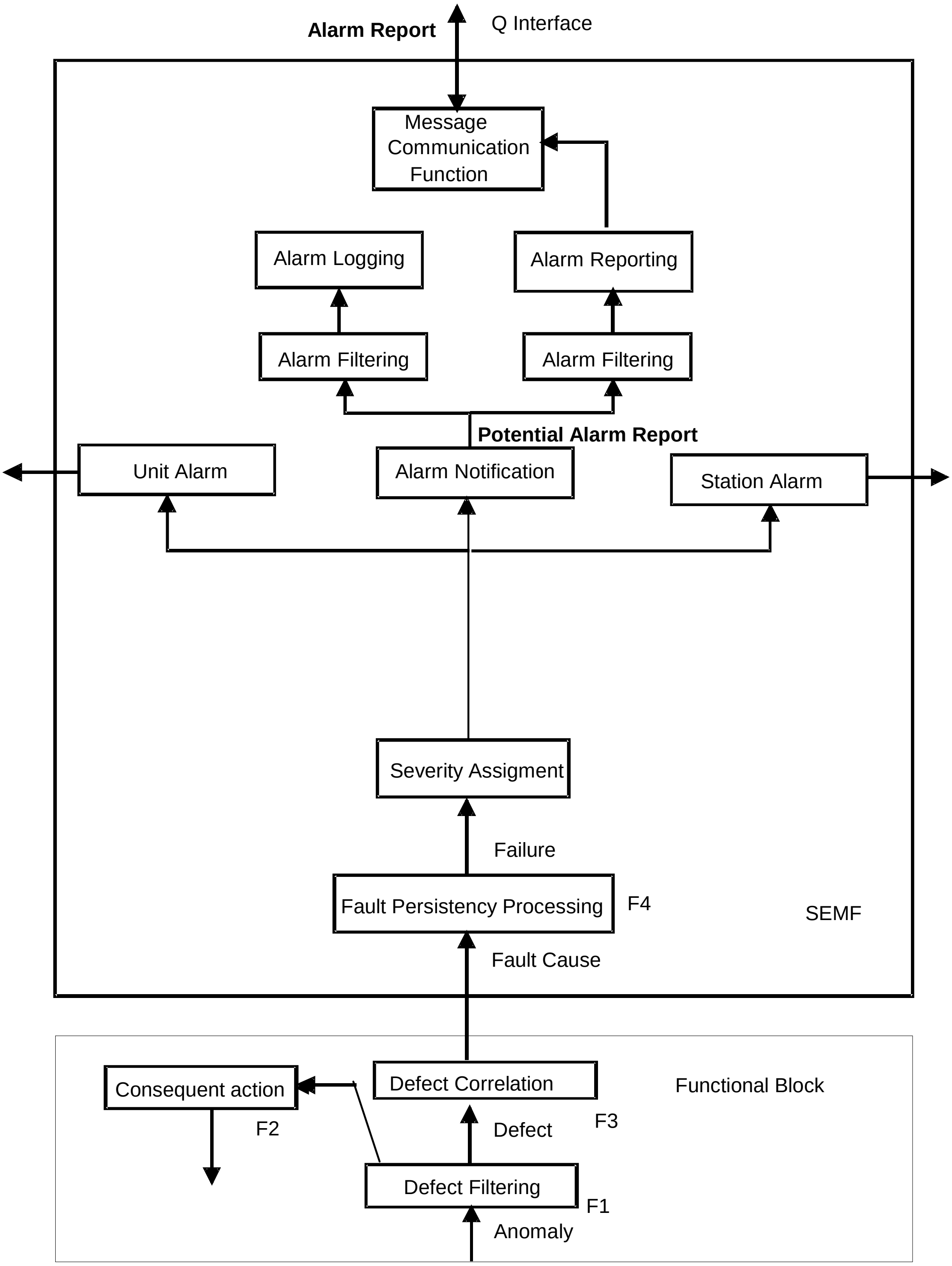


Figure 1: Fault management

4.3 Time stamping

Fault cause notification implies the time-stamping of its activation/deactivation time. The stamped time shall be the one indicated by the local real time clock of NE. The time-stamping shall have a resolution of one second with respect to the NE clock. The relationship between the time given by a particular NE and the Universal Time Co-ordinated (UTC) is for further study.

5 Performance monitoring

Performance monitoring is important part of the performance management, that provides functions to evaluate and report upon the behaviour of telecommunication equipment and the effectiveness of the network or network element. Its role is to provide information for maintenance purposes and for network error performance evaluation.

The performance monitoring requirement is generic in that it defines the parameters for paths and sections independent of the physical transport network providing the paths.

ITU-T Recommendation. G.826 [8] defines error performance parameters and objectives for international digital paths at or above the primary rate. It is worthwhile noticing that ITU-T Recommendation. G.826 [8] is only applicable to path layer and no direct allocation of the objectives can be derived for NEs.

All the SDH equipments are described in terms of functional blocks, so a minimum set of parameters common to all equipments will be used.

5.1 General principles

5.1.1 Generic definition of the block

The error performance parameters are based upon the measurement of blocks defined as follows:

A block is a set of consecutive bits associated with the path and the section; each bit belongs to one and only one block. Consecutive bits may not be contiguous in time.

Subclauses 5.2.1, 5.3.1 and 5.4.1 contain definition of block sizes for paths, multiplex and regenerator sections.

5.1.2 In-service monitoring

Each block is monitored by means of an inherent Error Detection Code (EDC), e.g. Bit Interleaved Parity (BIP). The EDC bits are physically separated from the block to which they apply. If there is a discrepancy between the EDC and its controlled block, it is always assumed that the controlled block is in error, because usually it is not possible to determine whether a block or its controlling EDC is in error.

Estimation of errored blocks on an in-service basis is dependent upon the type of EDC available.

5.1.3 Out-of-service monitoring

The out-of-service monitoring can be used for Bringing-Into-Service (BIS) purposes of trails. The description of BIS is recommended in ITU-T M-Series recommendations and it is outside of the scope of the present document.

The out-of-service monitoring can be performed by using the same approach as for the in-service monitoring.

5.1.4 Error performance events and parameters

Error performance parameters are evaluated from the following error performance events:

- **EB** - **Errored Block**. A block in which one or more bits are in error.
- **ES** - **Errored Second**. A one-second period with at least one errored block or at least one defect.
- **SES** - **Severely Errored Second**. A one-second period which contains ≥ X % errored blocks or at least one defect. An SES is also an ES.
- **BBE** - **Background Block Error**. An errored block not occurring as part of an SES.

The defects and performance criteria are listed in the relevant sections. The value of X is given in subclause 5.2.2 for Path, in subclause 5.3.2 for Multiplex Section (MS) and subclause 5.4.2 for Regenerator Section(RS).

The error performance parameters are:

- **ESR** - **Errored Second Ratio**. It is the ratio of ES in available time to total seconds in available time during a fixed measurement interval.
- **SESR** - **Severely Errored Second Ratio**. It is the ratio of SES in available time to total seconds in available time during a fixed measurement interval.
- **BBER** - **Background Block Error Ratio**. It is the ratio of errored blocks in available time to total blocks during a fixed measurement interval, excluding all blocks during SES and unavailable time.

These parameters shall only be evaluated during the available periods. For a definition of the entry to/exit from criteria for the unavailable state see subclause 5.1.5.

5.1.4.1 Determination of error performance events and parameters

Error performance events defined in subclause 5.1.4 are determined by anomalies (errored blocks) or by defects. The procedure to determine the error performance events is shown in figure 2. The shown diagram is intended to be a simplified version to explain the relationship between anomalies, defects and error performance events. The diagram is applicable to a uni-directional trail.

cES, cSES and cBBE represent counts of ES, SES, BBE respectively. These counts are reset at the start of a measurement period.

EB is the count of errored blocks within an ES whilst % EB represents the proportion of errored blocks within an ES compared to the number of blocks per second.

In figure 1 the entering/exiting processes to/from unavailable state are not described. Furthermore for figure 2 it is evident that if the trail is in unavailable state no counter need to be updated. In practice, the status of a second (i.e. error-free, ES or SES) shall always be determined before testing the status of path availability. In other words, error events are always detected regardless of whether the path is available or not - only the *counting* of events is inhibited during unavailability periods for the purposes of long-term performance monitoring. This process is reflected in the flow chart although consequent actions on changes of availability state are not.

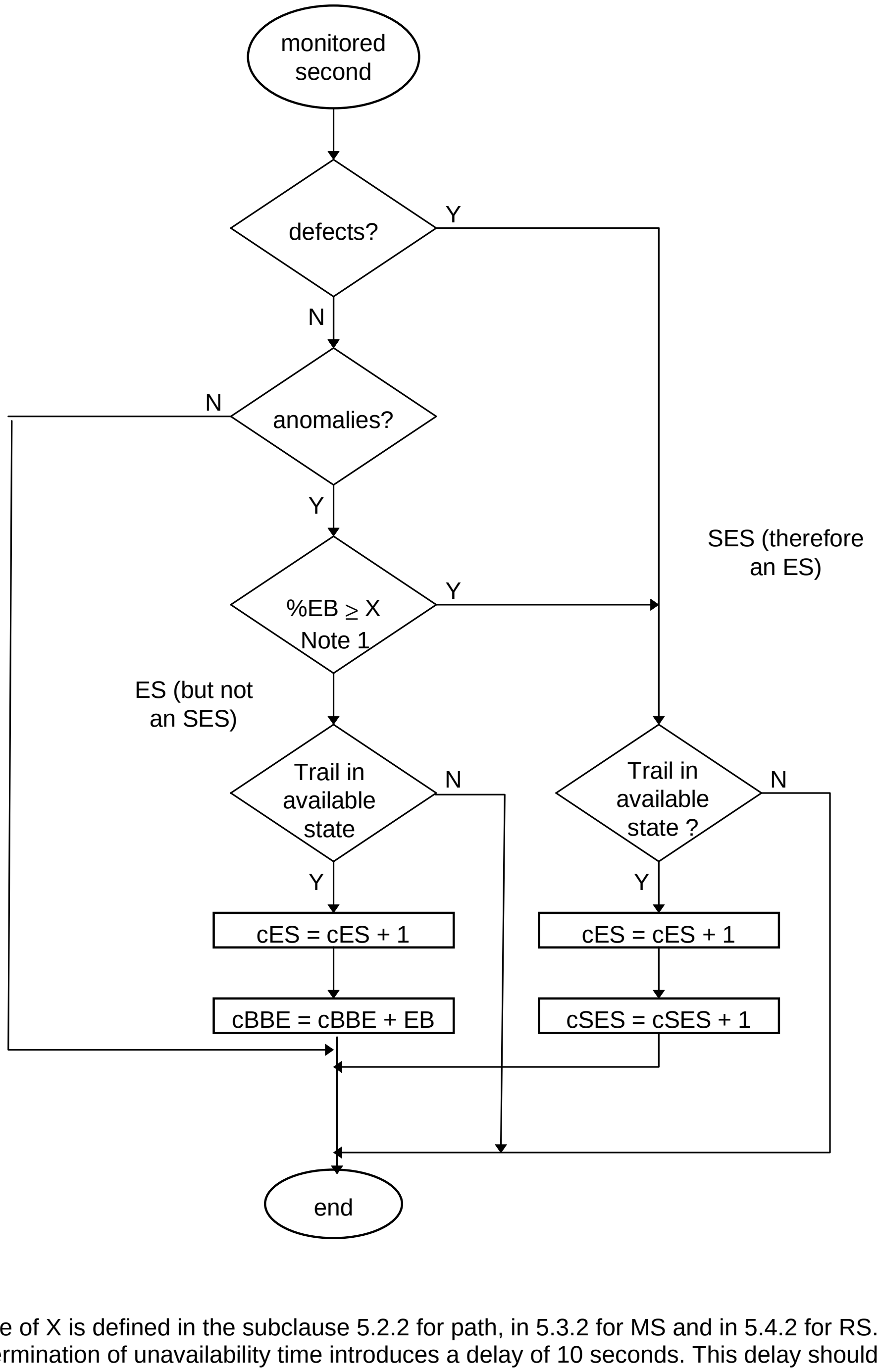
In case of path, error performance parameters can be evaluated during, or at the end of, a measurement period P as follows:

$$BBER = cBBE \Big/ \left[\left(P - UAS - cSES \right) \text{x} \left(\text{block per second} \right) \right] \quad (1)$$

$$ESR = cES \Big/ \left(P - UAS \right) \quad (2)$$

$$SESR = cSES \Big/ \left(P - UAS \right) \quad (3)$$

Performance parameters of a path uni- or bi-directional are determined by means of the information at the near-end and at the far-end. When a near-end SES is caused by a near-end defect, the far-end performance can not be evaluated during that second. When a near-end SES is resulting from ≥ 30 % errored blocks, which does not cause a near-end defect contributing to performance monitoring, the far-end performance evaluation continues during the near-end SES (the Near-End and Far-End information are defined in subclause 5.1.7.3).



NOTE 1: The value of X is defined in the subclause 5.2.2 for path, in 5.3.2 for MS and in 5.4.2 for RS.

NOTE 2: The determination of unavailability time introduces a delay of 10 seconds. This delay should be considered when counting BBE, ES and SES.

Figure 2: Flow chart illustrating the evaluation of error performance events by means of defects and anomalies

5.1.5 Definition of unavailability

A period of unavailable time begins at the onset of ten consecutive SES events. These ten seconds are considered to be part of unavailable time. A new period of available time begins at the onset of ten consecutive seconds, none of which is SES. These ten seconds are considered to be part of available time.

An example of determination of unavailable period is given in figure 3.

Those criteria are given for a single direction. Unavailability criteria for a path or a section are defined in specific clauses in the present document.

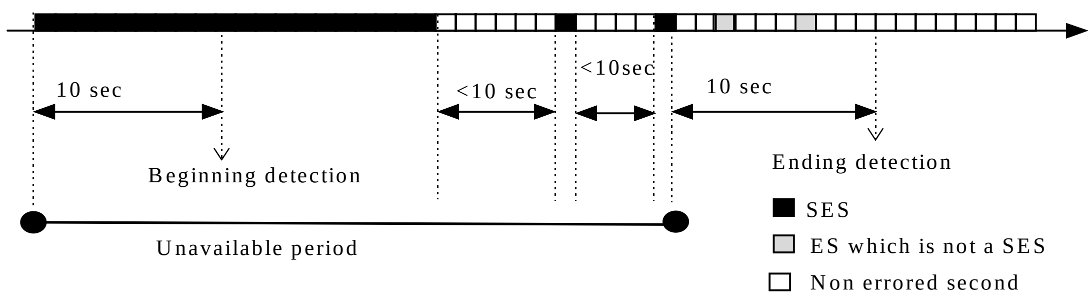


Figure 3: Example of unavailability period determination

5.1.6 Unavailability parameters

Unavailability parameters are given in ETS 300 416 [9] and they are:

- **AR** - **Availability Ratio**. It is the proportion of time that a path or a section is in the available state during an observation period. AR is calculated by dividing the total available time during the observation period by the duration of the observation period.

- **OI** - **Outage Intensity**. It is the number of unavailable period in the observation time.

NOTE: The reciprocal of OI parameter, Mean time between digital path Outages (MO) can be used for design, measurement and maintenance applications.

These parameters are evaluated by the OS. As an example they can be evaluated by means of the date-time stamping of the beginning and ending of unavailable periods recorded in the equipment.

The notifications have to be sent to the OS for the beginning and ending of unavailable periods.

5.1.7 Performance data collection

Two types of performance information collection are defined:

- the collection as specified in ITU-T Recommendation M.2120 [10], i.e. based on information of each direction of transport separately. It is further on referred to as uni-directional history management. This is for maintenance application.

- the collection as specified in ITU-T Recommendation G.826 [8], i.e. based on information of both directions of transport together. It is further on referred to as bi-directional history management. This is for performance application.

The history registers in NEs are suitable for fault location procedure. Any collection of data for long term analysis (e.g. 1 month data collection for performance evaluation) can be performed by the NMS/OS.

Data collection for maintenance and performance purposes require different sets of registers, if both options are implemented in the same trail.

This description of performance information collection is a generic requirement. Its application to paths or sections is defined in specific clauses hereafter.

5.1.7.1 Data collection for maintenance purposes

The 15 minute and 24 hour registers are defined for in-service measurement and for maintenance purposes.

A 15 minute period has been recognized suitable to undertake maintenance action, if needed, in the short period. A 24 hour period has been recognized suitable to detect long term degradation in the network. The maintenance procedure are recommended in ITU-T Recommendations M.2120 [10] and M.2101 [11].

Each performance event is counted, during available time, over two different periods of time of 15 minutes and 24 hours respectively. The register containing the count of present period is usually called "current register".

In any NE the periods of 15 minutes for the counting of all performance events start synchronously.

In any NE the periods of 24 hours for the counting of all performance events start synchronously.

Anyway, it shall be possible to reset an individual current register to zero by means of an external command coming from the OS.

These counters operate as follows:

- 15 minute register

At the beginning of a counting interval the register shall be reset to zero. At the end of the period, the non-zero counts are stored in registers in the Network Element (NE). Each 15 minute period is identified with a time stamp (see subclause 5.1.11).

- 24 hour register

Performance events are counted separately over a consecutive periods of 24 hours each, by cumulating 15 minute period counts. It is not required to update 24 hour current register on second by second basis.

At the beginning of a counting interval the register shall be reset to zero. The non-zero counts are stored in registers in the Network Element (NE). Each 24 hour period is identified with a time stamp (see subclause 5.1.11).

5.1.7.2 Data collection for error performance purposes

Performance events are counted separately over a consecutive period of 24 hours each. At the end of the current 24 hour period, the counts are stored in historical registers and the current 24 hour counts reset to zero.

The counting is stopped during unavailability period.

It shall be possible to reset an individual current register to zero by means of an external command coming from the OS.

This is essentially applicable to the path performance application according to ITU-T Recommendation. G.826 [8].

5.1.7.3 Performance monitoring history

The concepts of "Near-End" and "Far-End" performance monitoring are used to refer to performance monitoring information associated with the two directions of transport. For a trail from A to Z:

- at node A the near-end information represents the performance of the unidirectional trail from Z to A, while the Far-End information represents the performance of the unidirectional trail from A to Z;

- at node Z the near-end information represents the performance of the unidirectional trail from A to Z, while the Far-End information represents the performance of the unidirectional trail from Z to A.

At either end of the trail (A or Z) the combination of near-end and far-end information presents the performance of the two directions of the trail.

At node A (or Z) the near-end error performance events, Near-End ES (NE ES), Near-End SES (NE SES), and Near-End BBE (NE BBE) are derived by means of the near-end information at local node A (or Z). At node A (or Z) the far-end error performance events, Far-End ES (FE ES), Far-End SES (FE SES), Far-End BBE (FE BBE) are derived by means of far-end information at node A (or Z).

- *Uni-directional history management*

Performance events are counted during available time over periods of 15 minutes and 24 hours.

The 15 minute registers form a stack of at least 17 registers, one current and 16 recent. At the end of the 15 minute period, the content of the current 15 minute register is transferred to the first of the recent registers, with a time-stamp to identify the particular 15 minute period. When all of the 15 minute recent registers are full, a wrapping mechanism is used to discard the oldest information.

NOTE: Wrapping is the deletion of the earliest record to allow a new record when all registers are full.

The 24 hour registers form a stack of two registers, one current and one recent. The current 24 hour register shall be reset to zero at the end of each 24 hour period, after the data have been transferred to the recent 24 hour register.

These registers will be provided per performance event and per direction of transmission. The uni-directional performance monitoring in based on counts of Near-end performance events. This is the uni-directional history management and it is illustrated in figure 4.

Performance events (BBE, ES, SES) counts may be monitored for a threshold crossing as specified in subclause 5.1.8.

- *Bi-directional history management*

Performance events are counted during available time over periods of 24 hours.

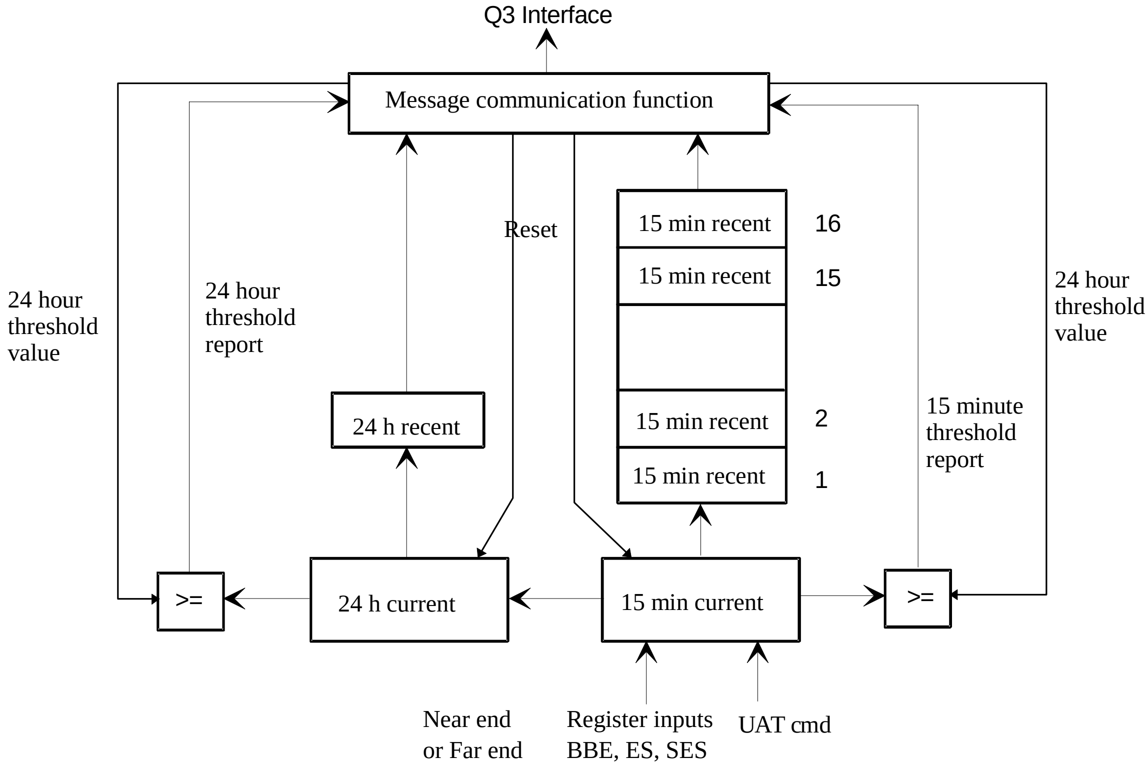
The 24 hour registers form a stack of 2 registers, one current and one recent. The current 24 hour register shall be reset to zero at the end of each 24 hour period, after the data have been transferred to the recent 24 hour register.

The bi-directional performance monitoring in based on counts of Near-end and Far-end performance events The bi-directional history management is illustrated in figure 5. It is essentially applicable to the path performance evaluation. For uni-directional path near-end data collection is applicable only.

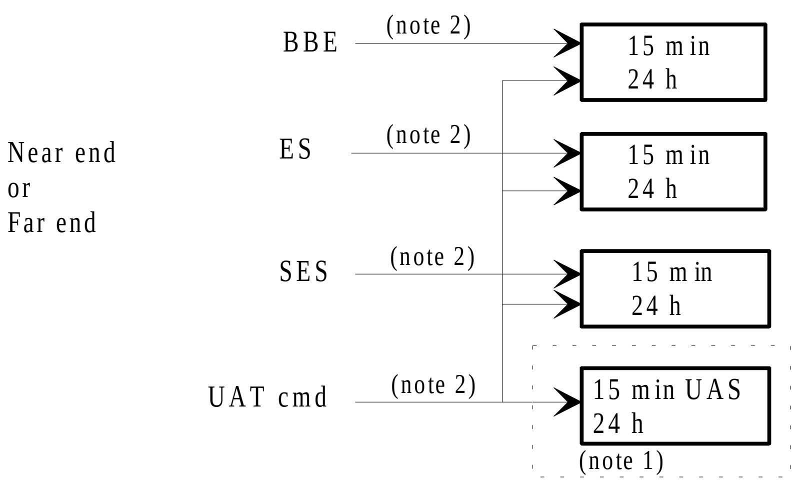
- *Reporting*

Performance data stored in registers may be collected by the OS for analysis without affecting the content of the register, when requested by the OS, periodically or upon the crossing or reaching of a performance monitoring threshold.

Performance events (BBE, ES, SES) counts may be monitored for a threshold crossing as specified in subclause 5.1.8.



A)

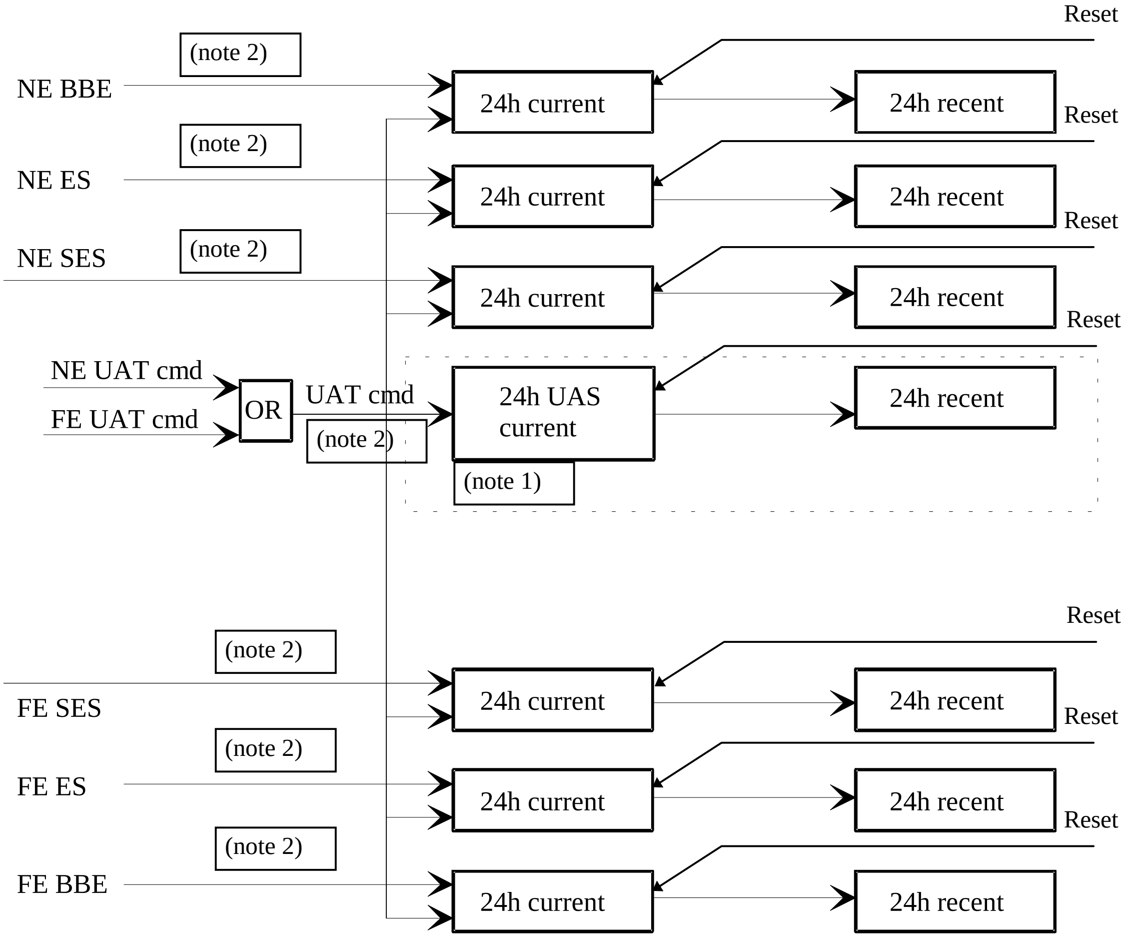


NOTE 1: The UAS register is optional.

NOTE 2: The determination of unavailable time introduces a delay of 10 seconds. This delay should be considered when counting BBE, ES and SES.

B)

Figure 4: A) Registers process for maintenance purposes B) Uni-directional history management



NOTE 1: The UAS register is optional

NOTE 2: The determination of unavailable time introduces a delay of 10 seconds. This delay should be considered when counting BBE,ES and SES.
NE SES, NE BBE, NE ES - Near-End performance parameter
FE SES, FE BBE, FE ES - Far-End performance parameter

NOTE 3: For uni-directional path near-end data collection is applicable only.

Figure 5: Registers process for performance purposes

5.1.8 Performance filtering and thresholding

The performance filtering and thresholding mechanism should be used for maintenance application only.

5.1.8.1 15-minute treatment

A threshold can be crossed at any second within the 15 minute fixed window. As soon as a threshold is reached or crossed for a given performance event, a threshold report is generated. This is illustrated in figure 6.

Optionally a reset threshold should be supported. A reset threshold occurs at the end of the 15 minute period in which the count of performance event is less than the reset threshold value and there was not an unavailability period in the 15 minute period. It can only occur subsequently to a 15 minute period with a corresponding crossing threshold. No more than one threshold report shall be generated until there has been a 15 minute period with a count of performance events less than the reset threshold value. This is illustrated in figure 7, figure 8 and figure 9.

5.1.8.2 24 hour treatment

A threshold can be crossed at any 15 minute within the 24 hour fixed window. As soon as a threshold crossing is detected, a threshold report is generated. This is illustrated in figure 6.

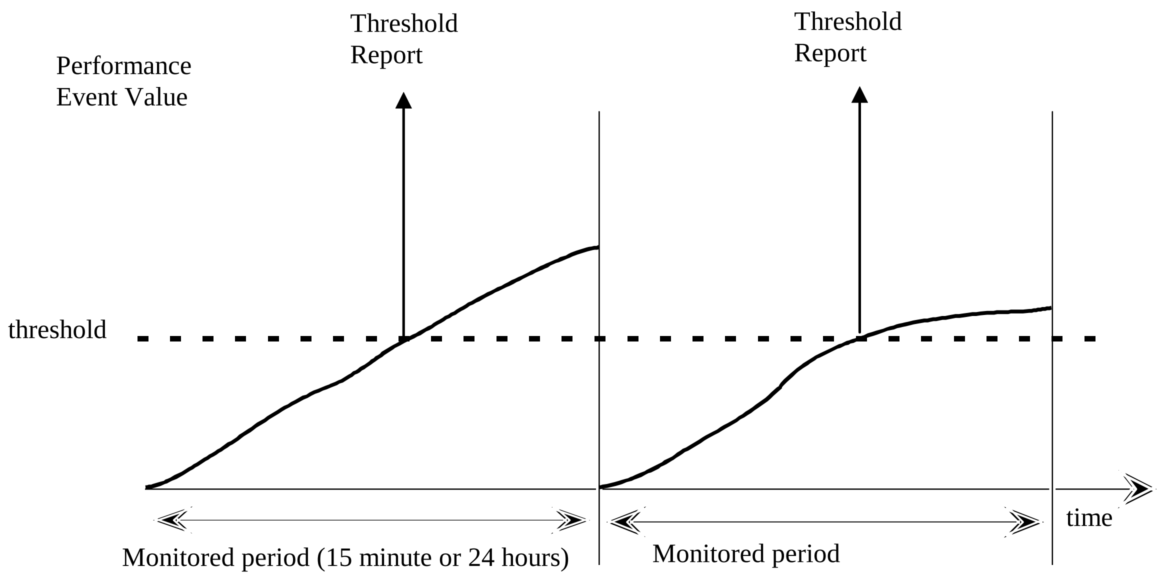


Figure 6: Threshold report for a performance event

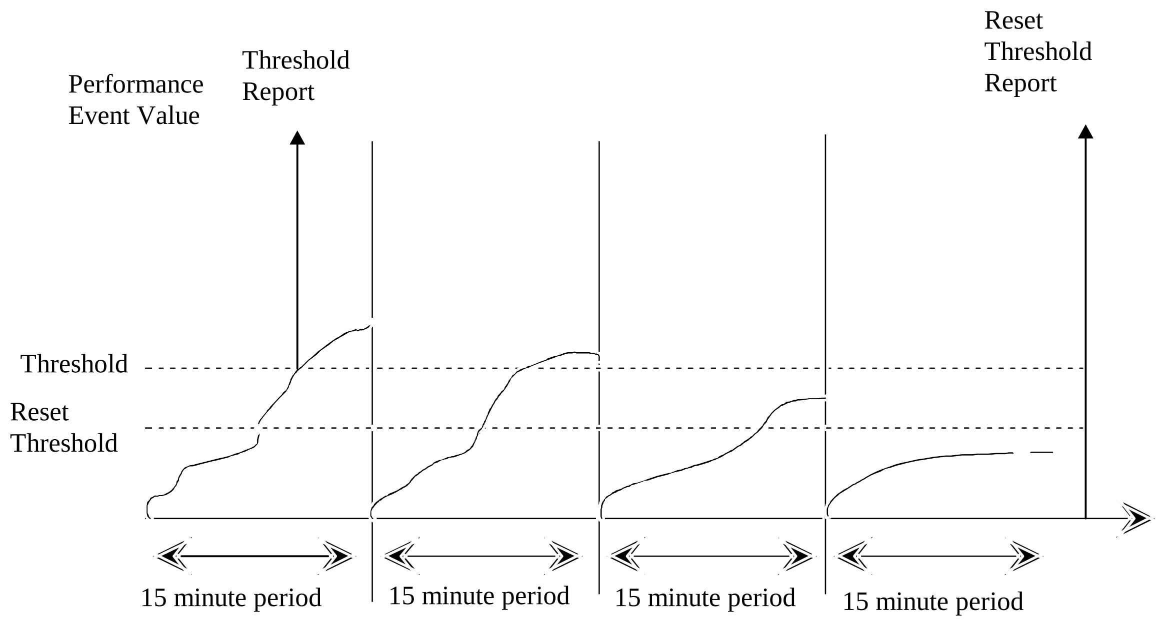


Figure 7: Threshold reports with reset threshold report

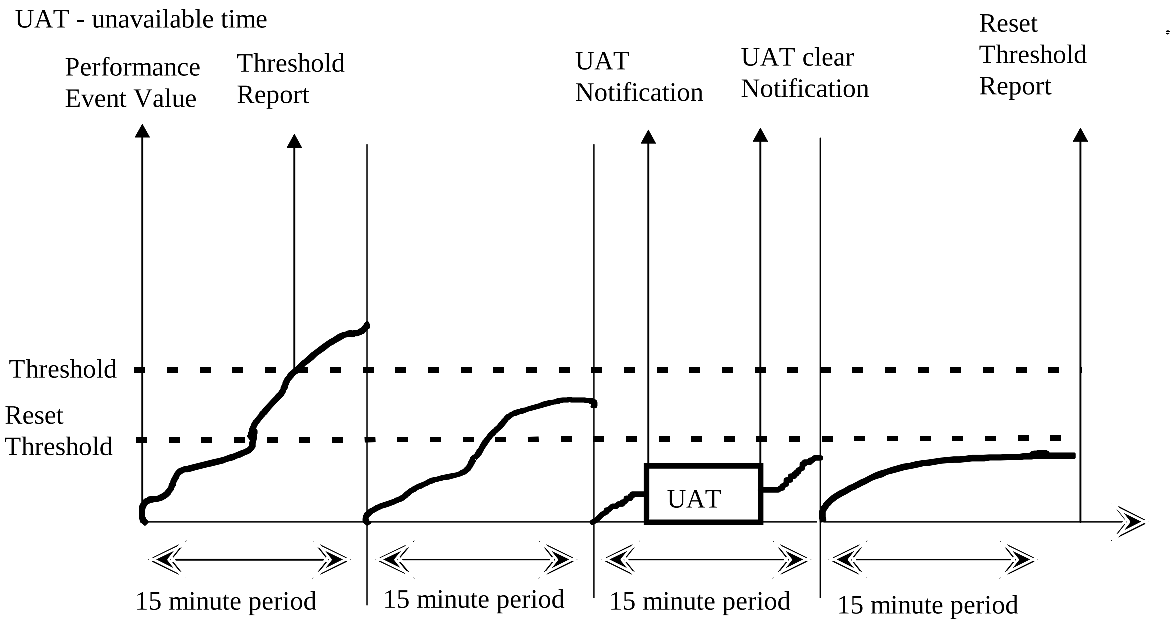
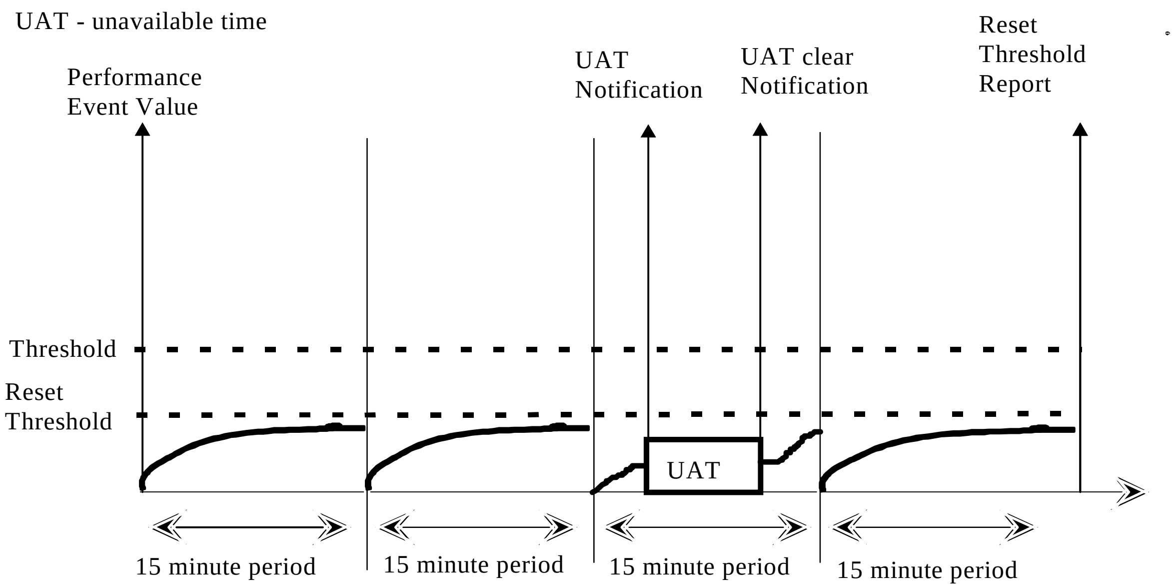


Figure 8: Notifications sent when there are a threshold crossing and an unavailable period



NOTE: No threshold notifications are sent in this case.

Figure 9: Notifications sent when there is an unavailable period

5.1.9 Synchronous Equipment Management Function (SEMF)

The SDH equipment functional blocks interact with the SEMF by exchanging information across the reference points Management Point (MP). The performance primitives detected in the atomic functions and exchanged across the MP reference points for performance management are described in ETS 300 417 [3]. The SEMF contains a number of registers to process and store performance information, based on the information received from the functional blocks.

The additional monitored events which are described in relevant clauses. The SEMF shall perform the monitoring history as described in subclause 5.1.7 and the performance filtering and thresholding described in subclause 5.1.8.

Anomaly processing, defect filtering and consequent action functional blocks are defined in ETS 300 417 [3].

The Unavailable State Control determines when a period of unavailable time begins and ends.

The Message Communication Function (MCF) provides facilities for the transport of TMN messages passed across Q interface to and from the Management Application Function (MAF), as well as facilities for the transit of messages.

5.1.10 Maintenance thresholds

Maintenance evaluation is done with the content of performance registers. Maintenance information is elaborated on thresholds reaching or crossing, as described in subclause 5.1.8.

Threshold values

The threshold values for performance events counted over 15 minutes and 24 hours should be programmable. The maximum threshold values are:

- for 15 minutes Register:
  a) 900 for the ES and SES events;
  b) 2^{16} - 1 for the BBE event in the case of Virtual Container (VC)-11 up to VC-4 paths;
  c) 2^{24} - 1 for the BBE event in the case of VC-4nc paths and STM-N (n and N $\leq$ 16) (note).

NOTE: The maximum values for BBE events for VCs and STM-N is smaller than the maximum number of BBEs that could be theoretically be detected in a 15 minute period.

- for 24 hour Register:
  a) 86 400 for ES and SES events;
  b) 2^{24} - 1 for the BBE event.

5.1.11 Time-stamping

Registers containing performance event counts shall be time stamped. The stamped time shall be the one indicated by the local real time clock of the NE. The time-stamping shall have a resolution of one second with respect to the NE clock. The relationship between the time given by a particular NE and the UTC is for further study.

The start of 15 minute and 24 hour counts should be accurate to within ± 10 seconds with respect to the NE clock. E.g., a 15 minute register may begin its 2:00:00 count between 1:59:50 and 2:00:10.

5.1.12 Additional performance events and parameters

The following additional performance events and parameters are defined:

- **Consecutive SES** (CSES)- the CSES event occurs when a sequence of X consecutive SES is detected with X in the range[2,9]. The sequence is terminated by an unavailable period or when a second that is not a SES is encountered.

- **Pointer Justification Events** (PJE) - this event happens when a justification indication is generated at the transmitted end.
  - PJE+ is the parameter that count PJE events due to a positive justification request.
  - PJE- is the parameter that count PJE events due to a negative justification request.

- **Protection Switch** (PS) - a PS event is declared when a protection switching system causes the service to be switched to or from a back-up or nominated protection line. This event may or may not cause a limited disruption to the digital path. This primitive is used to track the occurrence of the other performance events, which may have been caused by the protection switch event.
  - Protection Switch Count (PSC) definition is for further study.
  - Protection Switch Duration (PSD) definition is for further study.

Radio specific additional performance parameters are defined in EN 301 129 [12].

The additional performance parameters are optional and they are applicable to a specific SDH layer as defined in table 1.

When implemented, CSES are collected during available time. In bi-directional path CSES evaluation be accomplished for each direction independently. Consecutive SES are time stamped and stored. At least 6 time-stamped CSES event are recorded.

Table 1: Additional performance events and parameters

Additional performance parameters	RS	MS	High Order Path	Low Order Path
CSES	O	O	O	O
PJE+/PJE-			O	
PSC		O	FFS	FFS
PSD		O	FFS	FFS
NOTE: O stands for optional.				

5.2 Performance monitoring of SDH paths

Performance monitoring of paths is defined according to subclause 5.2. Performance parameters are defined in terms of errored blocks and defects.

5.2.1 Block definition

In accordance with ITU-T Recommendation G.826 [8] table 2 defines, for each type of path, the block size and the associated error detection code.

Table 2: Block definition and associated error detection code.

VC-n	Nb bits/block	Nb blocks/s	Error detection code
VC-11	832	2 000	BIP-2
VC-12	1 120	2 000	BIP-2
VC-2	3 424	2 000	BIP-2
VC-3	6 120	8 000	BIP-8
VC-4	18 792	8 000	BIP-8
VC-4-4c	65 168	8 000	BIP-8

5.2.2 Error performance parameters

Error performance parameters are evaluated from the performance events EB, BBE and ES which are defined in subclause 5.1.4.

A SES event is defined as a one-second period which contains ≥ 30 % EB or at least a defect.

These parameters shall only be evaluated during the available periods.

The defects which trigger a ES, or SES events are listed in subclause 5.2.3.2.

5.2.3 Events and parameters determination

5.2.3.1 Anomalies

In-service anomaly conditions are used to determine the error performance of an SDH path. The following anomalies are defined:

- a_1 an EB as indicated by an EDC;
- a_2 path remote error indication (HP-REI, LP-REI).

5.2.3.2 Defects

In-service defect conditions is used by SDH equipments to determine performance events. The defects can be classified in the following categories:

- d_1 near-end defect;
- d_2 far-end defect.

The defects which determine error performance parameters and their classification is defined in table 3.

5.2.3.3 Determination of the performance events

In order to evaluate performance parameters, the performance events (EB, ES and SES) are determined with the observed anomalies and defects in the functional blocks of SDH equipments according the following definition:

ES: A near-end ES is observed when, during one second, at least one anomaly a_1, or one defect d_1 occurs.
A far-end ES is observed when, during one second, at least one anomaly a_2, or one defect d_2 occurs.
For the ES event, the actual count of EBs is irrelevant, it is only the fact that an EB has occurred in a second which is significant.

SES: A near-end SES is observed when, during one second, at least 30 % EBs (derived from anomaly $a_{1,}$) or one defect d_1 occurs.
A far-end SES is observed when, during one second, at least 30 % EBs (derived from anomaly a_2) or defect d_2 occurs.

BBE: A near-end BBE is observed when an anomaly a_1 occurs in a block not being part of an SES.
A far-end BBE is observed when an anomaly a_2 occurs in a block not being part of an SES.

The values of threshold of EBs for SES for each SDH path type are given in table 3.

Table 3: EB thresholds needed to declare SES according to the path type

Path Type	Threshold of EBs for SES (Number of Errored Blocks in one Second)
VC-11	600
VC-12	600
VC-2	600
VC-3	2 400
VC-4	2 400
VC-2-5c	600
VC-4-4c	FFS

When a near-end SES is caused by a near-end defect, the far-end performance can not be evaluated during that second. When a near-end SES is resulting from ≥ 30 % errored blocks, which does not cause a near-end defect contributing to performance monitoring, the far-end performance evaluation continues during the near-end SES.

Table 4: Information classification according to type and affected direction

Information	Indication type	Direction	Path order
EB	Anomaly	Near-End	High/Low Order
HP-REI	Anomaly	Far-End	High Order
LP-REI	Anomaly	Far-End	Low Order
AU-dLOP	Defect	Near-End	High Order
AU-dAIS	Defect	Near-End	High Order
HO-dTIM	Defect	Near-End	High Order
HO-dRDI	Defect	Far-End	High Order
HO-dUNEQ	Defect	Near-End	High Order
HO-dPLM	Defect	Near-End	Low Order
-dLOM	Defect	Near-End	Low Order
TU-dLOP	Defect	Near-End	Low Order
TU-dAIS	Defect	Near-End	Low Order
LO-dTIM	Defect	Near-End	Low Order
LO-dUNEQ	Defect	Near-End	Low Order
LO-dRDI	Defect	Far-End	Low Order

5.2.4 Unavailability of path

Definition of unavailability for a single direction is given in subclause 5.1.5. This is used from a maintenance point of view.

From a performance point of view a uni-directional path is in the unavailable state according the definition given in subclause 5.1.5, a bi-directional path is in the unavailable state according the definition given in subclause 5.2.4.2. The count of performance are inhibited during the unavailable time.

5.2.4.1 Criteria for a uni-directional path

The criterion for a uni-directional path is defined in subclause 5.1.5.

5.2.4.2 Criteria for a bi-directional path

A bi-directional path is in the unavailable state if one or both directions are in the unavailable state. This is illustrated in figure 10.

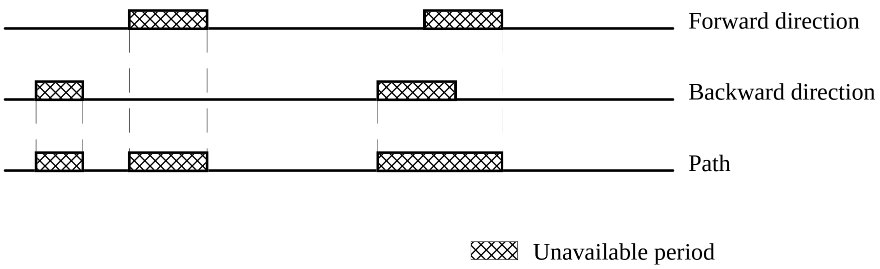


Figure 10: Example of bi-directional path unavailability determination

5.2.5 Data management

5.2.5.1 Performance monitoring history

Maintenance application

Performance events (ES, SES, BBE) are cumulated during available time over periods of time of 15 minutes and 24 hours.

All this information is stored in registers (17 registers of 15 minute threshold and 2 registers of 24 hour threshold). See figure 4a and figure 4b.

Performance application

For bi-directional path performance events are counted bi-directionally during available time, while for uni-directional path performance events are counted in one direction, as defined in subclause 5.1.7, over periods of time of 24 hours.

Error performance monitoring history for paths is given in subclause 5.1.7 (see figure 5).

5.2.5.2 Error performance evaluation

Typically error performance evaluation is done by the NMS/OS over a long period of time (1 month is suggested) using parameters BBER, ESR and SESR. This period is sliding by one day.

Long term error performance evaluation can be accomplished at each side of bi-directional path by looking at the Near-End event counters (backward direction) and Far-End event counters (forward direction).

The end-to-end performance objectives for a path of 27 500 km are given in table 1 of ITU-T Recommendation G.826 [8]. They have to be multiplied by the allocation of the considered path. This allocation is calculated with the principles given in ITU-T Recommendation G.826 [8] for international digital paths.

5.2.5.3 Unavailability management

The unavailability periods are date time-stamped (beginning and ending), in order to calculate the corresponding parameters. The datation shall be provided with a one-second resolution. At least 6 periods of unavailability should be stored.

NOTE: The NMS/OS can compute the unavailability parameters (AR and OI) by means of notification of starting and ending of unavailability periods. For this reason the storage of starting and ending times of the above 6 unavailability periods is under reconsideration.

The availability parameters AR and OI are evaluated by NMS/OS over 12 months.

5.2.6 Maintenance thresholds configuration

Principles of thresholding are given in subclause 5.1.8. In the following the default values for the threshold are given.

5.2.6.1 15-minute thresholds

Threshold values should be programmable. Threshold default values for each type of path are given in table 5a , while reset threshold default values are in table 5b.

Table 5a: path 15-minute threshold values

Path Type	Nb Blocks/s	Nb ES	Nb SES	Nb BBE
VC-11 , VC-12	2 000	120	15	9 000
VC-2	2 000	150	15	9 000
VC-3	8 000	150	15	36 000
VC-4	8 000	180	15	36 000

Table 5b: path 15-minute reset threshold values

Path Type	Nb Blocks/s	Nb ES	Nb SES	Nb BBE
VC-11 , VC-12	2 000	5	0	50
VC-2	2 000	10	0	50
VC-3	8 000	10	0	200
VC-4	8 000	20	0	200

5.2.6.2 24-hour thresholds

Threshold values are programmable. Default values for each type of path are given in table 6.

Table 6: path 24-hour threshold values

Path Type	Nb Blocks/s	Nb ES	Nb SES	Nb BBE
VC-11 , VC-12	2 000	350	20	12 000
VC-2	2 000	400	20	12 000
VC-3	8 000	600	20	48 000
VC-4	8 000	1 500	20	48 000

5.3 Performance monitoring of multiplex sections

This subclause deals with performance management of multiplex sections just for maintenance purposes.

5.3.1 Block definition

5.3.1.1 Block definition for STM-N sections (1 ≤N ≤ 16)

The N x 24 BIP-1s contained in the B2 bytes of an SDH multiplex section in a STM-N (1 ≤N ≤ 16) pertain to N x 24 different blocks. Thus, a generic multiplex section in a STM-N comprises N x 24 blocks within a 125 µs frame.

The generic i-th block (1 ≤ i ≤ N x 24) is equivalent to the i-th bit of the B2 bytes and the corresponding monitored bits in the same frame as defined in ITU-T Recommendation G.707 [13].

5.3.1.2 Block definition for STM-64 section

For further study.

5.3.1.3 Block definition for STM-0 section

For further study.

5.3.1.4 Block sizes

Table 7 defines, for each type of multiplex section, the block size (number of bits per block), the number of blocks per second (blocks/s), the associated EDC and the number of blocks per frame.

Table 7: Block sizes, blocks per frame, blocks per second and EDCs for SDH multiplex sections

Section type	Block Size	Blocks per Frame	Blocks/s (N x 24 x 8 000)	EDC
STM-0	FFS	FFS	FFS	FFS
STM-1	801 bits	24	192 000	BIP-1
STM-4	801 bits	96	768 000	BIP-1
STM-16	801 bits	384	3 072 000	BIP-1
STM-64	FFS	FFS	FFS	FFS

5.3.2 Error performance events

Error performance events: EB, BBE, ES (note 1) are defined in subclause 5.1.4.

A SES event is defined as a one-second period which contains more than X % EBs (note 2) or at least one defect.

NOTE 1: The use of ES parameter for STM-4, STM-16 and STM-64 sections should be reconsidered.

NOTE 2: A provisional value X=15 is suggested for STM-1.

The defects which trigger ES, and SES events are listed in subclause 5.3.3.2.

These events shall be collected during available periods only.

5.3.3 Events determination for multiplex sections

5.3.3.1 Anomalies

In-service anomaly conditions are used to determine the error performance of an SDH multiplex section. The following anomalies are defined for a multiplex section:

- a_1 An EB indicated by the EDC;
- a_2 Multiplex section remote error indication (MS-REI).

5.3.3.2 Defects

In-service defect conditions are used by SDH equipment to determine performance events. The following categories of defects are defined for multiplex sections:

- d_1 Multiplex section Alarm Indication Signal (AIS) (MS-dAIS);
- d_2 Multiplex section remote defect indication (MS-RDI).

5.3.3.3 Determination of the performance events

For SDH multiplex sections the performance events are determined as follows:

ES: A near-end ES is observed when, during one second, at least one anomaly a_1, or one defect d_1 occurs.
A far-end ES is observed when, during one second, at least one anomaly a_2, or one defect d_2 occurs.
For the ES event, the actual count of anomalies is irrelevant, it is only the fact that an anomaly has occurred in a second which is significant.

SES: A near-end SES is observed when, during one second, at least Z EBs (derived from anomaly a_1) or defect d_1 occur (see note).
A far-end SES is observed when, during one second, at least Z EBs (derived from anomaly a_2) or a defect d_2 occur (see note).

BE: A near-end BBE is observed when an anomaly a_1 occurs in a block not being part of an SES.
A far-end BBE is observed when an anomaly a_2 occurs in a block not being part of an SES.

NOTE: The value of Z is obtained by multiplying the number of blocks per second by X % (from the SES definition).

The values of threshold of EBs for SES for each SDH multiplex section type are given in table 8.

Table 8: EB thresholds for SES for various multiplex section types

Multiplex Section Type	Threshold Z of EBs for SES (Number of Errored Blocks in one Second)
MS STM-1	28 800
MS STM-4	FFS
MS STM-16	FFS
MS STM-64	FFS
MS STM-0	FFS

Reference events are determined with the observed anomalies and defects. Information which has to be taken into account for performance is listed in table 9.

Table 9: Information type and affected direction

Information	Indication type	Direction
EB	Anomaly	Near-End
MS-REI	Anomaly	Far-End
MS-dAIS	defect	Near-End
MS-dRDI	defect	Far-end

The detection mechanisms give errored block or defect indication, which is cumulated over a one-second period to determine its state: non-errored second, ES or SES.

When a near-end SES is caused by a near-end defect, the far-end performance can not be evaluated during that second. When a near-end SES is resulting from ≥ X % errored blocks, which does not cause a near-end defect contributing to performance monitoring, the far-end performance evaluation continues during the near-end SES.

5.3.4 Unavailability of multiplex section

In a generic multiplex section two different directions of transmission can be identified. The performance monitoring for maintenance treats these directions as complete independent entities.

The unavailability definition for single direction applies.

5.3.5 Data management

5.3.5.1 Performance monitoring history

Maintenance application

Performance events (ES, SES, BBE) are cumulated during available time over periods of time of 15 minutes and 24 hours.

All this information is stored in registers (17 registers of 15 minute threshold and 2 registers of 24 hour threshold). See figures 4a and 4b.

Performance application

Error performance application is not required for MS.

5.3.5.2 Unavailability management

The unavailability periods are date time-stamped (beginning and ending), in order to calculate the corresponding parameters. The datation shall be provided with a one-second resolution. At least 6 period of unavailability should be stored.

NOTE: The NMS/OS can compute the unavailability parameters (AR and OI) by means of notification of starting and ending times of unavailability periods. For this reason the storage of starting and ending times of the above 6 unavailability periods is under reconsideration. The availability parameters AR and OI are evaluated by NMS/OS over a long period of time (X month) [X=12 months provisional value].

5.3.6 Maintenance thresholds configuration

Principles of thresholding are given in subclause 5.1.7. In the following the default values for the threshold are given.

5.3.6.1 15-minute thresholds

Threshold and reset threshold values should be programmable. Threshold default values are given in table 10a, while reset threshold default values are in table 10b.

Table 10a: MS 15-minute threshold values

STM-N	Nb Blocks/s	Nb ES	Nb SES	Nb BBE
STM-1	192 000	50	10	[12 000 x 24] note 1
STM-4	768 000	note 2	10	FFS
STM-16	307 200	note 2	10	FFS
NOTE 1: The default value for STM-1 is provisionally agreed. NOTE 2: The use of ES parameter is under study.				

Table 10b: MS 15-minute reset threshold values

STM-N	Nb Blocks/s	Nb ES	Nb SES	Nb BBE
STM-1	192 000	5	0	[100 x 24] note 1
STM-4	768 000	note 2	0	FFS
STM-16	3 072 000	note2	0	FFS
NOTE 1: The default value for STM-1 is provisionally agreed. NOTE 2: The use of ES parameter is under study.				

5.3.6.2 24-hour thresholds

Threshold values should be programmable. Threshold default values are given in table 11.

Table 11: MS 24-hour threshold values

STM-N	Nb Blocks/s	Nb ES	Nb SES	Nb BBE
STM-1	192 000	150	15	[18 000 x 24] note 1
STM-4	768 000	note 2	15	FFS
STM-16	3 072 000	note 2	15	FFS
NOTE 1: The default value for STM-1 is provisionally agreed. NOTE 2: The use of ES parameter is under study.				

5.4 Performance management of regenerator sections

This subclause of document deals with performance management of regenerator sections just for maintenance purpose.

5.4.1 Block definition

5.4.1.1 Block definition applicable to STM-1

The BIP`s contained in the B1 byte of an SDH regenerator section in an STM-1 pertain to 1 block. Thus, a generic regenerator section in an STM-1 comprises 1 block within a 125 µs frame.

The BIP-8 code and the corresponding monitored bits in the same frame are defined in ITU-T Recommendation G.707 [13].

5.4.1.2 Block definition applicable to STM-N (4≤N≤64)

For further study.

5.4.1.3 Block definition applicable to bit rates STM-0

For further study.

5.4.1.4 Block sizes

Table 12 defines, for each type of regenerator section, the block size (number of bits per block), the number of blocks per second (blocks/s), the associated EDC and the blocks per frame.

Table 12: Block sizes, blocks per frame, blocks per second and EDCs for SDH regenerator sections

STM-N	Block Size	Blocks per Frame	Blocks/s	EDC
STM-0	FFS	FFS	FFS	FFS
STM-1	19 440 bits	1	8 000	BIP-8
STM-4	FFS	FFS	FFS	FFS
STM-16	FFS	FFS	FFS	FFS
STM-64	FFS	FFS	FFS	FFS

5.4.2 Error performance events

Error performance events: EB, BBE, ES (Note) are defined in subclause 5.1.4.

A SES event is defined as a one-second period which contains less than X % EBs or at least one defect. The value of X is defined in table 13.

NOTE: The use of ES parameter for STM-4, STM-16 and STM-64 sections should be reconsidered.

The defects which trigger ES and SES events are listed in subclause 5.4.3.2.

These events shall be collected during available periods only.

Table 13: SES thresholds for SDH regenerator sections

STM-0	STM-1	STM-4	STM-16
FFS	X = 30 %EB	FFS	FFS

5.4.3 Events determination for regenerator sections

5.4.3.1 Anomaly

In-service anomaly conditions are used to determine the error performance of an SDH regenerator section. The following anomaly is defined for a regenerator section:

- a_1 An error as indicated by the EDC.

The EDC used to detect errored block for SDH regenerator is a BIP-8 code.

5.4.3.2 Defects

In-service defect conditions are used by SDH equipment to determine performance events. The following categories of defects are defined for regenerator sections:

- d_1 Regenerator section defects (dLOS, RS-dLOF, RS-dTIM).

5.4.3.3 Determination of the performance events

For SDH regenerator sections the performance events are determinated as follows:

ES: A near-end ES is observed when, during one second, at least one anomaly a_1, or one defect d_1 occurs. For the ES event, the actual count of a_1 is irrelevant, it is only the fact that an anomaly has occurred in a second which is significant.

SES: A near-end SES is observed when, during one second, at least Z EBs (derived from anomaly a_1) or defect d_1 occur (see note).

NOTE: The value of Z is obtained by multiplying the number of blocks per second by X % (from the SES definition).

BBE: A near-end BBE is observed when an anomaly a_1 occurs in a block not being part of an SES.

The values of threshold of EBs for SES for each SDH regenerator section type are given in table 14.

Table 14: Thresholds Z for SES according to the regenerator section type

Path Type	Threshold Z of EBs for SES (Number of Errored Blocks in one Second)
RS STM-1	2 400
RS STM-4	FFS
RS STM-16	FFS
RS STM-N (N>16)	FFS
RS STM-0	FFS

Reference events are determined with the observed anomalies and defects. Information which have to be taken into account for performance are listed in table 15.

Table 15: Information type and affected direction

Information	Indication type	Direction
EB	Anomaly	Near-End
dLOS	Defect	Near-End
RS-dLOF	Defect	Near-End
RS-dTIM	Defect	Near-End

The detection mechanisms give errored block or defect indication, which is cumulated over a one-second period to determine its state: non-errored second, ES or SES.

5.4.4 Unavailability of regenerator section

In a generic regenerator section two different directions of transmission can be identified. The performance monitoring for maintenance treats these directions as complete independent entities.

The unavailability definition for single direction applies.

5.4.5 Data management

5.4.5.1 Performance monitoring history

Maintenance application

Performance events (ES, SES, BBE) are cumulated during available time over periods of time of 15 minutes and 24 hours.

All these information are stored in registers (17 registers of 15 minute threshold and 2 registers of 24 hour threshold). See figures 4a and 4b.

Performance application

The error performance application for regenerator section is not required.

5.4.5.2 Unavailability management

The unavailability periods are date time-stamped (beginning and ending), in order to calculate the corresponding parameters. The datation shall be provided with a one-second resolution. At least 6 period of unavailability should be stored.

NOTE: The NMS/OS can compute the unavailability parameters (AR and OI) by means of notification of starting and ending of unavailability periods. For this reason the storage of starting and ending times of the above 6 unavailability periods is under reconsideration.

The availability parameters AR and OI are evaluated by OS over a long period of time (X month) [X=12 months provisional value].

5.4.6 Maintenance thresholds configuration

Principles of thresholding are given in subclause 5.1.7. In the following the default values for the threshold are given.

5.4.6.1 15-minute thresholds

Threshold and reset threshold values should be programmable. Threshold default values are given in table 16a, while reset threshold values in table 16b.

Table 16a: RS15-minute threshold values

STM-N	Nb Blocks/s	Nb ES	Nb SES	Nb BBE
STM-0	FFS	FFS	FFS	FFS
STM-1	8 000	180	15	9 000
STM-4	FFS	note	FFS	FFS
STM-16	FFS	note	FFS	FFS
NOTE: The use of ES parameter is under study				

Table 16b: RS 15-minute reset threshold values

STM-N	Nb Blocks/s	Nb ES	Nb SES	Nb BBE
STM-0	FFS	FFS	FFS	FFS
STM-1	8 000	20	0	200
STM-4	FFS	note	FFS	FFS
STM-16	FFS	note	FFS	FFS
NOTE: The use of ES parameter is under study				

5.4.6.2 24-hour thresholds

Threshold values should be programmable. Threshold default values are given in table 17.

Table 17: RS 24-hour threshold values

STM-N	Nb Blocks/s	Nb ES	Nb SES	Nb BBE
STM-0	FFS	FFS	FFS	FFS
STM-1	8 000	1 500	20	48 000
STM-4	FFS	note	FFS	FFS
STM-16	FFS	note	FFS	FFS
NOTE: The use of ES parameter is under study				

History

Document history		
V1.1.1	April 1998	One-step Approval Procedure OAP 9831: 1998-04-03 to 1998-07-31
V1.1.1	August 1998	Publication

ISBN 2-7437-2484-6
Dépôt légal : Aout 1998