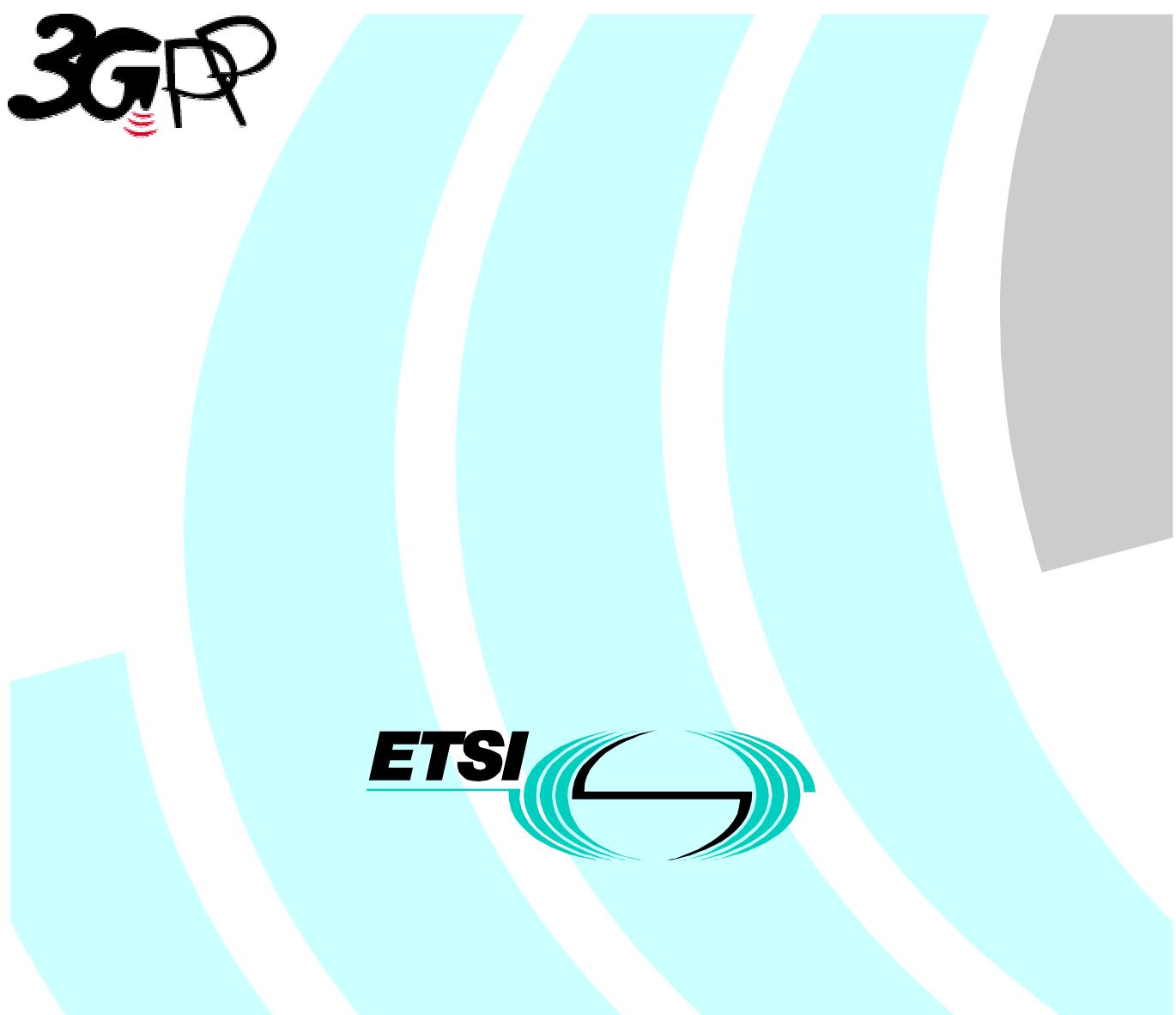


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Introduction

The present document is part of a set of TSs which describe the requirements and information model necessary for the Telecommunication Management (TM) of 3G systems. The TM principles and TM architecture are specified in 3G TS 32.101 and 3G TS 32.102.

A 3G system is composed of a multitude of network elements (NE) of various types and, typically, different vendors which inter-operate in a co-ordinated manner in order to satisfy the network users' communication requirements. The occurrence of failures in a network element may cause a deterioration of this NE's function and/or service quality and will, in severe cases, lead to the complete unavailability of the NE. In order to minimise the effects of such failures on the quality of service as perceived by the network users it is necessary to:

- detect failures in the network as soon as they occur and alert the operating personnel as fast as possible;
- isolate the failures (autonomously or through operator intervention), i.e. switch off faulty units and, if applicable, limit the effect of the failure as much as possible by reconfiguration of the faulty NE/adjacent NEs;
- if necessary, determine the cause of the failure using diagnosis and test routines; and,
- repair/eliminate failures in due time through the application of maintenance procedures.

This aspect of the management environment is termed "Fault Management" (FM). The purpose of FM is to detect failures as soon as they occur and to limit their effects on the network quality of service as far as possible. The latter is achieved by bringing additional/redundant equipment into operation, reconfiguring existing equipment/NEs, or by repairing/eliminating the cause of the failure.

Fault Management encompasses all of the above functionalities except commissioning/decommissioning of NEs and potential operator triggered reconfiguration (these are a matter of Configuration Management, cf. [1]). It also includes associated features in the OS, such as the administration of a pending alarms list, the presentation of operational state information of physical and logical devices/resources/functions, and the provision and analysis of the alarm and state history of the network.

1 Scope

The present document specifies the overall requirements for 3G Fault Management as it applies to the NE, EM and NM.

Clauses 4 and 5 define the fault management concept and functional requirements for the detection of faults and the generation, collection and presentation of alarms, operational state data and test results across 3G systems. These functions are described on a non-formal level since the formal standardisation of these functions across the different vendors' equipment is not required. The functional areas to be specified in this part of the document cover:

- fault surveillance and detection in the NEs;
- notification of alarms (including alarm cease) and operational state changes;
- retrieval of current alarms from the NEs;
- fault isolation and defence mechanisms in the NEs;
- alarm filtering;
- management of alarm severity levels;
- alarm and operational state data presentation and analysis at the OS;
- retention of alarm and operational state data in the NEs and the OS; and
- the management of tests.

Any (re)configuration activity exerted from the OMC as a consequence of faults will not be subject of the present document, these are described in [1].

Clauses 6 and 7 of the present document describe specific aspects of the Fault Management for the UTRAN and the CN, respectively, with particular emphasis on the exact fault definitions and alarm information to be generated. The definition of the test procedures and the relationship with the UTRAN resp. CN management architecture as defined in [3].

Finally, Clause 8 of the present document defines the functional requirements for the standard Ift-N, for the purpose of Fault Management of 3G networks, as seen from the Network Manager (NM). The Ift-N is fully standardised so as to connect systems of any vendor to the NM via this interface.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.

[1] 3G TS 32.106: "3G Configuration Management".

[2] 3G TS 32.101: "3G Telecom Management principles and high level requirements".

[3] 3G TS 32.102: "3G Telecom Management architecture".

[4] 3G TS 32.106: "3G Performance Management".

- [5] ITU-T Recommendation X.710: "Common management information service definition for CCITT applications".
- [6] ITU-T Recommendation X.711: "Common management information protocol specification for CCITT applications".
- [7] ITU-T Recommendation X.721: "Information technology - Open Systems Interconnection - Structure of management information: Definition of management information".
- [8] ITU-T Recommendation X.731: "Information technology - Open Systems Interconnection - Systems Management: State management function".
- [9] ITU-T Recommendation X.733: "Information technology - Open Systems Interconnection - Systems Management: Alarm reporting function".
- [10] ITU-T Recommendation X.734: "Information technology - Open Systems Interconnection - Systems Management: Event report management function".
- [11] ITU-T Recommendation X.735: "Information technology - Open Systems Interconnection - Systems Management: Log control function".
- [12] ISO 8571: "File Transfer, Access and Management".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

Active alarm: an alarm that has not been cleared. An alarm is active until the fault that caused the alarm is corrected and a clear alarm is generated

Alarm: an alarm is an abnormal network entity condition which categorises an event as a fault

Alarm notification: a notification used to inform the recipient about the occurrence of an alarm

Clear alarm: an alarm where the severity value is set to "cleared"

Event: this is a generic term for any type of occurrence within a network entity. A notification or event report may be used to inform one or more OS(s) about the occurrence of the event

Fault: a deviation of a system from normal operation. This deviation may result in the loss of operational capabilities of the element or the loss of redundancy in case of a redundant configuration

Notification: information message originated within a network entity to inform one or more OS(s) about the occurrence of an event

Steady fault: a steady fault is characterised by well-defined conditions for the declaration of its presence or absence, i.e. fault occurrence and fault clearing conditions. This implies that the fault can be both detected and cleared automatically by the fault management functions of the network entity

Unsteady fault: an unsteady fault is characterised by a defined condition for the declaration of the fault, but no clearing condition exists. This implies that the fault can be detected but not cleared automatically by the fault management functions of the network entity

3.2 Abbreviations

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

CCITT	The International Telegraph and Telephone Consultative Committee
CM	Configuration Management
CMIP	Common Management Information Protocol
CMIS	Common Management Information Service
CMISE	Common Management Information Service Element
EIR	Equipment Identity Register
ETSI	European Telecommunications Standards Institute
FTAM	File Transfer Access and Management
FTP	File Transfer Protocol
HLR	Home Location Register
ISO	International Standards Organisation
MMI	Man-Machine Interface
MML	Man-Machine Language
MOC	Managed Object Class
MOI	Managed Object Instance
MS	Mobile Station
MSC	Mobile Services Switching Centre
NE	Network Element
NMC	Network Management Centre
OA&M	Operation, Administration and Maintenance
OMC	Operation and Maintenance Centre
OS	Operations System
OSI	Open System Interconnection
O&M	Operations and Maintenance
QoS	Quality of Service
RNC	Radio Network Controller
TFTP	Trivial File Transfer Protocol
TMN	Telecommunications Management Network
TS	Technical Specification
VLR	Visitors Location Register

4 Fault Management concept

Any evaluation of the network elements' and the overall network health status will require the detection of faults in the network and, consequently, the notification of alarms to the OS (EM and/or NM). Depending on the nature of the fault, it may be combined with a change of the operational state of the logical and/or physical resource(s) affected by the fault. Detection and notification of these state changes is as essential as it is for the alarms. A list of active alarms in the network and operational state information as well as alarm/state history data are required by the system operator for further analysis. Additionally, test procedures can be used in order to obtain more detailed information if necessary, or to verify an alarm or state or the proper operation of NEs and their logical and physical resources.

The following subclauses explain the detection of faults, the handling of alarms and states and the execution of tests.

4.1 Faults and alarms

Faults that may occur in the network can be grouped into one of the following categories:

- Hardware failures, i.e. the malfunction of some physical resource within a NE.
- Software problems, e.g. software bugs, database inconsistencies.
- Functional faults, i.e. a failure of some functional resource in a NE and no hardware component can be found responsible for the problem.

- Loss of some or all of the NE's specified capability due to overload situations.
- Communication failures between two NEs, or between NE and OS, or between two OSs.

In any case, as a consequence of faults, appropriate alarms related to the physical or logical resource(s) affected by the fault(s), shall be generated by the network entities.

The following subclauses focus on the aspects of fault detection, alarm generation and storage, fault recovery and retrieval of stored alarm information.

4.1.1 Fault detection

When any type of fault described above occurs within a 3G network, the affected network entities must be able to detect them immediately.

The network entities accomplish this task using autonomous self-check circuits/procedures, including, in the case of Nes, the observation of measurements, counters and thresholds. The threshold measurements may be predefined by the manufacturer and executed autonomously in the NE, or they may be based on performance measurements administered by the EM, cf. [4]. The fault detection mechanism as defined above shall cover both active and standby components of the network entities.

The majority of the faults will have well-defined conditions for the declaration of their presence or absence, i.e. fault occurrence and fault clearing conditions. Any such incident shall be referred to in the present document as a steady fault. The network entities must be able to recognise when a previously detected steady fault is no longer present, i.e. the clearing of the fault, using similar techniques as they use to detect the occurrence of the fault. For some faults, no clearing condition exists. For the purpose of the present document, these faults shall be referred to as unsteady faults. An example of this is when the network entity has to restart a software process due to some inconsistencies, and normal operation can be resumed afterwards. In this case, although the inconsistencies are cleared, the cause of the problem is not yet corrected. Manual intervention by the system operator will always be necessary to clear unsteady faults since these, by definition, cannot be cleared by the network entity itself.

For some faults there is no need for any short-term action, neither from the system operator, nor from the network entity itself, since the fault condition lasted for a short period of time only and then disappeared. An example of this is when an NE detects the crossing of some observed threshold, and in the next sampling interval, the observed value stays within its limits.

For each fault, the fault detection process shall supply the following information:

- the device/resource/file/functionality/smallest replaceable unit as follows:
 - for hardware faults, the smallest replaceable unit that is faulty;
 - for software faults, the affected software component, e.g. corrupted file(s) or databases or software code;
 - for functional faults, the affected functionality;
 - for faults caused by overload, information on the reason for the overload;
 - for all the above faults, wherever applicable, an indication of the physical and logical resources that are affected by the fault if applicable, a description of the loss of capability of the affected resource.
- the type of the fault (communication, environmental, equipment, processing error, quality of service) according to [9];
- the severity of the fault (indeterminate, warning, minor, major, critical), as defined in [9];
- the probable cause of the fault;
- the time at which the fault was detected in the faulty network entity;
- the nature of the fault, i.e. steady or unsteady;

- any other information that will help understanding the cause and the location of the abnormal situation (system/implementation specific).

For some faults, additional means, such as test and diagnosis features, may be necessary in order to obtain the required level of detail. See subclause 4.3 for details.

4.1.2 Generation of alarms

For each detected fault, appropriate alarms shall be generated by the faulty network entity, regardless of whether it is a steady or unsteady fault. Such alarms shall contain all the information provided by the fault detection process as described in subclause 4.1.1.

In order to ease the fault localisation and repair, the faulty network entity should generate for each single fault, one single alarm, also in the case where a single fault causes a degradation of the operational capabilities of more than one physical or logical resource within the network entity. An example of this is a hardware fault which affects not only a physical resource but also degrades the logical resource(s) that this hardware supports. In this case the network entity shall generate one single alarm for the faulty resource (i.e. the resource which needs to be repaired) and a number of events related to state management (cf. subclause 4.2) for all the physical/logical resources affected by the fault, including the faulty one itself.

In case a network entity is not able to recognise that a single fault manifests itself in different ways, the single fault is detected as multiple faults and originates multiple alarms. In this case however, when the fault is repaired the **network entity** must be able to detect the repair of all the multiple faults and clear the related multiple alarms.

When a fault occurs on the connection media between two NEs or between a NE and an OS, and affects the communication capability between such NE/OS, each affected NE/OS will detect the fault as described in subclause 4.1.1 and generate its own associated communication alarm toward the managing OS. In this case it is the responsibility of the OS to correlate alarms received from different NEs/OSs and localise the fault in the best possible way.

Within each NE, all alarms generated by that NE shall be input into a list of active alarms. The NEs must be able to provide such a list of active alarms to the OS when requested.

4.1.3 Clearing of alarms

The alarms originated in consequence of faults need to be cleared. To clear an alarm it is necessary to repair the corresponding fault. The procedures to repair faults are implementation dependent and therefore they are out of the scope of the present document, however, in general:

- the equipment faults are repaired by replacing the faulty units with working ones;
- the software faults are repaired by means of partial or global system initialisations, by means of software patches or by means of updated software loads;
- the communication faults are repaired by replacing the faulty transmission equipment or, in case of excessive noise, by removing the cause of the noise;
- the QOS faults are repaired either by removing the causes that degraded the QOS or by improving the capability of the system to react against the causes that could result in a degradation of the QOS;
- Solving the environmental problem repairs the environment faults (high temperature, high humidity, etc.).

It is also possible that a steady fault is spontaneously repaired, without the intervention of the operator (e.g. a threshold crossed fault). In this case the NE behaves as for the steady faults repaired by the operator.

In principle, the NE uses the same mechanisms to detect that a fault has been repaired, as for the detection of the occurrence of the fault. However, for unsteady faults, manual intervention by the operator is always necessary to clear the fault. Practically, various methods exist for the system to detect that a fault has been repaired and clear alarms and the faults that triggered them. For example:

- The system operator implicitly requests the NE to clear a fault, e.g. by initialising a new device that replaces a faulty one. Once the new device has been successfully put into service, the NE will clear the fault(s). Consequently, the NE will clear all related alarms.
- The system operator explicitly requests the clearing of one or more alarms. Once the alarm(s) has/have been cleared, the NE will detect that the fault condition has ceased.
- The NE detects the exchange of a faulty device by a new one and initialises it autonomously. Once the new device has been successfully put into service, the NE will clear the fault(s). Consequently, the NE will clear all related alarms.
- The NE detects that a previously reported threshold crossed alarm is no longer valid. It will then clear the corresponding active alarm and the associated fault, without requiring any operator intervention. The details for the administration of thresholds and the exact condition for the NE to clear a threshold crossed alarm are implementation specific and depend on the definition of the threshold measurement, see also subclause 4.1.1.
- Unsteady faults/alarms can, by definition, not be cleared by the NE autonomously. Therefore, in any case, system operator functions shall be available to request the clearing of unsteady alarms/faults in the NE. Once an unsteady alarm/fault has been cleared, the NE will clear the associated unsteady fault/alarm.

Details of these mechanisms are system/implementation specific.

Each time an alarm is cleared the NE shall generate an appropriate clear alarm event. A clear alarm is defined as an alarm, as specified in subclause 4.1.2, except that its severity is set to "cleared". The relationship between the clear alarm and the active alarm is established:

- by re-using a set of parameters that uniquely identify the active alarm (cf. subclause 4.1.2); or
- by including a reference to the active alarm in the clear alarm.

When a clear alarm is generated the corresponding active alarm is removed from the active alarm list.

4.1.4 Alarm forwarding and filtering

4.1.5 Storage and retrieval of alarms in/from the NE

For fault management purposes, each NE will have to store and retain the following information:

- a list of all active alarms, i.e. all alarms that have not yet been cleared; and
- alarm history information, i.e. all notifications related to the occurrence and clearing of alarms.

The storage space for alarm history in the NE will be limited. Therefore it shall be organised as a circular buffer, i.e. the oldest data item(s) shall be overwritten by new data if the buffer is full. Further "buffer full" behaviours, e.g. those defined in [11], may be implemented as an option. The storage capacity itself, and thus the duration for which the data can be retained, will be Operator and implementation dependent.

4.1.6 Fault Recovery

After a fault has been detected and the replaceable faulty units have been identified, some management functions are necessary in order to perform system recovery and/or restoration, either automatically by the NE and/or the EM, or manually by the operator.

The fault recovery functions are used in various phases of the fault management:

- 1) Once a fault has been detected, the NE shall be able to evaluate the effect of the fault on the telecommunication services and autonomously take recovery actions in order to minimise service degradation or disruption.
- 2) Once the faulty unit(s) has (have) been replaced or repaired, it shall be possible from the EM to put the previously faulty unit(s) back into service so that normal operation is restored. This transition should be done in such a way that the currently provided telecommunication services are not, or only minimally, disturbed.
- 3) At any time the NE shall be able to perform recovery actions if requested by the operator. The operator may have several reasons to require such actions; e.g. he has deduced a faulty condition by analysing and correlating alarm reports, or he wants to verify that the NE is capable of performing the recovery actions (proactive maintenance).

The recovery actions that the NE performs (autonomously or on demand) in case of faults depend on the nature and severity of the faults, on the hardware and software capabilities of the NE and on the current configuration of the NE.

Faults are distinguished in two categories: software faults and hardware faults. In the case of software faults, depending on the severity of the fault, the recovery actions may be system initialisations (at different levels), activation of a backup software load, activation of a fallback software load, download of a software unit etc. In the case of hardware faults, the recovery actions depend on the existence and type of redundant (i.e. back-up) resources. Redundancy of some resources may be provided in the NE in order to achieve fault tolerance and to improve system availability.

If the faulty resource has no redundancy, the recovery actions shall be:

- a) Isolate and remove from service the faulty resource so that it cannot disturb other working resources;
- b) Remove from service the physical and functional resources (if any) which are dependent on the faulty one. This prevents the propagation of the fault effects to other fault-free resources;
- c) State management related activities for the faulty resource and other affected/dependent resources, cf. subclause 4.2;
- d) Generate and forward appropriate notifications to inform the OS about all the changes performed.

If the faulty resource has redundancy, the NE shall perform action a), c) and d) above and, in addition, the recovery sequence that is specific to that type of redundancy. Several types of redundancy exist (e.g. hot standby, cold standby, duplex, symmetric/asymmetric, N plus one or N plus K redundancy, etc.), and for each one, there is a specific sequence of actions to be performed in case of failure. The present document specifies the Fault Management aspects of the redundancies, but it does not define the specific recovery sequences of the redundancy types.

In the case of a failure of a resource providing service, the recovery sequence shall start immediately. Before or during the changeover, a temporary and limited loss of service shall be acceptable. In the case of a management command, the NE should perform the changeover without degradation of the telecommunication services.

The management of the redundancies is strictly related to the way they are modelled in the MIM of the NE. For the modelling of the redundancies, the relationships shall be defined among the objects, which participate in each redundancy. This will identify the objects and the roles that they have in the redundancy. By defining the relationships, also the role of the objects participating in the relationships are implicitly defined by the relationships' attribute values.

The NE shall provide the OS with the capability to monitor and control any redundancy of the NE. The control of a redundancy by the OS (which means the capability to trigger a changeover or a change-back) can be achieved by means of state management, cf. subclause 4.2.

If a fault causes the interruption of ongoing calls, then the interrupted calls shall be cleared, i.e. all resources allocated to these calls shall immediately be released by the system.

4.1.7 Support of Maintenance Action

4.1.8 Configuration of Alarms

4.2 State management

The State Management is a common service defined within Configuration Management (TS 32.106) and used by several management areas, including Fault Management. In this clause, some detailed requirements on State Management as they apply to the Fault Management are defined.

From the point of view of Fault Management, only two of the three primary state attributes are really important: the Administrative state and the Operational state. In addition the resources may have some secondary 'status' attributes which give further detailed information about the reason of the primary state.

The Administrative state is used by the Operator to make a resource available for service, or to remove a resource from service. For example:

- for fault correction the Administrative state can be used to isolate a faulty resource;
- in case of redundancy the Administrative state can be used to lock the active resource and let the standby resource to become active (preventive maintenance);
- for Test management the Administrative state can be used to put a resource out of service to run an intrusive test on it.

The Operational state gives the information about the real capability of a resource to provide or not provide service.

- The operational state is "enabled" when the resource is able to provide service, "disabled" when the resource cannot provide service.
- A resource can lose the capability to provide service because of a fault or because another resource on which it depends is out of service (e.g. disabled or locked).
- In case a resource does not lose completely its capability to provide service, the Operational state shall be "enabled" and the Availability status shall be "degraded".

The changes of the state and status attributes of a resource must be notified to the relative manager(s) as specified in TS 32.106.

When a state change is originated by a failure, the alarm notification and the related state change notifications must be correlated to each other by means of explicit relationship information.

4.2.1 Propagation of state change

Within a managed element, when for any reason a resource changes its state, the change must be propagated, in a consistent way, to all the other resources that are functionally dependent on the first one. Therefore:

- In case of a fault occurring on a resource makes that resource completely out of service, if the current operational state is "enabled", it shall be changed to "disabled" and a state change notification shall be generated. Then, all the dependant resources (following the fault dependency diagram specific to that managed element) must be checked and, in case they are "enabled" they shall be changed to "disabled". In this process, also the secondary status must be changed consistently, in a way that it shall be possible to distinguish whether an object is disabled because it is faulty or because of it is functionally dependent on another object which is disabled.

- In case a faulty resource is repaired, the Operational state of that resource is changed from "disabled" to "enabled" and all the dependent resources are turned back to "enabled" (this is the simple case). In more complex cases, some of the objects may be disabled for different causes (different faults or faults plus locks on different superior resources), in this cases the repaired resource can be turned "enabled" only when all the causes are cleared (i.e. faults are repaired and superior resources are unlocked). Also in this process the secondary status must be changed consistently.
- In case the operator locks a resource, the process of the state change propagation is similar to the first case (resource failure) except for the locked resource which does not change its operational state but only the administrative state from "unlocked" to "locked". The dependent resources are processed as in the first case.
- In case the operator unlocks a resource, the process of the state change propagation is similar to the second case (fault reparation) except for the first resource (the unlocked one) which does not change its operational state but only the administrative state from "locked" to "unlocked". The dependent resources are processed as in the first case.

4.3 Test management

x Fault management requirements

This clause defines the FM requirements from the OS's perspective. According to the concept described in clause 4, the NEs shall maintain alarm and state change information. This information shall then be forwarded to one or more OS(s), i.e. the OMC and/or NMC. The OMC's role to play in this environment depends on implementation options chosen by the vendor and the network operator.

- The NMC interface (cf. clause 8) may be implemented in the NEs or the OMC. This means that the OMC may not be involved in the forwarding of alarm and state information to the NMC, if the NMC interface is implemented in the NE. In contrast, the OMC may have to act as a mediation device if the interface to the NMC is implemented in the OMC and the interface between OMC and the NEs uses a different (proprietary) technology.
- The network operator may choose to operate his network, in terms of FM, mainly from the NMC. This implies that functions for the forwarding and retrieval of alarms and states as well as the processing and user interface presentation of this information may not be required in the OMC, but the NMC. As a consequence, all of these functions, as described in the following subclauses, are optional in the OMC, which means they may or may not be implemented, but if implemented, they shall comply with the present document. Details of these considerations are a matter of vendor/operator agreement.

x.y Alarm and state management

x.y.z Alarm/state change forwarding and filtering

Alarm and state change events shall be forwarded by the NE, in the form of unsolicited notifications, according to the following scheme:

- as soon as an alarm is entered into or removed from the pending alarms list;
- immediately when an operational state change event is recorded in the NE.

If forwarding is not possible at this time, e.g. due to communication breakdown, then the notifications shall be sent as soon as the communication capability has been restored.

If the NMC interface is implemented in the NE, then the destination of the notifications is the NMC, and the interface shall comply with the stipulations made in clause 8. If the NMC interface resides in the OMC, proprietary means may be employed to forward the notifications to the OMC. Note that, even if the NMC interface is implemented in the NE, the OMC may still also receive the notifications by one of the above mechanisms, however, the present document does not explicitly require the NEs to support the OMC as a second destination.

The event report shall include all information defined for the respective event (cf. subclauses 4.1.2, 4.1.3 and 4.1.4), plus an identification of the NE that generated the report. This NE identification shall be identical to the identifiers defined within the CM domain, see [1].

The system operator shall be able to allow or suppress alarm reporting by the NE. As a minimum, the following criteria shall be supported for alarm filtering:

- the NE that generated the alarm, i.e. all alarm messages of that NE will be suppressed;
- the device/resource/function to which the alarm relates;
- the severity of the alarm, except "clear". Suppression of alarm clear messages shall be determined according to the following stipulations:
 - if the initial alarm was not suppressed, then the alarm cleared message shall also be forwarded;
 - if the initial alarm was suppressed, then the criteria set for alarm suppression at the time the cleared message occurs shall be taken into account;
- the time at which the alarm was detected, i.e. the alarm time; and,
- any combination of the above criteria.

The same functionality and criteria, as far as applicable, shall also be available for state changes, as follows:

- the NE that generated the state change event, i.e. all state change messages of that NE will be suppressed;
- the device/resource/function to which the state change relates;
- the time at which the state change occurred; and,
- any combination of the above criteria.

The result of any command to modify the forwarding criteria shall be confirmed by the NE to the requesting operator.

x.y.z Retrieval of alarm and state information

The NEs shall offer a facility for an OS to retrieve alarm and operational state information stored in the NE (cf. subclause 4.1.5). If the interface to the NMC is implemented in the NEs, then this facility shall be implemented according to the stipulations given in clause 8. If the NMC interface resides in the OMC, then proprietary means may be employed on the NE-OMC interface, however, a bulk data retrieval based on existing protocols, such as FTP, TFTP, or FTAM, is anticipated. Note that either of the two above mechanisms may still be used by the OMC even if the NMC interface resides in the NEs.

The alarm retrieval facility shall entail the following features:

- read alarms from the alarm history;
- read state changes from the state change history;
- retrieve the pending alarms from the NE; and
- read current values of the operational state.

It shall be possible to apply filters to each of the above operations as defined in subclause 5.1.1, plus the "cleared" alarm severity level.

x.y.z Support of Maintenance Action

In order to facilitate maintenance of the network, the system shall support the following OMC commands:

- request isolation of device for maintenance. Ongoing calls shall be allowed to be terminated by the users.

- request clearing of calls for maintenance. This will isolate the device addressed by the command, and ongoing calls using the device will be cleared.
- clear device from control channels (Node B - per channel, per carrier, per cell). It shall be possible to specify an alternate device to take over the channel(s), otherwise automatic reconfiguration shall be performed.
- establish priorities for automatic reconfiguration. This will force the NE's automatic reconfiguration after a fault to follow a scheme predefined by the system operator.

The NE shall confirm the result of the command to the requesting system operator.

x.y.z Configuration of Alarms

It shall be possible to configure the alarm actions, thresholds and severities through OMC commands, according to the following requirements:

- upon detection of a fault, certain actions will be carried out by the NE, e.g. putting the defective device/resource/function out of service. It shall be possible to change these activities for each individual fault.
- the operator shall be able to configure any threshold that determines the declaration or clearing of a fault. If a series of thresholds are defined to generate alarms of various severities, then for each alarm severity the threshold values shall be configurable individually.
- it shall be possible to modify, in the NE, the severity of each alarm defined in the system, e.g. from major to critical.

The NE shall confirm the result of any such alarm configuration command to the requesting system operator.

x.y.z Communication failure

If forwarding of alarms or state change events by a NE is not possible due to communication breakdown, then the notifications shall be sent as soon as the communication capability has been restored. The recipient of the notifications, i.e. the OMC and/or NMC, shall notice the communication failure and generate appropriate internal alarms in order to alert the system operator of the problem.

5 N interface

5.1 Fault Management concept of Itf-N

An operations system on the network management layer (i.e. the NM) provides fault management services and functions required by the 3G operator on top of the element management layer.

As pointed out in clause 5, the N interface (Itf-N) may connect the network management system either to EMs or directly to the NEs. This is done by means of IRPs. In the following, the term "subordinate entities" defines either EMs or NEs, which are in charge of supporting the N interface.

This clause describes the properties of an interface enabling a NM to supervise a 3G-telecommunication network including - if necessary - the managing EMs. To provide to the NM the fault management capability for the network implies that the subordinate entities have to provide information about:

- events and failures occurring in the subordinate entities;
- events and failures of the connections towards the subordinate entities and also of the connections within the 3G network;
- the network configuration (due to the fact that alarms and related state change information are always originated by network resources, see [1]). This is, however, not part of the FM functionality.

Therefore, for the purpose of fault management the subordinate entities send notifications to a NM indicating:

- alarm reports (indicating the occurrence or the clearing of failures within the subordinate entities), so that the related alarm information can be updated;
- state change event reports, so that the related (operational) state information can be updated.

The forwarding of these notifications is controlled by the NM operator using adequate filtering mechanisms within the subordinate entities.

The Itf-N provides also means to allow the NM operator the storage ("logging") and the later evaluation of desired information within the subordinate entities.

The retrieval capability of alarm-related information concerns two aspects:

- retrieval of "dynamic" information (e.g. alarms, states), which describes the momentary alarm condition in the subordinate entities and allows the NM operator a synchronisation of its alarm overview data;
- retrieval of "history" information from the logs (e.g. active/clear alarms and state changes occurred in the past), which allows the evaluation of events that may have been lost, e.g. after an Itf-N interface failure or a system recovery.

As a consequence of the requirements described above, both the NM and the subordinate entity must be able to initiate the communication.

5.2 Management of alarm and state change event reports

5.2.1 Mapping of alarm and related state change event reports

The alarm and state change reports received by the NM relate to functional objects in accordance with the information model of Itf-N. This information model tailored for a multi-vendor capability is different from the information model of the EM-NE interface (if an EM is available) or from the internal resource modelling within the NE (in case of direct NM-NE interface), thus a mapping of alarm and related state change event reports is performed by a mediation function within the subordinate entity.

The mediation function translates the original alarm/state change event reports (which may contain proprietary parameters or parameter values) taking into account the information model of the Itf-N.

If a mediation application function is needed, it works according to the following principles:

- Every alarm notification generated by a functional object in a subordinate entity is mapped to an alarm report of the corresponding ("equivalent") functional object at the Itf-N. If the functional object generating the original alarm notification has not a direct corresponding object at the Itf-N, the mediation functions maps the alarm to the next superior functional object in accordance with the containment tree of the Itf-N.
- Every state change notification generated by a functional object in a subordinate entity is mapped to a state change report of the corresponding ("equivalent") functional object at the Itf-N. If the functional object generating the original state change notification has not a direct corresponding object at the Itf-N, the mediation functions maps the alarm to the next superior functional object in accordance with the containment tree of the Itf-N.

Every alarm notification generated by a manufacturer-specific, equipment-related object in the subordinate entity is mapped to an alarm report of a generic logical object, which models the corresponding equipment-related resource.

NOTE: In some cases a failure or the locking of an equipment-related object implies also the change of the operational state of its corresponding functional object within the NE or EM (if EM is available). The mapping of this state change notification to an alarm or state change notification of the corresponding functional object at the Itf-N is subject of further study.

On the Itf-N the correlation between functional related and the generic logical objects (modeling equipment-related network resources) is performed explicitly by means of a relationship attribute in the functional object class definition.

With regard to the multi-vendor capability of the Itf-N, this mapping concept combines the following requirements:

- Precise information about manufacturer-specific, equipment-related failures for the NM operator in charge of network maintenance (this information is provided in some parameters of alarm reports mapped to the generic logical objects).
- If functionality is affected, an additional alarm report concerning the related functional object is provided for the NM operator in charge of network's quality of service.

If possible, the two types of alarm reports generated by the mediation function shall be correlated.

5.2.2 Real-time forwarding of event reports

If the Itf-N is in normal operation (the NM connection to the subordinate entities is up), alarm and related state change event reports are forwarded in real-time to the NM via appropriate filtering located in the subordinate entity. These filters may be controlled either locally or remotely by the managing NM (via Itf-N) and ensure that only the event reports which fulfil pre-defined criteria can reach the superior NM. In a multi-NM environment each NM must have an own filter within every subordinate entity which may generate notifications.

5.2.3 Alarm clearing

On the Itf-N, alarm reports containing the value "cleared" of the parameter perceivedSeverity are used to clear the alarms. The correlation between the clear alarm and the related active alarms is performed by means of unambiguous identifiers.

This clearing mechanism ensures the correct clearing of alarms, independently of the (manufacturer-specific) implementation of the mapping of alarms/state change events in accordance with the information model of the Itf-N.

5.3 Retrieval of alarm and state information

The retrieval of alarm and state information comprises two aspects:

a) Retrieval of current information

This mechanism shall ensure data consistency about the current alarm/state change information between the NM and its subordinate entities and is achieved by means of a so-called synchronisation ("alignment") procedure, triggered by the NM. The synchronisation is required after every start-up of the Itf-N, nevertheless the NM may trigger it at any time.

b) Logging and retrieval of history information

This mechanism offers to the NM the capability to get the alarm/state change information stored within the subordinate entities for later evaluation.

5.3.1 Retrieval of current alarm information on NM request

The present document defines a flexible, generic synchronisation procedure, which fulfils the following requirements:

- The alarm information provided by means of the synchronisation procedure shall be the same (at least for the mandatory parameters) as the information already available in the alarm list. The procedure shall be able to assign the received synchronisation-alarm information to the correspondent requests, if several synchronisation procedures triggered by one NM run at the same time.
- The procedure shall allow the NM to trigger the start at any time and to recognise unambiguously the end and the successful completion of the synchronisation.
- The procedure shall allow the NM to discern easily between an "on-line" (spontaneous) alarm report and an alarm report received as consequence of a previously triggered synchronisation procedure.

NOTE: This requirement is for further investigation.

- The procedure shall allow the NM to specify filter criteria in the alignment request (e.g. for a full network or only a part of it).
- The procedure shall support connections to several NM and route the alignment-related information only to the requesting NM.
- During the synchronisation procedure new ("real-time") alarms may be sent at any time to the managing NM.

If applicable, an alarm synchronisation procedure may be aborted by the requesting NM. (This requirement is for further investigation.)

5.3.2 Retrieval of current state change information on NM request

The requirements defined above for the alarm synchronisation procedure are valid analogously for the retrieval of current state change information as well.

Nevertheless the state change synchronisation procedure takes into account only the object instances whose state information is different from a combined default state. As combined default state the following values (according to [7]) shall be used:

- Operational state: enabled.
- Administrative state: unlocked.
- Usage state: idle (if supported).

5.3.3 Logging and retrieval of alarm and state change history information on NM request

The alarm/state change history information may be stored in the subordinate entities in dependence on the NM requirements. The NM is able to create logs for alarms/state change event reports and to define the criteria for storage of alarm/state change information according to [11].

The subsequent retrieval of stored information is possible on NM request in two different ways:

- via a read command with appropriate filtering;
- via bulk data transfer, using standardised file transfer procedures, as mentioned in subclause 5.1.2.

Nevertheless these particular requirements are not specific for alarm or state change information.

5.4 Co-operative alarm acknowledgement on the Itf-N

The acknowledgement of an alarm is a maintenance function that aids the operators in his day to day management activity of his network. An alarm is acknowledged by the operator to indicate he has started the activity to resolve this specific problem. In general a human operator performs the acknowledgement, however a management system (NM or EM) may automatically acknowledge an alarm as well.

The alarm acknowledgement function requires that:

- a) All involved OSs have the same information about the alarms to be managed (including the current responsibility for alarm handling).
- b) All involved OSs have the capability to send and to receive acknowledgement messages associated to previous alarm reports.

A co-operative alarm acknowledgement means that the acknowledgement performed at EM layer is notified at NM layer and vice versa, thus the acknowledgement-related status of this alarm is the same across the whole management hierarchy.

The co-operative alarm acknowledgement on Itf-N shall fulfil the following requirements:

- Acknowledgement messages may be sent in both directions between EMs and NM, containing the following information:
 - Correlation information to the alarm just acknowledged. - Acknowledgement history data, including the current alarm state (active | cleared), the time of alarm acknowledgement and, as configurable information, the management system (EM | NM) and the operator in charge of acknowledgement (the parameter operator name or, in case of auto-acknowledgement, a generic system name).
 - Acknowledgements notifications sent to NM shall be filtered with the same criteria applied to the alarms.
- The alarm acknowledgement procedure on the Itf-N shall cope with different customer requirements concerning the acknowledgement competence between operators working at EMs and NM. This matter may be managed by means of a "competence type" information, which may be controlled by every connected EM.
- Every time the communication between the two management systems is established, the NM is able to determine which OS is most suitable to handle the acknowledgement of alarms.
- Taking into account the acknowledgement functionality, the above described synchronisation procedure for retrieval of current alarm information on NM request may be extended. Additionally to the requirements defined in subclause 8.3.1, this extended synchronisation procedure relates not only to the active, but also to the "cleared and not acknowledged" alarms, which have still to be managed by the EM.

5.5 Overview of IRPs related to fault management

The N interface is built up by a number of IRPs. The basic structure of the IRPs is defined in [2] and [3].

For the purpose of Fault Management the following IRPs are needed:

- Alarm IRP
- Notification IRP
- Log IRP
(NOTE: This IRP may not be part of Release 1999)

Annex A (informative): Change history

Change history					
TSG SA#	Version	CR	Tdoc SA	New Version	Subject/Comment
S_07	2.0.0	-	SP-000013	3.0.0	Approved at TSG SA #7 and placed under Change Control
Mar 2000	3.0.0			3.0.1	cosmetic

History

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