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Concept and requirements
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Contents

Foreword

This Technical Specification (TS) has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

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Introduction

The present document is part of a TS-family covering the 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Telecommunication Management; Performance Management (PM), as identified below:

TS 32.401: "Concept and requirements";

TS 52.402: "Performance measurements - GSM";

TS 32.404: "Performance measurements - Definitions and template";

TS 32.405: "Performance measurements Universal Terrestrial Radio Access Network (UTRAN)";

TS 32.406: "Performance measurements Core Network (CN) Packet Switched (PS) domain";

TS 32.407: "Performance measurements Core Network (CN) Circuit Switched (CS) domain; UMTS and combined UMTS/GSM";

TS 32.408: "Performance measurements Teleservice";

TS 32.409: "Performance measurements IP Multimedia Subsystem (IMS)";

TS 32.425: "Performance measurements Evolved Universal Terrestrial Radio Access Network (E-UTRAN)";

TS 32.426: "Performance measurements Evolved Packet Core (EPC) network";

TS 32.452: "Performance measurements Home Node B (HNB) Subsystem HNS";

TS 32.453: "Performance measurements Home enhanced Node B (HeNB) Subsystem (HeNS)".

The present document is part of a set of specifications, which describe the requirements and information model necessary for the standardised Operation, Administration and Maintenance (OA&M) of a multi-vendor GSM, UMTS or LTE PLMN.

During the lifetime of a PLMN, its logical and physical configuration will undergo changes of varying degrees and frequencies in order to optimise the utilisation of the network resources. These changes will be executed through network configuration management activities and/or network engineering, see 3GPP TS 32.600 [3].

Many of the activities involved in the daily operation and future network planning of a PLMN network require data on which to base decisions. This data refers to the load carried by the network and the grade of service offered. In order to produce this data performance measurements are executed in the NEs, which comprise the network. The data can then be transferred to an external system, e.g. an Operations System (OS) in TMN terminology, for further evaluation. The purpose of the present document and its companion parts 2 and 3 is to describe the mechanisms involved in the collection of the data and the definition of the data itself.

1 Scope

The present document describes the requirements for the management of performance measurements and the collection of performance measurement result data across GSM, UMTS and LTE networks. It defines the administration of measurement schedules by the Network Element Manager (EM), the generation of measurement results in the Network Elements (NEs) and the transfer of these results to one or more Operations Systems, i.e. EM(s) and/or Network Manager(s) (NM(s)).

The basic Performance Management concept that the present document is built upon is described in clause 4.
The requirements of how an EM administers the performance measurements and how the results can be collected are defined in detail in clause 5. Measurements available for collection by NEs are described in the following specifications:

- TS 52.402 for GSM systems;
- TS 32.405, TS 32.406, TS 32.407 and TS 32.408 for UMTS and combined UMTS/GSM systems;
- TS 32.409 for IMS networks;
- TS 32.425 for E-UTRAN.
- TS 32.426 for EPC.
- TS 32.452 for Home Node B (HNB) Subsystem (HNS).
- TS 32.453 for Home enhanced Node B (HeNB) Subsystem (HeNS).

Effort has been made to ensure consistency in the definition of measurements between different NEs and generations. The performance measurement result is described in Performance Measurement File Format Definition (3GPP TS 32.432 [29]).

The following is beyond the scope of the present document, and therefore the present document does not describe:

- the formal definition of the interface that the EM uses to administer performance measurements in the NEs;
- the formal definition of the interface that the EM uses to collect measurement results from the NEs;
- how the data, once accumulated and collected, could or should be processed, stored, or presented to an end user;
- the information which may be obtained through the collection and processing of call or event related records which have been produced by the NEs primarily for the purpose of raising bills and other charges.

The management requirements have been derived from existing telecommunications operations experience. The management definitions were then derived from other standardisation work so as to minimise the re-invention factor. References are given as appropriate.

The objectives of this standardisation are:

- to provide the descriptions for a standard set of measurements;
- to produce a common description of the management technique for measurement administration and result accumulation; and
- to define a method for the bulk transmission of measurement results across a management interface.

The definition of the standard measurements is intended to result in comparability of measurement result data produced in a multi-vendor wireless network, for those measurement types that can be standardised across all vendors' implementations.

As far as possible, existing standardisation in the area of Performance Management has been re-used and enhanced where particular requirements, peculiar to the mobile telephony environment, have been recognised.

The present document considers all the above aspects of Performance Management for a GSM, UMTS or LTE network and its NEs defined in the core Technical Specifications. However, only those aspects which are specific to a GSM/UMTS/LTE system and particular to wireless network operation are included in the present document.

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. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TS 32.101: "Telecommunication management; Principles and high level requirements".

[2] 3GPP TS 32.102: "Telecommunication management; Architecture".

[3] 3GPP TS 32.600: "Telecommunication management; Configuration Management (CM); Concept and high-level requirements".

[4] 3GPP TS 25.442: "UTRAN Implementation Specific O&M Transport".

[5] ITU-T Recommendation E.880: "Field data collection and evaluation on the performance of equipment, networks and services".

[6] ITU-T Recommendation X.731: "Information technology - Open Systems Interconnection - Systems Management: State management function".

[7] ISO 8571: "Information processing systems - Open Systems Interconnection - File Transfer, Access and Management".

[8] – [9] Void.

[10] 3GPP TS 32.300: "Telecommunication management; Configuration Management (CM); Name convention for Managed Objects".

[11] 3GPP TS 32.302: "Telecommunication management; Configuration Management (CM); Notification Integration Reference Point (IRP): Information Service".

[12] 3GPP TS 32.111-1: "Telecommunication management; Fault Management; Part 1: 3G fault management requirements".

[13] - [19] Void.

[20] 3GPP TR 32.800: "Telecommunication management; Management level procedures and interaction with UTRAN".

[21] 3GPP TS 32.111-2: "Telecommunication management; Fault Management; Part 2: Alarm Integration Reference Point (IRP): Information Service (IS)".

[22] 3GPP TS 52.402: "Telecommunication management; Performance Management (PM); Performance measurements - GSM".

[23] Void.

[24] 3GPP TS 32.622: "Telecommunication management; Configuration Management (CM); Generic network resources Integration Reference Point (IRP): Network Resource Model (NRM)".

[25] W3C REC-xml-20001006: "Extensible Markup Language (XML) 1.0 (Second Edition)".

[26] W3C REC-xmlschema-0-20010502: "XML Schema Part 0: Primer".

[27] W3C REC-xmlschema-1-20010502: "XML Schema Part 1: Structures".

[28] W3C REC-xmlschema-2-20010502: "XML Schema Part 2: Datatypes".

[29] 3GPP TS 32.432: "Telecommunication management; Performance Measurement File Format Definition".

[30] 3GPP TS 32.342: "Telecommunication management; File Transfer (FT) Integration Reference Point (IRP): Information Service (IS)".

[31] 3GPP TS 32.404: "Telecommunication management; Performance Management (PM); Performance measurements - Definitions and template".

[32] 3GPP TS 32.405: "Telecommunication management; Performance Management (PM); Performance measurements - Universal Terrestrial Radio Access Network (UTRAN)".

[33] 3GPP TS 32.406: "Telecommunication management; Performance Management (PM); Performance measurements - Core Network (CN) Packet Switched (PS) domain".

[34] 3GPP TS 32.407: "Telecommunication management; Performance Management (PM); Performance measurements - Core Network (CN) Circuit Switched (CS) domain".

[35] 3GPP TS 32.408: "Telecommunication management; Performance Management (PM); Performance measurements - Teleservice".

[36] 3GPP TS 32.409: "Telecommunication management; Performance Management (PM); Performance measurements - IP Multimedia Subsystem (IMS)".

[37] 3GPP TS 32.425: "Telecommunication management; Performance Management (PM); Performance measurements Evolved Universal Terrestrial Radio Access Network (E-UTRAN)'.

[38] 3GPP TS 32.426: "Telecommunication management; Performance Management (PM); Performance measurements Evolved Packet Core (EPC) network'.

[39] 3GPP TS 32.452: "Telecommunication management; Performance Management (PM); Performance measurements Home Node B (HNB) Subsystem (HNS)'.

[40] 3GPP TS 32.453: "Telecommunication management; Performance Management (PM); Performance measurements Home enhanced Node B (HeNB) Subsystem (HeNS)'.

3 Definitions and abbreviations

3.1 Definitions

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

network Element Manager (EM): provides a package of end-user functions for management of a set of closely related types of Network Elements. These functions can be divided into two main categories:

- Element Management Functions for management of Network Elements on an individual basis. These are basically the same functions as supported by the corresponding local terminals.
- Sub-Network Management Functions that are related to a network model for a set of Network Elements constituting a clearly defined sub-network, which may include relations between the Network Elements. This model enables additional functions on the sub-network level (typically in the areas of network topology presentation, alarm correlation, service impact analysis and circuit provisioning).

Network Manager (NM): provides a package of end-user functions with the responsibility for the management of a network, mainly as supported by the EM(s) but it may also involve direct access to the Network Elements. All communication with the network is based on open and well-standardised interfaces supporting management of multi-vendor and multi-technology Network Elements.

Operations System (OS): generic management system, independent of its location level within the management hierarchy.

3.2 Abbreviations

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

3G	3rd Generation
AGCH	Access Grant Channel
APN	Access Point Name
ASN.1	Abstract Syntax Notation 1
AuC	Authentication Centre
BER	Basic Encoding Rules
BSC	Base Station Controller
BSS	Base Station System
BSSAP	BSS Application Part
BTS	Base Transceiver Station
CBCH	Cell Broadcast Channel
CCCH	Common Control Channel
DCCH	Dedicated Control Channel
DCN	Data Communication Network
DER	Discrete Event Registration
EIR	Equipment Identity Register
EM	(Network) Element Manager
EPC	Evolved Packet Core
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
FACCH	Fast Associated Control Channel
FTAM	File Transfer Access and Management
FTP	File Transfer Protocol
GGSN	Gateway GPRS Service Node
GMSC	Gateway Mobile Services Switching Centre
GPRS	General Packet Radio Service
GSM	Global System for Mobile communications
GSN	GPRS Service Node
HLR	Home Location Register
HO	Handover
HPLMN	Home PLMN
IMEI	International Mobile Equipment Identity
IMSI	International Mobile Subscriber Identity
ISDN	Integrated Service Digital Network
ISO	International Standards Organisation
Itf	Interface
LLC	Logical Link Control
LR	Location Register
LTE	Long Term Evolution
MS	Mobile Station
MSC	Mobile Services Switching Centre
MSRN	Mobile Subscriber Roaming Number
MTP	Message Transfer Part
NE	Network Element
NM	Network Manager
NSS	Network Sub System (including EIR, HLR, SMS-IWMSC, MSC and VLR)
OA&M	Operation, Administration and Maintenance
OACSU	Off-Air Call Set Up
OS	Operations System (EM, NM)
OSI	Open Systems Interconnection
PCCCH	Packet Common Control Channel
PCCH	Packet Paging Channel
PCH	Paging Channel
PLMN	Public Land Mobile Network
PM	Performance Management

PTCH	Packet Traffic Channel
PVLR	Previous VLR
QoS	Quality of Service
RACH	Random Access Channel
Rec.	Recommendation
RF	Radio Frequency
RNC	Radio Network Controller
RR	Radio Resource
RXLEV	Reception Level
RXQUAL	Reception Quality
SACCH	Slow Associated Control Channel
SCCP	(ITU-T) Signalling Connection Control Part
SDCCH	Stand alone Dedicated Control Channel
SGSN	Serving GPRS Service Node
SMS-IWMSC	Short Message Service Inter Working MSC
SNDCP	Sub Network Dependency Control Protocol
SS	Supplementary Service
TCAP	(ITU-T) Transaction Capabilities Application Part
TCH	Traffic Channel
TFTP	Trivial FTP
TMN	Telecommunications Management Network
TMSI	Temporary Mobile Subscriber Identity
UE	User Equipment
UMTS	Universal Mobile Telecommunications System
UTRAN	Universal Terrestrial Radio Access Network
VLR	Visitors Location Register

4 Concept

Any evaluation of PLMN-system behaviour will require performance data collected and recorded by its NEs according to a schedule established by the EM. This aspect of the management environment is termed Performance Management. The purpose of any Performance Management activity is to collect data, which can be used to verify the physical and logical configuration of the network and to locate potential problems as early as possible. The type of data to be collected is defined by the equivalent measurements (refer to TS 52.402 [22] and TS32.404 [31]). The present document concentrates on the requirements of GSM, UMTS and LTE telecom management to produce this data. Any management actions performed at the OSs subsequently to analyse the performance data are not considered in the present document.

Data is required to be produced by the NEs to support the following areas of performance evaluation:

- traffic levels within the network, including the level of both the user traffic and the signalling traffic (clause 4.1.1);
- verification of the network configuration (clause 4.1.2);
- resource access measurements (clause 4.1.3);
- Quality of Service (e.g. delays during call set-up, packet throughput, etc) (clause 4.1.4); and
- resource availability (e.g. the recording of begin and end times of service unavailability) (clause 4.1.5).

The production of the measurement result data by the NEs also needs to be administered by the EM. Several phases of administration of performance measurements can be distinguished:

- the management of the performance measurement collection process (clause 4.2.1);
- the generation of performance measurement results (clause 4.2.2);
- the local storage of measurement results in the NE (clause 4.2.3);
- the transfer of measurement results from the NE to an OS (EM and/or NM) (clause 4.2.4); and

- the storage, preparation and presentation of results to the operating personnel (clause 4.2.5).

In respect to the evaluation of the results produced by the measurements the following has to be considered:

- to understand the nature of the results received from the network (clause 4.3.1);
- to assure the reliability and accuracy of the measurement results (clause 4.3.2);
- to ensure comparable measurement results for the same measurements being performed in equipment from different vendors (clause 4.3.3);
- the ability to identify the results in the management systems: with respect to the measurement jobs by the EM, and with respect to the measurement types and measured resources by the NM (clause 4.3.4); and
- to take into account that, in a set of n correlated measurements, any (n-1) out of the defined n measurements may be provided by the network (clause 4.3.5).

Performance measurements may also be used to supervise operator defined threshold values and generate alarms upon exceeding the thresholds (clause 4.4).

The following clauses provide further background on the performance measurement concept that is applicable to GSM, UMTS and LTE networks. Although any implementation of GSM, UMTS and LTE network elements shall adopt the concept described below, not all of the text - due to its conceptual nature - is usable to actually determine compliance of the equipment. In these cases, more strictly specified requirements, against which conformance shall be proven, are found in clause 5 of the present document.

4.1 Measurement result data requirements

This clause describes the typical requirements for performance data to be produced by the NEs, which comprise a GSM, UMTS or LTE network. It is important to note that an actual measurement value collected from the network may be used to satisfy requirements in more than one category of measurement described below.

4.1.1 Traffic measurements

Traffic measurements provide the data from which, among other uses, the planning and operation of the network can be carried out.

The types of traffic evaluations for which PLMN specific measurements may be used include:

- traffic load on the radio or core network interfaces (signalling and user traffic);
- usage of resources within the network nodes;
- user activation and use of supplementary services, etc.

Examples of measured values may include:

- pages per location area per hour;
- busy hour call attempts per BSC, RNC, MSC;
- handovers per BSC/RNC per hour, etc.

4.1.2 Network configuration evaluation

Once a network plan, or changes to a network plan, have been implemented it is important to be able to evaluate the effectiveness of the plan or planned changes. Typically, the measurements required to support this activity indicate the traffic levels with particular relevance to the way the traffic uses the network.

4.1.3 Resource access

For accurate evaluation of resource access, each measurement result would need to be produced for regular time intervals across the network, or for a comparable part of the network.

4.1.4 Quality of Service (QoS)

The user of a PLMN views the provided service from outside the network. That perception can be described in observed QoS terms. QoS can indicate the network performance expected to be experienced by the user. For further detail see ITU-T Recommendation E.880 [5].

The QoS parameters applied by the network to specific user services may also be relevant to determine the charges levied towards the user for the provision of those services.

4.1.5 Resource availability

The availability performance is dependent on the defined objectives, i.e. the availability performance activities carried out during the different phases of the life cycle of the system, and on the physical and administrative conditions. For further detail see ITU-T Recommendation E.880 [5].

4.2 Measurement administration

The range of measurements which will be available from the NEs are expected to cover all of the requirements described in clause 4.1. However, not all of these measurements will be required all of the time, from every occurrence, of every relevant NE. Therefore, it is necessary to administer the measurements so as to determine which measurement types, on which measured resources, at which times, are to be executed. With a highly distributed network like a GSM, UMTS or LTE mobile telecommunication system it is also necessary to gather the measurement result data so as to perform consistent analysis of the results and to evaluate the interactions between the NEs.

This clause describes the requirements for the various areas of administration of measurements.

4.2.1 Measurement job administration

Measurement jobs, i.e. the processes which are executed in the NEs in order to accumulate measurement result data and assemble it for collection and/or inspection, will need to be scheduled by the EM for the period or periods for which gathering of data shall be performed.

The administration of measurement jobs by the EM comprises the following actions:

1) Create/delete a measurement job. This action implies the instantiation respectively deletion of a measurement collection process within the network.

2) Modifying a measurement job, i.e. changing the parameters (specifically the schedule) of a measurement job that has been previously created.

3) Definition of measurement job scheduling. This action defines the period or periods during which the measurement job is configured to collect performance data.

4) Specification of the measurement types to be contained in the job, e.g. "number of GPRS attach attempts". In GSM, the measurement jobs are administered by individual measurement types, which are specified in TS 52.402 [22]. In UMTS and LTE, the measurement jobs may be administered per individual measurement type or per measurement family, which comprises a collection of related measurement types. The measurement types and families for UMTS and combined GSM/UMTS networks are specified in TS 32.405 [32], TS 32.406 [33], TS 32.407 [34], TS 32.408 [35] and specified in TS 32.409 [36] for IMS. Measurement types and families for E-UTRAN are specified in TS 32.425 [37] and for EPC in TS 32.426 [38]. Measurement types and families for Home Node B (HNB) Subsystem (HNS) are defined in TS 32.452 [39] and for Home enhanced Node B (HeNB) Subsystem (HeNS) in TS.32.453 [40].

5) Identification of the measured resources, i.e. the NEs (e.g. MSC, NodeB) or NE components (e.g. trunkgroups, radio channels, transceivers) to which the measurement types or measurement families, specified in the measurement job, pertain.

6) Suspend/resume a measurement job. The "suspend" action inhibits the collection of measurement result data by a measurement job, regardless of its schedule, without deleting it. The "resume" action will re-enable measurement result data collection according to the measurement job schedule. It may also be possible for the system to

suspend a measurement job without any operator"s action in case of overload. It should then be possible, at any time, for the operator to resume a job suspended by the system.

7) Setting up any necessary requirements for the reporting and routing of results to one or more OSs (EM and/or NM).

8) Retrieval of information related to measurement jobs, i.e. view the current measurement job definition.

A measurement job is thus characterised by a set of measurement types and/or measurement families which all pertain to the same set of measured resources and share the same schedule. Typically a large number of measurement jobs will run simultaneously within the NEs comprising the PLMN, and one or more EM is involved in the administration of those measurement jobs. In order for the operator to manage this large number of measurement jobs effectively and efficiently, it is necessary that the administration functions in the EM can not only deal with individual measurements on individual NEs, but also scope the execution environment across the measured resources, and apply an additional filter to the resources/NEs selected by the measurement scope. The scoping and filtering of the measurement(s) shall then be automatically adapted if measured resources that match the selection criteria are added or removed.

There are several instances of this "plug&measure" feature:

1) execute the same (set of) measurement type(s) on a set of identical resources within a single NE. An example of this is to measure the average bit error rate on all channels in a cell, or all channels of the cell that match the filter criterion;

2) execute the same (set of) measurement type(s) on a set of identical NEs or resources according to the hierarchical structure of the network. Examples of this are to measure the average bit rate on all Iu_{PS} links of the same U-MSC or to measure inter-cell handovers for all cells attached to the same BSC;

3) execute the same (set of) measurement type(s) across all resources/NEs of the same type that belong to a specific administrative domain. An example of this is to measure the call set-up failure rate in all cells located in a certain city, or otherwise defined geographical area (this may be a combination of scope and filter), or within the responsibility area of system operator number 2.

The definition of those administrative, or management, domains may be part of either the measurement job administration functions or the CM functions provided by the EM. The functionality of scoping and filtering of measurements within the same NE may either be distributed across the NE and the EM (e.g. EM creates a single measurement job with scope and filter, and NE determines the measured resources that match the selection criteria), or it may be realised solely in the EM (EM determines measured resources from the scope and filter specified by the system operator, and multiple measurement jobs will be created), according to implementation choice.

4.2.2 Measurement result generation

Each measurement job will be collecting result data at a particular frequency, known as the granularity period of the measurement job. At the end of the granularity period a scheduled result report is generated for each measurement job that is actively collecting performance measurement result data, i.e. for all the measurement types and measured resources covered by the job.

The measurement result data can be collected in each NE of the network with a number of collection methods:

- cumulative incremental counters triggered by the occurrence of the measured event;
- status inspection (i.e. a mechanism for high frequency sampling of internal counters at pre-defined rates);
- gauges (i.e. high tide mark, low tide mark);
- discrete event registration, where data related to a particular event is captured.

These collection methods are:

- **Cumulative counter:** The NE maintains a running count of the event being counted. The counter is reset to a well-defined value (usually "0") at the beginning of each granularity period.
- **Status inspection:** Network elements maintain internal counts for resource management purposes. These counts are read at a predetermined rate, the rate is usually based upon the expected rate of change of the count value. Status inspection measurements shall be reset at the beginning of the granularity period and will only have a valid result at the end of the granularity period.

- **Gauge:** Gauges represent dynamic variables that may change in either direction. Gauges can be integer or real valued. If a gauge is required to produce low and high tide marks for a granularity period (e.g. minimum and maximum call duration), then it shall be reinitialised at the beginning of each granularity period. If a gauge is required to produce a consecutive readout over multiple granularity periods (e.g. cabinet temperature), then it shall only be reinitialised at the start of a recording interval (see definition of "recording interval" in clause 5.2.1.2).

- **Discrete Event Registration (DER):** Data related to a particular event is captured. Every n^{th} event is registered, where n can be 1 or larger. The value of n is dependent on the frequency of occurrence of the event being measured.
  DER measurements shall be reset at the beginning of each granularity period and will only have a valid result at the end of the granularity period.

The measurement result data can be collected in a non-3GPP defined NE of the network with a number of collection methods which are not defined in this document. These collection methods are referred to as 'externally defined collection methods'

This following item describes the collection method to be used for collecting measurements result data from a non-3GPP defined NE.

Transparent Forwarding (TF): The non-3GPP defined NE maintains a count based on the NE"s 'externally defined collection method'. The 3GPP system maintains a measurement count that is a snapshot/reading of the non-3GPP defined NE count at each granularity period.

4.2.3 Local storage of results at the NE/EM

It is necessary for the NE to retain measurement result data it has produced until they have been sent to, or retrieved by, the destination OS(s). Depending on implementation and configuration details, e.g. the transfer method, the number and type (EM/NM) of the destination OS(s), this data will be retained at the NE under the control of the destination OS(s), or solely under the control of the EM. The storage capacity and the duration for which the data will be retained at the NE will be Operator and implementation dependent.

If the measurement result data are routed to an NM via the EM, then it is necessary for the EM to retain the data at least until they have been successfully transferred to the NM. The storage capacity and the duration for which the data will be retained at the EM are Operator and implementation dependent.

4.2.4 Measurement result transfer

Measurement results produced by the NEs are transferred to an external OS for storage, post-processing, and presentation to the system operator for further evaluation. In a network with more than one OS (e.g. EM and NM) the data may be required by several OSs. It is therefore necessary to support the possibility for multiple destinations for the transfer of measurement result data.

From the NE to the EM, the results of the measurement jobs can be forwarded in either of two standard ways:

1) the scheduled result reports, generated by the measurement jobs executing in the NE, can be sent to the EM as soon as they are available (notifications);

2) the reports can be stored in the NE (files) and transferred to or retrieved by the EM when required.

From the network to the NM, measurement results can be forwarded via a bulk transfer (i.e. file-based) interface. It is an implementation option whether this interface to the NM resides in the EM or in the NEs.

It should be noted that, depending on an Operator's needs, measurement results may have to be transferred to the EM only, the NM only, or both. Depending on a vendor's implementation, measurement results may be transferred to the NM directly from the NE or via the EM. This implies that not all of the result transfer options described above have to be implemented in all cases.

4.2.5 Performance data presentation

The performance data user interface presentation, including the storage and preparation of the data in the OS(s), is outside the scope of the present document.

4.3 Measurement type definitions

This clause looks at the requirements for the definition of the individual measurement types.

4.3.1 Nature of the result

The measurement types defined for the GSM and UMTS systems have to be collected in the NEs. As each NE has its own role to play in the provision of the mobile service then each will have a different perspective on the performance of the network. The measurement type definitions shall, therefore, contain a description of the intended result of the measurement in terms of what is being measured. Appropriate information is included in the measurement type definition templates, see TS 52.402 [22] and ts 32.404 [31].

4.3.2 Perceived accuracy

The accuracy of measurements can be seen in three ways:

- whether the result produced represents all occurrences of the defined event;
- whether related measurements produced for the same period refer to the same events; or
- whether a measurement result refers to the whole or part of a granularity period.

Representation of all occurrences: the definition of a measurement needs to accurately reflect which types of events are to be included in the collection of the data. If a general event or procedure description can be characterised by several sub-types then the measurement definition will have to be precise as to which sub-types are included or specifically excluded from that measurement. Depending on the measurement definition, it may prove more acceptable to count the event or procedure by causes, e.g. successful termination, unsuccessful termination for all reasons. If the definition of a measurement refers to specific failure causes then care shall be taken to assess whether all causes are included - the sum of which can provide the total number of failures - or whether a count of the total is defined as well as for the specific causes. This is particularly important if not all of the causes are supported by an implementation, or if not all of the causes are requested in the measurement job definition.

Same period for the same two events: consider two events being counted which refer to the same resource allocation procedure, falling on either side of a granularity period boundary. I.e. the attempt is counted in one period while the termination is counted in the subsequent period. This will lead to discrepancies appearing in the actual figures when trying to compare attempt and termination counts for the same period. In order to avoid this discrepancy, implementations shall ensure that the termination of a procedure started within a given granularity period shall be captured within the measurement results for that same period, even if the termination of the procedure falls within the next granularity period.

Measurement collection periods: a typical measurement collection period can be interrupted by system events.

These interruptions can be one or more of the following:

a) failure of the measured network resource;

b) failure of the measurement procedure;

c) the measured network resource only becomes available after the measurement period has commenced;

d) the measurement procedure only becomes available after the measurement period has commenced.

e) system error (e.g. disk failure/lack of memory);

f) communication error (e.g. link failure between the network manager and the measured network resource).

Any such interruption implies that the affected measurement result is incomplete, and in extreme circumstances, no result reports at all can be generated. In these cases the measurement result shall highlight such interruptions to indicate that the result is suspect (see also setting of suspectFlag in Performance Measurement File Format Definition 3GPP TS 32.432 [29]).
Any actions to be taken subsequently with regards to the usefulness of the data will depend on the circumstances and the requirements of individual Operators.

4.3.3 Comparability of measurement result data

In a multi-vendor network it is important to know that measurement result data produced by equipment from one supplier is equivalent to the measurement result data being produced by the equivalent equipment from another supplier. This is particularly important when analysing data across the whole network. The measurement type definitions (in TS 52.402 [22], TS 32.405[32], TS 32.406 [33], TS 32.407 [34], TS 32.408 [35],TS 32.409 [36], TS 32.425 [37], TS 32.426 [38], TS 32.452 [39] and TS 32.453 [40]) shall therefore use a common understanding of the events being measured (e.g. by relating to protocol messages) so as to produce comparable results.

4.3.4 Measurement identification

In complex networks it is easy to generate large amounts of performance data. For the administration of the measurement jobs, and for the attribution of result data to the correct measurements, it is essential for the EM that all measurement result data is recognisable in respect of each request made. For post-processing of the measurement results in the NM, it is essential that measurement results can be attributed to the correct measurement types and NEs/measured resources.

As all the required information to distinguish the measurement results for each request, already exists in the definition of the request, it makes sense to use this information, rather than create anything new. The information, which can be used to distinguish requests from each other's, may be e.g. NE name, measurement type, granularity period, or a combination of these. NE names defined within the realm of CM (3GPP TS 32.600 [3] and the associated network resource model in other 32.6xx TSs) shall be reused. For the measurement job administration in the EM, it is also possible to use measurement job ids, or other implementation specific parameters that identify the measurements.

4.3.5 (n-1) out of n approach

The measurement result values generated by a NE can be obtained in a number of different ways. For example, measurements can be defined to provide the number of attempts for a certain procedure plus the number of failures and the number of successes, where the sum of the successes and failures equals the number of attempts. This means that actually any 2 of the above 3 measurements provide the same information. Therefore, an approach has been adopted in the present document and its companions, 3GPP TS 52.402 [22] and 3GPP TS 32.404 [31], to allow a vendor to choose any (n-1) out of the n defined counters for implementation (2 out of 3 in the above example). The benefit of this approach is to avoid redundancy in the measurement implementation, while at the same time leaving freedom for implementation of the measurements in the network elements. As all n result values of the measurement results are relevant for system operators, the missing n^{th} value shall be calculated by post-processing running on the NM.

It is important to note, however, that, depending on the measurement type definition, some implementation choices can offer more detailed information than others. For example, if per-cause failure measurements are specified, then the implementation of the "attempts" and "successes" measurements still allows post-processing to calculate the number of failures, but per cause information can not be derived. Therefore, in this case, the failure measurement should always be implemented, while there is still freedom to choose the "attempts" or the "successes" measurement as the other one to be implemented. The "failure" measurement should still be capable of delivering a total value, if not all failure causes are supported or if the results are not requested for (all of) the failure causes in the set-up of the measurement job.

Note that the principal problem, described above, also exists for measurements where sub-types are specified.

4.4 Performance alarms

Instead of, or in addition to, generating regular scheduled result reports, measurements may be administered in a way so as to supervise operator-defined thresholds. The thresholds are set when instantiating the measurements, and alarms are generated when the threshold value is crossed. These performance alarms are generated instead of, or in addition to, the generation of the scheduled result reports, as configured by the system operator. In UMTS, the alarms are sent to the OS via the Alarm IRP specified in TS 32.111-2 [21]. In GSM, according to implementation choice, the alarms are sent either via the Alarm IRP or via the Q3 interface specified in the GSM 12.xx series of specifications. Depending on the nature of the measurement (cumulative counter, status inspection, gauge, discrete event registration), the observed value, which is checked against the threshold, can only be derived at the end of a granularity period (status inspection and discrete event registration), and may have to be reset at the beginning of a new granularity period (cf. clause 4.2.2).

A GSM, UMTS or LTE NE may also generate threshold alarms based on system-internal supervision of counters and their threshold values. Neither the threshold nor the counters can be administered, but they depend on internal system

behaviour, defined by implementation. As the present document only specifies results and alarms based on manageable performance measurements, the system internal threshold alarms explained above are outside the scope of the present document and are solely within the realms of Fault Management.

5 Functional requirements

5.1 Introduction

This clause describes all basic functions to allow the system operator to have measurement data collected by the NEs and to forward the results to one or more OS(s), i.e. EM and/or NM. All functions are gathered to provide the system operator with the means to administer, plan, execute measurements and to store and evaluate the measurement results.

Building on the concept established in clause 4 of the present document, the following clauses further specify the requirements that all standard GSM, UMTS and LTE implementations shall comply to.

5.2 Basic functions

The Performance Management concept as applicable in the present document is based on the general framework for 3G-telecom management defined in 3GPP TS 32.101 [1] and 3GPP TS 32.102 [2]. A particular feature of this general framework is the existence of the fully standardised interface labelled "Itf-N", that connects the network with the Network Manager (NM). In the context of Performance Management, Itf-N can be used for:

- the transfer of files containing performance measurement result data generated in the network;
- the emission of "performance alarms" (notifications).

It should be pointed out that, on the network side, Itf-N may be implemented either in the NEs or in the EM, according to vendor choice.

As an example, figure 1 outlines this concept in the context of the UTRAN.

As the O&M functions for NodeB are partitioned into Logical and Implementation Specific O&M (see 3GPP TR 32.800 [20]), it should be understood that the functionalities described in the present document are completely within the scope of Implementation Specific O&M. This implies that no information pertaining to measurement administration and result transfer, as described here, is exchanged between the RNC and NodeB via the Iub interface. Such information may, however, be sent or received by the NodeB over the Iub physical bearer, see 3GPP TS 25.442 [4].

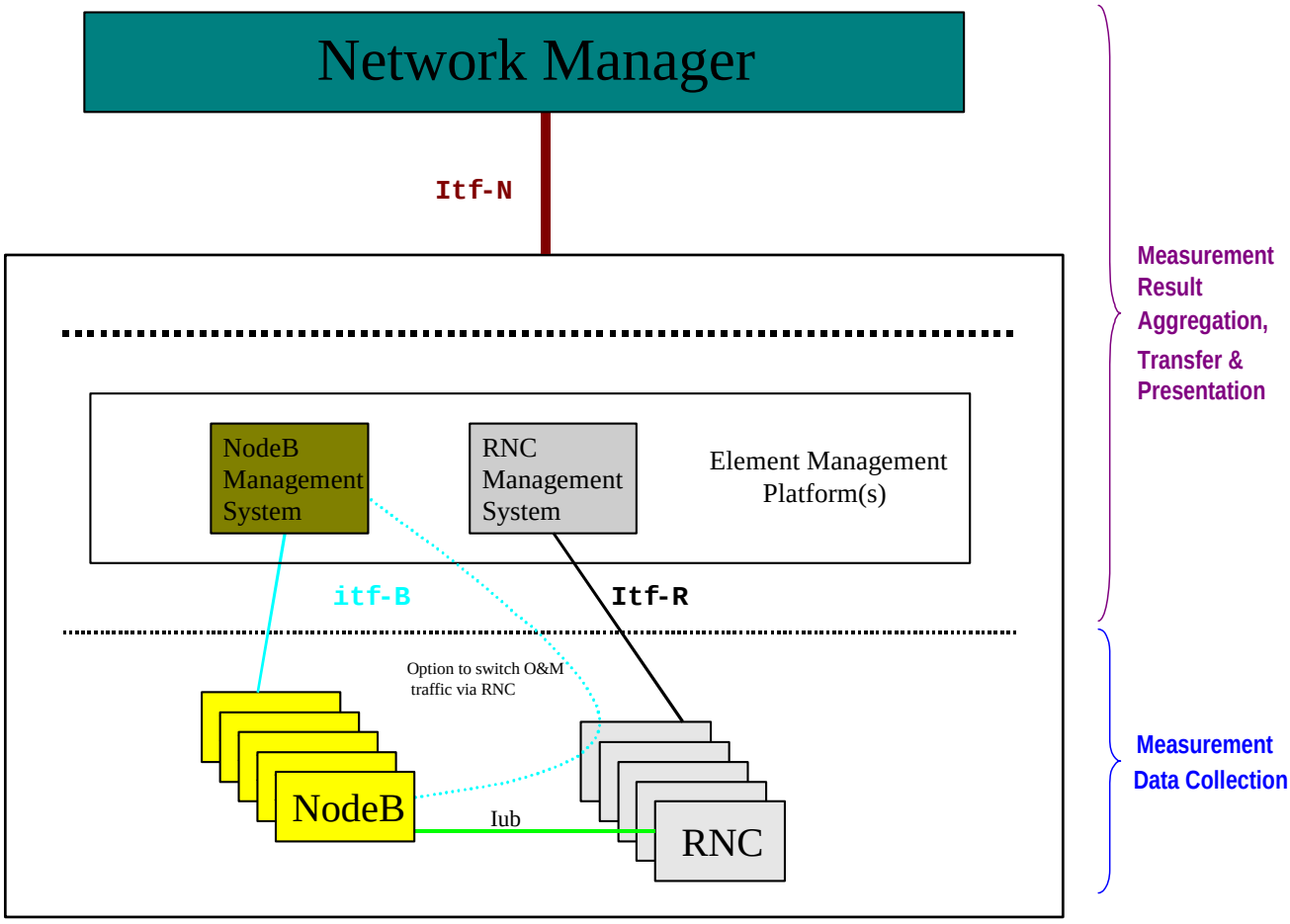

Figure 1: UTRAN Performance management concept

The basic requirement from an NE for measurements is to collect data according to the definition of the measurement jobs and to provide results to at least one OS (EM and/or NM). The data collected in the NE shall be made available for collection by or transfer to the OS(s) according to the schedule defined by the measurement job parameters. The NE shall be able to supply the result data at least to the NM if the Itf-N is implemented in the NEs, result provision from the NE to the EM is optional in this case. The NE shall be able to provide the result data to the EM if the Itf-N is implemented in the EM.

The EM shall be able to administer the measurements, e.g. create/delete measurement jobs and define their schedules. If the measurement results are transferred from the NEs to the EM, then the EM can control:

- the immediate ("real time") transfer of scheduled reports from the NE to the EM;
- the storage of scheduled reports in the NE; and
- deferred retrieval by the EM of scheduled reports stored in the NE.

In GSM, the optional Q3 interface specified in 3GPP TS 52.402 [22] can be used to perform these functions, while in UMTS, they are executed through a proprietary interface. Depending on the implementation option chosen for the Itf-N, the EM and/or NM may be involved in the control of the measurement result transfer to the NM.

The basic functions of the NM are beyond the scope of the present document. However, any NM that supports the network functions as described here must provide the NM side of the Itf-N, and the ability to handle the measurement result data that it receives, according to the file format(s) specified in the Performance Measurement File Format Definition 3GPP TS 32.432 [29]. The measurement result data may then be used in its original form or post-processed according to the system operator requirements. It is further anticipated that NM systems will have sophisticated functions for the management, preparation and presentation of the measurement result data in various forms.

The following clause summarises the measurement administration functions required in GSM, UMTS and LTE networks. They are then specified in more detail in clauses 5.x below.

(Performance) measurement administration functions allow the system operator, using functions of the EM, to determine measurement data collection in the network and forwarding of the results to one or more OS(s).

(Performance) measurement administration functions cover:

1) measurement data collection requirements:

   - **measurement types.** Corresponds to the measurements as defined in TS 52.402 [22], 3GPP TS 32.405 [32], TS 32.406 [33], TS 32.407 [34], TS 32.408 [35], TS 32.409 [36], TS 32.425 [37], TS 32.426 [38], 32.452 [39] and 32.453 [40] or defined by other standards bodies, or manufacturer defined measurement types;

   - **measured network resources.** The resource(s) to which the measurement types shall be applied have to be specified, e.g. one or more NodeB(s);

   - **measurement recording**, consisting of periods of time at which the NE is collecting (that is, making available in the NE) measurement data.

2) measurement reporting requirements:

   - this allows the system operator to specify the measurement related information to be reported, if required (e.g. omitting zero valued counts).. The frequency at which scheduled result reports shall be generated also has to be defined, if it may deviate from the granularity period. Particular functions, which exceed the requirements set out in the present document, are provided if the optional Q3 interface specified in 3GPP TS 52.402 [22] is implemented for GSM.

3) measurement result transfer requirements:

   - The result transfer requirements in the present document are limited to the file based Itf-N, used to forward the measurement results to the NM. If ItF-N is implemented in the EM, then measurement results can be transferred from the NE to the EM, and/or they are stored locally in the NE and can be retrieved when required. If Itf-N is implemented in the NEs, then the PM result files are sent directly from the NE to the NM, involving control by the EM as required, The EM shall support all administration functions necessary to fulfil the above result transfer requirement.;

   - measurement results can be stored in the network (NEs or EM, depending on implementation option chosen for Itf-N) for retrieval by the NM when required.

A (performance) measurement job, covers the measurement data collection as described in point 1 above. If the Q3 interface for GSM is implemented, it also covers the measurement reporting requirements, as described in point 2 above. In UMTS, the reporting requirements may be covered by the measurement job, or they may be administered per NE, per management domain, or per EM, as chosen by the vendor. It is up to the implementation whether requirements for the result transfer or the local storage of results are specified within the measurement job, particularly since the use of standard protocols, such as FTP, is foreseen.

A measurement job can be created, modified, displayed or deleted by the EM. In addition, measurement job activities in the NE can be suspended and resumed on request of the EM.

The system operator shall specify the required measurement parameters upon initiation of a measurement job. These parameters consist of, among others, recording schedule, granularity, and measurement type(s), as listed above.

A standard set of measurements that generate the required data is defined in 3GPP TS 52.402 [22] for GSM, in 3GPP TS 32.405 [32], TS 32.406 [33], TS 32.407 [34], TS 32.408 [35] for UMTS and combined GSM/UMTS systems,in TS 32.409 [36] for IMS, in TS 32.425 [37] for E-UTRAN, in TS 32.426 [38] for EPC, in TS 32.452 [39] for Home Node B (HNB) Subsystem (HNS) and in TS.32.453 [40] for Home enhanced Node B (HeNB) Subsystem (HeNS) However, a significant number of additional measurements is expected from real implementations. These will mainly consist of measurements for the underlying technologies, which are not 3G specific, such as ATM or IP, but is also due to specific vendor implementations. While the NM interface (Itf-N) for result transfer of both standard and non-standard measurements is fully standardised Performance Measurement File Format Definition 3GPP TS 32.432 [29], the interface between EM and NE is only standardised in functional terms. In UMTS, implementation details of this interface are vendor specific. In GSM, it may be implementation specific or implemented in compliance with the OSI interface specified in 3GPP TS 52.402 [22].

5.3 Plug & Measure

To be completed in a later Release.

5.4 Measurement jobs

Measurement jobs may be only visible at the (proprietary) interface between the EM and the NE. Measurement job administration functions in the EM may hide the measurement jobs from the user interface by providing higher levels of abstraction for the benefit of ease of use.

When defining a measurement job, the following aspects have to be considered.

5.4.1 Measurement job characteristics

5.4.1.1 Measurement types

Every measurement job consists of one or more measurement types (as defined in Performance Measurement File Format Definition 3GPP TS 32.432 [29]), for which it collects measurement data. The measurement type(s) contained in a job may apply to one or more network resources of the same type, e.g. a measurement job may be related to one or several NodeB(s). A measurement job will only produce results for the measurement type(s) it contains.

5.4.1.2 Measurement sub-types

Many of the measurement types specified produce single result values, i.e. the measurement is characterised by a single measurement type as specified in TS 52.402 [22], TS 32.405 [32], TS 32.406 [33], TS 32.407 [34], TS 32.408 [35], TS 32.409 [36], TS 32.425 [37], TS 32.426 [38], TS 32.452 [39] and TS.32.453 [40]. In other cases, however, the event or procedure being measured can be characterised by several sub-types, or, depending on the measurement definition, by several causes, e.g. successful termination of a procedure and unsuccessful termination for all failure causes. As far as a measurement type is defined to capture per cause information of the event or procedure being measured, the causes and cause codes are specified in "other" 3GPP TSs, i.e. in the TS defining the procedure being measured. In other cases, the sub-types are specified in the measurement type definitions in TS 52.402 [22], TS 32.405 [32], TS 32.406 [33], TS 32.407 [34], TS 32.408 [35], TS 32.409 [36], TS 32.425 [37], TS 32.426 [38], TS 32.452 [39] and TS.32.453 [40]. For UMTS systems, combined UMTS/GSM systems and for LTE systems, this information is described in detail in the measurement definition templates, see TS 32.404 [31].

Per cause measurements, where the causes are defined in the 3GPP TS that specifies the procedure or event being measured, may lead in certain cases to a huge number of measurement sub-types which will increase substantially the size of the measurement result file. Since not all per cause measurements may be useful for the system operator, two options are possible for the management of the corresponding measurement sub-types:

- support all the sub-types corresponding to the cause codes defined in the 3GPP TS that specifies the procedure or event being measured. In that case, the sum over the result values of all supported per cause measurements is equal to the total sum across all defined sub-types, and therefore no sum value shall be provided in the measurement result files.

- support only a subset of the causes (allowed only if the cause codes are specified in "other" 3GPP TSs). In that case, the first value of the result sequence in the measurement result files must be the total sum across all the sub-

types as defined in the "other" 3GPP TS, which may then be different from the sum over the result values of the supported sub-types. The keyword *.sum* placed behind the measurement type is used to identify the sum subtype.

If the definition of a measurement refers to specific failure causes or other sub-types then care shall be taken to assess which causes or sub-types are included. The choice of the supported causes/sub-types in the above cases is manufacturer dependent. Measurement job administration in the EM may also allow the system operators to select the sub-types of the measurement types that make up the measurement job, otherwise all sub-types supported by an implementation are included.

5.4.1.3 Measurement schedule

The measurement schedule specifies the time frames during which the measurement job will be active. The measurement job is active as soon as the starttime - if supplied in the schedule - is reached. The system shall support a job starttime of up to at least 30 days from the job creation date. If no starttime is provided, the measurement job shall become active immediately. The measurement job remains active until the stoptime - if supplied in the schedule - is reached. If no job stoptime is specified the measurement job will run indefinitely and can only be stopped by EM intervention, i.e. by deleting or suspending the measurement job.

The time frame defined by the measurement schedule may contain one or more recording intervals. These recording intervals may repeat on a daily and/or weekly basis and specify the time periods during which the measurement data is collected within the NE. A recording interval is identified by an interval starttime and an interval endtime, which lie between 00.00 and 24.00 hours, aligned on granularity period boundaries. Thus the length of a recording interval will be a multiple of the granularity period. For a single measurement type it shall be possible to specify several measurement jobs with different recording intervals as long as these intervals do not overlap. If it is required that a measurement type be observed by multiple measurement jobs with overlapping schedules then the system shall support multiple instances of that measurement type.

5.4.1.4 Granularity period

The granularity period is the time between the initiation of two successive gatherings of measurement data.
Valid values for the granularity period are 5 minutes, 15 minutes, 30 minutes, 1 hour. The minimum granularity period is 5 minutes in most cases, but for some measurements it may only make sense to collect data in a larger granularity period. The granularity period shall be synchronised on the full hour, but its value is not required to be changeable during the lifetime of the job.

5.4.1.5 Measurement reporting

Each measurement job running on an NE produces scheduled measurement reports (measurement records) at the end of each granularity period, and contains the information as requested by the system operator. This information consists of:

- an identification of the measurement job that generated the report;
- an identification of the involved measurement type(s) and the measured network resource(s) (e.g. NodeB);
- a time stamp, referring to the end of the granularity period;
- for each measurement type, the result value(s) and an indication of the validity of the result value(s);
- an indication if the scan is not complete, and the reason why the scan could not be completed.

The exact layout of the measurement reports (measurement records) generated by the NEs may be vendor specific. Multiple measurement reports shall be collated, based on reporting period, into a measurement result file for transfer, e.g from the NE or the EM. The file format of this aggregated file is specified by Performance Measurement File Format Definition 3GPP TS 32.432 [29]. Clause 5.5.2 specifies how these reports can be transferred to the destination EM and/or NM.

5.4.1.6 Illustration of the measurement scheduling principles

The diagram below gives an example of a NE which runs a measurement job, with a 15 minute granularity period, that has a recording interval start and end time, respectively, of 12:00 and 14:00.

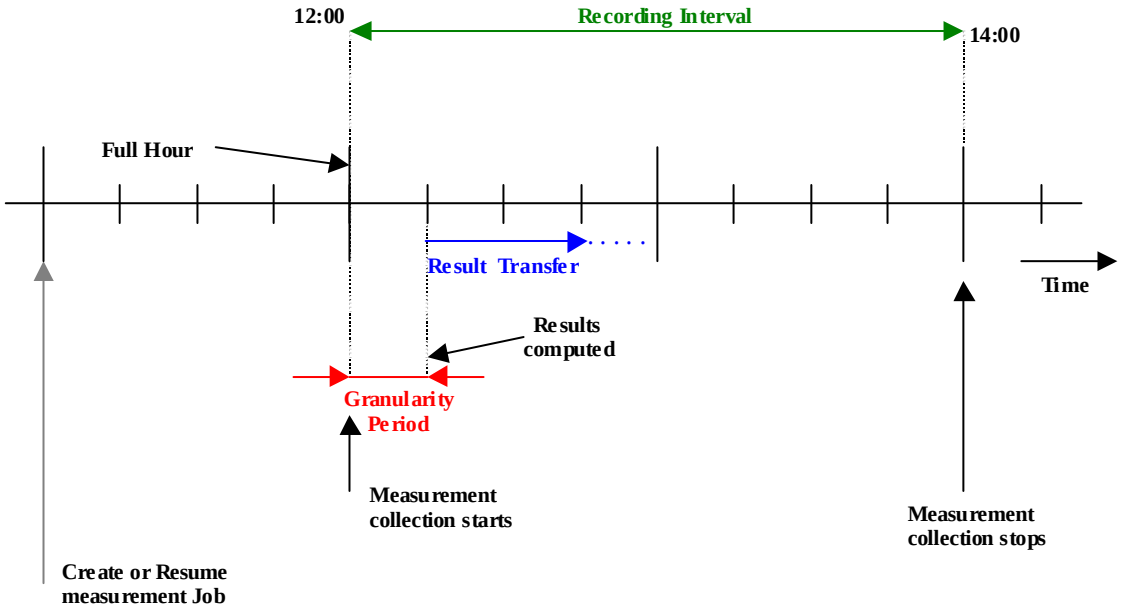

Figure 2

- At 12:00 the measurement job starts collecting data for its defined measurements.
- At 12:15, and every 15 minutes during the Recording Interval, the results for the measurements will be computed from the data gathered over the previous 15 minutes, and measurement reporting occurs as specified in clause 5.3.1.4.
- Beginning at 12:15, the results for the expired granularity periods may be sent to a destination OS.
- At 14:00 the measurement job activity is terminated for this recording interval.

5.4.2 Measurement job state and status attributes

Void.

5.4.3 Measurement job administration

Measurement jobs can be administered by the EM according to the following stipulations.

Creating a measurement job: On creation of a measurement job, all information has to be supplied in order to collect the required data from the selected network resources as specified by the measurement job characteristics (see clause 5.2.1).

Modifying a measurement job: In general, the modification of measurement job parameters may be requested by the EM during the lifetime of a measurement job when the job is suspended (explained below).

Displaying a measurement job: The system operator shall be able to get a list of all measurements that are currently defined, together with all available actual information as stored in the NE. This information consists of the data that is supplied on creation/modification and the actual state and status information of the measurement job.

Deleting a measurement job: A measurement job is automatically deleted by the system when it reaches the job endtime and all scheduled measurement reports have been generated. A created measurement job can also be deleted by manual intervention at any time. When deleted, the measurement process associated with the job is stopped, and all allocated resources are freed.

Suspending/resuming a measurement job: On normal operation, the measurement job collects measurement data within the NE according to the actual values of the measurement job parameters. However, the system operator may decide for some reason to discard temporarily the collection of measurement data (e.g. in case of system overload or congestion, measurement results temporarily not used,...). The system operator therefore is able to suspend a defined measurement job at any time. This implies that the measurement job definition remains in the system, but that no measurement gathering activities are performed for this job. When the measurement job is resumed, measurement data collection is started again at the next granularity period within the measurement schedule. In addition to the suspend operation which may be triggered by the operator, the system may selectively suspend one or more measurement jobs in case of overload. When a measurement job is suspended, a 'job suspended' notification shall then be generated so that the Network Manager(s) will be warned of such an event.

5.5 Measurement results

5.5.1 Measurement result characteristics

During its specified recording intervals, each measurement job produces a result at the end of the granularity period if it is not suspended. Performance Measurement File Format Definition 3GPP TS 32.432 [29] provides for each measurement type that is specified within the present document a description of the expected measurement result.

Measurement results for all measurements of a particular measurement job are gathered in a single report at the end of the granularity period. The report may contain - in addition to the specific measurement results - fixed information, which is global for all measurement results associated with that measurement job, such as an identification of the involved network resources and a time stamp referring to the time at which the NE started collecting the measurement results. If measurement results are sent to the EM then the exact format may be vendor specific. For details about the standard file format for the transfer of measurement results to the NM via Itf-N Performance Measurement File Format Definition 3GPP TS 32.432 [29].

Once the result reports have been generated, they shall be stored locally within the NE if so requested by the EM/system operator. The storage capacity and duration as well as the method how the data may be deleted from the NE will be implementation dependent.

If some or all of the requested measurement data cannot be collected by a measurement job, this shall be indicated in the measurement report, cf. clause 5.4.1.5. In extreme cases, no report at all can be generated by the measurement job. This means that the destination of the result report (EM and/or NM) shall be capable of coping with missing or incomplete measurement reports.

5.5.2 Transfer of measurement results

During the recording intervals specified for a measurement job, scheduled measurement reports are generated at the end of each granularity period if the measurement job is not suspended. These reports can be transferred to the EM in either of two ways:

1) immediate notifications:

   - the reports are automatically forwarded to the EM at the end of the granularity period.

2) deferred retrieval:

   - the reports are stored locally in the NE, where they can be retrieved when required.

For each individual report, the transfer of measurement results in either one or both ways is to be established by the system operator, i.e. under the control of the EM. The actual control of the result transfer and the mechanisms applied may be implementation specific.

Each implementation shall support a file transfer facility to an external OS (i.e. not supplied by the NE vendor), such as an NM. This facility shall be implemented using either the FTAM ISO 8751 [7], (T)FTP protocol or FTIRP([30]). This interface may be located either in the NEs or the EM, as chosen by the vendor. As a result, it may not at all be necessary to transfer measurement result reports to the EM, if:

- the NM interface is implemented in the NEs, and

- the Operator chooses to post-process measurement results only in the NM.

Details of the file format to be used on the NM interface can be found in Performance Measurement File Format Definition 3GPP TS 32.432 [29]. The measurement report file conventions and transfer procedure are also specified in Performance Measurement File Format Definition 3GPP TS 32.432 [29].

The results of the measurement job can be forwarded to the EM in either of two standard ways:

1) the scheduled result reports generated by the NE (notifications) can be sent to the EM as soon as they are available;

2) the reports can be stored in the NE (files) and transferred to or retrieved by the EM when required.

It shall be possible for the EM to specify the details for its result retrieval as a part of the measurement administration.

Measurement results can be forwarded to the NM via a bulk transfer interface. It is an implementation option whether this interface resides in the EM or the NEs. Depending on the implementation, the control of the bulk transfer of measurement results to the NM may involve the EM and/or the NM. See Performance Measurement File Format Definition 3GPP TS 32.432 [29] for details.

In a network with more than one OS (e.g. EM and NM) the data produced may be required by several OSs. It is therefore necessary to support the possibility for multiple destinations for transfer of data.

All scenarios for the result transfer, as far as they are relevant for standardisation of 3G systems, are defined above. It should be noted that, depending on an Operator's needs, measurement results may have to be transferred to the EM only, the NM only, or both. Depending on a vendor's implementation, measurement results may be transferred to the NM directly from the NE or via the EM. This implies that not all of the result transfer options described above shall be implemented in all cases, however, those procedures that are implemented shall comply with the present document. A detailed specification of the measurement result transfer to the NM can be found in Performance Measurement File Format Definition 3GPP TS 32.432 [29].

5.6 Usage of Alarm IRP for performance alarms

Performance alarms allow Network Operators to be quickly informed of significant PM-related events. Authorized users can (a) set the measurement thresholds and (b) define the characteristics of related performance alarm notifications (e.g. perceivedSeverity). (a) Crossing or (b) reaching of thresholds shall result in the emission of a performance alarm notification.

Performance alarms may be defined against any managed object supporting measurement definitions, e.g. UtranCell, SgsnFunction. The source object of the performance alarm shall be the source object instance of the measurement that caused the alarm. Upon threshold (a) crossing or (b) reaching, the subscribed users (i.e. Notification IRP Managers) shall be notified via the Alarm IRP and Notification IRP. The Alarm IRP and Notification IRP are described in TS 32.111-2 [21] and TS 32.302 [11].

All parameters of the alarm notification as described in TS 32.111-2 [21] can be used for performance alarms. This information shall be provided by the PM application as the user of the Alarm IRP, with respect to at least the event type, probable cause, perceived severity, and thresholdinfo, plus all other user supplied mandatory parameters of the alarm notification. The parameter thresholdinfo shall be present for all performance alarm notifications and shall contain information pertinent to the context in which the performance alarm was triggered.

The thresholdinfo parameter shall provide the following information:

- The identifier of the measurement which (a) crossed or (b) reached the threshold
- The value of the measurement
- The threshold (a) crossing or (b) reaching direction (up or down)
- The threshold value (if hysteresis thresholds are supported, both raise and clear trigger values are provided)

Once a performance alarm has been raised, it shall be managed as other kinds of alarms, e.g., acknowledged, unacknowledged or annotated. Performance alarms may not be cleared manually (i.e., via the ADMC [automatic detection and manual clearing], see 3GPP TS 32.111-1" [12]). Performance alarms shall be cleared when the threshold is (a) crossed or (b) reached in the opposite direction to the one that triggers the alarm.

5.7 Threshold Management

To be able to monitor the overall health of the network, authorized users will have to set the thresholds used for generating Performance Alarms (see section 5.6). It is the Operator"s responsibility to ensure that threshold values are defined appropriately in order to detect performance degradations before they become service affecting.

An alarm threshold may be defined for one or more instances of a managed object class supporting measurements. The threshold will be monitored based on a monitor granularity period, where the monitor granularity period is a multiple of measurements collection granularity period. Following threshold creation, it shall be possible to query the threshold information defined for an object instance.

The threshold definition shall allow the user to assign up to four different severity levels (critical, major, minor, warning) based on different threshold values. The threshold direction should also be defined as increasing or decreasing, according to which direction raises the Performance Alarm. More generally, any Performance Management specific parameters of the triggered alarm notification as described in TS 32.111-2 [21] will be specified within the threshold configuration information.

All performance measurement types are available for threshold management. When defining thresholds, the user shall be able to select from any of the performance measurement types relevant for the object instance to which the threshold applies.

Thresholds are evaluated as performance data become available. For each measurement type, the current value is checked against the defined alarm threshold(s). Depending upon the previous value for this measurement type, a new alarm, a changed alarm or a clear alarm may be raised upon the (a) crossing or (b) reaching of this threshold.

The behaviour of performance alarms shall be the same as that of the AlarmIRP ([21]).

The threshold value for cumulative counters should be a rate of variation defined in an independent way of the monitor granularity period, e.g. an alarm could be triggered when PDP context activation requests are received at a rate exceeding 20 requests/s.

The following figure describes examples of threshold crossing for a Cumulative Counter measurement type in the context the changed alarm is supported:

- At T1, a new alarm notification A1 (minor) is generated when Level 1 is crossed
- At T2, a changed alarm notification A1 (critical) is generated when Level 2 and 3 are crossed
- At T3, a changed alarm notification A1 (minor) is generated when Level 3 and 2 are crossed
- At T4, a cleared alarm notification A1 is generated when Level 1 is crossed

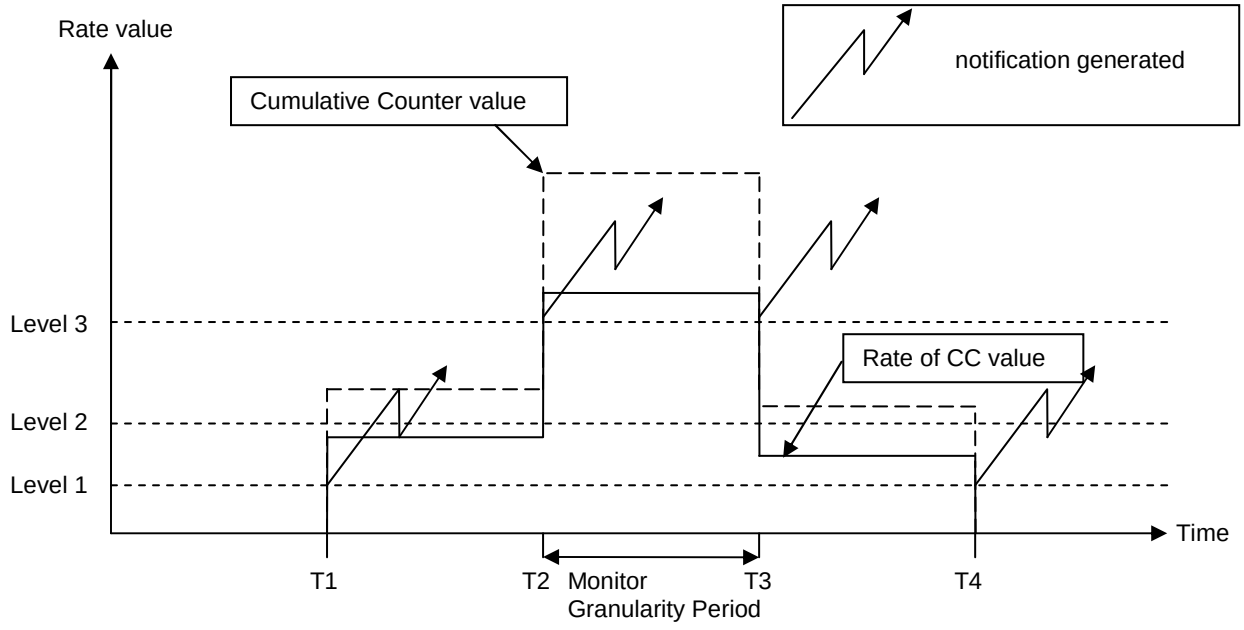

Figure 3: Examples of rate-based threshold crossings for a CC measurement type

For **gauge** measurements, the observed value of a gauge at the end of the monitor granularity period is compared to the threshold value.

The following figure describes examples of threshold crossing for a Gauge measurement type in the context the changed alarm is supported:

- At T1, a new alarm notification A1 (minor) is generated when Level 1 is crossed
- At T2, a changed alarm notification A1 (major) is generated when Level 2 is crossed
- At T3, a cleared alarm notification A1 is generated when Level 2 and 1 are crossed

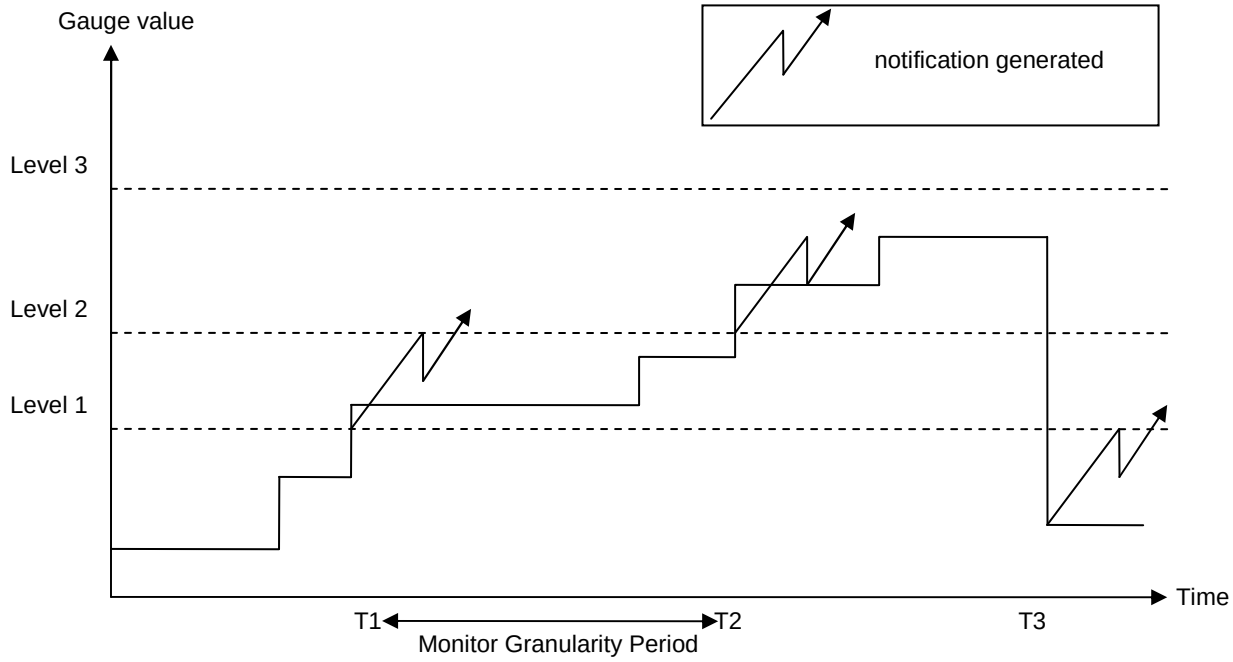

Figure 4: Examples of threshold crossing for a Gauge measurement type

In order to avoid repeatedly triggering Performance Alarms around a particular threshold level, an hysteresis mechanism may also be provided by defining threshold levels in pairs (high levels and low levels). In that case, the high level value shall be greater than or equal to the low level value.

For each pair of high and low threshold levels, one of them shall generate an alarm notification, and the other shall generate an alarm clear notification. If the direction of the threshold is increasing, a new alarm will not be generated before the measurement value has (a) crossed or (b) reached the high level threshold value. Furthermore, the alarm will not be cleared before the measurement value has reached the low level threshold value. For decreasing thresholds, the opposite is applied. The alarm notification shall always be generated before the alarm clear notification. The hysteresis mechanism can be used for both Gauges and Cumulative Counters thresholds.

The following figure describes examples of threshold crossings with hysteresis for a Gauge measurement type in the context the changed alarm is supported:

- At T1, a new alarm notification A1 (e.g. minor) is generated when notifyHigh1 is reached
- At T2, a changed alarm notification A1 (e.g. major) is generated when notifyHigh2 is reached
- At T3, a changed alarm notification A1(e.g. minor) is generated when notifyLow2 is reached
- At T4, a cleared alarm notification A1 is generated when notifyLow1 is reached
- At T5, a new alarm notification A2 is generated when notifyHigh1 is reached

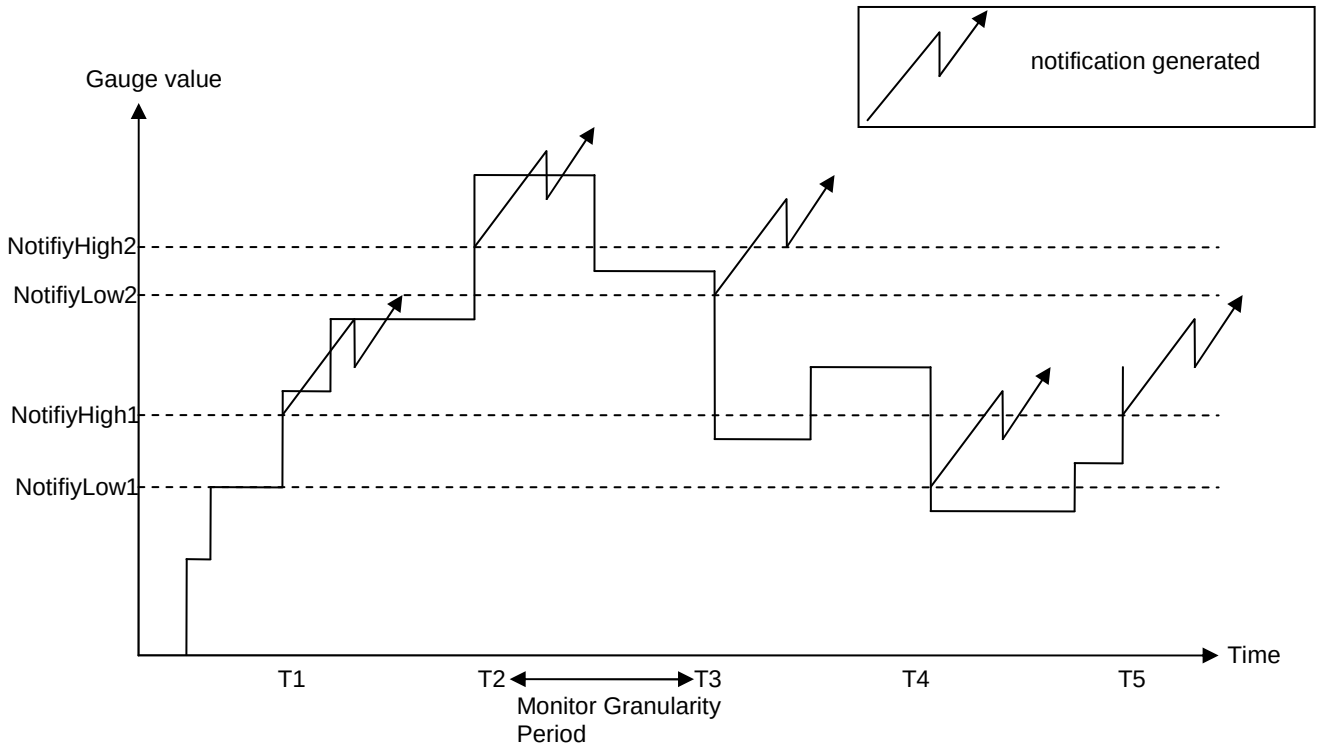

Figure 5: Examples of threshold crossings with hysteresis for a Gauge measurement type

For a threshold crossing with hysteresis example of Cumulative Counter measurement type, the monitored value for the alarms generation would be the derivative of the CC value, i.e. its rate of variation.

For DER and SI, the value of the counter will be calculated over the complete monitor granularity period. For **SI,** the counter will be sampled at regular time intervals and the mean value over the monitor granularity period will be calculated and compared with the threshold. For DER type, the threshold is compared with the mean value of all observations collected during the monitor granularity period. For a DER type, if no observations are made during the monitor granularity period then the DER will have a value of NULL. No valid comparison with a threshold can be made in this case. If an alarm has previously been detected it will remain outstanding.

The following figure describes examples of threshold crossings for a DER measurement type in the context the changed alarm is supported:

- At T1, a new alarm notification A1 (minor) is generated when Level 1 is crossed
- At T2, a changed alarm notification A1 (major) is generated when Level 2 is crossed
- At T3, a cleared alarm notification A1 is generated when Level 1 is crossed

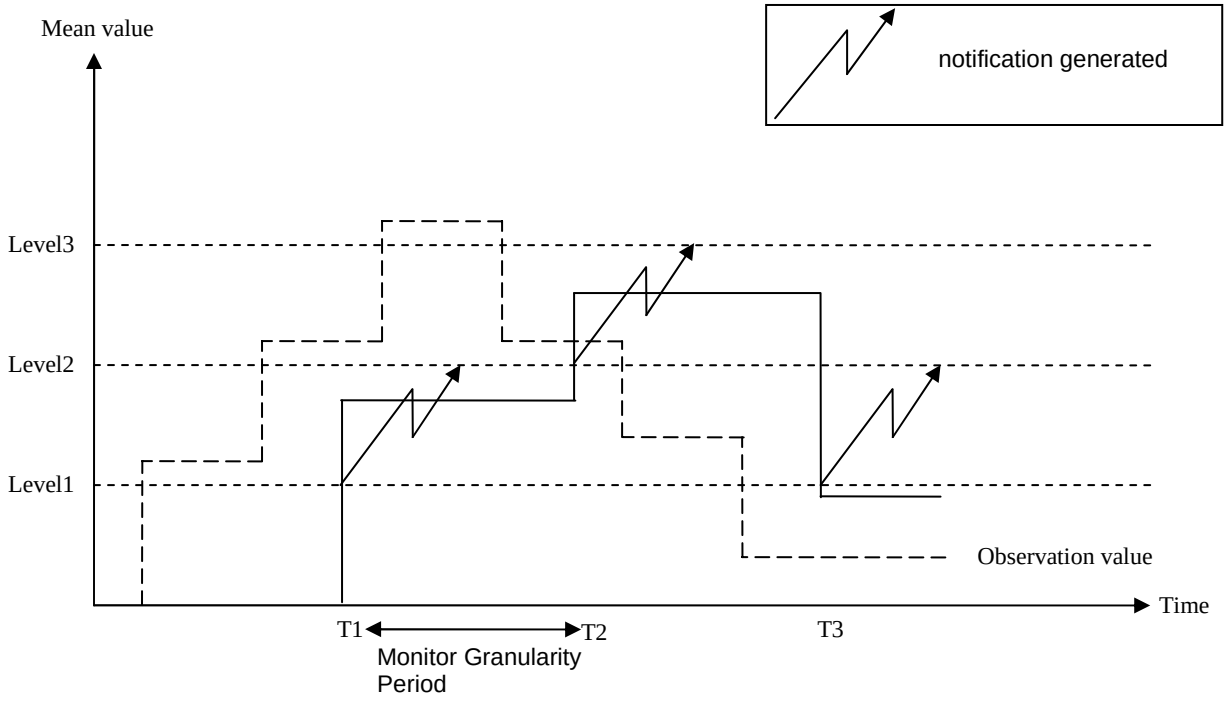

Figure 6: Examples of threshold crossings for a DER measurement type

Annex A (informative): Change history

Change history								
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Cat**	**Old**	**New**
June 2001	SA_12	SP-010237	--	--	Submitted to TSG SA #12 for Information.	--	--	1.0.0
June 2001	--	--	--	--	MCC editorials	--	1.0.0	1.0.1
Sep 2001	SA_13	SP-010467	--	--	Submitted to TSG SA #13 for Approval	--	2.0.0	4.0.0
Dec 2001	SA_14	SP-010638	0001	--	Correction of declaration in XML header	A	4.0.0	4.1.0
Mar 2002	SA_15	--	--	--	Automatic upgrade to Rel-5 (no Rel-5 CR)	--	4.1.0	5.0.0
Sep 2002	SA_17	SP-020502	0003	--	Description of Alarm IRP usage for performance alarms	C	5.0.0	5.1.0
Sep 2002	SA_17	SP-020502	0004	--	Addition of measurement file XML schema and miscellaneous alignments with CM	B	5.0.0	5.1.0
Jun 2003	SA_20	SP-030291	0006	--	Clarification of NE file generation behaviour in case of multiple granularity periods	A	5.1.0	5.2.0
Jun 2003	SA_20	SP-030291	0008	--	Correction of Measurement Result File Name Definition for alignment with Windows based systems	A	5.1.0	5.2.0
Sep 2003	SA_21	SP-030430	0009	--	Addition of 'jobId' and 'reportingPeriod' parameters in the file format definition	C	5.2.0	6.0.0
Sep 2003	SA_21	SP-030430	0010	--	Removal of measurement job state and status attributes	C	5.2.0	6.0.0
Sep 2003	SA_21	SP-030430	0011	--	Refinement of the conditions for setting 'suspect flag'	B	5.2.0	6.0.0
Dec 2003	SA_22	SP-030755	0012	1	Add requirements for Measurement Job overload management	B	6.0.0	6.1.0
Jun 2004	SA_24	SP-040265	0015	--	Correction in requirement for granularity periods	A	6.1.0	6.2.0
Sep 2004	SA_25	SP-040572	0018	--	Correction of measObjInstId and measType length limitations in the Measurement Report File Format	A	6.2.0	6.3.0
Sep 2004	SA_25	SP-040573	0019	--	Removal of XML DTD file format definitions	C	6.2.0	6.3.0
Sep 2004	SA_25	SP-040573	0020	--	Add jobId in PM file name	B	6.2.0	6.3.0
Dec 2004	SA_26	SP-040783	0021	--	Removal of annexes from Performance Management Concepts and Requirements	D	6.3.0	6.4.0
Dec 2004	SA_26	SP-040783	0022	--	Add requirements for Threshold Management	B	6.3.0	6.4.0
Feb 2005	--	--	--	--	History box clean-up to show only the 32401 Dec 2004 CRs	--	6.4.0	6.4.1
Jun 2006	SA_32	SP-060260	0024	--	Update an obsolete reference related to the Rel-7 withdrawn 32.403	F	6.4.1	7.0.0
Dec 2007	SA_38	SP-070734	0025	1	R7 CR 32.401-700 Correct definition of counter type Discrete Event Registration (DER) - Align with 32.404	F	7.0.0	7.1.0
Dec 2008	SA_42	--	--	--	Upgrade to Release 8	--	7.1.0	8.0.0
Dec 2009	-	-	-	-	Upgrade to Release 9	--	8.0.0	9.0.0
Sep 2010	SA_49	SP-100488	0027	--	Remove restriction from PM file type for NE	F	9.0.0	10.0.0
May 2011	SA_52	SP-110285	0029	1	Add missing references to performance measurements TSs and remove obsolete references. Add missing text referring to LTE.	F	10.0.0	10.1.0
Dec 2011	SA_54	SP-110706	0030	-	Remove outdated text and correct faulty section references	F	10.1.0	10.2.0
2012-09	-	-	-	-	Update to Rel-11 version (MCC)		10.2.0	**11.0.0**
2014-10	-	-	-	-	Update to Rel-12 version (MCC)		11.0.0	**12.0.0**
2015-06	SA_68	SP-150313	0031	2	Add collection methods for counters defined in other SDOs	F	12.0.0	**13.0.0**

History

Document history		
V13.0.0	March 2016	Publication