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Foreword

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where:

x the first digit:

1 presented to TSG for information;

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y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

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Introduction

One of the targets of SON is to keep the network quality and performance with minimum operator attention and maintenance costs. Self-healing is a SON functionality which detects problems itself and solves or mitigates these problems to avoid user impact and to significantly reduce maintenance costs.

1 Scope

The present document is focused on studying on self-healing of SON. This study provides the general procedure of self-healing, and collects the use cases of self-healing and proposed related requirements. The findings and proposals of the study may be used to help generate new Technical Specifications (TS) and/or enhance existing Technical Specifications.

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 TR 21.905: "Vocabulary for 3GPP Specifications".

[2]   3GPP TS 32.111-1: "Telecommunication management; Fault Management; Part 1: 3G fault management requirements".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply.
A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

alarm: See 3GPP TS 32.111-1 [2].

fault: See 3GPP TS 32.111-1 [2].

Stop condition: The self-healing procedure may include one or more iterations until the related fault is resolved or the thresholds of some parameters (e.g. iteration counter or iteration duration time, etc.) are reached. These thresholds are used to determine whether to stop the procedure if the related fault is still not resolved after several iterations or a long time. We call these thresholds as well as fault resolution the stop conditions.

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply.
An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

EPC	Evolved Packet Core
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
NE	Network Element
OAM	Operation Administration Maintenance
SON	Self Organizing Networks

4 Self-healing overview

4.1 General description

Self-healing is a functionality of SON. The purpose of self-healing is to solve or mitigate the faults which could be solved automatically by triggering appropriate recovery actions.

From the point of view of fault management, for each detected fault, appropriate alarms shall be generated by the faulty network entity, regardless of whether it is an ADAC or an ADMC fault.

So, the trigger of self-healing is alarm. The self-healing functionality monitors the alarms, and when it finds alarm/s which could be solved automatically, it gathers more necessary correlated information (e.g. measurements, testing result, etc) and does deep analysis, and then according to the analysis result, it triggers appropriate recovery actions to solve the fault automatically.

The self-healing functionality also monitors the execution of the recovery action/s and decides the next step accordingly. After a self-healing iteration ended, the self-healing functionality shall generate and forward appropriate notifications to inform the IRPManager about all the changes performed.

4.2 Recovery actions

In the case of software faults, the recovery actions may be：

> a) system initializations (at different levels),
>
> b) reload of a backup of software,
>
> c) activation of a fallback software load,
>
> d) download of a software unit,
>
> e) reconfiguration, etc.

In the case of hardware faults, the recovery actions depend on the existence and type of redundant (i.e. back-up) resources.

If the faulty resource has redundancy, the recovery action shall be changeover.

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

> a) Isolate and remove the faulty resource from service 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;
>
> d) Reset the faulty resource;
>
> e) Other reconfiguration actions, etc

In the case of other kinds of faults, the recovery actions are FFS.

4.3 General self-healing procedure

The logic view of the general self-healing procedure is shown in figure 1:

Loop: Always running

Step 1

Monitor Alarms

Alarm/s which can be self-healed is/are found ?

Yes

Step 2
Get correlated information (measurements, CM data, testing result, etc)

Step 3
Analyse and Diagnose (i.e. identify recovery actions)

Step 4
Trigger the execution of recovery actions

Step 5
Evaluate the self-healing result

No

Have all known faults been solved?

Yes

Step 6
Clear the original alarm/s.

No

Is the stop condition of Self-healing reached?

Yes

Step 7
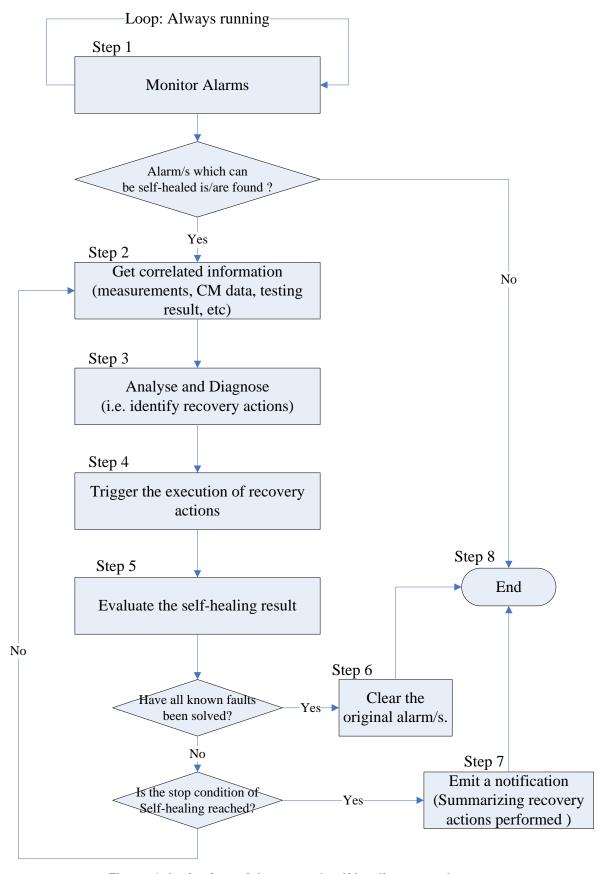Emit a notification (Summarizing recovery actions performed)

No

Step 8
End

Figure 1: logic view of the general self-healing procedure

Step 1: The self-healing functionality monitors the alarms, and when it finds alarm/s which can be solved automatically, go to step 2.

Step 2: It gathers more necessary correlated information (e.g. measurements, CM data, testing result, etc).

Step 3: Based on the alarm and gathered correlated information, it does deep analysis and diagnosis, and gives the result: recovery actions.

Step 4: It triggers appropriate recovery actions to solve the fault automatically.

Step 5: It evaluates the result of self-healing:

If it finds that the fault has been solved, then go to step 6.

Else:

If it finds that the stop condition of self-healing is reached, then go to step 7.

If it finds that the stop condition of self-healing is not reached, then go to step 2.

Step 6: Clear the original alarm/s. Go to step 8.

Step 7: A notification shall be raised summarizing what the system has already done trying to cure the problem. Go to step 8.

Step 8: The iteration of self-healing is ended.

5 Use cases of self-healing

5.1 High level use case

5.1.1 Alarm monitoring and self-healing

Use Case Stage	Evolution / Specification	<<Uses>> Related use
Goal (*)	In the OAM system, the alarms are monitored realtimely. When an alarm which can be self-healed is raised, it is treated as the trigger of the self-healing and the gathering of correlated information. By gathering the correlated information and further analysis, the self-healing actions of the fault shall be triggered. The monitored alarms and the self-healing actions shall be configurable by the operator.	
Actors and Roles (*)	Self-healing function, IRPManager	
Telecom resources	The E-UTRAN/EPC network including its OSS.	
Assumptions	The network is properly installed and running.	
Pre conditions	Network is in normal operation.	
Begins when	Automatically triggered when an alarm received, the alarm may be emitted by NE or OAM system.	
Step 1 (*) (M)	The self-healing functionality monitors the alarms, and when it finds alarm/s which can be solved automatically, goes to step 2.	
Step 2 (*) (M)	It gathers more necessary correlated information (e.g. measurements, CM data, testing result, etc).	
Step 3 (*) (M)	Based on the alarm and gathered correlated information, it does deep analysis and diagnosis, and gives the result: recovery actions.	
Step 4 (*) (M)	It triggers appropriate recovery actions to solve the fault automatically.	
Step 5 (*) (M)	It evaluates the result of self-healing: If it finds that the fault has been solved, then the iteration of self-healing is ended. If it finds that the recovery is failed, then an alarm shall be raised summarizing what the system has already done trying to cure the problem. If the fault hasn't been solved and the recovery is not failed, then the iteration of self-healing runs again.	
Ends when (*)	Ends when all steps identified above are completed or when an exception occurs.	
Exceptions	FFS.	
Post Conditions	If the fault has been solved, the alarm is disappeared. Otherwise an alarm shall be raised summarizing what the system has already done trying to cure the problem.	
Traceability (*)		

5.2 Use cases

5.2.1 Self Recovery of NE Software

Use Case Stage	Evolution / Specification	<<Uses>> Related use
Goal (*)	The NE software is recovered to the initial status or the status of latest backup, to ensure the NE software runs normally.	
Actors and Roles (*)	FFS	
Telecom resources	The E-UTRAN/EPC network including its OSS.	
Assumptions	The network is properly installed and running.	
Pre conditions	The operator has the initial backup or the latest backup of the NE software and configuration data.	
Begins when	The software monitoring functionality detects the abnormal status and emits appropriate alarm/s.	
Step 1 (*) (M)	The software monitoring functionality detects the abnormal status and emits appropriate alarm/s.	
Step 2 (*) (M)	The self-healing functionality monitoring the related alarm/s, and triggers the healing procedure: a. Verify the version of software, if it is found that the software is destroyed, restore the backup of the destroyed software. b. Check the configuration data, if it is found that the configuration data is incorrect, reconfigure or restore the configuration data. c. If necessary, restart the process. d. If it is still abnormal after the healing procedure, a notificaton shall be raised to notify the IRPManager.	
Ends when (*)	Ends when all steps identified above are completed or when an exception occurs.	
Exceptions	FFS.	
Post Conditions	The NE software is running normally or the operator processes the problem manually.	
Traceability (*)		

5.2.2 Self-healing of board faults

Use Case Stage	Evolution / Specification	<<Uses>> Related use
Goal (*)	System detects board faults and mitigates or solves them automatically to avoid user impact (E.g. system switch to standby board automatically when active board malfunctions).	
Actors and Roles (*)	FFS	
Telecom resources	The E-UTRAN/EPC network including its OSS.	
Assumptions	The network is properly installed and running.	
Pre conditions	Network is in normal operation.	
Begins when	The system detects a board fault.	
Step 1 (*) (M)	The system detects a board fault	
Step 2 (*) (M)	The self-healing functionality monitoring the board faults and triggers the healing procedure: a. The self-healing functionality collects the redundant information of the faulty board, and processes accordingly: • If there is a stand-by board and the stand-by board is in operational state, then the failed board will be blocked and a changeover will be started automatically. Reset the blocked board, if it turns to normal, then it treated as the redundant board. • If there is not a redundant board or the redundant board is in abnormal status, then the failed board will be blocked. b. A notificaton shall be raised to notify the IRPManager the healing result and all the healing actions performed, whether successfully or not.	
Ends when (*)	Ends when all steps identified above are completed or when an exception occurs.	
Exceptions	FFS.	
Post Conditions	The device is running normally or the operator processes the problem manually.	
Traceability (*)		

5.2.3 Use case self-healing of Cell Outage

Use Case Stage	Evolution / Specification	<<Uses>> Related use
Goal (*)	When cell outage (e.g. sleeping, out-of-service, etc) faults are detected, the self-healing functionality resolves and compensates them automatically.	
Actors and Roles (*)	Self-healing function, IRPManager	
Telecom resources	The E-UTRAN/EPC network including its OSS.	
Assumptions	The network is properly installed and running.	
Pre conditions	Network is in normal operation. The related NE does not have redundant hardware.	
Begins when	A cell outage fault is detected.	
Step 1 (*) (M)	The self-healing functionality monitors the cell outage conditions and triggers the healing procedure.	
Step 2 (*) (M)	The self-healing functionality tries to heal the fault. The self-healing functionality may use different means to heal the fault, for example: ● Try to re-establish the cell. The re-establishment can be tried several times. If the healing is successful, then the cell compensation is not needed; otherwise: Cell compensation is processed as below: 1. Disable the faulty cell; 2. Option: Backup related configuration information; 3. Reconfigure the adjacent cells to compensate the faulty cell. The details of reconfiguration of the adjacent cells are FFS.	
Step 3(*) (M|O)	The self-healing functionality monitors the removal of the cell outage alarm. If a cell outage is recovered and the related cell has been compensated by a reconfiguration of other cells, then: a. Check the state of the cell. If it is disabled, then enable it. b. May reconfigure the adjacent cells to recovery the performed compensating actions. The details of reconfiguration of the adjacent cells are FFS.	
Ends when (*)	Ends when all steps identified above are completed or when an exception occurs.	
Exceptions	FFS.	
Post Conditions	The cell is running normally or the operator processes the problem manually but the end users are not or only minimally affected.	
Traceability (*)		

6 Requirements of self-healing

6.1 Business requirements

REQ_SH_CON_001 The IRPManager shall be able to choose the alarms to be monitored and the corresponding self-healing actions.

REQ_SH_CON_002 It shall be possible for the self-healing actions to be confirmed by the IRPManager before they are executed.

REQ_SH_CON_003 The self-healing functionality shall be performed with minimal human intervention.

6.2 Specification level requirements

REQ_SH_FUN_001 If the self-healing fails, the IRPAgent shall inform the IRPManager about the self-healing result.

REQ_SH_FUN_002 The self-healing actions shall be logged and the log made available through Itf-N.

REQ_SH_FUN_003 The IRPAgent shall support a capability allowing the IRPManager to enable and disable the self-healing functionalities.

7 Conclusions and Recommendations

According to the research result until now, although the procedures of different self-healing functions are similar, the detail alarm/s which a self-healing function monitors and the recovery actions are different. Even for the same self-healing function from different vendors, the monitored alarm/s and the recovery action/s may be different. So, it is recommended that the solutions of self-healing should be implemented in case by case manner.

For further specification work, it is recommended to define a general framework for the self-healing function, including the faults that a self-healing function may resolve and the general method of the self-healing function. The alarms monitored by the self-healing function and the recovery actions of the self-healing function may not be specified for all self-healing use cases.

Annex A:
Change history

Change history							
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
Jun 2009	SA#44	SP-090290	--	--	Submission to SA for information	---	1.0.0
Sep 2009	SA#45	SP-090548	--	--	Submission to SA for approval	2.0.0	9.0.0