Integrated view on telecommunication network status

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Abstract - Services provided by telecom operators rely on network infrastructure. Hence, every network operator has centralized network management center (official names vary), established for managing network (tracing current network status, triggering restoring actions etc.). Global network problems are represented by sequence of alarms (faults) from network resources. In our previous papers, we have focused on alarm correlations leading toward automatic global network problem recognition. This paper defines the model of integrated view on telecommunication network, integrating more sources of real-time data in the unique network view. We have used multi-level model for network presentation. This model enables global network view on the top level, with drill-down possibilities toward details hidden in lower levels. Network elements have their own attributes, recalculated periodically from network data. Based on object attribute's values and predefined threshold values, the object status is recalculated as well. In the network presentation model, object status data from lower levels are propagated to the top level using propagation rules. The top view gives global network status overview, integrating data from different sources. Integrated data sources are fault and performance data as primary, and end-to-end testing results as well as customer's trouble tickets as secondary sources.

I. INTRODUCTION

Services provided by telecom operators rely on operator's network infrastructure. Network infrastructure capacity (read: "cost") should be optimized, but service level from the customer's point of view must not be degraded, in order to respect SLA [6]. Because of that, every network operator has some kind of centralized network and/or service operation and maintenance center (official names vary, such as "Operation and Maintenance Center", "Network/Service Operation Center", etc.), tracing current network status and triggering appropriate restoring actions in case of network problems.

Global network problems are represented by sequence of alarm events coming from network resources. In our previous papers - [1], [2], [3] and [4] - we have focused on alarm correlations leading toward automatic global network problem recognition based on huge number of incoming alarm events. Functional area that covers, but it is not limited to, detection of network alarms is called fault management [7].

In this paper we are going to define the model for unified, integrated view on telecommunications network. The main idea is to present telecommunication network in more or less standard way, respecting multi-level network structure. Based on telecommunication network data coming from different sources (network faults, performance indicators, end-to-end testing results, customers' complaints, etc.), status of every network elements is recalculated periodically. Unified view should integrate as much network real-time data as possible, presenting network view containing all relevant status information. In our future research work, this model should be implemented, and usage results should be presented.

This paper is structured as follows: first we will present short introduction; then, we are going to present the network model overview. Since global network status is based on aggregation of underlying network object's status information collected from different sources, we have paid special attention to data sources as well as object's status recalculation. Next, we have touched basic implementation aspects of model presented, such as potential techniques, GUI requirements, data collection requirements and object's status recalculation remarks. Finally, hints for future work are given.

II. MODEL OVERVIEW

A. *Network model*

As a first step, it is necessary to mark usage of more or less standard multilevel network model, made from nodes and connections between them. This model enables global network view on highest (or top) level, with drill-down possibilities toward details "hidden" in lower levels (figure 1). For the purpose of network presentation, it is allowed to add virtual graphical elements in the model, serving as "containers" for "real" network elements; "Real" network elements are graphical abstraction of existing network resources, both nodes and connections between nodes, while "containers" are virtual objects containing real network elements or other containers. In this paper, the term "network element" or "object" will refer to "real" network element. Usage of containers allows creation of any logical network structure (e.g. network elements organized geographically, by vendor, by technology or any other criteria). That structure is tree-like structure, where "leafs" are network elements.

The status of any tree component depends on the status of underlying “leafs”.

Object status is propagated from lower to higher levels based on some predefined criteria. Typical status values are “normal”, “warning”, “minor”, “major” and “critical”, respecting ITU-T recommendation X.733 [8]. The simplest criterion is to propagate most critical status to higher level. In combination with well-defined object's status recalculation rules, this criterion satisfies our requirements.

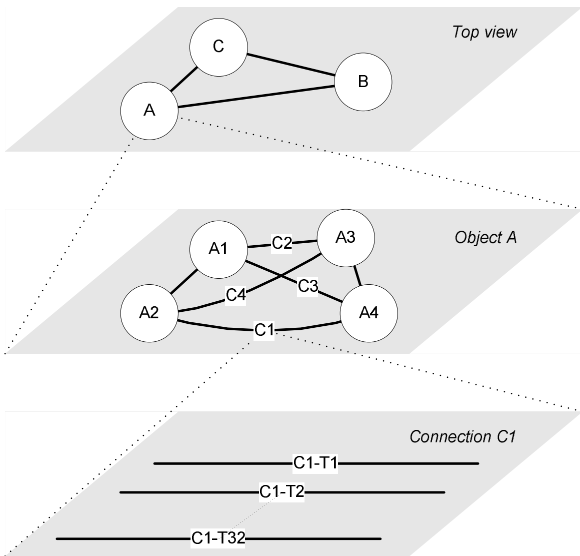

Figure 1 Network model

However, there are other status propagation criteria. Typical example is node containing two or more underlying objects working in parallel. In that case, it is not necessary to propagate every status change to higher levels; propagation rules can be defined using simple logical statements (AND, OR).

B. Object attributes recalculation

Every network element (node or connection) has its own attributes. In our terminology, we will call it object's attributes.

Some of object's attributes are static. For instance, object name and object network address are static attributes. Those attributes are important for network presentation, since immediately visible and readable static information can increase network personnel’s reaction time when a network element problem occurs.

For our model, dynamic object's attributes are much more valuable. Number of idle, busy or blocked communication trunks, or number of operational base station transceivers (BTS) for one base station controller (BSC) in GSM network (BSC controls number of associated BTS in GSM network) are typical examples.

Dynamic object's attributes values should be collected from the network periodically in acceptable time interval. Time interval must be short enough in order to have recent information from telecommunication network received with acceptable time delay. Likewise, the interval must be long enough in order not to occupy network resources. Very frequent interrogation of dynamic object's attributes can decrease performance of network itself.

The first step in the status recalculation is collection of raw data from different sources. For instance, object attribute can be the number of operational base station transceivers for one base station controller in GSM network. Let us assume that information about every base transceiver station is accessible through system's database. That information (is BTS operational or not) is dynamic object attribute related to BTS object.

In the second step, it can be built in into another dynamic object's attribute, for instance “the percentage of operational BTS for specific BSC”. This object's attribute is related to BSC object.

Periodical collection and aggregation of object's attributes lead us toward recalculation of object's status.

C. Object status recalculation

Object's attributes values are mostly numeric. Even in the case of “string” attributes, there is predefined set of possible string values that can be replaced by integer constants. Hence, it is possible to define threshold values, based on the specific network element (object), the specific object attribute and the specific numeric attribute value. In the case of threshold violation, object's status change is triggered. As we have mentioned above, allowed status values are “normal”, “warning”, “minor”, “major” and “critical”. In parallel with the status change, it is possible to initiate other actions triggered by threshold violation detection, such as sending of emails or SMS messages, sound alert generation or generation of trouble-tickets.

Network elements that serve as “containers” for other network elements change their status based on the status of underlying objects and predefined status propagation criteria, built in the network model. For instance, propagation criteria can be “propagate most critical status”, as we have explained in the network model section.

When new data from specific source are available, it is necessary to recalculate status information for all objects since we do not know which objects will be affected by the new data. The best practice for new data integration in network model is:

- delete all previous raw data from the same source; leave other data
- collect all available data from given source
- recalculate all objects' attributes
- recalculate all objects' status information
- refresh network model

After detection of the new data from a specific source, all previously collected data from the same source are deleted. New data are imported, and recalculation is done based on all available data. That ensures the availability of the most recent network status, based on real-time data.

D. Data sources

The main question is "which data sources should be included in the model that enables integrated view on telecommunication network?". Even in the case that the model of integrated view on telecommunication network is defined well, irrelevant data sources can decrease reliability and usefulness of the model.

Since integration of fault management as well as performance management [7] data is "standard" in network management models, it is reasonable to include it in our model.

Hence, we propose the use of correlated fault management data as primary source, but also we propose other sources. It is important to avoid inclusion of "raw" fault management data, since number of alarm events coming from telecommunication network is huge. Correlation and decreasing alarm number are out of the scope of this paper, but we have considered it in our previous papers [1], [2], [3] and [4]. Also, we have discussed that "smart" alarm correlation should include information about network inventory and its logical connectivity, as described in [5].

Fault management data are included in our model as dynamic object attributes. The number of object's attributes related to fault management data may vary, but the most important are:

- number of active alarms per network element
- number of alarms in last N seconds per network element

Based on these two attributes, it is possible to derive other, more specific attributes - for instance "the number of active critical alarms per network element". These attributes are used for object's status recalculation together with data from other sources.

Performance management data should be included in integrated telecommunication network view. Collection of performance data is periodic action, where time interval should be optimized. Relatively short interval between collections of performance data can potentially decrease network performance while relatively long interval can decrease reliability of performance data obtained.

Performance management data can be the subject of separated performance management system, but also can be included in our model. There are two main reasons for that. The first reason is less complexity of performance data collection in comparison with fault management. The second reason is compatibility to our philosophy, where object attributes can be considered as performance indicators.

In our model we propose simple performance data collection model that includes periodic collection of raw performance data and its storage in performance management database. That performance management database is used in the process of object's status recalculation.

Combining fault and performance data, we can obtain integrated picture of current network element status, presenting impact of network element's faults as well as network element's performance indicators on its status. Since elements are parts ("leafs") of telecommunication network model, recalculation respecting status propagation rules will lead us toward integrated view on telecommunication network. In comparison with the presentation of fault management data only, this integrated view is enhanced and much more reliable.

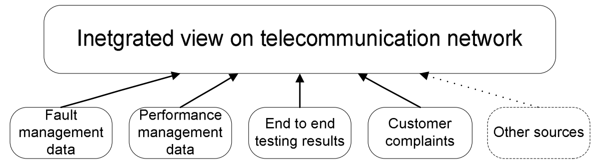

Figure 2 Integration of different data sources in integrated view on telecommunication network

Correlated fault and performance management data are primary sources for our integrated view on telecommunication network. However, there are a number of other activities performed by telecom operators. The results of those activities can be of great importance for network status presentation. Hence, we have decided to include it in our model as secondary data sources.

Typically, all telecom operators perform end-to-end (E2E) testing actions. E2E tests provide us with customer's experience of telecommunication network. Those tests can be related to some specific network technology (e.g. UMTS), specific network area, specific users, etc.

For every test performed, there is a possibility to define appropriate thresholds. If we assume every relevant E2E test result as object attribute, there is possibility to include it in object's status recalculation, together with correlated fault and performance data. Of course, not all E2E test results will be included in the model, but the most important should be. E2E tests included in our model must be performed periodically within appropriate time interval, as we have discussed before. If it is not possible, we can consider asynchronous reception of E2E testing data in the case of threshold violation. In that case, it is reasonable to leave the possibility of E2E test triggering "on demand", in order to enhance object attribute set when data from primary sources suggests the need for it.

Another important function performed by telecom operators is help desk function. Official names also vary, but this should be a point of interaction between operator and operator's customers, especially in the case of customers' complaints.

If significant number of customer's tickets (complaints) is received by service desk with the same or similar content, it is reasonable to trigger potential problem indication to be integrated in the network view. This should be done by the service desk manager, but it requires basic knowledge about mappings between different ticket types and specific network elements.

Probably this source is much more appropriate for service management, but we have decided to use it here as a secondary source. It can be of great importance if some "technical" systems (e.g. fault management) are out of service, since it relies on human resources.

Future research work should focus on the proof of concept for the usage of secondary sources as well as detection of other potential data sources that can be included in the integrated view on telecommunication network (figure 2).

III. IMPLEMENTATION ASPECTS

A. *Graphical user interface*

Graphical user interface (GUI) is not of our interest, but it is probably the most crucial component during implementation of such model. Namely, this model is dedicated to be used by network personnel, during network management process. So, it is necessary to implement simple and presentable graphical user interface if we want our model to be proved in real telecommunications world.

In case of our own GUI development, probably the most acceptable is the use of web technology. In that case, there is no need for installation of GUI client components.

However, there are a number of commercial tools that can be used for network model graphical presentation. There are two main requirements for it:

- the tool should satisfy network model presentation requirements
- the tool should be "opened" allowing integration with different data sources

In our future research work we will present the way of GUI implementation. According to our present experience, there are a number of commercial tools satisfying requirements mentioned above.

B. *Data collecting*

Since the model presented includes data from different sources, different techniques will be needed for data collection.

For fault management data, existing fault management systems will be used as data source. Almost every fault management system has its own "northbound" interface. So, fault management data will be collected via "northbound" interface using appropriate communication protocols. The most common is SNMP (Simple Network Management Protocol) [9], but it depends on fault management system.

Performance management data can use the same technique, or some alternative techniques can be used. For instance, if not all performance data are available through standard protocols, there is possibility to obtain it from system databases, or via MML (Man-Machine Language) commands from network directly.

Man-machine language commands allow network operators to interrogate all network elements' performance indicators in "raw" manner. For instance, for every communication route it is possible to obtain a number of idle/busy/blocked trunks. For our purposes, we have considered the possibility to act as MML operator where MML response will be stored in ASCII file and parsed. Parsed data can be used as data source for our model. This technique allows processing of data from different network element types. However, any other technique is welcome if it allows integration of needed and currently not accessible data.

E2E testing systems usually have some kind of northbound interfaces. Further, those systems typically allow alerting by SMS or e-mails, in case of threshold violation. So, data from E2E testing systems can be accessed by receiving SMS messages or e-mails, even if standard "northbound" interface does not exist.

Integration with the help desk is not standard, but generally all we need is a simple application possibly integrated with help desk manager application portfolio, enabling to generate and send SNMP trap message, XML, SMS, e-mail or any other message that will be received by collecting system.

IV. NEXT GENERATION NETWORK CHALLENGES

Generally, current network management solutions follow two general directions: ITU-T's concept of TMN (Telecommunication Management Network) for "telco" networks and IETF's SNMP based model, for IP networks [10]. Although, SNMP is widely used in telco world, with specific MIB philosophy as described in [11]. Working on this model, we have followed exactly mentioned philosophy, and preliminary tests were done on classical telecommunication network, extended with IP equipment.

The NGN (Next generation Network) is expected to integrate services offered by traditional networks as well as IP services into a single platform. It provides independent access to applications and its contents. Hence there are number of network management challenges for NGN, because of dynamic topology, multiple services, heterogeneity etc. This model presented is able to cope with those challenges primarily because of following:

- Network presentation model is generic and is able to present any network architecture
- E2E testing results are included in model as important source of data.
- Integration of correlated fault and performance data, where it is not important which is network management philosophy on fault and performance management level.

Also, model can be extended with other data sources, as shown on figure 2.

Potential other data sources are data obtained by other network management tools. Of course, it depends on technical conditions relevant for data interchange between tools, for instance existence of northbound interface.

V. CONCLUSION

In this paper we have presented the model for integrated view on telecommunication network. Its main purpose should be implementation of appropriate tool respecting model that will relieve network monitoring and present integrated view on telecommunication network.

We have emphasized the use of relatively standard network model, but we have defined different sources that will be used for presentation within network model. The first two (primary) sources are fault and performance management data. Further (secondary) sources are end-to-end testing results as well as customer's complaints received by help desk.

We believe that the combination of different sources increases the level of view relevance. Our future research should be driven in three directions: the first is tool implementation leading toward the second direction: the proof of "multi-source" concept. Finally, potential usage of other data sources within integrated view should be third direction of our future research. This will be of interest in NGN environment, as described in section 4.

REFERENCES

[1] O. Jukić and M. Kunštić, "Network problems frequency detection using Apriori algorithm", Proceedings of the 32nd International Convention MIPRO 2009, pp. 77-81, Opatija, May 2009.

[2] O. Jukić and M. Kunštić, "ABCDE – Alarm Basic Correlation Discovery Environment", Proceedings of the 33rd International Convention MIPRO 2010, pp. 298-303, Opatija, May 2010.

[3] O. Jukić and M. Kunštić, "Logical inventory database integration into network problems frequency detection process", Proceedings of the 10th International Conference on Telecommunications CONTEL 2009, pp. 361-365, Zagreb, June 2009.

[4] O. Jukić, M. Špoljarić and V. Halusek, "Low-level alarm filtration based based on alarm classification", Proceedings of the 51st International Symposium ELMAR 2009, pp. 143-146, Zadar, September 2009

[5] O. Jukić and M. Kunštić, "Logical inventory database integration into alarm correlations discovery environment", Int. J. Intelligent Information and Database Systems, Vol. 4, No. 6, pp. 643-655, November 2010.

[6] Costa, R., N. Cachulo, P. Cortez, "An Intelligent Alarm Management System for Large-Scale Telecommunication Companies", EPIA 2009, pp.386-399, Berlin, 2009

[7] Udupa, K.D., TMN – Telecommunications Management Network, McGraw-Hill Telecommunications, New York,1999.

[8] ITU-T: Recommendation X.733, Geneve, 1992.

[9] M. Kunštić, O. Jukić and A. Oblak, "SNMP protocol as base for alarm and data collecting system in telecommunication network management process", Proceedings of International Conference on Software, Telecommunications and Computer Networks SoftCOM 2003, pp. 386-389, Split, October 2003.

[10] M. Li and K. Sandrasegaran, "Network management challenges for Next Generation Networks", Proceedings of IEEE Conference on Local Computer Networks – 30th Anniversary, 2005.

[11] O. Jukić, "Comparison of SNMP management features between "classical" telecommunications network and IP based network", Proceedings on 2009 International Conference on Software, Telecommunications & Computer Networks SoftCOM 2009, Split, 2009