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Intelligent Solutions for Umbrella Systems in Telecommunication Supervision Systems

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***Abstract*—**This paper indicate the importance of telecommunications supervision systems (TSS), integrating heterogeneous TSS into single system thru umbrella systems, introduces the structure, features, requirements of TSS and TSS related intelligent solutions.

***Keywords*—**Telecommunication, telecommunication supervision systems, umbrella systems

I. Introduction

VARIOUS information and communication related technologies have recently become part of our everyday life. Information transmission channels fill up our homes, working places, the whole country. The complexity of these systems is so large that in a way these networks behave as autonomous systems, with a „life of their own". Reliability and availability are the critical points in their design, regulated by international standards and recommendations and modules ensuring them taking often up to 90% of the whole system (calculated in „space", definitely not in runtime). These systems are usually containing duplicated and multiplicated cores, with hot and cold stand by components, automatic self diagnostic subsystems, and autonomous failure recovery strategies, but nevertheless, human supervision at some level is unavoidable.

II. The Importance of Remote Supervision Systems in Telecommunication

Telecommunication supervision systems considerably enhance reliability and availability of the telecommunication networks and potentially their connected subsystems (such as safety and security subsystems, building mechanical subsystems, weather observation modules, etc.), increasing the Quality of Service (QoS). The application of highly developed TSS contributes to the decrease of total operational costs as with their help remote actions and manipulations can often be done from a distance, and even human staff involving operations can be logistically optimized. They are also helpful in systems design, build up, maintenance, and quality control. As quality assurance plays an eminent role in the telecommunication field, TSS is even more important here than in many other application areas of remote supervision.

A. The importance of umbrella systems

All major telecomm manufacturers have developed their own complex hardware/software solutions for the remote supervision of their equipment. These are, however, not compatible with each other, and usually it is not possible to integrate them into a single system. Compatibility is in contradiction with company interests, except within the products of the same firm, sometimes only within the range of a certain product group. One of the key issues here is the use of communication protocols that channel the information on status and alarm conditions to the operators. These protocols usually conform to general standards but they are still individual enough to be kept as industrial secrets, so that even the exact correspondence between a status report and a system condition cannot be established in most cases. The coding of these protocols is not at all motivated by general data transmission security requirements but much more by the interests of the manufacturers in excluding the possibility of building components originating from another company into the same system. This forces telecomm companies to remain faithful to the originally selected product family. The non-uniformity and non-compatibility of such protocols and also of user surfaces is not in the interests of the users, even, it is desirable that umbrella systems exist that can be superimposed on any combination of individual equipment and supervised group cluster, with arbitrary local supervision modules. In optimal case, the umbrella system would completely hide all component systems at lower levels and all status information coming from any of those subsystems would be homogenized and presented in a uniform way, so as if the whole system would be a single one. This also means that information appearing at the operators' level should be as detailed and rich as it is possible based on the partly hidden information sources contained in the individual protocols of the various elements of the network.

B. Possible solutions for the umbrella system

It is a difficult problem to interpret manufacturer specific protocols in a legally clean and scientifically correct way. Decoding the protocols in a direct form falls in the category of „reverse engineering", which might be illegal under circumstances, as it might violate patents or copyrights.

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Instead, we apply another "clean" solution, which needs however much more sophisticated approaches from the engineering point of view. The subsystem produces an output to every particular input. If the whole system is considered to be a black box, the "reversing" of its operation can be done by applying a systematic identification approach, which involves a considerable amount of sophistication and machine intelligence. As a matter of course, such identification can usually not provide as complete information on the system as obtaining its primary description. Whenever it is available it must be directly included in the umbrella system input. Further, feedback to the system under the umbrella is not possible without the explicit knowledge of the subsystem. In every case, the overall umbrella system provides information on all subsystems in a uniform way, possibly in a single operator's surface, on a single physical screen. If the subsystems' protocol is not explicitly known, control actions can be initiated from the individual subsystems' supervision terminals. Well documented interfaces available for systems are usually at least five to ten years old, and are not typical for the most up to date equipment.

Another important advantage of the umbrella system is that it can integrate all other than directly telecommunication related systems. Such an approach is implementing the "intelligent space" concept, where all relevant state information is evaluated at the same time. This includes all equipment in the buildings where telecommunication units are installed, mechanical, electric, safety and security related machinery, lightning protection, weather information concerning the area where the microwave communication is taking place, etc. The concept of intelligent space requires a much more general overview of the global system and its environment to be given and often that decision support to be done with only the ultimate conclusions being communicated to the operator, rather than the individual observations.

Let us take a simple example. If there is heavy rain in a certain region, it might stop communication among the stations in that area completely. In the borderline areas communication will be unreliable with a high error rate. If individual supervisory systems report on alarm conditions concerning the communication between pairs of microwave stations, it might easily lead to the erroneous conclusion that a mechanical or electronic failure has occurred. If by coincidence, the core area of the rain affected region falls into two or more subsystems' competency, there is no way to recognize the system and extension of the failure, not to mention the geographical shifting of the affected area due to a storm front moving along, etc. The intelligent umbrella system unites all alarm reports into a single cumulative log, and is able to recognize connectedness, geographic dislocation, border area behavior, etc. and report accordingly. This could save tremendous expenses and loss of maintenance staff time, but only if the appropriate intelligent decision algorithms are implemented at the umbrella level. In the next, the basics of a computational intelligence "tool" will be summarized that we have proposed for being the main base for the intelligent modules in the overall supervision system.

III. Telecommunication supervision systems

A. Goals

Telecommunication supervision system has to be able to provide all functions concerning the design, commission, maintenance, quality control, administration and change of a telecommunication network. The main activity of telecommunication systems can be either the supervision and/or the control of the system, depending on the direction of the interaction with respect to the system. The applied management systems can be functionally further divided into network management and operational system functions.

B. General structure

A possible general structure of the system is depicted on Fig. 1. Information from the supervised equipments gets to the central Query module through the Equipment Driver (ED) module. The former module does the administration of the data base and passes the information towards the Graphical User Interface (GUI). Operators can control the condition of equipments and intervene into their operation.

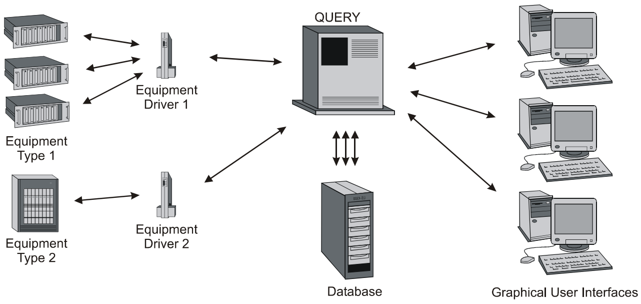

Fig. 1
General structure of a telecommunication supervision system

- Graphical User Interface (GUI): the interface that enables operators to supervise the system; one module for each working dispatcher workstation.
- Equipment Driver (ED): connection with the supervised equipments (status, remote commands) Each equipment is assigned an own ED.
- QUERY: transmits information between GUIs, EDs and the data base. It also supplies log functions and executes queries from GUIs. This central module is scalable, allows distributed operation on parallel, multiple hardware if the implementation requires.
- Database: Stores all events of the system (conditions of supervised equipments, intervention of operators, etc) in a chronological order. It also provides the centrally stored information (structure of the system, description of equipments, administrative information) that is necessary for the operation of the distributed system.

C. Structure and functions of the Equipment Driver

ED communicates directly with the supervised equipment and with the Query module. This module implements the communication protocol that can be standard or unique depending on the supervised equipment. The communication, and accordingly the structure of ED can be either Event Triggered (ET) or Time Triggered (TT). TT communication better supports requirements of real time systems (reliability, congestion avoidance). Within the supervision system, though, ET communication, and the use of Positive Acknowledgement and Retransmission (PAR) protocol is more preferable. The protocol conversion being also a function of ED, required severe awareness.

D. Communications between modules

As we noted earlier, ET communication is more practical and preferable between the modules of supervision system. The most suitable is the use of any PAR protocols. There are many implementations of PAR protocols, which share the following principles:

- The communication is initiated by the transmitter client.
- The receiver is authorized to delay the transmitter through the bidirectional communication system.
- Erroneous communication is detected by the transmitter, and not by the receiver. The receiver has no information about the time of the error.
- Protocols use time redundancy for error correction, which increase the delay of the protocol.

The operation of PAR protocol, in short:
Given are a transmitter, a receiver, a communication channel, a time-out value, and a retry counter.

- Transmitter: Sets counter to zero. Starts time-out. Sends message. Accepts confirmation. Notifies client. If there is no confirmation within the time-out value, then it checks the counter. If the counter is full, disconnects communication and sends error signal, otherwise increments counter and resends message.
- Receiver: Message arrives to the receiver. It checks if the same message has been arrived already. If no, it sends confirmation and notifies client about the message. If yes, it only sends confirmation.

E. Structure and functions of the central module (Query)

The Query module consists of several parts according to its distributed operation and operational purposes. The internal structure of the system and the links between its sub-modules are depicted on Fig. 2.

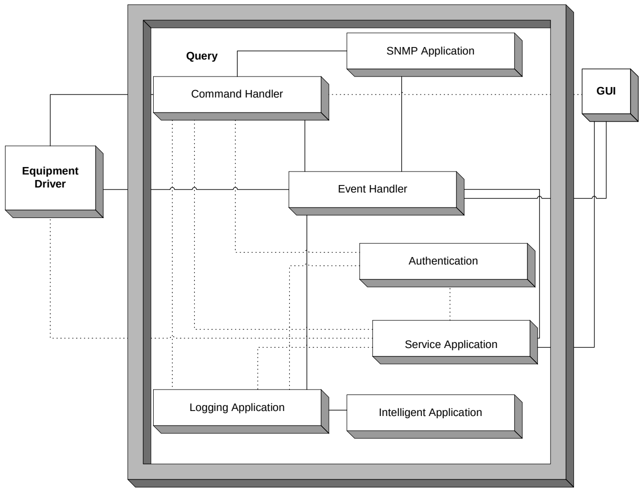

Fig. 2
Internal structure of the Query module

1) The Command Handler

This module forwards the commands coming from GUI towards the appropriate Equipment Driver. It is connected with the Authentication, Logging Application, Event Handler and Service Application modules.

2) The Event handler

This central module handles all events of equipments supervised by the supervision system; it processes them in a sequential order. For the sake of real-time supervision, this module is equipped with a minimal functionality restricted to simple message distribution. Events are sent by message diffusion to all registered clients, e.g. to graphical terminals.

3) Authentication

This module authenticates users' commands, i.e. it decides if a command is executable. If yes, then it generates an accept message, otherwise a reject message. Messages are received from Command handler and Service Application module. It also sends every incoming and generated outgoing message to the Logging Application module.

4) Logging Application

This module administrates all messages that pass through the Query module into the data base. It is connected with all sub-modules of Query; it alerts the Intelligent Application module on the events, and receives events from all the other modules. The module logs events into the appropriate table of the data base.

5) Service Application

The module provides several services simultaneously. Some of its functions is available for only one client at a time (status update, status query), while other requests can be answered simultaneously (in a competing way). The Service Application creates service processes for each service type; these processes serve the individual requests themselves. Independent tasks are implemented by multithreading. It has the following major tasks: stores the state of the system (state table), serves the requests of Equipment Drivers (e.g. download of equipment list) , connection with GUIs; provides the necessary services for all GUIs (e.g. login handling, system configuration, etc.).

6) *SNMP Application*

This module allows the connection to other opened systems, and integration under other TNMS systems [7]. It supplies bidirectional (events and commands) interface for the integration to other supervision systems. Events and alerts are sent to the Event Handler, while command to the Command Handler. The authorization check is performed by the Authentication module.

7) *Intelligent Application*

This module implements a decision support system by the combined application of different artificial intelligence techniques (fuzzy algorithms [4], [5], [8], data mining [9, 10], expert systems and neural networks [7], [3]). It monitors the state of the system (events, alerts) and the users' commands. It informs the Event Handler about the events and alerts, and receives the commands from the Logging Application. During the execution of uninterrupted computation, the possible motions and warnings are sent to GUIs via the Event Handler. The module executes the required computations in a different thread for each different type of decision support system. The main thread receives the events and commands, and passes them to each thread. In order to implement multithreading, the use of standard POSIX threads are advised due to their portability.

F. *The functions of the Graphical User Interface*

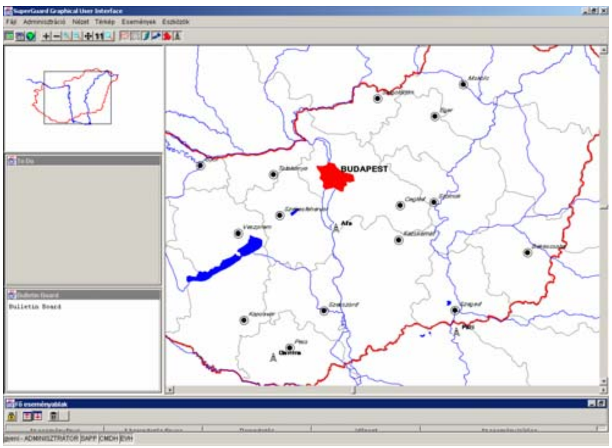

Fig. 3
Graphical user interface with vector map

GUI has the following main functions: event monitoring (in log table, graphically, or in text messages), event initiating (commands, equipment configuration, masking), administration tasks (maintenance of users and authorization), system maintenance/build tasks (supervising new equipments, reconfiguration of networks)
Three different visualization levels providing different specialization: overview (lot of equipments, only errors) see Fig. 3., basis station window (fewer equipments, few information) Fig. 4., device window (one equipment, all available information)

The overview is shown in a full screen window, while the other two levels appears as pop-up windows that hide the partially the overview.
Basically, the following three settings could be practical for the overview: distributed setting (common appearance of map and log file), event window setting (based on log files, filtered tables), map oriented setting (map data are emphasized).
Settings can be alternated by the appropriate button on the Toolbar.

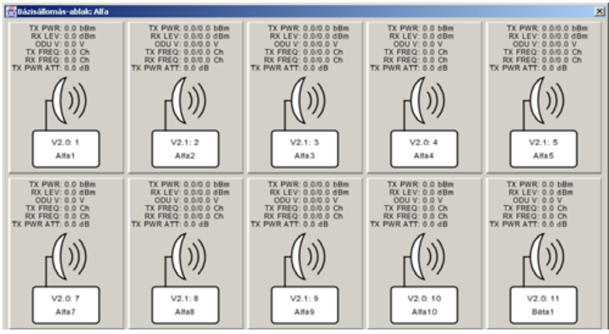

Fig. 4
Basis station window

IV. Local Intelligence

On local intelligence we mean such parts that have no global knowledge of the system, which facilitate users' routine tasks that may be repeated several hundred times daily. These functions do not require soft computing techniques in all cases.

A. *Intelligent user interfaces*

Comprehensive supervision systems require built-in map. One needs a vectorial map to obtain suitable quality at various zoom settings. The handling of vectorial maps offers numerous ways to incorporate intelligent functions, e.g. the setting of detailness of a map.
In order to avoid the proliferation of information in every zoom settings and the overlapping of object labels, it has to be evaluated before visualization what is the level of visualizable objects, and what is the locations of the object labels within certain regions, respectively. This complex calculation can get even more difficult if the user is allowed to alter from the optimal detail level settings (determined for the given zooming) by switching on/off the visualization of certain object types.
Another solution is the intelligent resize of the work area. There is a vast number of information on the screen of supervision softwares. The information is ordered in a redundant way according to the different views. For example, an error that concerns a given equipment is visible on the map, audible on the speaker, reflected in its parameters, and in the log list. These information could be visualized on a large area with the lack of perspicuity. In practice, usually several

overlapping windows, or alternatively, several screen settings of different resolutions, are applied. In the former case, the operator — unless being lucky — can only follow up a problem by immediately reacting upon the sound signal. Otherwise, it is very likely that the need of intervention is realized only later. Though, even the usage of different views cannot guarantee the prompt reaction, since it can be problematic the same functions are available at different places due to the variety of settings.

A more suitable solution is the usage of a sole setting, where the program resizes the work area according to the signalled events and the actual functions being used in such a way that provides the optimal perspicuity for the operator. So, when the operator was working on the map and the signalled event fell out of the scope of the map, then the intelligent setting enlarges the screen portion of the map against the other screen areas.

B. *Intelligent event handling*

A workplace where several tens of events happen by the minutes requires great concentration and circumspection. In order to facilitate this task, a software component that helps the operator to process these events has a significant role.

Basically, events are of two types:

- Events that can be solved promptly,
- Events that can be solved over a longer period of time.

In the operation supervision system events are visualized not only on the map and in the corresponding log table but also in a “To Do” list. The problems that are assumed to be solved can be deleted from this list, while those events that cannot be solved promptly go to a waiting list. This policy alleviates the problem of disregarding smaller problems among the others. Deleted problems reappear if they are realized to be still present.

All the above indicated problems relate equipments. One can directly access without any further search the detailed description of the equipment, its linked equipments or even its physical location on the map from the row of a processable problem.

V. Complex Intelligence

An entire telecommunication system is a fairly complex network having lot of interconnectivities and relations. Casual relations are discovered by the network’s designers and operators during the design and the operation phases, but some deeper interconnections may often remain hidden. Exploration and perhaps numeralization of these relations require soft-computing techniques.

The possible application areas of soft computing techniques in telecommunication supervision systems are the followings:

- automatic data collection
- revelation of casual relations
- propositions for system configuration
- problem (failure) prognostication
- alert masking setting

A. *Overall deductions based on data collection*

Data collection for different demonstrational purposes is a frequent task in supervision systems. A typical example of this is the collection of transmitting-receiver signal levels in a given period of a day. The timing of such a task can be connected with the threshold value of traffic data. The determination of the close-to-minimum or close-to-maximum traffic data values based on the actual charge and on the backed-up data in the data base also requires soft-computing algorithms.

The intelligent is able to reconfigure the system, or give suggestions on the system expansion based also on charging and traffic measurements and data and on the data base. In order to increase operation safety the intelligent system may also suggest multiplication of systems components of high priority that are exposed to massive traffic, and aging.

B. *Searching casual relations*

Revelation of casual relationships is a simple routine task for human thinking. However, there exist such cases — typically multiple complex problems — that humans are unable to discover the relationships.

For example, let us assume that one is given the following information one after the other: decrease of transmission level under threshold, signal level drops to zero, power supply switches off, all possible error messages appear, since nothing works.

The operator’s conclusion: output amplifier had gone wrong due to aging, the shield of the power supply switched off. Contrary, the process could have been the following: Due to the increase of outside temperature, the interior temperature has also been increased, and the air conditioning system should have switched on. Air conditioning has not switched on because of the failure of its temperature sensor. Due to the high interior temperature the capacity of the output amplifier has been decreased, and independently, the temperature shield of switched off the power supply in order to avoid overheating.

Obviously, we need some additional information to automatically deduce an appropriate conclusion; these are the exterior and interior temperature in the case of the example. However, it is not very likely that the operator being provided with the additional information — in contrast with the machine intelligence — is able to filter the significant new data.

Telecommunication systems can be expanded monthly, or even daily. When expanding, some system components — although working properly — may flush operators with error messages due to the non-operational functioning. Masking of events and equipments aims at solving this very problem. The setting and maintenance of these maskings require increased awareness. Similarly as at masking setting, the intelligent software module can improve the build-up of a remote supervision system at the design by offering suggestions for alert masking and time-out value settings.

C. *5.3. Analysis of equipment aging*

Remote supervision systems are very reliable systems with high availability times. One may reckon that the analysis of equipment aging in such a system that practically constantly provides typical parameters about the operation of the equipment is a simple problem. However, here we face the problem complexity: the system has to draw conclusion from an immense amount of data, and moreover, the operating system oscillates under normal operational conditions, and operators intervene manually to compensate parameter degradation. The analysis of equipment aging can be easily extended by the statistical analysis of the failure signals stored in the data base.

VI. Conclusion

Our umbrella system completely hides component systems at lower levels. All status information coming from any of those subsystems would be homogenized and presented in a uniform way, so as if the whole system would be a single one. Our above ideas on the intelligent operation of telecommunication supervision system and on the implementation tasks might seem futuristic. However, all the previously addressed problems could be solved in theory and in practice; the intelligent telecommunication supervision system implemented by the mentioned manner in fact the deeper level exploitation of the available information by means of soft-computing techniques.

References

[1] L. Raman: Fundamentals of Telecommunications Network Management, 1999
[2] H. Wang: Telecommunications Network Management, 1999
[3] G. J. Klir, B. Yuan: Fuzzy Sets and Fuzzy Logic: Theory and Applications
[4] L. T. Kóczy, K. Hirota: Interpolative reasoning with insufficient evidence in sparse fuzzy rule bases, *Information Sciences 71*, 1993, pp. 169-201.
[5] L. T. Kóczy, T. D. Gedeon: A model of intelligent information retrieval using fuzzy tolerance based on hierarchical co-occurrence of words, *Soft computing in Information Retrieval*, 2000, pp. 48-74.
[6] L. T. Kóczy, K. Hirota, L. Muresan: Interpolation in hierarchical fuzzy rule bases, *Int. Journal of Fuzzy Systems*, Vol.1, No.2, 1999, pp. 77-84.
[7] A Simple Network Management Protocol: SNMP (RFC 1157)
[8] L. T. Kóczy, K. P. Csányi: A brief overview of fuzzy logic FQAS 2000, 4th *International Conference on Flexible Query Answering Systems 2000*. Warsaw, Poland
[9] D. Tikk, J. D. Yang and S. L. Bang: Hierarchical text categorization using fuzzy relational thesaurus. *Kybernetika*, **39**(5), pp. 583–600, 2003.
[10] D. Tikk and Gy. Biró: Experiment with a hierarchical text categorization method on the WIPO patent collection, *Proc. of the 4th International Symposium on Uncertainty Modeling and Analysis (ISUMA 2003)*, pp. 104–109, University of Maryland, USA, September, 2003.