ABSTRACT

At this time, telecommunication networks are present everywhere. These networks are not only rather complex, but they are also made up of different components. That is the reason telecommunication network management (TMN) is so relevant.

This paper deals with two important aspects of telecommunication network management: managed objects and expert system rules. Definition of objects is based on a structure provided by ISO guidelines. Expert system rules are necessary to develop the expert fault management.

The NOMOS project (Integrated Expert System for the Management of a Power Utility Telecommunication Network) considers the concepts mentioned above. This project was sponsored by the Spanish Ministry of Industry and Energy. NOMOS has been applied to five different systems in two important power utilities, "Compañía Sevillana de Electricidad" (CSE) and "Unión Eléctrica Fenosa" (UEF).

Keywords: Expert System, Telecommunication Network Management, Object Oriented Technology, Managed Object, Object Classes, Fault Management.

1. INTRODUCTION

Nowadays, telecommunication networks constitute an essential pillar for not only companies' day-to-day activity, but also for people in general. Many organizations and institutions depend on them to work on and ensure their growth and their survival. At the same time as telecommunication services evolve and our dependence increases, network technologies also develop in order to satisfy user needs. Telecommunication network management turns into an outstanding aspect of telecommunications. Therefore, it is advisable to invest all investigator efforts in reaching suitable solutions for this area. The set of tools and systems that provides this management support is called Telecommunication Network Management System (TNMS) [1].

This paper describes the research works into NOMOS project. This project allows to define and develop an Integrated Management Expert System for telecommunication networks for power utilities.

The proposed management system is based on (figure 1): 1) the definition of those protocols that must be integrated in the system to connect it with different managed components, 2) the description of any objects included in the network, along with the attributes of the objects, and 3) the definition of the rules to allow the network to achieve the expert management.

As protocol integration is not the subject matter of this paper, we should focus on the objects and the expert rules definition.

2. DEFINITION OF OBJECT CLASSES

A distributed management environment, such as telecommunication operations at a power utility, includes multiple management entities at multiple sites. All these entities have to communicate with one another to achieve their goals [2]. When management systems are combined to support an overall function or requirement, integration is required. Standardization is essential to achieve the flexible, integrated management. A framework for effective integration includes the following basic principles:
* A common way for management entities to communicate one another.
* A uniform set of management functions that will be performed.
* A common way to structure, to identify management information and to show information to users.

So it is necessary to define management information, usually called object, to be able to manage a network. The standard GDMO (Guidelines for the Definition of Managed Objects) [3] is used to define objects in NOMOS project. This standard has been defined by ISO to describe OSI managed objects and is based on the object-oriented paradigm. The whole model of objects is built taking as basis abstraction, information hiding, inheritance and polymorphism principles.

A managed object [4] is composed of:
* Attributes. They are characteristics of objects. They are data required for management purposes.
* Operations. These define the actions that can be apply to the attributes.
* Notifications. They are some spontaneous information about any abnormal behaviour that may occur in an object.
* Relationships and behaviour. The systems are explained by means of its behaviour and relationships with other objects. So, the behaviour is also a part of attribute and notification specifications.

It has been developed a tool to obtain a specific and exhaustive list of the object classes in order to integrate different telecommunication networks in NOMOS. This tool makes it easy the definition of a structure, called Object Classes. Such structure describes any objects that have to be considered in NOMOS for each particular situation. Object Classes structure is also called Object Classes tree because it stands for a hierarchy.

In NOMOS framework, an object class is made up of (figure 2):
* A name. It is a name to identify unmistakably the Object Class.
* A parent Object Class. This is to inherit any characteristics from a parent.
* Characteristics. It refers to a whole of facts. They are some details that identify an Object Class.
* Number of objects. This shows the maximum and minimum number of objects that may exist in a particular Object Class.
* Help. This is a text information about the object class that it is showed whenever the user requires help.

Figure 3 shows an example of a dialog box where the System Object Classes of a network are defined in NOMOS. There is an Object Class called "MDM 34/8:Third Order MUX". If the "Modify" button is pressed, then the definition of an Object Class dialog box (Figure 4) will be shown. That dialog box allows to describe attributes, actions, and so on. There is a list of attributes (AIS indicator, Overflow indicator, ...) related to the "MDM 34/8: Third Order MUX" Object Class in figure 5.

Each telecommunication network in NOMOS has its own hierarchical Object Classes tree. An Objects tree is defined according to an Object Classes tree. This Objects tree includes each managed object associated to a telecommunication network. Objects trees are the same hierarchy as Object Classes trees.

There is another tool to define the objects related to some Object Classes. This tool helps users not to make any mistakes filling in the objects' relationships.

Figure 6 shows an example of an Objects tree dialog box. All those objects belong to a microwave network in NOMOS. The parent object is the network, called "SSR". The children of this object are other objects, called "stations". The Object Class of an object is put into brackets. The Object Class of the stations is called "base".
There are some actions that can be accomplished like moving throughout the Objects tree, copying an object, renaming, etc. Figure 7 shows the children of the "Barrios Station" object. One of them is called "MUX-3 with Pinar". This object is a "MDM 34/8: Third Order MUX" Object Class. Both the "MUX-3 with Pinar" object and the "MDM 34/8: Third Order MUX" Object Class are the same characteristics.

All the management information is described this way. First, an Object Classes tree is created, and then an Object tree is defined according to it.

3. EXPERT SYSTEM RULES

One of the main characteristics of NOMOS [5] is that makes it possible to achieve an alarm expert management in different power utilities networks. Such expert management intends to solve, or at least to lessen, two inconveniences that commonly appear in communication networks [6] due to the complexity of these networks: on the one hand, the great amount of information to manage, and on the other hand, the need of having a high-qualified experienced system operator.

In order to solve these drawbacks, a series of rules is defined to collect operators' knowledge. These rules carry out the following tasks (figure 8):

* Redundant alarms are filtered not to saturate the operator capacity. This filtering is not accomplished indiscriminately. Those alarms that show a service degradation or that can mask certain failures are not eliminated.

* Some possible failures, which may have occurred in the system, are detected using the information collected by the alarms.

* A severity index is created to give priority to some alarms. The expert sets it up.

* Some recommendations are shown to network operators in order to let them put right any failures or improve the system operation.

* All these tasks have to be carried out in real time.

Although rules are specific for each management system environment, there are some characteristics shared:

* Rules are generic being valid for a single alarm or a group of alarms, regardless the place where alarms occur.

* The relationships among rules are based on temporal simultaneously criteria. Therefore, several alarms will not be related if they take place at a temporal interval greater than a certain value.

* Rules are structured in a modular way to be able to add new expert knowledge.

NOMOS develops a specific set of expert rules for each different network. For example there is a set of rules for the microwave network of the power utility CSE, a network makes up of 39 stations. Some results of the expert management are shown next paragraph.

Thus, summarizing the test carried out, the system filters on average, 93.7% of the alarms coming from the network. At worst, this figure is superior to 89%. In the same way the obtained results show that in 50% of the cases the expert system offers only one location, (understood as equipment, or equipment elements, and the station where it is installed), for a determined fault. In 39.1% of the cases it shows a double location, and only in 10.9% of the cases, a triple location is offered. It never offers more than three possible locations for a fault. The exact place where the fault occurs is always one of the locations offered by the expert system.

In addition to these results, one of the system development objectives was the real time operation capacity. The test carried out confirms that the time to process up to 600 alarms, is below five seconds (figure 9); if readers take into account that the biggest volume observed, while the system was operating, were 260 alarms per minute, obviously the requirement for its operation in real time is met.

4. CONCLUSIONS AND FUTURE RESEARCH LINES

This paper describes object and expert rules definition in NOMOS project in order to manage a power utility's telecommunication network. NOMOS has been applied to: a microwave network, a Cross-Connect Digital network of TITAN and a PABXs network of ALCATEL, which belong to CSE, and two transmission equipment networks, one of NOKIA and the other of ALCATEL, and, a modern
A network of TELDAT, which belong to UEF.

One of the future developments in NOMOS is the integration of expert system rules as management object attributes. This approach will establish a relationship among objects and alarms. When objects are set up only attributes values are identified and defined to add new expertise. So the knowledge base consistence is not necessarily checked as it was using the traditional way.

REFERENCES

Figure 7

![Diagram](image1.png)

Figure 8

![Diagram](image2.png)

Figure 9

![Graph](image3.png)