Configuration Management Integration For Telecommunications Networks: An Implementation Experiment

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Abstract

The competitive scenario in telecommunications has been forcing companies to adopt standards to reach an ntegrated management of the telecommunications network, which makes the interoperability of different providers easier. In spite of the continued efforts to acquire management products in compliance with the standards, companies have faced the problem of legacy management systems already installed in the existing networks. Specifically, efficient configuration of communication circuits requires an open management framework in order to accelerate the configuration process, which would drop the related costs, as well as make more management information available for other management areas at multiple management levels. This paper describes the design and implementation of a configuration management system, whose goal is to provide the interoperability between two existing management systems that operates at network and service levels in the configuration functional area.

1. Introduction

The continuous growth in the number and diversity of the components of the telecommunications network has turned the activity of communication circuit provisioning more and more complex, which becomes worse when several vendors are involved. Due to these factors, the commercialization process of network resources (circuits) might become inefficient.

The commercialization of circuits by a telecommunications company is done by sales consultants who usually have no information concerning the availability of resources, and that is why, many times, they do not answer the clients' questions before the sale takes place, if the order is feasible. A study of the feasibility of implementing the circuit becomes necessary, which involves verifying the availability of modems, metallic pair, user port at the multiplexors and bandwidth in a trunk channel connecting two places.

This scenario shows the diversity of components (human, physical and logical) involved in the network management systems for this purpose. A plan of open management well prepared and an architecture that allows the interoperability between the proprietary management systems are necessary to reduce the direct costs of the commercialization process of the network circuits, as well as to supply information in several levels of different management areas.

1.1. Network Management Legacy Systems

Telecommunications systems have been continuously improved, and that leads to na environment made up of networks and heterogeneous equipment. This heterogeneity means managing this environment is something complex. The legacy solutions, present at the companies, turn network management into something inefficient, causing problems such as the presence of multiple interfaces for different systems, non-operable systems, insufficiency of gathered information, specific and isolated database with redundant and inconsistent information.

The competitive environment has forced many companies to adopt standards that will make an integrated network management possible, as well as the interoperability of different manufacturers' systems. The integrated network management requires that manufacturers supply their products within the standards established by recommendation, with standard interfaces which make the interaction with other manufacturers' management systems possible. Despite continuous efforts to acquire management products in compliance with the standards, companies have faced the problem of legacy management systems working for networks that have already been installed.

The purpose of this paper is to describe a configuration management system, conceived with an architecture based on the TMN principles, and implemented according to a pragmatic approach described in the article.

1.2. System Mapping According to TMN Principles

The elaboration of a common architecture which enables the interoperability between management systems is one of the most important activities of the process to standardize the telecommunications network management [1]. Specifically, the principle of decomposition in management layers defined by ITU-T is relevant for this work. Through that principle, the functionality of the system might be grouped in management layers, according to the level of participation at the management network, in relation to network element, network element management, service or business.

For the system described in this article, the layer network element, network and service are relevant. The proprietary legacy management systems are represented in the network element and network layers. The former enables the acess to elements through proprietary protocols, and the latter acts in order to make the network circuits available. The system described in this paper acts upon the service layer, using the funcionality of legacy system described before, providing a unified view of the network, and all of its access point. This allows an integrated configuration function, which makes the pre-sale of services more efficient.

1.3. Configuration Management

The system has been implemented following the aspects of Configuration Management, considering the commercialization requisites, the operation users' needs and the provisioning of circuits.

A telecommunication network may encompass different equipment and devices spread out around several different locations in an organization, and many of them are involved in frequent configuration changes. The goal of the configuration management is to allow the preparation, initiation, execution, operation and suspension of the interconnection services within the network. Therefore, its function is to maintain and monitor the physical and logical structure of a network, including the function of checking the components existence and the interconnection between the components.

1.4. Paper Organization

In section 2, some possible approaches for the interoperability of legacy network management systems are discussed. In section 3, the management system is presented. It is related to the implementation of a real solution for the interoperability between legacy management systems, including the adaptation aspects, an application of configuration management, and interfaces with the user. Section 4 presents the conclusions that have been reached.

2. Interoperability of the Legacy Network Management System

In telecommunications companies, there is a large number and diversity of equipment in operation which does not have interoperable interfaces. Integration of telecommunications network management is a known problem. Most of the solutions are still in use and they are based on proprietary products, made up of hardware and/or software specifically oriented to combination of products that already exist in the network. Some possible approaches for the implementation of interoperability between legacy management systems will be presented in the next sections.

2.1. Approach Using Proprietary Solutions

A possible approach to solve the existing problem is the confinement of the solution of management to one single vendor, adopting its conventions and methodologies to set up and manage networks. It is not hard to realize that during the bidding process for purchase and installation of networks, many companies, even though they might not have meant to do it, confined their solutions to vendors that won the bidding. It may be said that this solution, adopted without many alternatives, has led the scenario of telecommunications networks to a situation of total dependence on the resources of their vendors. However, this practice is no longer accepted and this approach belongs now to the past.

2.2. Approach Using TMN Architecture

The appearance of standard networks management solutions has come up with the inclusion of "Management Framework" [3] in the reference model ISO/OSI (International Organization for Standardization/Open Systems Interconnection). One of the concepts found within this recommendation concerns the management environment, which is in general made up of two or more open systems that cooperate to monitor and control the network resources. In 1985, ITU (International Telecommunications Union) started studying the standardization of telecommunications network management, creating a basic concept called TMN (Telecommunications Management Network). TMN has been defined as a management network, independent of the telecommunications network, whose goal is to gather, distribute and process the management information.

TMN Architecture introduces the concepts of manager and agent [3], which correspond to the roles performed by management system modules. Agents and Managers exchange information about the managed objects through specific protocols and a common view of the structure of information named MIB (Management Information Base). The substitution of the current structure for a TMN structure is very expensive. The implementation of standard interfaces through Q adaptors [1] requires a lot of effort and expenses to map the data in the network elements and to identify the functions to be executed in the adaptors. This difficulty has restrained the introduction of TMN in the management environments of companies. This introduction has been implemented gradually according to the economical benefit produced.

2.3. Approach Using Internet Architecture

The SNMP Protocol was the first non-proprietary management protocol, public and easily implemented, which enables the effective management of heterogeneous environments. The SNMP management module consists of a centralized plan, that is, a station is configured with a manager and the other network elements perform the role of agents or proxy agents, which work as the proxy for those pieces of equipment that do not implement SNMP [4]. Each agent has an MIB containing the variables related to managed objects. SNMP admits the existence of a distributed management, with configured stations to perform the role of managers and agents and allowing communication between managers to exchange management information.

2.4. Approach Using CORBA

Other standardization options have attracted the interest of the telecommunications community, specially the CORBA standards (Common Object Request Broker Architecture) of OMG (Object Management Group) [5]. CORBA specifications involve all the necessary functionality for building the management systems distributed and oriented to objects, considered the basic requisites when the OSI standard for management was developed. A distributed application consists of separate pieces that run in different nodes of the network and cooperate among themselves to reach a common goal.

CORBA standard was developed when the technologies of telecommunications network management were in an advanced maturity condition, which led to a group of specifications that are more adequate to implement distributed objects. Another point that makes the CORBA standard interesting is that the products built according to those specifications aim at corporation systems, and consequently reach a wider market. The result is that, as the commercialization schedule is larger, the price of products based on this technology tends to be smaller than the price of the so-called management platforms.

OMG has a task force for the telecommunications area which aims at creating a CORBA framework for telecommunications network management systems. The context of the solutions of interoperability between systems based on CORBA and systems based on TMN, or proprietary, has been split into two parts [9]:

- **Specification Translation**: it is the translation of the objects module described in ASN.1/GDMO or SNMP MIB for definitions written in IDL CORBA or vice-versa.
- **Transaction Translation**: it is the translation, within execution time span, of the basic interactions between systems, concerning communication protocol as well as message format.

2.5. Pragmatic Approach

In general, the implementation of an integrating management system in an environment where there are legacy systems does not mean to replace the already existing systems. It just aim at allowing their interoperation, the integration to other existing systems or to those to be implemented, with possibly some improvement in functionality. That is a complex task, which is worsen by the difficulty in "opening" the existing systems, and expanding them to interoperate with interfaces, protocols and already implemented mechanisms.

We say that an approach is pragmatic when the main goal for the integration of legacy systems is not the attachment to standards but the use of existing tools and the simplification of the integration process. However, some principles may be followed so that an open system might be obtained in opposition to the proprietary systems prior to the integration, with interfaces that are as close as possible to the standard ones. The principles listed below have been followed to conceive this integrating system:

- Trying to solve specific problems in a comprehensive way.
- Using protocols and open and/or standard mechanisms internally.
- Producing an open and documented information model, close to TMN architecture.
- Defining open and, if it is possible, standard documented interfaces.
- Using tool kits adequate to the system purpose.

2.6. Information Models

No matter the approach chosen, a definition of the information model for the integrating system becomes necessary. That is a complex task and the effort made by ITU-T for the production of information models for TMN cannot be discarded. Even though it is not always feasible, the model should contain, as much as possible, the information suggested by ITU-T, within the proposed structure, and should be described through the same syntax.

Nevertheless, the reutilization of a standard model, at anyone of the levels previously mentioned, is not an ordinary task. The difficulty rests on mapping the functionality of the existing equipment in the suggested objects by international organizations. That mapping is crucial and characterizes the reutilization of the objects already defined.

The structuring of management information for representation of MIB in the Reference Model OSI implements in an intensive way the concepts of object orientation. Each type of network element to be managed is represented in an abstract way as an objects class, and each resource of a certain existing type within a determined moment in the network is an instance of the respective class. All data and management operations applicable to the resource are encapsulated in the corresponding object. The access to the resource for management reasons is done through the object, using CMIP protocol messages.

3. Integration of Configuration Management

The system described in this article is an application of configuration management which works at service level and supplies support for the operational planning of the provisioning activity. It works at service level to make a facilities consultation component available in a deterministic transport network. It is related to commercialization aspects of the services with the clients. The basic functions are:

- Interface with the clients to hire new services;
- Interaction with the multivendors of services;
- Interaction with the network management layer in order to obtain the configuration data;
- Path Setup algorithm to find the routes involving equipment managed by distinct systems in the original management.

The system was built under the pragmatic approach principles previously explained, having been planned as a modular system which might be changed in relation to its functionality through configurable parameters to satisfy its needs. It has a multivendor capacity, that is, it was developed so that its basis was an open architecture, in order to receive systems and applications from any vendor, for which it might be possible to develop a wrapper module according to description given in section 3.2.1. The user's interface planned is friendly and easily accessed through Web architecture.

The system's architecture makes an open interface available for interaction with proprietary management systems through TCP/IP socket and an open protocol concerning application. The purpose of the architecture is to allow the implementation of management functionality that do not exist in the proprietary management system at the service layer. In this way, that architecture allows the improvement of (closed) proprietary management systems so that the operator's service requisites are fulfilled.

The architecture has been divided into three basic layers: adaptation, management application and interface with the user.

Communication between layers takes place through open protocols. HTTP (*Hyper Text Transfer Protocol*) is used between GUI and the management application layer. The use of that protocol allows the implementation of applications distributed in a simple way, through HTML pages - *Hyper Text Markup Language*.

Communication between the management application layer and the adaptation layer takes place through TCP/IP socket. TCP/IP socket is a communication mechanism that uses the TCP protocols for communication with data delivery guarantee, or UDP for communication without delivery guarantee. The choice of socket was made chiefly due to the comprehensiveness of the systems that support this protocol, an essential requisite for the implementation of agents in heterogeneous systems.

A protocol based on ASCII messages is related to the communication between the adaptation layer and the management application layer. This protocol is described in section 3.2.3.

3.1. Implementation Architecture

The implementation architecture is described in this section. This architecture is shown in figure 2, where the following elements are observed: Interface with the user; Manager; Adaptation Agent; and Legacy Management System. These elements might be mapped in TMN physical architecture as:

- **WS** - WorkStation: represented by interface with the user. It acts as a terminal connected via DCN (Data Communication Network) to an OS (Operations System). This terminal should be able to process and offer support to data visualization within a format that can be presented to the user, so that the user can manipulate the necessary data for provisioning.
- **OS** - Operations System: it should implement MAF (Management Application Function) represented by the manager of the proposed system. This block should enable the distribution of data treatment functions. These functions include support application programs, database functions, support for users' terminals, analysis programs (in this case, path setup algorithms), data formatting and report.
- **MD** - Mediation Device: it should implement the Adaptation Function that allows communication with the legacy systems and the MAF represented by the agents of the suggested system. It might involve one or more process from the following categories: process of conversion of information between the different models of information, process involving the interoperation of high level protocols, process of data treatment (concentration, gathering, formatting and translation), process of decision making and process of data storing.

That mapping with TMN architecture should take into consideration that the functions of the proposed system, as well as the Telecommunications Management Network,
might be implemented in several physical configurations so that it provides a high degree of flexibility in the choice of topology of the managed networks and in the adequacy to the organizational structures of different administrations. Aspects of implementation related to the specifications of standard interfaces are not being taken into consideration.

Concerning technology, the system interacts with the legacy systems by consulting their data base. The necessary information may be also obtained through direct communication with the network element, depending on the restriction imposed for legacy system

The advantages of the use of architecture in this case were:

- The architecture allowed the integration of the two legacy management systems, each one serving the part of the whole deterministic network;
- The architecture allowed the improvement of the legacy management systems through the implementation of new facilities which are not provided by legacy systems.

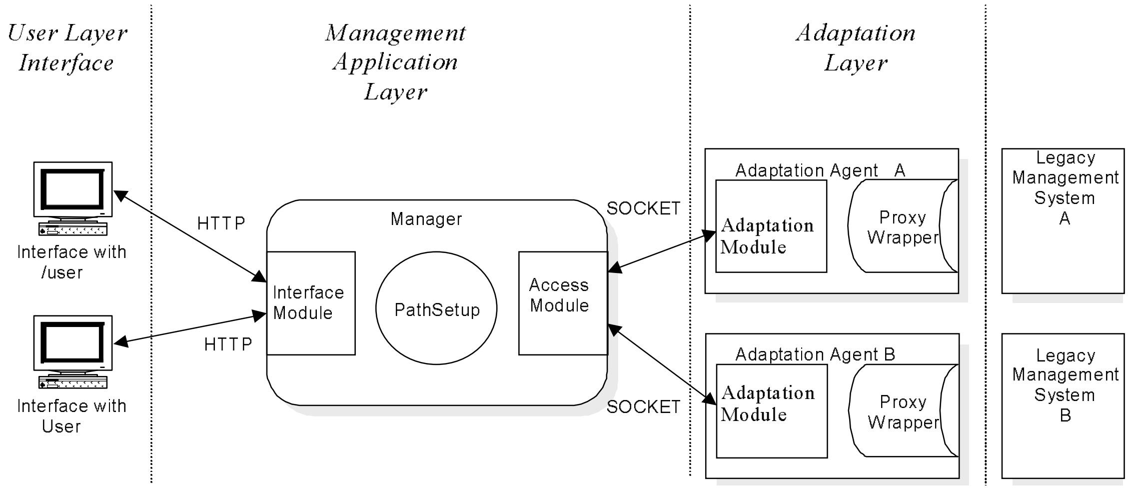

Figure 1 - Interoperability Architecture of Legacy Management Systems

The software modules are logically organized in three layers, shown in figure 1: adaptation, management application and interface with the user. They will be explained in detail in the next sections.

3.2. Adaptation Layer

The adaptation layer aims at interacting with a proprietary system and it makes a well known open interface with the management application layer available. The implementation of the adaptation layer takes place through an adaptation agent in the environment of the legacy system.

The adaptation agent is made up of two modules: the proxy wrapper and the adaptation module.

3.2.1. Proxy Wrapper Module

The role of the proxy wrapper is to obtain the necessary information for the adaptation module, using the tools of the environment of the legacy system.

In the specific case of the experiment developed, the legacy system has as its environment the DEC VMS Operational System and DEC DBMS Database Manager.

The language for consultation with database from DEC DBMS (DML - Database Management Language) was used to obtain relevant data for the mapping of information modules.

The tasks involved in the development of this module are related to the study and understanding of the data model defined for each one of the systems of legacy management. The semantic assessment of these models results in the construction of a filter, where just the data that are necessary for the management application are retrieved from the legacy database[10].

3.2.2. Adaptation Module

The adaptation module implements the mapping of legacy information models and of management application. Consultation of the data of the legacy information model is possible through the calling of the functions of the proxy wrapper module. The data, translated into the open information model, are made available to the management application layer through the protocol related to application.

The management information model proposed in this paper is a translation of the specification utilized by the data model network view used by the database of the legacy management system. The model defines an Entity/Relation diagram implemented in an Oracle database. The components used in the specification of a table bring just part of the information contained in the legacy database.

The mapping of the data model aims at relating the data model of the managing systems of the DEC DBMS database to an Oracle database which serves the path setup module.

The entities present in the Entity/Relation model are: Equipment (representing the equipment of the deterministic network, multiplexors and routers), User Ports (containing information about the free user ports per equipment), Link (containing information about the 2Mbits/s links), Time-slot (containing information about the link time-slots) and Envelope (containing information about the envelopes inside a time-slot). Further details about modeling may be found in [10].

3.2.3. Application Protocol

The application protocol has been defined based on the mapping of the information models of management application and of the legacy system. Four messages are involved in the communication between the adaptation agent, in the legacy system, and the management application. The standard format of the protocol has two fields to define the operation and the objects and five other fields that contain the specific parameters of the operation, as shown in figure 2.

Operation	Object	Param1	Param2	Param3	Param4	Param5

Figure 2 - Application Protocol Standard Format

The operations defined for use in the deterministic network experiment are:

Code	Operation	Description
0	GET	Operation for requesting agent's values
1	GET RESPONSE	Answer operation towards agent for management application

The objects defined for use in the deterministic network experiment are:

Code	Object	Description
0	User port	Access point in the mutiplexor
1	Link	Link between two network elements
2	Time-slot	Time-slots vector inside a link
3	Envelope	Envelopes vector inside a time-slot

The specific parameters for each operation in an object are shown below:

- A specific multiplexor's user port request:

01	ID-MUX

- Answer to Request:

11	ID-PORT1	ID-PORT2	ID-PORT3	ID-PORT4	ID-PORT5

- Link request, the ID-NE field specifies the link source network element:

02	ID-NE

- Answer to request, the ID-NE field specifies the link destination network element defined in ID-LINK:

12	ID-NE ID-LINK-1	ID-NE ID-LINK-2	ID-NE ID-LINK-3

- Vector request of time-slots of a specific link:

03	ID-NE	ID-LINK

* Answer to request, the time-slot vector has 32 entries indicating if the specific time-slot is used or free:

13	TIME-SLOT VECTOR

* Envelope request of a specific time-slot:

04	ID-NE	ID-LINK	ID-TIMESLOT

* Answer to request, the envelopes vector has 20 entries indicating if the specific envelope is used or free:

14	ENVELOPES VECTOR

This protocol is used between the access module of the management application layer and the adaptation agent (see figure 2). Further details about the protocol may be found in [10]

3.3. Management Application Layer

In the management application layer the necessary management facilities, normally not offered by the legacy management systems, are implemented. The interface with the user is reached through Web architecture, through the CGI standard - Common Gateway Interface. The interface with the adaptation agent is reached through the application protocol, described in section 3.2.3. The management application layer is composed by three modules which will be described below.

3.3.1. Data Access Module

This module is responsible for the interface with the adaptation agent. It uses the application protocol described in 3.2.3 to obtain the necessary data from the adaptation agent, supplying to the management application a transparent path of access to legacy management systems.

3.3.2. Inter-Network Path Definition Module - Path Setup

This module implements a path setup algorithm which, given two stations - source and destination, (according to figure 3) and a transmission speed, should find a path that has enough space to transmit data at the requested transmission speed. The problem is divided into two parts: generation of possible paths between the access points and checking of the existence of space for transmission considering the requested transmission speed.

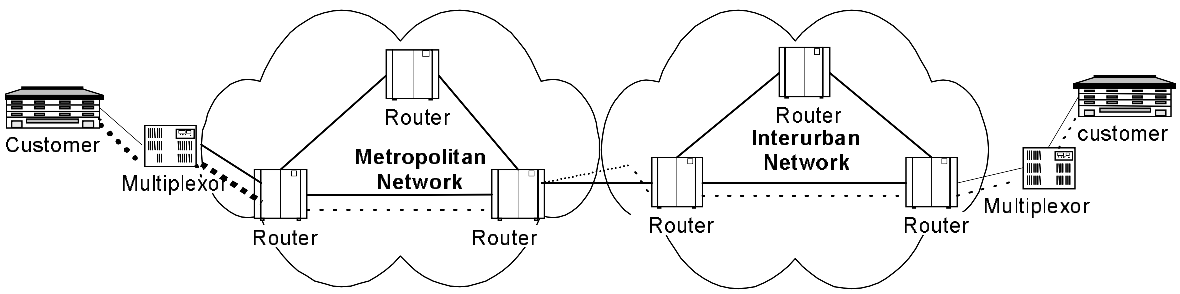

Figure 3 - Example of a Path Between Networks

Generation of Possible Paths

For the generation of paths, an algorithm based on wide search has been used [11] [12]. This algorithm is a strategy of systematic control where there are global movement (along several stages) and local movement (along a single stage.) That strategy was chosen to avoid the use of the same node several times, the use of many more stages than necessary and the utilization of a useless sequence of companies without being able, many times, to reach a solution. The algorithm of wide search, from an initial root state, generates all the root ramifications, applying to the initial state each one of the pertinent rules. Then, the procedure is repeated recursively for all the successors obtained. The basic difference between the algorithm used and the wide search is that the latter does not stop its execution when it finds one solution, but when it finds several of them. The program allows us to limit the number of solutions to be found before its ending.

It should be remembered that a network may contain more than one network element (multiplexor or router) and, considering the scenario of such deterministic network, where each graph node represents a network station, the algorithm used is a variation of the wide search algorithm.

Checking the Existence of Space

The checking of the existence of space is the second part of the algorithm and its entry are the paths generated in the previous stage, so that it has all the existing ways between the listed stations. It is just a matter of observing which one offers space enough for data transmission (considering the user's requested transmission speed).

The paths are generated in an increasing order, related to the number of equipment visited. Then, that part of the path setup takes the paths in the order they were generated in the previous stage.

3.3.3. Interface Module

This module is responsible for receiving user's consultation requests through HTTP protocol, and for calling the path setup module to answer the request. The path setup module uses the functions of this module to send an answer to the user. The work of this module is defined in the communication standard of the CGI plan - Common Gateway Interface - used in Web architecture.

3.4. User Interface Layer

The user may visualize the information of the network elements maintained by the two legacy management systems through a uniform and unified interface. When new network elements are added to the network, the system identifies in a transparent way this change. The database is updated and the path setup may check the new data without any problem.

The interface with the user has been implemented by using the HTML language - Hyper Text Markup Language. That allows the use of the system, implemented using the architecture, from any platform that runs an HTML browser.

4. Conclusions

During the development of the proposed architecture, the technologies used make the environment flexible to satisfy the commercialization needs. The system includes utilities that enable the data download of other systems, being able to provide the integrated management of telecommunications networks from the legacy management systems. Economically, the solution is interesting for the company, considering its investment potential in the short run. From the operational point of view, the users of the system, companies, can count on a single graphic interface to manipulate data from different systems. The language of this interface is more accessible to the company, and that makes the peculiarities of each one of the legacy management systems transparent.

The path setup algorithm implemented executes the same procedures of the legacy algorithms, which corresponds to the production of the same paths. This peculiarity guarantees to the companies compliance with the rules of business defined in their commercialization procedures.

The next stage should be tested considering some changes in architecture implementation. This second stage includes the development of modules using IDL/CORBA, as follows:

Manager-------IDL/CORBA-------Wrapper Agent (NMS Legacy)

The experiment reported in this paper deals with an alternative solution for heterogeneous networks isolated within the telecommunications network. Analysis of the alternatives for the building of architecture has become necessary, so that a solution could be developed which would not interfere in the legacy management process, considering the vendors' maintenance contracts. All the details of the construction of legacy networks have been studied, including functionality of management systems, aspects and characteristics of equipment and of the network and, mainly, the aspects of commercialization of a company.

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