

Protocol Conversion Approach to Include Devices with Administration Restriction on a Framework of Reference of Management Network

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Abstract. Considering the problem of handling devices with management limitations, the solution can be based on protocol conversion through finite-state converter in combination with the SNMP proxy agent functions and using the serial ports of legacy equipment and small devices with processing restrictions as sensors on a Ad Hoc network or Internet of Things. It reviews the framework of reference of management network, giving details of the challenges for the mentioned devices and the state of art of the existing solutions. This paper approximates to the proposed solution due to the research is in progress.

Keywords: Network management · SNMP · Proxy · Legacy systems · Protocol conversion · Finite-state converter · Ad Hoc · Serial communications

1 Introduction

Although, the major telecommunication devices are developed with management protocol support to their administration like SNMP (Simple Network Management Protocol), some of them have restricted access to their system variables through some management protocol or sometimes do not support it. This can happen for several reasons: (a) it does not consider it in the initial design, (b) the manufacturers develop own management applications as business model, (c) they are legacy systems which replacement can be expensive at the financial and operational level, or, (d) because their hardware is limited on processing and their resources are used in another kind of process.

This paper is an approach to the development of a solution that focus in the building of protocol converter SNMP to serial for integrating legacy devices or equipment with processing restrictions in a management network already constituted. It is necessary to resolve questions about its construction, implementation, diversity challenges, cost and scalability.

In the Sect. 2, it explains briefly the framework of reference of the network management, the SNMP protocol as common element in the major of management networks and the serial communications advantages. In the Sect. 3, it is detailed the propounded problem for legacy systems and for elements with processing restrictions in an Ad Hoc network or Internet of Things (IoT). It explains some existing solutions like to use an independent software or to include additional hardware and the limitations that it implies. In the Sect. 4, it gives an approach to the solution based on a finite-state converter model that works together with the SNMP proxy features and its implementation in legacy systems and Ad Hoc networks. By last, in the Sect. 5, it describes the research scope and the possible use of its results.

2 The Framework of Management Network

The management systems in a telecommunications infrastructure refer to the activities, methods, procedures and tools that permit the operation, management, maintenance and provisioning [1] of the network. These systems permit to model management network environment such as organizational, information, functional and communications [2], each one performing a different role but complementary, where the operation variables and available services on the network are controlled and monitored, following and registering the components network performance to detect unexpected behavior to take actions to avoid failures or improve the services performance, control deviations and manage resources.

A network management system is based on the agent/manager model that consist in a manager, a managed system, a management information database and a network protocol [2] where the monitored parameters information of a devices are captured, controlled and registered, i.e., the percent of use of a processor, the temperature, the traffic level, among others.

2.1 Management Protocol

To administrate a telecommunications network, applications are used on which all the information coming from the devices or network services through management protocols like WMI (Windows Management Instrumentation), CMIP (Common Management Information Protocol), ANMP (Ad hoc network management protocol), NETCONF (Network Configuration) or SNMP. The last one is the most commonly used, both in IPv4 and IPv6, and it is part of the Internet protocols stack defined by the IETF (Internet Engineering Task Force) in recommendations RFC (Request for comments) that describe its definition, structure, architecture, syntax, applications, transport messages, coexistence between versions, and more; they have been updated according the protocol has evolved from version 1 to version 3.

The operational parameters of a devices or service are represented by resident objects on a management information base (MIB), defined in a structure management information (SMI) and using ASN.1 (Abstract Syntax Notation One) format [3]. Each parameter or administration variable is a unique element detailed

with an object id (OID), which follows the hierarchical tree format of SMI and it examines the device's MIB to get the wanted information. The data is registered in the management application to monitor, control and administration it. The challenge of this model is the way to handle devices without management network protocol support or equipment with restricted hardware to process this kind of functions.

2.2 Asynchronous Serial Communications

The serial ports are interfaces that transmit information one bit per time and they often use asynchronous protocols as RS232, RS485 or USB, although there are synchronous protocols too such as MIDI, SPI or microware. The serial ports are ideal for communications between embedded systems. They have some advantages as the exchange of any kind of information (they often are in sensors, switches, motor controllers, relays, displays, among others), the hardware is inexpensive, its format is not complex, cables can be very long (USB is an exception) and the wireless technology enables transmitting serial data [4]. Its main limitation is the transfer information rate.

The use of serial communications in telecommunications equipment has been extended like alternative method of control, diagnosis and debug. Some devices, like the legacy systems, can be only handled through this kind of interfaces, wherewith some management restrictions appear as mentioned in the next section.

3 The Challenge

What happens if a device in a telecommunications network is not managed, maybe because it is a legacy equipment that does not support any management protocol or because it is a sensor or a small device with limited resources? The reality is that it will be able to operate and provide its services, however, when problems occur in the network, it will not be possible to determine their origin or take contingent measures to solve or prevent the occurrence of incidents again.

Thus, when one wants to keep a historical record of the operating attributes of these equipment, it can only be done manually through remote control applications such as telnet, SSH or web access, whose results show values in real time, but with historical data limitations that entails: insufficient data, unreliable records, possible typing errors, inability to integrate the information captured with the management systems, nullity in correlation of events, forgetfulness in the capture of information by the operator, etcetera. With this, system performance information is not available, which is vital for making decisions about the proper management and operation of the telecommunications network.

In this way, there are also challenges in the integration of the different applications that are used both to manage and control, as well as to collect the operating information of the equipment in a communications infrastructure, and, in addition, a network has devices from different vendors, running management

applications to each of them [1]. These considerations add risk factors that make the operation of systems more complex than it should be.

The previous challenges can be presented in different scenarios, so this research aims to address the conversion of management protocols in legacy systems, following a procedure whose result can be applied in agents of Ad Hoc networks with limited processing, such as mesh networks, IoT or embedded systems.

3.1 Legacy Systems

The Legacy systems are those devices, applications or services that are in a phase of “obsolescence” or are being replaced by new technologies, but the companies continue to use them because they have invested a lot of money in their purchase, their services are still active, they have returned the investment or because its replacement is very difficult to be critical in the operation [5].

An example of this challenge is in the satellite earth stations, whose topology is shown in Fig. 1. They are operating since several years, whose components as transmitters, amplifiers, converters, signals radio frequency controllers and others may lack of monitoring and they are not configured in the management network. These devices use serial communications for their control because the antennas are generally far from the baseband equipment, exceeding the distances allowed by other types of connections such as Ethernet.

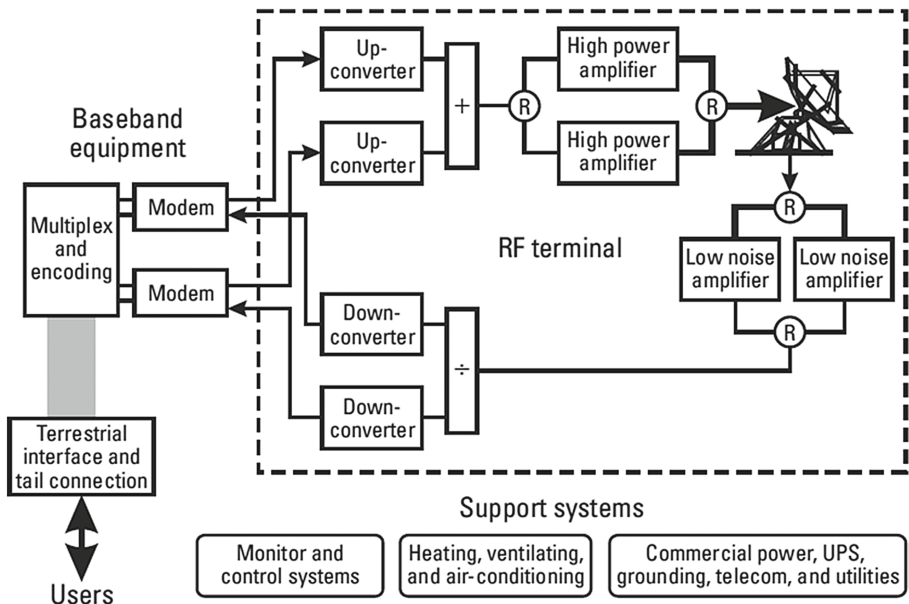


Fig. 1. Elements of an earth stations. The support systems use control and monitoring systems (Source: Elbert [6], p. 22)

An earth station can be operated locally or remotely, provided that it has an adequate monitoring and control design, which allows administrators to detect, diagnose and solve technical problems, as well as facilitates the execution of changes or configurations [6]. The facilities to do this are included within the devices, but they are not exploited when there are limitations of integration to the management infrastructure.

The most of the research that is done to include, maintain, or migrate legacy systems is focused on software rather than hardware, perhaps to replace a device may be easier than a specific application, although no less expensive. However, the results of such research can be associated to understand, for example, things that contribute to a successful migration process such as cost, duration, defects or capabilities [7]. In addition, the integration of legacy systems has other challenges besides technical ones that could be considered elements of user acceptance such as culture, information quality, utility, ease of use, compatibility, among others [8], and where organizational factors are very influential.

3.2 Sensors on Ad Hoc Networks

Another example of the administration challenges of devices with management limitations are the networks of wireless sensors or IoT, whose components have characteristics of heterogeneity, reduced energy consumption and particularities of wireless link [9] that must be considered for the development of any application. The sensors within an Ad Hoc, mesh or sensor network are designed to perform a specific function and due to their compact form factors have energy restriction that limits their lifetime or that of their batteries. Favorably there are working orientations [10] that seek to solve this limitation by designing the node and its wireless link as efficient as possible and using a strategy of collaboration between nodes.

Integrating these two concepts at the level of network management, it can be inferred that the approach of assigning optimal roles to the sensors to make them more efficient can leave out the management processes but there may be a collaborative method with an auxiliary node that supports and take charge of this service, so that the sensors are responsible for processing only the information relevant to your application.

3.3 Current Solutions

The market offers answers to the administration and monitoring challenges of telecommunications equipment without compatibility with the management protocols, developing drivers for each device and putting them to work on proprietary applications, such as Compass¹, Dataminer² or NetBoss XT³, huge cost is high (depending on the number of equipment on the network, development

¹ <http://www.kratosnetworks.com/products/network-management/compass>.

² <http://www.skyline.be/dataminer>.

³ <http://netboss.com/page/netboss-xt>.

requirements and administration functions, its cost is on range from \$100,000 to \$250,000 USD)⁴ and generates the difficulty of using multiple applications in management systems.

There are also solutions based on the conversion of different protocols to SNMP using physical converters from serial to Ethernet such as ipConv⁵, Red Lion⁶ products or developments in embedded systems [11], but mostly used in industrial automation networks such as SCADA, in which protocols like Modbus, DNP3, PROFIBUS, among others are used. The use of these solutions allows migrating serial legacy systems to Ethernet networks, but they have scalability obstacles because of the use of a hardware element for each component to be included in the network and as its use has not been extended to telecommunications equipment, suppliers must develop to give full management of the devices and without the limitations offered by the mentioned protocols.

These are the reasons why the inclusion of legacy systems or equipment with hardware limitations, to a management network is expensive, restricted and often evaded.

4 Protocol Conversion

The challenges mentioned above, seen from the logical connectivity, can be summarized in a problem of incompatibility of communication processes, so the problem may be treated with a software approach based on the conversion of protocols.

There are a variety of examples of protocol conversion, but there is no general theory that summarizes that procedure [12], however, there is an important development of formal models that can be used for the specification and accuracy of the conversion, seeing the incompatibility of protocols as a problem of syntax and semantics of messages that are exchanged for each protocol [13]. Since protocol conversion can take place in a huge diversity of environments, there are many methods that give different solution approaches such as protocol projection, Okumura approach, quotient approach [14] or multi-layer based OSI model through the normalization of the protocol and its requirements [15]. A specific option for the SNMP protocol is a proxy SNMP agent whose role is to translate requests, responses and notifications of management information and forward of those messages to the manager, using a suitable format [16].

4.1 Proposed Model

It is proposed the use of the finite-state converter model proposed by Lam [13], where it is sought to achieve interoperability between two protocols by

⁴ Information based on actual quotes with each provider.

⁵ <http://ipcomm.de/product/ipConv/en/sheet.html>.

⁶ <http://www.redlion.net/products/industrial-networking/communication-converters/>.

constructing a common image protocol by adding functionalities using a finite-state machine. Considering the Fig. 2, where the SNMP protocol is called as P and the serial protocol as Q which handle different semantics and syntax, so that messages M and N can be understood by both parties, a protocol converter C must be used to translate messages so that interoperability can exist. Thus, the part of the network called PC can be seen as a process that interacts with P , whose state is defined by a tuple (s_1, s_2, m_1, m_2) where s_1 and s_2 are states of C and Q respectively, while m_1 and m_2 represent message sequence in the $P - C$ and $C - Q$ sections. The same logic is handled for QC .

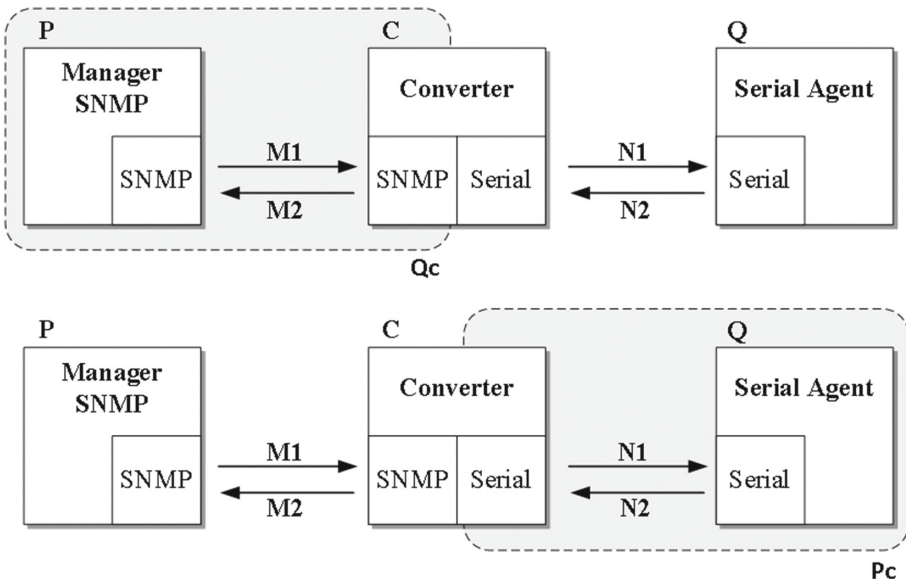


Fig. 2. Ways to see the conversion system. Exchange of messages between a P protocol and a PC process or between a Q protocol and a QC process (Source: own)

In the model, it is sought to break down each protocol at the flowchart level to understand how the messages enter and leave each node according to the internal events that appear in each one of them. Once you have these details, state machines are built to relate them.

4.2 Building the Relation

The challenge is considered as a problem of format and syntax incompatibility between both SNMP and serial protocols. So, a translation of the management information messages is done according to RFC3413 [16], making a preconfigured translation table (see Fig. 3), which will serve to make the mapping of management information through a direct translation approach as mentioned

by Korner [17] in a conversion work similar to this research. In this case, the MIB for each device does not exist, so it must be created as per the parameters or attributes that can be measured in each equipment that is to be integrated into the management network, which, in turn, it will be related to a no relational database (NoSQL), ideal to work on distributed systems with low capacity machines.

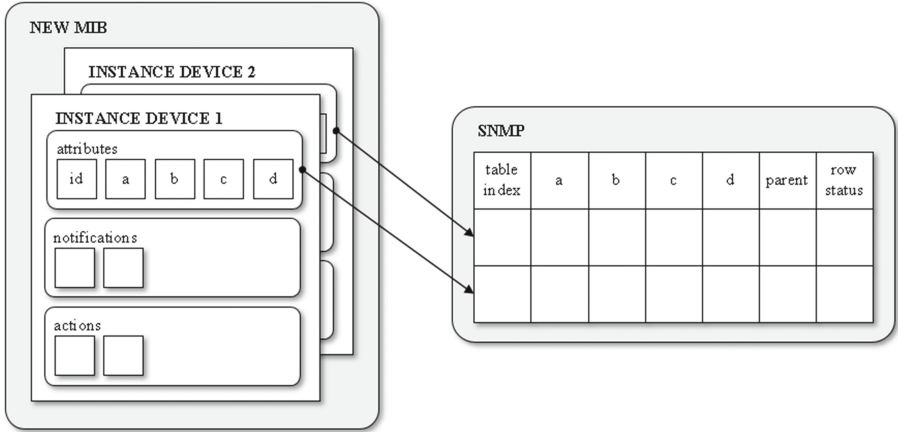


Fig. 3. Attributes translation approach of each device to SNMP (Source: Koerner [17], p. 351)

To construct the finite state machines of the SNMP and serial protocols (shown in the Fig. 4), are used: (a) a set of primitives that define the internal communications of the SNMP engine subsystems specified on the RFC3411 [18] for a SNMP agent, and (b) the exchange communication messages of the serial connections used in the flow control according to RS-232 specification [19], applying the most common configuration with TxD and RxD messages⁷ and combined with the connectionless service primitives [20].

The converter protocol image is built through the flow of messages analysis and relating the states of each protocol where are executed the consult functions of the operational variables of the device (“responding” on SNMP and “listening” on serial) using the transition flows designed to establish transmission, reception and format states. The translation table (Fig. 3) is applied in the “formatting” state.

⁷ Another control signals, like RTS (request to send), CTS (clear to send), DTR (data terminal ready) or DSR (data set ready), are not considered because they are applied over modem communications, and that kind of connections are not part of the scope of this research.

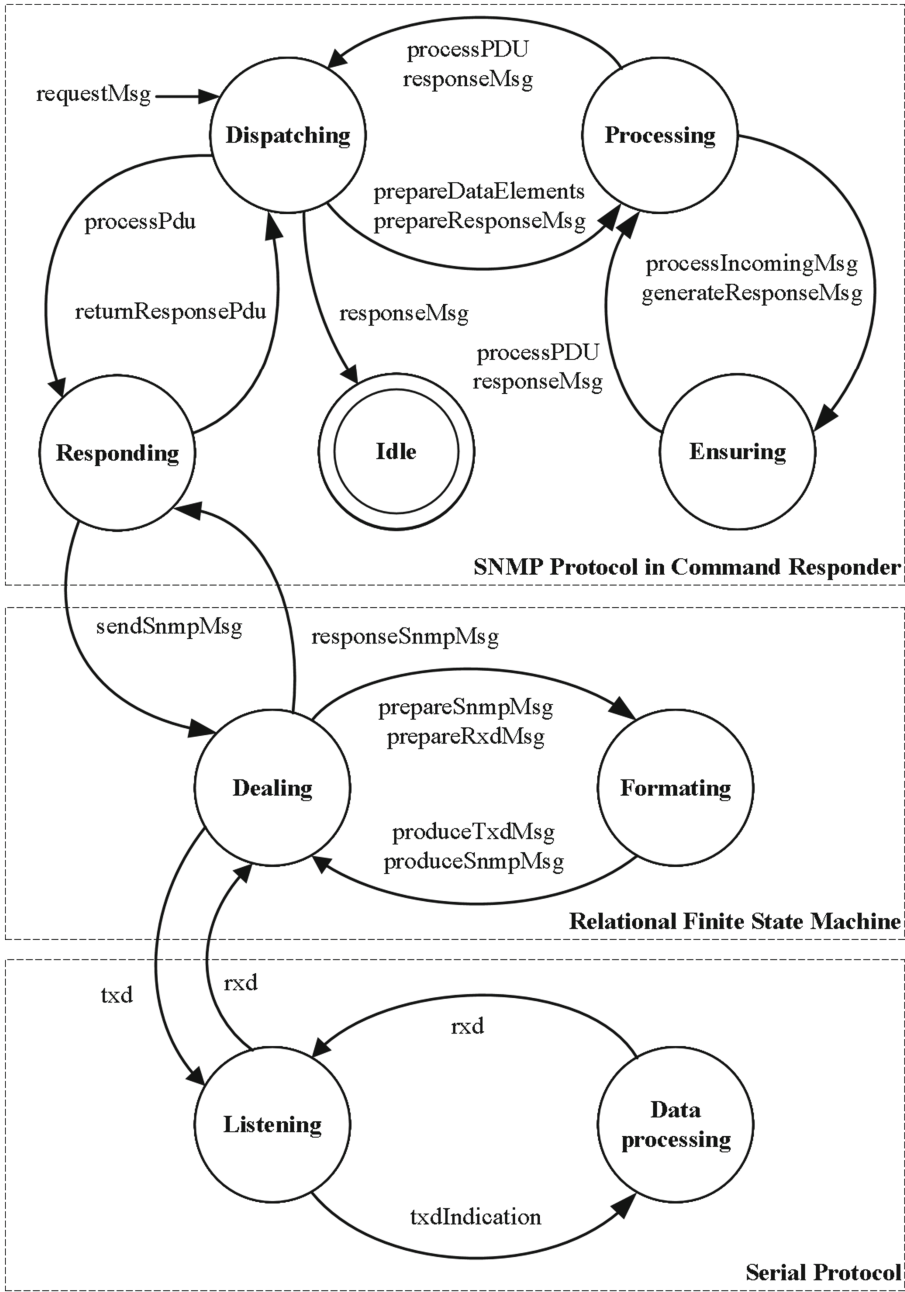


Fig. 4. The converter image protocol SNMP to serial design through finite state machines (Source: own)

4.3 Application on Ad Hoc Networks

To extend this model to Ad Hoc networks can be make if the proposed solution is seen as a protocol that can be executed in an agent that acts as a cluster header and in turn as an SNMP proxy that performs the translation functions between the main manager and the agents that are in that cluster, similar to the operation of the management systems in hierarchical networks where there are multiple intermediate managers who collect and process the information under their domain and then transmit it to a higher level. As shown in Fig. 5, there is a proxy agent for each cluster that exists on the network. This model of management in Ad Hoc networks is proposed by Chain, Jain and Singh [21] in whose work they use the ANMP as network management protocol.

Ad Hoc networks have different operating characteristics than infrastructure networks, so there are some additional challenges that are beyond the scope of this research but which may be useful for future work, such as mobility, integration with routing protocols, selection and change of clustered header agent, among others.

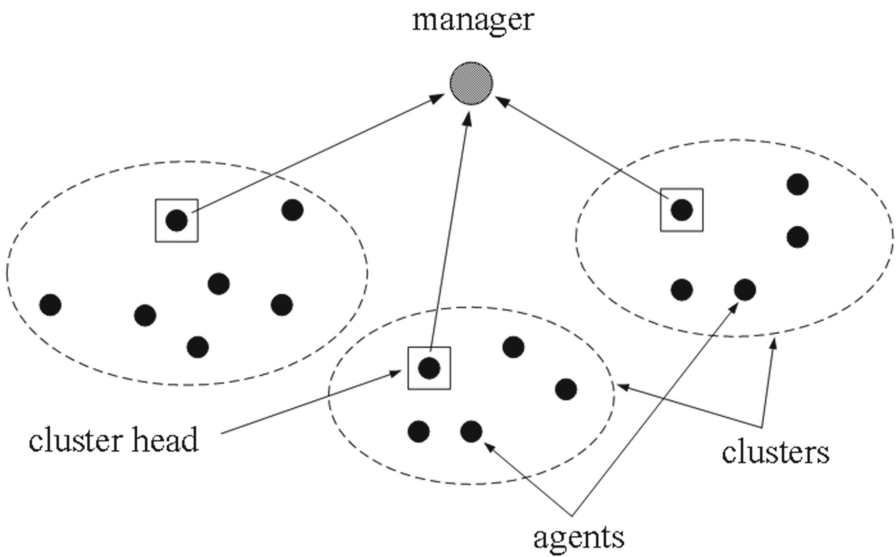


Fig. 5. Hierarchical architecture in an Ad Hoc network (Source: Chain, Jain y Singh [21], p. 1512)

5 Research Approach

The questions that are intended to solve with this research are: is it possible to develop a converser communications protocol serial to SNMP based on software to integrate legacy or process-constrained devices into the management

network, what would be the appropriate implementation, how does it solve the diversity challenges, if it would be seen as an update to legacy systems with a low cost implementation and if it could be scalable to other types of heterogeneous interfaces or elements in a network.

To solve these questions and achieve the proposed objectives, the development has to be applied in devices of a satellite earth station (which are legacy systems) and wireless sensors to include them in applications of management that exist in the market; the converter protocol must have the sufficiency to relate the commands of administration and operation of the equipment, with a MIB where a unique OID is assigned for each variable, and of course; this solution should provide the ability to capture performance information, report events and modify operating parameters through the SNMP protocol.

5.1 Use of Results

The result of this research work may serve as an improvement tool in the administration and operation processes of the telecommunications infrastructure of companies that use legacy systems, making the monitoring of the operating variables more efficient because:

- It will facilitate the inclusion of the devices in the management systems that are already available using standardized protocols
- It will improve the quality of the service in availability issues since the online registration of the information will serve for early detection of incidents or to do reactive diagnosis, eliminating or reducing the downtime
- It will help in the control of changes because it will be possible to have remote access to the equipment avoiding the displacement of technical personnel to the places where the devices are
- Opportunities will be opened to eliminate, mitigate or transfer new risks that could appear and that otherwise would not be detected
- It will reduce the costs of operation and maintenance due to the automation of management processes and avoiding the purchase of new equipment or independent management systems

Acknowledgments. For the development of this paper, it took advantage of the members comments of the research group in dynamic telecommunications networks and distributed programming languages - TLÖN, and professor Oscar Agudelo from Universidad Nacional de Colombia.

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