Use of SNMP in the Management of Electrical Energy Measuring Systems

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Abstract

The conventional measuring systems face imprecision and inefficient problems. Imprecision because measurements done by a human being can be imperfect. Inefficient because it's difficult to control a whole complex net like the electrical energy distribution only with a large group of people. The automatic measuring systems are an alternative to the conventional systems as a way to provide a better quality of service. So it's necessary an effective management on the measuring net components. Aspects like prevention of failures in devices until consumption readings are considered in the choice of a management protocol. SNMP is an efficient and simple alternative and its use in SALAME system (Electrical Energy Remote Measuring System) validates this subject. We show the facility of the information treatment like polling of the devices, control of communication errors, remote control of the devices and information to the consumers in the management station of SALAME system with the use of SNMP. In this article we accentuate the facility and importance of this subject to the remote measuring system management and its implementation in a real system.

1. Introduction

The electrical energy networks management by the companies of electrical energy faces the dependency problem of human information that can be imprecise and taken by an inefficient way. Imprecise because measurements done by a human can be imperfect, and inefficient because it's difficult to control a whole complex net like the electrical energy distribution only with a large group of people. It's necessary to have automation in this process aiming to reduce expenses and increasing the precision of the prognostics realized. Besides that, consumers are unprovided of more detailed informations about its electrical energy use, not only in quantity but also in quality.

An electrical energy measuring system (or just measuring system) is a conjunct of components and an interaction form between these to provide the things to be analyzed. The most used measuring system nowadays is the presential measuring, constituted by meters and readers men that realize the reading of consumption in the residences or in industrial and commercial institutions. As explained before, this kind of reading brings imprecision and inefficiency to the process. Remote measuring systems bring a better agility and permit a bigger control in their components. These systems allow to read in any moment the consumptions of the meters, and also allow the management (monitoration and control) in their devices. For such a thing, it's necessary a management protocol able to manipulate and keep easily the measuring network.

Trying to find a solution for these and other problems related to the measuring systems, SALAME system (Electrical Energy Remote Measuring System) was developed in an association between Federal University of Campina Grande and CELB/SAELPA. The management protocol choice SNMP (*Simple Network Management Protocol*) has facilitated the manipulation of the network devices and has propitiated a better quality of service by the electric companies involved.

In this article we try to give emphasis to the importance of the SNMP protocol use to the management of measuring systems. In section 2 we show the elements that compose the measuring network from the system architecture. In section 3 we give emphasis to the management station of SALAME system and its main functions. In section 4 we give a general view of SNMP protocol and the importance of its use to the system. In section 5 we study a Management Information Base (MIB), to the measuring systems and, finally, in section 6 we introduce the final considerations.

2. Architecture of SALAME system

SALAME measuring system has as a general objective to improve the obtainment process of the data concerning to the network distribution of electrical energy as a way to open a new channel of information providing to the clients of the distribution company; in addition, the system helps in the network device support.

In figure 1 we see the architecture of SALAME system.

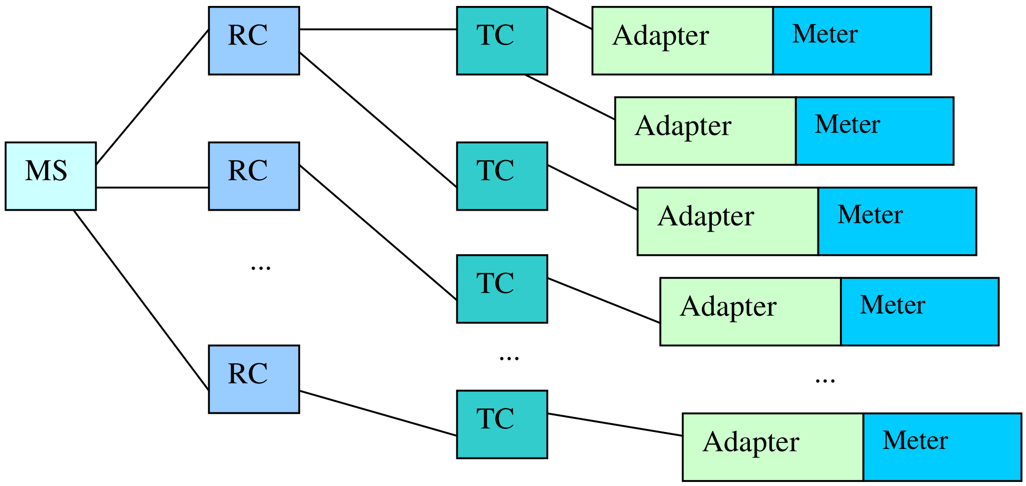

Figure 1 – Architecture of SALAME system

Every communication made between the system modules is done by prosecution, meaning that a module can never give the information to another one if it doesn't have been required. The Management Station (MS) is a software component that acts in network that its main function is to manage the devices. The Regional Concentrator (RC) is also a software component that has as a main function the obtainment of the data related to the measuring and concentrator states. The Transformer Concentrator (TC) has the function to monitor a reduced group of meters. The only changes that need to be realized in the conventional measuring system is to put an electronic adapter to the TC communication with the meters and the insertion of the TCs in the transformers. The communication between the components is detailed in the following subsections.

2.1 Management Station

The management station (MS) communicates with the regional concentrator (RC) by the TCP/IP protocol and the application protocol used to realize the measuring readings and system devices control is the SNMP protocol (Simple Network Management Protocol).

2.2 Regional Concentrator

The communication between the Regional Concentrator (RC) and Transformer Concentrator (TC) is done through radio link, using the application protocol MODBUS.

2.3 Transformer Concentrator

The communication between the TC and the meters is done through the Power Line Carrier (PLC) using the electric net of low tension; the application protocol used is the MODBUS. In fact, the communication is done between TC and the Adapter of the meter.

2.4 Meters (monophases, triphases)

The meters are installed in the consumers' dependences. Each meter has a connected adapter as way to effectuate the communication.

3. Management Station Functions

Conventional energy measuring systems don't give support to the monitoration of their devices. There are technical inspections to the meters when they show any problem. This brings two problems. The first one talks about the expenses involved in the support of the devices and the second one talks about the diminution of the service quality given to the clients. If there are management and effective monitoration of the devices such problems can be solved. This is possible because a continuous management makes possible a previous identification of the potential problems, and they can be treated before they happen.

In a remote measuring system the management station has this important monitoration role in its devices. We'll show in the following topics the functions of the management station of SALAME system.

3.1 Access control to the system

As MS controls the measuring system like a whole and it is available in network, it's necessary that there is an access control in its functions. Besides that, people with different roles in an electrical company must have different access levels to the MS. Thinking about this, the access control happens through the authentication name of login and password. The figure 2 shows the logon page.

Figure 2 - Logon of the Management Station

3.2 Communication error management

The communication between the devices of the electrical energy networks is propense to failures, because of its complexity and embracing. Such factors, failures in the conventional measuring system aren't easy to be identified. If there is a remote monitoration the failures identification between the devices becomes automatic. This functionality is very important because becomes easier and quick the failures correction process in the system. In architecture of figure number 1, the possible errors would be between MS-RC, RC-TC or TC-Meter. The figure 3 shows the communication errors happened in a determined time interval.

Figure 3 – Communication errors

3.3 Remote Control of the devices

One of the most important functions of the MS is the one that remotely controls the network devices. This control is necessary to let the system independent of humans information to be gathered. Consumption reading and the breaks of the energy supply are remote control examples that can be seen in figure 4.

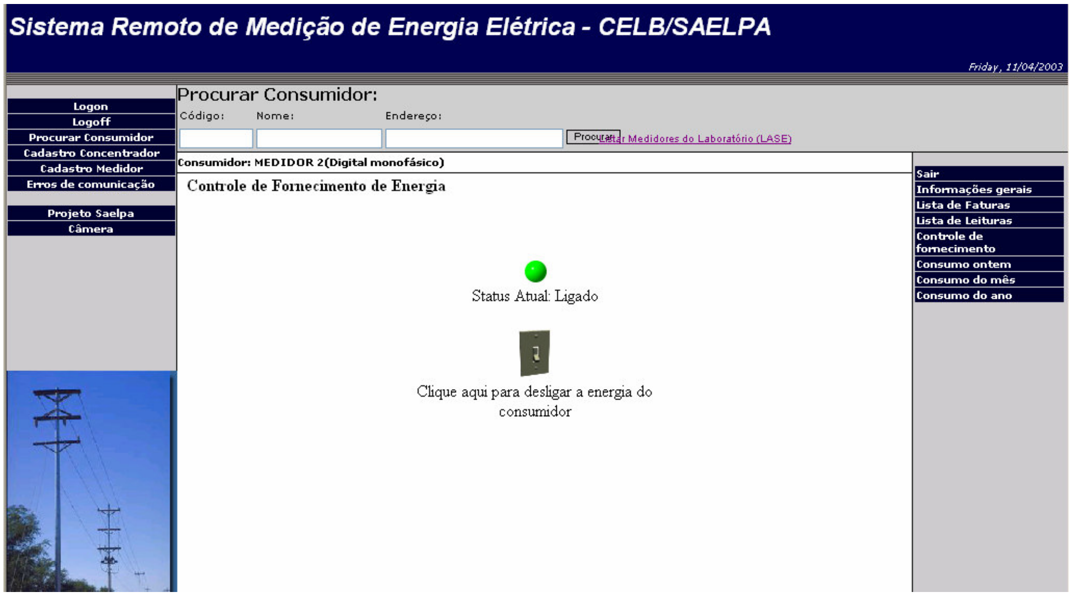

Figure 4 – Energy supply control.

3.4 Polling of the devices

To the MS get the information about the meters readings regularly, it's necessary to make polling in all the meters registered. With the polling the MS keeps itself up-to-date with the consumption data and the meters status continuously. It's possible, if the meter isn't answering to requisitions for a time, that the polling doesn't be realized anymore on that meter and to be reported an error to repair the meter. And also, by demand, it's possible to incapacitate the polling in the meters from a determined RC.

3.5 Management of execution logs

In computer systems there are two kind of well defined users: the ones that use the system as an order, in other words, they use the functionalities that the system offers to the business and also the ones that use for management and improvement. It's necessary that logs for each kind of user be created, because the first kind needs information referents to the correct use of the system (non-technical informations) and the second kind needs technical information to solve eventual problems that happen in the system utilization. In this way, the MS was created to give two kinds of logs: the logs of general users, that are reported in system's screen and the management system logs, that are saved in files.

3.6 Network devices control (insertion, update and deletion of meters and concentrators)

To the measuring system, is extremely important to have the possibility of making the control (insertion, update and deletion) of all the devices in the network through web. Regional Concentrators and Meters can be controlled by the management station, as well as the list and identification of the owners consumers of the meters. The figure 5 shows the insertion of a concentrator.

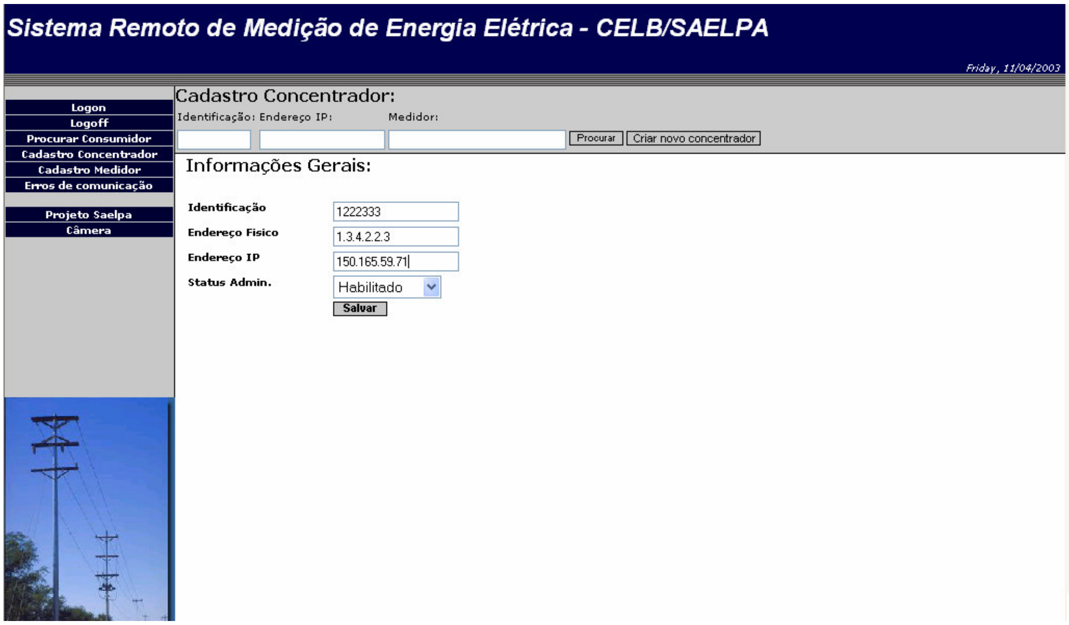

Figure 5 - Insertion of a concentrator

3.7 Reports to the clients

For that the client has disposable 24x7 the data relatives to the consumption of his residence, the MS disposes the reports that refers to the dairy, monthly and annual consumption, as well as the last readings of consumption realized. With these data the client can analyze the tops of consumption effectuated and to take decisions of the use of electrical machines that they couldn't do before. A graphic of the day consumption can be seen in figure 6.

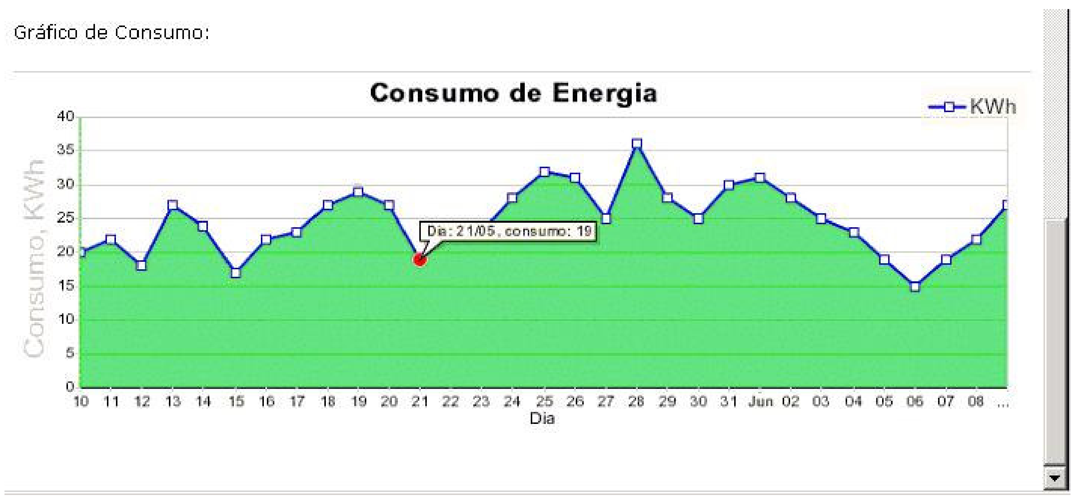

Figure 6 – Day consumption of a determined client

4. SNMP and its use in SALAME system

Networks systems need to be managed. Due to its heterogeneous nature the choice of the set of metrics to be gathered and, mainly , the management protocol used can bring a better quality to the network operation.

Networks management systems can be divided in four components [1]. The first of them are manageable elements. They are what the system monitors and controls. The second component is the management station, and its interface allows that users monitor and control the network devices. It is in the management station that reside the manager software. The third component is the management protocol used. Such protocol allows the management communication between the management stations and the agents (manageable elements). The forth and as important as the other components are the management informations, that are obtained from the network devices. In SNMP world (Simple Network Management Protocol), this component is detailed in the Management Information Base – MIB, object of study in item 4. In SALAME system there are these four components. The manageable elements are the RCs, TCs and meters. The management station has this same name in the system. The management protocol is the SNMP and the management informations are the variables that are in the MIB of management specially elaborated to manage an electric energy distribution network.

An important aspect in SNMP protocol is that it helps not only to know if the device is working, but also if it is working well. This protocol works in protocol IP (Internet Protocol) and it allows not only the physics devices management (routers, printers, meters), but also of softwares (SGBDs and Web Servers).

Let’s imagine a situation as motivation to the devices management of energy measurings. An electric energy company supplies a city with 2 million habitants, where there are, between residences, commercial buildings and industries, 500 thousand measuring points. For each point there is an installed meter and in operational state. Daily, 200 reclamations of broken meters arrive to the consumer attendant people, needing that the company contacts the employees to fix the devices.

See that this is a situation that happens today with the energy companies. This and many other problems, like transformer burst, break of energy because of a demand problem and the famous by-pass connections could be solved if there was a constant monitoration of these devices. SNMP comes to help in this and in other networks management problems, reducing the dependence of human informations to have an effective monitoration of the network.

SNMP defines two kind of elements: the managers (Management Stations – MS) and the agents. The MSs realize consultations to the agents to get some informations about its state. The agents provide such necessaries informations to the effective management of the devices. In figure 7 there is an illustration of the communication flow between the agents and the managers.

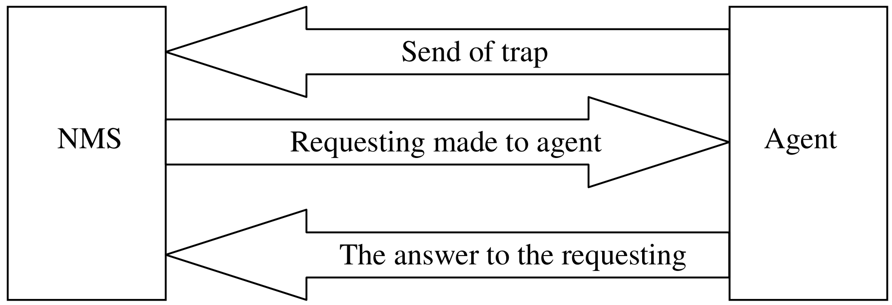

Figure 7 – Communication flow

Occasionally the agent can send a trap to the MS, but this situation won't be treated in this article. The transport protocol used by SNMP is UDP (User Datagram Protocol), a non-orientated protocol to a connection, having as consequence an unreliable communication. The choice of an unreliable communication protocol makes that the use of SNMP has a low overhead, reducing the impact in the network performance. This aspect is too relevant when we take in consideration that the network that we intend to manage is naturally of large scale. The figure 8 shows the communication between TCP/IP and SNMP.

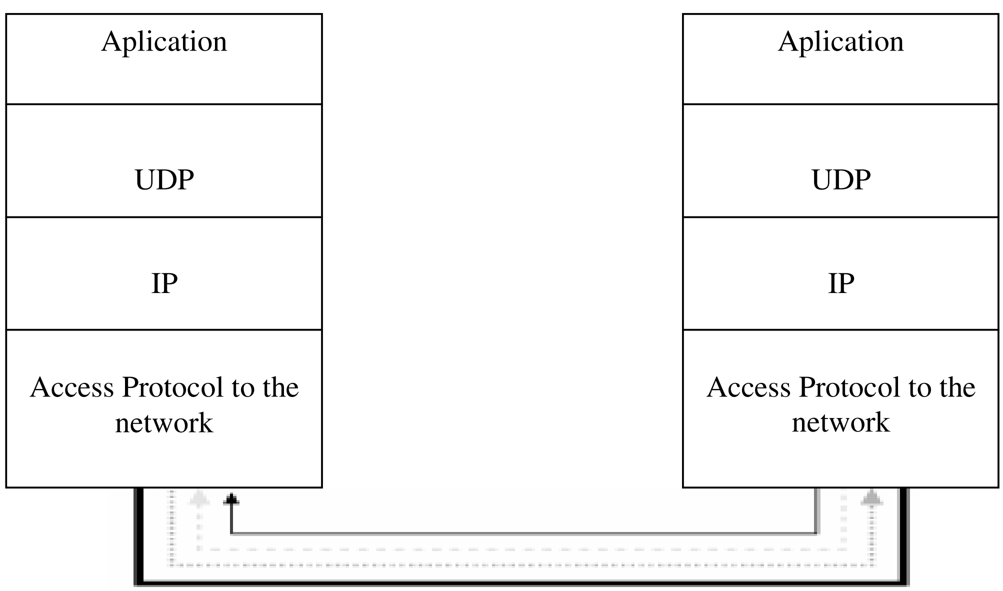

Figure 8 - Model of communication TCP/IP and SNMP

The managed objects are disposed hierarchically in a tree. Each sub-tree has an specific OID (Object Identifier), that is an unique identification of the object in the hierarchy. An OID is a sequence of numbers, or names to a better human legibility, separated by point (.). As an example, the OID .1.3.6.1.4.1.12214 in SALAME system is the same of .iso.org.dod.internet.private.enterprises.ufcg. The conjunct of the manageable objects forms the MIB (Management Information Base) that is a virtual data bank of the management objects. The agents SNMP control a MIB (if it's SALAME system are the regional concentrators). We can say that the OID is the only identification key of an object in the MIB. Let's see in figure 9 the objects tree built to the devices management in SALAME system.

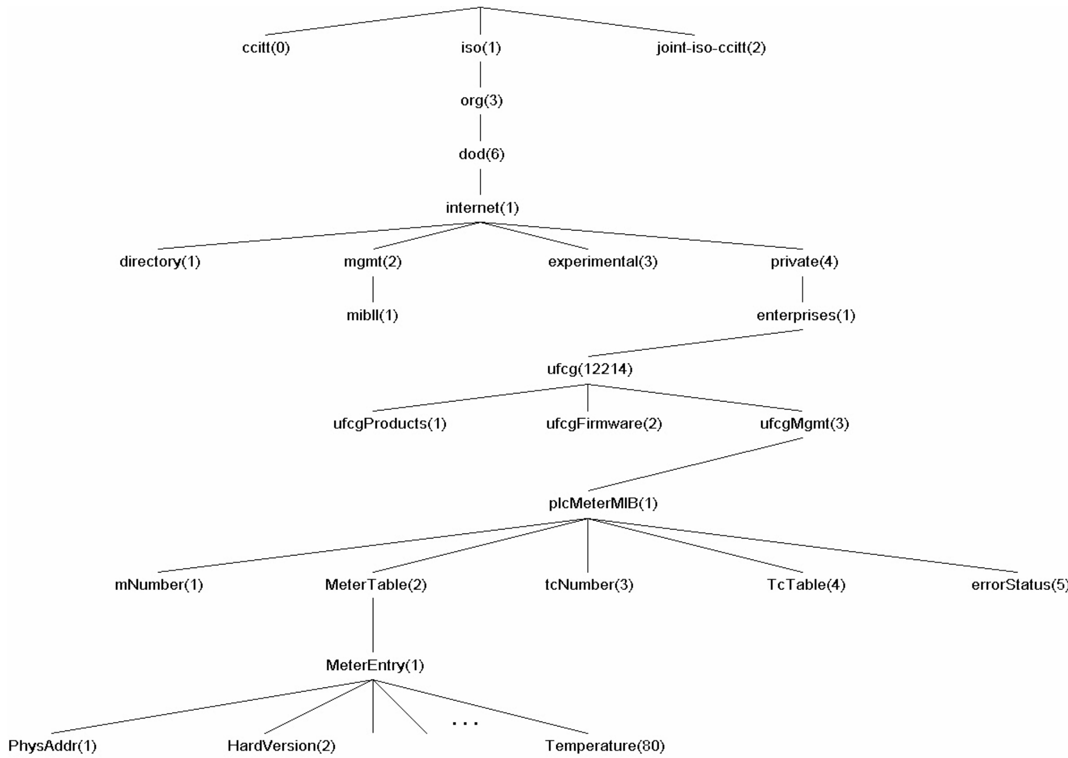

Figure 9 – Structure of the objects tree of SALAME system

The SNMP protocol supports two kinds of operations: get and set. The get operation is originated in MS and passed to the specific agent that will give back the answer of the requesting.

This is typically of monitoring. To occur a get is necessary that the MS identifies which is the object of MIB and what variable (instance) it's interested to receive. This is made through the OID that identifies uniquely the object. The figure 8 shows an example of the operation get in the system, where the OID .1.3.6.1.4.1.12214.3.1.2.1.7.x.x.x.x.x.x is the same of .iso.org.dod.internet.private.enterprises.ufcg.ufcgMgmt.PlcMeterMIB.MeterTabl and MeterTable.MeterEntry.Consumption.<PhysAddr>., the requisition is the meter consumption of physical address x.x.x.x.x.x, like in figure 10.

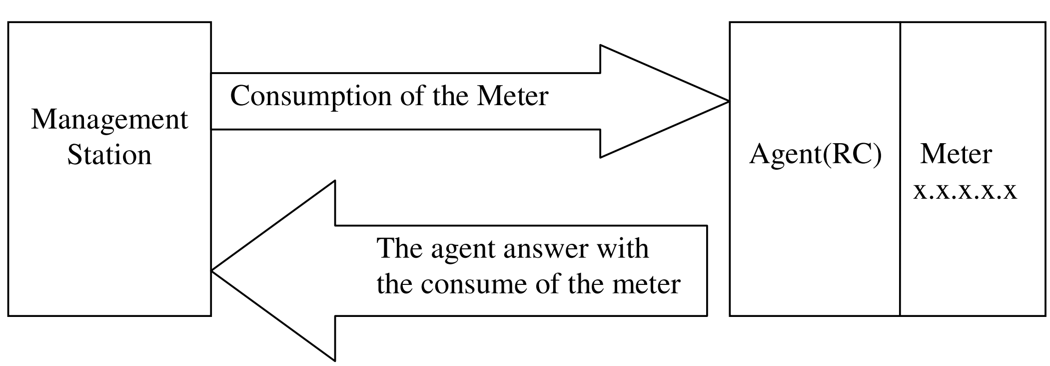

Figure 10 – Consumption requisition

The operation set has its origin in the MS and it's sent to the specific agent, passing the OID that it wants to change. Variables of the read-only kind from MIB can't be changed; so, it can't have any set operation in them. Meter consumption, for example, is a read-only variable that can't be changed by SNMP operations. An example of a set operation in SALAME system is the administrative status update (adminstatus) of a meter. Let's see in figure 11 the operation cycle.

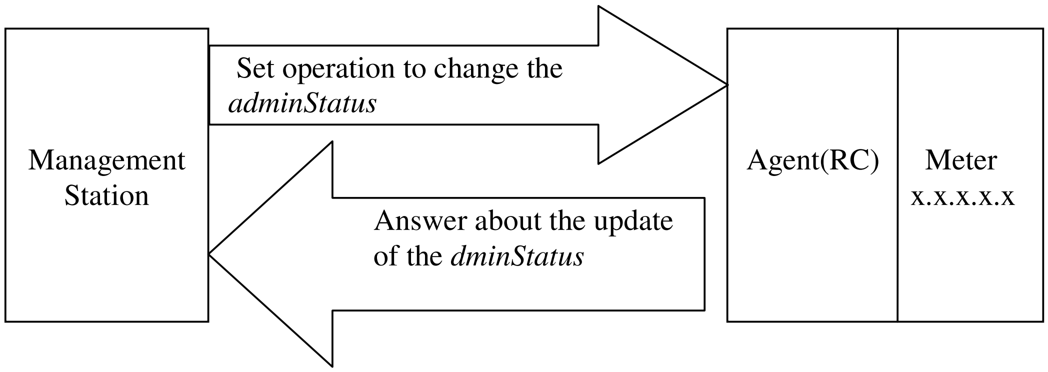

Figure 11 – Set Operation to change the adminStatus

Notice that this simple set operation causes in the turn-off effect the meter and as consequence the energy break of a consumer, if the adminStatus were on before. The simple operations like get and set allow us to monitor and control in an efficient way the network meters, or any device managed by SNMP protocol.

4. A MIB to the Measuring Systems Management

A MIB defines the objects (and, in an indirect way, its instances) that can be manipulated in a system. This approach gives a great flexibility to the management station, because any new device that comes to be integrated can be managed by MS, needing to have only an entry in the MIB, becoming an orthogonal system.

In SALAME system, aspects like communication errors, control and monitoring of the devices, and others, that give a better management level, were inserted on the MIB to provide a better quality.

The manageable objects in MIB are:

Value	**Object**	***Read Write***	**Bytes**	**Description**
1	PhysAddr	RW	4	Physical address of a meter
2	HardVersion	R	1	Hardware version of a meter
3	SoftVersion	R	1	Software version of a meter
4	DateAndTime	R	4	Date and time of a meter
5	AdminStatus	RW	1	Admin status of a meter: (1) on, (2) off
6	OperStatus	R	1	Operational status of a meter: (1) on, (2) off
7	ContAbert	R	4	Opens counter of a meter
8	CommErr	R	4	Errors counter of meter communications
9	TemporizadorT1	RW	4	Timer to medium demand

10	TemporizadorT2	RW	4	Timer to maximum demand
11	EnergiaAt1	R	4	Active energy (KWh)
12	EnergiaAt2	R	4	
13	EnergiaAt3	R	4	
14	EnergiaAtT	R	4	
15	EnergiaRtInd1	R	4	Inductive reactive energy (KVAhrL)
16	EnergiaRtInd2	R	4	
17	EnergiaRtInd3	R	4	
18	EnergiaRtIndT	R	4	
19	EnergiaRtC1	R	4	Capacitive reactive energy (KVAhrC)
20	EnergiaRtC2	R	4	
21	EnergiaRtC3	R	4	
22	EnergiaRtCT	R	4	
23	PotenciaAt1	R	4	Active Potency (KW)
24	PotenciaAt2	R	4	
25	PotenciaAt3	R	4	
26	PotenciaAtT	R	4	
27	PotenciaRtI1	R	4	Inductive reactive potency (KWrL)
28	PotenciaRtI2	R	4	
29	PotenciaRtI3	R	4	
30	PotenciaRtI4	R	4	
31	PotenciaRtC1	R	4	Capacitive reactive potency (KWrC)
32	PotenciaRtC2	R	4	
33	PotenciaRtC3	R	4	
34	PotenciaRtCT	R	4	
35	PotenciaAp1	R	4	Apparent potency (KVA)
36	PotenciaAp2	R	4	
37	PotenciaAp3	R	4	
38	PotenciaApT	R	4	
39	TensãoF1N	R	4	Phase voltage (V)
40	TensãoF2N	R	4	
41	TensãoF3N	R	4	
42	TensãoFM	R	4	
43	TensãoL12	R	4	Line voltage (V)
44	TensãoL23	R	4	
45	TensãoL31	R	4	
46	TensãoLM	R	4	
47	Corrente1	R	4	Current (A)
48	Corrente2	R	4	
49	Corrente3	R	4	
50	CorrenteT	R	4	
51	DistorcaoHT1	R	1	Harmonic distortion of voltage (%)
52	DistorcaoHT2	R	1	
53	DistorcaoHT3	R	1	
54	DistorcaoHC1	R	1	Harmonic distortion of ccurrent (%)
55	DistorcaoHC2	R	1	
56	DistorcaoHC3	R	1	
57	Frequencia1	R	1	Frequency
58	Frequencia2	R	1	
59	Frequencia3	R	1	
60	DemandaAtMed	R	4	Medium active demand (KW)
61	DemandaAtMax	R	4	Maximum active demand (KW)
62	DemandaApMed	R	4	Medium apparent demand (KVA)
63	DemandaApMax	R	4	Maximum apparent demand (KVA)
64	DIC	R	4	Individual Interruption Duration for Unit Consumer (UC)
65	MDIC	R	4	Maximum Duration of Continuous Interruption

				for UC
66	FIC	R	4	Frequency of Individual Interruption for UC
80	Temperatura	R	4	Temperature

Table 1 – Main objects from MIB

The variables DIC, MDIC and FIC are rules imposed by ANEEL (National Agency of Electrical Energy - Brazil) to evaluate the quality of the services by electric energy companies. The great part of the presents variables in MIB are electrical properties that are collected from meters and concentrators. The active energy is the consumption, particularly important to billing. This property is also used to plot the daily, monthly and annual graphics of the residential, commercial and industrial consumption. Temporaries graphics of active energy allow to determine the top consumption patterns, allowing the consumers a better adaptation to the consumption schedules. It isn't good to the consumers and to the energy company that some tops of energy happen in a determined schedule. With tension, frequency and current it's possible to verify the quality (tension, frequency) of the provided energy and load balancing (current) in triphase alimentation. The harmonic distortion has also the important job of verifying the quality of the provided energy.

The demand variables, medium and maximum, can be calculated in time intervals. It's interesting to the consumer, because knowing that there is a major energy demand in a determined time, if he doesn't consume in the same, he will pay less in the energy bill. To the company is also interesting, because it doesn't load the electrical network. Besides that, if there is information of a high demand in any places, it's possible to increase the network capacity of the area before distribution problems occur.

Related to the inductive reactive energies (energy that isn't changed in work, but it's paid by the consumers) are particularly interesting to the industries because the inductive reactive energy (the most common) determines the potency factor and, consequently, the increment in the industrial consumer bill.

From the analysis of many variables, it's possible to observe specific problems like the famous "by-pass connection" and the transformers burst. This last one, is due to a preventive analysis, reduce the inconvenience by the companies part (expenses with new equipments and employees) and the consumers (a better quality).

There are too variables that aren't physical properties in the MIB. AdminStatus and OperStatus, Physaddr, HardVersion and SoftVersion used to the meter identification and temperature, specifically of transformer concentrator and of post, too important to prevent accidents. The ConAbert variable is to stores the quantity of openings done in the meter, and it can accuse the by-pass connection problems, for example.

ComErr is a variable that keeps the quantity of communication errors that has happened with a meter and ErrorStatus stores the status of the last operation effectuated (get or set). This last one is very important because may contains the communication errors between the devices and where they were happening. The possible kind of communication errors to this variable are between: RC-TC, TC-Meter.

We can see that a well defined management MIB allows improving the quality of service to the consumers and reducing the time of information collect by the company. In the choice of these variables, we take in consideration managements and quality aspects, not only in the ANEEL level but also in the company level.

5. Final Considerations

SALAME system has the objective to reduce the information access time to the companies and the energy consumers in an automatic way. With the use of SNMP protocol, the communication between the system components becomes more simplified and the obtainment of informations more precise. The network management becomes a less expensive process, because it's only necessary to keep and analyze the values of MIB. Energy distribution problems as a preventive control of equipments failures and by-pass connection can be reduced or even eliminated in a agile way from this management station.

All of this brings a better management level by the companies and better perspectives of service improvement to the consumers.

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