Architecture in network administration for heterogeneous environments and its application in EHAS networks

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Abstract

Hispanic-American Health Link (EHAS) Foundation provides communication networks and offers information services through those networks to contribute to improve health services in rural zones of Latin American countries, therefore, when it was started implementing EHAS networks it was evident the necessity to have a management system to monitor and control those networks in an adequate way, it means, a system that takes into account that EHAS networks use Wi-Fi, VHF and HF technologies, have low bandwidth, even Wi-Fi links that cover long distances, and additionally that HF and VHF stations do not have connectivity all the time because of the high energy consumption that it implies. This article describes the path that was walked to establish a management architecture for EHAS networks which are a heterogeneous environment, and finally describes the characteristics and uses of the EHAS network management system.

Key words: *Computer Communication Networks; Biomedical Technology; Information Services; Health Services; Health Sciences, Technology and Innovation Management; Internet; Electronic Mail; Wi-Fi; VHF; HF.*

Resumen

Arquitectura de gestión de redes para entornos heterogéneos y su aplicación a las redes EHAS: Sistema de gestión de redes EHAS

Enlace Hispanoamericano de Salud (EHAS) proporciona redes de comunicaciones y ofrece servicios de información a través de esas redes para contribuir a mejorar los servicios de salud en zonas rurales de países de América Latina, por tanto, una vez se empezaron a instalar las redes EHAS se hizo evidente la necesidad de un sistema de gestión que permitiera monitorear y controlar esas redes de forma adecuada, es decir, que tuviera en cuenta que las redes EHAS utilizan las tecnologías Wi-Fi, VHF y HF, poseen bajo ancho de banda, incluso los enlaces Wi-Fi debido a que son de larga distancia, y además que los equipos no están conectados todo el tiempo a la red, sobre todo las estaciones VHF y HF debido al gran consumo de energía que habría. En este artículo se describe el camino que se recorrió para establecer una arquitectura de gestión para las redes EHAS teniendo en cuenta que es un entorno heterogéneo y finalmente se describen las características y usos del sistema de gestión de redes obtenido.

Palabras clave: *Redes de Comunicación de Computadores. Tecnología Biomédica; Servicios de Salud; Servicios de Información; Gestión de Ciencia, Tecnología e Innovación en Salud; Internet; Correo Electrónico; Wi-Fi; VHF; HF.*

Resumo

Arquitetura de administração em rede para ambientes heterogêneos e a sua aplicação nas redes EHAS

A Fundação Enlace Hispano Americano de Saúde (EHAS) fornece redes de comunicação e oferece serviços de informação, que contribuem para melhorar os serviços de saúde em zonas rurais dos países latino-americanos; contudo, quando foi iniciada a implantação das redes EHAS ficou evidente a necessidade de se ter um sistema de gestão para monitorar e controlar essas redes de uma forma adequada. Isso significa um sistema que leva em conta que EHAS usa redes Wi-Fi, VHF e HF, têm baixa largura de banda mesmo com links Wi-Fi pois cobrem grandes distâncias, e adicionalmente as estações VHF e HF não têm ligação o tempo todo por causa do elevado consumo de energia que isso implica. Este artigo descreve o percurso utilizado para estabelecer uma gestão de arquitetura da rede EHAS em um ambiente heterogêneo e, finalmente, descreve as características e utilizações do sistema de gestão da rede EHAS.

Palavras-chave: *Redes de Comunicação de Computadores; Tecnologias Biomédica; Serviços de Informação; Serviços de Saúde; Gestão de Ciência, Tecnologia e Inovação em Saúde; Internet; Correio Eletrônico; Wi-Fi; VHF; HF.*

INTRODUCTION

The EHAS Foundation (Hispanic American Health Line) is a not-for-profit organization that seeks to improve health services in isolated rural zones in Latin America by means of the use of adequate information and communications technologies, i.e., low cost, low consumption and preferably wireless connections.

EHAS works with Technologies, such as Wi-Fi, VHF and HF to provide communication of the health outposts with its reference health center and hospital and the Internet and chooses the technology depending on the characteristics of propagation of the areas it communicates with. Taking this into consideration, one can decide which of the EHAS networks contain the mix of Technologies or, put in another way, are heterogeneous environments.

The EHAS foundation has worked in data transmission through VHF, HF and, in communications, long-distance Wi-Fi. In both cases it seeks to provide good quality communications to its uses. It offers information services about these networks based on electronic mail, since this service is provided by both Wi-Fi, as well as VHF and HF networks.

Taking into consideration the objective of the EHAS foundation, it is necessary that the EHAS networks operate adequately most of the time, however, since where the system was installed, nothing was known about its configuration, performance or defects, its problems could not be detected or the causes on a timely basis and, therefore, problems could not be solved efficiently. The need for an administration system of EHAS networks became evident, one that would perform the tasks of monitoring and control over the Wi-Fi routers and VHF and HF stations, considering the characteristics of EHAS networks.

METHODS

Firstly, the present administration technologies were studied, such as: IPMI (Intelligent Platform Administration Interface), an Intel standard[1]; HPI (Hardware Platform Interface) and AIS (Application Interface Specification), SAF (Service Availability Forum) specifications[2]; WBEM (Web Based Enterprise Administration), CIM (Common Model Information) and WS-Administration, DMTF (Desktop Administration Task Force) standards[3]; SMASH (Systems Administration Architecture for Server Hardware) and DASH (Desktop and mobile Architecture for System Hardware), DMTF initiatives; WSDM (Web Services Distributed Administration), an OASIS (Organization for the Advancement of Structured Information Standards) standard[4].

Secondly, the possibilities of integration of these administration Technologies was studied, and found that it was possible to map out IPMI to CIM, and HPI and AIS to SNMP and that it is possible to map HPI and AIS to CIM.

Next, administration technologies and its integration possibilities were taken into consideration. Incidentally, the Linux Debian operational system is used in the EHAS networks, which meets the requirements of CGL (Carrier Grade Linux)[5] of OSDL (Open Source Development Lab); the administration architecture was established for network administration for heterogeneous environments, which is shown in Figure 1.

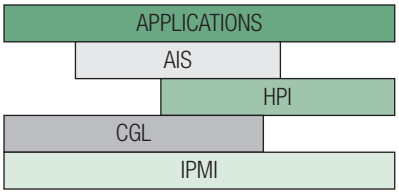

Figure 1 - Architecture of administration of nets for heterogeneous environments.

After that, this architecture was adapted to network administration standards at the level of the current most important applications.

SNMP. SNMP is one of the most widely used administration standards due to its simplicity. In this case, SNMP agents can be had that support MIBs SNMP for HPI and AIS, and that communicate with the administrator via SNMP.

SNMP-AgentX. Subagents of SNMP can be obtained, which will support MIBs SNMP for HPI and AIS, which will communicate with the master agent via AgentX, in which it will communicate with the administrator through SNMP.

WBEM. WBEM is presently one of the most important administration standards due to the fact. It is Web based and uses CIM, which is an information model oriented towards objects. In this case, CIM providers which incorporate the AIS and HPI functionalities, which communicate with CIMIM (CIM Object Manager), which, in turn, communicates with the administrator via HTTP.

WBEM-SNMP. One can obtain an SNMP provider that will support the MIBs SNMP for HPI and AIS, which will communicate with CIMIM, which, in turn, communicates with the administrator via HTTP.

WBEM-SMASH. SMASH permits the administration of heterogeneous servers. SMASH uses CIM and CLP (Com-

mand Line Protocol), a command/response protocol that travels over a transport protocol based on text messages.

WBEM-DASH. DASH uses CIM and WS-Administration. DASH permits office and independent mobile sales administration systems. DASH uses CIM and WS-Management. WBEM is integrated with SMASH and DASH as infrastructure of services and administration.

RESULTS

Upon analyzing these architectures it was determined that none of them was adequate for the EHAS networks because all required permanent connectivity between the administrator and the managed equipment. Also, in the case of SNMP, at this moment there are not all of the MIBs for the required administration information and WBEM consumes a great deal of bandwidth, a limited resource in EHAS networks.

On the other hand, SMASH uses CLP, a protocol that could be important for the EHAS networks, because it is based on commands, but, unfortunately the implementations of this initiative are still under development. DASH could also be interesting for EHAS networks due to the fact that the wireless routers require a livian administration system; however, there are no implementations of this initiative.

Both SMASH and DASH allow administration outside the bandwidth and outside service that refers to administration that can be performed independently of the state of the apparatus and of the operational system, and, even though there may be no relation with the administrator due to absence of connectivity between the administrator and the managed team, these are interesting characteristics for any administrative solution.

Finally, the Web-based standards also are not the best alternative to administering EHAS networks, since their use also leads to a high bandwidth consumption.

Taking the above into consideration and that administration architecture of networks in heterogeneous environments, as well as the standards used in them have very interesting characteristics, the following observations can be made:

- IPMI defines an intelligent hardware subsystem that allows monitoring and control of the main system hardware. Generally, it is used to monitor temperature, voltage levels, etc.
- HPI demonstrates the hardware characteristics in a model and allows performing function calls to monitor and control hardware. HPI provides services to applications independently of its hardware.
- AIS defines an interface to applications which is highly available (accessible). AIS demonstrates high availability of the system in a model and allows to make function calls that support this model.

Finally, for EHAS networks, the following developments have been decided for EHAS networks:

- Hardware and firmware of the interface board that also allows data communication by VHF and HF, allows monitoring of temperature, voltage, etc. of the managed equipment.
- A package that performs hardware analysis, the interface board and allows to make function calls the manage is and obtain administration information. In the HF and VHF stations, this package is called ehas-board and in Wi-Fi routers, it is called erouterboard.
- A package that allows to perform monitoring and control of HF and VHF stations and Wi-Fi routers and is called ehas-netman. This package uses ehas-board and erouterboard in its stations and routers, respectively.
- A package that allows the configuration and adequate functioning of EHAS equipment, both HF and VHF stations, as well as Wi-Fi routers and that utilizes the packages mentioned above and many other needs for this end. In the stations, this package is called ehas-station and in the routers, it is called ehas-router.

Zabbix[6] is an open-source network administration tool that allows performing monitoring of networks in a very complete manner and has flexible and modular architecture.

Analyzing observations on IPMI, HPI and AIS and the developments for an administration system of EHAS networks mentioned above, the following comparison was made as is shown in Table 1.

It should be mentioned before making the decision to use Zabbix[6] that MIBs 802.11 which provides Avantcom[7] for agent Net-SNMP[8], open source SNMP tools were explored, such as MRTG[9], Cricket[10], Cacti[11] and developments proper were also developed using RRDTool[12], however, it was finally determined that Zabbix offers many functions and, more importantly, can be adapted to perform EHAS networks administration due to its architecture.

Having established the levels of administration architecture for EHAS network administration, it was necessary to

Table1 - Correspondence between standard of EHAS administration and developments.

Standard of administration	EHAS Development
IPMI	Hardware and firmware of the interface board
HPI	ehas-board/erouterboard
AIS	4 ehas-netman
Applications	Managed Equipment: ehas-station/ehas-router Management equipment: additions and improvements to Zabbix

determine the manner in which the administrator and the managed equipment communicate with each other, since EHAS networks, in addition to being in heterogeneous environments and having reduced bandwidths have a very peculiar characteristics, which they are disconnected. VHF and HF stations only are connected for certain instants in time and Wi-Fi routers can also have periods of disconnection, since they use IEEE 802.11 technology for long distances.

In first place, it was established that, in a system for administration of EHAS networks, the administrator must not depend on permanent connectivity with the managed equipment to perform monitoring and control tasks and, secondly, that the managed equipment should gather its own administration information and send it the moment it has connection. These aspects determined that the best alternative to obtain communications between administrator and managed equipment of EHAS networks is electronic mail[13], such as shown in Figure 2.

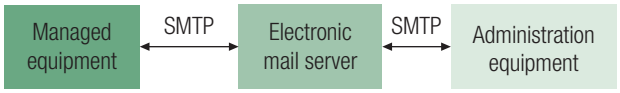

Figure 2 - Components of the administration architecture for EHAS networks.

Finally, considering the levels of administration architecture of EHAS networks and communication between administrator and managed equipment is made by electronic mail, an administration architecture for EHAS networks was obtained, which is shown in Figure 3.

It is important to mention that presently the functions of ehas-board and erouterboard are integrated to ehas-station. It has been shown that ehas-station works correctly in the routers, which makes it possible to maintain a single package.

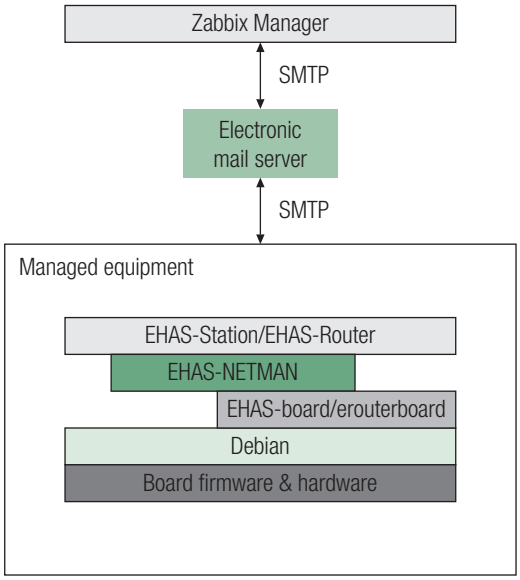

Figure 3 - Administration architecture for EHAS networks.

In managed equipment, ehas-netman is charged with performing monitoring and control tasks in managed equipment, in other words, it is the administration agent.

In the administrator, the fact that Zabbix is based on the Model-View-Controller (MVC) paradigm was take advantage of. This permits to separate the control logic from the data visualization, which is more easily done by inclusion of a communication mechanism based on electronic mail between the administrator and the managed equipment. In Figure 4, the administration components are shown.

In Figure 4, it is shown that Zabbix does not only have its model components, view and control, rather, with each one of them, a component model, view and control is found of the EHAS administration system, SGRE (EHAS network administration system), since it was necessary to make additions and improvements to Zabbix to achieve an administration system that allows to perform the tasks of monitoring and control desired on EHAS networks.

The system of administration of EHAS networks allows the managed equipment to gather and send administration information by electronic mail and for the administrator to add managed equipment automatically, as well as add variables, triggers of events, actions by events and graphs to each managed equipment. It also obtains administration data in electronic mail and insert them into the database. The EHAS networks administration system also allows breaking down additional administration information to what Zabbix breaks down, such as the hierarchy of EHAS networks, logs and information of the managed equipment. Finally, the EHAS administration system, in addition to mak-

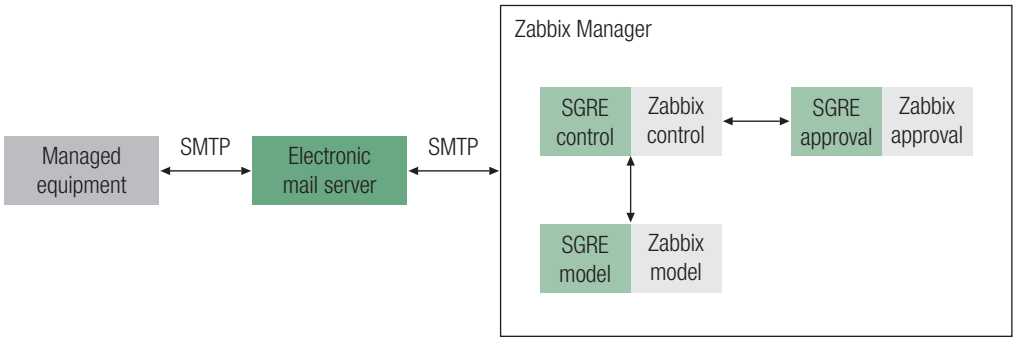

Figure 4 - Management components of the administration system EHAS Component networks.

ing the monitoring of EHAS networks possible, allows controlling them, since it is possible to execute commands over one or several managed units in a safe manner.

Below, the administration information is mentioned that is found in each one of the logs of managed equipment sent by electronic mail to the administrator obtained from the execution of commands and logs and system files. These logs make it possible to have a vision of the variables monitored in the EHAS networks administration system.

Log with system information

- Name of the equipment
- Packages installed
- Partition table
- Memory
- System files
- Buses
- Printers
- Configuration information of the equipment
- This log is sent every 15 days.

Logs with information every five minutes

- Temperature and state of the CPU
- Time turned on
- Interfaces, including wireless interfaces and their clients.

"Alive" Log

- Log that sends from each managed equipment at a certain time to indicate if it is working. This time is configured into the managed equipment and is less than one day. This administration information of monitored interfaces is sent by electronic mail, or it sends itself with the daily administration information.

Daily Log

- Administration configuration information
- State of hard drives
- Total space, used and available, of storage
- State of CPU, according to temperature
- Inappropriate restarts of the system
- Start time
- Information about electronic mail, interface board and modem connections
- Information on telephone status
- Information on mail line
- Information on UUCP mail line
- Information on radio connections
- Printer information
- Information on UUCP communications
- User information.

DISCUSSION

The EHAS administration system obtained is adequate to perform tasks of monitoring and control of EHAS networks considering that these networks use different technologies, such as Wi-Fi, VHF and HF, have a reduced bandwidths and their equipment not being connected all the time to the network.

The previous conclusion is obtained because the administration system of EHAS networks allows monitoring of a total of one hundred and twenty variables in HF and

VHF stations and Wi-Fi routers, in addition to triggering events due to equipment failure or when variables, such as battery voltage, board temperature, CPU temperature, inappropriate restarts, free storage space, signal level of a wireless interface or of a client are found to be above or below a threshold, and also because the EHAS networks administration system allows to alert about events through electronic mail that is sent when an alarm is present and when it is overcome, as well as because it allows to display graphs that show transmission speed and reception of HF and VHF stations and packages transmitted and received, signal and noise of Wi-Fi routers, among others. In the administration system of EHAS networks, the managed equipment is added automatically, but it can also be added, modified or eliminated through the Zabbix administrative interface.

As previously mentioned, the administration system of EHAS networks also allows the display administration information obtained in tables, graphs and maps, allows the display of hierarchy of EHAS networks, logs, information of each managed equipment, as well as executing commands over an equipment or group of equipment in a secure manner.

Through to the administration system of EHAS networks, it has been able to determine how the use of networks, for example through intertwining traffic, mail sent, calls made, etc. have contributed to detecting and diagnosing problems due to climactic conditions, the same person, etc. which affect the proper functioning of the network, for example, reduction of signal noise, problems in the power source systems, etc. and if known aspects that affect services offered about the networks, for example, the interfaces of other networks, among others.

The administration system of EHAS networks has been operating for several months in more than 60 HF, VHF and Wi-Fi stations in EHAS networks in Peru and Colombia, showing very good results. Some of the networks that are being administered through the EHAS administrations system networks obtained are: Cusco, Upper Amazons, Pastanza, Morona, Napo and Iquitos.

Hereafter, some images obtained from the administration system of EHAS networks are shown. In Figure 5, signal and noise levels are observed in wireless interfaces of a Wi-Fi router, and in Figure 6, server information is shown.

The administration system of EHAS networks was the result of a joint project among EHAS-Colombia, EHAS-Spain and EHAS-Peru, which was in charge of the interface board and is a system that contributes so that the EHAS foundation fulfills its objective of taking telemedicine to isolated rural zones in Latin American countries.

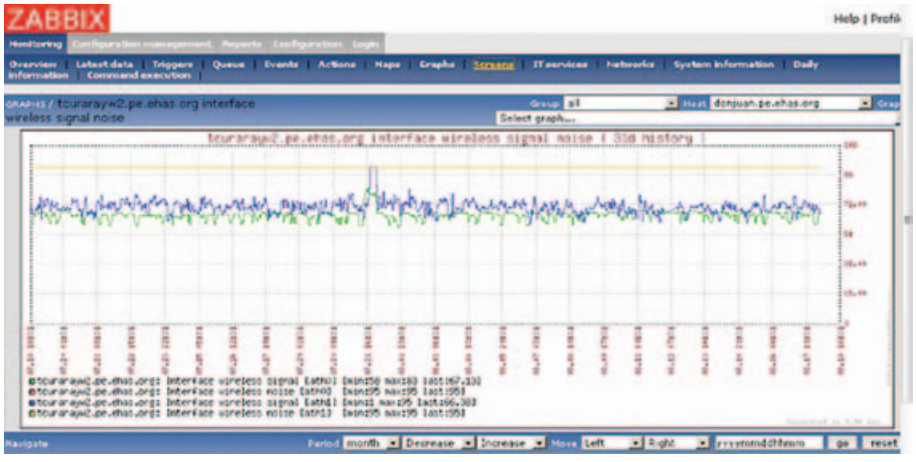

Figure 5 - Multiple Variables Graph in Zabbix.

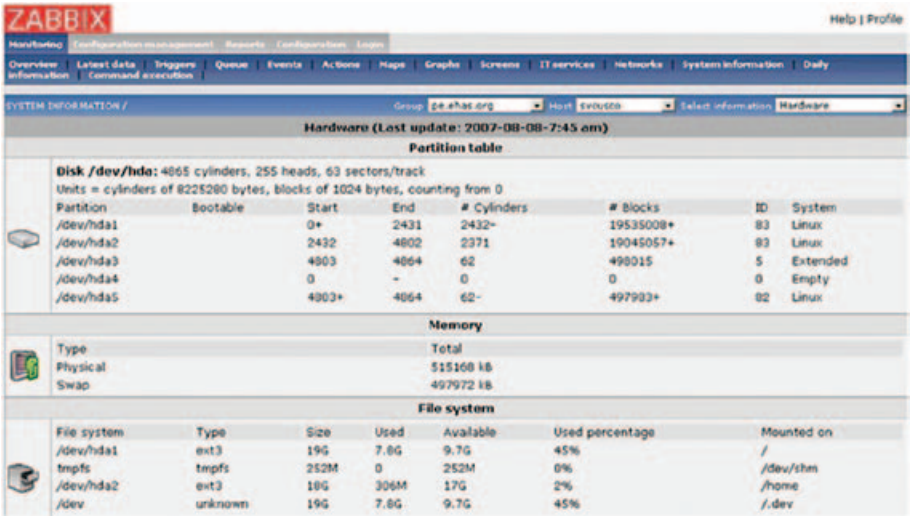

Figure 6 - Chart with information of the system in Zabbix.

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