SCADA WEB
Remote Supervision and Maintenance of Industrial Processes

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Keywords: Remote Supervision, Control, Maintenance, Industrial Process, PLC, OPC, OPC-DA, SCADA, Web, Internet, Java, GSM, GPRS, SMTP, PLC.

Abstract: This article explains a SCADA System called SCADA Web developed by CARTIF Foundation. This SCADA System makes possible remote monitoring and control from the process controlled by PLC using Web Technology. SCADA Web has been developed on platform Java EE and provides visualization and control signals, trend charts, alarms, historical data and alarm reports.

1 INTRODUCTION

Internet, together with the use of technologies such as GMS/GPRS/UMTS (International Engineering Consortium), provides communication mechanisms with a great number of possibilities (GeneraLynx). These technologies are present more and more in the industry.

Nowadays, a large extent of automation industrial solutions demand maintenance and supervision systems because of the high complexity and the need of managing a large volume of data.

Computers are the main support for supervision and maintenance systems due to the high performances and informations that they can process.

The main reasons to develop a SCADA Web (Janeiro, J. R., 2006) have been the growing use of the supervision and maintenance system on computers and the features that support the technologies GSM/GPRS/UMTS and Internet.

This paper is organized as follows. In Section 2 the characteristics that a remote supervision and maintenance system have to support are presented.

The SCADA Web Application arquitecture necessary to supervise a process in a remote way is presented in Section 3.

In Section 4 the main features and an operation manual of the SCADA Web Application is presented.

Conclusions and open issues for future research are discussed in Section 5.

2 REMOTE SUPERVISION AND MAINTENANCE OF INDUSTRIAL PROCESSES

Nowadays, more and more systems are being supervised in a remote manner in order to keep the process running in a correct state. The most important applications to be carried out are maintenance actions, although this depends on the nature of the process.

The traditional arquitecture of these systems in relation to remote supervision is composed by a Web Server that, after a correct authentication, allows access to remote supervision services of an industrial process. The supervision systems have to fulfill the next requirements:

- It is only necessary one computer and an Internet connection to supervise the system
- There is not need of special software installation in the remote computer, except for some specific plug in.
- Independence of the remote computer operative system.
- The access to applications must be controlled to avoid risks, due the that these remote supervision tasks can be accessible through a network like internet.
- Be careful with the exchange between remote computer and the process due to security problems. One possible solution is the use of safe communication protocols like HTTPS.

Maintenance systems send alarms or warning by means of SMS and e-mail. These methods supply an efficient notification reducing failure correction times and therefore reducing process costs.

3 SCADA WEB ARCHITECTURE

The acronym of SCADA Web Application comes from SCADA (Supervisory Control And Data Acquisition) and WEB (World Wide Web). This application makes remote supervision and maintenance of any industrial process possible. The above-mentioned process can be controlled by PLC´s of different brands by means of a web browser, an e-mail client and a mobile.

This application offers a number of features beyond the usual characteristics of a simple SCADA system. It contains elements focused towards industrial process maintenance like SMS messaging (Short Message Service) using technology GSM/GPRS (Global System for Mobile Communications /General Packet Radio Service) and e-mails.

Using OPC-DA(OPC-Foundation) protocol (OLE for Process Control-Data Access) based on OLE/COM/DCOM (Object Linking and Embedding/Component Object Model/Distributed Component Object Model) it is possible to access the variables.

In order to avoid the use of DCOM technology due to problems with the firewalls (OPC Programmers' Connection), we have developed an application called OPC gateway to supervise the process without limiting the structures of control. This application uses OPC-DA implementation in its interface "Automation" allowing the SCADA Web Application to access the variables by means of strings UNICODE based on Sockets. Although the OPC gateway application support DCOM, it is expected to be installed in the same computer where the OPC-DA server is located so that it is only necessary to use COM technology.

The use of OPC-XDA(OPC Foundation) (OLE For Process Control- XML Data Access) instead of OPC-DA was ruled out because of the generally scarce in utilization of this protocol by PLC´s manufacturers. Even so, it is desirable that the application supports both protocols in future versions.

In fact, the SCADA Web Application is a Web application developed using the platform Java EE (Java Enterprise Edition) (Sun Microsystems).

Apache Tomcat (The Apache Software Foundation) has been the server used. SCADA Web Application is based on the next technologies: JSP, Servlet, Applet, Beans, JDBC, JavaMail, JAF and JAXB. The use of these technologies leads to a high development cost of the application, a null or low acquisition cost and high flexibility and scalability compared, for example, to commercial SCADA.
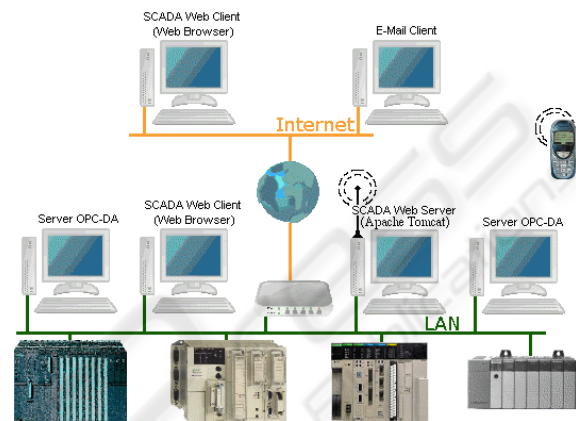

Figure 1: SCADA Web Application Structure.

The configuration parameters of SCADA Web Application are inserted in an XML file called *scadaweb.xml*. This file has to keep the xml schema which is defined in the file *scadaweb.xsd* The use of an XML file to configure the application allows a high degree of flexibility and scalability in the parameters configuration, as well as a simplification of the configuration process to the user.

Thanks to JAXB (Java Architecture for XML Binding) the schema XML is mapped to JAVA classes providing a simple way to access the configuration file *scadaweb.xml*. The SCADA Web Application is divided in two modules called Supervision and Maintenace modules. Next, these modules will be explained.

3.1 Supervision Module

This module has the typical characteristics of a comercial SCADA. An industrial process can be remotely supervised via WEB thanks to this module.

Although this module was designed for remote supervision via WEB, it can be used for local supervision of a process. Furthermore, thanks to its generic design, it's possible to supervise the process using informatics nets so complex as desired (LAN, Internet, Routers, ...).

The Supervision Module of SCADA Web Application is a multiuser system that lets to several

remote users supervise the same process at the same time.

This module is based on a client-server architecture (Applet-Servet/JSP) which allows to distribute the computacional load of the application between Tomcat Apache server and remote machines.

An Applet is an application, written on Java, which is executed on a Web browser. Using an applet allows us to have a more complete interface from the point of view of the client.

A Servlet is a Java class that is carried out on an application server in order to answer clients requests. The clients are Applet´s in the case of SCADA Web.

A page JSP is a file that combines HTML targets with script targets which belong to Java Server Pages specification. The page JSP has a similar aspect to HTML targets, but they are changed in Servlet in order to compile and generate the appropriated class files. The resulting file from the transformation of page JSP is a combination of HTML code cointained in JSP page and dynamic content which is especified by JSP specification targets. The exchange of information between Applet and Servlet is carried out by HTTP tunneling, in other words, transmitting binary information using HTTP protocol.

Due to security obsession this protocol is usually the only possible method of information transmission.

3.2 Maintenance Module

This module is executed as a daemon checking permanently that alarms have been configured to take place. Alarm notification is carried out by maintenance workers using two diferent methods depending on configuration.

The first method consist of an alarm notification using GSM/GPRS technology by SMS. It is necessary that the computer where SCADA Web application is installed, is connected to a GSM/GPRS modem, normally through a serial port. Communication between modem and SCADA Web is made by standard AT commands. The library command used to operate the computer ports is one from the RXTX organization (RXTX Serial and parallel I/O libraries supporting Sun's CommAPI).

The second method consist of alarm notification using e-mails. A SMTP server which is configurable in SCADA Web Application is used. In this case the library used is JavaMail from Sun Microsystems.

4 SCADA WEB

SCADA Web Application is executed within applications servers. This application allows an interaction between user and process by means of three interfaces, HTTP, GSM/GPRS and e-mails.

The first interface, HTTP, makes it possible to supervise the process in a remote manner from a web browser.

The interface GSM/GPRS is oriented to offer an instantaneous warning procedure reducing failure correction times and the costs of industrial processes.

Finally, the e-mail interface carries out the same functions that GSM/GPRS interface, although it allows to send more information. The main reason is to provide redundant alarm warning procedures, so that the user is notified as soon as possible. E-mail, unlike GSM/GPRS, is used to notify less critical alarms. The HTTP interface has been grouped inside what has been called Supervision Module, while GSM/GPRS interface and e-mails are in Maintenance. Next, these modules are explained.

4.1 SCADA Web Configuration

As in other software applications, the configuration of SCADA Web Application is done by an XML file according to XML Schema called *scadaweb.xsd*.

This configuration file has four blocks well differentiated: Parameters, Maintenance, Protocols, and Users.

The reading frecuency of PLC´s variables in "Paramaters Block" is normally about half a second. The update frequency of the different databases of the supervisory system is also configured These are called reports or historical data.

Inside the "Maintenance Block" the neccesary basic parameters required by the above-mentioned block are configured. There are two sections in this block: SMS and E-MAIL. In SMS Section the port is configured. It contains the modem GSM/GPRS the PIN, the SMS Server phone and the alarms to detect besides text message and the phone where it will be sent.

The SMTP server (address and port), the sender address, alarms to detect together with the content and message addressee are configured in E-MAIL Section.

In Protocol Block the available protocols, in this case OPC-DA, are added together with the adress and port of OPC-DA server.

In Users Block passwords, usernames and access permission to the different parts of the program are configured.

4.2 Supervision Module

The necessary requirements to access SCADA Web application are Internet connection and a computer.

After previously stated requirements are fulfilled it is necessary to open a web browser window and to connect to the server where the SCADA Web application is installed. A similar window is showed in Figure 2.

Figure 2: Initial Window of SCADA Web.

In this window it is neccesary to authenticate in order to access to the application. After a correct authentication, it is possible to access the applications: "Builder" and "Viewfinder".

The "Builder Application" is going to allow the creation of a series of windows with components thanks to a high level graphic interface with the user.

Linking ones with the others it is possible to build a SCADA system of a specific installation.

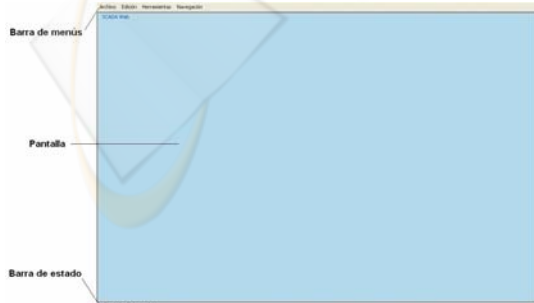In the figure 3 an image of "Builder Application is showed".

Figure 3: SCADA Web Application: "Constructor".

The application allows to add windows so that a SCADA system can be built with so many windows as desired. Each window can be associated to a wallpaper.

Hereafter the available components of the application will be explained. Every component has a properties dialogue box associated that allows to realize its configuration.

Some of the components that can be added (Besides of labels, rectangles and image components) are:

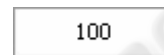- **Text Field** displays analog and digital variables.

Figure 4: Text Field Component.

- **LED** can be associated with one or more digital variables. This element makes it possible, by means of colors, to show the state of the variables. A typical example is failure-non failure state monitoring and on/off motor state

Figure 5: LED Component.

- **Button** is used to control digital or analog variables. When the button is pressed, depressed or is pressed during a time period, the variable changes of value.
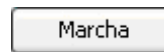

Figure 6: Button Component.

- **Vertical Bar Graph** simulates a level and it is associated with analog and digital variables.

Figure 7: Vertical Bar Graph.

- **Toggle** allows to supervise digital variables. The monitoring of variables is carried out by the state (pressed/depressed) in which the

toggle can be found. When the user presses, the toggle the variable value is modified. In Figure 9 the dialogue window to configure the component is depicted.
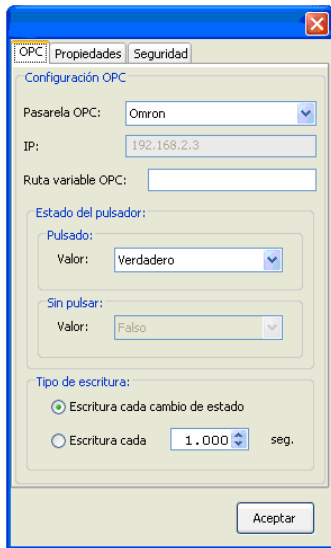

Figure 8: Toggle Component.

Figure 9: Dialogue window of a toggle.

Alarms. In the SCADA Web Application it is also allowed to configure alarms. It is possible the monitoring and recognition of alarms. Alarms are administered in the server. Because of this, the consistency of all alarms by users can be saved. In this way we can supervise remotly and simultaneously the process.

Moreover, in order to avoid lacking firmness in relation to dates, every happened event is registered according to server time. All these events are registered in a database to a subsequent consultation. In Figure 10 the alarms component is showed.

Figure 10: Alarms Component.

Alarm Reports. Alarms are registered in a database which can be looked up using the "Report Component". The generated reports can be printed.

Figure 11: Reports Component.

Trend Charts. Besides monitoring process variables using controls explained before is possible to obtain the trend of these variables by graphics using their corresponding component. Their value can be also scaled as it is showed in the Figure 12(JFree.org).

Figure 12: Graphics Component.

Historical Data In this last component the data to register in a database are configured. Later, during the process supervision it will be possible to do consultations of these data by graphics or accessing directly to the database to obtain the real value. An example is depicted in Figure 13 (JFree.org).

Besides, is necessary to configure users that could use this SCADA system and the permission level of each one. Due to this and to the fact that each component has a permission level associated is possible to control the access as well as to adapt the SCADA system according to permission level of the authenticated user.

Figure 13: Historical Component.

After having built the SCADA system of a particular installation, then it will be possible to keep

in a local hard disk or in the server. In the last instance it is possible to do a remote supervision of the process if you have a computer and internet connection.

"Viewfinder Application" makes it possible to carry out the SCADA system created with the "Builder Application". In order to configurate these configurations it is necessary to open them and after a correct authentication the variable update frequency will be fixed.

The configuration of update variable frequency make it possible to adapt the refresh time to the necessities of the person that wants to supervise the system. A clear example happens in industry when the system goes to be supervised simultaneously by workers in the monitoring process and quality control.

4.3 Maintenance Module

This module sends alarms of the industrial process by SMS messages and e-mails. The complete configuration is done by XML configuration file.

Thanks to this module the alarm notification time generated is decreased and the costs in the industrial process associated with alarms are reduced. Furthermore, all alarm events and e-mail and SMS messages associated are registrated in SMS and e-mail databases.
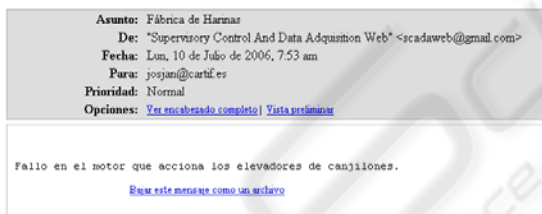

Figure 14: An alarm e-mail.

5 CONCLUSIONS

A system SCADA for remote monitoring and control of procceses is suggested. This SCADA Web Application consists of a sub-application called "Builder" that allows to make SCADA systems for an industrial plant and a sub-application "Viewfinder" whose function is supervise an industrial process based on SCADA systems built by the "Builder".

The process variables of an industrial plant controlled by different PLC´s brands can be remotely supervised by this application. It is only necessary to have a computer and Internet connection. The SCADA system can also represent by graphics the current evolution of process variables and the configuration of alarms to warn when a failure takes place. Besides, these alarms are registered and can be recognized by user.

There is a possibility of printing and the monitoring reports by SCADA system of industrial plant.

The SCADA system allows to create historical data in order to a later consulting in a visual way.

In the SCADA permission levels to adapt the posibilites of supervision tasks to worker permission level who supervises the installation are configured.

Finally, it shoud be remarked that thanks to use an object orientation programming language and an organization of application in components it is possible easily add new elements in this application.

ACKNOWLEDGEMENTS

REFERENCES

International Engineering Consortium. Global System for Mobile Communication, <http://www.iec.org/online/tutorials/gsm/> (last accessed on January 10, 2007)

Janeiro, J. R., 2006. Supervisión remota de procesos industriales controlados por Autómatas Programables, University of Valladolid. Spain, 1nd edition.

JFree.org. JFreeChart, <http://www.jfree.org/jfrechart/> (last accessed on January 10, 2007)

OPC Foundation. Specifications,http://ww.opcfoundation.org (last accessed on January 10, 2007)

OPC Programmers' Connection. OLE for Process Control, http://ethernet.industrial-networking.com/ieb/article display.asp?id=21 (last accessed on January 10, 2007)

RXTX. Serial and parallel I/O libraries supporting Sun's CommAPI, <http://ww.rxtx.org> (last accessed on January 10, 2007)

Sun Microsystems. Java Enterprise Edition, <http://java.sun.com/javaee/> (last accessed on January 10, 2007)

The Apache Software Foundation. Apache Tomcat, <http://tomcat.apache.org> (last accessed on January 10, 2007)

GeneraLynx. Remote supervision and control by WAP, <www.euroines.com/down/DemoDoc/WapScada%20DD.pdf> (last accessed on January 10, 2007)