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APLICATION OF INTERNET IN THE SCADA SYSTEM

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ABSTRACT

Supervisory Control and Data Acquisition (SCADA) system employ a wide range of computer and communication technologies. Advances in the technologies have helped in improving the effectiveness of SCADA. One such recent technological development is Internet and the World Wide Web. The operational and commercial needs of the power industry require information systems to not only perform traditional functions but also support many of the new functions, specifically to meet the needs of competition with deregulation. The rapid developments of the Internet and distributed computing have opened the door for feasible and cost-effective solutions. This paper describes and demonstrates a unique Internet-based application in a substation automation that is implementing based on the existing control system, SCADA system and information technologies (IT).
Keywords: SCADA system, Technologies, Power system, Energy management, Internet.

SCADA SİSTEMİNDEKİ İNTERNET UYGULAMASI

ÖZET

Denetim ve veri elde etme (SCADA) sistemi bilgisayar ve iletişim teknolojilerinde geniş çapta kullanılmaktadır. Teknolojik ilerlemeler SCADA'nın etkinliğinin artmasına yardım etmiştir. Bu teknolojik ilerlemelerden birisi internette ve dünya çapındaki ağda olmuştur. Güç endüstrisindeki işletimsel ve ticari ihtiyaçlar sadece geleneksel fonksiyonları değil aynı zamanda pek çok yeni destek fonksiyonunda, özellikle rekabetin gerektirdiği düzenlemelerle karşılmasında, danışma sistemini gerektirmektedir. Dağılım hesapları ve internetteki hızlı gelişmeler mümkün ve etkili maliyet çözümlerindeki kapıyı açmıştır. Bu makale, SCADA sistem ve bilgilendirme teknolojileri (IT) olarak uygulanan mevcut kontrol sistemine dayalı, başka bir otomasyon yerine kullanımda eşsiz bir internet tabanlı uygulamayı tanımlamakta ve göstermektedir.
Anahtar Sözcükler: SCADA sistemi, Teknoloji, Güç sistemi, Enerji yönetimi, İnternet.

1. INTRODUCTION

IT plays an increasingly important role in all fronts. In the deregulated environment, information becomes the key to secure operation, profitability, customer retention, market advantage, and growth for power industry. SCADA systems are essential parts of the distribution management system (DMS) and energy management system (EMS) that employ a wide range of computer and communication technologies. A SCADA system gathers incoming power system data for further

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processing by a number of distributed processes. The control commands for operating a power system can also be issued through the SCADA system.

The privatization of electric utility companies all over the worlds has brought along not only competition in the electric supply industry but also numerous changes in the SCADA/DMS /EMS. One of the changes requires that the EMS exchange information with external organizations such as generators, distributors and breakers. This data exchange is neither time critical nor needed on a dedicated basis, but it requires quick access and data security. Technological advances in Internet and world wide web (WWW) have made it possible to develop a low cost WWW display system for accessing information via tabular displays and one-line diagrams on the net. Currently, the generation of one-line diagrams for SCADA/DMS/EMS applications at most installations are done manually. VLSI placement and routing algorithms [1-8] have been used for the substation one-line diagrams. Graphical User Interface (GUI) [9-11] of various complexities have been developed to simulate and display the dynamic of power systems. SCADA systems of various designs [12-14] have also been implemented for monitoring and controlling the power systems, however, they are normally not designed for Internet access.

Web-based conception has been elaborated and implemented [15, 16] by researches all over the world. Their experience has indicated that the Internet/Intranet can be successfully employed in real-time systems. But how to integrate the existing SCADA system with the Internet is a challenge.

2. SOFTWARE TECHNOLOGIES

2.1. Client/Server Architecture

The evolution of distributed computer architecture results in the birth of client/server architecture. Traditional enterprise applications are, for the most part, self-connected monolithic programs that have limited access to one another's procedures and data. They are usually cumbersome to build and expensive to maintain because even simple functional changes require the entire program to be rewritten, recompiled, and re-tested. By contrast, the client/server structure provides the scalability and robustness required to support mission-critical applications throughout the enterprise comprising thousands of users [17, 18].

2.2. Network Programming

Networking enables programs to retrieve information stored in computers located anywhere in the world. People can communicate with each other on the network. Network programming is ideal for the SCADA display project for two reasons:

- Easy to access: The SCADA real-time data can be accessed by an authorized user anywhere. For example, the current operating condition of power system in a country can be accessed and visually viewed by an authorized technical consultant and equipment manufacturer in other country on the network.
- Low investment: No special hardware investment is needed for Internet access.

2.3. The Java Language

As the global Internet continues to grow, Java is uniquely suited to build the next generation of network application. It provides solutions to a number of problems which are difficult to address in other programming languages. The level of safety whit Java applets is far greater than what can be obtained from other software [19]. The choice of Java technologies, such as zero client installation, on demand access, platform independence, and transaction management are suitable for the design of the online SCADA display system.

2.4. Database Programming

SQLJ [18, 19] is a way to embed the structured query language (SQL) in Java programs and to reduce the development and maintenance costs of Java programs that require database connectivity.

3. SYSTEM DESIGN

Given the pressure to bring new services to market, an important challenge facing the software is how to integrate new services and network element to the existing system. This paper describes an example of the integration of the existing SCADA software with the advanced network technologies [18]. The system is based on the Siemens Spectrum SCADA software, which is a distributed network automation system designed to run on the Unix system. It is used as the major monitoring and control system supporting raw substation connection information and real-time data. Spectrum was developed under C/C++/Pascal.

Facing this problem, a software prototype named SpecNET was developed based on the advanced computer and network technologies. SpecNET is workflow software that models, coordinates, and integrates some of the SCADA functions, such as the one-line diagram generation and real-time data display. Figure 1 illustrates the SpecNET architecture. Internet/Intranet users access the SCADA system data through the SpecNET server. JavaCON, which stands for Java connectivity to SCADA, is used as a data communication bridge between the existing SCADA system and the SpecNET server. The SpecNET server receives messages from the existing SCADA system through JavaCON and provides the necessary support for client site. Useful information will be saved to the database through the connection between SpecNET server and database server.

The SpecNET server is written entirely in Java and does not require any native code. A Java interpreter is required to parse the byte code each time the web server program runs. As shown in Figure 2, the server supports four roles: client function, JavaCON function, man-machine interface (MMI) function and database operation.

3.1. JavaCON

Currently, existing SCADA systems are developed based on different platforms using different language. For example, spectrum was coded in C/C++, and JavaCON acts as a bridge between the existing SCADA system and SpecNET server through a Java network interpreter (JNI) connection. JNI is used when the SpecNET server wants to talk with the SCADA server. Figure 3 shows how the JNI ties the SpecNET server site application to the SCADA server.

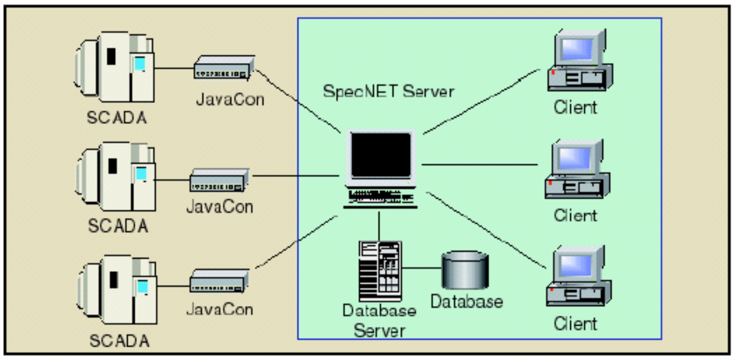

Figure 1. Main configuration of SpecNET

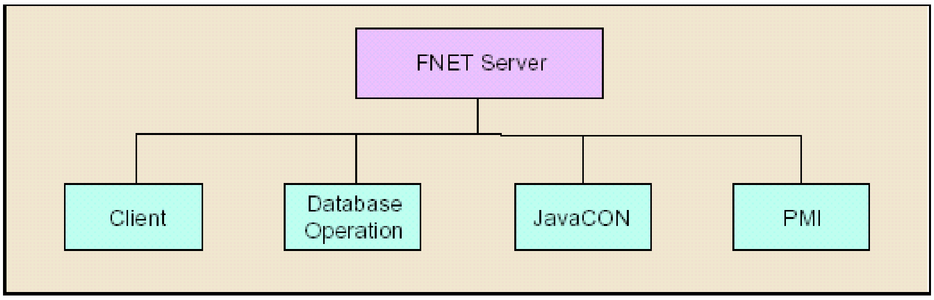

Figure 2. SpecNET server function

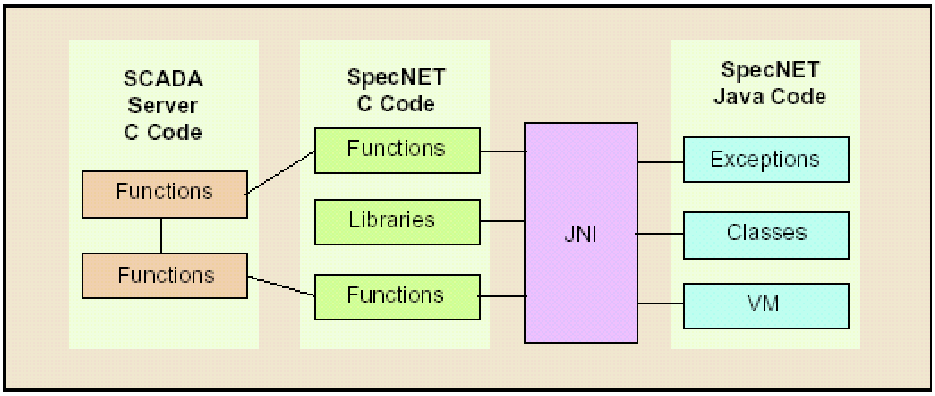

Figure 3. JavaCON JNI structure

3.2. Database Operation

The SpecNET database stores the static and dynamic data of the SCADA system. Most of the database can be used for storing historical data whit the Java database connectivity and open database connectivity (JDBC/ODBC) driver. The historical data consists of logged data, events, and dynamic data of one-line diagrams. The system status and the real-time data are stored in the database at a periodicity specified by the user. Access to the database is provided through a series of interface modules that read and write data to the database tables.

Database operation on the server site is through RMI and JDBC. JDBC is a Java application program interface (API) for executing SQL statement. It lets the Java program send SQL statement to the appropriate database. Four steps are executed before using the JDBC API to access the database:

- Important the JDBC classes
- Register the JDBC driver
- Open connectivity to the database
- Query the database

After these steps, the Java program can talk to the database.

3.3. Client

Java makes programming for communication between the client and server easy [15, 21]. The communication between server and client contains three parts: the server site program, the client site program and the protocol between them. Every client must have a user name and identification number so that only authorized users can visit the SCADA system information. The rendezvous between the clients can visit the specified protocol. After these steps, the clients can visit the real-time SCADA system.

3.4. Man Machine Interface (MMI)

The MMI is supported by the auto-generation of one-line diagrams and GUI displays. As the power system becomes more and more complex, the one-line diagram layout is becoming increasingly complex and, in turn, is placing even higher demands on one-line diagram autogeneration tools. Automated layout consists of two primary functions:
- Determining the positions of the modules (substation or its components), called placement
- Interconnecting the modules whit wiring, called routing

VLSI placement and routing algorithms have been used for the substation one-line diagram autogeneration. As shown in Figure 4, the autogeneration of the one-line diagram contains stream input data, placement, routing, and dynamic data linkage.

1) Stream input data: the stream input data contain the connectivity information of the network. They include the component's names, their start and end nodes, component ratings and modeling parameters.

2) Placement and routing: when the data is read by the autogeneration module, a substation topology is created according to the connectivity of the components. The topology is accessed by the placement and routing modules.

Components placement determines the location of the component within the one-line diagram. It determines the minimum length of interconnection and minimizes line crossovers. It distributes the nodes of components evenly in the frame. Placement is crucial in the overall design cycle, as its output must be routable. The overall quality of the layout is determined in this stage.
Milestone methods of the VLSI design such as the force-directed method [2-8] is used for the power components placement. After placement, the diagram is ready for line routing. Hightower algorithm [17, 18] is chosen as the routing algorithm. It only stores line information. Therefore, it is better than that of alternative algorithms, such as Lee and Maze [4-6].

3) Dynamic data linkage: After routing, the SCADA system data will be dynamically linked to the static one-line diagram. The real and reactive power (MW/MVAR), voltage, current, and running status of the power system components will be linked to the database and displayed at the position close to the respective component. When the display is refreshed each time, their values will be retrieved automatically from the database and updated on the one-line diagrams.

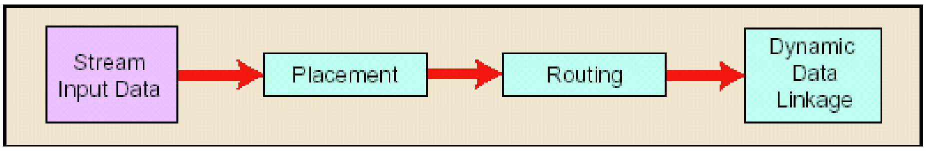

Figure 4. Process involved in one-line diagram generation

4. SYSTEM SECURITY

Some of the most potentially valuable developments in the high-speed technology resolution are Internet, Intranet, and Extranet that connect electric utility companies via applications directly to external organization, such as their customers, IPPs, distributors, brokers, and strategic partners.
Security is typically less of a concern for the Intranet level, because Intranet applications are deployed within the firewall. Performance of the Intranet is limited only by the speed of the enterprise network.

Extranet applications extend the Intranet architecture beyond the firewall by allowing the information access over a public network. Data security at this level could be protected by using firewall, cryptography, digital certificate (DC), and public key infrastructure (PKI). The performance of the Extranet is more of a concern, since internetwork delays must be considered.
At the Internet level, the requirements for information exchange should be less critical in terms of performance and security.

5. IMPLEMENTATION

The laboratory setup consists of three major modules. The first module is the SCADA simulator runs a power flow program which provides all the analog and digital data that are normally supplied by the real-time SCADA system. The second module is the web server program. The third module is an Internet browser such as Netscape or Explorer, which runs on a PC.

5.1. Real-Time Power System Simulator

The real-time power system simulator is developed using Visual C++. The power system model is initially loaded into the simulator from the database. Due to change of load, the power flow calculates a new solution every 5 seconds and the results are stored in the database. Through the simulator, the user can open or close the breaker on the one-line diagram. This triggers a new power flow solution in the next update. The web server receives the SCADA data through JavaCON.

5.2. Client Displays

The MMI consists of multiple displays. The first and highest level is the map of country that presents an overview distribution of the substations. The second and third levels represent a smaller area of the entire country map but with more details in the area displayed. The lowest level of the display is the substation's one-line diagram.

6. CONCLUSION

The problem of providing access to SCADA data to users working in different departments on the various locations in the power utility company was shown. Internet and SCADA system interconnection was presented as solution and application of Internet in the SCADA system is investigated that allows users to access real-time and historical SCADA data through web browser, easily, in a secure way and at low cost of hardware, software, installation, administration, and management. Also SCADA information can be available anywhere in the world through an Internet connection.

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