Mobile phone-based SCADA automation

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Supervisory Control And Data Acquisition (SCADA) is a term first introduced in the1960s in Bonville Power Administration and first published in a PICA (Power Industry Computer Application) conference. SCADA systems are used for monitoring and controlling of industrial processes from remote areas. The need to monitor the process and possibly to control the operation of industrial systems from virtually anywhere within the control is becoming an important issue. However with the different types of platforms used in present SCADA systems, incompatibility has become the main obstacle[1]. Other factors that pose problems include cost, security, accessibility, system integration, data integrity and consistency[2].

Many companies are considering SCADA systems to provide access to real-time data display, alarming, trending and reporting from remote equipments by using different communication media such as internet, private lease line (PLL), dial-up connection, satellite and radio modem. Recent technological advances have made location transparency achievable through Internet at a relatively low cost and at an acceptable level of security. Some of the potentially valuable developments are Intranet and Extranet. Nowadays, improvements in the visual interface of the operating systems have fairly high-resolution graphical animations used in SCADA system programs.

In spite of all these improvements, a need has emerged to obtain various information about the system instead of controlling it from specific centres. SCADA systems have opened to the world via Internet to meet this requirement. Despite all these improvements, the SCADA system needs a computer connected to the Internet. Recent years have experienced a growing trend towards personal computers and workstations becoming ''portable'' and ''mobile''. This has led to a big expansion of wireless networking, which is advancing in terms of technology and usage/penetration[3].

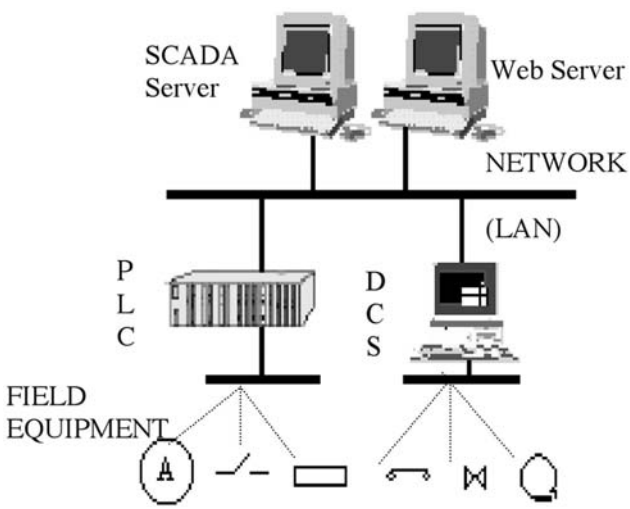


Figure. 1:. A conventional SCADA system.

SCADA systems require both hardware and software for their successful execution. User-designed control parameters, graphic system diagrams, trend charts, alarm screens and programmable control logic are some of the features of the software program for the SCADA systems.

This paper discusses the use of mobile phone as a SCADA system. An experimental prototype crane system is monitored by a mobile phone in a sample SCADA system. An attempt is made to provide some insight into design considerations for wireless mobile phone based automation as used in modern SCADA systems. It is emphasised that with some basic knowledge of design considerations, it is easier to take the right automation approach and choose the right equipment for the task at hand. Test results have indicated that the mobile-based SCADA integration using a GPRS or WAP transfer scheme could enhance the performance in day work without giving up much in the response times of SCADA functions.

Review of conventional SCADA system

SCADA is used to observe and supervise the shop floor equipments in various industrial applications. SCADA software, working on DOS and UNIX operating systems used in 1980s, is an alarm-based program which has a fairly simple visual interface.

The main components of a conventional SCADA system [3-5] are remote terminal units (RTUs) at substations and plants, data processing units and man-machine interfaces (MMIs). A conventional SCADA system architecture is given in *Figure 1* where all monitoring, processing and control are constrained within the local area network located in the control centre. Dedicated channels are required to guarantee the time responsiveness of the system.

Web-based network architecture

A typical SCADA system architecture is shown in *Figure 2*. In SCADA system architecture, the data systems are on the highest level. These systems are used for planning and storing data. The programs, including server and client used by operator and system, are on the MMI part. PLC and RTU level is responsible for connection between sensors and actuators on the shop floor with the system[6-7]. In this level, there is logic controller software that controls shop floor equipment in design manner. *Figure 3* shows

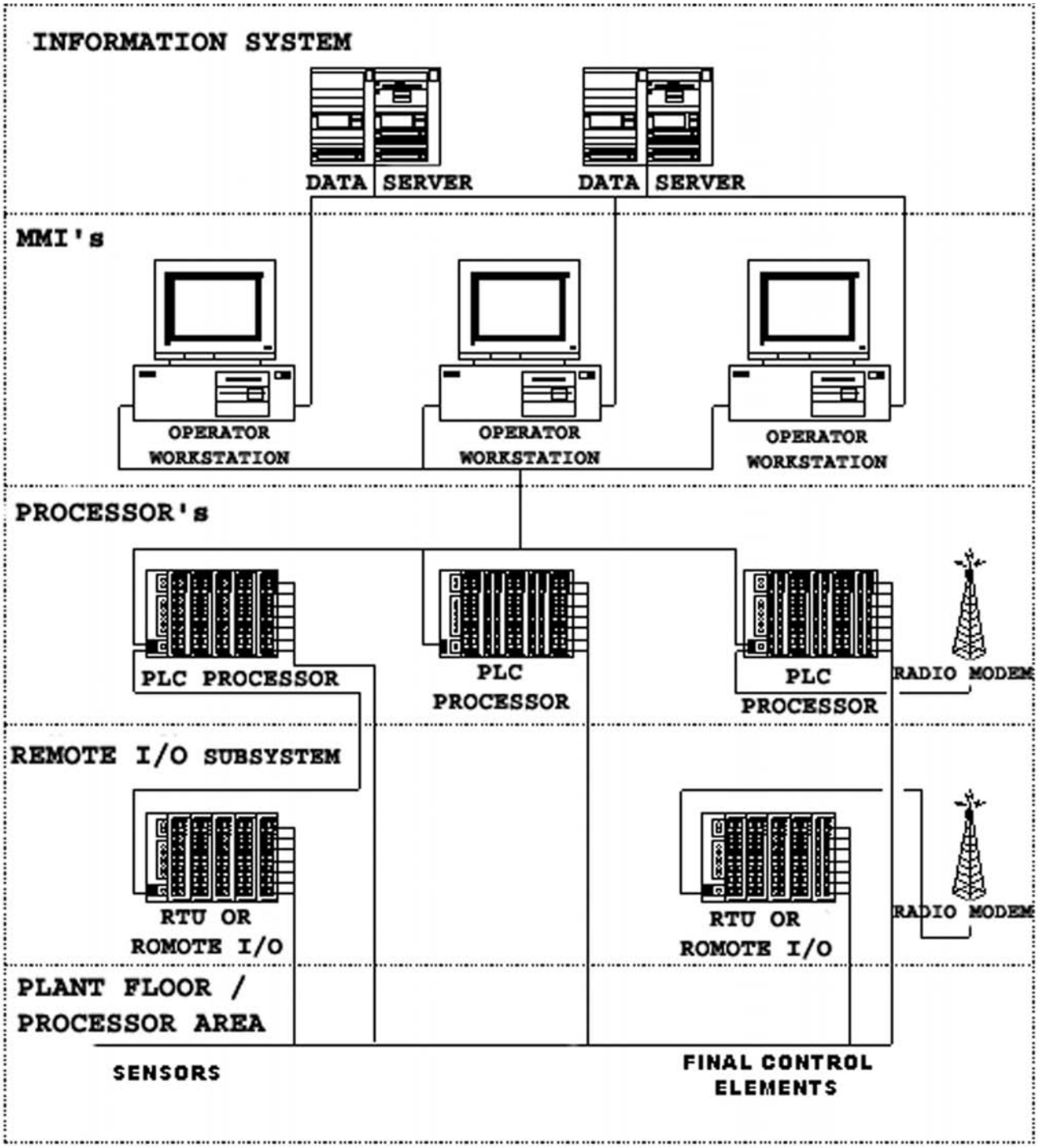


Figure 2: Typical SCADA system architecture.

the basic components of a web access based SCADA system[8].

Typically, a web access based SCADA system contains five elements. These are SCADA nodes, clients, project nodes, thin client and network. The SCADA node communicates in real-time with automation equipment. Typical automation equipment includes programmable logic controllers (PLCs), single loop controllers, direct digital control systems (DDC), distributed control systems (DCS) and I/O (Input / Output) modules. Full animation client uses an ActiveX control inside Internet Explorer web browser to view real-time data, acknowledge alarms, and change set points, status and other data. The Client then communicates directly with the SCADA node using proprietary communications over a TCP/IP network connection. The project node is a centralised database server. It can be physically separated from the SCADA node or combined. A copy of the database of all SCADA nodes is kept on the project node. Remote configuration and graphics building occur on the project node using a web server to exchange data with remote clients. The configuration database and graphics are then downloaded to the SCADA Node from the project node. The project node is a web server. The Thin Client interface supplies static snapshots of graphics as GIF files. No plug-in or ActiveX control is required. The Thin Client is intended for use with PDA, pocket PCs and handheld computers, but other ASP enabled web browsers can view the graphics. Real-time data, alarms and changes to data are through a text type interface. The

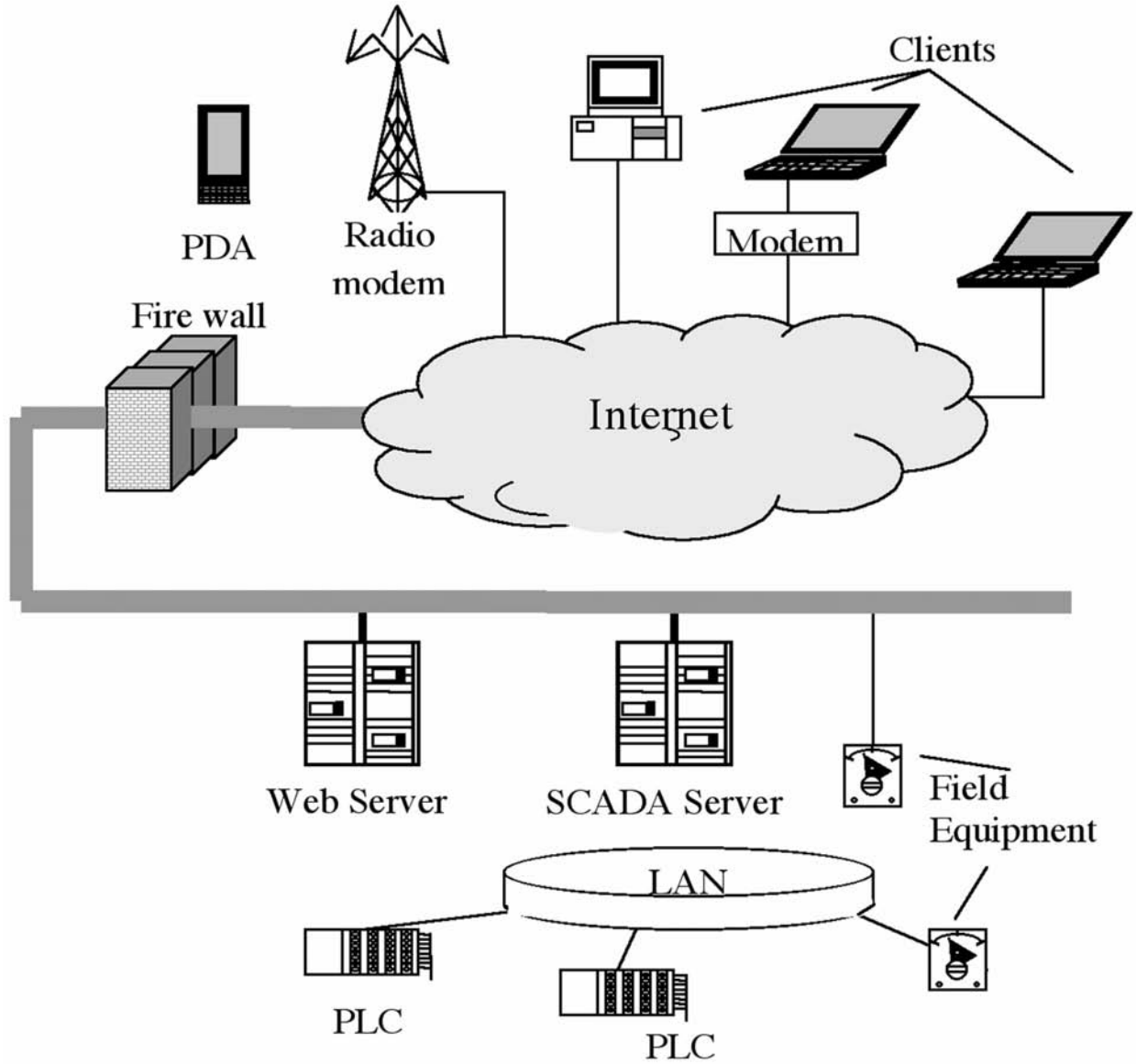


Figure 5: Designed mobile based SCADA system architecture.

Thin Client does not communicate with the SCADA Node directly. The Thin Client communicates directly to the project node only. A network supplies the connection between the nodes and clients. Any TCP/IP network will work including Local Area Networks (like Ethernet), a corporate intranet, the Internet, or dial-up connections.

Internet/web-based SCADA systems have many advantages, such as wide area connectivity and pervasive, routable, parallel polling, redundancy and hot standby, large addressing range, integration of IT to automation and monitoring networks, and standardisation.

The introduced Java-based application for SCADA system was created with networking, compatibility and support for an open geographical distributed environment as its main objectives. A consistent GUI for SCADA systems will enable inexperienced operators to become proficient in its usage with minimal training. Thus reducing the cost requirement to invest in training staff on sophisticated and hard-to-configure systems.

With a Java-based application, any Java-enabled browser can be used to view and control the SCADA system from any terminal of any existing operating platforms within the control centre. The application is platform independent and portable, where system data can be shared, reused and accessed at a much-reduced cost. As the application is downloaded from the Web-based server system onto the client system for execution via a Web browser, scalability and performance are no longer tightly tied to the Web-based server system. High performance requirements have also been addressed through multithreading in the application. This new Java-based application, when applied to the SCADA system, provides an easy, effective and low investment means of accessing data. No special hardware is needed for the set-up.

Designed software architecture

The designed software architecture consists of three different programs:

-Mobile Phone Program
-Server Side Program (SSP)
-SCADA Controlling Program (SCP)

Mobile Phone Program

Mobile Phone Program is designed by using J2ME (Java

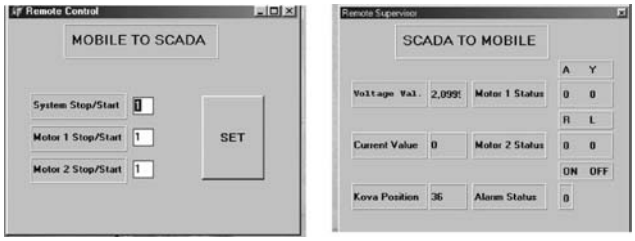


Fig. 4: Remote Control and Remote Supervisor programs screen shot.

Micro Edition) to be downloaded to mobile phone with GPRS (General Packet Radio Service) or WAP (Wireless Application Protocol). The program sends the data required for the web server in accordance with the protocol using preferably GPRS or WAP internet access technology, receives the data sent by web server and communicates it to the user with the help of graphical interface analyzing these in its structure.

The application routine has two stages. At the first stage, current and voltage values of the system, state of motor 1 and motor 2 (on/off) and bucket position value are sent to the mobile phone from the SCADA server. These data received by the mobile phone are interpreted by J2ME application and some related graphical animations are offered to the user. At the second stage, the authorised user can control the SCADA system values via the mobile phone. In our case study, authorized users can control the state of motor 1, motor 2 and the system on/off position by using J2ME application program in the mobile phone.

Server Side Program (SSP)

SSP is designed by using any server side script (ASP, PHP etc) or Java Servlet (Server Applet) reason for preference in case of excessive use. It receives the request data sent by the program integrated into the mobile phone. It reads the values of these from the state/position database located in the computer in which the web server is installed. This data is sent to the mobile phone via Internet in accordance with the program in the mobile phone and the protocol between them[9-11].

SCADA Controlling Program

This program is installed in the same computer with the SCADA system and has a visual interface, receives the data pertaining to the state of the system connecting with SCADA and saves it to the condition-stating database in the computer in which the web server is installed.

Two different programs have been produced and used to monitor and to control the SCADA system via mobile phone. A remote control program (mobile to SCADA) has been used to control the SCADA system via mobile phone. A remote supervisor program (SCADA to mobile) has been used to monitor the SCADA system via mobile phone. The data flow diagram of a designed model system is illustrated in *Figure 5*.

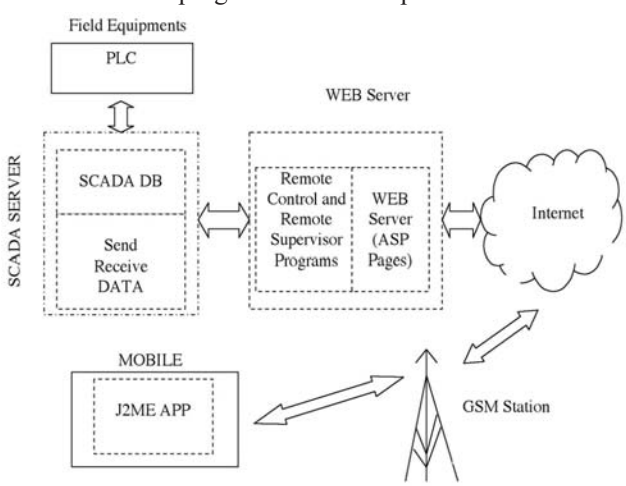


Figure 5: Designed mobile based SCADA system architecture.

Developed application

In order to test the developed system, a model crane, which can move in two directions by using two DC motors, is used. The model crane is controlled by using a Siemens S7 300-312 IFM PLC ad SM334 I/O card. A CP5611 MPI Bus Card obtains the data interface between PLC and server. The SCADA program is WinCC. The mobile phone is Siemens M50 with 228Kb user storage and used for designed Java application.

A model crane system has been prepared to realise this SCADA system application. Equipments of this model system are a model crane, computer, Siemens S7-300 CPU 312 IFM and SM 334 (AI4/AQ2) Programmable Logic Controller (PLC). The crane can turn itself through 360 degrees and act at the y-axis. These properties of the crane can be controlled by using two DC motors. The PLC has been used as a bridge, which provides data transfer, between the server and the test equipment. Small programs in SCADA software carry out the most important part of the control actions procedures. Data exchange between the server and PLC are realised by MPI bus protocol via a CP5611 MPI bus card installed on the server computer at 187.5 kB/s data exchange rate. A block diagram of the mobile-based SCADA application model is illustrated in *Figure 6*. The server monitor and SCADA screen shot is shown in *Figure 7*.

All the system equipments are shown in *Figure 8*. The model crane has four sensors, three of which are used for left-right direction and one is used for crane height. The SCADA application screen in mobile phone is shown in *Figure 9*.

J2ME Application Program (JAP) operating in mobile phone is prepared in Sun One Studio 4. The program has been tested in Siemens M50 emulator and then downloaded to the mobile phone.

Operation of the system

In operation of the system, SCADA software in the server is operated in the first place. Later SCP, which realises the process of sending data to SSP, is operated. After SCP operates, it transfers the data reading from SCADA database to the web page designated with ASP (Active Server Page) responsible for setting up the connection between the mobile phone and SCADA system. The simple quantities of data received by ASP page from SCP installed in the web server are stored in ASP page.

This reaches the ASP page by means of GPRS or WAP after JAP in the mobile phone is operated and this information is saved in the JAP database. Analysing the data in this database, the JAP program turns it into a value diagram, bar graph, text message and various graph animation, which the operator can understand. As long as the program in the mobile phone operates, the exchange of data between mobile phone and SCADA system is automatically realised.

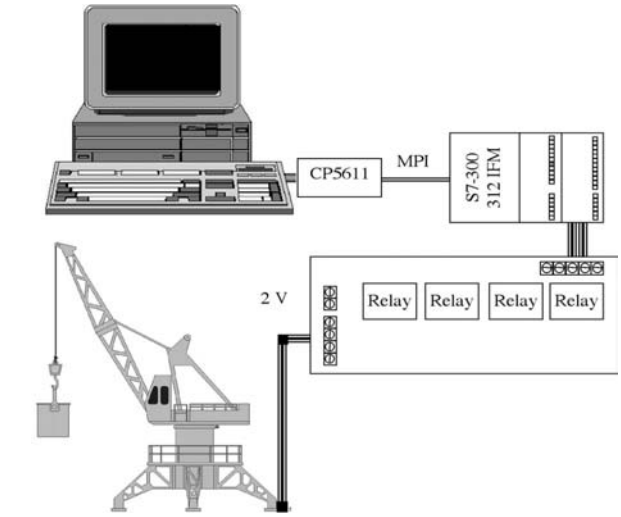


Figure 6: Mobile based SCADA application block diagram.



Fig. 7: The server monitor and SCADA screen of test prototype.



Figure 8: Mobile based SCADA application.

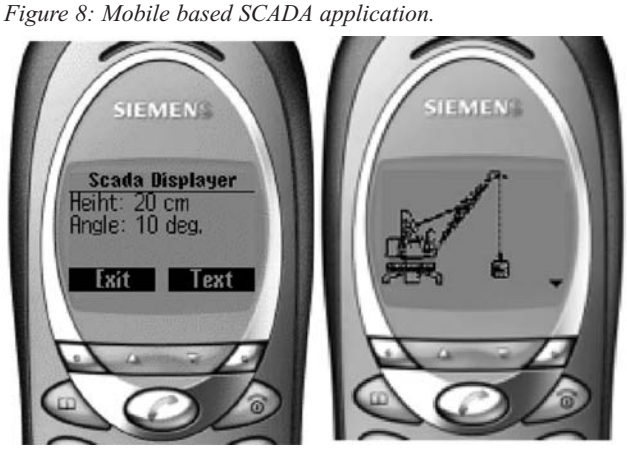


Figure 9: SCADA application screen page in mobile phone

Conclusions

In this study, a Java-enabled mobile phone has been integrated into a SCADA system as a client. Therefore, the obligation of a SCADA system to work with a PC is not necessary. Because the monitoring and controlling of the plant process are realised with the use of present GSM base stations, no cost of network settings is required. Because the exchange of data with the SCADA system is realised through GPRS or WAP, the expenditure of connection is considerably low.

The conditions in a process plant of an automation system are harsh and the site is remote. Resources for data communication are difficult to obtain under these conditions; thus, wireless channel communication through a mobile phone is practical and efficient in a process control environment. The mobile communication industries and the public have a strong interest in the WAP technology application in mobile phone networks; and the WAP API in power industry applications is one area that requires extensive investigation. The objectives of this study are to: replace the existing conventional SCADA system with one new mobile-based system controlling the sample crane; increase the SCADA attain envelope to include all of the locations not currently reached; provide a SCADA system with WAP based software applications; and install minimum new hardware.

SCADA systems are alarm-based systems and these alarms are monitored and controlled from an operator in a control centre, and maintenance operators are informed. In this type of conventional alarm management system faults due to human mistakes can occur. Integrating the mobile phones of the maintenance operators to the SCADA systems can minimise these faults. The maintenance and authorised operators can monitor and control the system by their Java-enabled mobile phones. Although, the alarms occurred in the system, these can be sent to authorised personnel or operators as a SMS message so that the system security can be maximised.

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