Remote Monitoring System Version 2.0

by

Kartika Sari Mursaid

A disssertation submitted in partial fulfilment of
the requirements for the
Bachelor of Technology (Hons)
(Information System)

JUNE 2006

Universiti Teknologi PETRONAS
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1) Global System for mobile communications
2) IT/IS -- Thesis

CERTIFICATION OF APPROVAL

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Approved by,

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(Norshuhani Zamin)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
June 2006

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

KARTIKA SARI MURSAID

ABSTRACT

Remote Monitoring System version 2.0 (RMSv2) is an enhancement of Remote Monitoring System (RMS) over GSM Platform (Failure Detection) developed by Norazila Razali. RMS is designed to monitor Petronas remote cathodic protection stations throughout Malaysia. In the event of failure, the system will send signals in Short Message Service (SMS) from remote failure detection sites to a central station over Global System for Mobile Communications (GSM). The objective of this project is to improve the weaknesses of the previous version, which are lack of user friendliness, lack of customizability, and lack of commercialization value. The scope of study includes understanding the program written for the previous version and researches related to SCADA systems. The methodology chosen is the iterative waterfall model. In RMSv2, enhancements are done to increase the user friendliness or RMS.

ACKNOWLEDGEMENT

It is difficult to name all the people who have directly or indirectly helped me in my effort to complete my project. Hence I apologize to those I fail to mention. I owe Allah S.W.T. a great debt of gratitude for this grueling but rewarding experience, which hopefully helped me to become a better person.

Special thanks and apologies must go to my supervisor, Madam Norshuhani Zamin, who has been supportive in commenting my works and patient for my tardiness.

My appreciation goes to my families, who have motivated me when I need the encouragement.

I would like to thank Dg Syarmi Erina Ag Arshat, Marina Rosihan, Safuraa Mohamed, Daeng Haryanti, Nurul Izza Mat Ali and Zurabika Zainudin for being helpful along the way.

I sincerely apologize for troubles I might have caused. Thank you all– your kindness will never be forgotten.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

This project is an upgrade to Remote Monitoring System (RMS) over GSM Platform (Failure Detection) developed by Norazila Razali through collaboration with Neural Manufacturing Sdn Bhd. RMS was developed by exploiting information on Supervisory Control and Data Aquisition (SCADA) technologies resulting in a lower costing yet effective monitoring system. The RMS monitors specified information regarding PETRONAS Gas Cathodic Protection (CP) sites located throughout Malaysia. The remote monitoring devices collect periodical readings of key data from a site. Data collected is sent automatically to the RMS application via GSM in the form of text message (SMS). The SMS will be processed by the RMS application and stored in a database. The RMS successfully collects readings from sites automatically, alerts staff in charge of any failures, and stores SMS received in a database.

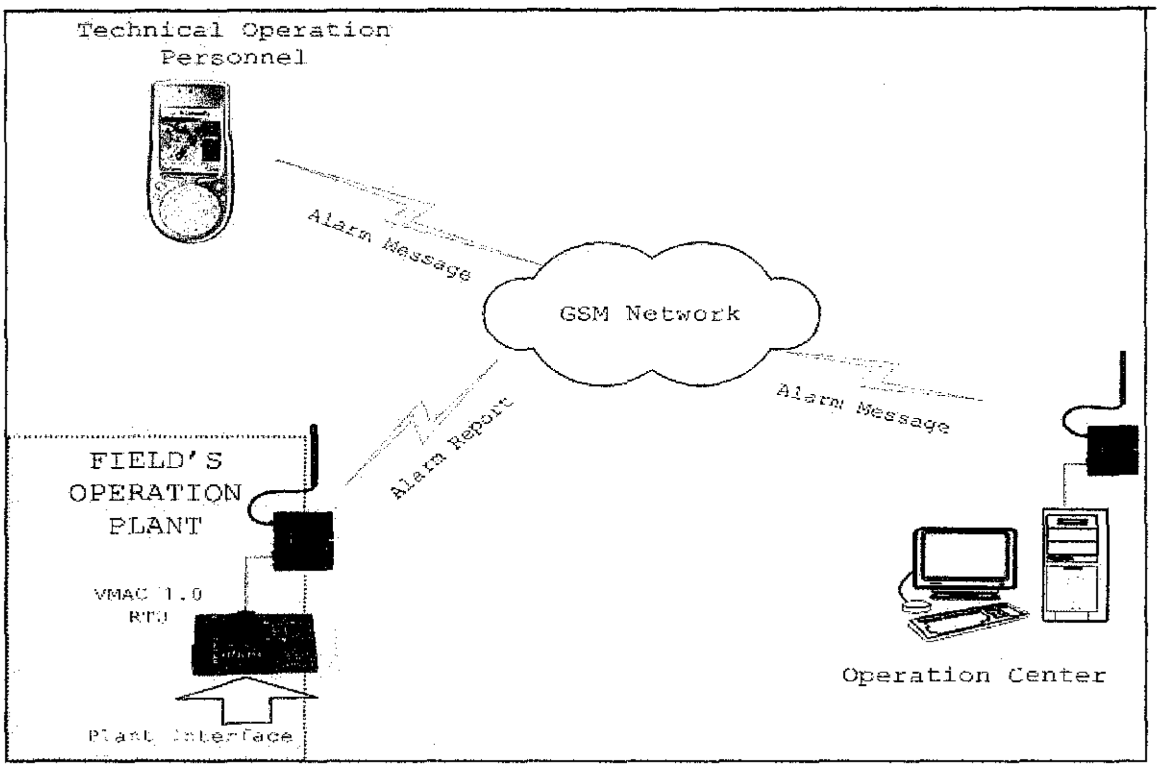

Figure 1.1: System uses GSM Network

1.2 Problem Statement

1.2.1Lack of User-Friendliness

Before going live, the developer of RMS conducted a User Acceptance Test (UAT) in which Neural Manufacturing staff evaluates the RMS. Overall, the staffs are satisfied with the RMS and they provided comments for future enhancements. One feedback from staff related to user friendliness is: Still need some adjustment especially on the user interface.

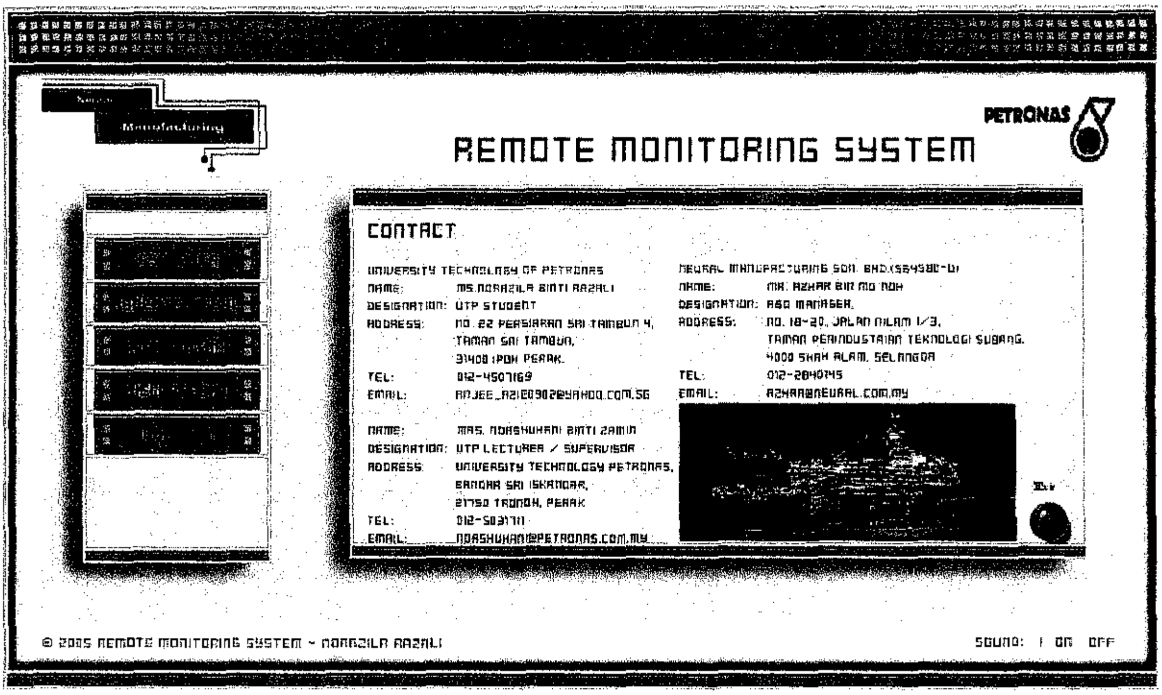

Figure 1.2: The use of uppercase letters hinders readability

Figure 1.2 shows a screenshot from RMS. Apparently too much uppercase letters hinders readability. This can be remedied by using a more readable font, with less use of uppercase letters.

In the report screen of RMS, the SMS received is referred under the 'Message' column. Each bit represents one sensor connected to a specified port at the RTU. Bit 1 implies that error is detected at the particular port and bit 0 vice versa. These binary numbers however don't convey much information to operators. This suggests an enhancement to make the message more transparent and readable to user. The conversion from binary to text should be done at the software level to prevent tapping of message when the message is being delivered to the RMS.

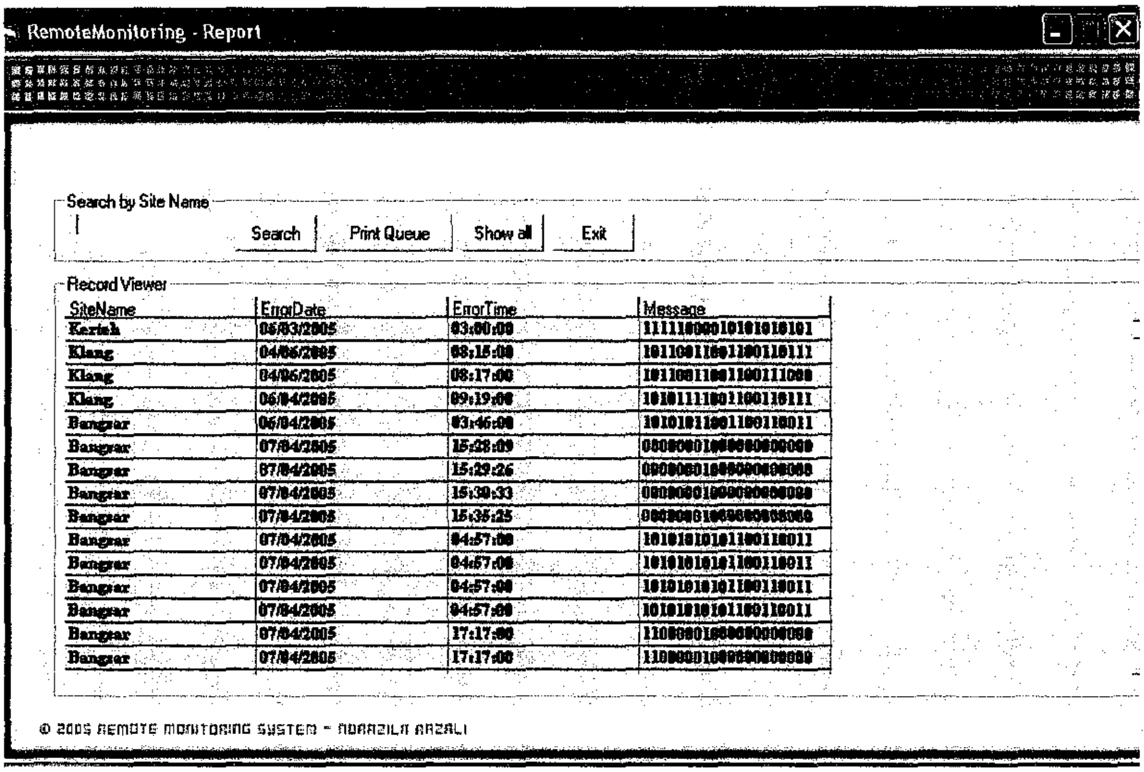

Figure 1.3: Binary numbers don't convey much information

1.2.2 Lack of Customizability

The RMS is developed exclusively for PETRONAS CP sites. Images and text in the application are hard coded and cannot be customized for usage by other organization.

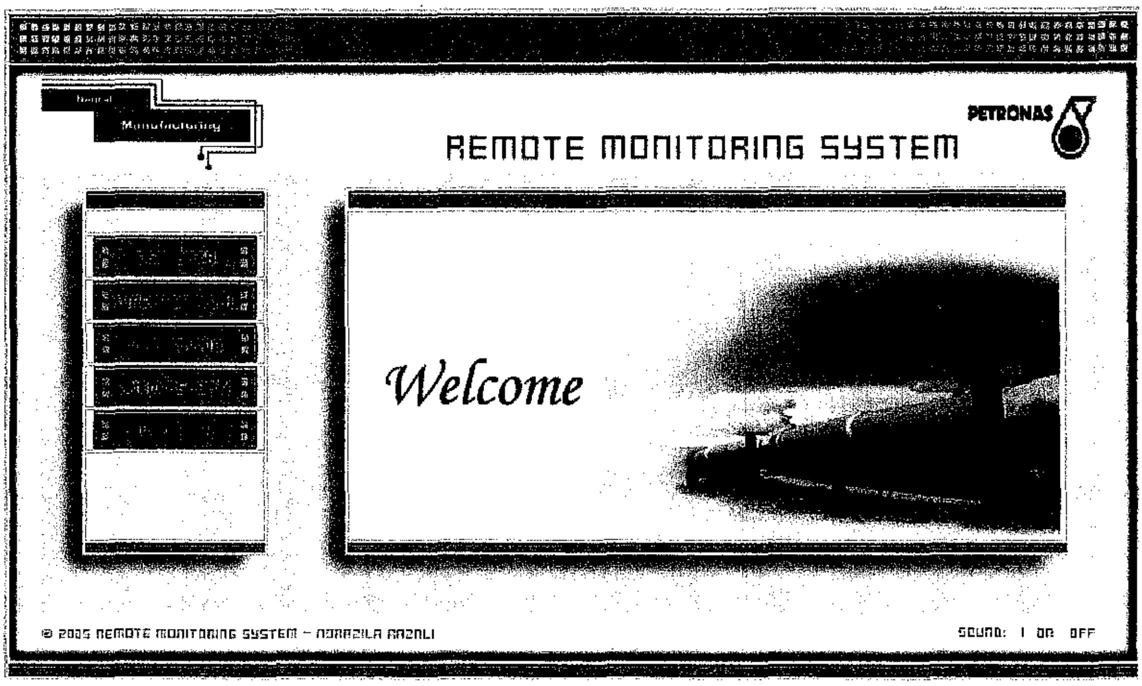

Figure 1.4: Welcome screen of RMS

1.2.3 Lack of Commercialization Value

Due to the two problems mentioned, the RMS lacks commercial value. Improving user friendliness and increasing the customizability of RMS would contribute to a higher commercial value.

1.3 Objectives and Scope of Study

The objective of this study is to upgrade the RMS and to overcome the problems mentioned to meet the product commercialization standards and requirements. In order to achieve this, I need to go through the reports written by the developer and study the Visual Basic codes of the project. Only then I would understand the RMS thoroughly. I will get information on current SCADA systems so that I'll be able to pinpoint any other areas that can be improved on the RMS. Still, the main objective would be to improve on the user friendliness and customizability.

Four major elements for the project are GSM Data Process, Hyperterminal, Map Editor and Database. In GSM Data Process, connection between GSM Modem and the Visual Basic program is established using RS-232 communication port.

The hyperterminal provides user means to communicate with the SIM card stored in the GSM modem. User will be able to get retrieve data such as time, date, site name, and error message.

The Map Editor acts as an image editor where maps and their information can be added. The last element, the Database, stores data received from the SMS platform.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview of SCADA Systems

Supervisory Control and Data Acquisition (SCADA) networks are used for industrial measurement, monitoring, and control systems, especially by electricity and natural gas utilities, water and sewage utilities, railroads, telecommunications, and other critical infrastructure organizations. They enable remote monitoring and control of an amazing variety of industrial devices, such as water and gas pumps, track switches, and traffic signals. A SCADA system gathers information, such as where a leak on a pipeline has occurred, transfers the information back to a central site, alerting the home station that the leak has occurred, carrying out necessary analysis and control, such as determining if the leak is critical, and displaying the information in a logical and organized fashion. SCADA systems range from relatively simple networks that monitor environmental conditions of a given location to incredibly complex systems that monitor all the activity in a power plant or a municipal water system.

A SCADA system collects all of the information about a process. The SCADA system then needs to display this data to the operator so that they can comprehend what is going on with the process. Unfortunately, Brandel [1] claims that well-designed interfaces have been more afterthought than top-of-mind. Take [2] in his article argues that the clarity of displays can determine how well the plant is run; lack of information can result in poor operational efficiency, excessive wear and tear and, in extreme cases, failure to see a problem may be dangerous. According to Hexatec Systems [3], SCADA system is the closest thing to a nervous system anywhere within a utility, and it is inherently obvious that neglecting the system that monitors all critical events in real-time will quickly lead to operational paralysis.

A properly functioning SCADA system will provide correct data interpretation and enhanced capability to respond.

According to Walski [4] SCADA systems consist of:

One or more field data interface devices, usually remote terminal units (RTUs), or programmable logic controllers (PLCs), which interface to field sensing devices and local control switchboxes and valve actuators.

- A communications system used to transfer data between field data interface devices and control units and the computers in the SCADA central host. The system can be radio, telephone, cable, satellite, etc., or any combination of these.
- A central host computer server or servers (sometimes called a SCADA Center, master station, or Master Terminal Unit (MTU).
- A collection of standard and/or custom software [sometimes called Human Machine Interface (HMI) software or Man Machine Interface (MMI) software] systems used to provide the SCADA central host and operator terminal application, support the communications system, and monitor and control remotely located field data interface devices.

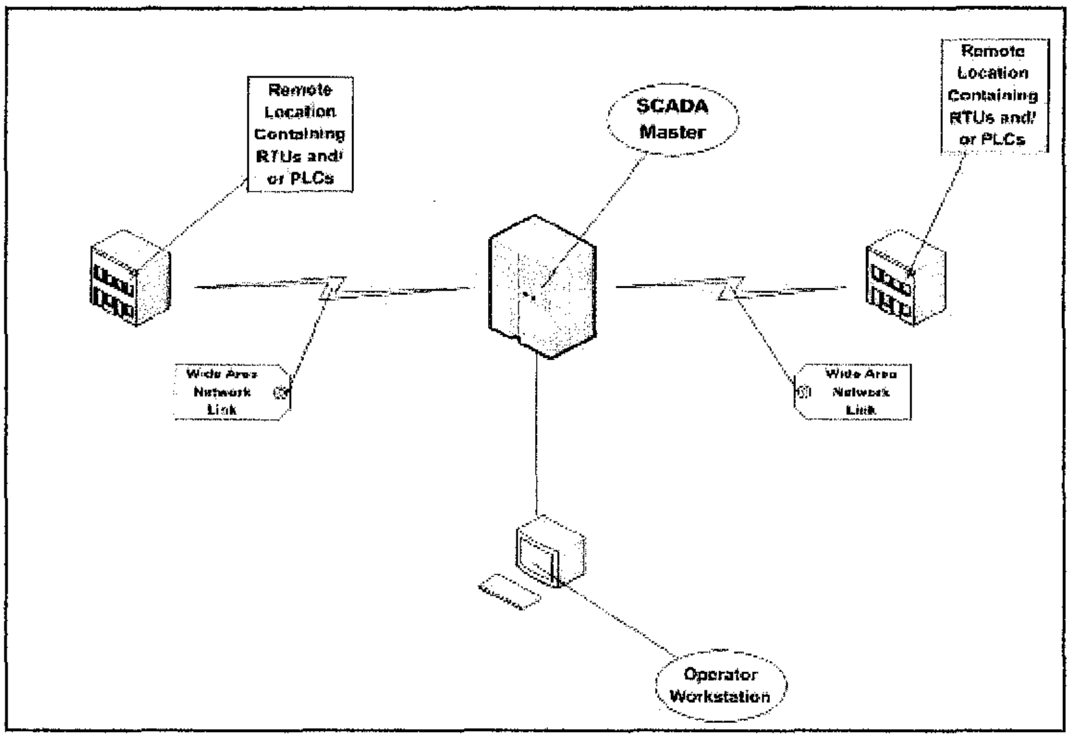

Figure 2.1: A typical SCADA system

(Reference: National Communications System Technical Information Bulletin [5])

2.2 SCADA Communications Network

The communications network is intended to provide the means by which data can be transferred between the central host computer servers and the RTUs. The Communication Network refers to the equipment needed to transfer data to and from different sites. The medium used can either be cable, telephone or radio. Some of the ways SCADA systems are deployed are satellites, leased telephone lines, radio, power line carrier and fiber optics. Subsequent sections discuss satellite, GPRS, GSM, and leased line approaches.

2.2.1 Satellite Based SCADA

Plumas-Sierra Rural Electric Cooperative (PSREC) installed redundant, commercially available satellite Internet connections, from two separate providers, at two of its substations. These satellite Internet connections serve as redundant communications paths for the substations and enable their integration into its SCADA system. This approach is discussed by Rice and his colleagues [6] in their paper titled "Integrating Remotely Located Substations Into SCADA Systems: A Case Study Using Commercially Available Satellite Internet Service Providers for SCADA Communications". Significant improvements to its existing SCADA system were needed to increase their system reliability. The ability for operators to monitor and control various devices at substations throughout the system is extremely important. Such control would allow conscious decisions to be made to restore or cut off power to areas as required. Five of PRSEC's 13 substation has been integrated with the SCADA system. Apparently leased line is not cost efficient for PRSEC, because two of its substations are located in remote regions, putting monthly service cost for the Ethernet connection at around $1,500 per month, per station.

PSREC began testing satellite communications option. Initial tests consisted of polling a single relay for basic target and metering information and sending a control command using both OPC and DNP/IP protocols. Both protocols, after some adjustments to delay timeouts, worked extremely well. Monthly subscription to the satellite service would cost $75 per month, as compared to the $1,500 a month estimate for the frame-relay service. This accounts for an approximate savings of $50,000 over the course of 3 years.

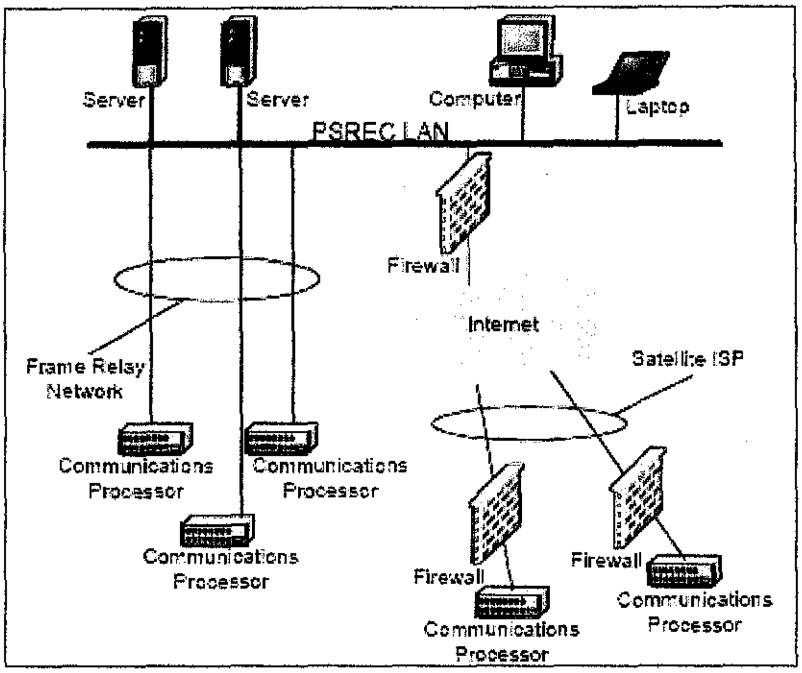

Figure 2.2: PSREC SCADA system architecture

PSREC has implemented a successful communications scheme using commercially available satellite ISPs. After a few network modifications and optimizations, their satellite communications times are comparable to their landline counterparts at a fraction of the cost. The result is an acceptable communications alternative for remotely located substations within a utility's system.

Satellite-based communications have a higher degree of unknowns to account for, making them a higher risk. However, for stations that are not critical to a utility's reliable operation, satellite communications offer a very economical alternative to other methods of communications.

2.2.2 GPRS Based SCADA

A GPRS roll-out is enabling British Waterways to monitor the UK's canal networks more effectively, suggested in a report by Antony Adshead [7]. British Waterways looks after about 2,000 miles of canals and rivers in the UK. Two crucial requirements that compel it to monitor the network are to keep the canals and river on top condition by tracking flow rates and water levels, and because it is vital to its marketing department.

British Waterways SCADA team uses remote devices connected to its central management systems via Vodafone's GPRS network. The whole network now feeds information automatically into its SCADA system, as opposed to previous methods - staff visiting device or poll monitoring devices by phone.

It is estimated that it would have cost up to £20,000 to install telephone lines at some sites, and radio links were often unaffordable. GSM was well established and the team looked at it as a possible communications medium, but was wary of call costs charged on a time basis.

GPRS was regarded as being costly, but their remote telemetry units send fairly small amounts of data, which is ideal because the cost is related to the amount of data sent. In fact, the costs actually turned out to be lower than they anticipated.

At each remote location is a monitoring device attached to a basic ruggedised PC. Every five minutes the monitoring units take a sample reading and every 15 minutes the data is transferred to British Waterways' SCADA systems.

Data is sent via the GPRS network to a SQL Server database at British Waterways' SCADA center where it is rendered onto a geographical information system.

The map displays the real-time status of the entire canal network alongside key operational information. Security is covered by running the entire communications network through a virtual private network tunnel.

Aside from monetary benefits, the SCADA system also covers risk management. If there is unexpected flooding or draining, critical information would be available to the SCADA team and pumps and sluices can be operated from the SCADA centers, or by field staff sent to manually intervene. Rather than waiting for alarms, trends can be spotted more quickly.

2.2.3 GSM Based SCADA

GSM modems provide an excellent way to implement network communications to remote locations. In an article from The Industrial Wireless Book [8], the potential offered by public network GSM is illustrated. United Utilities is responsible for electricity distribution in the North West of England, UK, with an area of 12,000 square kilometres containing around 2.2 million homes. There are over 60,000km of overhead lines and underground cables as well as 32,000 un-manned substations. As part of its Electricity Network Improvement Project (ENIP), the company has decided to use over 700 GSM modems to provide the communications interface between remote secondary switchgear and the Distribution Control Centre based in Manchester. The network update programme is designed to ensure compliance with quality of supply targets set by Ofgem, the government regulatory arm for power utilities in the UK. The use of GSM modems - supplied for this project by network hardware company Westermo - has been driven by the size of the region to be covered and the remoteness of the monitored sites.

The GSM network function is used by the utility company to isolate parts of the network effected by faults and assist restoration of customer electricity supplies in the shortest time. Ofgem currently requires restoration within three minutes, otherwise the power-out officially counts as a customer interruption resulting in a sliding financial penalty for the power company on a per-customer basis.

Until a remotely controlled automated system was put in place, network repair was a manual process of getting engineers out on the road, finding the fault and then isolating the failed circuit by manually operating the associated switchgear. This method was inadequate for the new supply target.

Wireless technology provides the only sensible route to network telemetry for United Utilities' remote switchgear locations. GSM offers the ability to call pre-set numbers and send/receive text messages, making it ideal for alarm monitoring and remote diagnostics in unmanned locations. United Utilities was able to meet its target, improving considerably the quality of supply to these rural customers.

RTU-based control systems control the actual switchgear remotely, either tripping or closing the associated actuator from command signals. The GSM modems make the actual connection between RTUs and the central control room in Manchester. The modems act as both transmitter and receiver, enabling network switchgear to be controlled centrally. Apart from switchgear control, the modems also send real-time information about other RTU inputs - for example equipment health and the condition of both the AC and DC back up supply to the control centre.

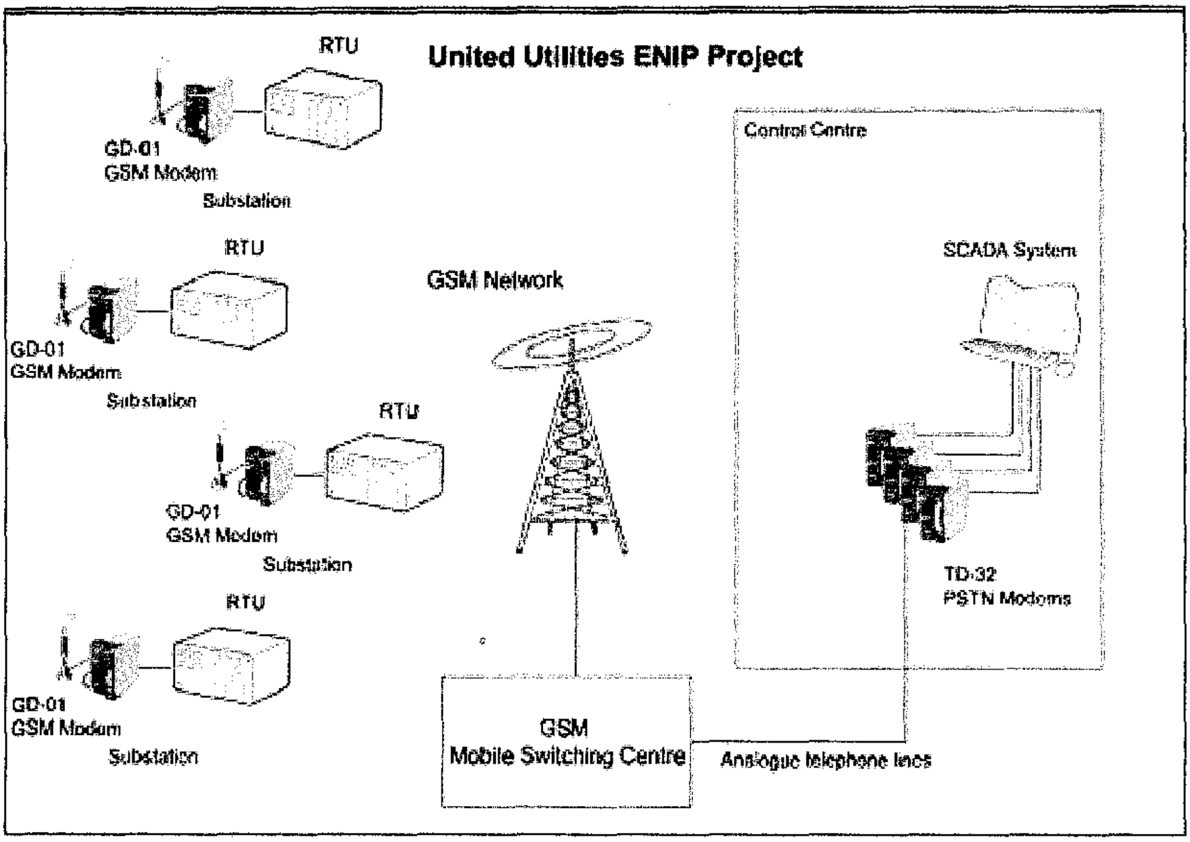

Figure 2.3: GSM based network used in ENIP

(Reference: The Industrial Wireless Book [8])

2.2.4 Leased Line SCADA

CMC limited [9] developed Standard Electric Traction SCADA software (SETSS) on Windows NT platform for its client, Indian Railways. Features include acquisition of analog and digital parameters, control of circuit breakers and interrupters located in sub stations and switching stations, automatic localization of faults, and logging and reporting of alarms and events. Major components of its technical architecture include transducers and relays, ruggedised RTUs with closed loop function, leased line telecommunication equipment, host computer systems in host standby configurations, and man machine interface (MMI).Deployment of this project reduced maintenance cost, and made transferring of operators easier. It also promotes safety during power maintenance and creates savings in energy billing by monitoring.

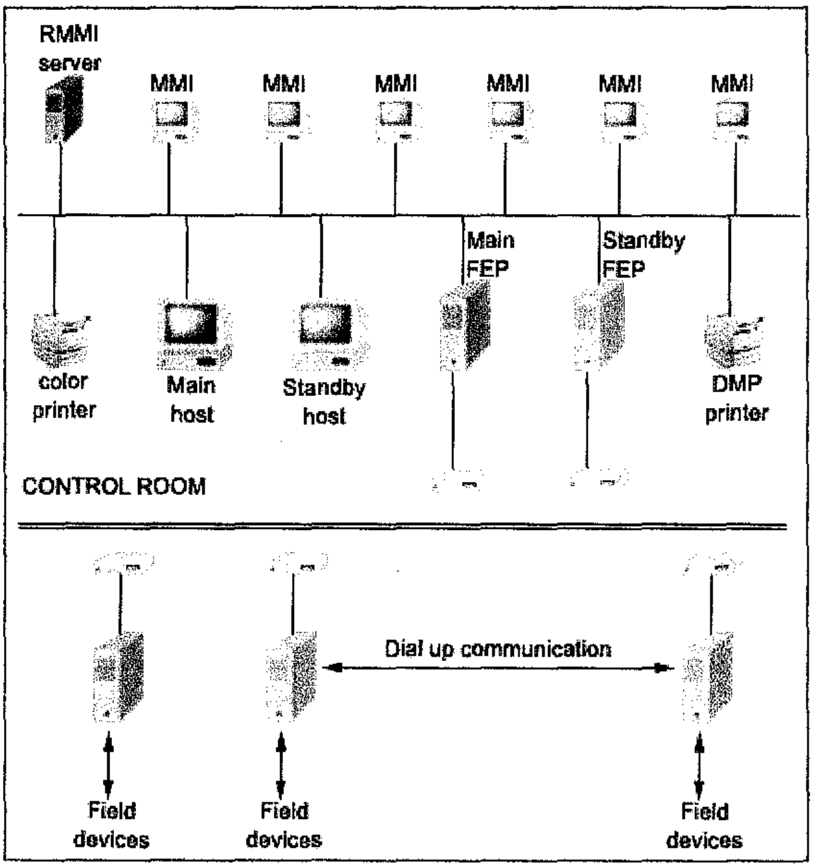

Figure 2.4: Traction SCADA – architecture diagram

2.3 Benefits of a SCADA system

A perfectly designed SCADA system offers the following benefits:

- Monitors in real time.

  As mentioned in section 2.2.2, British Waterways [7] SCADA system monitors their rivers and canals in real time, helping ensuring the rivers and canals in top condition.

- Minimizes the operational costs.

  According to Terry [10] Tennessee Valley Authority (TVA) has reduced operating costs with the implementation of SCADA systems at various remote hydro facilities by consolidating the control of multiple plants at one location.

- Provides direct information of system performance.

  SCADA software includes operator screens, where animation of objects depicts real time data. Objects that can be depicted are valve positions, tank levels and such.

- Improves system efficiency and performance.

  System efficiency is improved through energy savings achieved by employing SCADA on University of Arizona energy management [11].

- Increases equipment life.

  University of Arizona energy management's [11] web based SCADA enables them to throttle back their fans and pumps when the building was not at peak load, extending the equipment life as well as saving energy.

- Reduces labor costs required for troubleshooting or servicing the equipment.

  In a news release by EPG Companies Inc [12], their installed SCADA system reduced labor cost by eliminating the need for on-site visual inspections or data collection and it also reduced man-hours required for troubleshooting, freeing up personnel for other important tasks.

- Automated report generation reduces errors in calculations and interpretations.

  Large Midwest Natural Gas Company avoided inefficient data collection process by adopting SCADA solution by Cingular [13]. The SCADA system provided more accurate meter readings and data analysis compared to sending technicians to field.

- Uses advanced technologies.

  USFilter Control Systems [14] incorporates a high performance open source software architecture that utilizes a true multitasking operating system running a combination of standard and specially designed for water and wastewater application software modules.

2.4 Drawbacks of SCADA

Although SCADA systems are reliable and robust, they are not immune to some drawbacks:

- Security

  Harper [15] in his research suggested that SCADA systems are computer controlled devises that perform and relay physical changes in infrastructure systems to technical operators. They are capable of monitoring millions of data points simultaneously, and can therefore be manipulated by a cyber attack.

- High cost of software purchase

  As Sensaphone Inc [16] put it "Until recently, SCADA technology was often viewed as a luxury item by smaller industrial companies, unobtainable because of high costs and systems they simply could not fully utilize due to the massive I/O capacities of the systems."

2.5 SCADA in Pipeline Monitoring

Texas Gas Transmission monitors and supervises its 6,200-mile natural gas pipeline system across seven states from Louisiana to Indiana. This is as noted in Bailey and co-worker's [17] article titled "HMI, SCADA Reduces Pipeline Monitoring Supervision Cost". Texas Gas is part of Williams Companies Inc. Around-the-clock operations previously required continuous, in-person monitoring and supervision at the pipeline's 26 compressor stations.

2.5.1 Reduce Operating Cost

To reduce operating and labor costs, Texas Gas recently upgraded the pipeline's monitoring and control capabilities with a Citect 5.21 supervisory control and data acquisition/human-machine interface (SCADA/HMI) system from Ci Technologies. Managers and engineers can now check real-time conditions at each of the 26 stations from Texas Gas' central offices, field locations, or remotely via the Internet. This helped Williams consolidate monitoring and control functions, and implement condition-based maintenance.

2.5.2 Reduced Staffing

The new Citect HMI/SCADA system operates over a 384-kbps wide area network (WAN) to monitor data from the pipeline's 68,480 control and 129,827 data points, which communicate with Texas Gas' central operations center. The pipeline continues to operate 24 hours per day, but the HMI/SCADA system allowed staffing to be reduced to one maintenance shift at most compressor stations, and eliminated full-time staffing at smaller stations. Texas Gas saved tens of thousands of man-hours and more than $5 million per year.

Managers also save by remotely viewing pipeline data and taking corrective action from any location via Texas Gas' network or the Internet. Issues are often resolved now without requiring support personnel to visit a station or make unscheduled maintenance calls.

CHAPTER 3

METHODOLOGY

3.1 Implementation Model

The implementation model employed for this project is the iterative waterfall model.

In the requirements analysis phase, the problem is specified along with the desired objectives. In the same phase, constraints are identified.

In the specification phase, the system specification is produced.

In the system and software design phase, the system specifications are translated into a software representation. In this phase I will be concerned with data structures, software architecture, algorithmic detail and interface representations. The hardware requirements are also determined at this phase along with a picture of the overall system architecture. By the end of this stage I should be able to identify the relationship between the hardware, software and the associated interfaces.

In the implementation and testing stage the designs are translated into the software domain. Testing at this stage focuses on making sure that any errors are identified and that the software meets its required specification.

In the integration and system testing phase all the program units are integrated and tested to ensure that the complete system meets the software requirements.

In the maintenance phase the software is updated to meet changing customer needs, adapt to changes in external environment, correct errors and oversights undetected in the testing phase and enhance the efficiency of the software.

The feedback loops allow for corrections to be incorporated into the model.

The choice of this model is due to its enforced disciplined approach.

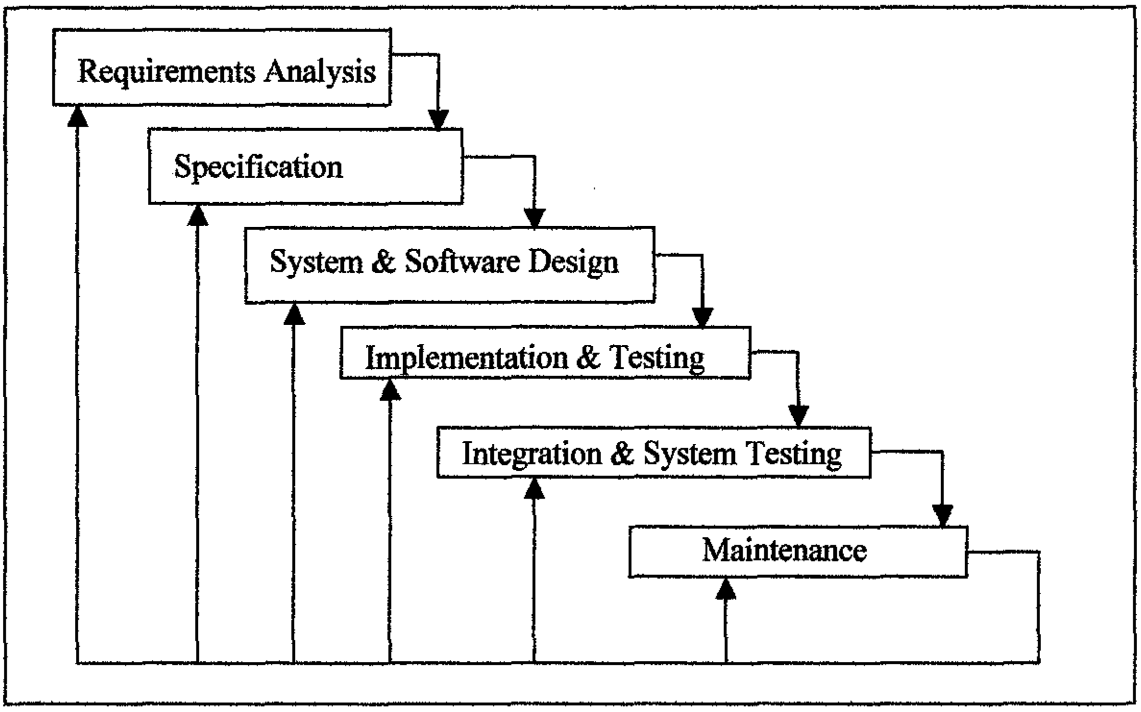

Figure 3.1: The waterfall model

3.2 Tools Required

Tools required are Visual Basic 6.0, Microsoft Access, Compact Remote System, sensors and GSM modems.

3.3 System Architecture

Figure 3.2 shows the system's architecture. Petronas Gas Cathodic Protection Stations are equipped with Remote Terminal Unit (RTU), which is connected to a GSM modem. Through the communication network this modem communicates with another modem that is connected to a master station, where the system program is installed. This way the master station can receives message from the RTU of any error occurred.

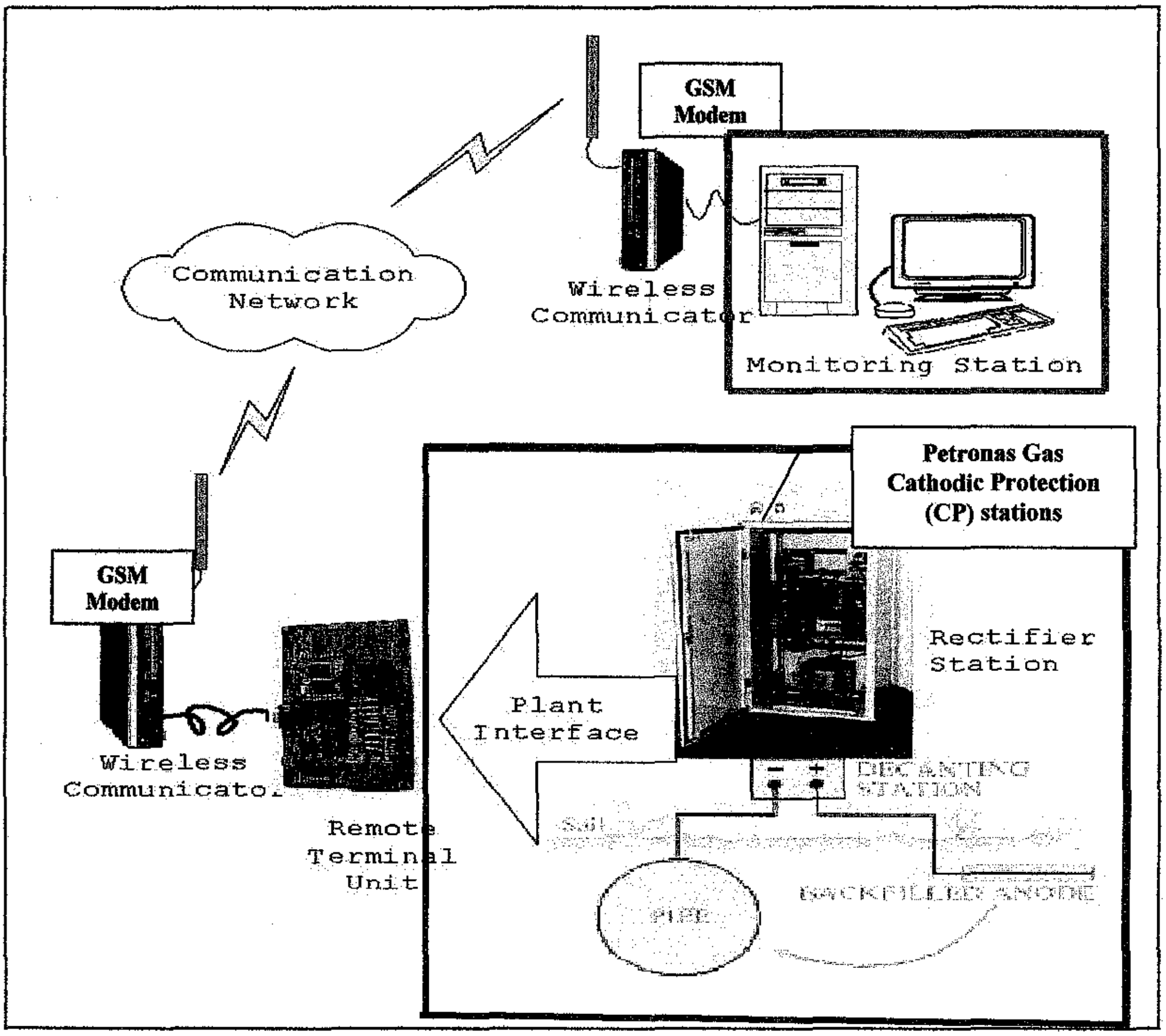

Figure 3.2: The Remote Monitoring System framework

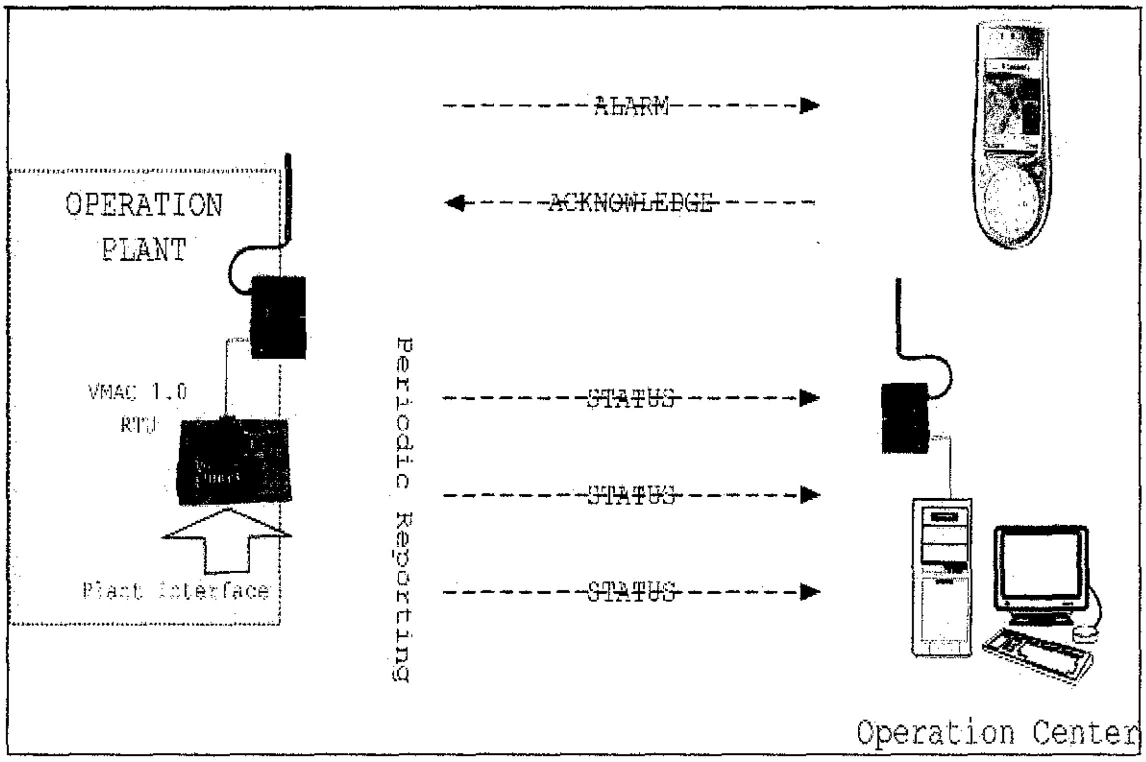

Figure 3.3: The GSM data process flow

Figure 3.3 shows the GSM data process flow. Aside from sending messages to the master station, the system also sends alarm messages to 3 additional mobile numbers. This is especially useful for certain staff, which needs to be informed about the alarm first hand.

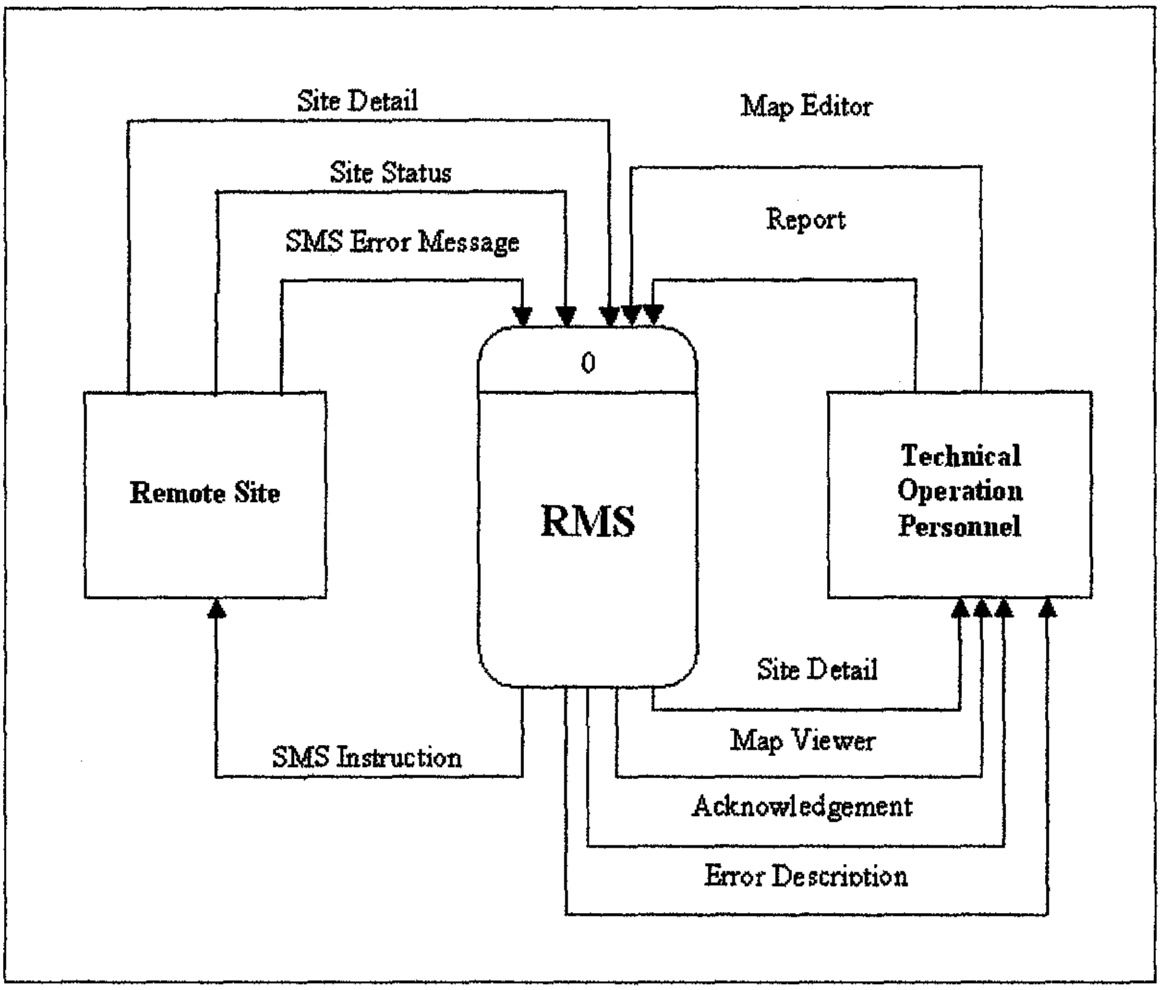

Figure 3.4: System's Context Data Flow Diagram

CHAPTER 4

RESULTS AND DISCUSSION

Enhancements for the previous version are done in Remote Monitoring System Version 2.0 (RMSv2). These enhancements are intended to increase the user friendliness of the system.

In the previous version, Remote Monitoring System (RMS), some forms can be closed with no warnings given. For example, in the GSM Data Process form, where closing this form will stop the system monitoring. In RMSv2, users are notified about this and asked if they are sure to close the window.

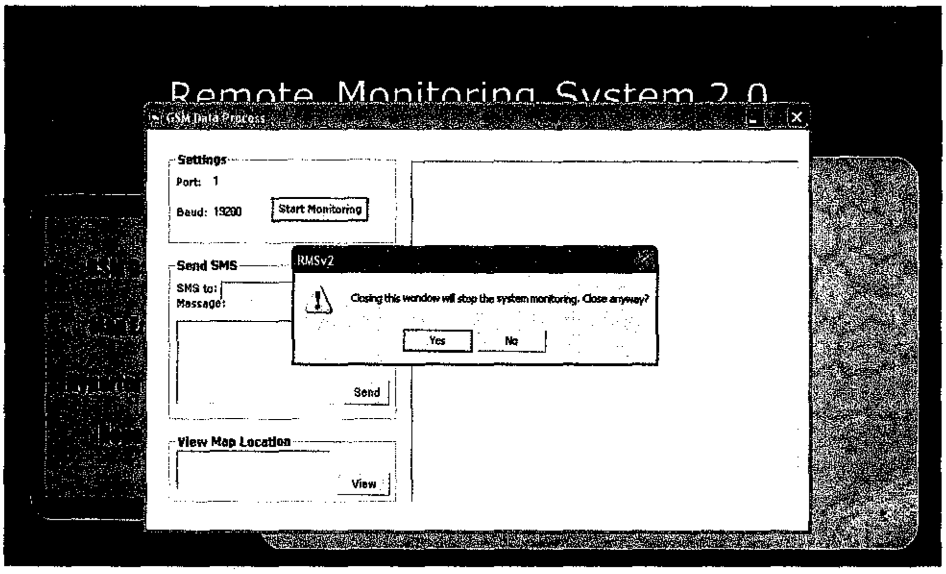

Figure 4.1: Users asked for confirmation

Another enhancement done in the GSM Data Process form is the dynamic drop down control included so users can pick staff names to send SMS to. This names are populated from the Staff table in the RMSv2 database.

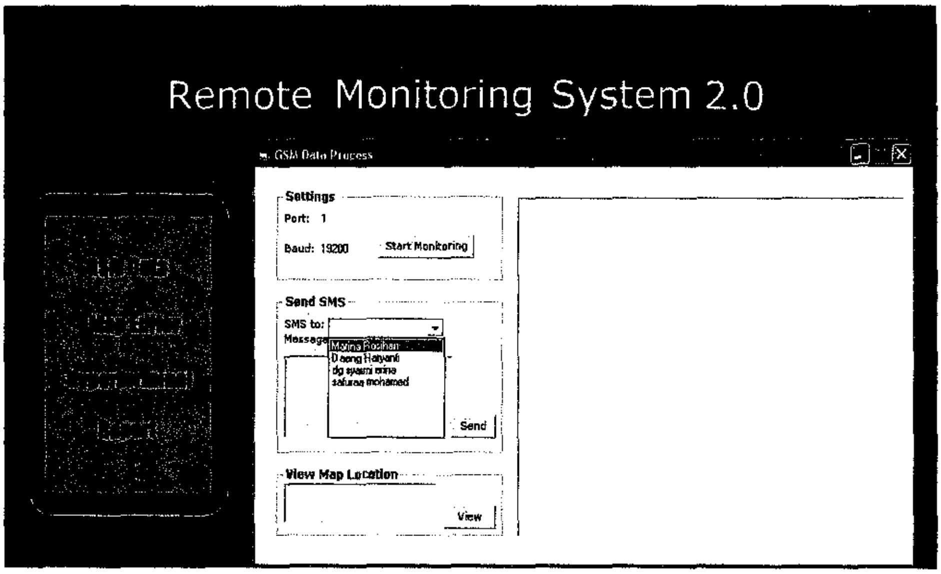

Figure 4.2: Dynamic drop down control populated with staff names

In the Report screen of RMS, error messages are displayed in binary numbers, making it hard for users to interpret. In RMSv2, the specific error type is displayed together with the message received.

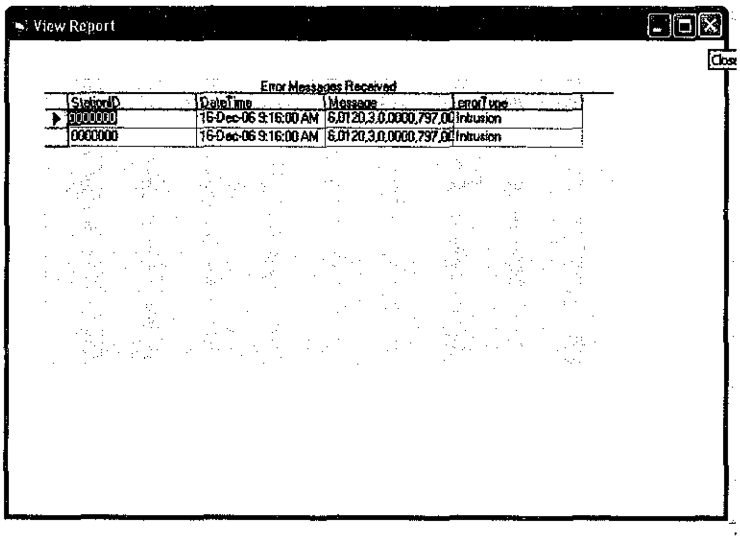

Figure 4.3: Error Type is displayed

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

SCADA systems are reliable in reducing cost and staffing. It has capabilities of monitoring processes, trending, failure alerting and data logging. The main drawbacks of SCADA systems are its high cost of software purchase and vulnerability to attacks.

To increase customizability, the project can be developed further to enable usage by more than one department. This would allow multiple monitoring as opposed to RMS, which is developed exclusively to monitor Petronas CP stations.

One potential area is smarthome, where remote monitoring can provide security to homeowners. Switches and other appliances status can be depicted on an interface. Owners can also control their appliances when not at home. This would prevent incidents such as fire.

It can also serve to help old people living alone. For instance, an alarm would be triggered if an elderly falls. This is detected by sensors on the floor. This way, the elderly can have independence that they would otherwise lose.

A two-way communication should be enabled between the central station and the remote terminal units. This way, a sensor check mechanism can be developed to check whether or not a sensor is working.

A feature that deletes messages from the SIM card whenever the SIM card's message storage is full can be added to the system. This will ensure smooth flow of incoming messages.

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