Design and Implementation of Locally Developed SCADA A Cost Effective Solution.

Tahir Nizamuddin, Author & Bilal Iqbal, Co-author

B.E Industrial Electronics

PCSIR, Institute of Industrial Electronics Engineering, (IIEE) Karachi

tnk786@yahoo.com, billalfb40@hotmail.com

Abstract

During the past decade, the industrial sector throughout the world has shifted from the classical methods of Control and Automation to the state of the art techniques. This allowed the industries to attain a higher percentage of growth and production, which consequently gave rise to reduction in costs of the products. In Pakistan, this trend of automation is gaining popularity at a very slow pace due to huge initial costs associated with it. This problem can be addressed by promoting locally developed SCADA systems, which might encourage the industries to take the path of modern automation.

I. INTRODUCTION

SCADA (Supervisory Control and Data Acquisition) as the name suggests is not a full control system but rather focuses on the supervisory level [8]. As such, it is a purely software package that is positioned on top of hardware to which it is interfaced, in general via Programmable Logic Controllers (PLCs), or other commercial hardware modules. SCADA systems are nowadays employed in major industries of the world including Oil and Gas, Petroleum, Food, Textile and other industrial sectors. In Pakistan also, SCADA systems is used in big budget industries like OMV Pakistan, SSGC, OGDCL, BP Exploration, Dewan Group of Industries, to name a few.

SCADA systems are developed by major companies, which include Wonderware Inc, Siemens, Rockwell Automation, Intellution and GE. However the prices they demand for their systems are discouraging the industries to switch towards automation.

This paper describes the SCADA systems in terms of their architecture and features so that local software industry can provide a locally developed SCADA system to industries, allowing them to have a competitive edge in the so called western dominated industrial era.

As a case study, "WinHMI", the SCADA system developed by our group will be presented which will provide the basic functionalities offered by the third party SCADA software being used in industries.

II. ARCHITECTURE OF SCADA SYSTEMS.

The architecture of SCADA systems consist of a client server topology where the data is gathered from different RTUs present in the field and the central MTU accumulates all the data and then stores it on a central database. This client server link is established by a modem or a wireless RF link that depends on the critical nature of the data and the distance between the RTUs and the MTU.

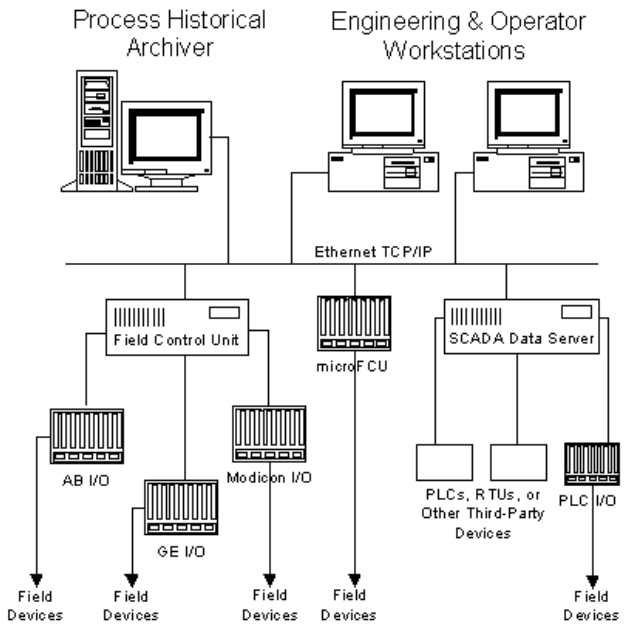

Fig 1: Architecture of SCADA system

A. *Hardware Architecture*

The hardware consists of field devices such as sensors, transducers, actuators, and loads, which are connected with the Programmable Logic Controller of any vendor. These PLCs will serve as the RTUs and they will send the data to the MTU (data server) through Modem or Wireless link. The link used in "WinHMI" is telephone line instead of a wireless link, due to time restrictions.

B. *Software Architecture*

The primary goal of SCADA system is to assist the operator in running a machine and managing a process. A good SCADA system will increase the productivity of the operator and machine, increase uptime, and assist in providing consistent product quality. The required functionality of SCADA will vary based upon the type and complexity of product produced, the type of machinery used, the skills of the operator, and the

degree of automation of the machinery. The types of functionality typically included are:

1.) Link between PLC and PC.
2.) Visual HMI
3.) Data Storage using Standard ODBC.
4.) Trending Real Time and Archived Data
5.) Creating Reports.
6.) Alarm Triggering using SMS technology
7.) Web Access

1.) PLC to PC Communication (OPC Servers).

OPC is an acronym for **O**LE for **P**rocess **C**ontrol and is used as the name for a standard interface for communication in automation engineering. OLE i.e. Object Linking and Embedding is a component software model of Microsoft. OPC Server basically connects the PLC to the front interface designed in any SCADA development tool e.g. Visual Basic, which is the development software of "WinHMI".

Fig 2: OPC Connectivity with Application

2.) Visual HMI.

Human Machine interface is Industrial Software used as a front end for Industrial Automation Systems while other devices such as Programmable Logic Controllers are used at the back end. It visually represents industrial devices in the form of visual components that indicate and up to some extent simulate characteristics of devices they represent. It is an integral part of any SCADA system and should be as clear and informative as possible.

3.) Data Storage using Standard ODBC [10]

The data mining facility should record the relevant data in the standard ODBC format, which include MS Access, Microsoft SQL, Oracle 8x or 9x and MS Excel (.CSV or .XLS). The data to be logged and the rate at which it should be logged should be dynamic and allowed to be changed by the operator of the SCADA system.

4.) Trending Real Time and Archived Data

To provide a means for visual analysis of data on current or past machine operation. Trending of data allows the decision makers to analyze and compare different data to make decisions. The trending option should be interactive and easy to understand. Bar Graphs, Pie Charts, and 3D Charts with configurable chart titles provide additional help to the operators and managers.

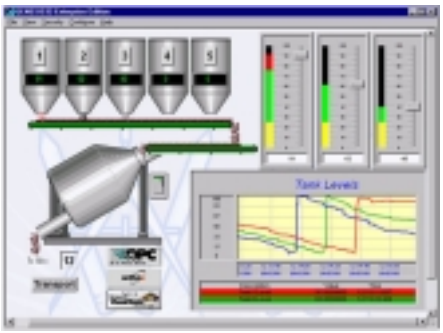

Fig 3: View of HMI (Courtesy ICONICS) [4]

5.) Creating Reports.

The user should be able to print daily, weekly or monthly report, which is a requirement no manager can live without. Reports are usually needed for documentation purpose and should have the entire process summary to give a snapshot of the data collected during the period.

6.) Alarm Triggering using SMS Technology

To provide notification to the operator of abnormal operating conditions and events. An added feature of Mobile based alarming facility provides extra flexibility. Whenever an alarming condition is detected by the PLC, it will send the signal to the PC that will then SMS the operator on its mobile devices. This enhances the SCADA operation of the system making the system more mobile and distributed.

7.) Web Access.

The Web Access should be fully bi-directional, which means you can not only view your process, but also fully control it from anywhere in the plant or around the planet. The viewing and controlling can be accomplished by using Microsoft IE, or any other browser, which can display Active Server Pages. The data is retrieved from the database, which resides at the server end.

III. IEEE STANDARDS FOR SCADA DESIGN.

A. *ISO 9241 [5]*

The ISO 9241 standard defines three components of quality of use applicable to the design of HMIs:

Effectiveness—Does the product do what the users require? Does it do the right thing?

Efficiency—Can the users learn the HMI quickly? Can they carry out their tasks with minimum expended effort, including a minimum of errors? Does it improve the productivity/effort ratio? Does it do things right?

Satisfaction—Do users express satisfaction with the product? Does the new product reduce stress? Do the end users now have a more satisfying job?

B. *ISO/IEC 11581 [2]*

When creating icons and visual objects representing real world objects for computer software there are many factors that the designer must consider from the

standpoint of both the user and the software. This standard defines those pre-defined set of rules.

C. IEEE 802 (Ethernet Protocol) [3]

It defines all the TCP/IP Transmission protocols and standards, which are used when data communication is achieved on a PC or a workstation present at a different area or platform. The transmission rate achieved is usually **1MBPS**, which also depends on the type of UTP or STP Cable, used, when LAN is considered or the speed of the modem when Internet is considered. Usually a rate of **56.6 KBPS** is achieved using a modem

D. OPC Standard (OLE for Process Control) [3]

The OPC standards specify the communication of industrial process data, alarms and events, historical data and batch process data between sensors, instruments, controllers, software systems and notification devices. This group of standards provides specifications for communicating real-time data from data acquisition devices such as **PLCs to display** and interface devices like **Human-Machine Interfaces (HMI).** The specifications focus on the continuous communication of data.

IV. VISUAL BASIC & SCADA [9]

By utilizing Visual Basic's built in functionality for user interface design and database connectivity and adding off-the-shelf plug-in objects or ActiveX controls for graphics, trending, PLC communications, and alarming, developers, OEMs, integrators, and users can create industrial SCADA applications. These applications have the flexibility to be designed in any way the user desires and are highly cost effective because they may be distributed in compiled form to many machines with few or no per machine royalty fees. The open architecture of Visual Basic allowing for the use of COM-based or ActiveX control plug-ins insures the developer will have choices when picking tools for building SCADA applications in Visual Basic. The presence of over 3,000,000 people worldwide who know Visual Basic provides investment protection for future modification and support of the application

V. IMPLEMENTATION

Our group implemented this SCADA concept as our final year project. The whole architecture described above was used and worked upon. Our main aim during the project work was to produce a SCADA system, which can be employed in any S&M industry without any hassle whatsoever. The IEEE Standards described above were used to make the software IEEE compliant. "WinHMI" offers complete SCADA functionality under Windows environment from single user to multi user environment.

- ***The Plant:***

The plant or the process on which this SCADA is tested is an industrial blending and mixing plant which mixes the two liquids according to the required concentration, maintains a required temperature and fills bottles of specified amount of liters. The operator gives all the parameters.

Fig 4: Main Screen "WinHMI"

The Following options are provided in this SCADA system

1) *User-friendly HMI*
2) *User settings*
3) *Security features and rights*
4) *Access to data archives*
5) *Networking*
1) *Report generation*
6) *Tag database*
7) *Mobile Alarming*

- *User-friendly HMI*

This HMI has a real time graphic display, which gives the complete visualization of the plant. This feature is important in any industrial HMI. The Data View model is also provided which gives the oscilloscope based visualization. The user can switch between the two views anytime during the real time monitoring. The components used in this HMI are Visual Basic ActiveX components, which are downloaded from Software Toolbox Inc.

The user or the operator is allowed to enter the parameter in the frame provided on the right hand side. These parameters are set points, which decide the output of the process.

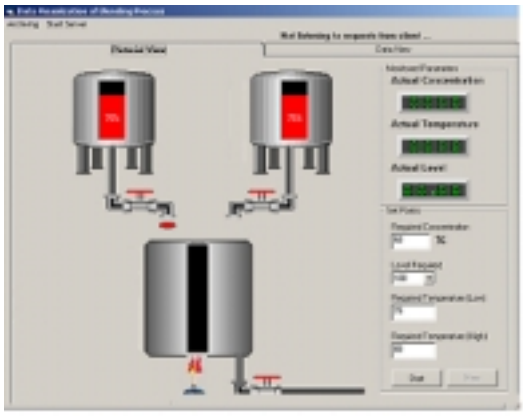

Fig 5: Real Time Data visualization screen "WinHMI"

- *User Settings*

The HMI allows the operator to set the parameters of the HMI according to the requirements. The settings page contains all the necessary settings, which the operator might need to change e.g. the logging time, the refresh rate, logging criteria etc, Client Server refresh rate.

The operator can switch to the Default values at any time, which are saved keeping in view the performance of the SCADA.

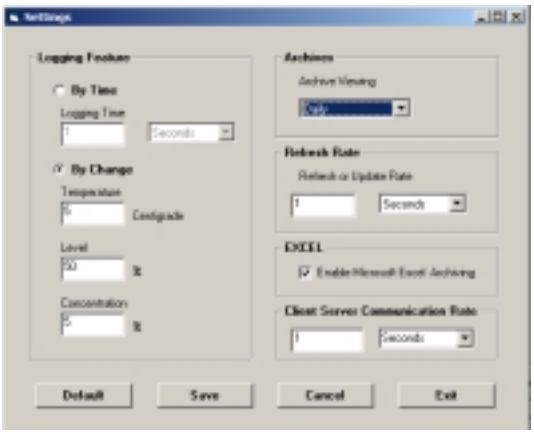

Fig 6: User Settings screen "WinHMI"

- *Security Features*

No SCADA can be implemented without taking care of the security concerns which, if not taken care of can make the industrial process vulnerable to frequent shutdowns. For this purpose different user access levels regulate the access rights that different people have.

1) Operators who can view the process and print reports of the process data.

2) Operators who in addition to above rights are allowed to start or stop the process

3) Operators who can also change the set points of the control process

4) Administrators who can give and take rights from the operators and can change the settings of the SCADA software.

- *Access to data archives*

The Data logging feature is also the fundamental part of an HMI. Here the Data is being logged simultaneously for trending and archiving purpose so that the user or the operator can view the Data any time afterwards. The data can be viewed on "Monthly Basis" or on "Daily Basis" which the user defines in the settings page. The data can be viewed later in the form of a Chart or in the form oh a Data Grid which provides a compact summary of the archived data

Most of the SCADA implementing industries require that their data be logged in Excel worksheet rather than in an MSAccess database. To cater their demands, this feature is also provided which allows the operator to log the data into Excel Worksheets as well.

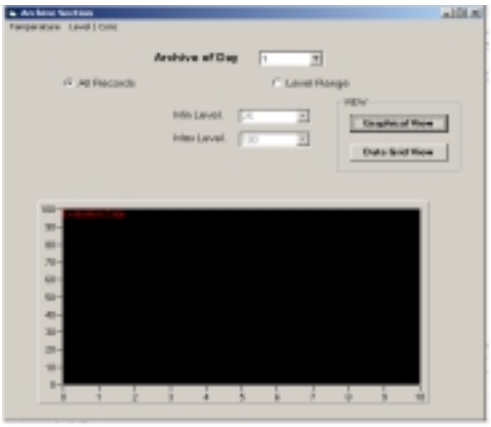

Fig 7: Data Archiver "WinHMI"

- *Networking*

The client server architecture is employed in "WinHMI" which allows upto eight RTUs to be connected to the main MTU. However, the connections are only limited to Local Area Network. The control, which is used to connect the RTU and MTU, is a Visual Basic tool "Winsock".

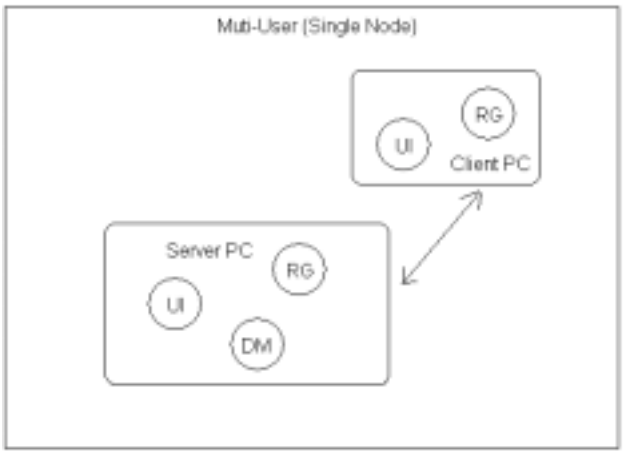

Fig 8: Implementation of SCADA network (Single Node).

At server side, the following methods listen to connections from the client.

```
' connect to the port
    tcpServer.LocalPort = 1256
    ' Listen for incoming data
    tcpServer.Listen
```

Similarly, at the client side, the following methods connect to the server.

```
tcpclient.Connect "192.168.0.1", 1256
    ITIme = 0
        While (Not bReplied) And (ITIme < 100000)
        DoEvents
```

```
    lTIme = lTIme + 1
   Wend

  If lTIme >= 100000 Then
     'Didn't reply or timed out. close the connection
     MsgBox "Unable to connect to remote server"
     Exit Sub
  End If
```

After making the connections, the data transfer is started by sending and receiving data using the Winsock method

```
1) frmintro.tcpclient.SendData sData
2) Private Sub tcpClient_DataArrival (ByVal bytesTotal As Long)
```

- *Report generation*

Report generation is also provided in this HMI. The user can view the monthly report or the daily report in a printed form for documentation purposes. This report contains all the process details, which has accomplished including the date, time when process started, and time when it ended, time taken by the process and no of fillings the process accomplished.
The max deviation from the set points during the process is also displayed to make sure that the quality of the required liquid remains under inspection.

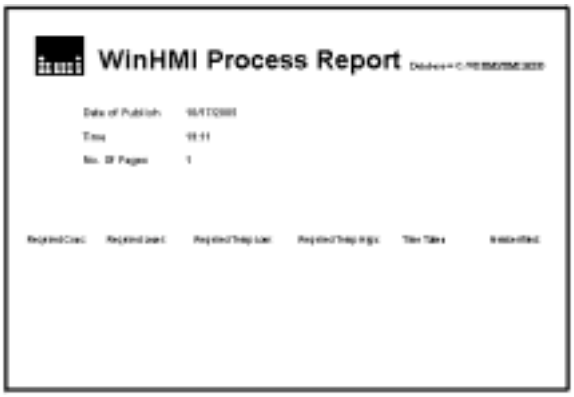

Fig 9: Report generation in "WinHMI"

- *Tag Database*

Tag database allows a summarized view of all the process variables. WinHMI provides this feature, which comes handy at the time of troubleshooting the problem, occurred during the process. Operators are not allowed to change the values of the process variables from this window; hence it can be termed as a Read Only window.

Fig 10: Tag Database

- *Mobile Alarming*

This feature is an effort to make the SCADA system more mobile and distributed. Very few SCADA systems are offering this feature. Whenever an alarming condition occurs during the process, immediately an SMS is sent to the mobile number saved in the software. This allows immediate handling of the situation even if the operator is not on seat. This feature is developed using a API called "SMS Gateway COM API", a product of Clickatell Inc.

VI. COST COMPARISON

The SCADA system developed by local developers will be much cheaper in cost due to the following reasons.

1.) No Loyalty Charges
2.) Limited Data Archiving Capacity and Features
3.) Lack of Features including Statistics and Estimation

SCADA Package	Cost of Purchase	Features Included
Siemens WinCC (Flexible)	$800	HMI, Trending, Alarming, Web Access, Statistics, IT & Business Integration
Locally Developed SCADA	$200 (Development Cost)	HMI, Alarming, Trending, Web Access, Data Archiving
Iconics Genesis32	$650	Data Mining, WebHMI, TrendWorX, AlarmWorX, VCRWorX

Table I: Price Comparison of SCADA systems

VII. CONCLUSION

It can be seen from the detailed analysis of the topic that the basic advantage of the above discussion is implementation of automated system in those industries, which are not aware of modern automation techniques. The use of SCADA in the industry will not only allow

them to minimize the cost associated with the display and recording instruments but will also account for better quality and higher productivity.

This SCADA system, which is implemented, is ready to use and has been tested with Siemens S7 314-IFM PLC. The multi-user operation has been tested.

However, there are some bugs and flaws in the discussed system when compared with the SCADA system in use, but gradual alterations and additions can be made since the basic architecture is available.

VIII. ACKNOWLEDGEMENT

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IX. KEY

SCADA – Supervisory Control and Data Acquisition
HMI - Human Machine Interface
S&M Industry – Small and Medium Industry
UI – User Interface
RG – Report Generator
DM – Data Manager
PLC – Programmable Logic Controller
MTU – Main Terminal Unit
RTU – Remote Terminal Unit
ISO – International Standard Organization
IEC – International Engineering Consortium

X. REFERENCES

[1] Richard Hodgkinson (IBM United Kingdom Ltd) & Denise Bell (Tivoli Systems) Bits & PCs - Designing Icons for Software Interfaces

[2] The Windows Interface Guidelines for Software Design, Microsoft Press, ISBN 1-55615-679-0

[3] Understanding, Applying and Implementing OPC, Demo Presentation, Matrikon OPC, Canada

[4] Genesis 32 Automation Suite Product Brief, ICONICS Inc.

[5] Usability Engineering by Jacob Nielson, Academic Press, ISBN 0125184069

[6] John B. Weber, Applying Visual Basic for Human Machine Interface Applications

[7] Axel Daniels & Wayne Salter, What is SCADA, CERN-CNL-2000-003 Vol. XXXV, issue no 3.

[8] Tony Stafford, Taking Back – A SCADA case study, Camrosa Water District, California. July 2002.

[9] Evangelos Petroutsos, Mastering Visual Basic 6, ISBN 81-7656-031-6, BPB Publications.

[10] Evangelos Petroutsos, Database Programming with Visual Basic 6, ISBN 81-7656-199-1, BPB Publications.