DEVELOPMENT OF SCADA LIKE APPLICATION USING ARDUINO WITH .NET INTERFACE

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ABSTRACT

Nowadays SCADA (Supervisory control and data acquisition) systems are used for Home automation, Greenhouse automation, E-agriculture etc. Basically these SCADA applications include Level Monitoring, Light & Climate Control, Security & Surveillance, control and manage spatially separated utility sites and Control of Shutters & Doors and so on. With the arrival of new hardware and software technologies here a system is proposed which can perform the similar SCADA applications at lower cost and lower maintenance. This paper proposes a viable solution for SCADA like applications which include Water level monitoring & control, Oil level monitoring & control and Displacement monitoring by using a microcontroller board and .NET interfacing. This system can not only perform these industrial applications but also proposes a fine web based solution to access all these acquired data and equipments. The Web interface was designed using Visual Studio with ASP.NET as the front end with SQL server as the back end which allows users to access monitoring panel. Here a remote based application is used which will allow the user to access the industrial data/equipments in industries via web/internet, it also overcomes the problem of weak encryption used by the SCADA. In future this system using .NET platform may replace these SCADA solutions.

Keywords: Arduino, .NET, SQL, SCADA, Web-Based solution.

1. INTRODUCTION

Traditionally some managers are required to collect accurate information for monitoring and controlling the equipments from remote assets such as pumps, tanks & booster stations of water/waste water, oil facilities etc. Conventionally this information is collected manually by collecting the recordings of the data. While manual collection of this data is the norm, plants want to move to an automated process using a central station for all monitoring and control, which can reduce or eliminate the need for manual data collections [1]. However, technological developments in the supervisory systems now make it possible to access process systems on the Internet [2]. Nowadays these types of applications are controlled by using Supervisory Control and Data Acquisition (SCADA) system. Basically SCADA is not a specific technology in fact it is a type of an application. Any application which gathers and analyses a system in order to control that system is an SCADA application. The proposed system can not only perform these industrial/SCADA applications but also proposes a fine web based solution to access all these acquired data and equipments.

Here a remote based application is used which can perform like an SCADA application will allow the user to access the industrial data/equipments in industries via web/internet, it also overcome the problem of weak encryption. This system is fully user-friendly and very cost effective with good flexibility. In this way the maintenance cost will be reduced and productivity will be increased. Apart from these advantages there are some limitations of this system like the problem of network coverage area of the users while sending the messages of equipment misalignment. To overcome this problem an alarm is also used here to sound in a predetermined fashion.

In general field devices are connected to the SCADA network, which is connected to the corporate network. Operators control the devices from PCs connected to the corporate network. Field devices consist of remote terminal units (RTU), programmable logic control (PLC), and intelligent electronic devices (IEDs). A number of RTUs in remote locations collect data from devices and send log data and alarms to a SCADA terminal using various communication links including traditional telephone and computer network, wireless network, and fiber-optic cables [3],[4].
SCADA systems provide real-time data acquisition (DAQ) and control all kinds of controllable plants. In addition, designing for SCADA-based systems could break through into interoperating with the World Wide Web (WWW), wide area networks (WAN), local area networks (LAN), and personal computers (PC) [5], [6]. The security features are already available in Internet technology like VPNs (Virtual Private Network).

A VPN tunnel is one simple way to ensure the security of the Ethernet traffic over the Internet. By creating a VPN tunnel between the remote modem and the SCADA system, the modem will be available on demand. This allows the SCADA master to do the polling [1].

### 1.1. Security Problems of SCADA system

i. It is a very bulky system, it requires a large maintenance.

ii. It is heavier and very expensive.

iii. It requires more power and having weak encryption.

iv. The SCADA system is more complicated than the sensor to panel type.

v. The operator can see only as far as the PLC [7].

vi. Since SCADA systems use leased telephone lines, twisted pair cable, microwave radio, and spread spectrum techniques, they have many of the same security vulnerabilities.

### 1.2. How does the .Net Interface Along with an Arduino Board Overcome these Problems?

With the introduction of .NET technology, by the Microsoft Inc., the whole internet technology is looking forward towards an era of integrating and unifying different languages platforms into one single framework. The installation of visual studio software is as simple as mounting the device. It offers multiple language support. It uses encryption for better security and consumes less power than that of the SCADA system. Also it is simple to use & requires less maintenance. It overcomes the security vulnerabilities of the SCADA system as the .NET interface doesn’t need any type of complex cabling. The Arduino IDE (Integrated Development Environment) is a cross-platform application written in Java, and is derived from the IDE for the Processing programming language and the Wiring project. It is designed to introduce programming to artists and other newcomers unfamiliar with software development.

### 2. APPLICATION ARCHITECTURE

The block diagram of the proposed system is shown in figure 1. The basic concept is to develop a system which can perform remote monitoring or controlling functions like the most widely used system in automation industries “The SCADA system”. Here an arduino board is used which is the heart of this system. An arduino board is nothing but a kit which is comprised of an atmega 8 bit µc chip with inbuilt ADC, a USB 8-bit FIFO IC means an FTDI driver that is serial/parallel interface converter and a power supply. The arduino board performs both monitoring & controlling action of the system.

![Figure 1. Block Diagram of the Proposed System](image-url)

Arduino hardware is programmed using a Wiring-based language (syntax and libraries), similar to C++ with some slight simplifications and modifications, and a Processing-based integrated development environment [8]. The Arduino IDE comes with a C/C++ library called “Wiring” (from the project of the same name), which makes many common input/output operations much easier. Arduino programs are written in C/C++, although users only need to define two functions to make a run able program:

i. setup() – a function run once at the start of a program that can initialize settings

ii. loop() – a function called repeatedly until the board powers off

A web server is designed using .NET interface on the USB Port of the laptop/PC. The web server is used to monitor...
the controlling action and restore all the information in the database. Here we are considering three real-time applications: (a) Water level monitoring & control (b) Oil level monitoring & control and (c) Displacement monitoring.

The Oil and water both have some different properties like water is a polar substance while oil is a non-polar. The arduino board is programmed here as per the requirement of the application which performs both controlling monitoring action for water & oil level and only monitoring action in case of the misalignment of the equipment a windows based programming is done. The web server can monitor all the three applications at a time. When the Oil/Water level will go below the set point the microcontroller performs its monitoring and controlling functions and the solenoid valve start feeding oil/water and when the Oil/water level will go above the set point the µc performs its monitoring and controlling functions and the solenoid valve stops feeding oil/water. Similarly in case of the displacement control whenever there will be a misalignment of one equipment with the other equipment it will give the information to the user by using the GPRS (General Packet Radio Service) module, it will send a message to the one user or the multiple user. Because of the wide coverage, the GSM(Global System for Mobile Communications)/3G networks can be used for implementation of telematics applications including automotive, home automation and also E-Agriculture domains[9]. GPRS is a packet-switched technology that is an extension of GSM. (GSM, Global System for Mobile Communications is a circuit-switched technology). The general difference between these types of networks is that the GSM net-work addresses all devices on the network by a phone number. On the GPRS/ EDGE network, all devices are addressable via an IP address, making data communications easy [1]. A key advantage of GPRS over GSM is that GPRS has a higher data transmission speed. GPRS can be used as the bearer of SMS.

This system is totally a self adaptive feedback control system. An alarm also sounds at a predefined level when a misalignment will occur that is nothing but an audio message. Hence we can say that this system have a supervisory property (Monitoring) as well as the data acquisition property (Data Repository) with a controlling function like an SCADA system. The developed system is much cheaper than that of the SCADA and also this system consumes less power. This project offers a low cost solution for the automation industries to be used in various automation domains like E-Agriculture, Home/Building automation and so on. A Username and password protection i.e. a log in process is also added here to permit the access to the system for only the authorized users. Once a system is connected to the internet, it is not impossible for other internet users to have access to the system that is why encryption is very important [10].

3. EXPERIMENTAL SET UP OVERVIEW

Figure 2 shows the experimental set up of the proposed system. It mainly comprises of an arduino board made by Bhasha Technologies, which is the heart of the experimental set up and few discrete components. A laptop/PC is needed for web interfacing.

![Figure 2. Experimental Set Up of the Proposed System](image)

3.1. Automatic Control (Self adaptive control system)

In so many applications, it’s not sufficient to be only able to measure the quantity. Many times we need to control the quantity. Either we need the quantity (water/oil level) to remain constant at some fixed value (i.e. set point) or we need to vary the quantity at some predetermined level. Adaptive control is the control method used by the controller which must adapt to a controlled system with parameters (e.g. when an aircraft flies its mass decreases gradually due to fuel consumption then that time a control action is needed that adapts itself to such changing conditions).

In this system we are trying to control the level of oil/water. First thing we have to do to control the level is to find the value of oil/water level to see at what level they are. After that we have to compare these measured values with the
desired value i.e. the set point. Is it higher/lower than the desired value? If yes then, how much? At last after comparing measured values to desired values, we should take the self adaptive control action.

3.2. Arduino Board

Arduino is nothing but an open source single board microcontroller which is designed to make the process of using electronics in multidisciplinary projects more accessible. Figure 3 shows the used arduino hardware set up. This kit can be made by us but it is not cost-effective so for the convenience it will be better to buy the hardware and develop the software. Here to develop the proposed system we use an arduino board made by Bhasha Technologies named as Freeduino USB. Freeduino USB is a cost effective, 100% hardware and software compatible to the popular Arduino Open Source Hardware platform.

Figure 3. Used Arduino Hardware Board [12]

3.3. Arduino Software Part

```c
/*
   DigitalReadSerial
   Reads a digital input on pin 2, prints the result to the serial monitor
   This example code is in the public domain.
*/
int WATERCNTRL =5;
int OILCNTRL =6;
int DISPCNTRL=7;
void setup() {
  Serial.begin(9600);
  pinMode(2, INPUT);
  pinMode(3,INPUT);
  pinMode(4,INPUT);
  pinMode(5,OUTPUT);
  pinMode(6,OUTPUT);
  pinMode(7,OUTPUT);
}
void loop() {
  int WATERVALUE = digitalRead(2);
  int OILVALUE = digitalRead(3);
  int DISPVALUE = digitalRead(4);
  delay(500);
  Serial.print("waterstatus");
  Serial.print(WATERVALUE, DEC);
  Serial.print("oilstatus");
  Serial.print(OILVALUE, DEC);
  Serial.print("displacementstatus");
  Serial.println(DISPVALUE, DEC);
  if (WATERVALUE == 1) {
    digitalWrite(WATERCNTRL, HIGH);
  }
else {
```

```c
```
4. OVERVIEW OF THE .NET INTERFACING

With the advent of computers, learning through computer-based environments (hypermedia tools, Web-based educational support, simulation environments, etc.) has dramatically increased [7]. In order to access the Internet remotely with a secure and authorized connection that is platform and device-independent the .NET framework provides an effective and ideal solution by using the concept of web services. The applications of web services provide a safe and secure connection at one end and the process or operation at the other end of the connection. The design of inbuilt web environment will be performed using web services in the .NET framework. The pages were designed using ASP.NET (Active Server Pages Dot Net) with SQL (Structured Query Language) server as the back end. Web services were then consumed from a different server into this server. The pages were integrated together and were hosted on the web.

A web server is a software tool, which manages (hosts) web pages and makes them available to browsers, either through a local network or through the Internet. Physically web servers and the client machines can be on same machine or separated miles apart. However this does not make any difference in terms of access. There are many web servers available in the market today. Apache, IIS (Internet Information Services), Enterprise Server by IPlanet are a few examples. ASP.NET runs on IIS network. The pages are created using VB.NET in ASP.NET as the front end. Since it is server side scripting, the code is compiled on the IIS, the web server for .NET. The VB code and the ASP code are embedded in a single page. Before the actual coding, all the required name spaces and libraries required for the code are called in using an import statement. These pages are referred as web forms in .NET terminology. All web forms have the extension of .ASPX.

The .NET Framework is a common environment for building, deploying, and running Web applications and Web Services. The .NET Framework contains a common language runtime and common class libraries – like ADO .NET, ASP .NET and Windows Forms - to provide advanced standard services that can be integrated into a variety of computer systems. The ADO.NET is a set of class libraries that comes with the Microsoft .NET framework. The .NET Framework provides a feature-rich application environment, simplified development and easy integration between a numbers of different development languages. The .NET Framework is language neutral. Currently it supports C++, C#, Visual Basic, and JScript (The Microsoft version of JavaScript). Microsoft's Visual Studio.NET is a common development environment for the new .NET Framework.

A Microsoft server-side Web technology ASP.NET takes an object-oriented programming approach to Web page execution. Every element in an ASP.NET page is treated as an object and run on the server. An ASP.NET page gets compiled into an intermediate language by a .NET Common Language Runtime-compliant compiler. Then a JIT (Just-in-Time) compiler turns the intermediate code to native machine code, and that machine code is eventually run on the processor. Because the code is run straight from the processor, pages load much faster. For most purposes, ASP.NET pages can be thought of just like normal HTML (Hyper Text Markup Language) pages that have certain marked up for special consideration. When .Net is installed, the local IIS web server is automatically configured to look out for files with the extension ‘.aspx’ and to use the ASP.NET module to handle them.

Partial Class _Default
Inherits System.Web.UI.Page
Protected Sub Button1_Click(ByVal sender As Object, ByVal e As System.EventArgs) Handles Button1.Click
    If TextBox1.text = "admin" And TextBox2.text = "password" Then
        Response.Redirect("livemonitoring.aspx")
    Else
        Label1.Text = "invalid uid or password"
    End If
End Sub
Protected Sub TextBox3_TextChanged(ByVal sender As Object, ByVal e As System.EventArgs) Handles TextBox3.TextChanged

digitalWrite(WATERCNTRL,LOW);
//
if (OILVALUE == 1) {
digitalWrite(OILCNTRL, HIGH);
}
else {
digitalWrite(OILCNTRL,LOW);
}
By using the above software part in Visual Studio, we created a Log In web page. After Log In, we get the status of the machine/equipments as shown in Figure 4.

![Screenshot of the Status of the Machine on Web Page](image)

**Figure 4.** Screenshot of the Status of the Machine on Web Page

### 5. Experimental Results

![Arduino Software Window with serial monitoring window](image)

**Figure 5.** Screenshot of Arduino Software Window with serial monitoring window

### 6. Conclusion and Future Work

This paper presents a system which has a supervisory property (Monitoring) as well as the data acquisition property (Data Repository) like an SCADA system. The developed system is much cheaper than that of the SCADA and also this system consumes less power. This project offers a low cost solution for the automation industries to be used in various automation domains like E-Agriculture, Home/Building automation and so on. This system can not only
perform these industrial applications but also proposes fine windows based solution to access all these acquired data and equipments. Here a remote based application is used which will allow the user to access the industrial data/equipments in industries via internet, it also overcome the problem of weak encryption used by the SCADA. This system is fully user-friendly and very cost effective with good flexibility. Apart from these advantages there are some limitations of this system like the problem of network coverage area of the users while sending the messages of equipment misalignment. To overcome this problem an alarm is also used here to sound in a predetermined fashion. In future this system using .NET platform may replace many SCADA solutions by using the advent programming skills.

REFERENCES

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