MULTI ELEMENT OPTICAL FIBRE SENSOR TELEMETRY AND CONTROL USING THE INTERNET

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Abstract: The interfacing of a sensor system to create a distributed network for both sensor interrogation and control via the Internet is reported on. The aim of this study is to create a platform to stimulate design and implementation of supervisory control systems using multiple sensors, which in this case have been chosen to be optical fibre based, but could also be applied to other areas of study.

Keywords: interfacing**,** internet, multiple sensors, web-based remote control.

1. INTRODUCTION

The Internet has experienced an unprecedented growth and is rapidly finding its way into becoming an integral part in the lives of modern citizens. The industry soon became aware of the vast potential of the Internet and the multitude of possible applications in various fields, including telecommunications and automation [1] [4]. Various technologies have been developed ranging from low cost global voice communications to remote monitoring and control of electronic devices [2].

It has become standard practice in industry to monitor and control machines and processes via a computer with a graphical user interface. The fact that the control computer has to be located in the plant poses an obstacle since it requires the user to view and control the process from a fixed location. Hence the need for a remote control and monitoring or sensing solutions had arisen, and many products have been created for this purpose. Optical fiber data transmission and also optical fiber sensors fill this role particularly well because it is immune to electrical interference and can withstand operation in harsh conditions [1].

The approach used in this aspect of the study is such that it provides an in-depth coverage of all the main aspects related to web based control by avoiding the use of specialised automation software. Any researcher can therefore better appreciate the integration of the various technologies that make up the system. It is expected that the devised system will be a low cost product, which can be used in an industrial or educational environment and easily modifiable for particular applications, especially for student project development. This paper presents a design overview of a proposed multi-element optical fibre sensor interface to the internet. The optical fibre sensor design is not discussed in this paper.

2. CONCEPTUAL DESCRIPTION

The interfacing of a sensor system to create a distributed network for both sensor interrogation and control via the Internet is a topic that is of interest in modern control processes [2]. The aim of this study is to create a platform to stimulate design and implementation of supervisory control systems using multiple sensors, which in this case have been chosen to be optical fibre based, but could also be applied to other areas of study, such as education [3].

The aim of the project was to develop a system for web-based remote control of industrial processes with a fibre optic interfacing. In a previous design a 8 optical fibre sensors was developed and multiplexed. This design is meant to interface to the multi-element optical fibre sensor system. The product will be made up of a combination of hardware and software. An example of a typical application and operation of the system will be provided in the paragraphs that follow.

The system could be installed in the following manner:
A dedicated controller would be connected to devices that can be controlled, for example switched on or off. These could be motors, valves or any other electrical apparatus. In addition, the controller would be able to read from eight general analogue channels, which would, be the opto electronic conversion from a intensity based multiplexed Mach Zehnder or Fabry Perrot sensor system. These channels can also be connected to the output of any properly calibrated transducer (a device that converts any physical quantity such as force, pressure, sound volume, or light, into a voltage of corresponding intensity). The controller can also read the state of general-purpose

alarms (on or off), would be located near the devices to be controlled and connected via optical fibre to the main computer from which it receives the commands.

The main computer would be permanently connected to the Internet and be configured as a web server, which means that it can be accessed with any standard web browser. The user can be located anywhere in the world and need only have Internet access via a computer equipped with a graphical web browser.

After typing the appropriate URL in the web browser the user is presented with a web page and requested to enter a username and a password. If these are accepted another web page is shown which displays the current state of the devices in the factory. The user can see which devices are currently turned on or off, if any alarm is activated, and the values of the eight analogue channels. The user should also be able to turn a device on or off, by clicking on the appropriate button on the web page. The web browser will send this request to the web server, which will in turn send the appropriate signal to the controller, which will carry out the action. Finally, the user will be able to see if the instruction was carried out successfully from the resulting web page.

The web page will automatically update itself periodically, so that it displays the most recent state of the devices in the plant. Therefore, the system will provide a real-time monitoring and control of the devices in the factory.

3. DESIGN SPECIFICS

3.1 Technical Specifications

The project as a whole can be divided into three different parts: the controller, the computer that acts as a web server, and the web pages seen by the user.

3.1.1 The Controller

A dedicated microcontroller-based computer, hereby referred to as 'the controller', was designed and built to perform the actual control and monitoring of the electrical devices attached to it. It was a robust standalone unit powered from the mains supply, and capable of operating continuously without interruption. Table 1 lists the I/O (input/output) lines connected to the controller and a description of their purpose.

Table 1: Controller I/O Lines

I/O Name	Purpose
8 Control lines	To turn devices on or off and to read their current state
8 Input channels	To read the current value of O/F sensor inputs
3 General purpose Alarms	To read the current state of the alarms (on or off)

The eight digital control lines can either read or toggle the state of the corresponding devices. The eight input channels can each be connected to the output of a transducer so that the voltage read corresponds to a particular measurement such as pressure, force or the level of a chemical in a tank, just to name a few, or as it was configured in this case, to 8 optical fibre sensor inputs. The actual measurement to be made is left to the discretion of the user, for greater flexibility. Three digital inputs are available to monitor the state of three general-purpose alarms. The user can choose which alarms to connect to these inputs. For example, one could be a fire alarm, the second alarm could be used for indicating a power failure, and the other to signal that some device in the factory is not operating properly. The controller is to be located in the plant, near the devices connected to it.

3.1.2 The Web Server

The web server is an essential component of the system, since it provides the link between the remote user and the controller. It will be installed on an IBM-compatible PC running the Linux operating system. The computer will be connected to the controller via fibre optic cables, in order to enable reliable data communications between the computer and the controller to be established, even in an environment prone to electrical noise.

As it is usual with a web server, the computer should have a permanent connection to the Internet (such as an ISDN or leased line), to enable remote control and monitoring at any time. The type of connection used is not critical to the project and should be chosen according to the individual needs of the application. A higher bandwidth connection is preferable if a large number of simultaneous visits to the web site are expected.

3.1.3 The Web Site

The web site is the collection of all the web pages designed to provide the interface between the user and the system [4] [6]. The home page of the web site will prompt the user for a login name and a password. There will always be only one login name called 'supervisor', which should be given to the person in charge of administrating the system. The supervisor will be able to add or delete guest users to the system, who will be able to monitor the state of the plant but unable to make any changes.

If the user logs in as a supervisor a web page will be shown displaying the current state of the eight control lines, the state of the three alarms and the values of the eight analogue channels. In addition, eight buttons will be available so that the supervisor can toggle the state of any of the devices connected to the control lines. A link to a web page where the supervisor can add or delete users will also be given.

All other users will not have these buttons available nor will they be granted access to the administration page.

Whenever the supervisor clicks on a button to switch a device on or off, another web page is created informing the user if the action was successfully carried out by the controller or otherwise.

The web pages will automatically be refreshed periodically so that all users can see the current state of the plant without the need to click any button.

It can be seen and understood that the project is not aimed at controlling a specific device or at providing automation for a particular factory or plant. The goal is to develop general or generic web based remote control technology that can readily be used for simple tasks, and easily adapted for specific applications, especially for student research applications involving optical fibre sensors. It is therefore clear that the requirements of any particular industrial process to be controlled would need to be taken into account so that the necessary changes in hardware and software could be made to the system. This is often the case in industrial automation, where a custom solution has to be developed for a particular application. This aspect of the project covers the front end and will largely concentrate on the software required to make this web interface work.

4. DESIGN OVERVIEW

The following section presents a design overview and the constraints that needed to be overcome. A brief explanation of the terminology used in Internet technology is also given. The World Wide Web is covered first, followed by a short discussion on the common gateway interface (CGI).

4.1 The World Wide Web

The World Wide Web, often called simply the web, is well known to users of the Internet. It is the collection of all HTML (HyperText Markup Language) documents available on the Internet, stored on different computers all over the world. Besides a permanent Internet connection, these computers run special server software which enables them to send HTML documents to a web browser. Hence, they are called web servers.

In networking terminology, a server is a computer that sends data to another computer called a client. The term is sometimes interchangeable, since a two-way communication is usually established [4]. The communication between the web browser (the client) and the web server is regulated by a set of procedures called the HyperText Transfer Protocol (HTTP). The distinction between the HTTP protocol and TCP/IP (Transfer Control Protocol/Internet Protocol) should be clear. HTTP is the protocol that regulates the flow of information between the web browser and the web server, without regard for the means actually used to transfer the data. The latter is the role of the TCP/IP protocol, which ensures that data is transferred reliably between the client and the server across the network.

4.2 The Common Gateway Interface

In a typical Internet browsing session, the user types in the URL (Uniform Resource Locator) which contains the address of the HTML document to be viewed. The web browser sends the request to the web server which replies by sending the document requested (or an error code, if the operation is not successful). Clicking on a hyperlink on the web page, results on another HTML document being displayed. The need for more interactivity between the user and the server led to the creation of the common gateway interface (CGI) which enables small programs to be executed to perform a variety of functions beyond that which is possible with HTML.

CGI is not a programming language, but an interface that allows small programs to interact with the web server (also called HTTP server). These programs, which may be written in any language, are called CGI programs or CGI scripts.

4.3 Approaches To Web Based Remote Control

There are many ways to implement a remote control and monitoring system using the Internet as the communication medium. Some of the commonly used methods are very briefly mentioned here.

LabView is commercial software for instrumentation and industrial automation with capabilities for remote control of equipment via the Internet. It has its own web server, which needs to be installed on the host computer with the appropriate hardware attached to it.

The FIX web server was created by Intellution, the company that developed the well-known SCADA (Supervisory Control and Data Acquisition) systems. The FIX web server is part of the FIX family of software, and enables users to view FIX plant process graphics in any standard web browser.

Presently the application of IP over wireless is investigated to further enhance the operation of the system.

4.4 Proposed Solution

The diagram of the web based remote control system is shown in figure 1. The client PC is the remote computer used to control and monitor the process. It is linked to the Internet via an unspecified connection. The web server is located in the plant and should have a permanent connection to the Internet, such as an ISDN line. The web server is connected to the first fibre optic transceiver (FOT1) via an RS-232 cable. FOT1 converts the serial data into equivalent optical information suitable for

transmission over the pair of optical fibres. It also reads the optical data received from the optical fibre and converts it into the equivalent electrical signal. The fibre optic transceiver on the other end (FOT2) has the same role as FOT1, enabling a serial communication to be established between the web server and the controller over the pair of fibre optic cables.

One solid-state relay will be connected to each control line, so that electrical devices or processes can be turned on or off.

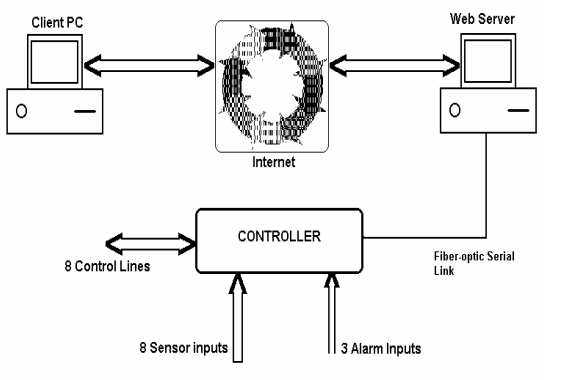

Figure 1: Diagram of the web based remote sensor interface and control system

The following is a description of how the system works on the software level. The home page requests the user to enter a login name and a password. Clicking on the submit button causes the browser to send the information encoded with the HTTP protocol to the web server, which executes CGI program 1. CGI program 1 checks that the username and password are valid, requests the current state of the process from the controller and generates a web page displaying the current state of the plant, based on the values received by the controller. The software written for the CGI program and the controller (called firmware, since it is stored in the program memory of the microcontroller chip) implement a protocol that enables a reliable communication between the web server and the controller to be established.

The web page displayed on the browser refreshes itself automatically by reading the most recent state of the plant as indicated by the web server. If the user logged in as a supervisor, additional buttons are displayed on the web page for toggling the state (on or off) of the eight control lines. This request is send to the web server that runs CGI program 2, which takes care of sending the appropriate signal to the controller. CGI program 2 also generates another web page indicating the result of the operation. The user can continue in the same manner, changing states as required or simply monitoring the plant.

The automatic update of the web pages will be achieved with the use of Java Applets. Java applets are small programs written in the Java programming language, which run on the client computer, adding special features to a web page [5].

5. CONCLUSION

This paper describes the technology available to design a remote access and control interface to a process monitored by 8 multiplexed optical fibre sensor lines, by means of the Internet. The technique was developed to achieve low initial investment cost as well as low operating and maintenance cost.

6. REFERENCES

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