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Distributed data acquisition and control system based on low cost Embedded Web servers

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Distributed data acquisition and control system based on low cost Embedded Web servers

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Abstract- In the present IT age, we are in need of fully automated industrial system. To design of Data Acquisition System (DAS) and its control is a challenging part of any measurement, automation and control system applications. Advancement in technology is very well reflected and supported by changes in measurement and control instrumentation. To move to high-speed serial from Parallel bus architectures has become prevalent and among these Ethernet is the most preferred switched Serial bus, which is forward-looking and backward-compatible. Great stride have been made in promoting Ethernet use for industrial networks and factory automation. The Web based distributed measurement and control is slowly replacing parallel architectures due to its non-crate architecture which reduces complexities of cooling, maintenance etc. for slow speed field processing. A new kind of expandable, distributed large I/O data acquisition system based on low cost microcontroller based electronic web server[1] boards has been investigated and developed in this paper, whose hardware boards use 8-bit RISC processor with Ethernet controller, and software platform use AVR-GCC for firmware and Python for OS independent man machine interface. This system can measure all kinds of electrical and thermal parameters such as voltage, current, thermocouple, RTD, and so on. The measured data can be displayed on web pages at different geographical locations, and at the same time can be transmitted through RJ-45 Ethernet network to remote DAS or DCS monitoring system by using HTTP protocol. A central embedded single board computer (SBC) can act as a central CPU to communicate between web servers automatically.

Keywords- Embedded Web server; remote I/O data; data acquisition and monitoring system (DAS or DCS), Real Time Processing, Data-acquisition, TCP/IP, AVR-GCC

I. INTRODUCTION

Electrical systems are necessary in each kind of building such as research laboratories, homes, factories, hospitals and so on. In many cases electrical systems manage critical applications, like freezer temperature, incubator internal temperature and so on [3]. All these systems contain devices that are sensitive to voltage variations, current deviations and to all the power quality and quantities [1] [2]. This system can measure and store any kind of electrical and non-electrical signals in embedded web server. And it can able to control the devices remotely. Embedded Web based acquisition and control system can adapt to the strict requirements of the data acquisition system, such as the function, reliability, cost, size, power consumption, and so on. In this paper, a new kind of remote I/O distributed data acquisition system based on embedded Web server has been investigated and developed, which can measure all kinds of electrical and thermal parameters such as voltage, current, thermocouple, RTD, and so on.[4] The measured data can be displayed through web pages from the server, and at the same time can be acquired at different geographical locations through RJ-45 Ethernet network using python based MMI to remote DAS or DCS monitoring system by using HTTP protocol. The system has the dual redundant network and global communication function, which can ensure the disturb rejection capability and reliability of the communication network. A central SBC can act as a central CPU to communicate between web servers.

II. STRUCTURE DESIGN OF THE WHOLE SYSTEM

The whole structure chart of the remote distributed data acquisition and monitoring system based on embedded web server platform is shown in Figure 1. In the scheme of the system, the remote I/O data acquisition modules are developed as embedded web servers having static IP with port 80, which can be widely used to diversified industries such as electric power, petroleum, chemical, metallurgy, steel, transportation and so on. This system is mainly used for the concentrative acquisition and conversion of a variety of electrical and thermal signals such as voltage, current, thermal resistance, thermocouple in the production process. The hardware boards which are built around microchip Ethernet controller (ENC28J60), Tx/Rx, MAC and PHY in one small chip, and ATmega-328P processors through Ethernet transformer, Magjack; RJ45 with integrated magnetics and LEDs or Ethernet network communication interface by using TCP/IP protocol. ENC28J60 is a small chip with 28 pins only and has a SPI interface which is easy to use from any microcontroller. The data in the embedded controller platform is transmitted to the remote client centers by Ethernet after further analyzed and processed. At

the same time, these data can be stored in the real time of the server. The system has the dual redundant network and global communication function, which can ensure the disturb rejection capability and reliability of the communication network. The hardware platform of the Remote distributed I/O data acquisition system based on embedded web server, a smart small TCP/IP stack by Guido Socher [1], uses 8-bit RISC processor with Ethernet controller. The MMI software platform uses the Python which runs HTTP Client GET-method on Ubuntu operating system.

The system is based on utilizing Embedded Web Servers (EWS) technology to design a Web-based Distributed Data Acquisition System (DDAS).

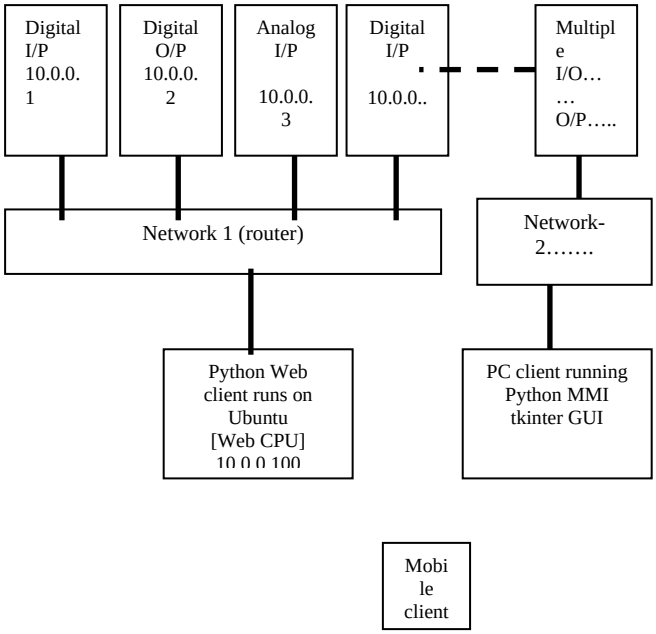

Figure 1. Structure of the whole system.

III. THE HARDWARE DESIGN OF THE SYSTEM

The general hardware structure of the Distributed data acquisition and control system based on EWS is shown in Fig 3. The distributed I/O data acquisition and control system based on embedded web server has each acquisition and control device equipped with 24-way acquisition/control channels for Analog input, Digital input & output. Each I/O channel can select a variety of electrical and non electrical signals like current, voltage, resistance etc. The measured data are stored in memory in which the memory is act as a data base during web server mode. The Ethernet controller directly supports the Ethernet service and RJ-45 communication. Hence the data has been stored and controlled by some other PCs or network via Ethernet.

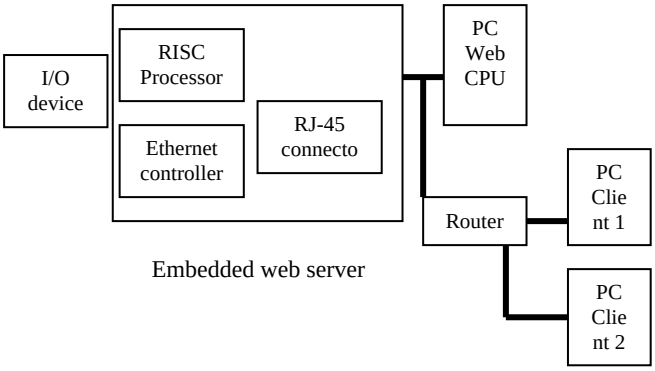

Figure 2. Structure of the distributed I/O data acquisition system based on Embedded Web server.

IV. SOFTWARE DESIGN AND REALIZATION OF THE SYSTEM

The system software of the distributed I/O data acquisition system based on embedded web server in Ubuntu platform, which is open-source and can be grafted, cut out and solidified with Python and PyQt. One of the main features of Python is that it is intrinsically very readable. PyQt are a set of Python bindings for Qt - a cross-platform application development framework that is used for creating GUI programs. PyQt allows creating custom-designed, Python-based GUI easily [6].

The basic functions including task management, system management, timer management, information management, queue management and so on. These functions are used though GUI service functions of the core.

The pseudo code for acquiring data from different I/Os are given below. Data1, data2, data3, data….n represents every I/O read return value which contains status of read. Index.html will contain the result data string.

```
mydatastations = [ ’10.0.0.1’, ’10.0.0.2’, ’10.0.0.3’]

import httplib

conn1 = httplib.HTTPConnection("10.0.0.1")

conn1.request("HEAD","/index.html")

res1 = conn.getresponse()

data1 = res1.read()

print data1

conn2 = httplib.HTTPConnection("10.0.0.2")

conn2.request("HEAD","/index.html")

res2 = conn.getresponse()
```

```
data2 = res2.read()
print data2
conn3 = httplib.HTTPConnection("10.0.0.3")
conn3.request("HEAD","/index.html")
res3 = conn.getresponse()
data3 = res3.read()
print data3
```

A test GUI designed to test such a set-up in Python is given below:

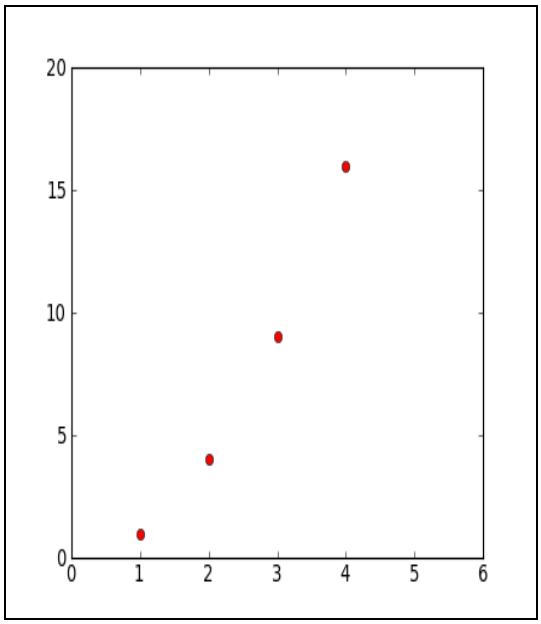

Figure 3. Pyplot data plot (ON/OFF LEDs)

A web server concept is useful to stream data through text files through standard http clients. So designing an MMI can have multiple options of language selection. Some of the common options to explore web server PLC MMI are LabVIEW, Python, Qt, PyQt, HTML & Javascript.

V. COMMENTS ON THE PROTOTYPE

The proposed system has a lot of benefits. The usage of standard protocols both for the acquisition network and for the distributed remote controlling. Moreover the Internet connection can be realized using both Ethernet and also be realized by Wi-Fi data link protocols [1]. Also embedded web servers guarantee a high robustness in terms of boot time and they can work also without any power supply (PoE) [1]. The prototype can be easily extended to more devices or machines. The system is demonstrated to be suitable for different embedded applications by attaching several real-time modules through appropriate interfaces.
Regarding the security issue, the prototype takes into account only a cipher authentication. So, adding security to this system is currently not in the scope of this work, presently it is for network which is private and standalone. So, using the screenshots coming from the developed application we will show how it is possible to use the proposed data acquisition system for a controlled channel. For that we have to reach the embedded web server by typing its address into the web browser (for example we tested the prototype in a LAN, where the server has the 10.0.0.40 address) and each web clients differ by the IP addresses. This produces the login form of Fig. 4. During the programming stage we set the credentials of the authorized users.

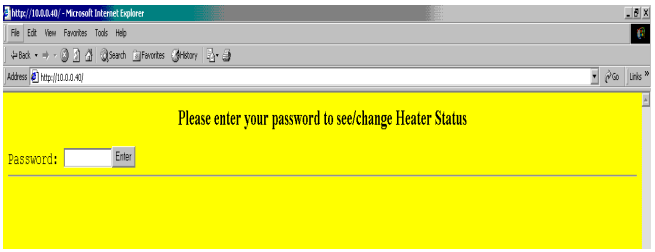

Figure 4. Snapshot of Home page, PC client 1

Figure 5. Snapshot of Monitor and Control selection page, for PC client 2

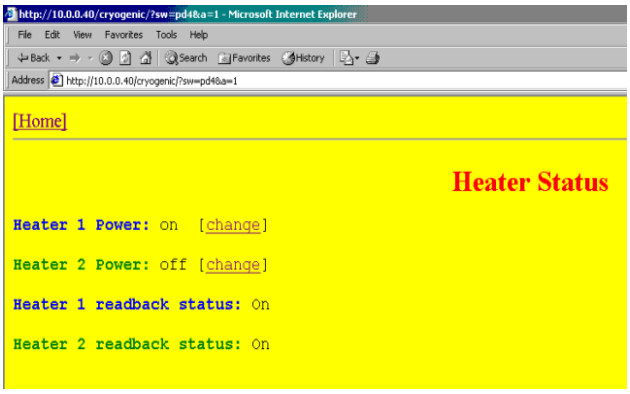

Figure 6. Snapshot of Status and Control page, for PC client 3

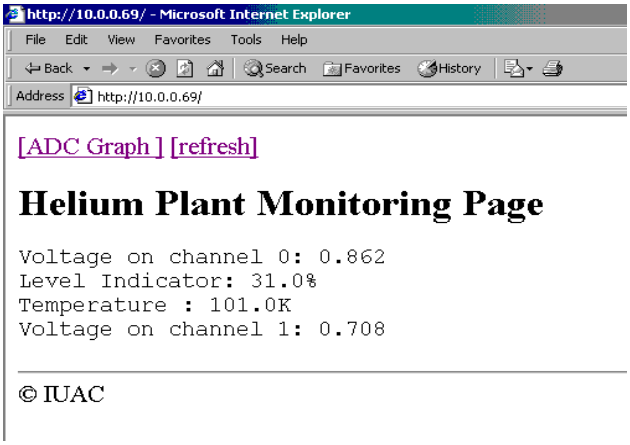

Figure 7. Snapshot of Monitoring page, for PC client 4

VI. CONCLUSIONS

A distributed and data acquisition and control system based on embedded Web server is designed in this paper. The system adopts Browser/Server mode and control the remote systems. Therefore, remote users can control and manage the operation using a Web browser over the internet.
With the rapid development of the field of industrial process control and the wide range of applications of network, intelligence, digital distributed control System, it is necessary to make a higher demand of the data accuracy and reliability of the control system. This embedded system can adapt to the strict requirements of the data acquisition and control system such as the function, reliability, cost, size, power consumption, and remote access and so on. This system operated by DDAS mode to acquire the signals and control the devices remotely. Embedded web server mode is used to share the data with clients in online. This concept can be widely applied to write MMI using LabVIEW, .NET etc.

ACKNOWLEDGMENT

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