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Embedded Web Server for Real Time Applications

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***Abstract* – The embedded systems have become important, especially for monitoring and control the industrial or home devices. This paper presents the design and development of interactive data acquisition and control system (IDACS) by using ARM9 processor and embedded web server application. The Embedded web server application and RTOS (Real Time Operating System), both are ported on ARM processor. The web pages which are required for web server are written by Hypertext markup language (HTML). It can be a network, intelligent and digital distributed control system. Single chip IDACS method improves the processing capability of a system and overcomes the problem of poor real time and reliability. It is beneficial for real time IDACS, Mission critical applications, remote data acquisition system, ATM networks and more.**

***Keywords* – Interactive Data Acquisition and Control System (IDACS), ARM, Embedded Web Server, RTOS (Real Time Operating System).**

I. INTRODUCTION

Data-acquisition system is widely used in industry field and consumer applications. In some applications, human beings have been replaced by unmanned devices that will acquire data and relay the data back to the base. There are data-acquisition and control devices that will be a substitute for a supervisor in a multisite job operation. A single person can monitor and even interact with the ongoing work from a single base station.

The aim of this project is to present a new system that consist of inbuilt Data Acquisition and Control system (DACS) with on-line interaction. Embedded Web Server is a system which consists of Internet software as well as application code for monitoring and controlling. By embedding Ethernet onto a device, it has the capability to communicate via Ethernet without using a computer. The server enables Web access to the automation and monitoring system and provides a scalable networking solution that is optimized for industrial automation. The users can browse the application pages of the system using web browser, and control the industrial appliances and enquire about their operational status. This IDACS system can able to measure the remote signals and control the devices through the reliable protocols and communication network. This system uses Real Time operating system to measure and control the whole process and embedded web server mode requires less usage, high reliability, security, controllability and portability. The client can access the whole industry from any remote place via its own local browser. In industry the single ARM acts as data acquisition and control system and as web server, so the system is compact with less complexity [1]. In this paper the system replaces the traditional system for remote access and control by embedded web server with Real Time Linux operating system. In a low operational-cost but flexible Internet-based data-acquisition system the main core of the system is an embedded hardware running a scaled-down version of Linux: a popular choice of operating system for embedded applications. A novel approach is introduced to minimize the operational costs while operating with a large amount of data. The system is demonstrated to be suitable for different embedded applications by attaching several real-time modules through appropriate interfaces acquiring function and data collecting and processing function into the single board based embedded system [2].

The new device offers a real-time, flexible, multi-channels, medium and high speed simultaneous signal acquisition, and programmable gain amplifiers are integrated into it. This paper described the new DAQ device in detail [4]. A networked DAS architecture where the software resources required by the data acquisition (DAQ) units are acquired from a server dynamically, to be stored and executed in local memory. When the DAQ unit needs to call an operation not contained in its memory, the new operation is requested from the server, while resources occupied by operations [5]. The porting of RTLinux on ARM platforms while configuring the real time kernel for above platforms, we need to select proper processor type. This paper also described the steps for running any real-time applications on ARM platform [6]. The principles and to design a system for Internet-based data acquisition system and control by using Advanced RISC Machine (ARM7/9) processor and in-build web server application with General Packet Radio Service (GPRS) technology. The main core of the system is an embedded hardware running on a NUT OS, an industrial grade RTOS for hard time applications. The embedded device communicates through General Packet Radio Service (GPRS), which makes it accessible from anywhere in the world through a web server built into the embedded device [3].The development of an embedded web server using ARM processor and a Real Time Operating System, RTOS. RTOS is used to monitor all the tasks of the web server. Embedded ‘C’ language has been used for the software implementation of the embedded web server. The web pages which are required for the web server were developed using HTML. The RTOS was successfully

ported on the ARM and the web server application is configured with the Real Time operating system. Both, the operating system and the web server application are ported on the ARM. This embedded web server is tested for its working, using a data acquisition web application hosted over a network of PC's [7].

II. Overview of IDACS

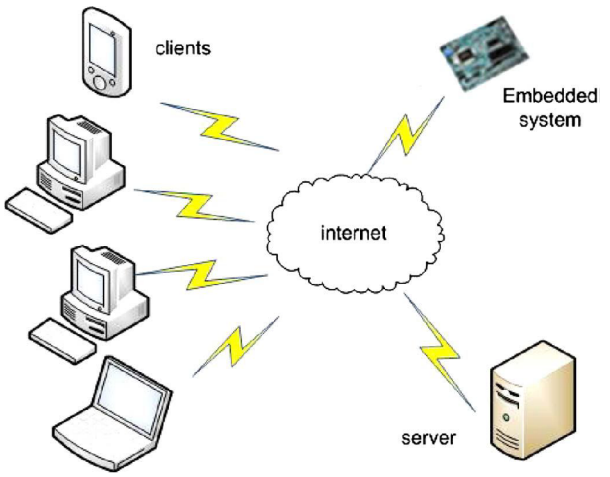

Fig.1. General Diagram of a DACS

Interactive Internet-based systems provide a way to monitor and adjust using standard web browsers and a PC. The target systems can be monitored and controlled independently from the location and the platform since standard web browsers can be used on the client side [3]. A typical data-acquisition system is connected to web clients via the Internet, as shown in Fig. 1. The data acquisition system needs to relay the acquired information for requesting clients. Digitally acquired data is stored in web server's data base. Whenever the client wants to access data, it sends the request to server; this request is taken by the router, which is connected to the internet. The web processes the request made by the client and finally connects to the desired web server to access the requested data and sends the data to the client.

Embedded Web Server:

A web server can be embedded in a device for providing remote access from a web browser to the device. The embedded system can be utilized to serve the embedded web documents, including static and dynamic information about embedded systems, to web browsers. Such type of web server is called an Embedded Web Server.

An embedded web server is an ARM processor that consists of an internet software suite and application code for monitoring and controlling machines/systems [3]. Embedded web servers are integral part of an embedded network. The proposed concept of DACS with embedded web server is developed on a single chip module. This is a single hardware which contains RTOS portable on ARM processor. The ARM processor is the responsible part for measuring signals and controlling the devices remotely. Measurements can be done by DACS mode and the data are shared with clients through embedded web server by embedded web server mode.

The Real Time Operating System manages all the required tasks in parallel and small amounts of time. Web based management user interfaces using embedded web server have many advantages: low development cost and high maintainability, ubiquity, user-friendly. Embedded web server has different requirements, such as low resource usage, high reliability, security, portability and controllability for which general web server technologies are unsuitable.

III. Block Diagram

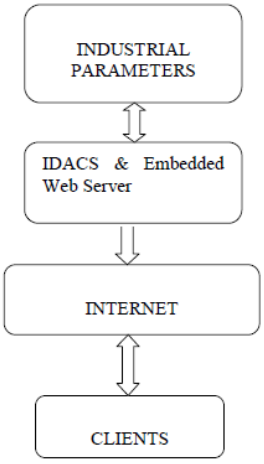

Fig.2 System Overview

A. Block Diagram Description

The overview of IDACS system and Embedded Web Server is shown in Fig 2. In hardware it is the major part of system. This system consists of single ARM processor which is portable with real time operating system. ARM processor is heart of this system. All processes are allocated with important resources and associated with reliable internet protocols followed by ARM9 processor.

Client:

To relay the acquired information to the requesting clients the data acquisition system is needed. The digitally acquired data get stored in web server's data base. Whenever the client wants to access data, it sends the request to server; this request is taken by the router, connected to the internet. The web processes the request and finally connects to the desired web server, accesses the requested data and sends the data to the client. Every client can access the industrial applications directly.

Internet:

The data-acquisition system is connected to web clients via the Internet. For monitoring and adjusting the standard web browsers and a PC, interactive internet-based systems provide a way. For the standard web browsers can be used

on the client side, the target systems can be monitored and controlled independently from the location and the platform.

IV. Hardware Structure of System

A. Hardware structure description

The new data acquisition system integrates data acquiring function, signal conditioning and data collecting and data processing function into the single board based embedded based system. Fig. 3 shows the hardware design of the system. In hardware IDACS design is the most significant part. The centre core of this system is ARM processor. The general hardware structure of the IDACS is shown in Fig.3. The interactive data acquisition and control system based on embedded ARM processor platform has universality. Each acquisition and control device is equipped with 24-way acquisition/control channels and isolated from each other. A variety of electrical and non electrical signals like current, voltage, resistance etc. can be selected by each I/O channel. Data acquisition is done by special ADC. The measured data is stored in external memory in which the memory acts as a data base during web server mode.

The ARM processor directly supports the Ethernet service and RS485 communication. Hence the data has been stored and controlled by some other PCs or network via RS485 & Ethernet. ARM processor has internal I2C module, so it has the ability to communicate with any other peripherals connected to it. The embedded Ethernet interface makes the remote data exchange between the applications easy. This system consists of Analog to Digital Converter which has the ability to transfer the converted digital data to ARM processor. This is the digital chip having I2C module internally. During the communication with ARM processor this ADC chip should be synchronized with the processors clock.

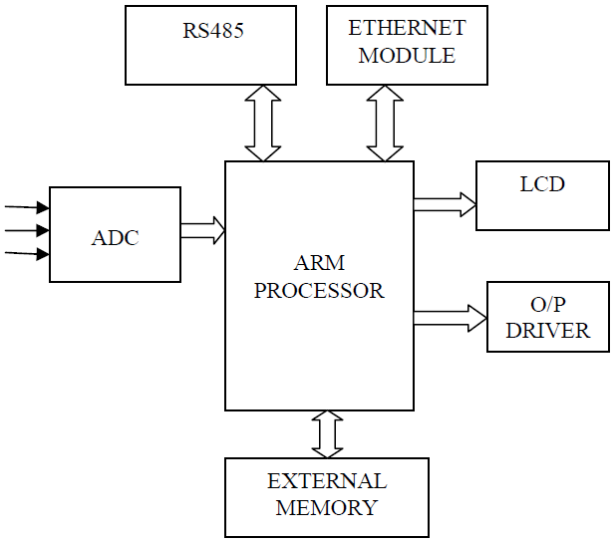

Fig.3. Hardware structure of system

V. Software Structure of System

Real-Time operating systems, which respond to any external unpredictable event in a predicted way and with strict timing constraints. The operating system is one of the important parts in the whole system. It functions managing all available resource and distributing them among different tasks in order.

A. The Embedded Operating Systems:

In the field of the embedded operating systems, realtime is a very important concept. The kernel of Real- Time systems is to complete a predefining operation in certain time; otherwise it would cause some serious consequences, such as bring down the performance or even cause the system breakdown. It is necessary to point out that the Real-Time system does not mean that the response and operating speed of the system is very high. Furthermore co-operating software and hardware it is essential to realize the real time operation [10]. It is necessary to get confirmed that the hardware fulfills the requirements of real-time operations. Real-Time

Operating should satisfy the demand of time limit, if not, the system will be considered as invalid even if the logic is right. In order to inspect the system, the states of the system must be collected and passed to the client controller in time, and then, the client controller will find the next executing step according to this information. RTLinux is a hardware real-time system rebuilt from the kernel of Linux. There are two parts in the RTLinux: the first part is the rebuilding of the kernel of Linux, which forms a small RTLinux real-time kernel within the kernel of Linux. This kernel provides an interrupt process of short time lapse which cannot be lapsed and rapped by Linux, and some bottom real-time and interrupt control processes. The second part is a Linux standard model which provides RTLinux Application Programming Interface (API). Through these API the real-time task can be founded, deleted, transferred and controlled. So in terms of the application of RTLinux, there are two fields: one is real-time field, the other is non-real-time field.

There are many ways to communication between these two fields, such as FIFO and memory [10].While the functions in real-time field satisfy the demand of realtime, it counts the design principle of RTLinux that is making the kernel as simply as possible, making the work in the real-time kernel model as few as possible and if it can be finished in Linux without affecting the real-time operation. Linux in RTLinux is used for the initialization of system and equipment and the management of dynamic resources. RTLinux completes hardware real-time task by using static distribution memory, because when there is no memory resource, the hard real-time operation is not available for the blocked thread. Since resources of the hardware of the embedded system are limited, RTLinux cannot be directly used as the operating system. Based on the actual application, the whole system can be

customized, and stored in a Flash with less capacity through configuring kernel, cutting down the shell and the embedded C library.

B. Characteristics of RT-Linux:

RT-Linux is a branch of embedded Linux, which has characteristic of combining hard real-time responsiveness with support for processor, and it has greatly broadened its application space to most hand–held devices. So RT-Linux makes ARM processor-based Linux applications realize their full performance potential. RT-Linux has a special core between Linux core and interrupts control hardware. Therefore, real-time tasks don't function as Linux processes but as modules which can be added by Linux. So RT-Linux is suitable for real-time application. Linux is an integrated and powerful TCP/IP protocol that provides a solid base for direct development of application layer protocol so as to reduce periods of software building.

RTLinux is a typical dual-kernel, one is Linux kernel which provides various features of general purpose OS, another is called RTLinux kernel which supports hard real time capability. Fig.4 illustrates the RTLinux architecture. RTLinux is RT Core with Linux as the secondary kernel. The unique feature of RTLinux is freely available to the public. As more development tools are geared towards RTLinux, it will become a dominant player in the embedded market.

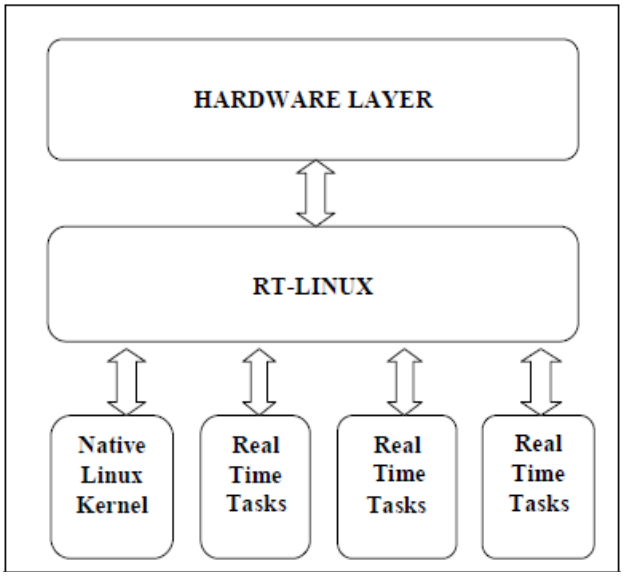

Fig.4. Software structure of system

Software of RT-Linux platform mainly consists of drivers and upper application programs. Drivers are considered as the programs which allow hardware peripheral to communicate with R T-Linux. They implement functions such as initiation and the release of equipment, transferring data between kernel and hardware.

C. Classification of Drivers of RT-Linux:

Drivers of RTLinux are classified as character device driver, net device driver and block device driver. Since RT-Linux integrates powerful TCP/IP protocol. It needs to install net driver available from released kernel during configuration. It needs to develop an LCD module and keyboard module driver which belongs to character driver.

D. Software design description:

To transplant the OS, design driving programming, package the API functions, disassemble and design multitasks, program control algorithms for the server and the client controller, etc. based on the requirement from real-time control, it is made up of two parts: one is the hardware part available for collecting the system state; the other is the standard Linux process. The standard Linux process is made up of the programs for server clients, driver communication, client interface and the kernel of system control, etc. The client controller is available for running the program.

VI. Conclusion

The design and development Embedded Web Server and new IDACS (Interactive Data Acquisition and Control System) is used to share the data with clients .The Embedded Web Server mode and IDACS both are carried out by Real Time Operating System (RTLinux). This Embedded Real Time DACS can be used for monitoring and controlling the industry appliances via web browser. This system can adapt the requirements of data acquisition and control system such as the function power consumption, reliability, cost, size and so on. This system will not only be useful in industry field, but also has great future in Smart-house applications, networked lighting control system and other distributed control systems. This system can be widely applied to electric power, petroleum, chemical metallurgy, steel, transportation.

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