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EMBEDDED WEBSERVER FOR METEOROLOGICAL DATA MONITORING

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ABSTRACT- Meteorological data monitoring in India currently involves manual methods or data feeding into personal computers, followed by transfer to the internet. This approach results in non-real-time data and poses challenges in resource management for both governmental and private sectors, such as industries. The proposed solution suggests replacing personal computers and large servers, which consume significant power, with a small, energy-efficient Embedded Web Server. This upgrade would provide real-time data, facilitating more effective resource management and planning for government and private entities alike.

The Embedded Web Server utilizes an ARM processor and can connect directly to LAN or the internet. Meteorological data plays a crucial role in diverse applications such as agriculture, industries, and predicting natural disasters like floods.

Keywords: Webserver, ARM Processor, Meteorological data monitoring.

I. INTRODUCTION

India, with 70% of its population dependent on agriculture and allied activities, faces significant challenges due to vast variations in topography and climatic zones, leading to diverse rainfall patterns and timings. Effective agriculture planning, monitoring, and support hinge crucially on accurate weather data. Presently, central agencies in India rely on disparate sources to gather weather information, formulate forecasts, and provide guidance to agencies supporting agriculture and related sectors.

However, the current weather monitoring and forecasting infrastructure in India is severely inadequate in terms of coverage, quality, and practical application for daily use by farmers and other stakeholders. Weather forecasts often cover extensive areas, spanning hundreds of thousands of square kilometers, which diminishes their relevance and utility at the local level. This generalization complicates decisions for farmers regarding seeding, pesticide application, irrigation, and harvesting timings.

Key factors contributing to this situation include centralized weather monitoring systems primarily located in cities like Hyderabad and Mumbai, a shortage of field staff trained in weather awareness, reliance on outdated manual equipment of poor quality, and a general lack of research focus in advancing weather monitoring technologies. Only a few institutions, such as ICRISAT, have adopted digital weather stations, highlighting the limited use of advanced technology in this critical area.

Addressing these challenges is essential for improving agricultural productivity and resilience in India, thereby enhancing livelihoods for millions dependent on the agricultural sector.

The rapid advancement of technology has ushered in the post-PC era, marked by significant progress in digital information and network technologies. A notable development in this evolution is embedded Internet technology, which represents a milestone in Internet history. This technology integrates Internet, Web, and embedded systems to enable monitoring, diagnosis, testing, management, and maintenance across equipment and diverse sub-networks connected to the Internet from various physical locations and subnets.

Monitoring meteorological data is crucial across multiple sectors including agriculture, defense, industrial process control, and for socio-economic applications related to weather, climate, and water services. It plays a pivotal role in advising strategies aimed at advancing understanding and leveraging the socio-economic benefits derived from weather, climate, and water information.

This integration of embedded Internet technology not only enhances operational efficiencies but also facilitates informed decision-making and resource management in these critical fields.

This paper introduces a Web-based gateway designed for on-site monitoring equipment networks to gather meteorological data using various communication protocols such as RS-232, CAN, and others. The gateway serves as a bridge between these protocols and the Internet, enabling remote browsing and management of on-site monitoring equipment via a web browser from any location.

Additionally, the paper outlines a method to optimize the network module specifically tailored for meteorological data monitoring applications. It discusses the integration of serial communication protocols for two types of industrial digital monitoring equipment and details the setup of a Web server.

The proposed system aims to address existing challenges by employing an ARM-based system capable of collecting real-time meteorological data and transmitting it via Ethernet. This setup eliminates the need for a personal computer and reduces dependency on large servers typically required for such applications.

II. LITERATURE REVIEW

The design of an embedded based web server draws on the interaction capabilities with the internet and explores innovative methods for human-computer interaction leveraging internet technologies [1]. Unlike traditional web servers that typically involve a Fat Server-thin client setup, an embedded web server must function as a thin server while maintaining the efficiency expected of a traditional server [2]. This approach aims to reduce costs and power consumption without compromising product efficiency.

Embedded systems capable of acting as web servers eliminate the need for a continuously running personal computer, which is often impractical in low-power and space-constrained environments where data acquisition occurs [3]. These systems are categorized into on-chip and out-chip integration forms, both of which have challenges such as high costs and inflexibility when hardware or supplier changes occur [3]. The need for low-cost embedded devices that support TCP/IP protocols is essential for direct data transmission without relying on a PC. This setup accelerates system development, supports future expansions, enhances the timeliness and accuracy of meteorological observations, and enables automated meteorological operations.

While previous embedded data acquisition designs often required a PC for data transmission, modern embedded systems capable of internet or Ethernet connectivity can now function as servers [2]. The rapid development of embedded systems has positioned them as vital components in control and data acquisition applications due to their high performance and cost-effectiveness [2][3][4].

Meteorological data acquisition parameters, such as measuring intervals and the number of monitored parameters, are defined by organizations like the World Meteorological Organization (WMO) [9] and the Indian Meteorological Department (IMD) [10]. Embedded web servers adhere to TCP/IP protocols for seamless data transmission over the internet, eliminating the need for protocol modifications and the use of a personal computer [5]. The design of the data gateway ensures transparency, avoiding the need for additional hardware memory for caching communication data and simplifying data collection and distribution in software.[2]

III. EMBEDDED DESIGN

The Embedded System consists of three parts as shown in the Figure 1.

Embedded Application
Embedded Operating System
Hardware Environment

Figure1. Basic Blocks of Embedded System

Embedded applications, such as a web server for meteorological data monitoring, rely on an embedded operating system to manage the interaction between application programming and hardware components. The operating system facilitates the execution of specialized functions by leveraging its provided mechanisms, tailored to the specific requirements of different embedded systems.

Embedded operating systems serve as a stable software platform for applications, ensuring system operation and enabling various functionalities. Examples of commonly used embedded operating systems include FreeRTOS, Linux, Windows Embedded, and others. These operating systems provide essential services such as task scheduling, memory management, and device driver support, crucial for embedded applications like web servers in meteorological data monitoring.

The hardware environment forms the foundation of the embedded operating system and includes components like processors and sensors. Different applications may necessitate distinct hardware configurations depending on their specific operational needs. For instance, a web server handling meteorological data may require robust processing capabilities and reliable sensor interfaces to gather and transmit real-time weather information efficiently.

In summary, embedded applications benefit from the symbiotic relationship between specialized operating systems and tailored hardware environments, ensuring reliable and efficient performance in diverse embedded system applications, including those for meteorological data monitoring.

3.1. HARDWARE DESIGN:

The hardware architecture of the Embedded Webserver is centered around an ARM processor and its peripherals. Meteorological data is gathered from sensors connected to the ARM processor. This data is stored in the processor's internal memory and can be optionally saved to external storage within the Embedded Webserver or transmitted to an external data server via the Embedded Webserver's Ethernet module.

Due to the ARM processor's low power consumption, the Embedded Webserver can efficiently operate on battery power. However, when AC power (230V or 110V) is available, a Power Supply section with a Step-down Transformer and Rectifier module is required to convert and regulate the power for the Embedded Webserver.

The Embedded Webserver includes Ethernet connectors for network connectivity. Human interface modules such as keyboards and LCD displays are designed to provide direct interaction between users and the Embedded Webserver.

For a clearer understanding, please refer to Figure 2, which provides a diagrammatic representation of the Embedded Webserver's hardware setup. This diagram illustrates the integration of the ARM processor, sensors, power supply components, Ethernet connectors, and human interface modules, ensuring efficient operation and user accessibility in meteorological data monitoring applications.

Sensors	Display	Keypad

Figure 2. Hardware Connections in Embedded System

3.2. SOFTWARE DESIGN:

To implement the embedded system effectively, software design plays a crucial role. The initial step involves programming a Bootloader, an assembly program tasked with initializing the ARM processor by configuring its registers and starting up the system. This Bootloader sets up the on-chip functions of the processor through register settings.

Once the Bootloader completes its task, the system proceeds to execute a Real-Time Operating System (RTOS) tailored for the ARM processor. The RTOS assumes responsibility for managing both the hardware and software aspects of the system. It is specifically designed to meet the requirements of the Embedded

Webserver, enabling it to schedule tasks efficiently. The kernel of the RTOS oversees task scheduling, ensuring optimal utilization of resources.

Within the RTOS, device drivers are integrated to facilitate communication between external devices and the ARM processor. These drivers enable seamless connectivity and interaction with sensors and other peripherals essential for meteorological data acquisition.

Figure 3 illustrates the components of the software design in an embedded system. A critical module within the RTOS is the TCP/IP stack, which defines how data is transmitted using the TCP/IP protocol over the internet. This module not only handles data transmission but also facilitates communication with other devices, ensuring interoperability and efficient data exchange.

In summary, the software architecture of the embedded system, comprising the Bootloader, RTOS, device drivers, and TCP/IP module, forms the foundation for reliable operation and connectivity of the Embedded Webserver in meteorological data monitoring applications.

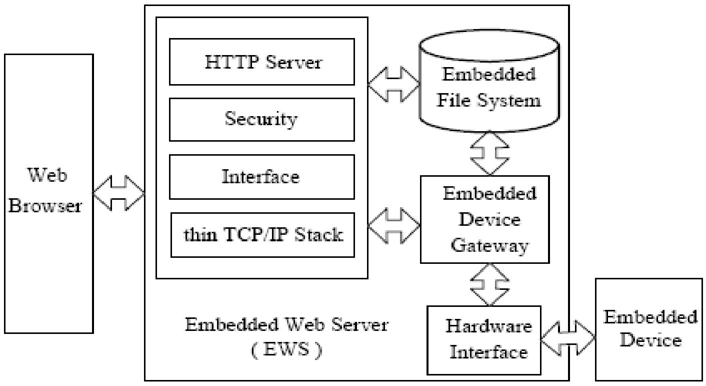

Figure 3. Software Components of Embedded System the RTOS should have a module for

receiving the data from the various sensors and other microcontroller or processors which are connected directly to the Embedded Web server or over the internet by using Ethernet cable. The RTOS should define at what intervals the data have to be stored either externally or internally to the Embedded Web server and also remove the data which are not required by Web server.

IV. BLOCK DIAGRAM

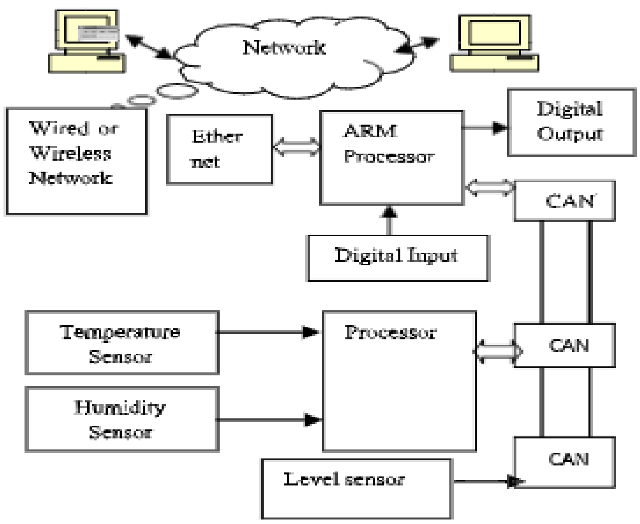

Fig 4 Embedded Web server for Meteorological Data Monitoring

V. WORKING OF EMBEDDED EBSERVER FOR METEOROLOGICAL DATA MONITORING

Figure 4: Block Diagram of Embedded Web Server for Meteorological Data Monitoring

Description:

ARM Processor (Web Server):

1. Acts as the central processing unit and web server for the Embedded Web server system.

2. Collects and stores meteorological data obtained from various sensors and possibly connected microprocessors/microcontrollers.

3. Manages data processing, storage, and transmission over the Ethernet connection.

Sensors:

1. Various sensors are connected directly to the ARM processor.

2. Sensors include devices for measuring temperature, humidity, pressure, wind speed/direction, etc.

3. Provide real-time meteorological data to the ARM processor for monitoring and analysis.

Microprocessors/Microcontrollers:

1. Optionally connected to the ARM processor via CAN (Control Area Network) protocol.

2. These devices may handle specific tasks or interface with sensors that are already integrated with microcontrollers.

3. CAN protocol ensures reliable data transmission over longer distances and includes built-in security features.

Ethernet Connection:

1. Enables the ARM processor to transmit meteorological data over the internet.

2. Follows the TCP/IP protocol suite for standardized communication.

3. Facilitates remote monitoring and access to meteorological data from any location with internet connectivity.

Key Features:

- Data Integration: ARM processor integrates data from sensors and possibly external microprocessors/microcontrollers.

- Data Storage: Meteorological data is stored within the ARM processor's memory for real-time and historical analysis.

- Communication: Ethernet connection ensures seamless data transmission using TCP/IP protocol suite.

- Remote Monitoring: Allows users to monitor meteorological data remotely via internet or network connection.

- CAN Protocol: Utilized for reliable and secure data acquisition from microprocessors/microcontrollers.

This block diagram illustrates the interconnected components and functionalities of the Embedded Web server system designed for meteorological data monitoring. It highlights the role of the ARM processor as a central unit capable of data collection, storage, and transmission, supported by robust sensor integration and CAN protocol for extended data acquisition capabilities.

The Web server has a display and keypad within itself so that there is no requirement of PC interface and the data can be seen in the Web server directly and incases there is a requirement to enter some data manually it can be done with the help of the keypad which is available in the Web server.

5.1. HARDWARE SPECIFICATION

- ARM Processor
- LCD
- Keypad
- Sensors (Temperature, Humidity, etc)
- LAN or Internet connection
- Personal Computer (PC)

5.2. SOFTWARE SPECIFICATION

- Free RTOS For ARM Processor
- ARM Keil µC 3
- HTML design using Dreamviewer8
- XP or Higher Operating System for PC with Internet Explorer

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