Design and Development of EMON - An Embedded Control System over Ethernet and TCP/IP

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Abstract

An Embedded Control System over Ethernet and TCP/IP - EMON, developed by the KC.03-13 project, is presented in this paper. The system can be the core of wide variety of embedded applications in Lab and Industrial Automation. The Ethernet with 10/100Mbps allows fast data exchange between Remote Measuring and Controlling Units (EDDKs) and the host computer with MMI software EMON. An EDDK is integrated by a Pentium processor, a flash disk, and Data Acquisition modules in PC/104 platform. With small size, robust and low energy operation, EDDKs are well applicable in industrial and mobile environment. The Pentium processor, large DRAM, and FLASH memory give powerful computing capability for development of complex and intelligent application program. The EMON Man-Machine Interface software of the system – EMON32 - can communicate easily with multi-EDDKs and has many functions and utilities suitable for the requirement of Supervisory Control and Data Acquisition applications.

1. Introduction

As with the rapid evolvement of information technology, sensors and other measuring devices for automatic production lines become more and more intelligent. The generation of measuring and controlling devices has been emerging from the generation of mechanical and electrical devices using low-level microcontrollers, to intelligent sensors with high-level microcontrollers, and embedded systems with modern processing algorithms. These intelligent measuring and controlling devices can remember and self-reason. They ensure accurate measuring results, filter noise, and provide more features then their older counterparts.

Production lines often require measuring and controlling the system’s data and status. Even more often do automatic production lines. Intelligent measuring and controlling units and control systems, which can connect to LAN and concurrently deal with multiple inputs from multiple sensors, are therefore needed.

The current remote measuring and controlling units use the standard serial connection RS422/485 at low speed, while the evolvement of IT has brought Ethernet to the speed of 10/100Mbps, hundreds of times faster then the serial connection. We applied the Ethernet technology to develop “An Embedded Control System over Ethernet and TCP/IP – EMON” to serve for the integration of remote control systems of technological processes. The system is more capable than other current serial-connected control systems. The demand for the system is potential, because it replaces the use of large and robust office-oriented LANs for control systems.

The system includes:

- Remote measuring and controlling units (EDDKs), capable of controlling industrial sensors and processing strong signals. EDDK is reprogrammable by
downloading the controlling software from Ethernet. EDDK was created based on PC/104 embedded technology. It includes a memory RAM, a large FLASH, and a network interface card with TCP/IP stack implemented.

- **EMON32** – the user-oriented and easy-to-use main controlling software in the EMON server, capable of communicating and exchanging data with EDDKs over Ethernet. The software supports remote uploading the controlling software of each EDDK.

![Figure 1 System architecture](image)

The system has a wide range of applicability, from automatic production lines to national security applications. EMON32 allows users to develop their own applications easily.

**Advantages:**

- The remote control system can exchange large data at a much higher speed then current fieldbus networks.
- EDDK is small, highly durable, low power-consumed, capable of running intelligent algorithms, and cheaper then current imported remote measuring and controlling devices.
- The software supports English and Vietnamese languages, suitable for applications in Vietnam.

2. **Why Ethernet and TCP/IP?**

Local Area Network (LAN) is a high-speed network designed to connect workstations, servers, terminals, and other processing units within a physical limit of an organization. Using the Ethernet technology, the connection speed between two units in a LAN can reach up to 100Mbps. Dual speed 10/100Mbps Fast Ethernet Network Interface Cards are very useful for the transition from 10Mbps to 100Mbps. For example, when a 10Mbps device communicates with a 10/100Mbps device, the transmission rate is 10Mbps. When the 10Mbps device is replaced by a 100Mbps device, transmission rate automatically switches to 100Mbps. The transmission rate is decided without interference from the controlling units.

The Internet protocols are the world's most popular open-system (nonproprietary) protocol suite because they can be used to communicate across any set of interconnected networks and are equally well suited for LAN and WAN communications. The Internet protocols consist of a suite of communication protocols, of which the two best known are the Transmission Control Protocol (TCP) and the Internet Protocol (IP). TCP/IP allows the transfer of data between two or more computer hosts. In addition, TCP/IP shows versatility as it is independent of physical hardware so it can deal with different kinds of networks.

Based on these advantages of Ethernet and TCP/IP, we developed the hardware structure for EMON as below.

![Figure 2 Hardware structure](image)

In order to ensure fast, secured, strong, and reliable communications between components, it is important to decide which operating system is most suitable for the connecting devices.

- **Operating system for EMON server:** Windows 98/ME, Windows NT/2000/XP are popular OSes supporting TCP/IP and able to connect to the Internet.
- **Operating system for EDDK:** A DOS-compatible, light, yet stable operating system. Only 64Kb is required for the OS. Hence, it is very suitable for
embedded applications. However, it does not support TCP/IP. Therefore, we developed a TCP/IP stack, which is 100% compatible with Ethernet, for the OS.

**IP address:** Every EDDK is assigned with a 4-byte IP address. We used class-C network address format. The network address is 10.10.3.xxx. An example of IP addressing is illustrated as below.

3. **EMON server and its software – EMON32**

The system can be configured to run up to four EMON servers at the same time. The minimum requirement for an EMON server is:

- Pentium 2 processor or compatible
- 64MB ram
- 20MB free hard disk space
- Touch Screen or normal monitor
- Windows 98 operating system
- Network Interface Card

EMON32 is the main controlling software of the server. It has the following main features:

- Running the control system in real-time.
  The user can configure the system using the system design tool. The behavior of and EDDK as well as its pins are configured in the system design.
- Uploading/downloading controlling programs of the EDDKs and running it when commanded
- Viewing real-time data received from EDDKs
- Generating reports in textual and graphical formats

Details of EMON32 can be found at [1].

4. **The remote measuring and controlling unit - EDDK**

We created and developed a multi-channel remote measuring and controlling unit – EDDK using the embedding technology. EDDK can be used to connect and control different industrial modules. For example, sensors, motors, valves, etc.

![Figure 4 An EDDK](image)

**EDDK’s controlling software:** The controlling software of an EDDK can be programmed using any ANSI C/C++ compiler. The running OS is DOS 6.22 compatible with TCP/IP stack for DOS. The software supports the following commands from an EMON server:

- Receive the name and the IP address of the server
- Receive the name and the IP address of each EDDK configured by the server
- Receive the current time from the server and synchronize it with its local time
• Download the new controlling software and self reload it
• Transmit real-time data to the server, as requested
• Transmit saved data to the server, as requested

For further technical information, please contact us at ptcat@ioit.ncst.ac.vn.

5. Conclusion

EMON – an Embedded Control System over Ethernet and TCP/IP, was developed from state-of-the-art technologies. The PC/104 embedding technology provides small but strong, robust, and reliable devices, which can sustain shakes and squirrels. Modules like CPUs, AOs, DAs, DIOs are easy to find and cheap. Fast Ethernet is the most popular network nowadays, providing 100Mbps transmission speed. TCP/IP is the main protocol of the Internet. It will be advantageous when we want to develop the system to be able to remote control over the Internet. The operating system of EDDK supports necessary routines for DOS and TCP/IP. The user will find it easy to program as only the controlling part needs implementing. EMON32 is running under Windows OS. It provides many tools to control the system in real-time. It is easy-to-use and user-oriented.

EMON – an Embedded Control System over Ethernet and TCP/IP is an easy-to-use control system utilizing cutting-edge technologies. It costs much cheaper than imported similar systems. Therefore, it will have high potential in domestic applications.

Bibliography


