

## Design & Implement of Embedded Web Technology in Traffic Monitoring System

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**Abstract.** The paper mainly discusses design of hardware & software for embedded web server with Heterogeneous network seamless connectivity and implement of key technology. It contains transplantation of embedded Linux operating system, design of embedded web server, transplantation of database and implementing method of main functions. Remote monitoring is realized to traffic information collection, monitoring traffic conditions, traffic control, information published and communication of traffic data by using combining EWS technology with Internet. The results indicate that the intelligent traffic control technology based on embedded web technology can achieve the integration of a wide range of information collection and it breaks through the traditional traffic monitoring technology for designing traffic monitoring system and provides the advanced technology based on embedded Web for designing modern traffic monitoring system. The testing showed the traffic monitoring system based on embedded Web technology has the good real-time and high reliability and good scalability and anti-interference performance. Meanwhile, it has also laid a good foundation for the further study of a new type of intelligent traffic information collection system.

**Keywords:** Component, embedded web technology, traffic monitoring system, EWS system, information integration, intelligent transportation

### 1. Introduction

With rapid economic development in China, transportation has increasingly become an extremely important component in the national economy and daily life. So it is very essential to build a modern intelligent traffic control system in order to resolve the traffic congestion of roads and reduce accidents. And video monitoring and traffic information transmission in this system plays an important role. Intelligent traffic for solving urban traffic management has become the people's consensus such as advanced and sophisticated video surveillance system as an important component of intelligent transportation for image acquisition, on-site snapshot, after taking of evidence and other important tasks. Monitoring systems are usually installed on the expressway, traffic junctions, toll stations and other key places according to the actual needs of current traffic monitoring. All the information is integrated to the monitoring center.

At present, the traffic management monitoring systems are based on the IPC as a host computer, and deploy dedicated monitoring configuration software. This method is not only costly, inefficient, but also troublesome for the system to update, and specialized training for management personnel, and restricted by space-time and geography. Moreover, some information cannot be shared for public information services.

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With the rise of the Internet technology, embedded Web technology goes into the mainstream at present, and CGI script and Web server support the program running on an embedded device. The managers can manage and monitor situations of traffic through the Web browsers.

This paper presents a method that combines embedded WEB technology with Internet to implement remote traffic monitoring through Web Server applications solidified in embedded ARM processor. Therefore managerial personnel can have the remote real-time monitoring of traffic management through Web browsers without time and geographical constraints as shown in Figure 1. Time-consuming effort of traditional local monitoring, as well as deficiencies in equipment maintenance, is effectively overcome and efficiency of traffic management is greatly improved. In order to classify information, embedded Web Server applications consist of different treatments of classification according to the types of information that are then properly displayed in the browsers. Attention is given especially for the effective separation of the confidential and public information [1,2].

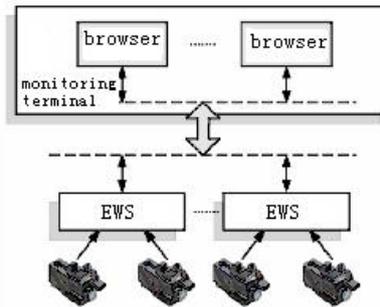


Figure 1 Embedded video monitoring system

## 2. System Design

EWS system is composed of embedded web server hardware & software system and traffic monitoring system, as shown in Figure 2. The hardware mainly consists of two main components: an embedded Web server and bus controller. The bus controller is for region of traffic monitoring to design, and each control point is identified corresponding to the embedded WEB server (EWS), and the hardware structure and software system of EWS are determined according to the corresponding control volume[3,4].

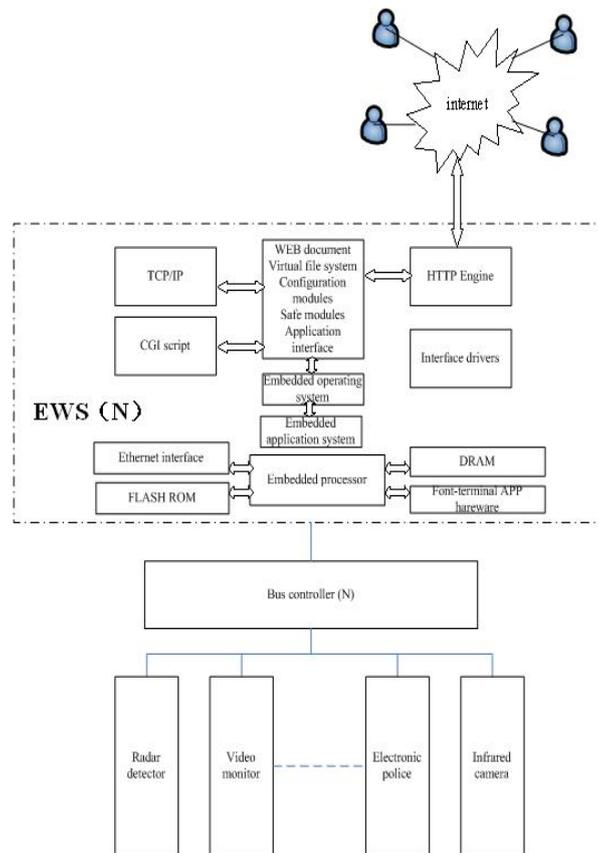


Figure 2 composition of system

### EWS Hardware System

EWS hardware system includes an embedded ARM processor, FLASH, ROM, DRAM, Ethernet port, front-terminal application system components and bus controller, as shown in Figure 3. The processor is Samsung S3C44B0X ARM7 that is suitable for quite poor working environment, supports uCLinux operating system, runs faster than 8-bit and 16-bit processor[11].

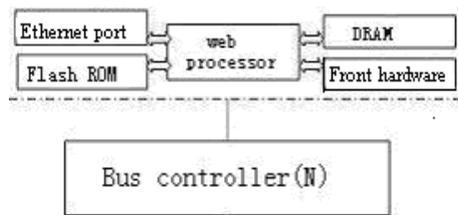


Figure 3 EWS hardware system

### EWS Software System

EWS software system includes HTTP engine, TCP / IP protocol, CGI script, virtual file system, configuration module, security module, application interface module, embedded operating system, embedded application, interface driver, embedded database SQLite[14].

CGI (Common Gateway Interface) design is the most important in EWS software system and defines the interface standard between Web server and CGI script. CGI programmed by C language is embedded with Html script. While CGI is executed, some special ports can be operated and the results are displayed in the browsers. The special operation is as follows: send some information to a Web server from the client, and put the received information into environment variables, then go to start the specified CGI script in order to complete specific task, and CGI script obtains the relevant information from the environment variable and decode it to some serial port, dispatch commands concerned to monitoring module on-site, then return the output with HTML format to browsers through Web server[10,13]. Its workflow is as shown in Figure 4.

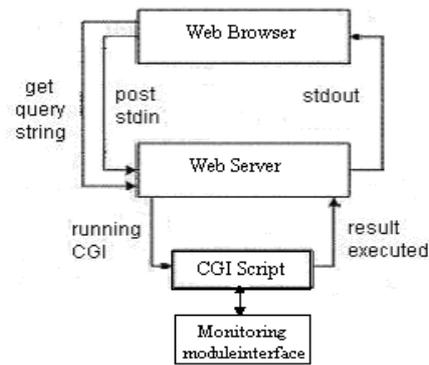


Figure 4 CGI workflow

### Transplanting Design of EWS Operating System

The selection of the operating system is essential in the EWS design. uClinux operating system is chosen according to the actual needs of the system as well as its stability and reliability.

uClinux is a branch of Linux--- Micro-Control-Linux. It is mainly aimed at non-MMU processor and supports multi-task with a complete TCP / IP protocol stack as well as multiple network protocols. uClinux also supports a variety of file systems.

First, Linux 2.4.20 is chosen for trimming & transplanting its kernel and devices drivers, configuring uClinux and processor, patching the compiler as well as building the cross-compiler environment. The kernel trimmed is mainly a set of configurations for hardware platform, file system, network protocols and so on. Moreover, retains serial console and common tools & commands. Then Web Server, Telnet daemon and other popular applications are transplanted. Usually the kernel is compressed into FLASH, and extract it into RAM to run with file system with romfs, and executable file format with flat as well as run-time library uCLibc with simplified. Typical drivers include the console terminal, serial devices, and block device drivers with file system. Module technology dynamically loaded in uClinux is used for drivers in developing and debugging ---makes drivers compiled into the kernel, boots directly to load, and also supports uCLibc DLL[2,13]. As shown Figure 5.

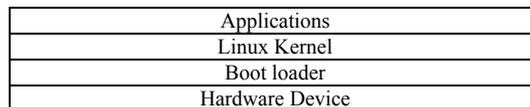


Figure 5 EWS software system

### SQLite Database Design

There are a large number of equipments in traffic Monitoring System at fields and some monitoring data should be stored in a database. Embedded database SQLite can be more easily used in embedded systems although SQLite is a lightweight relational database. It also supports multiple tables and indexes, transactions, views, triggers and a series of user interfaces and drivers. SQLite database is accessed By calling the C language API interface (Mainly call three API functions).

### Monitoring System

Monitoring system includes infrared cameras, electronic police, video surveillance devices, Radar detectors, bus controller and etc. The traffic information from the monitoring equipments is transmitted to the EWS through the bus controller. Then displayed in browsers through the EWS to implement traffic management and remote real-time monitoring [6].

### Communication protocol

TCP/IP protocol is implemented in uClinux kernel so the embedded system can communicate with the monitoring host through BSD Socket. Remote monitoring with B/S mode is realized because there are Web Server and IP address in the embedded system and HTTP protocol is also implemented. Moreover, IP address is directly accessed without DNS because of saving system resources. Serial communication is a

Important way for the embedded systems and peripherals. The Linux serials belong to character devices so the serial controls are realized by accessing (open, read, write) device files. Take UPS as an example, I/O voltage, current, power, fault monitoring information can be monitored and communication interface is RS232C: communication rate: 9600bs; data bits: 8; no parity; start bit: 1; stop bit: 1; hardware and software flow control: None.

### Multi-thread

It is lower Communication rate between the peripheral devices and the embedded system in Monitoring system but it is higher communication rate between the embedded system and monitoring host. Hence multi-thread technology is widely used in data collection and monitoring procedures in order to improve resource utilization and meet the real-time requirements. One is for receiving the data from a site and another is for polling commands of monitoring host. uCLibc and posix thread support are selected by the application while uCLinux kernel is compiled then the application can work with the thread library. The efficiency is improved and the resource is saved.

## 3. Configurations of Ews Hardware

EWS uses a Samsung S3C44B0X processor, K9F1208U0M Flash with 64M, HY57V561620SDRAM with 32M, CS8900A Ethernet port equipped with RS232 and USB1.1 standard, multiple 4-wire serial port with extended to connect multiple peripheral devices, I/O ports with expanding[13]. As shown in Figure 6.

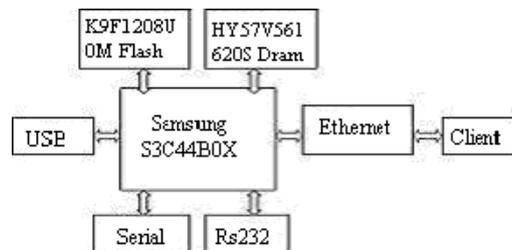


Figure 6 Hardware configurations

## 4. Detailed Design of Monitoring System

The decentralized monitoring and centralized management are generally used in traffic monitoring system. The entire system contains a monitoring center, a number of scattered remote monitoring terminals and telecom media.

The remote monitoring terminals include the video transmission terminals and the data transmission terminals[7]. The video transmission terminal is generally an infrared camera or monitor and the video signals from it are compressed by the MJPE or JPEG through the multi-function bus controller to form data frames that can be transmitted in the network, then the data frames are transferred into the EWS through the internal bus. The data transmission Terminals are such as the electronic police, radar detectors, vehicle detectors, variable speed limit signs, variable information panels and etc. These devices are responsible for data acquisition, data storage, and data transferring through the multi-function bus controller, and then transfer it to the EWS through the internal bus. Therefore managers are able to have the real-time monitoring of remote traffic management through EWS connected to the Internet / Intranet[5].

Software of the monitoring system consists mainly of information acquisition module and device control module. The information acquisition module is mainly to complete information collection on-site, and also to implement status information collection from its own peripheral devices. The information collected is uploaded to the host monitoring and displayed with the query. Thus the current field conditions, as well as equipment working status, are taken into consideration for appropriate control measures such as alarm. The device control module is mainly for controlling equipment operating parameters and information publication. The operating parameters mainly refer to the sampling period, sampling rate, alarm thresholds, mode of

equipment work and etc[8,9]. The specific process control is shown in the main program of the monitoring system in Figure 7.

As the EWS server starts running, the main module program is executed to access between the EWS and browsers, and the EWS sends data concerned to the sub-module program by using POST method. When a client

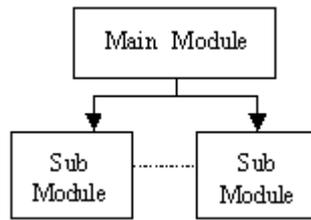


Figure 7 The main program of the monitoring system

from a browser sends the requests to the EWS, the corresponding sub-process is booted by the server daemon, then the sub-process meets each specific request. The sub-process is module mainly composed of several processing modules: ① general function module. ② static text processing module. ③ CGI module and error processing module [12]. Results from the sub-process module are returned to the client as the HTTP response message after The EWS application completes the corresponding operation.

## 5. System Function and Testing

The embedded Web traffic monitoring system is based on embedded Web technology as the core. Meanwhile, it is combined with traffic information acquisition, traffic surveillance, traffic control, information publication and other traffic control functions. Then the traffic data are collected, stored, managed, transmitted, analyzed, and displayed. The traffic managers or decision makers are provided with these data for decision making and management on the traffic situation. For example, when a vehicle runs the red light, the electronic police system detects the vehicle through the ground induction coil; its detector is triggered, at the same time the signal controller issues a "red light" signal to the electronic police system. When both conditions are matching, an image of the vehicle, with the relevant monitoring information is taken as illegal driving. For another example, while the radar detectors transmit the radar beam in the direction of the road and receive the reflected echoes of the vehicle, the speed of the vehicle is measured by echo analysis. If the speed exceeds the setting, it will direct the camera to obtain the relevant speeding monitoring information. With heterogeneous network seamlessly connected with embedded gateway design as well as the realization of key technologies, these traffic monitoring information are integrated to the EWS through a serial port, parallel port, USB and so on. On-site monitoring traffic information is sent to the web browsers via a EWS. So wherever the monitoring personnel are, the target region can be monitored and managed as long as it is connected to the Internet network. At the same time public travel information services can also be easily provided. Diagram of system function is as shown in Figure 8. The traffic information web browser is as shown in Figure 9.

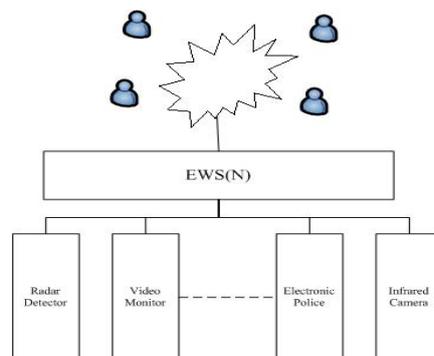


Figure8 Diagram of system function

Traffic Remote Real-time Monitoring		
Place	Date	Monitoring Information
SanXiaoKou	2008-10-11 5:43 PM	 Click for Traffic Information Detailed
SiPeiLou	2008-10-11 5:43 PM	 Click for Traffic Information Detailed
ChangJiangRoad	2008-10-11 5:43 PM	 Click for Traffic Information Detailed

Figure 9 UI of traffic information web browser

## 6. Conclusion

The system adapts an embedded Web server technology to implement data collection and video monitoring through using modular structure and heterogeneous network seamlessly connected. Therefore the managers can perform the traffic management and monitoring without the geographical and environmental limitation and the public information services are also provided. Intelligent traffic control system based on the embedded Web technology is widely used along with the development of the intelligent traffic.

The traffic monitoring system based on embedded Web technology possesses the low power consumption, high integration, real-time efficiency, software solid-state, and easy scalability. Moreover, it is able to effectively manage the increasing complexity of system resources, and makes some hardware virtualization. As data exchange with the outside interfaces only through the data transfer protocol, so the system is provided with the good device independence, replacement ability, commonality, scalability. It easily makes the system flexibly to be assembled, replaced, and upgraded. Therefore significant savings in investment and an increase of benefits are for the traffic monitoring system based on embedded Web technology.

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