

# Real Time Remote Video Monitoring System Based on Embedded Web Technology

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**Abstract**—Video surveillance systems play very important role in many fields of our society such as in banking, personal security, finance etc. Starting from small houses to big industries, now video surveillance is necessary and plays very important role to fulfill our security aspects in many ways. As technology is growing day by day, it's a revolutionary step towards video surveillance system by means of which one can monitor the entire system remotely on real time basis using embedded web server and ARM9 board. An USB camera is being used to capture the data from the background. Video 4 Linux is used to get the camera video data and then these captured data is transmitted over internet using embedded web server and ARM9 board on the TCP/IP based network. As real time operation was needed, live streaming data is converted into different frames and then these frames are transmitted via the internet using DM-9000 Ethernet controller in ARM9. The video received is displayed on web page using web browsers like mozilla firefox, google chrome. S3C2440 chip as controller in ARM9 board is the core of the whole system. Unlike other embedded systems this real time system provides client video monitor with the help of friendly ARM9 BSP and embedded web server.

**Index Terms**—ARM9, Embedded Linux, Embedded Web Server, V4L2.

## I. INTRODUCTION

WITH the rapid development of modern communication technology, Web technology has been widely used and was a great success. As the continuous development of information society, increasingly mature network technology applied to the embedded system has become a necessary tendency. With Web access ability of the embedded devices will get rapid development, the application in communication equipment, information home appliances, instruments remote management and other fields. Embedded Web server for embedded devices provide network interface, to realize the remote management and control, which is an important technology of the network embedded equipment<sup>[2]</sup>.

With the advancements in the IC technology, computer networking and communications technology, the video surveillance systems are playing a major role in this modern world, especially in the military, industrial and civilian security applications. These video surveillance systems are broadly classified into analog and digital video surveillance systems. The earlier or traditional video surveillance systems that are based on the coaxial cables as a transmission media are more complex, expensive and slow in speed of operation. But today in this digital world, the embedded video surveillance systems are more advantageous compared to the traditional surveillance systems, as it is provided at low cost with high performance and good stability.

Recent years monitoring facilities are necessary and useful for our daily life to make we secure. Starting from small houses to big industries, now video surveillance<sup>[6]</sup> is necessary and plays very important role to fulfil our security aspects in many ways. After all, people lead busy lives, come in and out of work, go on vacations, and run errands so investing in a remote video surveillance system is crucial to the well-being and safety of your home or business. Thus, much of the time you're not actually able to be onsite where your cameras are installed. One of the primary benefits of IP video is that you're not limited to viewing your remote video surveillance system on site. The advancements in video surveillance technology have made it possible to view your remote security camera from any internet-enabled PC or smartphone. Remote video surveillance enables users to view live video on a PC or laptop from just about anywhere in the world with internet access.

## II. SYSTEM OVERALL DESIGN

In this paper, we combine the mature technology of Web with the embedded and fully utilize the advantages of both. Applied the embedded Web technology in the field of equipment condition monitoring, the equipment remote monitoring system is designed based on embedded Web. Firstly, the function and structure of the system are designed.

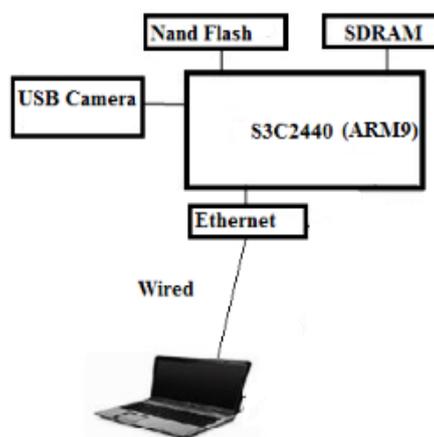


Fig. 1. Block diagram of video monitoring system

This comes up with a design solution of an embedded web-based remote monitoring system for video images. Starting from small houses to big industries, now video surveillance is necessary and plays very important role to fulfill our security aspects in many ways. In this paper videomonitoring system is designed bases on real time operating system i.e. Embedded Linux.

A web base control and monitoring system can make us control a system without distance. So developing a cost effective, programmable and high efficiency controller

webpage is necessary for the world competition. This system presents the structure of video capture based on S3C2440 processor and it introduces the embedded system, video capture. In the monitoring site, the system captures the video through the embedded multitask operating system. Lighttpd is using as the webserver. The purpose of this project is to build a remote control system through a webpage and this system is controlled through local area network by using an embedded TCP/IP network.

#### A. Hardware Platform Design

The S3C2440 processor is used as core of the hardware platform. The frequency Samsung S3C2440 is 400MHz and can up to 533MHz in the maximum. According to its mode of internal circuit 12MHz has chosen for the crystal. Joint Test Action Group (JTAG) is an international test protocol standard, software simulation, single-step debug and u-boot download can be carried out through the JTAG port, it's a simple and efficient means of developing and debugging embedded systems. The SDRAM capacity in the system is 64MB, working voltage is 3.3V, data bus is 32bit, clock frequency up to Auto-Refresh and Self-Refresh are both supported [4].

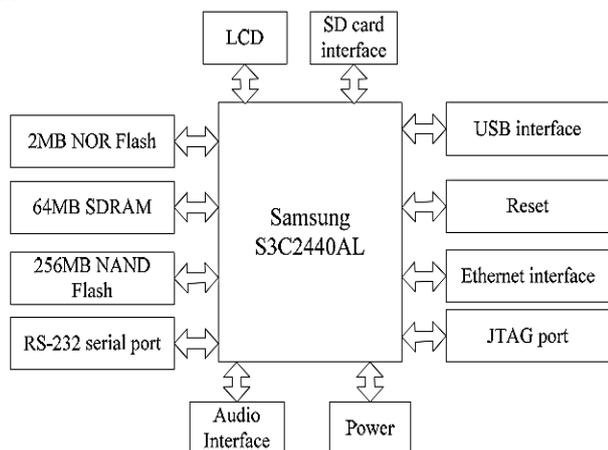


Fig. 2. Block diagram of hardware system

For supporting boot loader in the NAND Flash a buffer named Steppingstone is equipped in SDRAM. When the system starting, the first 4Kbyte content in NAND Flash is load to the Steppingstone and is executed. When Start up code, the contents of the NAND Flash are copied to the SDRAM in general. The data in NAND Flash are checked when ECC is used. The main program will be executed on the SDRAM based on the completion of copy. The LCD interface of S3C2440 is integrated 4-wire resistive touch screen interface which can be directly connected to four wire resistive touch screen [4].

### III. SYSTEM SOFTWARE DESIGN

Software development process based OS includes: the establishment of cross-compiler, the transplant of Bootloader, the transplant of embedded Linux, the development Embedded Web server.

#### A. Linux Operating System

In view of the open source code, Linux becomes a very powerful option in the field of embedded operating system, and many microprocessors have been transplanted into the

Linux operating system. This system will transplant Linux operating system into MINI2440 board. The Linux has a number of advantages, such as open source, Powerful kernel, supports multiple users, multiple processes, multithreading, powerful stability function, good real-time, Size function customizable, and Supports multiple system structure. To build embedded Linux development platform needs to construct cross compiling environment first, a set of complete cross-compiling environment includes the host and the target machine. For developing the host is a PC equipped with Ubuntu operating system with LTS version 14.04, the target machine is video monitoring terminal based on the MINI2440 board. The crossover compiler is GCC 4.4.3 for ARM edition, the version number for embedded Linux kernel source package is 2.6.32.2. It contains all the function module and system software. The terminal system software consists of four parts [8]:

- Boot loader
- Linux kernel
- Root file system
- Application program

The Linux operating system's transplant needs to complete three works: bootloader transplant, Linux kernel transplant and filing system transplant. Bootloader is running before the operating system kernel, the mainly role is initializing hardware equipment(including I/O, the special function register), establishing the memory space map and bringing the environment of the system's hardware and software to an appropriate state. The Linux operating system's kernel can provide good support to the ARM processor and manage most of components which connect to the periphery of the processor. The transplanted Linux kernel only needs to provide support to the hardware which will be used, therefore we may cut the kernel according to the practical application [10].

#### B. Porting of Bootloader

Bootloader [9] is a small program running before operating system kernel. Its main role is to initialize hardware equipment, establishing the memory space map and bring the environment of the system's hardware and software to an appropriate state. The bootloader used in this paper is Universal bootloader whose acronym is U-boot. U-boot is highly customizable to provide both a rich feature set and a small binary footprint. The Uboot downloaded to the target board's RAM through the serial port connection, and then bootloader was written to FLASH on the target machine class solid state storage device. Uboot is mostly used to load and boot a kernel image, but it also allows to change the kernel image stored in FLASH.

#### C. Porting of Linux kernel

Most embedded operating systems have been proprietary. If a new processor was designed and developed by a semiconductor company, they had to depend on an operating system company to port their operating system to the new processor. The other issue was with the development tools (compiler, debugger, simulator, and so on) for the given processor [9]. Usually the operating system company also provided these tools.

- 1) Download the Linux 2.6.32.2 tar.bz2 source package from official Linux website
- 2) Uncompress the source code of Linux kernel

- 3) Build cross-compiler environment on Linux host: The cross-compilation is the use of certain types of machines running on the compiler to compile a source program and generate object code run on another machine.
- 4) Download and install arm-linux-gcc compiler, tool chain
- 5) Modify the Makefile of kernel: Select the architecture as ARM and give the path of arm-linux-gcc from the system
- 6) Configure the kernel: make menuconfig, with a convenient menu-driven, user-interface, allows the user to choose the features of the Linux kernel that will be compiled<sup>[11]</sup>.
- 7) Compilation of kernel: After configured with the make command to the kernel, Compile the kernel using the following command,  
**#make ARCH=arm CROSS\_COMPILE=arm-none-linux-gnueabi-uImage**
- 8) After the compilation, "uImage" will be generated in arch/arm/boot directory. The Uboot image is to be transplanted to the target board. The generated uImage can be transferred to the board by TFTP (Trivial File Transfer Protocol) protocol.

#### IV. TECHNOLOGY OF EMBEDDED WEB SERVER

Embedded web server<sup>[5]</sup> refers to import Web Server at the scene the monitor and control equipment, in the support of appropriate hardware platforms and software systems, transfer traditional monitor and control equipment into an internet based, possessed with TCP/IP protocol as the underlying communication protocol and Web server technology as its core.

Embedded Web server software system usually include centre processing module<sup>[2]</sup>, HTTP engine, file system, configuration module, security module, application program interface. The server is the core of the central processing module, it is the control and the scheduling, HTTP engine realize the HTTP protocol, the file system access to resources, configuration module and security module implements the server configuration and security mechanism, application server interface implementation and application interaction. Application program interface module common are CGI (common gateway interface), SSI (server side contains) and HCPA (HTML-to-C pre-processor facilities), element order, custom, API interface and other forms, there are no corresponding realize standards.

In equipment Embedded Web server, make equipment can with today's biggest Internet network seamless connection, need not special line; Transmission content not only limited data and images, sounds and other multimedia information; Communication protocol (HTTP) is a standard and is open, independent of the system platform; The use of HTML (hypertext mark-up language) language has unity. Standardization independent of the client software interface hardware platform, greatly saves client development work. Use Web framework, openness and platform independence can greatly reduce the system design work. Embedded Web server is versatile, to be embedded into any of the equipment. Embedded Web server is application in embedded systems Web server architecture. It is currently the main application

equipment management and enterprise application network expansion.

#### A. Lighttpd Web Server

The resources of embedded devices are limited, and do not able to handle multiple user requests, so the specifically designed for embedded Web server are needed instead of Apache used in Linux. In embedded Linux systems, the typical Web Server<sup>[7]</sup> are Boa, httpd, thttpd and so on. Lighttpd is designed to provide a lightweight web server that is capable of serving large loads and using less memory than servers like the Apache HTTP server. It's commonly deployed on high traffic sites, including YouTube. With a small memory footprint compared to other web-servers, effective management of the cpu-load, and advanced feature set (FastCGI, SCGI, Auth, Output-Compression, URL-Rewriting and many more) lighttpd is the perfect solution for every server that is suffering load problems.

In order to set up of web server we have to follow the steps:

- 1) Download lighttpd source. The lighttpd-1.4.13.tar.gz version is used in this project.  
**#wgethttp://lighttpd.net/download/lighttpd-1.4.13.tar.gz**
- 2) Decompress and compile lighttpd source.  
**#tar -zxvf lighttpd-1.4.13.tar.gz**
- 3) Use ./configure generated Makefile files, modify Makefile
- 4) Compile and optimize.
- 5) Configure lighttpd: The default lighttpd configuration file: /etc/lighttpd/lighttpd.conf (download sample lighttpd.conf file)
- 6) Start lighttpd by the following command.  
**#lighttpd -m /lib/ -f /etc/lighttpd/lighttpd.conf**

#### B. Web Page Design

A static web page<sup>[5]</sup> (sometimes called a flat page/stationary page) is a web page that is delivered to the user exactly as stored, in contrast to dynamic web pages which are generated by a web application. Consequently a static web page displays the same information for all users, from all contexts, subject to modern capabilities of a web server to negotiate content-type or language of the document where such versions are available and the server is configured to do so.

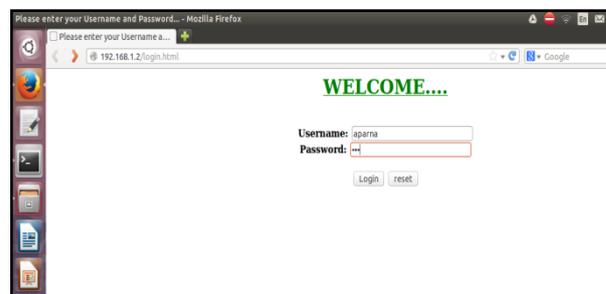


Fig. 3. Web page

Static web pages are often HTML documents stored as files in the file system and made available by the web server over HTTP (nevertheless URLs ending with ".html" are not always static). Static web pages are suitable for the contents that never or rarely need to be updated.

#### V. SYSTEM APPLICATION DESIGN

The software development mainly includes the system layer and the application layer two levels. The main duty of

system-layer software involves start up programs of Linux-2.6.32.2 and low-level drivers for various devices in development board (e.g., camera, USB interface and network card). The design for application layer software mainly includes three modules, namely, Video Capture Module<sup>[4]</sup>, Video Processing Module<sup>[4]</sup> and Data Transmission Module. The function of every module is shown in figure 4.

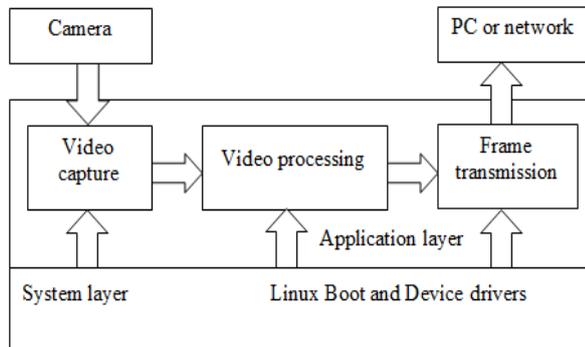


Fig. 4. System Processing Framework

When a USB camera is connected to the system after transplanting the camera drivers, the Linux generates a device file automatically under the directory: /dev/video0. Then it is easy to operate and access the video device.

#### A. Video Capture Based Video4Linux

Video acquisition system is built on the Video4Linux interface provided by the kernel. Video4Linux (V4L), is based on Linux to get video and audio data API interface, and video capture device and the appropriate driver, you can implement image/picture collection.

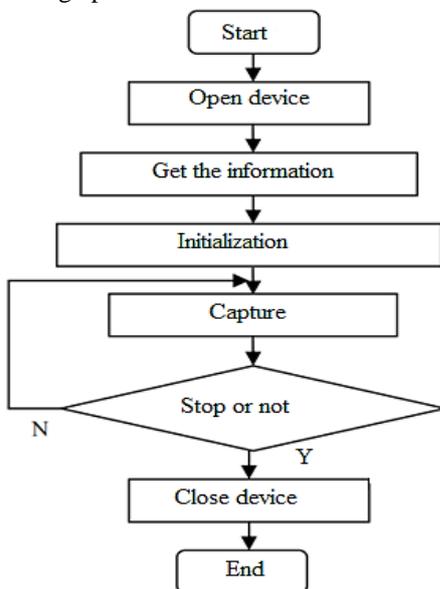


Fig. 5. V4L Capture Flow

V4L was video equipment's programming has provided a series of connection function. USB camera driver will need to provide basic I/O interface functions open, read, write, and close. Provides the interrupt processing procedure realization, the memory mapping function as well as realizes and so on to I/O channel's control interface function ioctl, and defines them in struct file operations. When the application procedure executive operations and so on open, close, read, write to the equipment document, The Linux kernel visit

driver provides function by the file operations structure. The basic process of video capture shown in Figure 5. V4L USB camera using the programming on the need to use Linux system calls the next two, respectively, ioctl() and mmap(). To open and close V4L2 devices applications use the open() and close() function, respectively. The video capture card is represented by /dev/video0.

Major device's control command in the function and data construction's application supported by Video4linux:

- 1) VIDIOC\_QUERYCAP : To check if the kernel device is compatible with this specification, and to query the functions and I/O methods supported by the device. It is used to identify kernel devices compatible with this specification and to obtain information about driver and hardware capabilities.
- 2) VIDIOC\_REQBUFS : To allocate device buffers applications call the with the desired number of buffers and buffer type. Memory mapped buffers are located in device memory and must be allocated with this ioctl before they can be mapped into the application's address space. Before applications can access the buffers they must map them into their address space with the mmap() function.
- 3) VIDIOC\_QUERYBUF : Used to query the status of a buffer at any time after buffers have been allocated with the VIDIOC\_REQBUFS ioctl. On entry to this method, the only fields of buffer which will be set are type and index, which identifies the specific buffer. The location of the buffers in device memory can be determined.

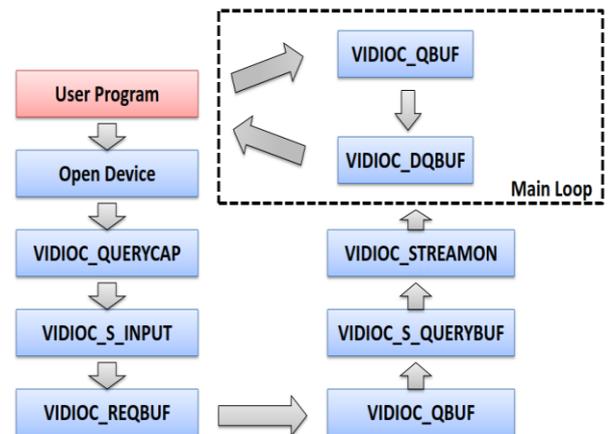


Fig. 6. V4L2 Processing Flow

- 4) VIDIOC\_QBUF : Before the application can start streaming I/O, it must put at least one buffer into the driver's incoming queue; for an output device, of course, those buffers should also be filled with valid frame data. To enqueue a buffer, the application will issue a VIDIOC\_QBUF ioctl.
- 5) VIDIOC\_DQBUF : Once streaming I/O starts, the driver will grab buffers from its incoming queue, have the device perform the requested transfer, then move the buffer to the outgoing queue. Eventually the application will want to claim buffers in the outgoing queue, returning them to the user-space state.

When the application is done it should generate a call to VIDIOC\_STREAMOFF, which must stop the device. The driver should also remove all buffers from both the incoming and outgoing queues, leaving them all in the user-space state.

The driver must be prepared for the application to simply close the device without stopping streaming first. The video equipment must be closed after Video Capture.

### B. Video Compression

The increasing demand to incorporate video data into telecommunications services, the corporate environment, the entertainment industry, and even at home has made digital video technology a necessity. A problem, however, is that still image and digital video data rates are very large, typically in the range of 150Mbits/sec. Data rates of this magnitude would consume a lot of the bandwidth, storage and computing resources in the typical personal computer.

For this reason, Video Compression standards have been developed to eliminate picture redundancy, allowing video information to be transmitted and stored in a compact and efficient manner. In multimedia, Motion JPEG (M-JPEG or MJPEG) is a video compression format in which each video frame or interlaced field of a digital video sequence is compressed separately as a JPEG image. Originally developed for multimedia PC applications, M-JPEG is now used by video-capture devices such as digital cameras, IP cameras, and webcams; and by non-linear video editing systems.

### C. Network Transmission Design

The network transmission<sup>[10]</sup> program sends real-time video data stream to different clients using multiple threads. The server communicates with the client after building the socket through the listening port that is bind to the socket.

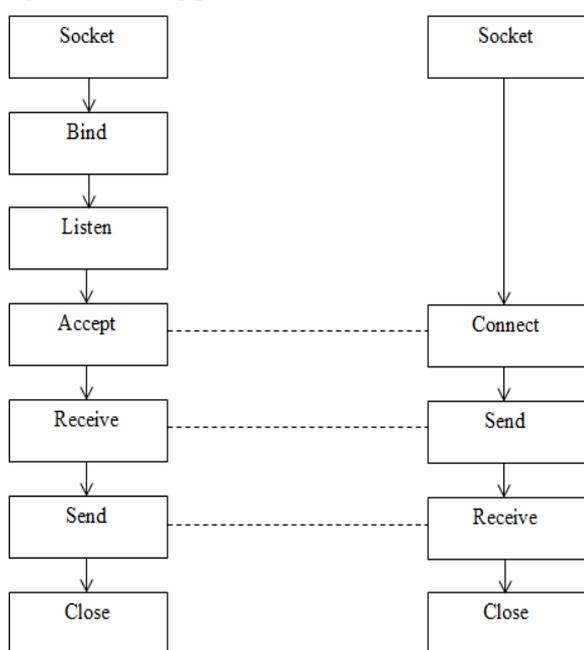


Fig. 7. Network transmission flow diagram

When a client request for a connection with the server, the server detects the request and opens a sub-thread to encapsulate the video data and then send the data packages to the client. In addition, the main thread continues to monitor the port for other client requests. The data transmission is based on the http protocol<sup>[6]</sup>. The data transmission is based on the http protocol. The network transmission flow diagram is shown in Figure 7.

Most inter-process communication uses the client server

model. These terms refer to the two processes which will be communicating with each other. One of the two processes, the client, connects to the other process, the server, typically to make a request for information. The client needs to know of the existence of and the address of the server, but the server does not need to know the address of (or even the existence of) the client prior to the connection being established. Once a connection is established, both sides can send and receive information. The system calls for establishing a connection are somewhat different for the client and the server, but both involve the basic construct of a socket. A socket is one end of an interprocess communication channel. The two processes each establish their own socket.

The steps involved in establishing a socket on the client side are as follows :

- 1) Create a socket with the socket() system call
- 2) Connect the socket to the address of the server using the connect() system call
- 3) Send and receive data. There are a number of ways to do this, but the simplest is to use the read() and write() system calls.

The steps involved in establishing a socket on the server side are as follows:

- 1) Create a socket with the socket() system call
- 2) Bind the socket to an address using the bind() system call. For a server socket on the Internet, an address consists of a port number on the host machine.
- 3) Listen for connections with the listen() system call
- 4) Accept a connection with the accept() system call. This call typically blocks until a client connects with the server.
- 5) Send and receive data

Once a connection has been established, both ends can both read and write to the connection. Naturally, everything written by the client will be read by the server, and everything written by the server will be read by the client.

The function of video data transmission part lies in spreading the compressed video to the remote PC customers, The DM9000A Fast Ethernet controller is used to transfer the video. The transmission of video data streaming is based on TCP/IP protocol. It is through these entities that resources can be made available data can be moved between hosts and remote user can communicate. The processed stream data packets are uploaded into server using TCP/IP protocol and transmitted so that user input the corresponding IP-address <http://192.168.1.2/monitoring.html> and then the webpage is opened and the output video can be streamed.

## VI. RESULTS

The processed stream data packets are uploaded into server so that user input the corresponding IP-address <http://192.168.1.2/monitoring.html> and then the webpage is opened and the output video is streaming as shown in below Figure 8.

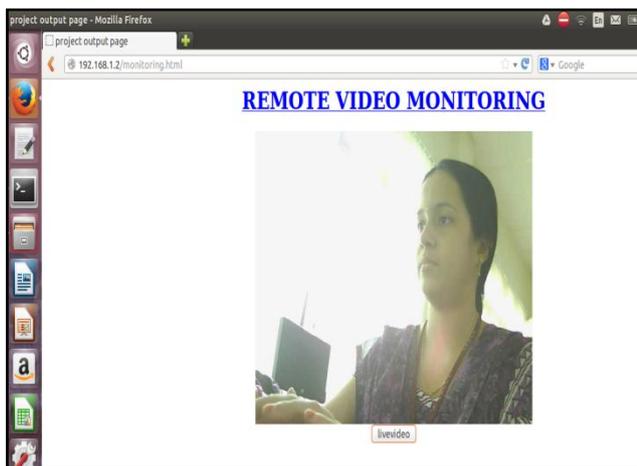


Fig. 8. Video streaming output

The YUV format input video is converted to JPEG frames and thus MJPEG video is obtained on the web browser. In below Figure 9 shows the program execution output.

```
Try to bring eth0 interface up.....NFS root ...Done
Please press Enter to activate this console.
[root@FriendlyARM /]# ./myvid
i: Using V4L2 device.: /dev/video0
i: Desired Resolution: 640 x 480
i: Format.....: YUV
o: HTTP TCP port.....: 8050
```

Fig. 9. Execution output on board console

It shows the system transmits MJPEG format video with 640x480 resolutions to the http port 8050.

## VII. CONCLUSION

The structure of video capture system based on S3C2440 processor is presented. Video 4 Linux is used to get the camera video data, which is transferred to the Web Server lighttpd, and the data is displayed on the client browser or on client. The monitoring system based on the embedded platform has advantages of small size, longer work time and stable performance. It is widely recognized and becoming the main flush of network remote monitoring system.

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