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Introduction to Video Surveillance Systems Over the Internet Protocol

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ABSTRACT

Video surveillance systems are currently undergoing a transition from traditional analog solutions to digital solutions. This paper will discuss how to implement a digital video surveillance system over internet protocol (IP). The hardware/software infrastructures that will be proposed are based on Texas Instruments TMS320C64x™ DSP. The related software collateral and standards will also be covered.

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1 Introduction

Video surveillance systems are very important in our daily life. Video surveillance applications exists in airports, banks, offices and even our homes to keep us secure. Video surveillance systems currently are undergoing a transition where more and more traditional analog solutions are being replaced by digital ones. Compared with the traditional analog video surveillance system, a digital video surveillance offers much better flexibility in video content processing and transmission. At the same time, it, also, can easily implement advanced features such as motion detection, facial recognition and object tracking. Texas Instrument DSPs can be used to design various video surveillance systems from low-end to high-end, from a portable implementation to plug-in implementation. The TMS320C64x DSP is a perfect candidate for a high-resolution, video surveillance system over the Internet protocol because of its architecture and peripherals such as video ports and on-chip EMAC.

Every digital video surveillance system can be divided into three modules: video capture module, network interface module, and central office module (see Figure 1). The video capture module is usually composed of a set of cameras and a video encoder device. This module captures the video and compresses the video raw data by a given video coding standard (MPEG2, MPEG4, H.263 …). The network interface module processes the video coded stream and delivers it to IP. The central office module monitors every video channel and controls the camera's actions.

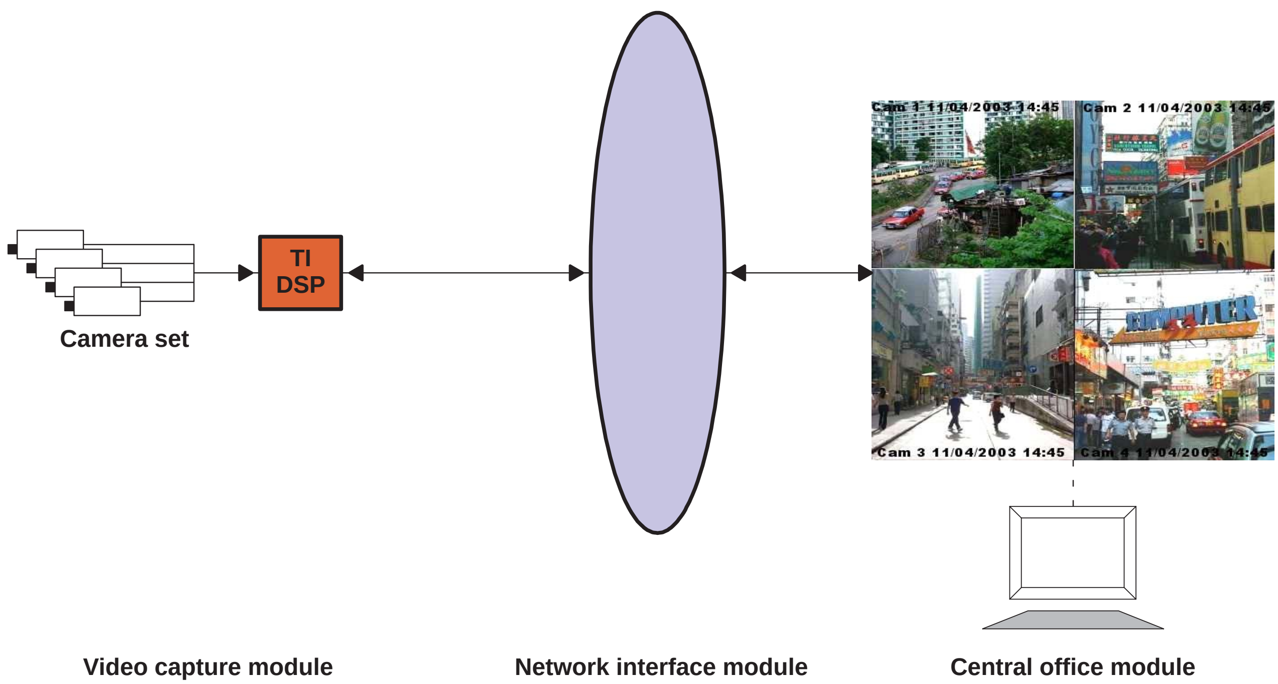

Figure 1. A Prototype of a Video Over IP Surveillance System

2 Hardware Infrastructure of C64x-Based Video Over IP Surveillance Systems

2.1 Video Capture Module

For any video surveillance system, a set of cameras are used to monitor a scenario. The captured videos can be transmitted to the central office over internet protocol (IP). Usually, multi-video channels are supported in the video capture module. The video ports in C64x™ including the DM642, provide a glueless interface to common video decoder and encoder devices. This is critical for the video capture module in a video surveillance system. The distinguishing features of the video port are listed below:

- Support of multiple resolution and video standards
- High speed DMA transfer between video devices and frame buffer memory
- Reduction video algorithm overhead through color separation and scaling
- Support of SDTV and HDTV resolutions
- Support of 8-bit and 10-bit (parallel) video standards such as ITU-BT.656, SMPTE 125M
- Graphics display support
- Programmable capture/display window size
- Large configurable FIFO with programmable thresholds
- 64-bit internal data port(s) for highest DMA bandwidth

The TMS320C64x DSPs are the highest-performance fixed-point DSPs in the TMS320C6000™ DSP platform. They are based on the second generation high-performance, advanced VelociTI.2™ very-long-instruction-word (VLIW) architecture developed by TI. The C64x DSP core processor includes: six general-purpose 32-bit registers and eight highly independent function utilities. C64x DSPs include a two-level cache-based memory architecture which is composed of level 1 programmer cache, level 2 data cache, and level 2 memory cache.

The TMS320C64x architecture provides a very efficient and extensive support for video processing implementations such as video coding. Some example include:

- LDNDW that can access packed video data in byte-wise is important for every video processing implementation.
- SUBABS4 instruction that can calculate eight absolute differences; every cycle is critical for the motion estimation in video coding.
- AVG2 and AVG4 instructions that perform dual 16-bit and quad 8-bit average are very helpful for the video pixel interpolation.

2.2 Networking Interface Module

The Ethernet media access controller (EMAC) on the C64x DSP devices provides an efficient interface between the C64x DSP core processor and the network [1]. It plays an important role in a video surveillance system over IP. The EMAC supports both 10 Mbits/second (Mbps) and 100 Mbps in either half- or full-duplex, with hardware flow control and quality of services (QOS) support.

The EMAC controls the flow of packet data from the DSP to the physical layer (PHY) [2]. The management data input/output (MDIO) module controls PHY configuration and status monitoring. Both the EMAC and the MDIO module interface to the DSP through a customer interface that allows efficient data transmission and reception. This custom interface is referred to as the EMAC control module, and is considered integral to the EMAC/MDIO peripheral. The control module is also used to control device reset, interrupt, and system priority.

3 Software Infrastructure of C64x-Based Video Over IP Surveillance Systems

A real-world video surveillance system supports various functions. For a DSP-based system, C64x has a variety of software collateral such as the chip support library, DSP/IMAGING libraries to shorten the development of commonly used imaging and math functions. A software infrastructure prototype of the video over IP surveillance system is shown in Figure 2.

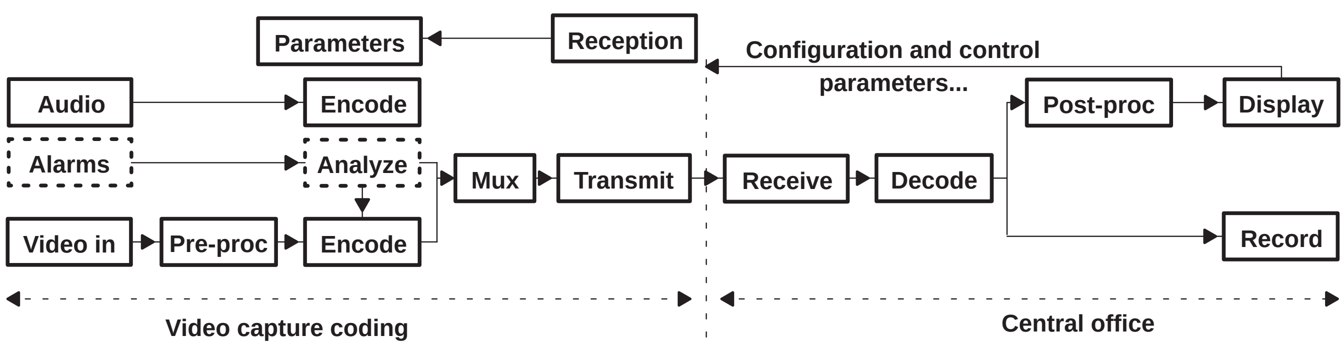

Figure 2. Software Infrastructure

3.1 Video Coding

Different video coding standards are implemented for various video surveillance systems. The C64x DSP performs well for all video coding standards such as H.263, MPEG2, MPEG4 and emerging H.264. The flexibility of the DSP allows it to encode/decode multichannel videos at various resolutions (CIF, 2CIF, VGA, D1) with frame rates of up to 30 FPS.

Since video surveillance systems are used under different environments, the environmental noise and system noise usually reduce the video quality and sometimes cause a false alarm. Preprocessing video data can significantly reduce the noise level and false alarm rate. The basic preprocessing technique is to use some type of low-pass filtering. Post-processing is used to reduce the artifacts generated during video coding. This step can improve the video quality significantly in a low-bit-rate transmission case.

3.2 Motion Detection

Motion detection is a key feature for a video surveillance system and can be used to alarm video/audio recording and transmission. However, reliable motion detection techniques should avoid the false alarms.

A realistic motion detection technique should tolerate the optical noise reproduced by camera and only respond to the movement in the region of interest (ROI). To measure movement in video scenes, motion detection can use the sum of absolute difference (SAD) and correlation. Sometimes, the color information can also enhance the performance of motion detection. Many smart video surveillance systems currently in market support this feature.

3.3 Image Dating

A real-time clock (RTC) exists in the video capture module. The date information provided by RTC is incorporated into the video stream. The data information can be used for the visualization of the recorded streams and incrustation for live visualizations. A regular image date appears as: *year_month_day_hour_minute_second .*

3.4 Channel Reference

Each video channel is referenced by a string of characters incorporated into the video stream. The video channel reference can be used for incrustation during live visualization. The channel reference can be defined by the supervisor in the central office over IP. An analog video output is available for local visualization (maintenance, control).

3.5 Control Management

A supervisor in a central office is capable of controlling the video capture/display module. Some of features that the supervisor can control over IP include: bit rate, frame rate and group of pictures (GOP) of video coding. A supervisor in the central office can also choose the name for each video channel. Details of control management are shown in Figure 3.

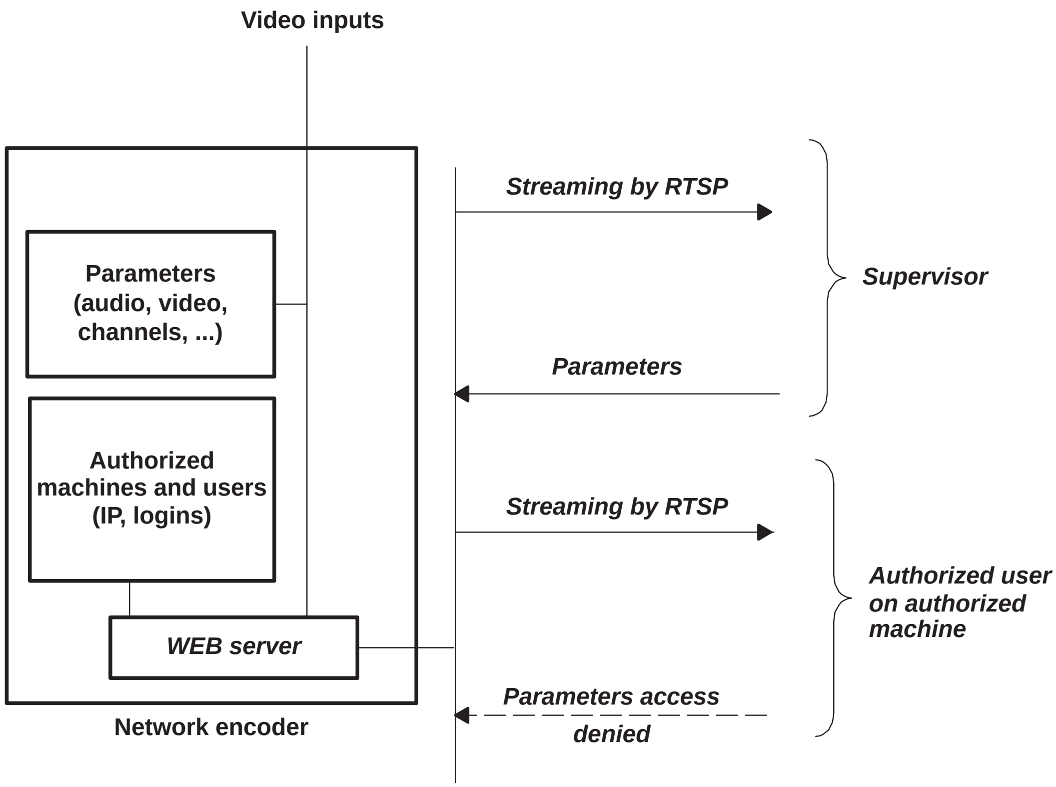

Figure 3. Control Management

3.6 RTSP/RTP

The encoded video stream can be transmitted to the central office through either an ISDN infrastructure or IP infrastructure. However it is expected that systems in the future will run under IP networks. Since the IP infrastructure is almost everywhere, the additional investment needed to provide video transmission over IP between IP nodes and central office is relatively small. The RTSP/RTP protocol is tailed for the video over IP implementation. TI's C6000 TCP/IP stack provides a low-cost, ready-to-use network connectivity which is critical to bringing differentiated product to market quickly including a detail Video surveillance system. This stack has been designed for development and demonstration of network enabled application on the TMS320C6000 DSP family. Using this stack, the C64x DSP developers can quickly move from development concepts to working implementations attached to the network. The TCP/IP stack is composed of several modules [1]:

- Operation system (OS) adaptation layer
- File descriptor functions
- Socket functions
- Low-level stack functions
- Hardware abstraction layer
- Additional protocols

The TCP/IP stack is designed to be executed in different operation modes with varying types of scheduling and exclusion methods. Except for the HAL and SERIAL interface layer, most modules are hardware independent. Even the HAL and SERIAL interface layer are divided into hardware dependent and independent portions. The well encapsulated software structure significantly reduces the development time for the new protocols including the RTSP/RTP protocols.

The real-time streaming protocol allows control of the multimedia stream delivery via RTP. The RTSP standardizes a comprehensive framework for real-time video/audio transmission and control over IP [3]. The delivery data can be either live data feeds or stored clips. This protocol provides a means for choosing delivery mechanisms based upon RTP.

The real-time transport protocol (RTP) is defined to enable the real-time data transmission over multicast or unicast network services [4]. The real-time control protocal (RTCP) not the RTP monitors the data delivery over IP. In the other words, RTP does not guarantee the service quality of a real-time stream. The RTP and RTCP are designed to be independent of the underlying transport and network layers.

3.7 IMGLIB

The TI C64x IMGLIB is an optimized video/image library for C programmers using TMS320C64X devices. It includes many c-callable, assembly-optimized, general-purpose image/video processing routines. These routines are typically used in computationally intensive real-time applications where optimal execution speed is critical. By using these routines, execution speeds considerably faster than equivalent code written in Standard ANSI C language can be achieved. In addition, by providing ready-to-use DSP functions, the TI IMGLIB can significantly shorten image/video processing application development time.

4 Reference

1. *TMS320C6000 TCP/IP Network Developer's Kit (NDK) User's Guide* (SPRU523)
2. *TMS320C6000 DSP EMAC/MDIO Module Reference Guide* (SPRU628)
3. H. Schulzrinne, A. Rao, and R. Lanphier, *Real-Time Streaming Protocol (RTSP)*, RFC 2336, Internet Engineering Task Force, Feb 1998
4. H. Schulzrinne, S. Casner, R. Frederick and V. Jacobson, *RTP: A Transport Protocol for Real-Time Applications*, RFC 1889, Internet Engineering Task Force, Jan. 1996

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