

# Universal Tuner: A Video Streaming System for CPU/Power-Constrained Mobile Devices

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## ABSTRACT

Due to the limited processing capability, memory constraints, and the power budget of mobile clients, multimedia coders and/or decoders are often difficult to implement on wireless handheld PDAs. In this Universal Tuner project, we designed and implemented a wireless video streaming system that transcodes MPEG-1/2 videos or live TV broadcasting videos to the BW or indexed color Palm OS devices. In our system, the complexity of multimedia compression and decompression algorithms is adaptively partitioned between the encoder and decoder. A mobile client would selectively disable or reenable stages of the algorithm to adapt to the device's effective processing capability. Our variable-complexity strategy of selective disabling of modules supports graceful degradation of the complexity of multimedia coding and decoding into a mobile client's low-power mode, i.e. the clock frequency of its next-generation low power CPU has been scaled down to conserve power. We modified the structure of the standard motion-compensated DCT video codecs to implement a simplified the encoder on a PC server and the decoder on a complexity-constrained PDA viewing client.

## Keywords

Compression, decompression, algorithms, partitioning, complexity, mobile, wireless, PDA, cell phone, graceful degradation, codec, multimedia, video, image, audio

## 1. INTRODUCTION

**Universal Tuner** is an IBM research project for streaming video on various hand-held or mobile phone devices through wireless. In this project, we implemented a prototype of a variable-complexity codec that can transcode MPEG-1/2 video or live TV broadcasting in real-time and stream it to the Palm-OS Personal Digital Assistant (PDA) devices. Figure 1 shows the system architecture of Universal Tuner.

Real-time compression or decompression of even simple multimedia standards can become impractical on complexity-constrained mobile devices. For example, we encountered real

complexity constraints while implementing a relatively simple animated GIF decoder on a Palm OS PDA operating with a 20 MHz Dragonball processor [1]. We measured decoding times for 80x80 GIF thumbnails to be one to five seconds per frame. For DCT-based multimedia standards that need more operations, the decoding speed on the Palm OS devices is far from real time.

Even though the speed of PDA's CPUs may increase in the future, power may be still a practical constraint that limits the application of multimedia on portable devices [2]. Next-generation PDA's will feature low power processors such as the Intel StrongARM that permit an operating system to conserve battery life by lowering the clock speed and the voltage [3]. Multimedia algorithms are hungry to consume processing cycles, and hence power. These complex algorithms will directly conflict with power conservation algorithms attempting to reduce the power consumed by a CPU and/or Multimedia DSP chip. Low power processors that operate at the lower end of their range in order to conserve power can effectively behave as complexity-constrained processors, thereby rendering impractical real-time processing of complex DCT-based multimedia standards such as MPEG-1/2/4 and H.26x.

In our Universal Tuner project, we designed a system that eliminates the complexity at the decoder by utilizing a variable partitioned-complexity strategy [4]. As shown in Figure 2, we design the encoding algorithm at the transcoding server and the decoding algorithm at the PDA client using a cascade of modules, which can be selectively disabled or enabled to the device's effective processing capability. We envision that our partitioned design will be operating in an environment in which battery life continues to serve as a primary constraint on wireless handhelds while next-generation wireless links may support greater bit rates. E.g., GPRS and 3G wireless systems intend to support bit rates on the order of 200 kbps to 1 Mbps per user. In such an environment, we feel that conserving battery power is a greater concern than conserving bandwidth.

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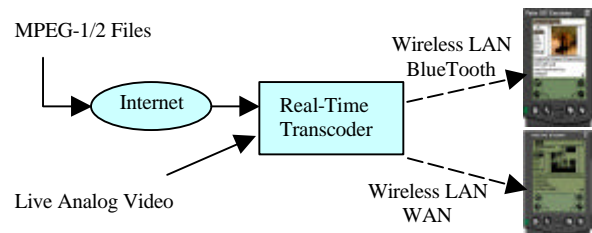


Figure 1: System Architecture of Universal Tuner

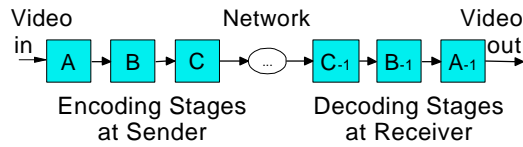


Figure 2A

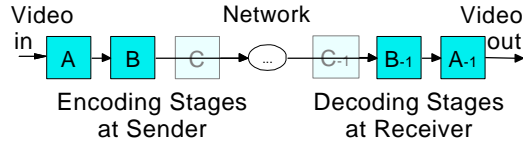


Figure 2B

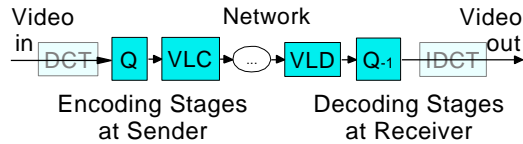


Figure 2C

Figure 2: Stages in a partitioned compression (encoder) and decompression (decoder) algorithmic pair are selectively disabled and reenabled to vary the complexity.

## 2. SYSTEM DESCRIPTION

The Universal Tuner system includes two parts -- a software video transcoder at the server end which can transcode MPEG-1/2 video or A/D converted live broadcasting video into client dependent format, and a software client application software on the color or Black-and-White Palm OS PDA.

An example of the client end is shown in Figure 3, this application is capable of displaying transcoded MPEG1/2 color video in both 80x80 thumbnail format (Figure 3(a)) as well as full-screen 160x160 viewing mode (Figure 3(b)). Using Palm IIIc emulator, we can show video in the 80x80 video mode at about 6 frame per second, where motion could be marginally considered as continuous in human perception, and 1.5 frame per second in the 160x160 video mode, which is perceptually similar to the slide show rather than the continuous motion video. In the client application end, we also added WML compatibility in the small video mode that can access information on the Internet through the transcoding server.

Figure 4 shows the block diagram of our current implementation of video transcoder. The input of the transcoder is a stream of video frames that is decoded from an MPEG-1/2 file on the local drive or received from the Internet. The other alternative is the video frames converted from live TV signals through the frame grabber PC card. In the transcoder, these RGB video frames are first resampled to either 80x80 or 160x160 image. Then, depending on whether the PDA device is Black and White or 256 colors (as in Palm IIIc), the color RGB frames are either dithered using halftoning or mapped to 256 colors using a shot-based optimal color map. In the color mode, we added a shot boundary detection functionality in order to update the color codebook for each new shot. After the color mapping or BW



(a)

(b)

Figure 3: Application Modes of Universal Tuner: (a) video is shown in the 80x80 mode with other functionalities; (b) video is shown in the full screen (160x160) mode.

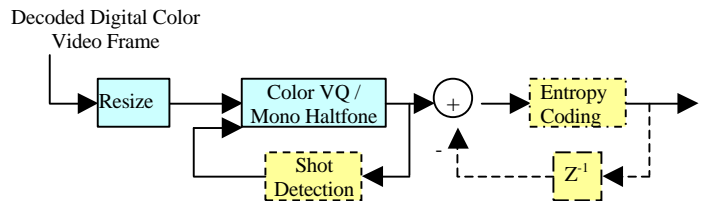


Figure 4: Block Diagram of Video Transcoder

halftoning, then the transcoder can selectively to enable an entropy coding process and an frame difference process that losslessly compress the coded bitstream

We have tested the effectiveness of the BW mode of our Universal Tuner in the real environments through a 9600 bps wireless modem. However, because of the limitation of the serial port connection speed in the previous Palm devices, we could only tested the color mode through the Palm emulator with the wireless LAN. Because the new Palm m500 series have supported the USB connection, we plan to further test our system in the WAN, Wireless LAN, and Bluetooth environments. These testing data will be reported in our demonstration

## 3. REFERENCES

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