Multimedia Power Management on a Platter: From Audio to Video & Games

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ABSTRACT

Today, battery-life is a major design concern for all portable devices ranging from cell phones to PDAs and portable game consoles. The purpose of this tutorial will be to give an overview of power management techniques that are applicable to multimedia applications running on such battery-operated portable devices. In particular, we will discuss a host of techniques, some of which are applicable to audio processing applications, some to video processing, and the others to interactive 3D game applications. The tutorial will be helpful to students, researchers, application developers and engineers who have a background in traditional real-time multimedia applications and would like to get an overview of the important issues and solutions pertaining to using and developing power management techniques for the multimedia domain.

Categories and Subject Descriptors

C.3 [**Computer Systems Organization**]: Special-Purpose and Application-Based Systems—*Real-time and embedded systems*

General Terms

Algorithms, Performance, Design

Keywords

Multimedia systems, Power management, Portable devices, Video, Games

1. BACKGROUND

Multimedia applications today constitute a sizeable workload that needs to be supported by a host of mobile devices ranging from cell phones, to PDAs and portable game consoles. Battery life is a major design concern for all of these devices. Whereas both – the complexity of multimedia applications and the hardware architecture of these devices – have progressed at a phenomenal rate over the last one decade, progress in the area of battery technology has been relatively stagnant. As a result, currently a lot of effort is being spent to develop high-level power management and application tuning techniques to minimize energy consumption and thereby prolong battery life. Such techniques include dynamically scaling the underlying processor's voltage and clock frequency in response to a time-varying workload, powering down certain system components when not being frequently used, and backlight scaling in LCDs with controlled image-quality degradation. Some of the application tuning techniques include selectively ignoring certain perceptually-irrelevant computations during audio decoding, and injecting metadata with workload information into video clips which can then be used to accurately estimate the decoding workload at runtime for better power management. In this tutorial, we plan to give a comprehensive overview of this area and discuss power management schemes for a broad spectrum of multimedia applications. In particular, we will talk about several power management and application tuning techniques specifically directed towards audio decoding, video processing and interactive 3-D game applications. Starting from the basics of power management for portable devices, we will discuss the necessary mathematical techniques, give high-level overviews of relevant algorithms and also present the hardware setup that is necessary to perform research and development in this area.

This tutorial will be specifically directed towards an audience who has some background in multimedia systems, but is relatively new to embedded systems and power management techniques. The level of the tutorial will be from introductory to intermediate and no background in embedded systems, computer architecture or hardware design issues will be assumed. The lectures will introduce the relevant background material; give an overview of the current state-of-the-art, focussing some of the important algorithms from each class – audio, video and games; introduce the hardware setup necessary to work in this area; and finally, talk about the issues and challenges currently being faced by the multimedia power management domain. The material to be presented will be useful to researchers, students, and software developers focussing on multimedia applications. It will particularly appeal to those who are familiar with multimedia systems and are interested in working on issues related to power management.

2. TUTORIAL ORGANIZATION

The main objective of this tutorial will be to cover various techniques for power management for audio, video and graphics-intensive game applications running on battery-operated portable devices. In particular, we would illustrate how power management techniques differ for audio, video and game applications and would present a number of techniques for each of these classes of applications. We would also give an overview of open research problems and the challenges facing this area. Finally, we would describe some of the hardware platforms that we have been using to conduct research in this domain and give demonstrations of selected power management techniques. An overview of the topics to be covered is given below.

- *Introduction:* We will start with the basics of power management schemes (e.g. dynamic voltage scaling and dynamic power management) and describe the relative merits and demerits of the different known techniques. This will be followed by discussing the important characteristics of audio, video and graphics-intensive game applications and why they are amenable to power management techniques.

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- *Power management for audio decoding applications:* For this class of applications, we will discuss how certain perceptually less important frequency bandwidths can be neglected while decoding, thereby reducing the decoding workload. This workload reduction is then exploited to run the underlying processor at a lower clock frequency, thereby saving energy and prolonging the battery life [1, 6].

- *Power management for video processing applications – offline analysis techniques:* Here, we will first discuss a workload prediction model for MPEG video. Using this model, it is possible to estimate the decoding workload for any video stream by performing a fast bitstream analysis. This technique is then used while downloading a video file from a desktop computer onto a portable device. During this process, the estimated workload information is inserted into the video clip as metadata information, which are then used at runtime for power management. In contrast to runtime/online workload prediction, such techniques often turn out to be less expensive and more accurate [7–9].

- *Power management for video processing applications – dynamic/runtime techniques:* Finally, we will discuss techniques for online or runtime prediction of video decoding workload. Such techniques often rely on history-based workload prediction, e.g., where the decoding workload of a frame is estimated to be the average of the workloads of a prespecified number of recently-decoded frames. Alternatively, control-theoretic feedback mechanisms are used to obtain better workload predictions. We will also discuss techniques for combining offline workload predictions with runtime estimates, which are then used to "tighten" the offline estimates [10].

- *Power management for interactive 3D games:* The last part of this tutorial will focus on power management techniques for graphics-intensive interactive 3D game applications. We will show that game applications are substantially different from video processing applications from the perspective of power management. It is possible to exploit the unique characteristics of game applications (e.g., the structural information in game frames) to accurately estimate their processing workload, which is then used for dynamically scaling the operating frequency and voltage of the underlying processor [2–5].

- *Summary and concluding remarks:* We will conclude by providing a high-level classification of the different techniques proposed. This will be followed by providing some details of the hardware and power measurement infrastructure required for conducting research and development in this area.

3. PRESENTER'S BIOGRAPHY

Samarjit Chakraborty is an Assistant Professor of Computer Science at the National University of Singapore. He obtained his Ph.D. in Electrical and Computer Engineering from ETH Zurich in 2003. For his Ph.D. thesis, he received the ETH Medal and the European Design and Automation Association's "Outstanding Doctoral Dissertation Award" in 2004. His work has also received Best Paper Award nominations at DAC 2005, CODES+ISSS 2006 and ECRTS 2007, all of which are premier conferences in the real-time/embedded systems area. Samarjit's research interests are primarily in system-level power/performance analysis of embedded systems. He has extensively published in major research forums on this topic including DAC, DATE, CODES+ISSS, ASP-DAC, RTSS and RTAS, and regularly serves on the technical program committees of many of these conferences. Over the last few years he has been working on various problems specifically related to power management of multimedia applications and have co-authored several papers and patents in this area.

Ye Wang received his Dr.-Tech. degree from the Department of Information Technology, Tampere University of Technology, Finland. In 2001, he spent a research term at the University of Cambridge, U.K., working with Prof. Brian Moore on compressed domain audio processing. He is currently an Assistant Professor with the Department of Computer Science, School of Computing, National University of Singapore. Dr. Wang has had a nine-year career with Nokia Research Center in Finland as research engineer and senior research engineer, where he worked on Digital Audio Broadcasting (DAB) receiver prototype development, optimization of perceptual audio coding algorithms, error resilient audio content delivery to mobile phones and compressed domain audio processing for multimedia applications on small devices. His research interests include audio compression and content-based processing, perception-aware and low-power audio processing, and error resilient content delivery to handheld devices via wireless networks. He holds a dozen patents in these areas and has published about 30 international journal and conference papers. He is a member of the technical committee, Coding of Audio Signals of the Audio Engineering Society; and a member of the Multimedia Communications Technical Committee, IEEE Communications Society.

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