California Energy Commission
Invitation to Participate - Computers
"Unified Power Control for Set Top Devices"

Vojin Zivojnovic
(vojin.zivojnovic@aggios.com)
AGGIOS, Inc.
Irvine, CA

1) Introduction

Typical smartphones, like the iPhone 4S use 0.03W when idle and less than 1W when in use*. In comparison, typical set top devices, like satellite, cable or IP devices use 100-1000 times more power when idle and 5-50 times more power when in use†. From end user's perspective those devices are converging and increasingly offer similar phone, tv and internet services. Therefore, for typical consumers it is hard to comprehend why the 115M US television households consume around 1.63.2TW for the set top devices and only around 50MW for the smartphones.

Our background is in the power management for mobile devices. We possess the necessary skills and technology to combine and manage hardware and software components and deliver optimal power efficiency for a wide class of mobile devices. In this project we shall utilize our mobile power management know how to address plug load devices in particular set top boxes for cable, IP or satellite service. We shall use the power profile of device hardware and software in combination with application and user activity information to automatically generate the optimum run-time power management software. By centralizing the information collection and decision making into a single process, analogous to a "control room", our technology shall control all aspects of the power consumption in the device and its external connections. Our main know how is in the aggressive fine grained control of the device sleep states. Whereas devices with traditional power management technology "sleep between viewing sessions", the devices with this technology "sleep between keystrokes". In this project we expect to take something as complex as system power management of a set top devices involving multiple layers of hardware and software and simplify it to the point that it is easy for developers to implement even the most sophisticated power management scenarios using common concepts. Our goal is twofold:

a) Demonstrate on a real life set top device that significant power savings can be achieved by applying mobile power management technology;

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* IPHONE 4S TECH SPEC. Retrieved from www.apple.com/iphone/iphone-4s/specs.html

† SETTOP BOX QUALIFIED PRODUCT LIST: Retrived from www.energystar.gov/ia/products/...lists/set_top_boxes_prod_list.pdf.

b) Demonstrate the prototype of executable power management software and related software tools to set top device manufacturers so they can automatically reduce power consumption of their devices even beyond the newest requirements of the "Test Procedure for Set-Top Boxes"[‡] of the Energy Conservation Program of the Department of Energy;

2) Goals

The first goal of the project is to apply the power management technology developed for mobile devices to the plug load devices and in particular set top devices for IP, cable or satellite connections and demonstrate significant energy savings. The second goal is to demonstrate feasibility of software tools which automatically generate optimal power management and lower the costs to develop new energy saving devices. This project is part of a larger project to automate the design of power management for a variety of plug load and battery powered devices.

3) State-of-the-Art

The newest IP, cable and satellite set top devices contain multiple heterogeneous subsystems with various functions and levels of performance. To save energy, many of these subsystems should be frequently put into a low power state or are powered off. This applies especially to energy-hungry main processors. In mobile devices the power management software runs alongside the operating system and continues to execute even while the main processor is powered off. It is able to manage energy while running on any active subsystem, including minimal hardware configurations with always-on-cores. This allows larger portions of the device to stay in low power mode longer and thereby save energy. Traditional energy management in set top devices in operating systems requires a fully powered main processor to execute, which severely limits energy saving capabilities.

Traditional energy management software in set top devices is an indivisible part of the operating system kernel. Modern kernels are highly complex software and even with open source, like Linux, only a handful of the largest corporations can afford sizeable teams of costly kernel designers to cope with the complexity. Newest power management solutions are operating system agnostic and come with tools to automatically generate energy management software tailored to the target device. We expect that this project shall reduces the barrier to entry for mid-sized and small companies by allowing them, with smaller investment, to match the energy efficiency of their larger competitors. This enables more set top devices to run more efficiently and save energy.

[‡] DEPARTMENT OF ENERGY, 10 CFR PARTS 429 AND 430, ENERGY CONSERVATION PROGRAM: Test Procedure for Set-Top Boxes; Retrieved from www.gpo.gov/fdsys/pkg/FR-2013-01-23/pdf/2013-01065.pdf

The basic principle of run-time energy management for electronic devices is to minimize (or turn off whenever possible) the clock frequency and supply voltage to the individual device components without impacting end-user quality of experience. Although the basic principle is simple, the implementation in real life devices has proven to be a major challenge. The complexity stems from the large number of hardware components and their interdependencies, intricate hardware-software relationships and unavoidable frequency and power switching latencies due to the natural inertia of hardware and software. These factors complicate the collaboration between hardware developers, device integrators and software developers working on the same device. As a consequence, the power saving potential in the hardware is either underutilized by the software or not utilized at all, in both cases delivering suboptimal products. This is particularly the case in the set top device industry which struggles with low margins and obsolete power management technology.

Despite the immense amount of research material on power management, the implementations in the final products are often limited by the lack of interest of providers of operating systems and devices to compromise perceived competitive advantages and larger profits for higher energy savings.

4) Energy Problem Targeted

Plug loads often have external or internal power supplies so that most or all of the energy is used as low-voltage direct-current electricity. As of 2010, plug loads consume approximately 15% of all building energy use, and that consumption is expected to grow to 29% in 2030[§]. Set top devices are among the most complex and most power hungry devices found in California households today. With the trend towards the Internet of Things their role shall only expand and result in even higher power consumption.

The project targets the PIER research issue “Buildings End-Use Energy Efficiency Research: Equipment and Appliances” as applied to set top and other information and communications devices.

[§] The California Energy Commission: Buildings End-Use Energy Efficiency Research - Equipment and Appliances http://www.energy.ca.gov/research/buildings/appliances.html