

Chapter 3.10

A Novel Energy Saving Approach through Mobile Collaborative Computing Systems

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ABSTRACT

Energy saving has been studied widely in both of computing and communication research communities. For handheld devices, energy is becoming a more and more critical issue because lots of applications running on handhelds today are computation or communication intensive and take a long time to finish. Unlike previous work that proposes computing or communication energy solutions alone, this paper proposes a novel energy savings approach through mobile collaborative systems, which jointly consider computing and communication energy cost. In this work, the authors use streaming video as investigated application scenario and propose multi-hop pipelined wireless collaborative system to decode video frames with a requirement for maximum inter-frame time. To finish a computing task with such a requirement, this paper proposes a control policy that can dynamically adapt processor frequency and communication transmission rate at the collaborative devices. The authors build a mathematical energy model for collaborative computing systems. Results show that the collaborative system helps save energy, and the transmission rate between collaborators is a key parameter for maximizing energy savings. The energy saving algorithm in computing devices is implemented and the experimental results show the same trend.

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1. INTRODUCTION

One of major challenges for enhancing user experience for handheld holders is energy, because battery can only last for a while in particular when computation intensive applications such as multimedia applications are executed. Even with the most updated energy efficient techniques, the device may still soon run out of power before the task is accomplished. To solve this problem, the handheld device can either shift the load to any device that may not have series energy concern (e.g., a plugged laptop or desktop), or collaborate with any other handhelds that can be reached through any communication methods. We call this joint computation among different devices for a common goal *collaborative computing*.

In general, collaborative computing utilizes resources (e.g., CPU, GPU) among a group of networked collaborative devices to accomplish tasks that are difficult for individual device to accomplish independently due to lack of computation resources. One typical collaborative computing scenario, grid computing, has been proposed specifically for heavy-load computing tasks (Spencer et al., 2002). Network plays an important role in collaborative computing because collaborative parties have to continuously exchange data and control commands. Today various wireless networks support reliable and high rate communications. Infrastructure-less wireless networks such as mobile ad hoc network (MANET) are getting mature. Heterogeneous devices such as laptop, desktop, PDA, projector, and TV are equipped with the wireless network interfaces. Because of the popularity of mobile devices and the above facts, it can be foreseen that such collaboration may also be applied to mobile environment, e.g., through mobile grid (Chu & Humphrey, 2004) under which mobile devices may collaborate with each other through wireless networks for better performance.

In this work we propose mobile collaborative systems and corresponding energy saving

techniques involving both computing and communication, to save energy and extend life span for mobile handhelds. In particular, a group of computing devices is connected through wireless networks and work for the same sequence of tasks in a pipelined manner. When computing a series of tasks that have a requirement on time interval between accomplishing any two consecutive tasks in the collaborative system, we investigate how to minimize the overall energy consumption on computation and data delivery by adjusting key parameters such as communication rate. This research is different from most of the previous work that proposes either computing (Pillai & Shin, 2002) or communication energy solutions (Lacage, Manshaei, & Turetletti, 2004; Benini & Micheli, 1999; Holland, Vaidya, & Bahl, 2001; Younis, Youssef, & Arisha, 2002), and jointly considers the energy cost for both computing and communication. Furthermore, we investigate the possibility that besides saving energy at individual devices, whether the collaborative computing systems can also save the overall system energy for accomplishing an application, compared to executing the same application at an individual device.

We adopt the dynamic voltage scaling (DVS) approach (Sachs, Adve, & Jones, 2003; Yuan & Nahrstedt, 2003; Rajan, Poellabauer, Blanford, & Mochock, 2007; Hughes, Srinivasan, & Adve, 2001; Weissel, Beutel, & Bellosa, 2002; Zhu, Melhem, & Childers, 2003; Hsu & Feng, 2004; Flautner, Reinhardt, & Mudge, 2001; Kim, Kim, & Min, 2004; Pillai & Shin, 2001), under which CPU voltage may be reduced if enough time is left for finishing a computing task. Correspondingly, the energy on computing can be reduced. However, unlike the approach (Liu, Chou, & Bagherzadeh, 2002; Liu, Chou, & Bagherzadeh, 2002) under which the transmission rate is set as high as possible so that within a delay requirement, a relatively longer time can be reserved for the connected device to compute, we argue that the concept of the higher the transmission

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