Chapter 12
Power Management Strategies based on Multi-Agent Systems for Portable Devices Equipped with Renewable Power Sources: Laptop Case Study

Rafael J. Valdivieso-Sarabia
University of Alicante, Spain

Juan M. Garcia-Chamizo
University of Alicante, Spain

ABSTRACT

Electronic portable devices present some technological challenges like battery life, providing services, and integration of renewable power supplies. These challenges can be improved using power management based solutions. Power management systems for electronic portable devices are ad-hoc solutions for each device, so solutions are not general enough to be applied to others. A model driven architecture approach is defined. It allows defining a general power management systems solution for portable devices. The general solution is based on agent modelling, which is parameterized, so it allows automatic retrieval of the power management multi-agent system for a particular device giving values to the model's parameters. Distributed management strategies are based on giving priority to renewable power sources and reducing power spikes when there is not enough power. A laptop equipped with a photovoltaic charger is introduced for simulating power demand and supply in order to discuss power management strategies for reducing electrical consumption.

INTRODUCTION

There is a significant growth in portable, embedded, and mobile computing devices like mobile phone, smartphones, handsfree, mp3 players, laptops, tablets, global positioning systems, autonomous wheelchair, medical monitoring sensors, etc. This fact may be consequence of miniaturization of electronic components like processors, flash memories, antennas, etc. and the social success of this kind of products. The Achilles heel of this kind of electronic devices is

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the power consumption-performance ratio. The power supply is determinant for power autonomy in these devices because they should be operative as long as they can, so power leaks could mean an authentic disaster in some critical situations. Electronic portable devices try to minimize power consumption of each intern component, although more and more are composed by a higher number of components in order to provide more and better services. Solutions based on larger batteries for improve power autonomy could make the device bigger and heavy. Moreover, this approach is not environmental sustainable because raw materials used to build batteries are finite and toxic. Sustainable development is defined by Brundtland (1987) as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Goodland and Daly (1996) relate social, economic, and environmental aspects as requirements to achieve it. Environmental sustainable development regarding to energy is related to renewable power supplies based on wind, sun, biomass, etc. The use of renewable power sources is usually associated with medium-large energy systems like: grid power plant, houses (Lucia & Gervino, 2006), vehicles (Tsuchiya, 2008; Ray, Lever, Streeter, & Price, 2007), although the use of renewable microgeneration for portable devices is becoming popular (Paradiso & Starner, 2005; Chang, Tran, Wang, Fuh, & Lin, 2010). The use of renewable power sources using smaller batteries seems to be environmental sustainable. The scenario composed by electronic portable devices, which should be operative while there is no grid connection available, equipped with batteries and renewable power sources suggest the use of power management systems in order to maximize the power autonomy. Power management policies are used in electronic devices for energy saving, although the different approaches are ad-hoc solutions, based on the particular features of the electronic device.

This chapter proposes a general power management system for portable devices that can be equipped with renewable power sources. Our approach is based on model driven architecture paradigm (Mellor, Scott, Uhl, & Weise, 2004). We define an agent based model of mobile power systems composed of multiple power supplies, storage elements and consumption components. The model makes it possible to create a power management solution for a particular portable device from the general model, giving appropriate values to the model parameters in order to improve the power autonomy. The power management system is conceived using distributed computational paradigm, specifically multi-agent system. It is automatically generated for JADE multi-agent software development framework (Bellifemine, Poggi, & Rimassa, 2001). Agent's interactions determine the power management strategies to apply in each moment. Strategies optimize energy distribution from power supply units to power consumption components using sustainable criteria and managing power consumption through cutting it down. Global power reduction is carried out by disabling or modifying non-critical features of consumer components in order to reduce the local consumption of each one. We present two strategies for triggering the load management. The first one consist in detecting components that are demanding energy over their average for disabling features of other components to make up for the overconsumption. The other strategy is to reduce power consumption if there is not power enough for all the components. It is determined when any batteries state of charge reaches a critical level, which should to be defined for each particular device. A laptop equipped with a photovoltaic generator and a full charged battery is simulated in order to discuss the power management strategies for this particular case study.