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Power Management Techniques for A Solar-Powered Embedded Device

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Abstract

The introduction of image processing into embedded devices made the working simpler. Supporting such devices requires a cost-effective power supply and maintenance methods because the number of devices in such an environment easily becomes enormous. Solar power and rechargeable batteries, among various energy-harvesting techniques for power supply to the embedded devices, is an attractive approach because solar power is virtually abundant. However, the power reserve management techniques and the usage of solar emitted power effectively because the power obtained through the solar source is available only during a certain period, and the amount of power obtained cannot be controlled. This project presents a simulator to analyze the power management schemes for solar-powered with a correlation range of an image and embedded systems. Using the simulator, the comparison of the power management processes function in a given environment. The results state that QoS of power management methods is achieved only through higher performance than a greedy online method.

Keyword - *Solar Power, Power Management Techniques, Adaptive Distribution*

I. INTRODUCTION

As IoT (Internet-of-Things) technology is adopted in many areas, the usage of embedded systems is growing in diverse ways. Now, have to answer the problems about how to power these embedded devices and effectively use energy for these devices. Since IoT aims to be accessible and installed in any device (Anything), whenever (Anytime), and wherever it is (Anywhere), embedded devices combined with IoT also must be accessible and installed anytime and anywhere.

To this end, various energy supply techniques are considered depending on the pros and cons of each technique. Among them, energy harvesting technologies such as solar power has been considered a promising power source. Solar energy is virtually an unlimited source of energy as long as the sun shines, and using it has the advantage of having low maintenance costs. Nevertheless, there still exist some disadvantages. For example, it is not possible to control the amount of solar energy gathered from solar panels, and there is a difference in the amount of energy that can be produced depending on the environments and atmospheric conditions such as clouds and seasons of the year. Also, need to consider energy storage for containing solar energy. Super-capacitor has unlimited charge-discharge cycles, but it self- discharges. In the case of a rechargeable battery, it is rechargeable, but it has limited charge-discharge cycles [1].

Present a simulator implemented to analyze the operation of embedded devices and to see how effectively the energy is used for activities of peripheral devices such as camera module used in image capture and network interfaces for transmission. Furthermore, compared the performance of the energy management schemes using an implemented simulator. Measured the energy harvested in winter and summer at Incheon, Korea, for use in simulation. The actual power consumption of embedded devices is measured with a real target for which we made a camera sensor device with a PIC microcontroller and a camera module.

II. RELATED WORKS

[1] ***Title: A Unified Stochastic Model For Energy Management In Solar-Powered Embedded Systems***

Author: Nga Dang, Roberto Valentini, Eli Bozorgzadeh, Marco Levorato, Nalini Venkatasubramanian

Description

The proposed system performance optimization algorithm is based on Markov Decision Process. The goal is to maximize the expected performance in the next harvesting period (which is a day for solar-powered systems) given the dynamics of harvesting, application, and characteristics of circuit and energy storage. The system performs actions subject to available QoS levels and application state. Each completed action earns a reward, representing system performance. The output of the optimization algorithm is an optimal policy lookup table that guides the system to take the right action once the actual harvesting state, application state, and energy storage state are detected at runtime. As opposed to deterministic approaches, our framework does not assume that energy harvesting availability or application state is known a priori. The best action is selected at every control time unit to adapt to variations in harvesting and application state quickly. The optimal policy guarantees to maximize the expected total system performance in the long run.

[2] *Title: Design And Power Management Of Energy Harvesting Embedded Systems*

Author: Vijay Raghunathan, Pai H. Chou

Description

Harvesting energy from the environment is a desirable and increasingly important capability in several emerging applications of embedded systems such as sensor networks, biomedical implants. While energy harvesting has the potential to enable near-perpetual system operation, designing an efficient energy harvesting system that realizes this potential requires an in-depth understanding of several complex tradeoffs. These tradeoffs arise due to the interaction of numerous factors such as the characteristics of the harvesting transducers, chemistry and capacity of the batteries used (if any), power supply requirements and power management features of the embedded system, application behavior. This paper surveys the various issues and tradeoffs involved in designing and operating energy harvesting embedded systems. System design techniques are described that target high conversion and storage efficiency by extracting the most energy from the environment and making it maximally available for consumption. Harvesting aware power management techniques are also described, which reconcile the very different Spatio-temporal characteristics of energy availability and energy usage within a system and across a network.

[3] Title: Power Management In Energy Harvesting Embedded Systems

Author: Clemens Moser

Description

Energy harvesting (also known as energy scavenging) is the process of generating electrical energy from environmental energy sources. There are various energy sources, such as solar energy, kinetic energy, or thermal energy. The term has been frequently applied in the context of small autonomous devices such as wireless sensor nodes. This thesis addresses power management in energy harvesting embedded systems. As an example scenario, we focus on wireless sensor nodes that are powered by solar cells. We demonstrate that classical power management solutions have to be reconceived and/or new problems arise if the perpetual operation of the system is required. In particular, we provide a set of algorithms and methods for different application scenarios, including real-time scheduling, application rate control, and reward maximization. The goal is to optimize the performance of the application subject to given energy constraints. Compared to state-of-the-art approaches, our methods optimize the system performance or achieve the same performance as state-of-the-art approaches requiring, e.g., smaller solar cells and smaller batteries, Dimension important system parameters like the minimum battery capacity or a sufficient prediction horizon have shown. Theoretical results are supported by simulations using long-term measurements of solar energy in an outdoor environment. Furthermore, to demonstrate the practical relevance of our approaches, we measured the implementation overhead of our algorithms on real sensor nodes

[4] Title: Dynamic Power Management In Environmentally Powered Systems

Author: Clemens Moser, Jian-Jia Chen, And Lothar Thiele

Description

The application scenarios investigated in this paper give fundamental insight into the challenges of power management for energy harvesting systems. While most conventional power management solutions aim to save energy subject to given performance constraints, performance constraints are not given a priori for the energy harvesting systems discussed in this paper. Rather, the performance is adapted in a best-effort manner according to the availability of environmental energy. The goal is to optimize the performance of the application subject to given energy constraints. Of course, the single approaches presented in this paper can also be combined. There may be two hierarchically structured schedulers that control the application. In the first step, an Application Rate Controller or a Service Level Allocator decides which and how many tasks are executed in the long run. In a second step, a Real-Time Task Scheduler decides about the short-term task ordering. For example, the Application Rate Controller may invoke a set of periodic tasks with different periods and phases. Besides, certain external events may trigger sporadic tasks (e.g., communication tasks using the onboard radio). In these situations, the Real-Time Task Scheduler will attempt to avoid deadline violation of time-critical tasks. To realize this combination of approaches, of course, the presented methods have to be adapted accordingly. For non-real-time applications, an Application Rate Controller or Service Level Allocator may be sufficient. The other way round, if the application parameters are determined by external conditions (e.g., sensor data, events, or the protocol between neighbor nodes), a Real-Time Scheduler for local signal processing may be required.

[5] Title: Paving the Path To A Green And Self-Powered Internet Of Things

Author: Mahyar Shirvanimoghaddam, Kamyar Shirvanimoghaddam, Mohammad Mahdi Abolhasani, Majid Farhangi, Vahid Zahiri Barsari, Hangyue Liu, Mischa Dohler, And Minoo Naebe

Description

Internet of things (IoT) is a revolutionizing technology that aims to create an ecosystem of connected objects and embedded devices and provide ubiquitous connectivity between trillions of not only smart devices but also simple sensors and actuators. Although recent advancements in the miniaturization of devices with higher computational capabilities and ultra-low power communication technologies have enabled the vast deployment of sensors and actuators everywhere, such an evolution calls for fundamental changes in hardware design, software, network architecture, data analytic, data storage, and power sources. A large portion of IoT devices cannot be powered by batteries only anymore, as they will be installed in hard to reach areas and regular battery replacement and maintenance are infeasible. A viable solution is to scavenge and harvest energy from the environment and then provide enough energy to the devices to perform their operations. This will significantly increase the device lifetime and eliminate the need for the battery as an energy source. This survey aims at providing a comprehensive study on energy harvesting techniques as alternative and promising solutions to power IoT devices. We present the main design challenges of IoT devices in terms of energy and power and provide design considerations for a successful implementation of self-powered IoT devices. We then specifically focus on piezoelectric energy harvesting and RF energy harvesting as the most promising solutions to power IoT devices and present the main challenges and research directions. We also shed light on the security challenges of energy harvesting enabled IoT systems and big green data.

III. EXISTING AND PROPOSED SYSTEM

A. Existing method

A framework for energy management in energy harvesting embedded systems is presented. Taking this as a referential example, the concentration is high on wireless sensor nodes. These are powered by solar cells. This brief explanation says that classical power management solutions must be rearranged and leads to the rise of many problems if the system needs a perpetual operation. In a mandatory constrain, we provide a set of algorithms and methods for various applicational scenarios; this includes real-time scheduling, application rate control, along reward maximization. The main view is to optimize the overall performance of the application concerning the given energy constraints. Optimization methods of the system performance allow the usage of smaller solar cells and batteries. The theoretical results are supported by simulations using long-term measurements of solar energy in an outdoor environment.

Disadvantages

- The Greedy Algorithm is only more efficient for short prediction horizons.
- A Real-Time Task Scheduler decides about the short-term task ordering.
- Task Scheduler will attempt to avoid deadline violation time critical of a task.

B. Proposed method

In recent times solar energy acts as a prominent source in every stream like Engineering and medical sciences. The Embedded system stays at the top in this usage. The modulation and sustainability suits were better for an embedded device rather than any other device. Due to more complexity and uncertainties involved in the production of energy leads the system working inefficiently. To overcome the energy availability and non-ideal characteristics, a new technique had been proposed to fulfill all the aspects, and the model is based on the technique used to manage power produced from solar cells efficiently, and the technique is mainly based on image processing. With the help of this technique, the system can run successfully in any atmospheric condition.

Depending on the amount of solar energy produced, the correlation range will be determined. According to the correlation value, instructions have to be given to the embedded device. The embedded part receives information from the processed image data. Charging of the battery will be done through the solar panel. According to the image data, the battery discharges the power to loads through the relay circuit, and the working of the circuit is entirely based on embedded programming. In terms of QoS and energy sustainability, the proposed method outperforms and stands best.

Advantages

- The proposed method of work enables a complete physical model and closed-loop control for solar-powered based systems. The optimization framework aims to maximize the expected performance of the systems in the long run.

IV. DESCRIPTION

A. PIC micro .controller

PIC (Peripheral Interface Controller) Microcontroller is a type of microcontroller which is said to be a next-generation version of the 8051 Microcontroller. Similar to the 8051, It also consists of a set of Registers, RAM, and stack to save the return addresses. This was made software-controlled in the latest versions.

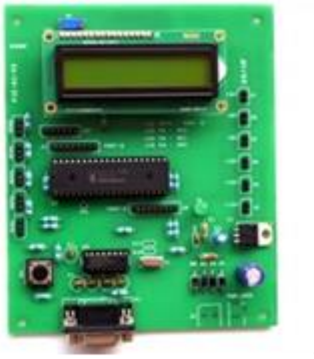

Figure (a) PIC

PIC16F877A IC

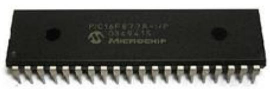

Figure (b) microcontroller

B. LC D (liquid crystal display)

It is considered to be the latest version of displays, which performs its functions using the liquid present inside in the form of layers. It has a better display comparing to the CRT (Cathode Ray Tube).

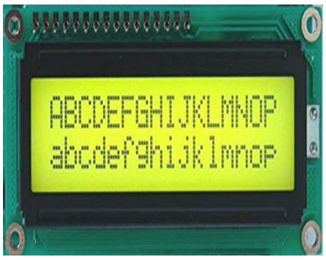

Figure (c) LCD

C. Solar panel

It is defined as a package of chemical cells together in a single board that performs the function of converting Light Energy into Electrical Energy. This energy is then used for running different appliances.

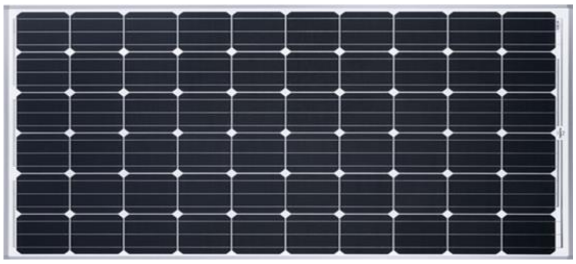

Figure (d) Solar Panel

D. Battery

It is a device that stores energy inside a well-defined structure and emits Direct current through the ports present in the construction. The major function of the battery can be said as the conversion of Chemical Energy into Electrical Energy. This process can be altered in rechargeable batteries.

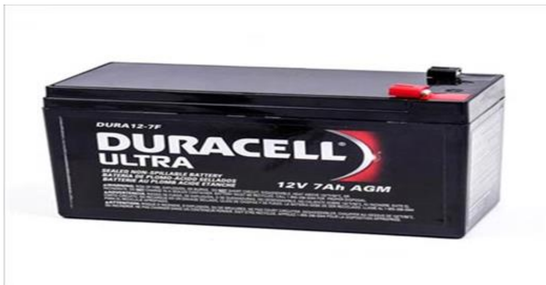

Figure (e) Battery

D. Relay Circuit

The device acts as a mediator between input and output circuits. This device comprises two ports, where the first one is connected to loads. Furthermore, the other one is connected to the input circuit.

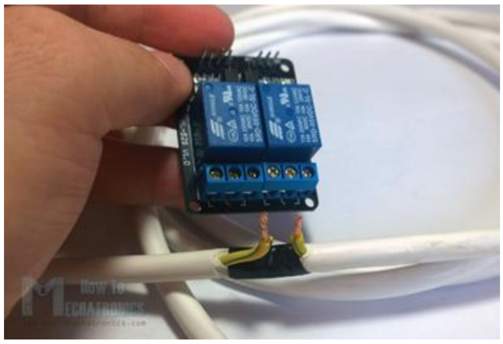

Figure (f) Relay circuit

V. OPERATION

1. The solar panel comprises of 10 watts power that has been used to supply power.
2. A battery of 12 volts is used to store the solar power coming from the solar panel.

3. The DC Adaptor gives the power used for components working.
4. All the operations have been done with the help of Programmable Interface Controller.
5. A microcontroller (PIC16F877A) IC is used to perform all the operations to be given for the circuit.
6. The power supply is done in uni-direction mode using a Biasing circuit.
7. A relay circuit is used for the output connection, and it comprises variable voltage units that vary in between (5-12v).
8. The simulation techniques have done all the operations mentioned above by using a MATLAB graphical user interface.

VI. CONCLUSION

This implemented a simulator technique for a solar-powered embedded device. Using the simulator, compare two energy management schemes, the greedy scheme, and the QoS-based energy management, using a capacitor and a rechargeable battery. The simulation results show that the QoS-based energy management can achieve higher performance than the greedy scheme. In the summer season, when the solar energy is harvested more so we can assume that the amount of energy harvested during a day is more than enough; the QoS-based scheme achieves even higher performance in the summer season when the solar energy is harvested more, so we can assume that the amount of energy harvested during a day is more than enough.

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