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Energy Management Strategies for Environmentally Powered Computing Platforms

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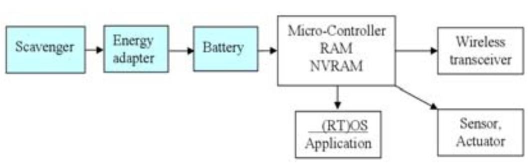
With the improvements in the field of low power digital design, environmental energy is becoming a feasible alternative[1] for pervasive embedded devices such as sensor nodes and bio-medical implants.

Most of the previous research for power management techniques considers systems that are powered up constantly from the electric grid or from batteries. In the case of traditional power management for batteries, the goal is to maximize the lifetime, since the total energy is limited.

Extending power management to capture energy harvesting is not straightforward because we search to attain autonomy through the adaptation of the system to the level of currently generated power, which is limited, unpredictable, yet densely available over time, since the environment is an inexhaustible energy source. The system also adapts to the level of previously generated energy that remains unused, which is kept in a storage element.



Block diagram of environmentally powered embedded system

Research Topics

The research is covering theoretical and practical aspects.

On the applicative side, we research the support at the middleware and the OS level s.t. the system performs with reliability computations meeting energy and timing constraints.

We have already assessed the usefulness of the opportunistic reconfiguration technique, which is a dynamic management scheme that customizes the system through the use of FPGA logic with the goal of minimizing energy consumption.

We plan to address the reliability of computation for such systems by performing checkpointing. We investigate the tradeoff between more frequent checkpointing that will allow a less significant roll-back in the case of a power outage, but which incurs, on the other hand, a higher time and energy overhead.

We also propose to apply formal validation techniques for assessing if the embedded device can attain perpetual operation given the probability distribution of the environmental energy and the transition system abstraction of the hardware/software components.

The TinyNode wireless sensor node developed in the LCAV group at EPFL is powered up by a solar panel.

Publications:

- **"An Opportunistic Reconfiguration Strategy for Environmentally Powered Devices"**, I. Folcarelli, T. Kluther, A. E. Şuşu, A. Acquaviva, and G. De Micheli, in ACM International Conference on Computing Frontiers, 2006.

[1]A state of the art WiFi transceiver consumes between 10-20mW in transmit-receive mode, while a very power-efficient processor can consume 1mW in active mode. A solar cell can generate between 100µW/cm² and 100 mW/cm², depending on the light conditions.