Self-powered Wearable Sensor Node: Challenges and Opportunities (Invited)

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ABSTRACT

In the near future, self-powered wearable sensor nodes are becoming as an emerging trend in healthcare applications. However, several design challenges exist before their wide usage, such as the limited and unstable power output as well as unpredictable power profiles. This paper shows an overview of candidate solutions and proposes that a cross-layer approach is needed.

1. INTRODUCTION

Modern wearable sensor nodes deployed on human bodies are promising in a broad range of healthcare applications. However, the limited operating time and frequent maintenance make the batteries become as a critical obstacle to be widely used. Recently, energy harvesting techniques are proposed to relieve those problems [1], and self-powered sensor nodes are attracting more and more attentions.

2. DESIGN CHALLENGES

A typical self-powered wearable sensor node consists of power supply system and computation system. The former harvests energy from ambient power sources, such as solar, vibration, temperature difference and RF energy, and the harvested power is converted into a proper level by a voltage regulator to charge an energy buffer and power the computation system. The latter performs information sensing, processing and transmitting. Instead of the advantages, several major design challenges exist in self-powered sensor nodes: 1) *Limited output power:* The typical generated power ranges from several μW to hundreds of μW, leading to a gap of several orders of magnitude between the harvested energy and the consumption of mainstream low power chips. 2) *Frequent power failures:* Lots of power failures occur frequently in self-powered systems, requiring efficient operations in an energy intermittent mode. 3) *Hard to predict:* The power profiles are determined by the ambient factors, which are hard to be predicted and affect the system performance.

3. RESEARCH OPPORTUNITIES

Several emerging techniques are promising to mitigate the problems in self-powered wearable sensors. First, near-threshold circuits [2], power gating [3] and nonvolatile memory [4] techniques can be used to fill the aforementioned gap by reducing dynamic and leakage power. Furthermore, simultaneous optimization of power supply and computation should be considered, because the mismatch between harvesting and consuming significantly affects the overall system efficiency. Second, circuit, architecture and software solutions should be developed to tolerate power failures, and nonvolatile processors [5] are one of such promising techniques. What's more, reliability issues, e.g. data inconsistency [6], is another problem in the energy intermittent system. Finally, as variations of power profiles introduce big uncertainty to the performance, power profiles should be added into traditional real-time scheduling techniques to guarantee the QoS requirement [7], where more advanced predicting methods are needed for energy harvesting.

4. CONCLUSION

Self-powered wearable sensor nodes have manifested strong vitality. However, the harvested power is limited, unstable and hard to predict, which prevents their wide utilization. This paper illustrates the unique challenges arising from such systems and lists the emerging techniques for those problems. We believe that cross-layer optimization from circuit to software is needed for self-powered wearable sensors, which is a quite promising direction.

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