Ecology-Aware Material Use as a Pervasive Trait in Intermittent Real-Time Systems

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With industry expectations of trillions of IoT devices to be employed in the coming years, questions about the sustainability of such endeavors arise naturally. In the context of intermittent computing, leaving behind batteries in favor of harvesting energy from the environment has been an active field of research for the last decade. Embedded platforms forgoing eco-unfriendly batteries for supercapacitors made from ubiquitous materials are commercially available.

Inherently, such intermittently powered systems come with (soft) real-time characteristics, as they need to assure forward progress and/or timely checkpointing of volatile state in the case of power failures. In the real-time community, it is well-known that changes on different levels of the system stack can affect the other levels (e.g., the timing behavior).

We argue that design decisions such as choosing more eco-friendly components should be made under consideration of their impact on the complete system stack. Consider again the example of intermittent computing. Broadly speaking, there exist two strategies for keeping state consistent across intermittent power failures: continuous checkpointing and just-in-time checkpointing after detecting an impending power failure. In comparison to lithium-based batteries, ceramics or dielectric capacitors come with a higher leakage leading to a higher degree of degradation. Therefore, using potentially unreliable capacitors in combination with just-in-time checkpointing may lead to inconsistent checkpoints during the lifetime of the system. Consequently, either a continuous checkpointing approach has to be used, or significant efforts have to be undertaken to consider the electrical processes inside the capacitor and their effect on the voltage and energy.

As shown by the example, characteristics like sustainability should be considered as cross-cutting concerns potentially affecting the complete system stack ranging from the hardware over the operating-system layer to the applications.