Optimizing Energy Consumption in Software Intensive systems

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The role of software is becoming increasingly important for a greener world.
Software technology enables systems to boost energy efficiency, streamline processes or adapt to the changes in the environment. Traditionally, this issue has been left out in the design process of software systems.

Considering green issues has a considerable impact to all aspects of software engineering including requirements engineering, architecture design, coding and verification because green aspect interfere with other quality values such as correctness, reuse, adaptability.

The previous work that is related to environmental issues mostly focus on the reduction of energy consumption, while leaving other system qualities (e.g. productivity) at a constant level. In certain situations, however, a lower standard on other system qualities might be acceptable, in which case the energy consumption can be further optimized. e.g. if highest productivity is not necessary, because the time-frame allows lowering it, then it might be lowered to save energy. Current research does not focus on designing systems in which energy consumption can be optimized, while it is possible to make trade-offs among a set of quality attributes.

There is a rich literature regarding the research on optimization techniques, run-time adaptation techniques and measurement theory, which can be refined to be utilized within green software engineering practices. We have explored this possibility in the context of embedded systems. These systems usually have a set of parameters that can be adapted at run-time e.g. the power given to a component, the speed of the system. For such parameters, the right values should be chosen, to optimize the energy consumption of a system, while choosing the right compromise for the other qualities. The range of possible values is often subject to constraints. For example, a component needs a certain amount of power under a given speed. This is an optimization problem known as multi-objective optimization (MOO) [1]. While well-known solutions exist for this problem, they have not been utilized from the perspective of green computing.

The goal of our research is to provide proper software models, styles [2], design patterns, composition mechanisms to effectively apply these MOO techniques in software intensive systems for goal of flexibly making trade-offs between energy consumption and other system qualities.

[1] R. L. Keeney and H. Raiffa, Decisions with Multiple Objectives:
Preferences and Value Tradeoffs, New York, 1976.

[2] A. de Roo, H. Sozer, M. Aksit, An Architectural Style for Optimizing System Qualities in Adaptive Embedded Systems using Multi-Objective Optimization. In: WICSA '09: Proceedings of the 8th Working IEEE/IFIP Conference on Software Architecture, 14-17 Sep 2009, Cambridge, UK, IEEE Computer Society Press.