RADIANCE: A tool for software behavior design and energy consumption categorization

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ABSTRACT. With the recent increase of the research community's attention, green software, also called sustainable software, has gained the spotlight as an opportunity for cutting back on the electrical energy expense world-wide. As a result, new approaches that cover the development, deployment, and execution of software have been garnered with the promise of a more efficient use of computational resources. Nevertheless, their adoption has been hindered by technicalities, and a lack of consistent guidelines from the analysis and design stages of the development.. In this paper, we present RADIANCE: a proof of concept web app for designing greener software with a model-driven approach based on the Behavior-Based Consumption Profiles (BBCP) Domain-Specific Modeling Language. RADIANCE, in contrast to other tools, embraces users with different levels of knowledge on green software and the BBCP approach, simplifying green software design. Moreover, RADIANCE assesses and rates the energy consumption of the profiles generated by the user, assisting the user to identify possible design changes that promote the creation of greener software.

KEYWORDS: Green Software Design, Green Software, Sustainable Software, Energy consumption, Sofware development

1. Introduction

With the recent increase of awareness on sustainability as a strategy for addressing the on-going energy and environmental crisis, green software has regained the spotlight as an opportunity to reduce the electrical energy expense. In our previous research (Larracoechea et al., 2022), we noticed a lack of green software approaches that target the analysis and design phases of the Software Development Life-Cycle (SDLC), with a majority of them targeting the development, testing and the deployment and maintenance phases, as seen in Table 1.

Table 1 Distribution of green within software tools throughout the SDLC

Contribution	Development	Testing	Deployment & Maintenance
(Aggarwal et al., 2015)	✓	✓	✓
(Hao et al., 2013)	✓	✓	✓
(Manotas et al., 2014)	✓	×	×
(Pathak et al., 2012)	✓	✓	✓
(Peltonen et al., 2015)	×	×	✓
(Oliner et al., 2013)	×	✓	×

Furthermore, as previous studies (Pang et al., 2015) conclude, industry programmers and university students are aware of the electrical energy expenditure associated to software execution, but, they are hindered by the lack of guidelines and tools to implement existing techniques with ease. The same can be said about the software development industry, where a previous study (Jagroep et al., 2017) identified that engineers consider software's energy efficiency as a parameter for successful software, but stakeholders neglect the expense of the overhead time that this goal demands.

In the following sections we present our tool, RADIANCE (softwaRe behAvior DesIgn And eNergy Consumption assEssment). RADIANCE is a web-based software behavior design and analysis tool based on the Behavior-Based Consumption Profiles (BBCP) Domain-Specific Modeling Language (DSML). RADIANCE's goal is twofold: (1) generate a consumption profile of the software designed on it so that energy consumption can be estimated from the analysis and

design phases of the SDLC and (2) blend the topic of green software with software design in order to lower the barrier of entry to green software development for students and professionals. The latter goal has a high priority to us, as we developed RADIANCE with an emphasis on usability and customizable levels of expertise that maximize its future adoption.

2. The core features of RADIANCE

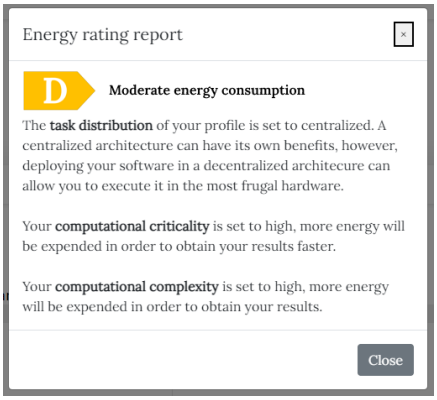
RADIANCE is a tool tailored for the BBCP DSML. The BBCP, in difference to other approaches, provides users with a series of properties that allow them to express the intensity of software consumption over time: how much software usage changes throughout a given set of hours, days or specific time-based events. RADIANCE supports the BBCP with 3 types of artifacts: schemas, profiles and collections. Schemas define the properties that constitute a profile. A profile is an instance of a schema filled with values that constitute the behavior of a software unit. Collections are agglomerated profiles that can represent a nuclear unit of software, such as a microservice, up to complete applications.

Figure 1 The UI of RADIANCE's builder

The UI of RADIANCE is divided into 2 main components: the manager and the builder. The manager is a library where the user can add, delete, duplicate and instance artifacts. The builder, visible in Figure 1 The UI of RADIANCE's builderFigure 1, is the most important component as it is responsible for assisting

the user throughout the process of software profiling with several mechanisms: a customizable UI, a dynamic sequence diagram of the designed operations, a dynamic step diagram that labels the energy consumption of parallel operations with shades of color and, finally, an algorithm that delivers a report with important points concern from an energy consumption stand point as seen in Figure 2 .

Figure 2 A sample energy rating report generated with RADIANCE



4. Demonstration

The demonstration will be divided in 2 parts: (1) an in deep explanation of the features available in RADIANCE and (2) a guided example of the creation of a profile that resembles GeForce Now, a cloud gaming platform. We selected GeForce Now due to its modern architecture that utilizes a cloud cluster in the network to render the video and sound stream, which is then sent back to the user by establishing an active exchange of data that negatively impacts the energy consumption of this software type. In addition, the profile will reflect the impact of the business model's constraints that affect the energy consumption, utilizing properties unique to the BBCP that constrain the usage of the profile through time.

5. Future work

There are still important validations that we need to perform before asserting that RADIANCE will in fact promote the design of greener software and introduce new users to it. To begin, we plan a usability test in the near future with university students in the IT field. The objective of the test will be to profile a specific example of a software unit and assess how many students can successfully achieve an energy rating report after a quota of time. Furthermore, we have a second usability test planned with several experts in software engineering and software design, so that we can insure that RADIANCE will be able to satisfy the needs of users with diverse levels of expertise.

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