MANAi - An IntelliJ Plugin for Software Energy Consumption Profiling

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Abstract—Developing energy-efficient software solutions is a tedious task. We need both, the awareness that energy-efficiency plays a key role in modern software development and the tools and techniques to support stakeholders involved in the software development lifecycle. So, we present the MANAi plugin which helps to make energy consumption of unit test methods explicit by providing visual feedback as a plugin to the Integrated Development Environment (IDE) IntelliJ. Our tool is intended to bring software energy consumption into the limelight as an important non-functional quality aspect in software development. Furthermore, with MANAi we provide a tool that eases the process of software energy experiments for a broad range of users from academia to industry.

Index Terms—energy efficiency, software energy profiling, tool

I. INTRODUCTION

Meeting sustainable design goals when developing software can play a crucial role in shaping our future. Given the ever-increasing demand for digitalization, software will continue to support or even take over different areas of our daily life. As a result, developing software faces ongoing challenges in providing sustainable and in particular energy-efficient software solutions. In supporting researchers and practitioners alike to tackle these challenges, software engineering research has provided considerable contributions to comprehend how energy is dissipated in software and how software design affects energy consumption. These contributions range from the implications of software design choices, to the development of energy optimized applications [1]–[2]. With our work, MANAi, we complement the body of existing methods with a tool that facilitates access to software energy profiling for a broad audience, ranging from computer science students and researchers to practitioners.

II. MANAi

The main goal of MANAi is to shed light on the energy implications of software design choices during development right where it is needed in the course of an IDE. MANAi shares some design considerations with the work from Liu et al. [3], mainly leveraging Intel’s Running Average Power Limit (RAPL) at its core to obtain energy readings. However, we take the idea of jRAPL [4] one step further and combine data obtained via Intel’s RAPL interface with the possibilities of expressive visualizations in IDEA’s IntelliJ IDE. Other existing plugins like EcoAndroid by Cuoto et al. [5] or Automated Android Energy-Efficiency InspectiON (AEON) maintained by the Software Engineering Lab at George Mason University, targeted for the Android platform, share some design considerations regarding visual feedback right within an IDE. To give the reader an impression, of what MANAi can do, refer to the illustrative example in Fig. 1. In particular, Fig. 1 outlines a unit test method after MANAi has obtained energy readings during its execution. The generated inline information attributed to the method provides users with insights, not only on the current energy feedback of a method, but furthermore it allows a user to get insights how the energy characteristics of the examined method has evolved, considering it has undergone several changes.

A. Architecture

MANAi is composed by two core modules, the Infrastructure (IFS) and the Experiment Environment (ExEn) module. The IFS module leverages the IntelliJ Platform SDK and provides components for energy experiment definition, data acquisition, visualization and configuration. The ExEn module facilitates the maven-plugin mechanism and is responsible to execute energy experiments defined and configured via the IFS module and report the recorded data obtained using Intel’s RAPL. Through the IFS module, a user can configure and define energy experiments within the development environment. The module further instructs the ExEn module to execute defined energy experiments and report recorded energy samples back to the user, e.g. through visual inline feedback attributed to the executed method (cf. Fig 1). If required, the ExEN module can be used in a headless manner (i.e. without IntelliJ) to allow scenarios which are independent of the IDE, e.g. as a step in a continuous integration pipeline. Additionally, the ExEN module has been designed with extensibility in mind, to ease future integration of additional methods to obtain energy readings next to RAPL.

1IntelliJ Platform SDK – https://tinyurl.com/2p9ed8za
2Maven Plugin Development – https://tinyurl.com/4v37zd5

Fig. 1. Depiction of a unit test method after execution via MANAi. The method is color coded and inline diagrams provide feedback on its energy characteristics.

1IntelliJ Platform SDK – https://tinyurl.com/2p9ed8za
2Maven Plugin Development – https://tinyurl.com/4v37zd5
The general workflow behind MANAi is described in Fig. 2. MANAi hooks into the compile process of Java source code and locates unit test classes as possible candidates for obtaining energy consumption readings. Entry points for an energy experiment in MANAi are unit test methods. MANAi automatically detects these unit test methods inside a Java project in IntelliJ and tags them as potential energy experiment candidates. These candidates are instrumented to obtain energy readings during their execution. The instrumented classes are stored within the currently opened project. Using IntelliJ’s internal program runner infrastructure, the instrumented classes and unit test methods are executed, and the energy data is being recorded. Finally, the recorded data is being visualized within the development environment.

As part of our replication package, we provide a short video that shows how this workflow presents itself from a user perspective.

B. Features

One of the key features of MANAi is that it offers different views and windows that provide expressive visual feedback to users about the energy characteristics of their Java projects. In what follows, we give a brief overview of these particular features:

a) Experiment Runner: The Experiment Runner facilitates IntelliJ’s internal program runner infrastructure to define and execute energy experiments from within the IDE. Defining an experiment consists of setting the sampling rate, the number of samples being collected and selecting the unit test classes and methods being executed. This allows for replication of experiments, as once an energy experiment is defined, it can be rerun multiple times.

b) Line Annotator: The Line Annotator allows for a fast and easy to comprehend visual feedback of the energy characteristics of a unit test method directly within the source code. Next to the last energy consumption recorded for a particular unit test, the inline charts highlight how the method has evolved, considering their energy attributes. This further allows comparing the energy characteristics of different unit test methods. Furthermore, users are able to inspect how a recent change to a method affects its energy consumption compared to recorded energy data of previous revisions. For example, let us assume we have a method that applies a rather naive approach to sorting an array of integer values, which we call Revision 1 as depicted in Fig. 3. Now, if we adopt the implementation of Revision 1 with a slightly more efficient sorting algorithm in Revision 2, the Line Annotator highlights if the applied changes led to an in- or decrease in energy consumption (cf. Fig. 3).

c) Summary Window: MANAi supports a detailed overview of the energy recordings, either represented as bar chart or using a contextual table view for the currently opened class (cf. Fig. 4). The Summary Window offers the possibility to compare different unit tests within the same class. The data presented consists of the initially specified sampling rate the number of samples, the recorded power and energy data. Power and energy consumption data is reported for its individual domains as specified by Intel RAPL [10, 13, 16].

In this paper, we presented a brief overview on MANAi and IntelliJ plugin for software energy profiling. We believe that MANAi contributes to the ongoing challenges around software sustainability by making energy characteristics of individual unit test methods in code explicit by providing visual feedback within the IDE. This way, our approach is beneficial for both education and development purposes. One of MANAi’s limitations is a decrease in accuracy if an instrumented test has a duration smaller than RAPL’s update rate. However, related work on RAPL has already provided possible solutions which are worthwhile being investigated in depth [17]. An additional open challenge is the distortion of results due to RAPL’s measurement overhead (cf. Desrochers et al. [18]). MANAi is hosted on an open-source GitHub repository. A prepackaged binary of MANAi can be obtained from [15]. For future work, we seek to extend the plugin’s support for other programming languages like Kotlin, which due to its support for Java Bytecode and raising popularity amongst developers makes it a promising candidate for integration.

3MANAi GitHub Repository – https://github.com/aschuler84/manai
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