

Problem Statement and Goals

Software Engineering

Team 6, EcoOptimizers

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Table 1: Revision History

Date	Developer(s)	Change
Date1	Name(s)	Description of changes
Date2	Name(s)	Description of changes
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[problem statement checklist](#)

1 Problem Statement

The Information and Communications Technology (ICT) sector is currently responsible for approximately 2-4% of global CO2 emissions, a figure projected to rise to 14% by 2040 without intervention [1]. To align with broader economic sustainability goals, the ICT industry must reduce its CO2 emissions by 72% by 2040 [2]. Optimizing energy consumption in software systems is a complex task that cannot rely solely on software engineers, who often face strict deadlines and busy schedules. This creates a pressing need for supporting technologies that help automate this process. This project aims to develop a tool that applies automated refactoring techniques to optimize Python code for energy efficiency while preserving its original functionality.

1.1 Problem

1.2 Inputs and Outputs

[Characterize the problem in terms of “high level” inputs and outputs. Use abstraction so that you can avoid details. —SS]

Inputs: Source code that requires refactoring for energy efficiency. **Outputs:** Refactored code with reduced energy consumption, along with performance and energy consumption reports.

1.3 Stakeholders

Direct Stakeholders

[**Software Developers**]: They will be the primary users of the refactoring library as they will be the ones to integrate the library into their code for better refactoring.

[**Business Sustainability Teams**]: These teams are responsible for considering how a company's practices affect the environment. They will especially be interested in viewing the metrics provided by the library on how it improves the energy efficiency of software over time, therefore decreasing the burden on hardware and minimizing the company's environmental footprint.

Indirect Stakeholders

[**Business Leaders**]: They focus on reducing operational costs associated with energy consumption, especially in large-scale or cloud-hosted applications. Use of the library in their products allows them to better achieve those goals.

[**End Users**]: While not directly affected by this refactoring library, end users of technology that use the library will benefit from more responsive and efficient software that consumes less power, especially in mobile, embedded, or battery-dependent applications.

[**Regulatory Bodies**]: They enforce energy consumption and sustainability standards, and ensure that software adheres to environmental regulations and may certify tools that meet efficiency requirements. Their oversight promotes the adoption of energy-efficient software practices.

1.4 Environment

Programming Language: Python will be the main language for developing refactoring tools and performing energy optimization. **Reinforcement Learning Library:** Stable Baselines will be the library to implement reinforcement learning techniques. **Development Frameworks and Tools:**

1. Github will be used for version control and for CI/CD integration to automate refactoring processes.
2. Visual Studio Code will be the IDE used.

Database: MySQL will be the database used to store and retrieve data about refactoring and energy consumption metrics.

[\[Hardware and software environment —SS\]](#)

2 Goals

3 Stretch Goals

4 Challenge Level and Extras

The expected challenge level of our project is general. This is due to the relatively straightforward technical knowledge required for its completion. The project primarily involves applying known software optimization and refactoring techniques, which are well-documented and accessible. Additionally, the required programming knowledge is in Python which is known by all of the team members and was taught in our undergraduate courses. Although the project does involve substantial development and research components, we anticipate the overall scope and depth of work to be manageable within the given timeframe.

To further enhance the project and address any potential gaps in the challenge level, we propose two additional activities: User Documentation and Usability Testing. These extras will allow us to provide support for future users of the tool and ensure that the tool meets user expectations and accessibility standards.

Approval of the challenge level and extras will be discussed with the instructor, and adjustments may be made as needed throughout the term.

Appendix — Reflection

[Not required for CAS 741 —SS]

The purpose of reflection questions is to give you a chance to assess your own learning and that of your group as a whole, and to find ways to improve in the future. Reflection is an important part of the learning process. Reflection is also an essential component of a successful software development process.

Reflections are most interesting and useful when they're honest, even if the stories they tell are imperfect. You will be marked based on your depth of thought and analysis, and not based on the content of the reflections themselves. Thus, for full marks we encourage you to answer openly and honestly and to avoid simply writing "what you think the evaluator wants to hear."

Please answer the following questions. Some questions can be answered on the team level, but where appropriate, each team member should write their own response:

Mya Hussain Reflection

1. *What went well while writing this deliverable?*

Our team was able to create a clear and concise plan as to what we were trying to achieve and investigate the details as to how we could potentially achieve it. We were able to brainstorm multiple possible routes to take depending on how successful we are while developing. We were also able to reach out to our supervising professor and receive many research papers that helped bring us up to speed as to what this project would require, so that we could set out realistic goals for the project.

2. *What pain points did you experience during this deliverable, and how did you resolve them?*

It took some time for the research papers we requested from our supervisor to actually hit our inboxes. In the meantime, we were on our own to brainstorm solutions for the problem. This was both a positive and a negative as on the positive side we got to do some self-study and think of some new ideas from scratch. While on the downside, we didn't know if our brainstormed ideas were methodologies our supervisor would want us to use. Learning with mentorship is great because we were able to gain confidence that what we were doing was correct due to our supervisor's experience. Being able to explore the project on our own was cool because we got to investigate a lot of different technologies surrounding the space regardless of how efficient the solution may be. So, in the end, our pain points were just learning experiences, before we were thrown a life vest.

3. *How did you and your team adjust the scope of your goals to ensure they are suitable for a Capstone project (not overly ambitious but also of appropriate complexity for a senior design project)?*

My team and I started the project off by getting very familiar with each other's strengths and weaknesses. We shared resumes, transcripts and highlighted all the former experiences we had before selecting a project that most aligned with our combined skillsets. Once we had a project, setting goals was the easy part as in our goals we ensured that we would have fallbacks if the project was overly ambitious allowing us to jump with a safety net. For example, we initially discussed the potential for developing a neural network that chooses the best refactoring for a given code input. Recognizing that we have low ML experience between us we opted to implement an algorithmic approach for our POC and attempt an ML implementation in semester 2 if the first one works properly. We also ensured that there would be middlemen libraries we could pull from if we were unsuccessful in writing all the code ourselves. The clearest example of this is there being smell detection code readily available in many online free to use libraries. Planning out these fallbacks between ourselves made sure everyone was comfortable with the project and that we could tweak the difficulty as time went by being that we are trying something new.

Ayushi Amin Reflection

1. *What went well while writing this deliverable?*

Writing the deliverable went quite well overall. The project itself was well defined and we were able to meet with the industry supervisor which helped clarify most of the details. Our team worked well together which helped each member to clarify any concerns particularly about the database we decided to use. Our team had some good discussions regarding making decisions on what languages and tools to use in the project such as our decision to use MySQL for our database.

2. *What pain points did you experience during this deliverable, and how did you resolve them?*

Not all the information was clarified or given by the supervisor at an early stage so writing this document took some time which caused us to delay working on this for a couple days. The team and I decided to consistently check in with the supervisor to encourage him to provide the required documents and information we needed as soon as possible. We used email as well as discord to directly reach out to the supervisor in which we finally ended up getting the information 2 days before the deadline and then crammed to finish the milestone documents.

Full Name Reflection

1. *What went well while writing this deliverable?*
2. *What pain points did you experience during this deliverable, and how did you resolve them?*

3. *How did you and your team adjust the scope of your goals to ensure they are suitable for a Capstone project (not overly ambitious but also of appropriate complexity for a senior design project)?*

Group Answers Reflection

1. *How did you and your team adjust the scope of your goals to ensure they are suitable for a Capstone project (not overly ambitious but also of appropriate complexity for a senior design project)?*

We carefully adjusted our project scope by focusing on the most important goals and prioritizing features that mattered most, while also setting clear milestones to keep us on track. The feedback we got from our supervisor helped us refine our goals, making sure we were ambitious but also realistic about what we could achieve.