

A Proposed Closed-Loop Method for Carbon-Aware Prioritization and AI-Based Energy Optimization of Active Software Components

Ajdin Muratović¹, Neman Palić²

University College "CEPS – Center for Business Studies", Kiseljak, Bosnia and Herzegovina

RESEARCH CONTEXT AND MOTIVATION

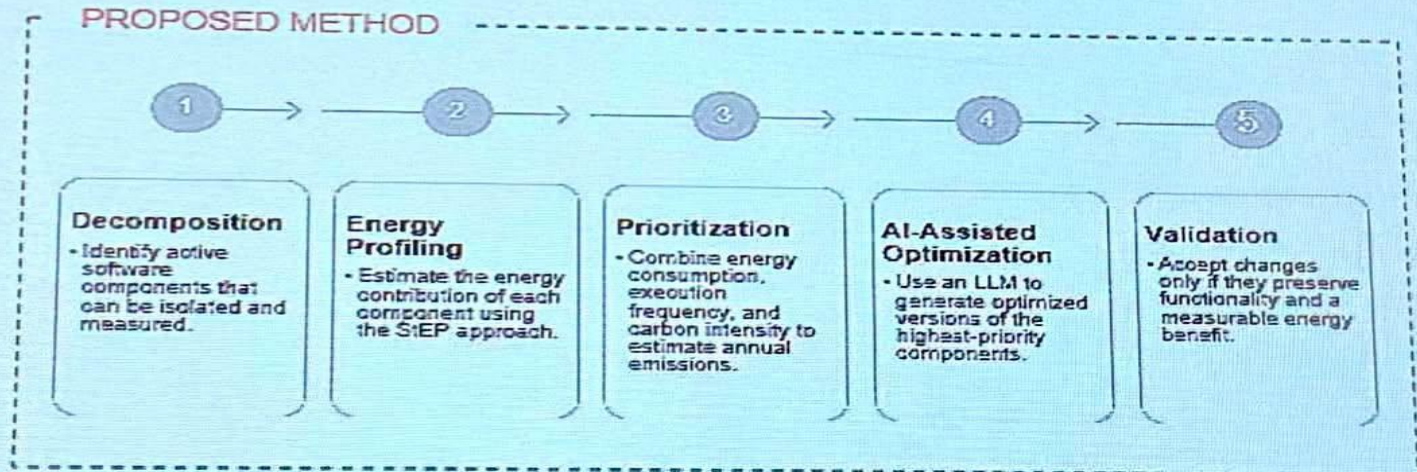
Software components within the same application can differ significantly in energy consumption and operational carbon emissions. Therefore, optimization should focus first on the components with the greatest environmental impact. The proposed method combines energy profiling, execution frequency, carbon intensity, and AI-assisted optimization into a unified closed-loop process.

OBJECTIVE

The aim of this work is to propose a closed-loop method for identifying and prioritizing software components according to their estimated annual operational emissions, and then applying AI-assisted optimization to the components with the highest priority.

Each proposed optimization is accepted only after functional validation and repeated energy measurements confirm an actual reduction in energy consumption.

PROPOSED METHOD



PRIORITIZATION AND CARBON IMPACT

$$\Delta E_i = E_B - E_{s_i}$$

Estimated energy contribution of component i per single execution, calculated as the difference between the baseline system and the version where the component is replaced by a stub.

$$E_{i,year} = \Delta E_i \cdot N_i$$

Estimates the annual energy contribution of component i by considering how often it is executed during the year.

$$O_{i,year} = E_{i,year} \cdot I$$

Converts the annual energy contribution into estimated annual operational emissions using the carbon intensity of electricity.

Components are ranked according to their estimated annual operational emissions, with the highest-ranked components receiving priority for AI-assisted optimization.

VALIDATION AND CONCLUSION

AI-generated candidate versions are accepted only if they preserve functional correctness and repeated measurements confirm a reduction in energy consumption. The method also considers the energy consumed by AI optimization and testing when assessing the overall benefit.

The proposed method integrates energy profiling, environmental prioritization, AI-assisted optimization, and validation into a single closed-loop framework.

Future work will focus on empirical validation in real-world software systems.