Assignment: Sustainable Software

This assignment is designed to help you critically reflect on the challenges involved in the design of sustainable software through a case study. Your objective is to not only treat the functionality of the software, but also demonstrate awareness of the broader sustainability implications of your choices through a dedicated sustainability assessment.

Case study: Server Workload Optimization with JIT

Your objective is to design an experiment that simulates a server's typical workload in order to evaluate its energy consumption over time. **Requirements: Linux knowledge and working install, Java Spring Boot, Python scripting, running commands in the terminal.** Your main deliverable is a max. 6 page report (excluding title page, table of contents, appendix, bibliography) that follows the LaTeX template attached separately. You may slightly deviate from the given template as long as you successfully fulfill all tasks in the assignment.

Part 1: Experiment Design and JIT Optimization

The following tasks need to be performed in order to complete the experiment design. For each task, we set up a few pointers to help you, but you have a lot of freedom in your design.

1. **Install testbed:** follow the setup **tutorial** from Github to get the testbed working on your local device.
2. **Design experiment:** simulating the workload of a server requires an understanding of what tasks the server usually performs. Is the experiment representative of a real world use case, or do you want to test the limits of the hardware? You are free to investigate either average or peak workloads as long as you justify your decision and document your assumptions. Run the experiment and record its energy consumption.
3. **Optimize with JIT compiler:** follow the setup **tutorial** to use the JIT compiler. Run the experiment once again while applying JIT and record its energy consumption. Investigate the effects of JIT and try to explain why the changes improve or diminish performance and energy consumption.

Part 2: Environmental Impact Assessment

After the design of your experiment, your objective is to use your results to assess its environmental impact. Only use the results for the JIT optimization. The following tasks need to be performed. For each task, we set up a few pointers to help you, but you have a lot of freedom in your assessment. Make sure to clearly document your assumptions at each point.

1. **Define system boundary**: which parts of your system are included in or excluded from your assessment? You can freely decide: do you take into account the manufacturing of your hardware? What time period does your assessment cover? Justify your decision.
2. **Estimate carbon footprint:** you can adapt one of the methodologies presented in the course. You can go into detail with respect to the temporal resolution: either add up the entire energy consumption and multiply it by a standard carbon intensity factor, or use the energy profile during the runtime and multiply it by the carbon intensity at each point

(if you can find corresponding data). The more detailed your result, the better your outcomes will be for the following part.

3. **Perform sensitivity analysis:** there is inherent uncertainty in assessing environmental impact, for example in the assumptions you have made until now. Quantify the effect of these assumptions through a simple sensitivity analysis on at least two parameters (for example, the carbon intensity of the electricity). Justify your choice of parameters.

Tip: don't be afraid to make assumptions! This is a developing (and secretive) field, so data isn't exactly abundant. The accuracy of the actual numbers isn't as important as reaching reasonable conclusions.

Part 3: Reflection

With your experiment and environmental impact assessment complete, it is time to reflect on the process. What limitations did you observe in your experiment design process? Has the application of JIT reduced the environmental impact of your code? What other useful sustainability measures could you infer from the impact assessment? Try to use quantitative figures (e.g. reduce emissions by 15% by running at night). These are a few suggestions for some aspects you could address.

Note on large language models: you may use LLMs for coding or writing support, or to explore a certain topic. However, LLMs are not considered valid references. Always use trustworthy sources for your claims and be critical about the information you obtain.

Grading Scheme: Sustainable Software

Part 1: Experiment Design and JIT Implementation

Part 2: Environmental Impact Assessment

1. Report clearly defines spatial and temporal system boundary **AND** embedded non-operational emissions are either quantitatively assessed **OR** receive a comprehensive qualitative discussion **OR** their exclusion is well-justified.
2. Report provides a quantitative estimate for the carbon emissions of the system **AND** explains the method by which it was obtained sufficiently so as to be independently replicated **AND** documents all assumptions made in the process. **BONUS:** estimate has detailed temporal resolution, emissions are calculated per time interval.
3. Report provides clear sensitivity analysis results for two parameters **AND** explains the method by which they were obtained sufficiently so as to be independently replicated **AND** contains a solid justification for the selection of parameters. **BONUS:** more than two parameters evaluated.

Part 3: Reflection

Reflection demonstrates critical attitude towards design process **AND** includes quantitative figures where possible.