Compiler optimization series and implementation choices

Effects on time and energy

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Implementations & Flags

4 AI generated[1] implementations of bubble sort in C:

- ➔ bubblesort.c (base implementation)
- ➔ bubblesort_optimized.c (reduced # of iterations)
- ➔ bubblesort_ll.c (linked lists)
- ➔ bubblesort_ll_optimized.c (linked lists, reduced # of iterations)

4 gcc compilation flags[2]:

- ➔ -O0
- ➔ -01 (reduce code size and execution time, without performing any optimizations that take a great deal of compilation time)
- ➔ -02 (increases both compilation time and the performance of the generated code, performs nearly all supported optimizations that do not involve a space-speed tradeoff)
- ➔ -03 (optimize yet more)

[1]https://openai.com/blog/chatgpt/
[2]https://gcc.gnu.org/onlinedocs/gcc-11.3.0/gcc/Optimize-Options.html#Optimize-Options

System Specifications

Hardware

- CPU: Intel(R) Core(TM) i5-6200U CPU @ 2.30GHz
- RAM: 8GiB @ 2133MHz

Software

- OS: Ubuntu 22.04 LTS
- C Compiler: gcc 11.3.0

Hypotheses

H1. Optimization strategies influence time and energy

H2. The versions of the programs compiled with optimization series will outperform the versions compiled with -O0

H3. Differences in implementation influence time and energy

H4. The linked list implementation will be outperformed by the array implementation

Compiler optimization series

Mean percentage improvement compared to version compiled with -O0

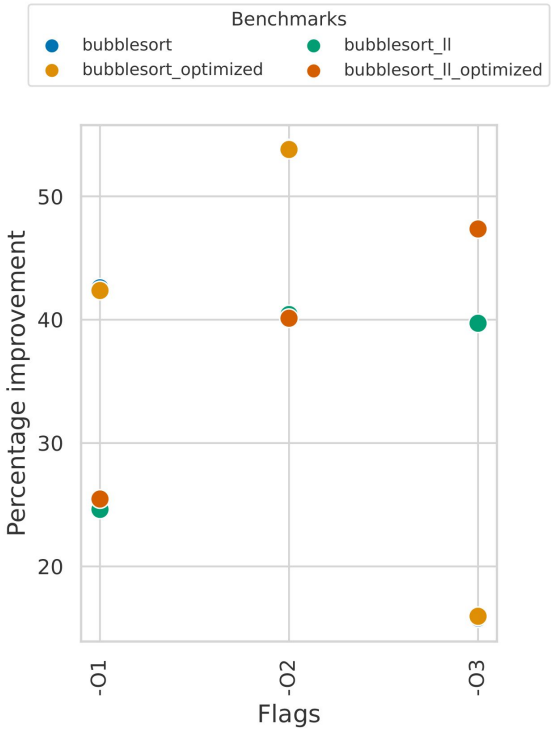

Fig.1: Socket energy

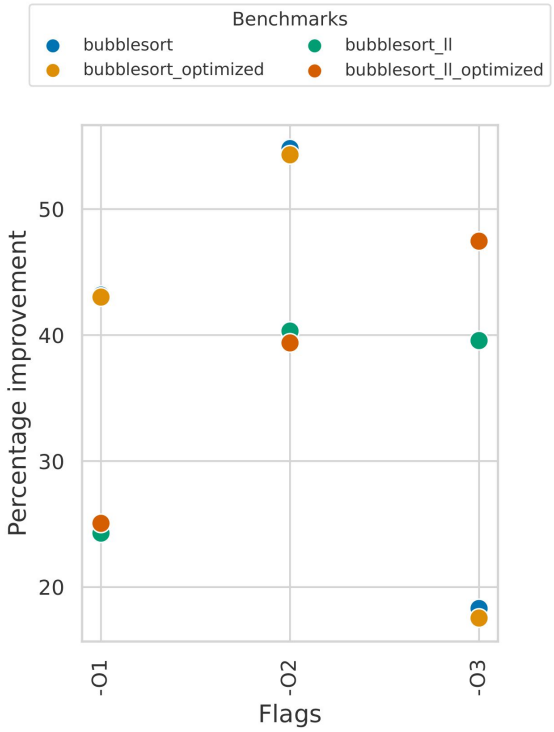

Fig.2: CPU energy

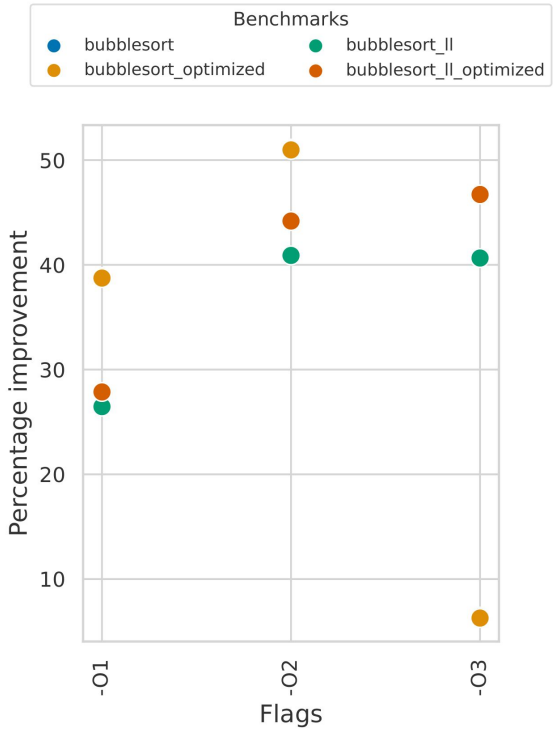

Fig.3: Execution time

Looking back...

H1. Differences in implementation influence time and energy

Random sampling was performed and the **differences** in both execution time and energy consumption were **not due to chance**.

H2. The versions of the programs compiled with optimization series will outperform the versions compiled with -O0

When compiled with -01, -02 and -03, all implementations improve reduce their **energy consumption by 15% to 55%**, and **execution time by 6% to 50%**.

Implementation choices

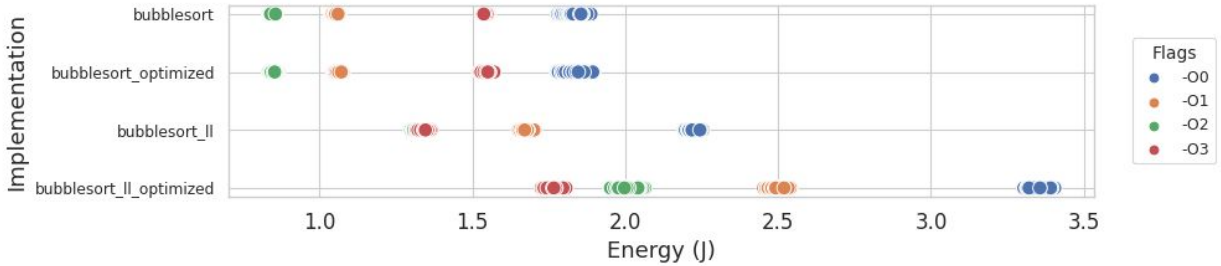

Fig.4: Socket energy

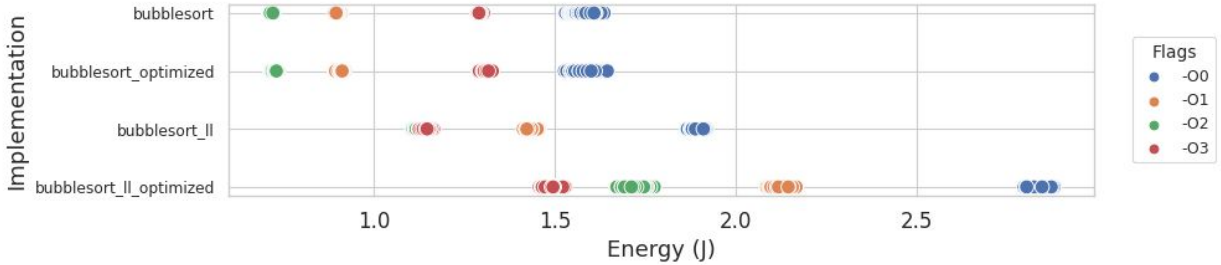

Fig.5: CPU energy

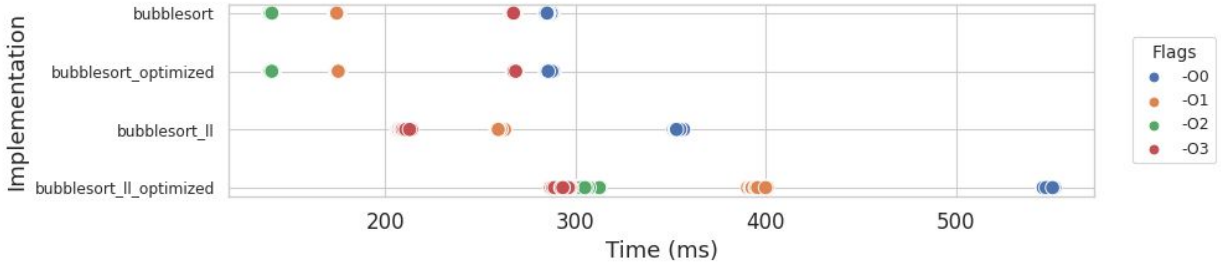

Fig.6: Execution time

Looking back...

H3. Optimization strategies influence time and energy

Random sampling was performed and the **differences** in both execution time and energy consumption were **not due to chance**.

H4. The linked list implementation will be outperformed by the array implementation

The **array** version might be **more efficient** as bubble sort takes advantage of the elements being stored in contiguous memory, and **linked lists** typically **require more memory**, which may also impact performance.

Extra: Time & Energy

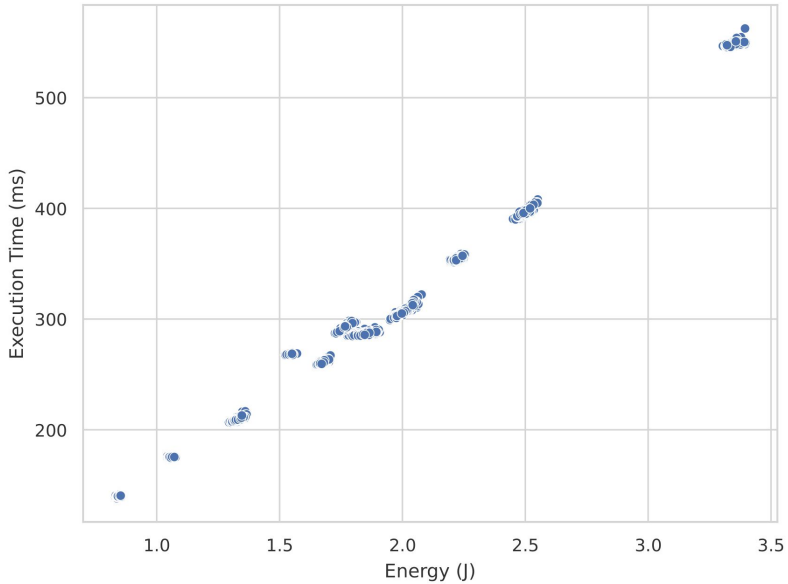

Fig.5: Time & Energy

Spearman's Correlation Coefficient

0.9774380559481982 (ρ < 0.05)

\+ time ↔ + energy
\- time ↔ - energy