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EECE3324: Computer Architecture Sec 01

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Homework #3

1. (20 points) Describe the loop unrolling optimization. Describe its effect on the branch instructions? What are the challenges in implementing loop unrolling optimization?

Loop unrolling optimization reduces the impact of wrong branch guesses. Loop unrolling aims to reduce the number of iterations of a loop by a factor of b. It does this by increasing the workload of each iteration by a factor of n, while decreasing the number of iterations by a factor of n. Loop unrolling can be invoked by using the –funroll-loops or –funroll-all-loops compiler optimization flag. -funroll-loops unrolls loops whose number of iterations is known at compiler time or when entering the loop. -funroll-all-loops unrolls all loops, even if the number of is unknown when the loop begins. The challenge with implementing loop unrolling optimization is that it is unknown if it will be beneficial. –funroll-loops makes the program larger and may or may not make it run faster. -funroll-all-loops usually makes programs run slower.

2. (10 points) Write a simple C program to demonstrate the assembly code generated by your compiler with and without loop unrolling. You can explore the GCC compiler options for enabling and disabling this optimization. Please show your assembly code in both cases.

I wrote an insertion sort and median of list program. The optimizations were run on the program and unlooping was observed. There were less instructions in the assembly output when unrolled with –O1 compared to running the program unoptimized. Between optimizations 1 and 2, O2 led to many more instructions than O1. There was no difference between O2 and O3.

Commands used to generate assembly code

```
gcc -S -funroll-loops hw3.c

gcc -S -funroll-loops –O1 hw3.c

gcc -S -funroll-loops –O2 hw3.c

gcc -S -funroll-loops –3 hw3.c
```

Study these references:
https://gcc.gnu.org/onlinedocs/gcc-4.5.2/gcc/Optimize-Options.html
https://diveintosystems.org/book/C12-CodeOpt/loops_functions.html