Compiler Optimisation

2 – Coursework

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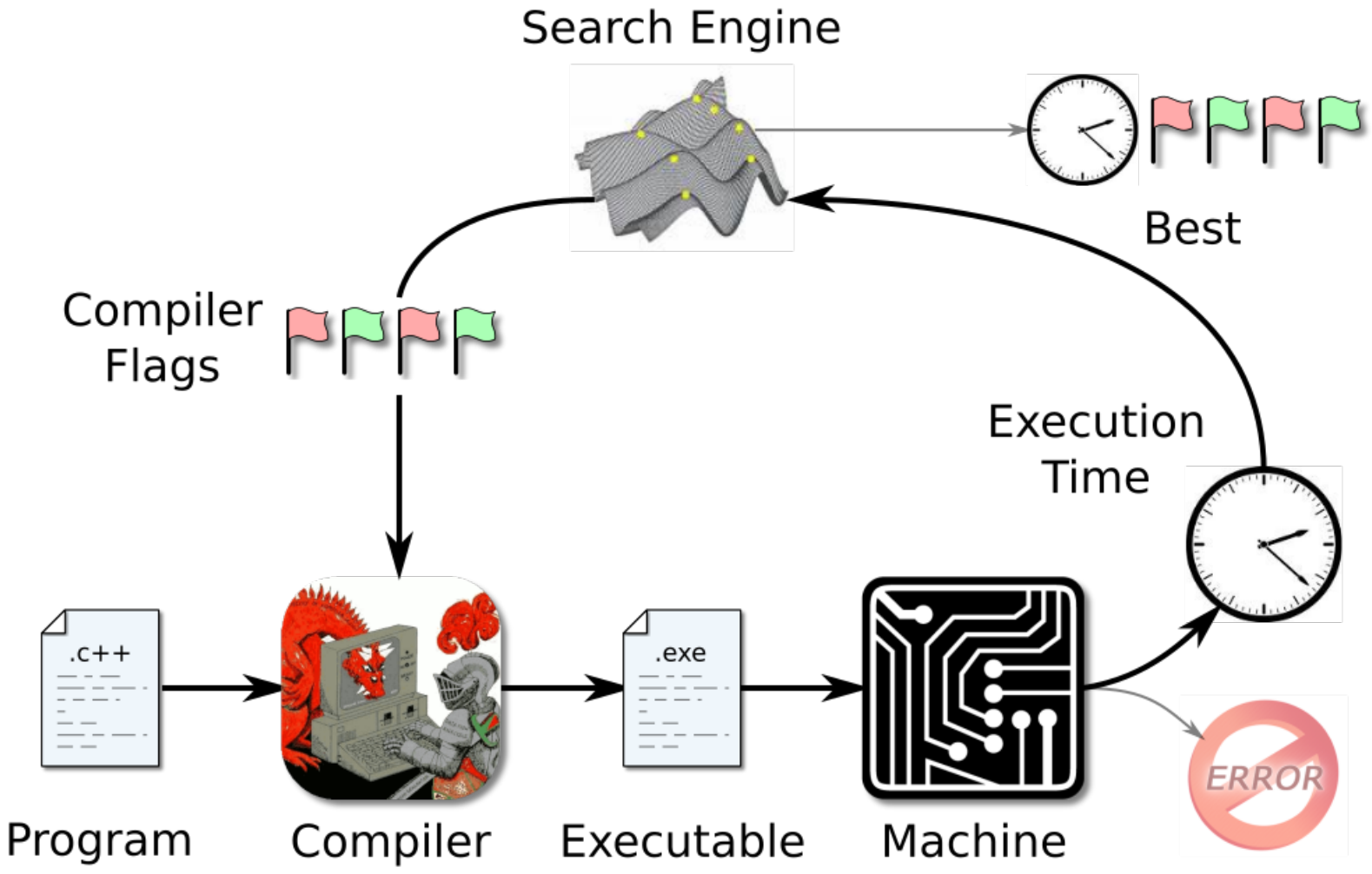
Course work

- Based on GCC compiler
- One piece of course work: 25% of course mark
- Set today and due **Thursday 4pm Feb 22rd 2018** week 6
- Feedback due **Thursday 4pm Mar 8th 2018** week 8
- Penalties for late submission.
- Plagiarism software used. Do your own work!

Iterative Compilation

Find the best way to compile a program



Goal

- Evaluate different compiler optimisation settings on a set of benchmarks.
- Try to beat -O3
- Write a report about your methodology and your findings.

Program Optimisation in GCC

- GCC supports some simple levels of optimisations: `-O1`, `-O2`, `-O3`
- At each level, a set of optimisations are enabled (25 for `O1`, 25+29 for `O2` and 19+28+9 for `O3`)
- At higher levels, more optimisations are enabled which results in **potentially**[1] faster code, but also slows down the compilation process.
- Rather than using these pre-defined optimisation options, the users can enable individual options themselves, e.g. "`-funroll-loops`".
- For more information on optimisation options see `http://gcc.gnu.org/onlinedocs/gcc/Optimize-Options.html`

[1] Not all optimisations make code better

Methodology: Evaluating Compiler Flags

- Always use -O3: Some optimisations won't work without it
- Randomly choose flags (on/off) and parameter values
  `http://gcc.gnu.org/onlinedocs/gcc/Optimize-Options.html`
- Evaluate 200 randomly chosen configurations
  (i.e. combinations of optimisations)
- Use the same configurations for all benchmarks!

Running Experiments

- Avoid noise:
  - Make sure no one else is logged on to the computer (using who) and no other applications are running (using top).
  - Dont run on top of AFS $\Rightarrow$ use `/disk/scratch` or `/tmp`.
  - BUT: move the results back to your home-directory and dont leave the data accessible to everyone
- Run benchmarks at least 10 times to get stable results.
  - Determine how many measurements you need to get a stable value.
  - Compute and report *average* runtime.
  - Also report the *variance* and the number of iterations you used.

Running Experiments - Cont.

- Use scripting languages to automate the process of evaluating optimisations on the benchmark programs.
- Example (pseudo code)

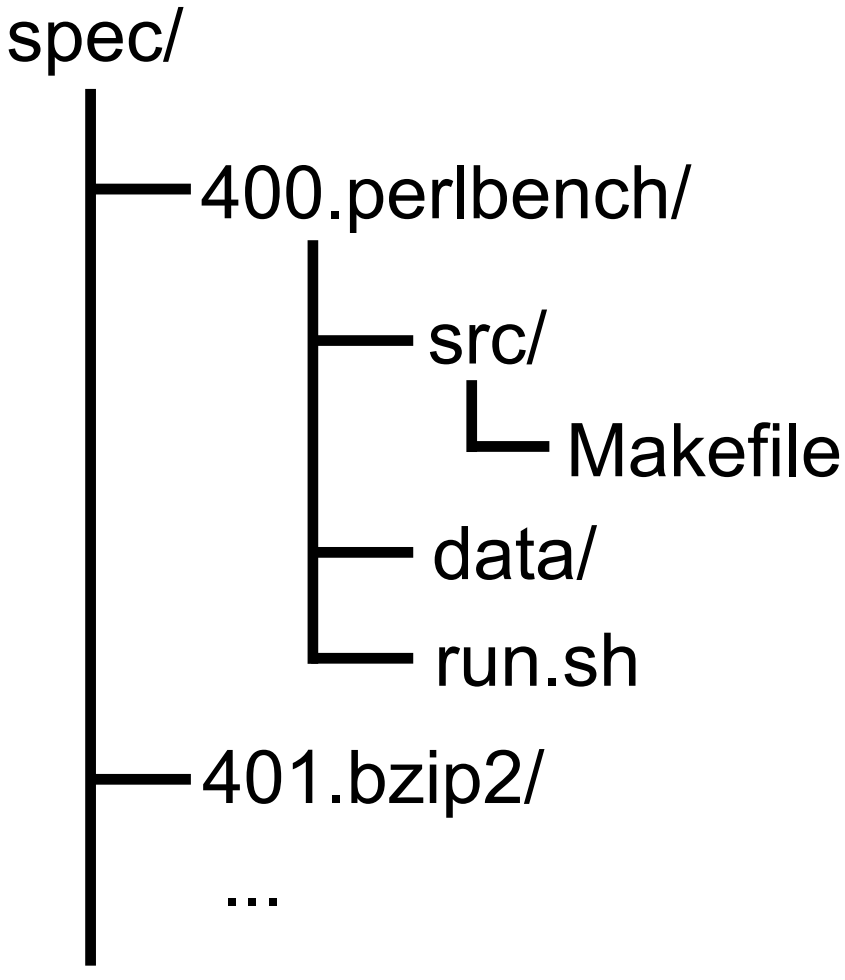
```
for each b in benchmarks
  for each o in optimisations
    compile b with o
    run b N times and record runtimes
    calculate average runtime and variance
  end
end
```

The Benchmarks

- We use 14 benchmarks from the SPEC CPU2006 and MediaBench II suites.
- CPU intensive benchmarks developed from real user applications.
- Download and extract the programs (use wget) from:

  `https://docs.google.com/file/d/0B5GasMlWJhTOaTdvaFkzUzNobDQ/edit`
- Let me know if you need more disk space!

Directory Structure



Compiling and Running the Benchmarks

- Compiling a program with certain optimisations enabled and executing it a single time:

```
cd 400.perlbench/src/
make CFLAGS="-funroll-loops -param max-unroll-times=4"
cd ../
./run.sh
```

Report and Results

- Maximum 5 pages + 2 pages for results
- Explain what you have done.
- Precisely describe the experimental setup.
  - Architecture and platform. Timing method.
  - Number of runs per benchmark/configuration
- For every program report performance of:
  - Baseline `-O0`, `-O1`, `-O2`, `-O3`
  - Best found flags for individual program.
  - Best found single set of flags across *all* programs.
  - Average across all flag settings (expected random performance).
- Results should be detailed: per-program, average, variance

Report and Results - contd.

- Store all raw data in a file. For each program:
  - First line: program name
  - Following lines: flag setting and all runtimes
  - Runtimes in milliseconds, without decimal digits

```
400.perlbench
"-O0" 837 833 890 850 813 828 ...
"-O1" 602 620 610 611 650 580 ...
...
401.bzip2
"-O0" 837 833 890 850 813 828 ...
"-O1" 602 620 610 611 650 580 ...
...
```

- e-mail file to: hleather@inf.ed.ac.uk WITH the subject: copt-results

Report Structure

- Abstract. (Summary of paper) and Introduction
- Evaluation methodology: Selection of flags, etc.
- Experimental setup: Platform. How time was measured. Number of runs.
- Results (for each program)
  - Baseline `-O0`, `-O1`, `-O2`, `-O3`
  - Best found flags for individual program.
  - Best found single set of flags across all programs.
  - Average across all flag settings (expected random performance).
- Analysis and Discussion of Results. Followed by conclusion.

Submission. Awarding of Marks

- Submit to ITO written report by Thursday 4pm Feb 22rd 2018.
- Marks are awarded for clear explanation of experimental methodology and thorough analysis of results.
- Remember wish to see optimisation setting that gives best results per program AND the setting that is best for all the benchmarks.

Final Remarks

- For further questions e-mail me
- Start early!! It takes time to run the experiments!
- Deadline: **Thursday 4pm Feb 22rd 2018**

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