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Error messages and debugging

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Debugging

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What is Debugging?

- Identifying the cause of an error and correcting it
- Once you have identified defects, you need to:
  - find and understand the cause
  - remove the defect from your code
- Statistics show 60% of bug 'fixes' are not correct,
  -> they remove the symptom, but not the cause
- Improve productivity by getting it right the first time
- A lot of programmers don't know how to debug!
- Debugging needs practice and experience:
  -> understand the science and the tools

Debugging (2)

- Debugging is a last resort:
  - Doesn't add functionality
  - Doesn't improve the science
- The best debugging is to avoid bugs:
  - Good program design
  - Follow good programming practices
  - Always consider maintainability and readability of code over getting results fast
  - Maximize modularity and code re-use

Errors are Opportunities

- Learn from the program you're working on:
  - Errors mean you didn't understand the program,
    If you knew it perfectly, it wouldn't have an error.
    You would have fixed it already
- Learn about the kind of mistakes you make:
  - If you wrote the program, you inserted the error
  - Once you find a mistake, ask yourself:
    - Why did you make it?
    - How could you have found it more quickly?
    - How could you have prevented it?
    - Are there other similar mistakes in the code?

How to NOT do Debugging

- Find the error by guessing
- Change things randomly until it works again
- Don't keep track of what you changed
- Don't backup the original
- If the error is suddenly gone, trying to understand the problem, is a waste of time
- Fix the error with the most obvious fix
- If wrong code gives the correct result,
  and changing it doesn't work, don't correct it.

Debugging Tools

- Source code comparison tools:
  diff, vimdiff, tkdiff, emacs/ediff
  - Help you to find changes
- Source analysis tools:
  compiler warnings, ftnchek, lint
  - Help you to find problematic code
    -> Always enable warnings when programming
    -> Always take warnings seriously
    -> Always compile/test on multiple platforms
    -> Only ignore warnings you understand, if at all
- Debuggers: gdb, idb, pdbg, ddd (GUI)

Purpose of a Debugger

- More information than print statements
- Allows to stop/start/single step execution
- Look at data and modify it
- *'Post mortem'* analysis from core dumps
- Prove / disprove hypotheses
- Easier to use with modular code
- No substitute for good thinking
- But, sometimes good thinking is not a substitute for a good debugger!

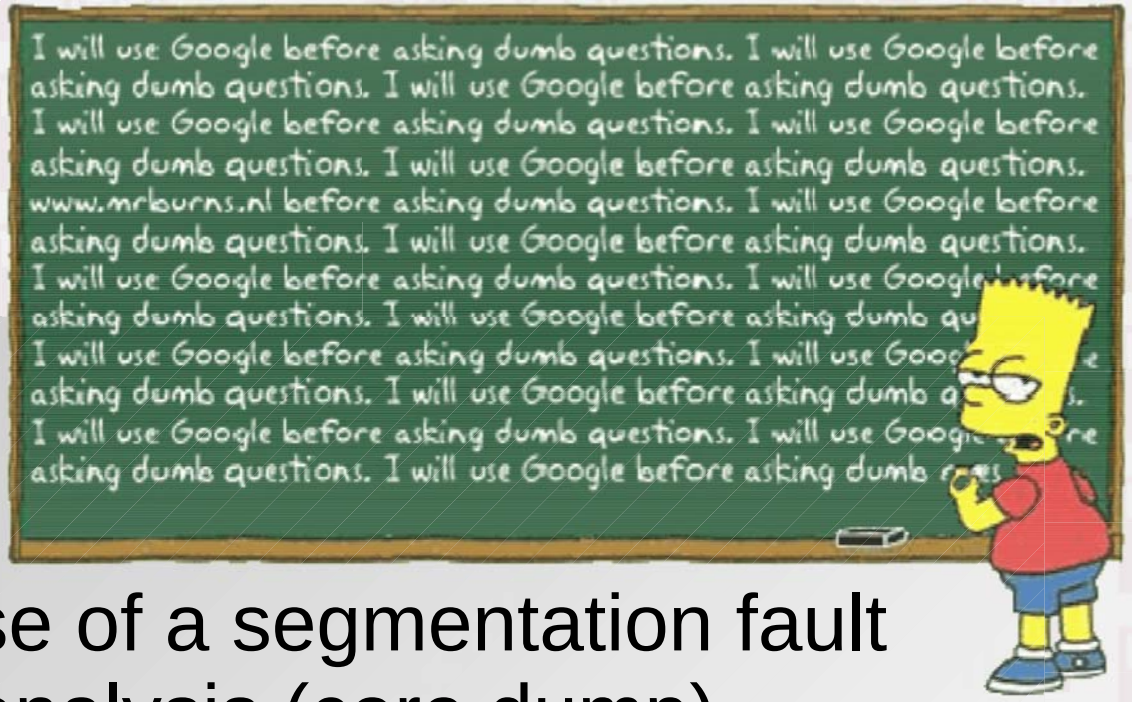
Using a Debugger

- When compiling use -g option to include debug info in object (.o) and executable
- 1:1 mapping of execution and source code only with disabled optimization
  -> problem when optimization uncovers bug
- GNU compilers allow -g with optimization
  -> not always correct line numbers
  -> variables/code can be 'optimized away'
- `strip` command removes debug info

How to Report a Bug

- Research whether bug is known/fixed
  -> web search, mailing list archive
- Provide description on how to reproduce the problem. Find a minimal input to show bug.
- Always state hardware/software you are using (distribution, compilers, appl. version)
- Demonstrate, that you have invested effort
- Make it easy for others to help you!

Demonstration



- Using a debugger. Available features.
- Identifying the cause of a segmentation fault from *post mortem* analysis (core dump).
- Identifying the cause of memory corruption from compiling with bounds checking
- Identifying memory leaks using `valgrind`
- `svn checkout --username akohlmey https://svn.gforge.escience-lab.org/svn/hpc-2008/trunk/week1/debugging`