Building your own C Toolkit: Part 1

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30th May 2013

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- Like a carpenter, build your own toolkit of useful tools to make C programming easier and more productive.
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- Principle: ruthless automation - when you find yourself doing something boring and repetitive, especially for the second or third time, think: can I automate it?

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- Basic Tools:
  - Programmer's Editors: Use a single editor well.
  - Automating Compilation (reminder): Use Make.
  - Automating Testing: ruthless testing.
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- I strongly recommend The Pragmatic Programmer (PP) book, by Hunt & Thomas. The woodworking metaphor - and a series of excellent programming Tips - comes from there.
- There's a tarball of examples associated with each lecture, as a shorthand tarball 01.list refers to the directory called **01.list** inside the tarball.
- Each directory contains a README file describing what's in it - in great detail.

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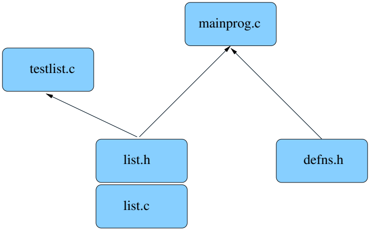
- Others like Emacs, very powerful and extensible. Like Eclipse, Emacs can be a whole development environment.
- Whichever editor you chose, after initial exploration of the possibilities, stick to it, learn it thoroughly and become expert in its use.

When multi-file C programming, eg:



Many source files:

- Module list comprising two files (interface list.h and impln list.c).
- Test program testlist.c
- Main program mainprog.c
- Separate basic defns header file defns.h.

Dependencies between the files are vital, determined by the #include structure:

- list.c includes list.h (check impln vs interface).
- testlist.c includes list.h
- mainprog.c includes list.h and defns.h

Make uses such file dependencies, encoded in a **Makefile**, to automatically compile your programs. A Makefile contains dependency rules between target and source files with actions (commands) to generate each target from its' sources.

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- If list.h is altered, then list.c, testlist.c and mainprog.c need recompiling, and testlist and mainprog need relinking against the list object file (list.o).
- Summary: Always use make. Keep your Makefile up to date.
- Exercise: why not auto generate your Makefiles? Many tools generate Makefiles automatically, easy to write.

- In Tip 62, Hunt & Thomas write:

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- Test ruthlessly and automatically by building unit test programs (one per module) plus overall program tests.
- Add make test target to run the tests. Run them frequently.
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- make test could run all test programs in sequence:

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  test:   testprogram1 testprogram2 ...
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  or invoke a test framework script with testprograms as arguments.
- Exercise: add test target to 01.list to run the obvious `./testlist`, or `./testlist|grep -v ok` to only report failures.

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- Test Driven Development (TDD) writes the test programs before implementing the feature to test.

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- Start gdb by `gdb PROGRAMNAME`. Inside gdb, type `run COMMANDLINEARGS`. Work with your program until it crashes.
- Back at the gdb prompt: type `where` to see the call frame stack - the sequence of function calls leading to the crash.

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- `frame N` allows you to switch to the Nth function call on the frame stack, i.e. select which of the function calls you want to look at, in order to examine that function's local variables.

- `list` will list 10 lines of the current function.
- `p EXPR` will print any C expression, including global variables and local variables in the current stack frame.
- `whatis VAR` displays the type of VAR.
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- You can also set breakpoints (`break LINENO|FUNCTIONNAME`), attach conditions on the breakpoints, single step through your program (`step` and `next`), continue until you hit another breakpoint (`cont`), and even watch variables as they are altered or accessed (`watch, rwatch`).
- Google for gdb tutorial for more info.
- Most important, leave gdb by `quit`.

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- Then I wrote a vi macro bound to an unused key that piped the next paragraph into proto % (current filename). Can do same for forward declarations of static functions using proto -s %.

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- Segmentation faults - gdb where (frame stack) may show it crashes in system libraries.

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- You may say: but those test programs are tiny. Does libmem scale to larger size programs?

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- Find dramatic non-linear behaviour around 10-11k iterations on lab machines: Twice as slow, CPU %age falls, starts doing I/O.
- What on earth is happening?

- Try monitoring with `top`, configured to update every second (d 1), sort by %age of memory (O n). Write this config out (W).

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- Run iterate with a time delay: `time ./iterate 11000 10` and watch top! iterate's memory grows bigger than the physical memory, tops out at about 85% of physical memory, the system starts swapping (%wait goes busy), load average goes high, machine goes very slow!

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  - run `./testhash` [simpler test program]
  - result: 2 non-freed 256K chunks reported:

```
File          Line     Size
hash.c   114      260264
hash.c   75       260264
```

- Libmem debugging session continued:
  - look at those two lines: line 75 is in `hashCreate(...)`:

    ```
    h->data = (tree *) malloc( NHASH*sizeof(tree) );
    ```

  - and line 114 is nearly identical in hashCopy().

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    result->data = (tree *) malloc( NHASH*sizeof(tree) );
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  - Look in corresponding `hashFree(hash h)` function.

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  - Aha! `h->data` is NOT FREED.
  - Add the missing `free(h->data)`, recompile (make).
  - Rerun `./testhash` and it reports no unfree()d blocks.
  - Rerun `./iterate 11000 10` again - no non linear behaviour, no memory leak reported. Job done! libmem rocks!

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- Summary: compile everything with libmem from day one. Save yourself loads of grief, double your confidence.
- Exercise: verify that the list example (in 01.list) runs cleanly with libmem. (Import CFLAGS and LDLIBS from 05.mem-eg's Makefile).