Building your own C Toolkit: Part 1

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- Build your own toolkit of useful tools and craft skills to make C programming easier and more productive.
- Occasionally: build your own tools!
- Principle: ruthless automation - when doing something boring and repetitive, think: can I save time by automating this?

Today, and the next two Thursdays, I'll show you some of the tools in my toolkit, in the hope they'll be useful to you! Today, we'll cover:

- Programmer's Editors: Use a single editor well.
- Automating Compilation (reminder): Use make.
- Automating Testing: Test often, test ruthlessly.
- Debugging: Use a debugger and know it well.
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- 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.

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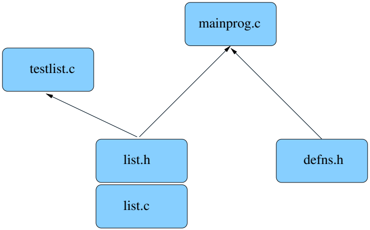
- Others like Emacs, very powerful and extensible. Like Eclipse, Emacs can be a whole development environment.
- After initial exploration of the possibilities, learn your chosen editor thoroughly and become expert in its use, including how to plug external tools into it.

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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- 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:

  > *Tests that run with every build are much more effective than test plans that sit on a shelf.*

- 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.
- Can run make test when you check a new version into git!

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- make test could run all test programs in sequence:

  ```
  test:   testprogram1 testprogram2 ...
          ./testprogram1
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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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- `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.
- Also, `up` and `down` move up or down one level on the frame stack.

- `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`.

- We often find ourselves writing hundreds of repetitive "pattern instances", eg:

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int plus( int a, int b ) { return (a+b); }
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- Note that our tool doesn't have to be perfect; just good enough to save us time.

- Once you have a tiny tool, don't be afraid to modify it when your needs change, or just for your convenience:
- Left-justify the function names in a field of some suitable width:

```
perl -nle '($f,$op)=split(/,/); printf "int %-15s( int a, int b ) { return (a${op}b); }\n", $f' < i
```

- Prefix the typename onto function names, eg. `int_plus`:

```
perl -nle '($f,$op)=split(/,/); printf "int %-15s( int a, int b ) { return (a${op}b); }\n", "int_${
```

- Noticing all those "int"s, let's make it easier to change:

```
perl -nle '$t="int"; ($f,$op)=split(/,/);
           printf "${t} %-15s( ${t} a, $t b ) { return (a${op}b); }\n", "${t}_${f}"' < input
```

- We could let the user set the type within the input, perhaps the first line of input, see 03.tiny-tool/README for details.
- More usefully, let the user change the type at any point in the input:

```
TYPE,int
plus,+
minus,-
TYPE,double
plus,+
minus,-
```

generates:

```
int    int_plus       ( int a, int b ) { return (a+b); }
int    int_minus      ( int a, int b ) { return (a-b); }
double double_plus    ( double a, double b ) { return (a+b); }
double double_minus   ( double a, double b ) { return (a-b); }
```

- To implement this, change the specification to:

```
INPUT:
  foreach line: F, Op pair
       special case: if F=="TYPE" then T=Op
OUTPUT:
  foreach F, Op pair where F!="TYPE":
   "T T_F( T a, T b ) { return (a Op b); }"
```

- Make our Perl one-liner:

```
perl -nle '($f,$op)=split(/,/); if( $f eq "TYPE" ) { $t=$op; next; }
           printf "${t} %-15s( ${t} a, ${t} b ) { return (a${op}b); }\n", "${t}_${f}"' < input
```

- See 03.tiny-tool/genfuncs3.c for a C implementation.
- Final thought, instead of hardcoding the output format in the printf, we could replace TYPEs with output TEMPLATEs, for example:

```
TEMPLATE,int int_<0>( int a, int b ) { return (a<1>b); }
plus,+
minus,-
TEMPLATE,double double_<0>( double a, double b ) { return (a<1>b); }
plus,+
minus,-
```

- Here, the marker <0> means "replace this marker with the current value of the first field". Our Perl one-liner becomes:

```
perl -nle '@f=split(/,/,$_,2); if( $f[0] eq "TEMPLATE" ) { $t=$f[1]; next; }
           $_=$t; s/<(\d+)>/$f[$1]/g; print' < input
```

- This is now a very simple macro processor.