C Programming Tools: Part 1

Building and Using your own Toolkit

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- But these Programming Tools lectures are not going to help you achieve basic competence in C.

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- When necessary: don't be afraid to Build your own Tools!
- The Core Principle: Ruthless Automation.
- Doing something boring and repetitive? especially for the second or third time?
- You are a programmer, automation is your core skill - so think: Can I save time by automating this boring task?

Or, to put that another way (as seen on the walkway a couple of years ago):

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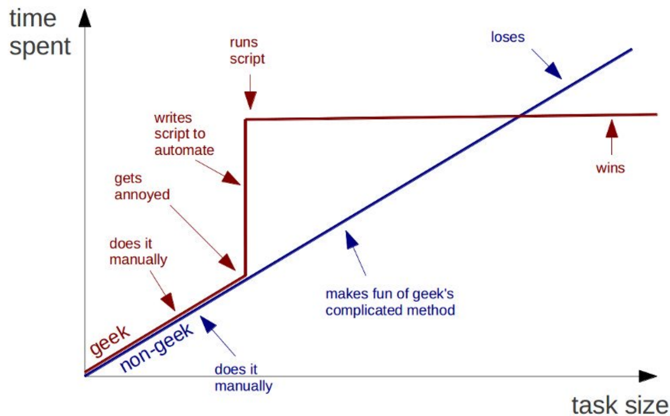
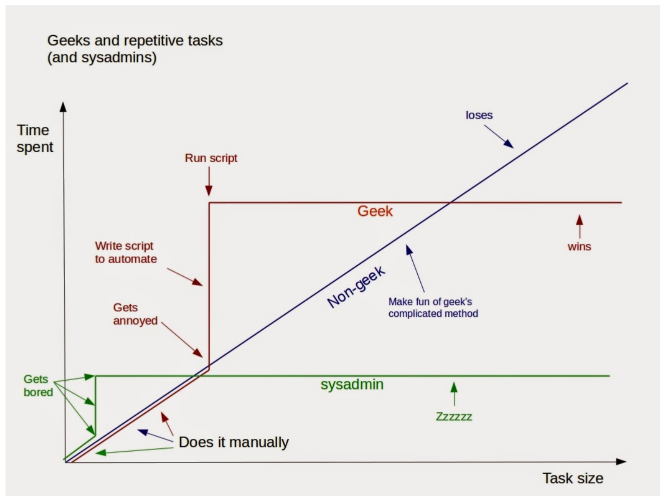
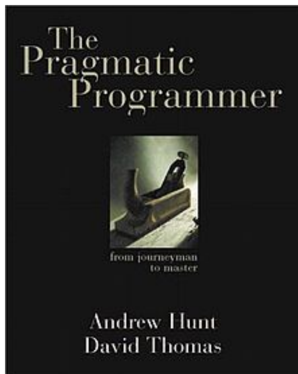
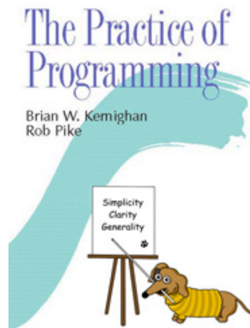


Or, adding SysAdmins into the mix:



For these Programming Tools lectures, I strongly recommend two books:





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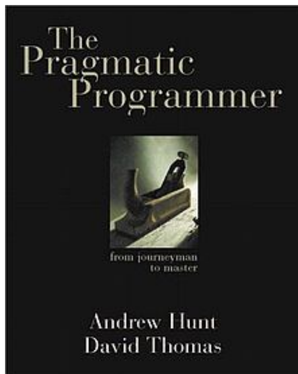

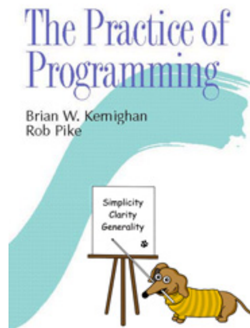

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- The Practice of Programming (PoP), by Kernighan & Pike.

Both books are brilliant expositions of expert-level programming craft.

Contents

Today, we'll cover:

- Programmer's Editors: Use a single editor well.
- Automating Compilation: Use make.
- Multi-Directory Programs and Libraries: How to lay out programs in multiple directories, a Makefile per directory.
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Notes:

- The handout (these slides) and a tarball (of examples and tools) are available on Materials and `http://www.doc.ic.ac.uk/~dcw/c-tools-2021/lecture1/`
- As a shorthand tarball 01.intlist refers to the directory called **01.intlist** inside the examples tarball. Each directory contains a README file (and indeed there's a top-level README). Read them - and if they tell you to do something, do it right away!

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- Why? Because programmers are notoriously sectarian when it comes to..

EDITOR WARS

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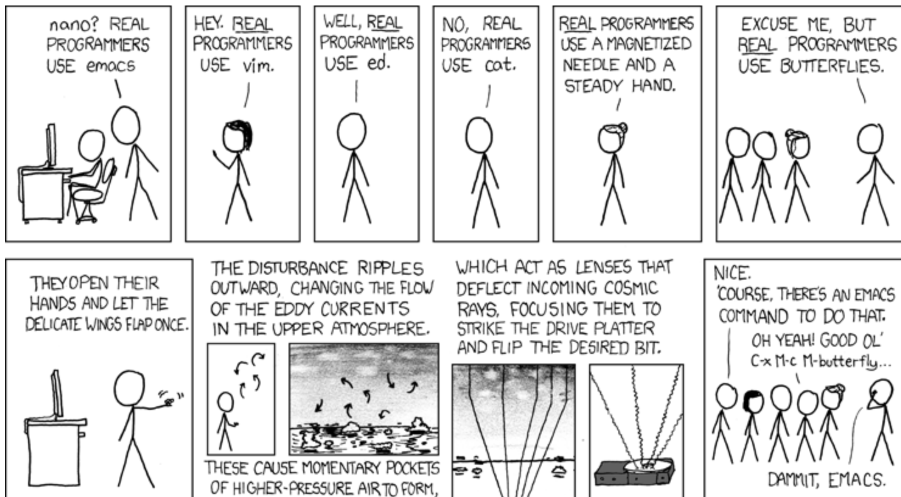
- IDEs such as Idea and CLion provide an editor, an automated compilation system and a debugging environment. If you're going to use an IDE, learn how to use it well, and how to extend and program it.
- Note that Hunt & Thomas aren't much in favour of IDEs. They say "We need to be comfortable beyond the limits imposed by an IDE". Neither am I:-) Neither is Will Knottenbelt.

Actually, it's well known that Real Programmers use Butterflies to edit source code:



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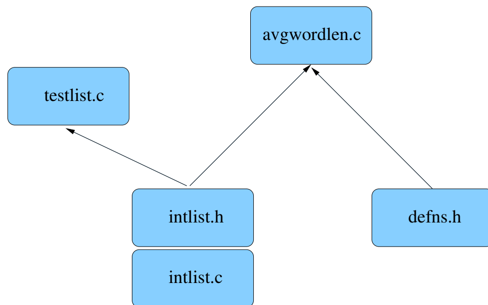

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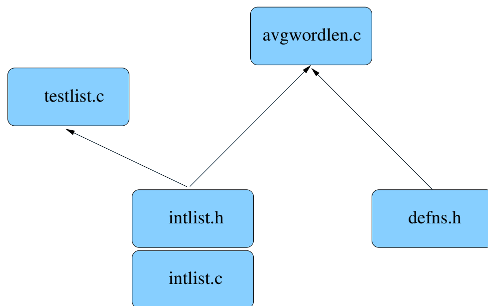

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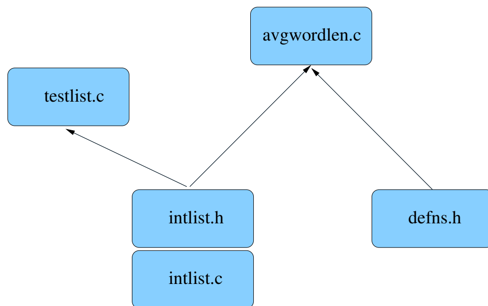

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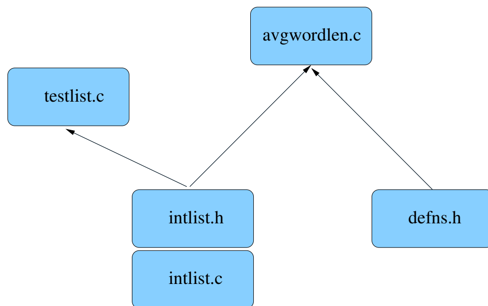

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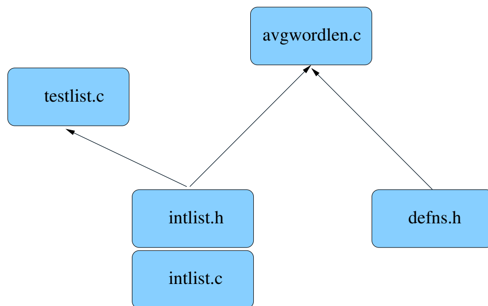

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- A main program avgwordlen.c, that uses intlists to do something vaguely useful.

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- That tool is make. But for it to do the job, we have to tell it the rules: when should each .c file be recompiled, and when should each executable be relinked from it's collection of object files.

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- **Make** needs such file dependencies, encoded as **Makefile** dependency rules between target and source files with optional actions (commands) to generate each target from the corresponding sources.

- Here's the Makefile for our example. It starts with some variable or macro definitions:

```
CC       = gcc
CFLAGS   = -Wall
BUILD    = testlist avgwordlen
```

$(CC) sets which C compiler to use, $(CFLAGS) is the C compiler flags, $(BUILD) the targets to build. Note that environment variables automatically become macros, eg $(HOME) represents your home directory.

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BUILD    = testlist avgwordlen
```

  `$(CC)` sets which C compiler to use, `$(CFLAGS)` is the C compiler flags, `$(BUILD)` the targets to build. Note that environment variables automatically become macros, eg `$(HOME)` represents your home directory.

- The remainder of the Makefile lists the target/sources/action rules:

```
all:    $(BUILD)
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        /bin/rm -f $(BUILD) *.o core
```

- Here's the Makefile for our example. It starts with some variable or macro definitions:

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- The remainder of the Makefile lists the target/sources/action rules:

```
all:     $(BUILD)
clean:
         /bin/rm -f $(BUILD) *.o core

testlist:       testlist.o intlist.o
avgwordlen:     avgwordlen.o intlist.o
avgwordlen.o:   intlist.h defns.h
testlist.o:     intlist.h
intlist.o:      intlist.h
```

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(assuming a `intlist.c` file exists in the current directory)
Make expands it to the more complete compilation rule:

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- This rule declares that intlist.o is up to date only if it is newer than intlist.c and intlist.h. If intlist.o doesn't exist or is older than either file, then the action is triggered - compiling intlist.c, producing intlist.o.
- make takes optional target names on the command line (defaulting to the first target), then performs the minimum number of actions needed to bring the desired targets up to date, based on the timestamps of the target and source files.

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- Make continues to work well for any size project - as long as it's all stored in a single directory.

Multi-directory Projects with Make

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- Each sub-directory should contain:
  - One or more modules (each a paired .c and .h file as usual).
  - Along with any associated test programs.
  - Plus a Makefile that compiles all the .c files, builds all the test programs, and builds a library containing the .o files belonging to those modules.

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  - Plus a Makefile that compiles all the .c files, builds all the test programs, and builds a library containing the .o files belonging to those modules.
- Let's split our existing intlist and avgwordlen directory up.
- What to split? The intlist module (and it's test program) is the obvious choice. It's:
  - Logically separate - it's highly cohesive.
  - Reusable - whenever we want a list of integers.
  - Depends on only the standard library.

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- There's a separate lib sub-directory to explore, which contains intlist.c, intlist.h, testlist.c (all unmodified) and it's own Makefile, which builds two core targets:
  - The executable testlist.
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- To do this, lib/Makefile has the following new parts:

```
LIB     =       libintlist.a
LIBOBJS =       intlist.o
BUILD   =       testlist $(LIB)
...
$(LIB):         $(LIBOBJS)
        ar rcs $(LIB) $(LIBOBJS)
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LIBOBJS =       intlist.o
BUILD   =       testlist $(LIB)
...
$(LIB):         $(LIBOBJS)
        ar rcs $(LIB) $(LIBOBJS)
```

- The new rule says that `$(LIB)` depends on `$(LIBOBJS)`, i.e. `libintlist.a` depends on `intlist.o`, and that the action invokes ar - the tool that builds library files.

- The top-level directory contains avgwordlen.c, defns.h and a Makefile,

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LDLIBS  =   -Llib -lintlist
BUILD   =   libs avgwordlen
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libs:
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- This tricks Make, with it's single directory view of the world, into first building everything in the lib sub-directory, before building avgwordlen in the current directory.

- You'll also notice the clean target now reads:

```
clean:
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- It's Makefile adds a new install target to install the library into your `~/c-tools/lib/x86_64` directory, and install intlist.h into `~/c-tools/include`.

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- Left for you to work through!

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- What about Gnu autoconf? It's widely used for portable software distribution, so is very powerful. I have to admit it's still on my to-do list to learn - but don't let that stop you trying it out.

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- So, I thought I'd have a go at it (clearly, time was hanging heavy on me in the first Lockdown:-)). It turns out to be delightfully simple to do this.
- In tarball 08.cbuild you will find the result. May I present cb - the new C builder. First, go into that directory, look around, and then make install - you now have a new `cb` command, and a man page `man cb` which explains how to use it.

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- Type `cb clean` and you'll see that it figures out what should be cleaned, all by itself.

- In test2 you'll see how cb supports building a library, and installing things. It's .build file has 3 parts:

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# Library LIB will be built from LIBOBJS
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- In the remaining test directories - left for you to investigate - you'll see examples of how cb supports libraries in separate subdirectories, and how it handles testing (via `cb test`).
- cb took me a couple of days to write - but of course it was based on the earlier Perl mfbuild so perhaps half the code was already written. It's still experimental, and it may not be feature complete. But I've already started using it as a potential mfbuild+make replacement.
- Give it a try - see what you think of it! Please give me any feedback.