`make` it Rain

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Introduction

What is GNU `make`?

GNU `make` is a tool which controls the generation of executables and other non-source files of a program from the program's source files.

GNU `make` gets its knowledge of how to build your program from a file called the *makefile*, which lists each of the non-source files and how to compute it from other files.

(The GNU `make` Project Page[1])

[1] `https://www.gnu.org/software/make/`

Basic Usage of GNU `make`

```
$ make
```

Advanced Usage of GNU `make`

To run `make`, there must be a file called `GNUmakefile`, `makefile`, or `Makefile` in the current working directory. Otherwise, it will return an error.

The `make` program takes an arbitrary number of parameters. Each of the parameters must be a *target*[2].

If no parameter is specified, the `all` target is assumed.

Examples:

```
$ make all
$ make a.out README.pdf
$ make makefiles.pdf
$ make profit
```

[2] More on targets later

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How to Make a `Makefile`

Understanding the Building Blocks of `Makefiles`

The main building block of a `Makefile` is the *rule*. Every `Makefile` contains a set of rules.

All rules are of the form

```
target: dependencies ...
        commands
        ...
```

Note: commands must be indented with the `TAB` character.

- The `target` is the file to be created by the rule.
- The `dependencies` (also known as prerequisites) are a list of the targets/files which need to exist for the `target` to be created.
- The `commands` are a list of the commands to create the `target` from the `dependencies`.

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A Very Simple Example

```
all: helloworld

helloworld: helloworld.c
        gcc -o helloworld helloworld.c
```

In this example, to build `helloworld`, GNU `make` will ensure that the `helloworld.c` file exists.

Why is this Better than a Bash Script?

But wait, I can do that with a BASH script:

```
[[ -f helloworld.c ]] && gcc -o helloworld helloworld.c
```

why do I need a `Makefile`?

GNU `make` only executes a target's commands if its *dependencies* have been updated since the last time `make` was called.

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Dependency Management

Dependency management is one of the best features of GNU `make`. Dependencies can even be chained!

```
all: presentation.pdf

presentation.pdf: presentation.tex
	xelatex -shell-escape presentation.tex

presentation.tex: presentation.rst xelatex.tex
	rst2beamer --template=xelatex.tex \
	    presentation.rst > presentation.tex
```

.PHONY

GNU `make` expects all targets to be *files or directories*. So if you have a file called `all`, you may run into problems.

To avoid this, you can define targets as being *phony*. This will basically make it so that those targets are perpetually out of date and will always be recomputed, regardless of whether or not they exist on the filesystem.

```
all: foo bar baz

.PHONY: all
```

A `Makefile` is not a Bash Script!

Do **not** write a `Makefile` that looks like this:

```
all: documentation
	gcc helloworld.c

documentation:
	xelatex -shell-escape doc.tex
	biber doc
	xelatex -shell-escape doc.tex
```

This `Makefile` will cause the program and the documentation to be compiled *regardless* of whether or not you've updated the corresponding source files (`doc.tex` and `helloworld.c`).

This is very bad if you are compiling a sizeable program.

Automatic Variables and Implicit Rules i

Often, you may have many files which have the same basic rule. For example you may want to compile a `.o` file for every `.cpp` file in a C++ project. Luckily, there's a syntax for that:

```
%.o: %.cpp
	g++ -c $< -o $@
```

- `%.o` as the *target* is a wildcard for all `*.o` targets.
- `%.cpp` means that if the target is `foo.o`, then it depends on `foo.cpp`.
- `$@` is the file name of the *target* of the rule.
- `$<` is the file name of the first prerequisite.

Automatic Variables and Implicit Rules ii

There are a lot of other useful automatic variables.

- `$@` is the file name of the *target* of the rule.
- `$<` is the file name of the first prerequisite.
- `$?` is the file names of all the prerequisites that are newer than the target, with spaces between them.
- `$^` is the names of all the prerequisites, with spaces between them.
- A bunch more... See `https://www.gnu.org/software/make/manual/html_node/Automatic-Variables.html` for a list.

Variables

If there are *automatic* variables, then there must be normal variables too, right? Yes!

You can define variables with the following syntax:

```
CXX=clang
OUTFILES=foo.o bar.o baz.o
```

and you can use them like this (*note, parentheses are required*):

```
all: $(OUTFILES)

%.o: %.c
	$(CXX) $< -o $@
```

Wildcards and Pattern Substitutions

Often it is useful to have glob-like wildcards in variables. To do this, you can use the `wildcard` function:

```
TEXFILES=$(wildcard *.tex)
```

You may then want to use all of those filenames to determine the targets to compute. To do this, you can use the `patsubst` (**pat**tern **subst**itution) function:

```
PDFFILES=$(patsubst %.tex,out/%.pdf,$(TEXFILES))
```

This will result in `TEXFILES` containing all of the `.tex` files in the directory, and `PDFFILES` containing all of those file names, but with `.pdf` instead of `.tex`.

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Managing TAR Files

You can use GNU `make` to manage TAR archives. This will create a `.tar.gz` containing all of the `.c` files in the directory.

```
CFILES=$(wildcard *.c)

all: test($(CFILES))

test(%.c):
        ar cr $@ $%
```

Note here that `$%` is another automatic variable containing the target member name. It is empty if the target is not an archive member.

Examples

Compiling a Presentation

```
FILENAME=makefiles
LATEX_COMPILER=xelatex -shell-escape

all: $(FILENAME).pdf

examples/%.pdf: examples/%.tex
	$(LATEX_COMPILER) -output-directory=examples $<

%.pdf: %.tex lug.cls
	$(LATEX_COMPILER) $<

.PHONY: all
```

Compiling a reStructuredText Presentation

```
RSTFILES=$(wildcard *.rst)
PDFFILES=$(patsubst %.rst,out/%.pdf,$(RSTFILES))

.PHONY: all
all: $(PDFFILES)

out:
	mkdir out

out/%.pdf: %.tex beamerthemecsam.sty csam.pdf | out
	xelatex -shell-escape $<
	mv $(patsubst out/%.pdf,%.pdf,$@) out

%.tex: %.rst xelatex.tex
	rst2beamer --template=xelatex.tex \
	    --theme=csam $< > $@
```

Additional Resources

- The GNU `make` Manual: `https://www.gnu.org/software/make/manual/html_node/index.html`
- Unix Makefile Tutorial: `https://www.tutorialspoint.com/makefile/`

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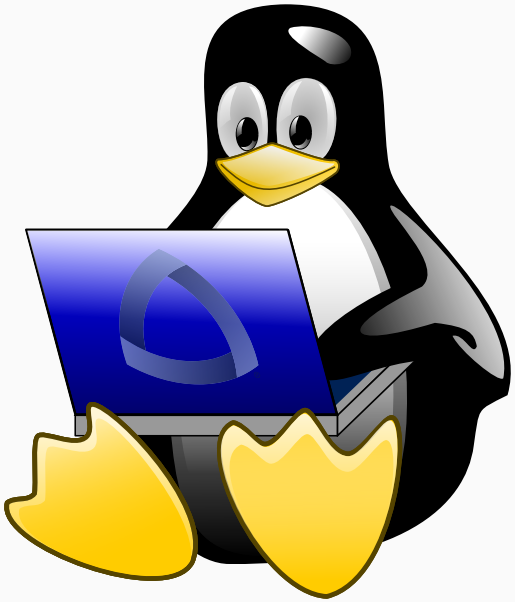

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