Lecture 6: Make Macros

Kenneth M. Anderson
Software Methods and Tools
CSCI 3308 - Fall Semester, 2003

Today's Lecture

- Brief review of make
- Explore make macros in more detail
  - Note: when you see "make macro" think "make variables"
- Brooks' Corner: The Mythical Man-Month
- but first…a quick look at Ant (a build management tool for Java programs)

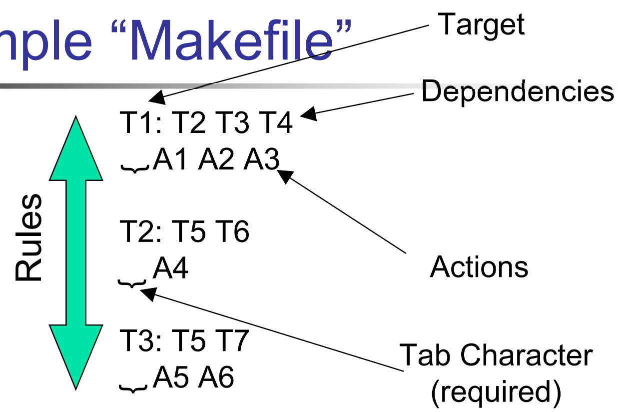
Unix Build Management

- In Unix environments, a common build management tool is "make"
  - Make provides very powerful capabilities via three types of specification styles
    - declarative
    - imperative
    - relational
  - These styles are combined into one specification: "the make file"

Make Specification Language

- Hybrid Declarative/Imperative/Relational
  - Dependencies are Relational
    - Make specifies dependencies between artifacts
  - Rules are Declarative
    - Make specifies rules for creating new artifacts
  - Actions are Imperative
    - Make specifies actions to carry out rules

Example "Makefile"



If a dependency changes, a rule's actions are executed to (re)create a rule's target

Make "Macros" - think "Variables"

- Make has variables known as "macros"
  - They are similar to shell variables with a few differences
    - Macros hold a string value
    - Macros are defined using an equal sign

```
INSTALLDIR = /home/faculty/kena/tmp/
```

- And is used by preceding its name with a dollar sign

```
$(INSTALLDIR)/program : program
    cp program $(INSTALLDIR)
```

- The parentheses are required, otherwise make assumes that a macro name is just one letter long
  - $INSTALLDIR is interpreted by make as $(I)NSTALLDIR

Macro Substitution

- Make variables perform strict textual replacement so the following two rules are equivalent
- (Do not do this in practice!):

```
program: output.o
   g++ output.o -o program
FOO = o
pr$(FOO)gram: $(FOO)utput.$(FOO)
   g++ $(FOO)utput.$(FOO) -$(FOO) pr$(FOO)gram
```


Using a '$' sign

- Since the dollar sign has special meaning…
  - it indicates the use of a macro
- …you need to "escape" it with a 2nd dollar sign, if you want it passed to the shell as part of an action
  - Note: make strips one of the dollar signs before invoking a shell to process the action
- Example: 'chapter$' is passed to `egrep` below

```
TableOfContents: book.txt
   egrep chapter$$ book.txt > TableOfContents
```

Increased Abstraction

- Macros increase the level of abstraction in a Makefile

```
program: main.o input.o output.o
    g++ main.o input.o output.o -o program
```

- is equivalent to

```
EXECUTABLE = program
OBJECTS    = main.o input.o output.o
$(EXECUTABLE): $(OBJECTS)
    g++ $(OBJECTS) -o $(EXECUTABLE)
```

- They can also save keystrokes

Increased Abstraction, cont.

- Why is this increase in abstraction important?
  - What benefit does abstraction typically provide?
- Definition of Abstraction
  - Identify the important aspect of a phenomenon and ignore the details

Increased Abstraction, cont.

- Allows the user of an abstraction to be independent of the hidden details
  - This allows the details to change without a user knowing about it (or caring)
- In makefiles, abstraction lets rules be defined that can be applied to many different situations

```
$(EXECUTABLE): $(OBJECTS)
    g++ $(OBJECTS) -o $(EXECUTABLE)
```

- The above rule can be applied to almost any C++ or C program

Definition and Use of Make Macros

- A shell script is executed from top to bottom. As such, a shell variable cannot be used before it is defined.
- Makefiles, on the other hand, are not executed top to bottom. Execution follows dependencies which can be anywhere in the file
  - As such, there is no concept of one rule coming before or after another rule
  - Therefore, all rules and macros are read entirely before the make algorithm is executed

Definition and Use, continued

- Shell Variables
  %echo $var
  %set var = hello
- In response to the first statement, the shell complains “undefined variable”
- Make Macros

```
all:
    echo $(VAR)
VAR = hello
```

- Running make on the above makefile produces
  echo hello
  hello

Advanced Macro Use

```
BASEDIR  = $(HOME)/csci3308
SRCDIR   = $(BASEDIR)/src/function
ARCHDIR  = $(BASEDIR)/arch/$(ARCH)
BUILDDIR = $(ARCHDIR)/build/function
BINDIR   = $(ARCHDIR)/bin
MANDIR   = $(ARCHDIR)/man
SOURCE   = function.cpp
OBJECT   = function.o
EXEC     = function

$(BUILDDIR)/$(OBJECT): $(SRCDIR)/$(SOURCE)
    g++ -c $(SRCDIR)/$(SOURCE) -o $(BUILDDIR)/$(OBJECT)
$(BINDIR)/$(EXEC): $(BUILDDIR)/$(OBJECT)
    g++ $(BUILDDIR)/$(OBJECT) -o $(BINDIR)/$(EXEC)
```


Brooks’ Corner: The Mythical Man-Month (Chapter 2)

- Cost does indeed vary as the product of the number of workers and the number of months
  - Progress does not!
  - The unit of the man-month implies that workers and months are interchangeable
    - However, this is only true when a task can be partitioned among many workers with no communication among them!

The Man-Month, continued

- When a task is sequential, more effort has no effect on the schedule
  - “The bearing of a child takes nine months, no matter how many women are assigned!”
  - Many tasks in software engineering have sequential constraints!

The Man-Month, continued

- Most tasks require communication among workers
- communication consists of
  - training
  - sharing information (intercommunication)
- Training affects effort at worst linearly
- Intercommunication adds n(n-1)/2 to effort
  - if each worker must communicate with every other worker

Intercommunication Effort

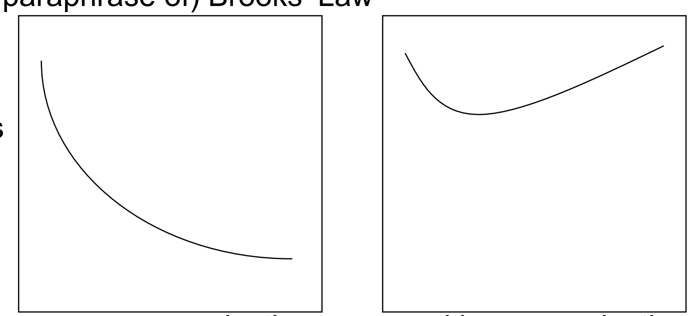
- 2 workers
- 3
- 4
- 5
- 6
- 7

- 1 path
- 3 paths
- 6 paths
- 10 paths
- 15 paths
- 21 paths

Comparison Graphs

"Adding more people then lengthens, not shortens, the schedule!"
-- (A paraphrase of) Brooks' Law

Months



no communication with communication

Workers

Scheduling

- Brook's rule of thumb
  - 1/3 planning
  - 1/6 coding
  - 1/4 component test
  - 1/4 system test
- More time devoted to planning, half to testing!

- In looking at other projects, Brooks found that few planned for 50% testing, but most spent 50% of their time testing!
  - Many of these projects were on schedule until testing began!