Development: gcc and make

CS 2204
Class meeting 8
Overview of development process

- Creation of source files (.c, .h, .cpp)
- Compilation (e.g. *.c → *.o) and linking
- Running and testing programs
Development tools in UNIX

- Creation of source files (.c, .h, .cpp)
  - Text editors (e.g. vi)
  - Revision control systems (e.g. rcs)
- Compilation (e.g. *.c→*.o) and linking
  - Compilers (e.g. gcc)
  - Automatic building tools (e.g. make)
- Running and testing programs
  - Debuggers (e.g. gdb)
- Integrated development environments (IDEs)
Compiling with **gcc**

- GNU C compiler
- Performs one or more of the following:
  - C pre-processing
  - Compilation
  - Linking
Basic **gcc** examples

- `gcc hello.c (compile hello.c, produce executable a.out)`
- `gcc -o hello hello.c (compile hello.c, produce executable hello)`
- `gcc -o hello hello.c other_functions.c (compile hello.c and other_functions.c, produce executable hello)`
Using intermediate files

- From any source file, you can produce an object file to be linked in later to an executable

```bash
gcc -c hello.c
gcc -c other_functions.c
gcc -o hello hello.o other_functions.o
```
Other important `gcc` options

- `-g`: include debugging symbols in the output
- `-l<name>`: include a library called `libname.a`
Include and library paths

- There are default directories in which gcc looks for include files and libraries
  - `-I<path>`: also look for include files in this directory
  - `-L<path>`: also look for library files in this directory
Defines in gcc

- Often programs contain conditional parts based on defines:

  ```c
  #ifdef DEBUG
  printf("value of var is \%d", var);
  #endif
  ```

- You can set preprocessor defines on the command line

  ```bash
  gcc -DDEBUG -o prog prog.c
  ```
Using \texttt{make} in compilation

- With medium to large software projects containing many files, it’s difficult to:
  - Type commands to compile all the files correctly each time
  - Keep track of which files have been changed
  - Keep track of files’ dependencies on other files
- \texttt{The make} utility automates this process
Basic operation of `make`

- Reads a file called `[Mm]akefile`, which contains rules for building a “target”
- If the target depends on a file, then that file is built
- If that file depends on a third file, then the third file is built, and so on…
- Works backward through the chain of dependencies
- Targets only built if they are older than the files they depend on
Basic Makefile example

program : main.o iodat.o dorun.o
  gcc -o program main.o iodat.o dorun.o
main.o : main.c
  gcc -c main.c
iodat.o : iodat.c
  gcc -c iodat.c
dorun.o : dorun.c
  gcc -c dorun.c
Types of lines in Makefiles

- Dependency or rules lines
- Commands
- Macro assignments
- Comments
Specify a target and a list of prerequisites (optional) for that target

```
target : prereq1 prereq2 prereq3 ...
```
Command lines

- Follow dependency lines
- MUST start with a TAB!
- Any command that can be run in the shell can be placed here

```
target : prereq1 prereq2
command1
command2
```

- Special variables in commands:
  - `$@` represents the target
  - `$?` represents prereqs that are newer than target
Macro (variable) assignments

- You can use macros to represent other text in a Makefile
  - Saves typing
  - Allows you to easily change the action of the Makefile

- Assignment:
  \[
  \text{MACRONAME} = \text{macro value}
  \]

- Usage: \$\{\text{MACRONAME}\}
Comments and other Makefile notes

- Comments begin with a ‘#’
- Can be placed at the beginning of a line or after a non-comment line

- Lines that are too long can be continued on the next line by placing a ‘\’ at the end of the first line
Invoking make

- Be sure that your description file:
  - is called makefile or Makefile
  - is in the directory with the source files
- make (builds the first target in the file)
- make target(s) (builds target(s))
- Important options:
  - \texttt{-n}: don’t run the commands, just list them
  - \texttt{-f file}: use file instead of [Mm]akefile
Basic Makefile example

program : main.o iodat.o dorun.o
    gcc -o program main.o iodat.o dorun.o
main.o : main.c
    gcc -c main.c
iodat.o : iodat.c
    gcc -c iodat.c
dorun.o : dorun.c
    gcc -c dorun.c
Simplifying the example Makefile with macros

OBJS = main.o iodat.o dorun.o
CC = /usr/bin/gcc
program : ${OBJS}
    ${CC} -o $@ ${OBJS}
main.o : main.c
    ${CC} -c $? 
iodat.o : iodat.c
    ${CC} -c $? 
dorun.o : dorun.c
    ${CC} -c $?
Suffix rules

- It’s still tedious to specifically tell `make` how to build each `.o` file from a `.c` file.
- Suffix rules can be used to generalize such situations.
- A default suffix rule turns `.c` files into `.o` files by running the command:
  
  ```sh
  ${CC} ${CFLAGS} -c $<
  ```

- `$<` refers to the prerequisite (file.c)
Simplifying the example
Makefile again

\begin{verbatim}
OBJS = main.o iodat.o dorun.o
CC = /usr/bin/gcc

program : ${OBJE}
  ${CC} -o $@ ${OBJE}
\end{verbatim}
Other useful Makefile tips

- Include a way to clean up your mess

  clean:
  
  /bin/rm -f *.o core

- Include a target to build multiple programs

  all:
  
  program1 program2 program3