3. MAKE UTILITY

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3.1 UNIX make Utility

- Two-fold purpose: 1) overview of UNIX make command, and 2) use within MM5 system
- As programming complexity increases from a single source file to multiple includes, dependencies and conditional compilation, make becomes a necessity

3.1 UNIX make Utility

- Only re-compiles what is required, recognizes tree-like structure of multiple source files for single executable

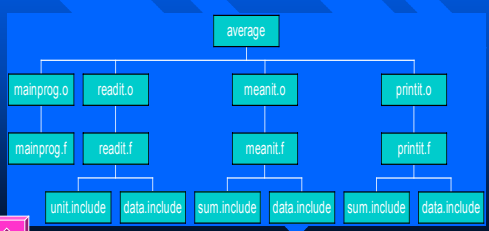
3.2 make Functionality

- Dependency is the underlying relationship between two files
- myprog.f ➔ myprog.o ➔ myprog.exe

myprog.f is a dependency file for the target myprog.o, and myprog.o is a dependency for the target myprog.exe

3.2 make Functionality

See section 3.8, hierarchical tree dependency structure



3.2 make Functionality

- Date and time of last modification used to determine whether dependency is out of date wrt target
- When improper time relationship exists, make uses rules to restore the target
- Hierarchy of include files, source, object and executable follows this sequential time dependency, leading to natural association of dependency timestamps

3.3 The Makefile

- Makefile, makefile (make –f make.file)
- File read by make utility which contains **dependency relationships** and rules for updating targets (**generation commands**)
- Dependency relations – determine when a file must be regenerated
- Generation commands – how do you build out of date files

3.4 Sample make Syntax

```
targetfile: dependencies
<tab>       command1
<tab>       command2

myprog.exe: mysource1.f mysource2.f
<tab>       f77 –o myprog.exe mysource1.f \
            mysource2.f
```


3.4 Sample make Syntax

- Rule – begins in the first position of a line, with the following format

  target : dependencies

- If the files to the right are NEWER than the files to the left of the colon, a new target is rebuilt

3.4 Sample make Syntax

- Dependency rule *MAY* be followed by one or more commands
- Commands must begin with a <tab> character to be recognized, otherwise they are seen as rules or macros, and then you are toast
- Commands are passed to the shell to execute (note this is **sh**, not **csh**)

3.5 Macros

- Similar to shell variables, syntactically and semantically

  MyFlags = -a –b –c –d

- Usage of $(MyFlags) expands to:

–a –b –c –d

- The () may be omitted if the macro name is only a single character
- () are not required as in csh for an array

3.6 Internal Macros

- Built in cool, short-cuts, sure to impress members of the digiterati

- $@ name of the current target
- $< dependency file, as if from implicit rule
- $? list of all dependencies newer than target
- $* basename of current target

3.7 Default Suffixes and Rules

- Typical default rules for FORTRAN, shut off with "make –r" ("make –p" for the brave and curious)

```
.f.o:
<tab>       $(FC) $(FFLAGS) –c $<

.f:
<tab>       $(FC) $(FFLAGS) $(LDFLAGS) \
            $< -o $@
```


3.7 Default Suffixes and Rules

- Typical default suffixes, typically at the beginning of a Makefile (or included near the top)

```
.SUFFIXES:  .o  .c  .f
```


3.7 Default Suffixes and Rules

- All of the MM5 system Fortran codes are set up to be processed by cpp.
- Not all Fortran compilers handle this in the same way.
- Gain uniformity through explicit rules:

```
.F.o:
<tab>       $(RM) $@
<tab>       $(CPP) $(CPPFLAGS) $*.F >! $*.f
<tab>       $(FC) –c $(FFLAGS) $*.f
```


3.8 Program Dependency Chart

- Head to that other slide, Dave

3.9 Program Components

```
PROGRAM mainprog
CALL readit
CALL meanit
CALL printit
STOP 99999
END
```


3.9 Program Components

```
SUBROUTINE readit
Include 'unit.include'
INCLUDE 'data.include'
OPEN(iunit, file='input.data', ACCESS = &
   'sequential', FORM='FORMATTED')
READ(iunut,FMT='(F10.4)' ) data
RETURN
END
```

3.9 Program Components

```
SUBROUTINE meanit
INCLUDE ‘data.include’
INCLUDE ‘sum.include’
DO L=1,length
  sum = sum + data(L)
END DO
sum = sum / FLOAT(length)
END
```


3.9 Program Components

```
SUBROUTINE printit
INCLUDE ‘data.include’
INCLUDE ‘sum.include’
PRINT *,data(1:length)
PRINT *,‘average = ’,sum
END
```


3.9 Program Components

- unit.include

```
PARAMETER ( iunit=7 )
```

- sum.include

```
COMMON /avg/ sum
```

- data.include

```
PARAMETER ( length = 10 )
COMMON /space/ data(length)
```


3.10 makefile Example 1

```
average: mainprog.o readit.o meanit.o printit.o
        f77 –o average mainprog.o readit.o meanit.o printit.o
mainprog.o : mainprog.f
        f77 –c mainprog.f
readit.o : readit.f unit.include data.include
        f77 –c readit.f
meanit.o : meanit.f data.include sum.include
        f77 –c meanit.f
printit.o : printit.f data.include sum.include
        f77 –c printit.f
```


3.10 makefile Example 2

```
average: mainprog.o readit.o meanit.o printit.o
        f77 –o $@ mainprog.o readit.o meanit.o printit.o
mainprog.o : mainprog.f
        f77 –c $<
readit.o : readit.f unit.include data.include
        f77 –c $<
meanit.o : meanit.f data.include sum.include
        f77 –c $*.f
printit.o : printit.f data.include sum.include
        f77 –c $*.f
```


3.10 makefile Example 3

```
OBJS = mainprog.o readit.o meanit.o printit.o
average: $(OBJS)
        f77 –o $@ $(OBJS)
readit.o : readit.f unit.include data.include
        f77 –c $<
meanit.o : meanit.f data.include sum.include
        f77 –c $*.f
printit.o : printit.f data.include sum.include
        f77 –c $*.f
```

3.10 makefile Example 4

```
.f.o:
        rm –f $@
        f77 –c $*.f
OBJS = mainprog.o readit.o meanit.o printit.o

average: $(OBJS)
        f77 –o $@ $(OBJS)

readit.o : unit.include data.include
meanit.o : data.include sum.include
printit.o : data.include sum.include
```

3.11 MM5 make Commands

- Directly put macro definitions into the make command
- Precedence over values initialized as macros inside the makefile

make "FC=f90" "FFLAGS=-g"

3.12 Top-level Makefile

- Example from TERRAIN, so just 2 levels: top and lower
- .IGNORE: same as –i
- AR = ar ru macros
- default: first target is default, any name
- uname –a > .tmpfile if test for vendor

3.12 Top-level Makefile

- grep CRAY .tmpfile
- if [$$? = 0] ; then blah
- $(MAKE) all "all" is the low-level target
- Note CPPFLAGS includes NCARGRAPHICS macro: NCARG or NONCARG

3.12 Top-level Makefile

- ??? fi ; \ end of each if ; then block
- Second target is terrain.deck
- Must specifically name any target (other than first) to activate it
- make terrain.deck
- clean: typical target to zap detritus

3.13 Low-level Makefile

.IGNORE: unnecessary with $(MAKE)
.SUFFIXES: .F .f .i .o pseudo target, expl suffixes

```
.F.f:
<tab> $(CPP) $(CPPFLAGS) $*.F > $@
```

OBS = ia.o … macro definition
SRC = $(OBJS:.o=.f) list of source files
cray dec hp ibm sgi sun default: first target

3.13 Low-level Makefile

- @echo "you need ... easy error trapping
- all: target specified in top-level Makefile
- terrain.exe data_area.exe rdem.exe three dependency files
- $(FC) defined in top-level Makefile
- anal2.o: then the list of dependencies
- Note crlnd.o is listed more than once

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