4010-350 Personal SE

C Miscellany
Make

C Structs

- Question: What is an object with no methods and only instance variables public?
- Answer: A struct! (well, sort of).
- A struct is a way of grouping named, heterogeneous data elements that represent a coherent concept.
- Example:

```
#define MAXNAME (20)

struct person {
    char name[MAXNAME+1] ;
    int age ;
    double income ;
} ;
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naming - the field names in the struct

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heterogeneous - the fields have different types

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coherent concept - the information recorded for a person.

Using Structs

- Declarations / definitions:

```
struct person mike, pete, chris ;
```

- Assignment / field references ('dot' notation):

```
mike = pete ;
pete.age = chris.age + 3
```

- Note: Space allocated for the whole struct at definition.
- Struct arguments are passed by value (i.e., copying)

WRONG

```
void give_raise(struct person p, double pct)
{
   p.income *= (1 + pct/100) ;
   return ;
}

give_raise(mike, 10.0) ;
```

RIGHT

```
struct person give_raise(struct person p, double pct)
{
   p.income *= (1 + pct/100) ;
   return p ;
}

mike = give_raise(mike, 10.0) ;
```

Enumerations

- We sometimes want symbolic constants that are related to each other.
- Example: The colors on a traffic light.
- The "old" C way:

```
#define GREEN (0)
#define YELLOW (1)
#define RED (2)
```

- Note: No inherent relationship among the constants.
- The "new and improved" C way (using enums):

```
enum light_color { GREEN, YELLOW, RED } ;       // the type

enum light_color jefferson_john_light ;         // a variable of the type
```

What *Are* Enums?

- Under the hood, an *enum* type is just a sequence of non-negative integers starting at zero.
  - That is, the values of GREEN, YELLOW and RED are the same in the #define statements **and the** light_color enum
  - A **enum type** is just "syntactic sugar" to make it easier to show the intent of your program.
- We use **enum types** to collect related symbolic constants under one "type roof".

Symbolic Type Names - typedef

- Suppose we have a pricing system that prices goods by weight.
  - Weight is in pounds, and is a double precision number.
  - Price is in dollars, and is a double precision number.
  - Goal: Clearly distinguish weight variables from price variables.
- Typedef to the rescue:
  - typedef ***declaration*** ;
  - Creates a new "type" with the variable slot in the ***declaration***.
- Examples:

```
typedef double price ;       // alias for double to declare price variabless
typedef double weight ;      // alias for double to declear weight variables

price p ;                    // double precision value that's a price
weight lbs ;                 // double precision value that's a weight
```

typedef In Practice

- Symbolic names for array types

```
#define  MAXSTR  (100)

typedef  char  long_string[MAXSTR+1] ;

long_string  line ;
long_string  buffer ;
```

- Shorter name for struct types:

```
typedef struct  {
    long_string  label ;  // name for the point
    double  x ;           // xcoordinate
    double  y ;           // ycoordinate
}  point ;

point  origin ;
point  focus ;
```

Make and **Makefiles**

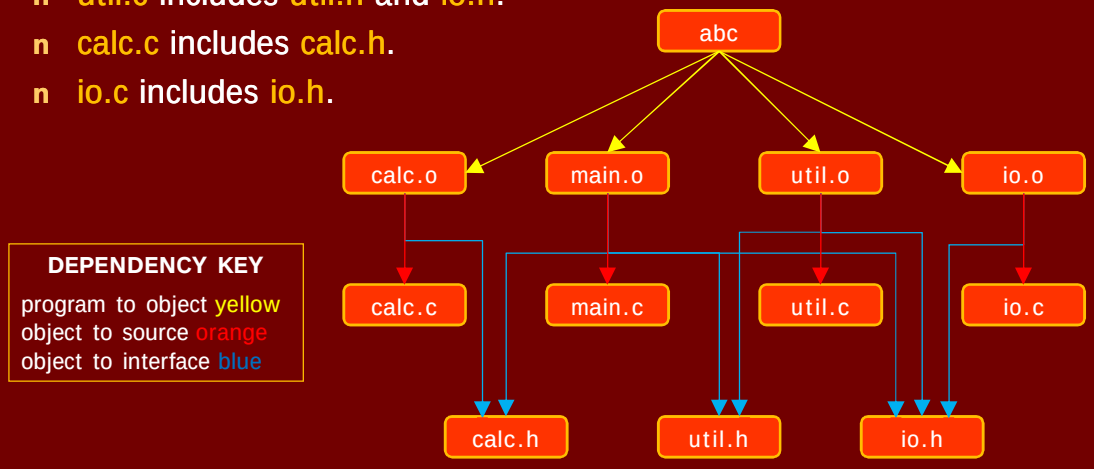
- Problem:
  - Program comprises many source files.
  - Recompiling everything is time-consuming and redundant.
  - Changes to a file may make other files obsolete.
  - How can we periodically regenerate the executable doing the minimum amount of work?
- Solution: *make* (or *ant*, *rake* and other similar programs)
  - Record obsolescence dependencies (a DAG).
  - Define commands to recreate obsolete files.
  - Depth first traversal of the DAG to bring things up-to-date.

What Is A Dependency?

- File A *depends* on file B if the correctness of A's contents are affected by changes to B.
- Thus an object file depends on its source:
  - A change to the source makes the object file incorrect.
- An object file depends on interfaces its source file uses:
  - Interface change may change the meaning of the source code
  - E.g., change a configuration constant, a **struct**, etc.
- An executable program depends on the object code files from which it is built.

Example

- Program abc made from main.o, util.o, calc.o and io.o.
- main.c includes calc.h, util.h and io.h.
- util.c includes util.h and io.h.
- calc.c includes calc.h.
- io.c includes io.h.



Dependencies in Makefiles

target: *dependency*$_1$ *dependency*$_2$ . . . *dependency*$_N$

For our example the dependency lines are

```
abc: main.o util.o calc.o io.o

main.o: main.c util.h calc.h io.h

util.o: util.c util.h io.h

calc.o: calc.c calc.h

io.o: io.c io.h
```

Is a Target Up-To-Date?

- A target is *up-to-date* iff
  - It exists (obviously).
  - It was modified later than any of its dependencies *after they have all been brought up-to-date*.
- What do we do if a file is *not* up-to-date?
  - We run one or more commands to bring it up-to-date.
  - For a program, we link the object files.
  - For an object file, we recompile its source.
- For make, command lines:
  - Follow the dependency line.
  - ***MUST*** begin with a ***hard tab*** (Tab key or CTRL-I).

Completed Makefile for the Example

```
abc: main.o util.o calc.o io.o
        gcc -o abc main.o util.o calc.o io.o

main.o: main.c util.h calc.h io.h
        gcc -c main.c

util.o: util.c util.h io.h
        gcc -c util.c

calc.o: calc.c calc.h
        gcc -c calc.c

io.o: io.c io.h
        gcc -c io.c
```

Assuming Existence of "Makefile"

`make`

`make abc`

- Default is first target; brings abc up to date.
- First brings main.o util.o calc.o and io.o up to date
- Then **relink** abc iff
  - abc does not exist
  - abc is older than at least one of its dependencies

`make main.o`

- Just brings main.o up to date.
- Any target can be specified.

Things to Note

- Targets need not have any dependencies.
- Targets need not ever really be made.
- Example: Generic "clean" target:

```
clean:
        rm -f *.o *~* *.exe
```