CMSC 216
Introduction to Computer Systems
Lecture 8
Pointers & Make

Administrivia

- Read Reek, Chapter 6: Pointers

Chapter 6, Reek

POINTERS (CONT.)

Type conversion with pointers

- Converting from one type to a pointer has some uses:

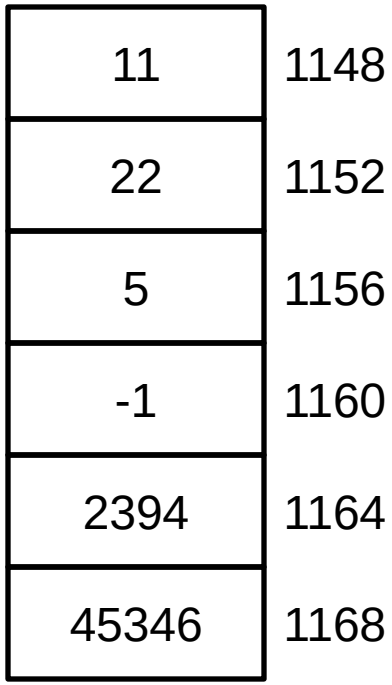
```
unsigned int i;
unsigned char *ch;
i = 0x543210ab;
ch = (unsigned char *) &i;
printf("%d\n", *ch);
printf("%d\n",
        * (unsigned char *) &i);
```

- Prints out either MSB or LSB of **i**, depending on architecture

Incrementing pointers

- Pointers can be incremented/decremented just like integer type variables, "moving" one element at a time
  - how much is added to the address depends on the size of the type to which the pointer points (as declared)
- Recall arrays are contiguous memory
- What does this function do?

```
int mystery(int array[]) {
  int *p = &(array[0]);
  int sum = 0;
  while (*p != -1) {
    sum += *p;
    p++;
  }
  return sum;
}
```



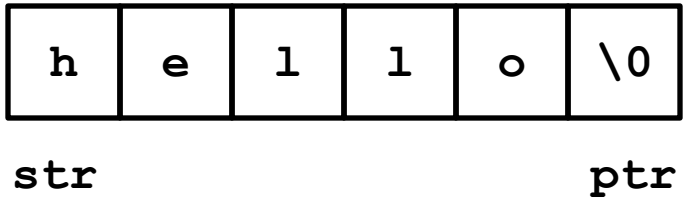
Incrementing pointers, cont.

- The postfix operators take precedence over the dereference operator and prefix operators
- `*` and prefix ops are at the same precedence level, and associate right to left
- `++*p` increments the value at the location to which `p` points, and evaluates to the incremented value
- `*p++` evaluates to the value at the location to which `p` points, and then advances `p`
- `(*p)++` evaluates to the value at the location to which `p` points, and then increments that value

Pointer arithmetic

- With two pointers in the same array, we can determine how far apart they are

```
size_t strlen(const char *str) {
  const char *ptr;
  for (ptr = str; *ptr; ptr++)
    ;
  return (size_t) (ptr - str);
}
```



Pointer arithmetic, cont.

- By adding an integer *n* to a pointer, we can get the address of the n^{th} element past the element to which the pointer currently points

```
int arr[] = {2, 3, 5, 7, 11};
int *p = &(arr[0]);
int *q = p + 4;
printf("%d\n", *q);
```

Output: 11

- Only valid forms of pointer arithmetic:
  - pointer - pointer
  - pointer ± integer

Pointer arithmetic, cont.

- We can also use relational and equality operators when working with multiple pointers

```
void sum_subarray(int array[], int idx1, int idx2) {
  int *ptr;
  int sum = 0;
  ptr = array + idx1;
  while (ptr <= array + idx2) {
    sum += *ptr;
    ptr++;
  }
  return sum;
}
```

(Not in the textbooks)

MAKE

Separate Compilation

- Placing code across several files allows us to update only parts of the object code for a program when changes occur
- We have been just compiling everything into an executable, bypassing the object code step
- Ex. from project #1:

```
gcc -c puzzles.c
gcc -c public01.c
gcc -o public01 public01.o puzzles.o
```

- Now, if we change **`puzzles.c`**, we only need to recompile half our program, and then link the object files together

The make utility

- Using make helps automate separate compilation, using a *Makefile* we write
- The Java compiler can tell if it has to compile other classes than the one you've told it to compile; C compilers can't
- Typing out the commands to build C programs is error-prone and can get annoying, especially if using several command-line options
- Note: this is a compressed description of Make; full manual is available online off of course information page

Example

- Recall Project #1 again:

publicX.c:

```
#include <stdio.h>
#include "puzzles.h"

int main() {
  size_t x = sizeof_long();
  ...
  if (is_nonzero(0))
    ...;
  else
    ...;
  ...
  return 0;
}
```

puzzles.h:

```
#include <stddef.h>

int is_nonzero(int);
size_t sizeof_long();
...
```

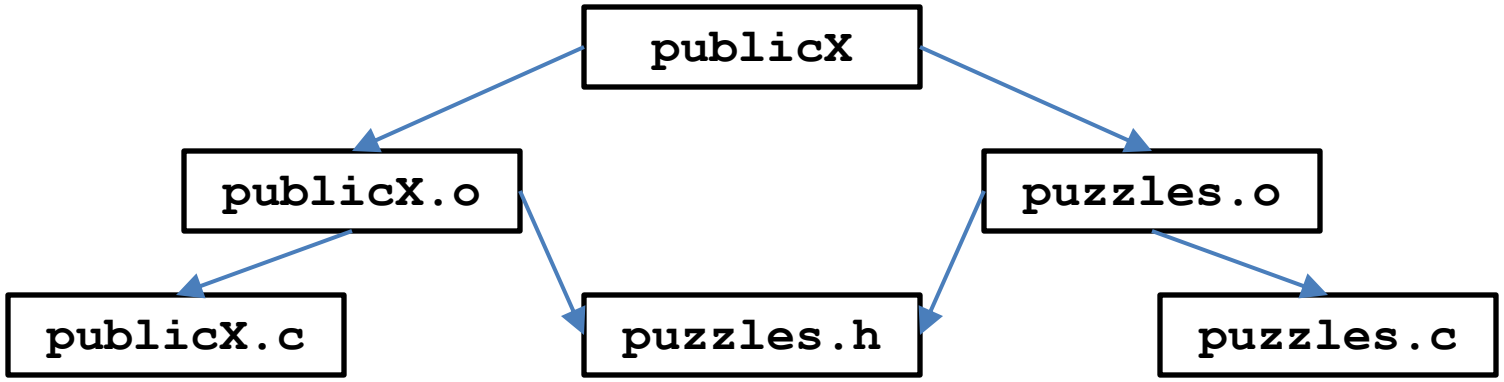
puzzles.c:

```
#include "puzzles.h"

int is_nonzero(int a) {
  ...
}
size_t sizeof_long() {
  ...
}
...
```

Dependencies

- Since **`main()`** is in **`publicX.c`**, we'll name the program **`publicX`**
- What needs to be compiled if ...
  - **`publicX.c`** is changed?
  - **`puzzles.c`** is changed?
  - **`puzzles.h`** is changed?



Basic dependency rules

- Executables depend on all the object files that could compose the program
- Executables made by linking object files
- Object files depend on their respective source files (**`x.o`** depends on **`x.c`**), and any header files **`#include`**d with **`quotes`** in the source file
  - **`x.o`** depends on **`y.h`** if **`x.c`** has "**`#include "y.h"`**"
- Object files made by compiling **`*.c`** files with **`-c`** flag

Example Makefile

```
publicX: publicX.o puzzles.o
        gcc -o publicX publicX.o puzzles.o

publicX.o: publicX.c puzzles.h
        gcc -c publicX.c

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

target

dependency list

command

must be a **tab** character!

Simplified Makefile notes:

- Pairs of lines are called rules
- Each rule (usually) has a target, a list of dependencies, and one or more commands
- The target is the item before the colon
- The dependency list contains those items that, if changed, should cause rebuilding of the target
- Lines with commands must begin with a tab character, and commands should perform the necessary actions to rebuild the target