CSE 31
Computer Organization

Lecture 4 – Arrays and C Pointers (cont.)

Announcements

- Lab
  - Lab 1 due this week (with 7 days grace period after due date)
    - » Demo is REQUIRED to receive full credit
  - Lab 2 out this week
    - » Due at 11:59pm on the same day of your next lab (with 7 days grace period after due date)
    - » You must demo your submission to your TA within 14 days from posting of lab
    - » Demo is REQUIRED to receive full credit
- Reading assignment
  - Chapter 4-6 of K&R (C book) to review C/C++ programming
  - Reading 01 (zyBooks 1.1 – 1.5) due 13-FEB
    - » Complete Participation Activities in each section to receive grade towards Participation
    - » IMPORTANT: Make sure to submit score to CatCourses by using the link provided on CatCourses
- Homework assignment
  - Homework 01 (zyBooks 1.1 – 1.5) due 20-FEB
    - » Complete Challenge Activities in each section to receive grade towards Homework
    - » IMPORTANT: Make sure to submit score to CatCourses by using the link provided on CatCourses

Arrays (1/5)

- Declaration:

  `int ar[2];`
  declares a 2-element integer array. An array is really just a block of memory.

  `int ar[] = {795, 635};`
  declares and fills a 2-element integer array.

- Accessing elements:

  `ar[num]`
  returns the `(num+1)` th element.

Arrays (2/5)

- Arrays are (almost) identical to pointers
  - `char *string` and `char string[]` are nearly identical declarations
  - They differ in very subtle ways: incrementing, declaration of filled arrays

- Key Concept: An array variable is a "pointer" to the first element.

Arrays (3/5)

- Consequences:
  - `ar` is an array variable but looks like a pointer in many respects (though not all)
  - `ar[0]` is the same as `*ar`
  - `ar[2]` is the same as `*(ar+2)`
  - We can use pointer arithmetic to access arrays more conveniently.
- Declared arrays are only allocated while the scope is valid

```
char *foo() {
    char string[32];
    ...;
    return string;
}
```

is incorrect!

What's wrong?

Arrays (4/5)

- Good practice: You should use a counter AND utilize a variable for declaration & checking for bounds
  - Not as good:

```
int i, ar[10];
for(i = 0; i < 10; i++){ ... }
```

  - Better:

```
int ARRAY_SIZE = 10
int i, a[ARRAY_SIZE];
for(i = 0; i < ARRAY_SIZE; i++){
... }
```

- Why? SINGLE SOURCE OF TRUTH
  - You're utilizing indirection and avoiding maintaining two copies of the number 10

Arrays (5/5)

- Pitfall: An array in C does not know its own length, and bounds are not checked!
  - Consequence: We can accidentally access off the end of an array.
  - Consequence: We must pass the array and its size to a procedure which is going to traverse it.

- Segmentation faults:
  - These are VERY difficult to find;
    be careful! (You'll learn how to debug these in lab…)

Arrays (one element past array must be valid)

- With array size `n`, we want to access from `0` to `n-1`. But test for exit by comparing to address one element past the array

```
int ar[10], *p, *q, sum = 0;
...
p = &ar[0]; q = &ar[10];
while (p != q)
sum += *p++;
     /* Same as
        sum = sum + *p;
        p = p + 1;
     */
```

  - Is this legal?

- C defines that one element past end of array must be a valid address, i.e., not cause a bus or address error

Arrays vs. Pointers

- An array name is a *read-only* pointer to the 1st element of the array.
- An array parameter can be declared as an array or a pointer; an array argument can be passed as a pointer.

```
int strlen(char s[]) {
    int n = 0;
    while (s[n] != 0)
        n++;
    return n;
}
```

```
int strlen(char *s) {
    int n = 0;
    while (s[n] != 0)
        n++;
    return n;
}
```

Can also be written as:
`while (s[n])`

Pointer Arithmetic (1/3)

- Since a pointer is just a memory address, we can add to it to traverse an array.
- `p+1` returns a pointer to the next array element
- `*p++` vs `(*p)++` ?
  - `x = *p++` → `x = *p ; p = p + 1;`
  - `x = (*p)++` → `x = *p ; *p = *p + 1;`
- What if we have an array of large `structs` (objects)?
  - C takes care of it: In reality, `p+1` doesn't add 1 to the memory address, it adds the size of the array element.

Pointer Arithmetic (2/3)

- C knows the size of the thing a pointer points to – every addition or subtraction moves that many bytes.
  - 1 byte for a `char`, 4 bytes for an `int`, etc.

- So, the following are equivalent:

```
int get(int array[], int n) {
    return  (array[n]);
     // OR...
    return *(array + n);
}
```

Pointer Arithmetic (3/3)

- What is valid pointer arithmetic?
  - Add an integer to a pointer.
  - Subtract integer from pointer.
  - Subtract 2 pointers (in the same array).
  - Compare pointers (<, <=, ==, !=, >, >=)
  - Compare pointer to `NULL` (indicates that the pointer points to nothing).

- Everything else is illegal since it makes no sense:
  - adding two pointers
  - multiplying pointers
  - subtract pointer from integer

Pointer Arithmetic to Copy Memory

- We can use pointer arithmetic to "walk" through memory:

```
void copy(int *from, int *to, int n) {
    int i;
    for (i=0; i<n; i++) {
        *to++ = *from++;
    }
}
```

- Note we had to pass size (n) to `copy`

Pointer Arithmetic Summary

- `x = *(p + 1)` ?
- `x = *p + 1` ?
- `x = (*p)++` ?
- `x = *p++` ? or `(*p++)` ? or `*(p)++` ? or `*(p++)` ?
- `x = *++p` ?
- `x = ++*p` ?