(1-1) C Review: Pointers, Arrays, Strings, & Structs

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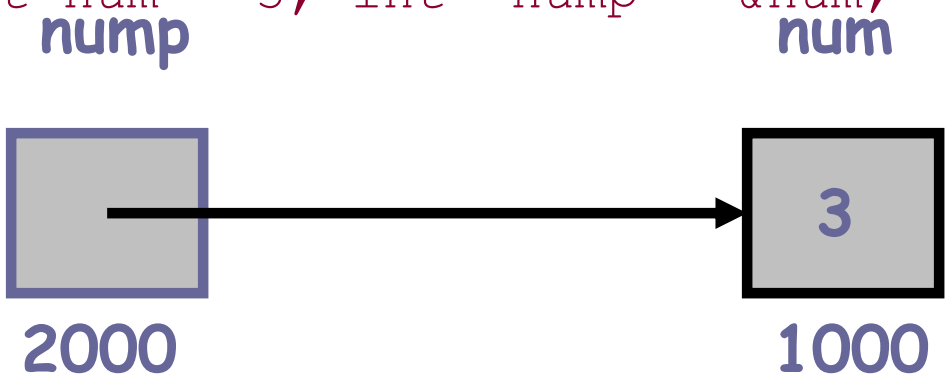
Crash Review on Critical C Topics

- Pointers
- Arrays
- Strings
- Structs

Pointers

Pointer Review (1)

- A pointer variable contains the address of another cell containing a data value
- Note that a pointer is “useless” unless we make sure that it points somewhere:
  - `int num = 3, int *nump = &num;`



- The *direct* value of *num* is 3, while the *direct* value of *nump* is the address (1000) of the memory cell which holds the 3

Pointer Review (2)

- The integer 3 is the *indirect* value of *nump*, this value can be accessed by following the pointer stored in *nump*
- If the indirection, dereferencing, or "pointer-following" operator is applied to a pointer variable, the indirect value of the pointer variable is accessed
- That is, if we apply **nump*, we are able to access the integer value 3
- The next slide summarizes…

Pointer Review (3)

Reference	Explanation	Value
num	Direct value of *num*	3
nump	Direct value of *nump*	1000
**nump*	Indirect value of *nump*	3
&*nump*	Address of *nump*	2000

Pointers as Function Parameters (1)

- Recall that we define an output parameter to a function by passing the address (&) of the variable to the function
- The output parameter is defined as a pointer in the formal parameter list
- Also, recall that output parameters allow us to return more than one value from a function
- The next slide shows a long division function which uses *quotientp* and *remainderp* as pointers

Pointers as Function Parameters (2)

- Function with Pointers as Output Parameters

```
#include <stdio.h>

void long_division (int dividend, int divisor, int *quotientp, int *remainderp);

int main (void)
{
        int quot, rem;

        long_division (40, 3, &quot, &rem);
        printf ("40 divided by 3 yields quotient %d ", quot);
        printf ("and remainder %d\n", rem);

        return 0;
}

void long_division (int dividend, int divisor, int *quotientp, int *remainderp)
{
        *quotientp = dividend / divisor;
        *remainderp = dividend % divisor;
}
```


Arrays

What is an array?

- A sequence of items that are contiguously allocated in memory
- All items in the array are of the same data type and of the same size
- All items are accessed by the same name, but a different index
- The length or size is fixed

More About Arrays

- An array is a data structure
  - A data structure is a way of storing and organizing data in memory so that it may be accessed and manipulated efficiently

Uses for Arrays?

- Store related information
  - Student ID numbers
  - Names of players on the Seattle Seahawks roster
  - Scores for each combination in Yahtzee
  - Many more…

The Many Dimensions of an Array

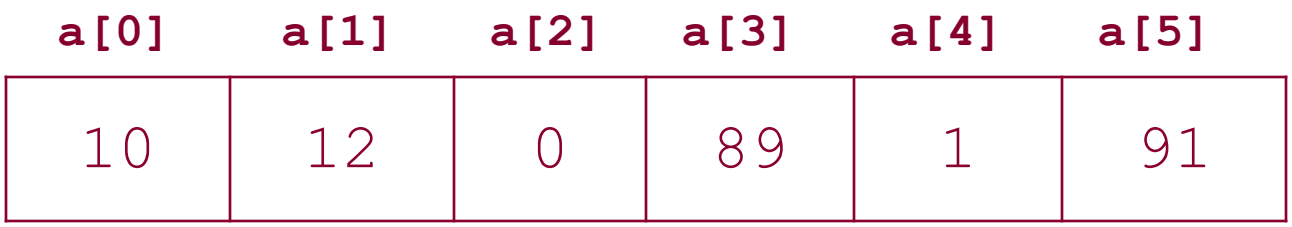
- A single dimensional array is logically viewed as a linear structure
- A two dimensional array is logically viewed as a table consisting of rows and columns
- What about three, four, etc., dimensions?

Declaring a Single Dimensional Array (1)

- Arrays are declared in much the same way as variables:

```
int a[6];
```

declares an array `a` with 6 cells that hold integers:



Notice that array indexing begins at 0.

Strings

String Fundamentals

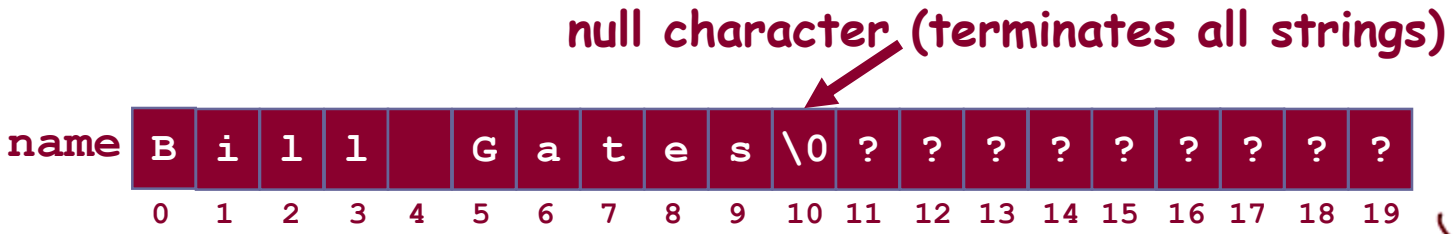
- A string is a sequence of characters terminated by the null character (‘\0’)
  - “This is a string” is considered a string literal
  - A string may include letters, digits, and special characters
- A string may always be represented by a character array, but a character array is not always a string
- A string is accessed via a pointer to the first character in it

String Basics (1)

- As with other data types, we can even initialize a string when we declare it:

```
char name[20] = "Bill Gates";
char *name = "Bill Gates";
char name[] = {'B', 'i', 'l', 'l', ' ', 'G', 'a', 't', 'e',
               's', '\0';}
// These are equivalent string declarations!
```

- Here's what the memory allocated to `name` looks like after either of the above is executed:



String Basics (2)

- When a variable of type `char*` is initialized with a string literal, it may be placed in memory where the string can't be modified
- If you want to ensure modifiability of a string store it into a character array when initializing it

String Basics (3)

- Arrays of Strings
  - Suppose we want to store a list of students in a class
  - We can do this by declaring an array of strings, one row for each student name:

```
#define NUM_STUDENTS 5
#define MAX_NAME_LENGTH 31
char student_names[NUM_STUDENTS][MAX_NAME_LENGTH];
```

  - We can initialize an array of strings "in line":

```
char student_names[NUM_STUDENTS][MAX_NAME_LENGTH] =
{"John Doe", "Jane Smith", "Sandra Connor", "Damien White",
 "Metilda Cougar"};
```

  - In most cases, however, we're probably going to want to read the names in from the keyboard or a file…

String Basics (4)

- Use `gets()` to read a complete line, including whitespace, from the keyboard until the <enter> key is pressed; the <enter> is not included as part of the string
  - Usage: `gets(my_array)`
  - If the user enters “Bill Gates” and presses <enter>, the entire string will be read into `my_array` excluding the <enter> or newline
- Use `puts()` to display a string followed by a newline
  - Usage: `puts(my_array)`

String Manipulation in C (1)

- Standard operators applied to most numerical (including character) types cannot be applied to strings in C
  - The assignment operator (=) can't be applied except during declaration
  - The + operator doesn't have any true meaning (in some languages it means append)
  - The relational operators (==, <, >) don't perform string comparisons
  - Others?

String Manipulation in C (2)

- The string-handling library <string.h> provides many powerful functions which may be used in place of standard operators
  - strcpy ( ) or strncpy () replaces the assignment operator
  - strcat ( ) or strncat () replaces the + or append operator
  - strcmp ( ) replaces relational operators
  - Several others…i.e. strtok ( ), strlen ( )

Pointers Representing Arrays and Strings (1)

- Consider representing two arrays as follows:
  - `double list_of_nums[20];`
  - `char your_name[40];`
- When we pass either of these arrays to functions, we use the array name without a subscript
- The array name itself represents the address of the initial array element

Pointers Representing Arrays and Strings (2)

- Hence, when we pass the array name, we are actually passing the entire array as a pointer
- So, the formal parameter for the string *name* may be declared in two ways:
  - `char name[]`
  - `char *name`
- Note that, in general, it is a good idea to pass the maximum size of the array to the function, e.g.:
  - `void func (char *name, int size);`

Structs

`struct` Type (1)

- C supports another kind of user-defined type: the `struct`
- `struct`s are a way to combine multiple variables into a single "package" (this is called "encapsulation")
- Sometimes referred to as an *aggregate*, where all variables are under one name
- Suppose, for example, that we want to create a database of students in a course. We could define a student `struct` as follows:

`struct` Type (2)

```
typedef enum {freshman, sophomore, junior, senior}
        class_t; /* class standing */

typedef enum {anthropology, biology, chemistry,
              english, compsci, polisci,
psychology,
              physics, engineering, sociology}
        major_t; /* representative majors */

typedef struct
  {
      int id_number;
      class_t class_standing; /* see above */
      major_t major; /* see above */
      double gpa;
     int credits_taken;
  } student_t;
```


`struct` Type (3)

- We can then define some students:

```
student_t student1, student2;
student1.id_num = 123456789;
student1.class_standing = freshman;
student1.major = anthropology;
student1.gpa = 3.5;
student1.credits_taken = 15;
student2.id_num = 321123456;
student2.class_standing = senior;
student2.major = biology;
studnet2.gpa = 3.2;
student2.credits_taken = 100;
```

Notice how we use the "." (selection) operator to access the "fields" of the `struct`

More About Structs

- Recall structs are used to represent real world objects
- They contain attributes that describe these objects
  - Such as a car, where the attributes of the struct car could include steering wheel, seats, engine, etc.
  - Such as a student, where the attributes of the struct student could include ID#, name, standing, etc.
- In many cases, we need a list or array of these objects
  - A list of cars representing a car lot
  - A list of students representing an attendance sheet

Arrays of Structs (1)

- Let's first define a struct student

```
typedef struct student
{
    int ID;
    char name[100];
    int present; // Attended class or not
} Student;
```

- Next we will build up an attendance sheet

Arrays of Structs (2)

```
int main (void)
{
    Student attendance_sheet[100]; // 100 students in the class

    return 0;
}
```

- Let's look at a logical view of this attendance sheet on the next slide

Arrays of Structs (3)

- Attendance sheet, which consists of multiple struct student types

0	1	2	…	99
{ID, name, present}	{ID, name, present}	{ID, name, present}	…	{ID, name, present}
1000	1108	1216		10692

Arrays of Structs (4)

- To initialize one item in the array, try:

```
attendance_sheet[index].ID = 1111;
strcpy (attendance_sheet[index].name, “Bill Gates”);
Attendance_sheet[index].present = 1;
   // 1 means in attendance, 0 means not in present
```


Pointers to Structures

- Recall that when we have a pointer to a structure, we can use the indirect component selection operator -> to access components within the structure

```
typedef struct
{
       double x;
       double y;
} Point;

int main (void)
{
       Point p1, *struct_ptr;
       p1.x = 12.3;
       p1.y = 2.5;

       struct_ptr = &p1;

       struct_ptr->x; /* Access the x component in Point, i.e. 12.3 */
       .
       .
       .
}
```


Keep Reviewing C Material!

References

- J.R. Hanly & E.B. Koffman, *Problem Solving and Program Design in C (8th Ed.)*, Addison-Wesley, 2016.
- P.J. Deitel & H.M. Deitel, *C How to Program (7th Ed.)*, Pearson Education , Inc., 2013.

Collaborators

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