Structure Topics

Here is the document on various topics of structures

- What are structures
- Declare them with and without Tags
- Initialize structures
- Computing Size of structures, use sizeof operator
- Access members of structures
- Assign one structure to another structure
- Compare one structure with another structure
- Pass Structures by Value
- Pass Structure by Reference - send the address
- Having Pointers as members
- Access structures using pointers
- Define and access array of structures

STRUCTURES.docx (https://csus.instructure.com/courses/94454/files/14915320/download?wrap=1)

STRUCTURES

Structures are derived data types—they're constructed using objects of other types. Structure is also a variable. A Structure can also be viewed as a container to hold many types of variables. Unlike arrays which hold only one type of variable, structures enable us to store multiple variables.

The various topics we will talk are

- Declare them with and without Tags
- Access members of structures
- Initialize structures
- Computing Size of structures, use sizeof operator
- Assign one structure to another
- Compare one structure with another - X, compare
- Pass by Value (default)
- Pass by Reference - send the address
- Having Pointers as members
- accessing structures using pointers
- accessing array of structures

we define a structure type as,

```
struct   _point {
    int x ;  // member variables
    int y ; // member variables
}  ;
```

Here struct is a keyword to describe a structure variable. x and y are member variables , each is a type of int. _point is a tag. Structure definitions should always end semicolon.

Member variables need not be same type too. Consider this structure,

```
struct  _profile {
     int age;
    char name [ 10 ] ;
```

} ;

In the above definition, we have a char variable and an int variable as members. _profile is a tag.

NOTE: There is no memory allocated to the structure, because it is just a type definition.

To define new structure variables using the above definitions, we could do

```
struct   _point  point;
struct   _profile   user1;
```

Here, point is a structure variable and user1 is also a structure variable.

So, what is the type of the variable - point ? It is struct _point and the type of user1 is struct _profile .

Using the definition of the struct _point , I can define new variables as

```
struct  _point  pt1,   pt2,  *ptr ;
```

In the above definition, we have pt1 and pt2 as structure variables and ptr is a pointer of type struct _point .

NOTE: No two variables of a struct can have the same name.

How do we access member variables using DOT operator

The Dot operator is represented by the symbol . To write values to the member variables, we use the DOT operator, like this

```
pt1.age = 20 ;
strcpy ( pt1.name, “John”) ;  // Note we cannot do pt1.name = "John"
```

similarly , we can read values of the variables like

```
int x = pt1.age ;
char myAge [10 ] ;
```

```
strcpy ( myAge, pt1.name) ;
```

Although structure names should be distinct, we may use the same name for members in different structures. By using the DOT operator, we can access the member variables uniquely.

The dot operator is mandatory to access a member variable even if the name of the variable is not defined elsewhere.

Declaring structures with and without tag names.
Consider

```
struct {
   int x ;
   int y ;
} x, y, z ;
```

is same as

```
struct  _point {
   int x ;
   int y ;
} x, y, z ;
```

But the latter method with tag name is better and preferred as we can declare more variables like this

```
struct _point  a, b, c ;
```

The other advantage is you can pass the struct variable to functions as the type is struct _point ;

The disadvantage with declaring structures without tags is

- you cannot define new variables and
- you cannot pass them to functions.

IT IS ALWAYS RECOMMENDED TO DECLARE STRUCTURES WITH TAG NAMES

Initialize Structure

We will discuss several methods to assign individual members with values.

Method 1: This is tedious way of initializing.

```
    // method 1 : initialize individual members
      pt1.age = 40;
      strcpy ( pt1.name, "John") ;
```

In the above method, we use the dot operator. Pay attention to the use of strcpy method to copy.

Method 2: We could also initialize the members using declaration such as

```
struct _profile p1  = { 30, "John" } ;  // order is important
```

As discussed, this method depends on the order of definition of the member variables, compiler will not make a guess if you mix the order like
struct _profile p1 = { "John" , 30} ; // this is incorrect.

That will result in compiler warning

Method 3: The other method is to assign one structure to another structure

```
struct  _profile p4 = p1 ;  // is already initialized, so we copy into p4
```

technically, this copies bit by bit from p1 to p4.

The last method is of course , we use the scanf function to initialize the initialize each and every individual members. but this is not recommended.

Sizeof Structures

One possible gotcha with structures is , you cannot sum the size of individual members to determine the size of a structure. It is machine dependent, it creates members on the word boundary, especially if it contains non-char type members. Generally , it is 4 bytes.

Let us consider a simple case:

```
struct  _user {
    int age ;
    char name[12] ;
 } ;
```

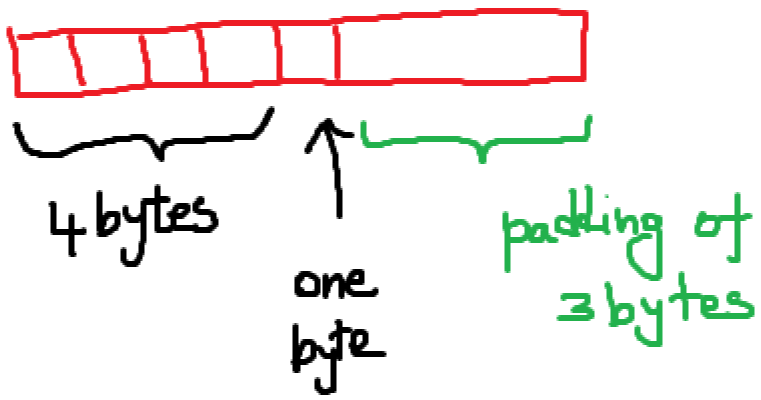
The size of this structure can readily be determined to be : 20 bytes , because int (4 bytes) plus 12 chars. This is very trivial.

But not so when it contains char and int variables , such as

```
struct  _user {
    int age ;
    char gender;
 } ;
```

In this case, it is not 5 bytes, it could be 8 bytes (or 6 bytes in some sysems) with a padding of 3 additional bytes next to the gender variable.

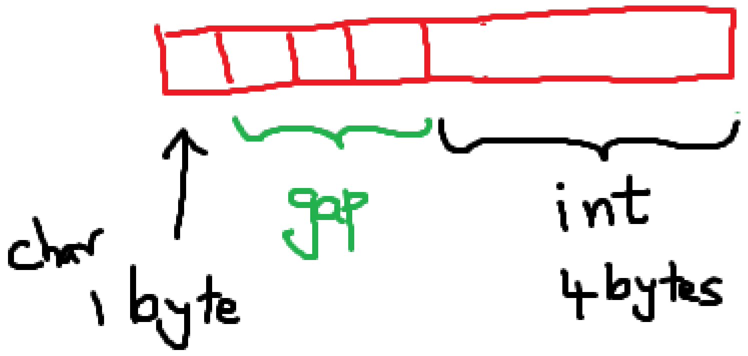
Here is the picture :



But if you change the order of the members

```
struct _person {
    char gender ;
    int age ;
 } ;
```

there will be a gap of 3 bytes.



The values in these gaps and paddings will be garbage. This is one of the main reasons you cannot compare two similar structures.

ASSIGN STRUCTURES and COMPARE STRUCTURE

Because structures have gaps or paddings, and these have garbage values, we could assign a structure variable to another similar type structure as it just a bit by bit copy. But you cannot compare two similar structures because during initialization it may have garbage values. But we cannot compare structures using any of the relation operators such as ==, <=, <, >, >=

Using Typedef structures

C provides the typefef construct , which lets the programmer provide a synonym for either a built-in or user defined data type. Although typedef may be used with any data tye, structures are generally used with typedef. typedef are just an alias to a type. For instance,

typedef int MyINT ;

MyInt becomes a synonym for int. Subsequently, we can declare new int type variables as

```
MyINT  age ;
```

In the above definition age is a variable of type MyINT. Note, the syntax of a typedef: First comes the keyword typedef, then the data type and followed by the user provided name for this data type.

A typedef is used only to create a synonym for a data type. By defining a tyepdef, we are not allocating any memory.

Similarly, we could define a structure using typedef as

```
typedef  struct {
   int x,  y ;
} Point_t  ;
```

To define a new variable - point, we simply say

```
Point_t p1, *ptr ;
```

It is not generally recommended to define a structure without a tag name though typedef definition above is sufficient. So, let us refine the above definition as

```
typedef   struct   _point  {
   int x,  y ;
} Point_t  ;
```

Now, I can define variables as

```
Point_t   p1,  p2,  *ptr ;
```

The above definition is generally used in nested structures as we will see soon.

Nested Structure

Structures can have other type of structures as members , this is known as nested structures.

```
typedef struct _cars {
    char make [ 12 ];
    char model [ 12 ];
} Cars_t;

typedef struct _person {
   char name[12];
   int age;
   Cars_t cars [ 2] ;
   char ch; // padding of 3 bytes , each cell
 } Person_t;
```

Pointers to Structures
C provides pointers to structure variables and a special pointer operator **->** for accessing members of structures.
Consider this structure

```
typedef struct _ram  {
  float price;
  int size ;
} Ram_t ;

Ram_t  p1, p2, *ptr;
```

we have two structure variables p1 and p2 of type Ram_t . We also have a pointer ptr defined.

```
/* we assign the address of p1 to ptr */
ptr = &p1 ;

/* assign values to price and ramSize */
(*ptr).price = 43.99;
( *ptr).size = 32 ; // GB
```

Some explanation : First we dereference ptr to get the address of p1. Then, we use . operator to access the individual members.

We need the parenthesis to enclose *ptr because the dot operator has higher precedence than the asterisk,   resulting in an operation *(ptr.price) which is definitely wrong because price is not a pointer.

Because the syntax (*ptr).price is very clumsy, C provides alternate syntax with -> (pointer operator) like

```
ptr->price = 43.99
ptr->size = 32
```

Please note there shouldn't be any space between – and >

This pointer to structure and accessing members using -> is little tricky, so lot of practice is needed.

Structure : Pass By Value and Pass by Reference

We can pass structures to functions by value much similar to other variables. We do not pass the contents, but the copy of the variable. The invoked function can change the copy, but not the actual value of the variable that was passed.

Consider this example,

```
typedef struct _profile {
     char name [ 16 ] ;
     int age ;
}  Person ;

void printProfile ( struct _profile p1 )
{
    // a copy of the struct is passed in
    p1.age ++ ;  // no effect in the main function variable p.age

     printf  ( " age = %d name=%s \n" , p1.age, p1.name ) ;
}
main ( )
{
     Person p = { "Sam", 10 } ;
    printProfile ( p ) ;
}
```

If an array is present in the structure as a member, the array is also sent as value when the structure is passed to function.

Structures can also be passed by reference.

Array of Structures

consider this simple int array

```
int data[3] = { 30, 40, 50 };
int *ptr = data ;  // make ptr point to data
```

We can print the values of data using the pointer ptr

```
for ( i = 0 ; i < 3  ; i++ )  {
    printf ( " %d \n", *ptr ) ;
   ptr++ ; // advance the pointer to the next cell
}
```

*In the above code, *ptr prints the cell data and ptr++ is advanced to the next cell because the ptr is type int and the array is also type int.*

We can define array of structures similarly.

We can define array of structures

```
struct _data {
  char name[12] ;
  int age ;
 } ;

struct _data *ptr ,  dataArray [ 3 ] =
            { "Carolyn", 30, "Barry", 50, "Pamela", 40 };
```

Here I defined an array of structure and Initialized them during declaration too.

NOTE HOW I defined them. You have to pay utmost care in making sure the order of the definition of the members.

Now let us point ptr to the first cell or the address of the first cell and first member

```
  ptr = dataArray ;
  // ptr = &dataArray[0] ; // alternate way
```

Generally the first method is preferred

```
// METHOD 1 ,  we use the pointer arithmetic to browse
// each and every cell
for ( i = 0 ; i < 3 ; i++ )  {
    printf ( "%d %s \n", ptr->age, ptr->name);
    ptr++;
  }

// METHOD 2, we use pointer offset to navigate
  ptr = dataArray ;
  for ( i = 0 ; i < 3 ; i++ )
    printf ( "%d %s \n", (ptr+i)->age, (ptr+i)->name) ;

// METHOD 3,  we use pointer as an array
  ptr = dataArray ;
  for ( i = 0 ; i < 3 ; i++ )
    printf ( "%d %s \n", ptr[ i ] .age, ptr [ i ] .name);

// METHOD 4, using the array itself
  for ( i = 0 ; i < 3 ; i++ )
    printf ( "%d %s \n",
              dataArray[i].age, dataArray[i].name);

// METHOD 5 // not a elegant method
  ptr = dataArray ;
  for ( i = 0 ; i < 3 ; i++ )
    printf ( "%d %s \n", (*(ptr+i)) .age, (*(ptr+i) ). name);
```

If you are using array, you could use Method 4. If you are using pointer, Method 1 can be used. They are the standard method of accessing members variables using pointers