Programming and Algorithms

COMP1038.PGA

Week 7 – Lectures 1, 2, 3: Structures

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Outline

- Introduction
- Structure Definitions
- Initializing Structures
- Accessing Members of Structures
- Using Structures with Functions
- Typedef
- Union

Introduction

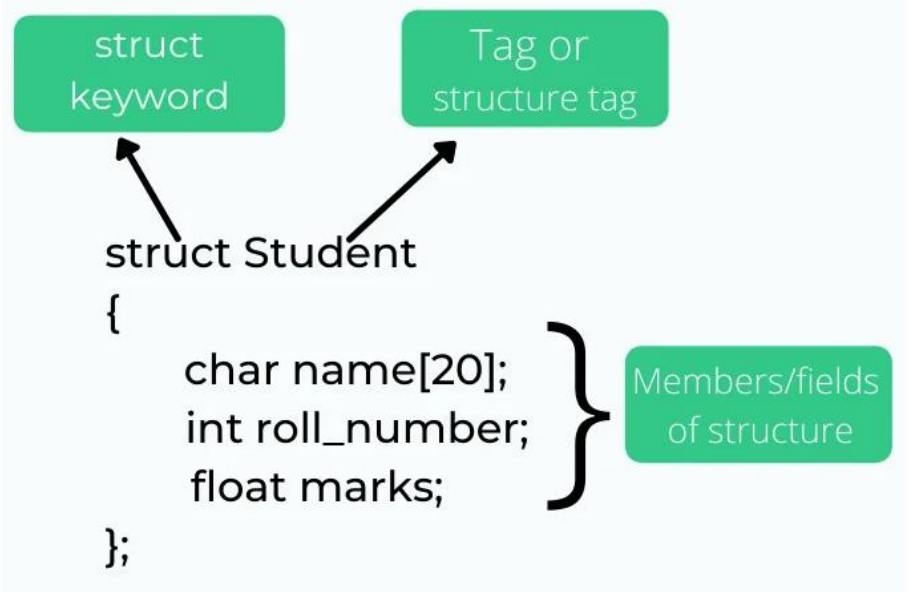
- Variables of primitive data types can only hold one value of a particular data type
- Array can hold multiple values of same data type
- In real life, data of different types is organized together
- Such as, Address book , library book information, student information, etc.
- Structure and Union are solution for this.

Structures

- Collections of related variables (aggregates) under one name
- Can contain variables of different data types
- Commonly used to define records to be stored in files
- Combined with pointers, can create linked lists, stacks, queues, and trees

Syntax Structure definition

```
struct <structure tag>
{
structure element 1 ;
structure element 2 ;
structure element 3 ;
.....
} ;
```



Source: https://www.geeksforgeeks.org/

Structure Definitions

- Example

```
struct Student {
        char name [20];
        char address [20];
        int rollno;
        char class[5];
        char year[20];
};
```

- struct introduces the definition for structure Student
- Student is the structure name and is used to declare variables of the structure type

Structure Definitions cont…

- **Structure information**
  - **A structure cannot contain an instance of itself**
  - **Can contain a member that is a pointer to the same structure type**
  - **A structure definition does not reserve space in memory**
    - **Instead creates a new data type used to declare structure variables**
- **Declarations**
  - **Declared like other variables:**

```
struct Student oneStud, Stud[66], *SPtr;
```

- **Can use a comma separated list:**

```
struct Student {
        char name [20];
        char address [20];
}oneStud, Stud[66], *SPtr;
```

Declaration of Struct variable

-
```
struct book
{
  char name ;
  float price ;
  int pages ;
} b1, b2, b3 ;
```
Inline structure declaration

-
```
struct
{
  char name ;
  float price ;
  int pages ;
} b1, b2, b3 ;
```
Anonymous structure declaration

```
struct book
{
char name ;
float price ;
int pages ;
} ;
struct book b1, b2, b3;
```
General structure declaration

N. B. If you declare structure variables through anonymous structure declaration then you can't declarer more structure variables later of the same structure type.

Structure Definitions cont…

- Valid Operations
  - Assigning a structure to a structure of the same type
  - Taking the address (&) of a structure
  - Accessing the members of a structure
  - Using the *sizeof* operator to determine the size of a structure

Initializing Structures

- Initialize structures
  - Example:

```
struct Student {
        char name [20];
        char address [20];
        int rollno;
        char class[5];
        char year[20];
        };
struct Student S1 = {"Peter", "Ningbo", 2543, "CS", "2021-2022"};

struct book
  {
    char name[10] ;
    float price ;
    int pages ;
  } ;
  struct book b1 = { "Basic", 200.50, 550 } ;
  struct book b2 = { "Physics", 300.48, 800 } ;
```

Assignment statements

- Example:

```
struct Student S2 = S1;
```

Same type of structure variables can directly copy from one another using assignment operator

- Could also declare and initialize as follows:

```
struct Student S2;
S2.name = "Peter";
S2.address = "Ningbo";
S2.rollno = 2543;
S2.class = "CS";
s2.year="2021-2022";
```

Member-by-member initialization

Accessing Members of Structures

- Accessing structure members
  - Dot operator (.) used with structure variables

```
struct Student S1;
printf( "%s", S1.name );
```

  - Arrow operator (->) used with pointers to structure variables

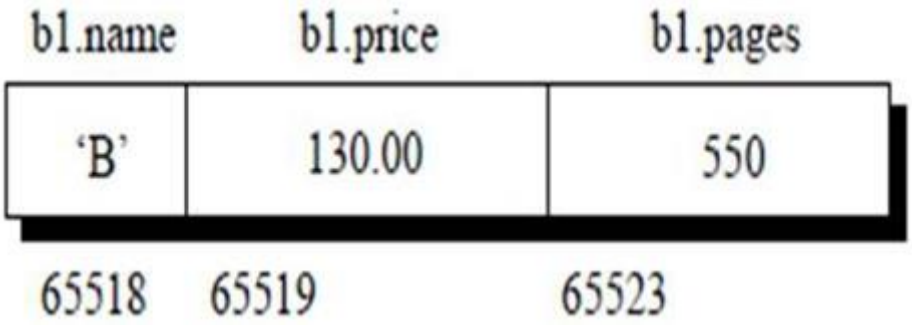
```
struct Student *SPtr = &S1;
printf( "%s", SPtr->name );
```

  - SPtr->name is equivalent to

```
( *SPtr ).name;
```

Memory allocation cont…

```
struct book
{
  char name;
  float price;
  int pages;
};
struct book b1 = {'B',130.00,550};
```



Array of Structures

```c
#include <stdio.h>

void main( )
{
    struct book
    {
        char name;
        float price;
        int pages;
    };
struct book b[3];
int i;
char c;

for (i = 0; i < 3; i++)
{
    printf ("Enter name, price and pages:  ");
    scanf ("%c %f %d", &b[i].name, &b[i].price, &b[i].pages) ;
    while ((c=getchar()) != '\n' && c != EOF);
}
printf ("\n%c %.1f %d\n\n", b[1].name, b[1].price, b[1].pages);
}
```

```
[z2019024@CSLinux Lecture_codes]$ ./LC_struct_1
Enter name, price and pages:  A 100.5 200
Enter name, price and pages:  B 110.8 250
Enter name, price and pages:  C 150.3 300

B 110.8 250
```

Array of structure
Format: structure variable name [size]
Like normal array index start from o

Additional Features of Structures

1. Structure and Assignment operator

- The values of a structure variable can be assigned to another structure variable of the same type using the assignment operator.
- No piecemeal copy is needed .

Additional Features of Structures cont...

Structure and Assignment operator

```c
#include <stdio.h>
#include<string.h>

void main( )
{
    struct employee
      {
         char name[10];
         int age;
         float salary;
      };
struct employee e1 = {"Peter", 30, 10000.00};
struct employee e2, e3;

strcpy (e2.name, e1.name);
e2.age = e1.age;
e2.salary = e1.salary;

e3 = e2;

printf("\n%s %d %.2f", e1.name, e1.age, e1.salary);
printf("\n%s %d %.2f", e2.name, e2.age, e2.salary);
printf("\n%s %d %.2f", e3.name, e3.age, e3.salary);
}
```

```
[z2019024@CSLinux Lecture_codes]$ ./LC_struct_2

Peter 30 10000.00
Peter 30 10000.00
Peter 30 10000.00
```

Member-by-member copy

Copying all the elements at one go

Additional Features of Structures cont...

2. Nested structure: One structure can be nested within another structure. Using this facility complex data types can be created. The following program shows nested structures at work.

```c
#include <stdio.h>

void main( )
{
  struct address
   {
     char phone[15];
     char city[25];
     int pin;
   };

   struct emp
   {
     char name[25];
     struct address a;
   };

struct emp e = { "Peter", "1234567890", "Ningbo", 315100 };

printf("\nname = %s \nphone = %s", e.name, e.a.phone);
printf("\ncity = %s \npin = %d", e.a.city, e.a.pin);
}
```

```
[z2019024@CSLinux Lecture_codes]$ ./LC_struct_3

name = Peter
phone = 1234567890
city = Ningbo
pin = 315100
```

Nested structure

Look carefully how to access nested structure member

Additional Features of Structures cont…

3. Structures With Functions

- **Passing structures to functions**
  - Pass entire structure
  - Or, pass individual members
  - Both pass call by value
- **To pass structure call-by-value**
  - Like an ordinary variable, a structure variable can also be passed to a function.
  - Or whole structure can be passed to a function
- **To pass structures call-by-reference**
  - Pass its address
  - Pass reference to it

Additional Features of Structures cont...

3. Passing individual structure elements

```
#include <stdio.h>

void display(char*, char*, int);
void main( )
{
  struct book
   {
     char name[25];
     char author[25];
     int callno;
   };

  struct book b1 = {"C How to program","Paul Deitel",101};

  display(b1.name, b1.author, b1.callno);
}

void display (char *s, char *t, int n)
{
     printf("\n %s %s %d", s, t, n) ;
}
```

```
[z2019024@CSLinux Lecture_codes]$ ./LC_struct_4

 C How to program Paul Deitel 101
```

Passing structure members

Called function

Additional Features of Structures cont…

3. Passing entire structure variable at a time

```c
#include <stdio.h>

struct book
 {
      char name[25];
      char author[25];
      int callno;
 };

void display(struct book);

void main( )
{
  struct book b1 = {"C How to program","Paul Deitel",101};

  display(b1);
}

void display (struct book b)
{
      printf ("\n%s %s %d", b.name, b.author, b.callno );
}
```

Passing the entire structure

Called function

```
[z2019024@CSLinux Lecture_codes]$ ./LC_struct_5

C How to program Paul Deitel 101
```

Structure and pointer

- The way we can have a pointer pointing to an int, or a pointer pointing to a char.
- Similarly we can have a pointer pointing to a structure.
- Such pointers are known as 'structure pointers'

Structure and pointer cont…

```c
#include <stdio.h>

void main ()
{
  struct book
  {
   char name[25];
   char author[25];
   int callno;
  };

  struct book b1 = {"C How to program","Paul Deitel",101};

  struct book *ptr;

  ptr = &b1;

  printf("\n%s %s %d", b1.name, b1.author, b1.callno);
  printf("\n%s %s %d", ptr->name, ptr->author, ptr->callno);
}
```

```
[z2019024@CSLinux Lecture_codes]$ ./LC_struct_6

C How to program Paul Deitel 101
C How to program Paul Deitel 101
```

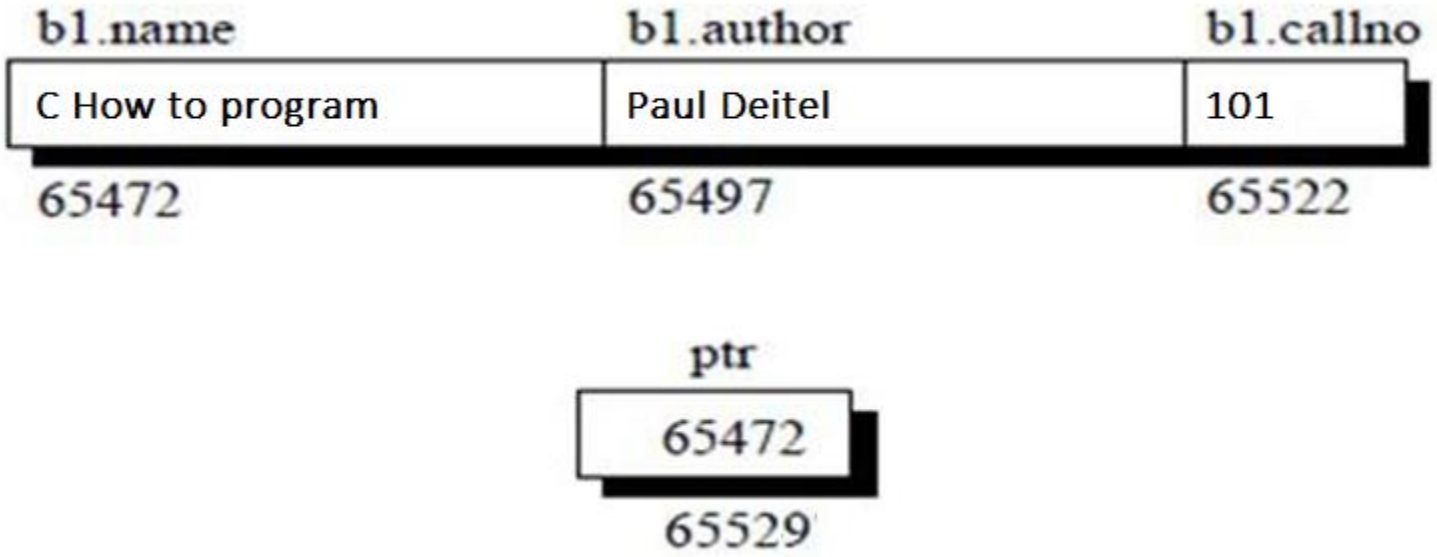
Structure variable

Defining structure pointer

Creating structure pointer

Accessing structure members through structure pointer

Structure and pointer memory map



Call by reference and structure

Passing address of a structure variable

```
#include <stdio.h>

struct book
{
char name[25];
char author[25];
int callno;
};

void display(struct book *);

void main()
{
  struct book b1 = {"C How to program","Paul Deitel",101};
  display(&b1);
}

void display (struct book *b)
{
  printf ("\n%s %s %d", b-> name, b->author, b->callno);
}
```

Passing structure pointer

Called function

```
[z2019024@CSLinux Lecture_codes]$ ./LC_struct_7

C How to program Paul Deitel 101
```

Array of structure and pointer

```c
#include <stdio.h>

struct book
{ char name[25];
char author[25];
int callno;
};

void display(struct book *, int);
int input(struct book *);

void main()
{ int n;
  struct book b1[20];
  n= input (b1);
  display (b1,n);
}

void display(struct book *b , int n)
{
  int i;
  printf("\n\t\t Books Available ");
  printf("\n\t Sr. No \t Name \t Author \t Call No \n");

  for(i=0;i<n;i++)
  {
    printf("\n\t %d \t\t %s \t %s \t %d",i+1, (b+i)->name, (b+i)->author, (b+i)->callno);
  }
}
```

Passing pointer of structure array

Called function

Input function

```
int input(struct book *b)
{
  int i, n;
  char c;
  printf("\n\t\t Enter No of books ");
  scanf("%d",&n);

  for(i=0;i<n;i++)
  {
    printf("\n\t Sr. No %d ", i+1);
    printf("\n\t Name: ");

    while ((c=getchar()) != '\n' && c != EOF);
    gets((b+i)-> name);
    printf("\t Author Name: ");
    gets((b+i)-> author);
    printf("\t Call No: ");
    scanf("%d",&(b+i)->callno);
  }
  return n;
}
```

Called function

```
[z2019024@CSLinux Lecture_codes]$ ./LC_struct_8

                Enter No of books 2

        Sr. No 1
        Name: C How to program
        Author Name: Paul Deitel
        Call No: 101

        Sr. No 2
        Name: Let us C
        Author Name: YPK
        Call No: 102

                Books Available
        Sr. No          Name    Author          Call No

        1               C How to program        Paul Deitel     101
        2               Let us C        YPK     102
```

Uses of Structures

- Data base management
- Changing the size of the cursor
- Clearing the contents of the screen
- Placing the cursor at an appropriate position on screen
- Drawing any graphics shape on the screen
- Receiving a key from the keyboard
- Checking the memory size of the computer
- Finding out the list of equipment attached to the computer
- Hiding a file from the directory
- Displaying the directory of a disk
- Sending the output to printer
- Interacting with the mouse

Thank you!

What would be the output of the following program?

```c
#include <stdio.h>
#include <string.h>

void main()
{
   struct gospel
   { int num;
    char mess1[50];
    char mess2[50];
   }m;
  m.num = 1;
  strcpy(m.mess1, "If all that you have is hammer");
  strcpy(m.mess2, "Everything looks like a nail");
  printf("\n%u %u %u", &m.num, m.mess1, m.mess2);
}
```

```
[z2019024@CSLinux pga]$ ./structure8

1397932336 1397932340 1397932390
```

What would be the output of the following program?

```c
#include <stdio.h>

struct gospel {
int num ;
char mess1[50];
char mess2[50];
} m1 = {2, "If you are driven by success", "make sure that it is a quality drive"};

void main( )
{
   struct gospel m2, m3;
   m2 = m1;
   m3 = m2;
   printf ("\n%d %s %s", m1.num, m2.mess1, m3.mess2);
}
```

```
[z2019024@CSLinux pga]$ ./structure8

2 If you are driven by success make sure that it is a quality drive
```

Point out the errors, if any, in the following programs:

```
1   #include <stdio.h>
2   #include <string.h>
3
4   void main( )
5   { struct employee
6     { char name[25];
7       int age;
8       float bs;
9     };
10    struct employee e;
11    strcpy (e.name, "Hacker");
12    age = 25;
13    printf ("\n%s %d", e.name, age);
14  }
```

1. At line 12, age will be e.age
2. At line 13, age will be e.age

Point out the errors, if any, in the following program:

```
1   #include <stdio.h>
2
3   void main( )
4   {
5     struct
6     { char name[25];
7       char language[10];
8     };
9     struct employee e = {"Hacker", "C"};
10    printf ("\n%s %d", e.name, e.language);
11  }
```

1. At line 5, structure name is missing. It will be ‘struct employee’
2. At line 10, 2nd format specifier of printf statement will be %s instead of %d

Point out the errors, if any, in the following program:

```
1   #include <stdio.h>
2
3   struct virus
4   { char signature[25];
5     char status[20];
6     int size;
7   } v[2] = {"Yankee Doodle", "Deadly", 1813, "Dark Avenger", "Killer", 1795};
8
9   void main( )
10  { int i;
11    for (i = 0 ; i <=1 ; i++)
12       printf ("\n%s %s", v.signature, v.status);
13  }
```

1. At line 12, array indexes of ‘v.signature’ and ‘v.status’ are missing. They will be ‘v[i].signature’ and ‘v[i].status’

typedef

- typedef
  - Creates aliases for previously defined data types
  - Use typedef to create shorter type names
- Typedef allows us to associate a name with a structure (or other data type).

typedef

Put typedef at the start of your program.

```c
#include <stdio.h>

typedef struct line {
   int x1, y1;
   int x2, y2;
} LINE;

void main()
{
   LINE line1;
   line1.x1 = 12;
   line1.y1 = 14;
   line1.x2 = 50;
   line1.y2 = 52;
   printf("%d, %d, %d, %d", line1.x1,line1.y1,line1.x2,line1.y2);
}
```

line1 is now a structure of line type

```
[z2019024@CSLinux Lecture_codes]$ ./LC_struct_14
12, 14, 50, 52
```

Typedef Example

```
typedef struct
{ char *first;
  char *last;
  char SSN[9];
  float gpa;
  char **classes;
} student;

student stud_a, stud[20] ,*sptr;
```

student is now 'struct student'

Typedef Example

```
struct employee
{ char name[25];
  int age;
  float bs;
}
typedef empoyee emp;
```

emp is now 'struct employee'

Union

- Like structures, but every member occupies the same region of memory!
  - Structures: members are "and"ed together
  - Unions: members are "xor"ed together

```
union VALUE
{ float f;
  int i;
  char *s;
};
```

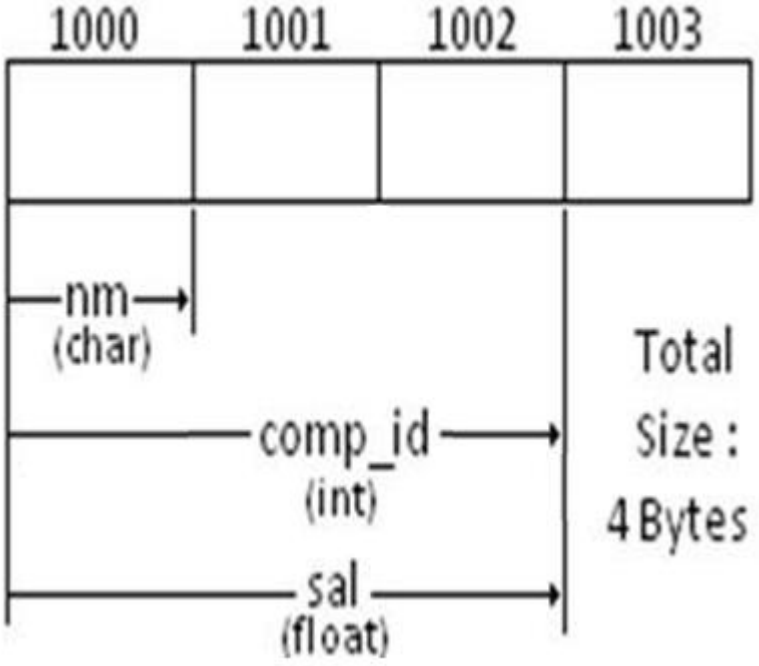
Union

- Storage
  - size of union is the size of its largest member
  - avoid unions with widely varying member sizes;
  - for the larger data types, consider using pointers instead
- Initialization
  - Union may only be initialized to a value appropriate for the type of its first member

```c
#include <stdio.h>

union Test
{
  int x;
  char c;
};

void main()
{
  union Test t = {1};

  printf("%d, %c", t.x, t.c);
}
```

```
[z2019024@CSLinux Lecture_codes]$ ./LC_struct_15
1,
```

Memory allocation and accessing elements




```
union techno
{ char nm;
   int comp_id;
   float sal;
}tch;
```

Accessing element:

```
tch.nm
tch.comp_id
tch.sal
```

Size of structure and union variables

```c
#include <stdio.h>

struct Stechno
{
  int comp_id;
  float sal;
  double id;
};

union Utechno
{
  int comp_id;
  float sal;
  double id;
};

void main()
{
  struct Stechno stch;
  union Utechno utch;

  printf("The size of structure variable: %d\n", sizeof(stch));
  printf("The size of union variable: %d\n\n", sizeof(utch));

}
```

```
[z2019024@CSLinux Lecture_codes]$ ./LC_struct_16
The size of structure variable: 16
The size of union variable: 8
```

Size of a structure variable is the total size of all the members.
Here, 4 byte (for int) + 4 bytes (for floats) + 8 bytes (for double) = 16 bytes

Size of a union variable is the size of largest member. Here, 8 bytes (for double)

Union usage

- Variable format input records (coded records)
- Sharing an area to save storage usage
- Unions not used nearly as much as structures

Thank you!