Chapter 15

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Chapter 15

Pointers

15.1 Introduction

C has a rich set of data types and operators. Pointer is a derived data type in C. A pointer is a variable which hold address of another variable/object as its content. The memory required for that variable/object can be allocated dynamically using a memory allocation function, such as malloc. The object may be any C data type such as integer, character, string, or structure. Pointers are frequently used in C programming. Pointers are one of the most distinct and exciting features of C language. It provides power and flexibility to the language. Although pointer may appear little confusing and complicated in the beginning, but trust me its a powerful tool and handy to use once its mastered.

Advantages of pointers in C:

- Pointers are closer to the hardware. They provide direct access to memory
- Pointers provide a way to return more than one value to the functions
- Reduces the storage space and complexity of the program
- Reduces the execution time of the program
- Provides an alternate way to access array elements
- Pointers can be used to pass information back and forth between the calling function and called function.
- Pointers allow us to perform dynamic memory allocation and deallocation.
- Pointers helps us to build complex data structures like linked list, stack, queues, trees, graphs etc.
- Pointers allow us to resize the dynamically allocated memory block.
- Addresses of objects can be extracted using pointers

Drawbacks of pointers in C:

- Uninitialized pointers might cause segmentation fault.
- Dynamically allocated block needs to be freed explicitly. Otherwise, it would lead to memory leak.
- If pointers are updated with incorrect values, it might lead to memory corruption.

15.2 Concept of pointer

Whenever a variable is declared, the C compiler allocates proper bytes of memory to store the value of that variable. In a computer memory, every memory has a unique address.

Example

int m = 50;

Here 'm' is an integer, which requires a 2 byte memory for its storage. Let us assume the system has chosen the address location 2000 for m. it stores the value 50 in location 2000.

Variable name	→ m
Value of the variable	→ 50
Address of the variable	→ 2000
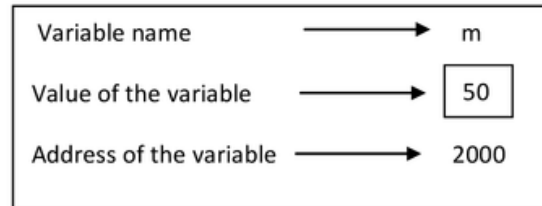
We can access the value 50 by either using the variable name m or the address 2000. Since the memory addresses are simply numbers they can be assigned to some other variable. The variable that holds memory address are called **pointer variables**. A **pointer** variable is therefore nothing but a variable that contains an address, which is a location of another variable. Value of **pointer variable** will be stored in another memory location.

Variable name	value	address
m	50	2000
Ptr	2000	2010
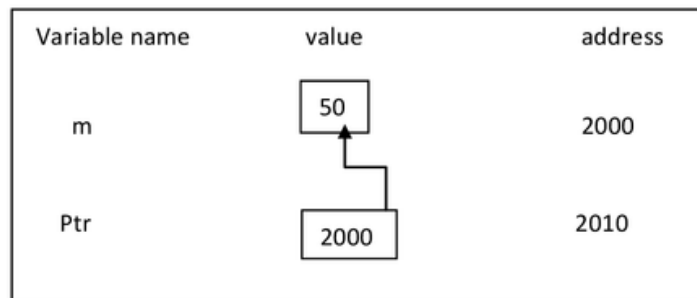
Pointer variable

The value of the variable ptr is the address of m. The value 50 can be referenced either by m or through pointer variable ptr. The variable ptr points to m. thus ptr gets the name pointer.

Accessing the address of a variable

While executing the declaration statement, C compiler allocates a memory for a variable is system dependent and it is not known for the users. But the allocated address is

extracted through the use of pointers. This can be done with the help of ampersand (&) operator in C. Any variable proceed with the & symbol, will return the address of the variable.

Example.

P = &m; // now P will return the address of m.

Another pointer operator available in C is '*' called "value at " operator. It gives the value stored at a particular address. This operator is also called "indirection operator".

Example

```
main()

{

int  i = 5;

printf("\n Address of i : = %u",&i);  //  Returns the address

printf("\n value i: = %d",*(&i));      // Returns the value at address of i

}
```
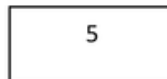
Explanation

While executing the declaration statement int i = 5, the compiler will allocate a 2 byte memory for I and stores the 5 in that location. Let us assume the location is 1000 & 1001.
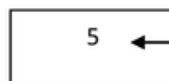
5

1000

&i will return the address 1000.

5

&i =1000

*(&i) will return the value of I at this address, i.e 5

5	← i or *(&i)

&i=1000

The & operator can be used only with a simple variable or an array element. The following are the illegal use of address operator.

        1.&100 // pointing at constant

        2. int x[5];

          &x; // pointing at array name

        3. &(x+y) // pointing at expression.

If x is an array , then &x[2]+&x[8] are valid expression, which points to 3rd and 7th elements of x.

Write a program to display the value of the variable along with the address.

Program

main()

{

    char a;

    int m ;

    float x;

    a = 'Z';

    m = 100;

    x = 10.25;

printf("\n %c is stored at address %u \n",a,&a;);

printf("\n %d is stored at address %u \n",m,&m;);

printf("\n %f is stored at address %u \n",x,&x;);

}

Output

Z is stored at address 4450

100 is stored at address 4454

10.25000 is stored at address 4460

15.3 Declaring pointer variable

Like other C variable, pointer variable also need to be declared before its first usage. Since pointer variable hold the address of another variable of same type. Pointer variable declaration is as follows

data_type *ptr_name;

the above statement provides the following information to the compiler

1. The asterisk(*) tells that variable ptr_name is a pointer variable.

2. ptr_name needs memory location, the content of that location hold the address of another variable.

Example

int *p; // declaration of a pointer variable p.

Here p is a pointer variable which holds an address of another integer variable as its content. Up to this only declaration part of pointer variable is created. It does not have any value, it means that we haven't store any address in the above declaration. This process can be done by the following initialing statement.

15.4 Initializing Pointer variable

The process of assigning the address of variable to a pointer variable is known as initialization of pointer variable. While assigning address of a variable to a pointer variable we should be careful enough in such a way that, address of a variable of any data type will be assigned to a pointer variable of the same type. Example , address of an integer variable will be assigned to a an integer pointer, and address of a floating point variable will be assigned to a floating pointer and so on.

Pointer and normal variable declaration statements

int i, j, *p; // integer variables and integer pointer declaration

float x, y, *q; // float variables and float pointer declaration

char c, d, *r; // char variables and char pointer declaration

initializing pointer variables.

p = &i; // valid initialization. Integer variable address is assigned to integer pointer variable

q = & x; // valid initialization. float variable address is assigned to float pointer variable

r = &c; // valid initialization. char variable address assigned to char pointer variable

Thus a pointer variable can be assigned the address of an ordinary variable or it can be assigned the value of other pointer variable provided both pointer variables are of the same type.

> int i,*a,*b;
>
> a = &i; // the address of int i is assigned to int pointer a;
>
> b = a; // the value of pointer a(address of i) is assigned to int pointer b.

in the last example both the pointers (a and b) belongs to same data type of int. A pointer can also be initialized to NULL value also. In ANSI C, the value of NULL=0;

> int *ptr = NULL.

15.5 Generic pointers

There is an exception in ANSI C, for pointer assignment. It supports generic pointer creation. Instead of creating pointer variable of one type and assigning address of a variable of same type to pointes, we can create generic pointers. Generic pointers are pointer variables which do not depend on any specific data type. So it can hold address of any variable as its reference. The data type belongs to generic pointer is void.

Example   void *Gp; // Gp is a generic pointer with data type as void.

> int a;
>
> float b;
>
> char c;
>
> Gp = &a; // Gp hold the address of int variable a;
>
> ------
>
> Gp = &b; // after some time Gp is reinitialized to hold the address of float variable b.
>
> ------
>
> Gp = &c; // after some time Gp is reinitialized to hold the address of char variable c.

All are valid assignment.

15.6 Accessing a variable through its pointer

Once pointer has been created and successfully assigned an address of a variable, the next step is to access the variable through its pointers. Accessing the variable through pointer is fast,

because pointers are closer to hardware. Accessing the variable can done using another operator * (asterisk) called indirection operator. Another name for this operator is dereferencing operator.

Example

int qms, *a, b ; // declaration of qms & b as normal int variables , a as pointer to an int.

qms = 200; // assigning the value 200 to qms

a = &qms; // the address of qms is assigned to an int pointer a;

b = *a; // content of the variable a is assigned to b;

when the operator * is proceeded with a pointer variable , it returns the value of the address location it hold. In this example, initially qms is assigned a numeric value 200, using assignment statement. Then, the address of qms is assigned to a pointer variable a. Now the representation of *a, will return actual value stored in the address location of qms. This value will be assigned to a pointer b; so indirectly the value 200 is assigned to b;

Example program using simple pointers

```
#include<stdio.h>

Void main()

{

    int balance;

    int &addr;

    int val;

    balance = 5000;

    addr = &balance;

    val = *addr;

    printf("\n  Balance  is  = % d",val);

}
```

Output

Balance = 5000

Example

Simple program illustrating pointers

```
#include<stdio.h>

void main()

{

int i = 5;

int k = 10;

int *ptr = &k;

printf("\n i has the value %d and is stored at %u ", i, &i);

printf("\n k has the value %d and is stored at %u ", k, &k);

printf("\n ptr has the value %u and is stored at %u ", ptr, &ptr);

printf("\n The value of the integer pointed by ptr is %d ", *ptr);

}
```

Output

i has the value 5 and is stored at 4002

k has the value 10 and is stored at 4004

ptr has the value 4004 and is stored at 4008

The value of the integer pointed by ptr is 10

15.7 Character pointer

Since text strings are represented in C by arrays of characters, and since arrays are very often manipulated via pointers, character pointers are probably the most common pointers in C. Strings are actually one-dimensional array of characters terminated by a **null** character '\0'. Thus a null-terminated string contains the characters that comprise the string followed by a **null**.

The following declaration and initialization create a string consisting of the word "Hello". To hold the null character at the end of the array, the size of the character array containing the string is one more than the number of characters in the word "Hello."

char greet[6] = { 'H' , 'e', 'l', 'l', ' o ','\0'};

Example program to demonstrate pointer to character string

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```c
#include<stdio.h>

#include<stdlib.h>

void main()

{

int i;

char *cp;

cp = " A String";

        while( *cp != 0)

        {

            putchar(*cp);

            cp++;

        }

}
```

Output

A String

22

In the above example, the loop sets a pointer 3 the start of the string, then walks along the string until it find the zero at the end. In C, each string is terminated by a NULL, to represent the end of the string. The number of iterations of the loop depends on the length of the string. The zero at the end, represent the end of the string.

15.8 Pointer Expressions

         C language allows us to perform arithmetic operations on pointers. The arithmetic operations on pointer can affect the memory location pointed by pointers or the data stored in the pointed location. Like other variable, pointer variables are also used in expressions. The expressions involving pointers has the same rule as other expressions. The following are few example of pointer expressions.

  If ptr1 and ptr2 are properly declared and assigned pointers, then the following statements are valid.

```
x = *ptr1 * *ptr2;  // same as (*ptr1) * (*ptr2)

total = total + *ptr1;

y = 10 * - *ptr2 / *ptr1; // same as ( 5 * ( -(*ptr2)))/(*ptr1)

*ptr2 = *ptr2 + 10;
```

Example Program

```c
#include<stdio.h>
#include<conio.h>
void main()
{
    int i=3,*x;
    float j=1.5,*y;
    char k='c',*z;
    printf("\nValue of i = %d",i);
    printf("\nValue of j = %f",j);
    printf("\nValue of k = %c",k);
    x=&i;
    y=&j;
    z=&k;
    printf("\nOriginal address in x = %u",x);
    printf("\nOriginal address in y = %u",y);
    printf("\nOriginal address in z = %u",z);
    x++;
    y++;
    z++;
    printf("\nNew address in x = %u",x);
    printf("\nNew address in y = %u",y);
```

```
        printf("\nNew address in z = %u",z);
    }
```

Output :

Value of i = 3
Value of j = 1.500000
Value of k = c
Original address in x = 65524
Original address in y = 65520
Original address in z = 65519
New address in x = 65526
New address in y = 65524
New address in z = 65520

Observe the last three lines of the output. 65526 is original value in x plus 2, 65524 is original value in y plus 4, and 65520 is original value in z plus 1. This so happens because every time a pointer is incremented it points to the immediately next location of its type. That is why, when the integer pointer x is incremented, it points to an address two locations after the current location, since an int is always 2 bytes. Similarly, y points to an address 4 locations after the current location and z points 1 location after the current location. This is a very important result and can be effectively used while passing the entire array to a function.

The way a pointer can be incremented, it can be decremented as well, to point to earlier locations. Thus, the following operations can be performed on a pointer:

1. **Adding Numbers to Pointers :** Adding a number to a pointer leads the pointer to a new location which is the given by: Original location+(number added*bytes taken by the variable) For example, if an integer pointer "ptr" points to 65524, the statement "ptr=ptr+5" would make to pointer now point to 65524+(2*5) i.e. 65534.

2. **Subtracting numbers from pointers :** The subtraction pointers is similar to that of addition. The only difference is that in Subtraction the new location will be: original location -(number*bytes taken by variable).

3. **Subtracting Pointers :** If you subtract a pointer from other pointer, the result will be the number of memory locations existing between the address pointed by both the pointers. For example, if a pointer "ptr1" pointing to location 65524, is subtracted from a pointer "ptr2" pointing to location 65532, the result will be 8.

Unacceptable Pointer Arithmetic Operations

The following arithmetic operations involving the use of pointers, are not allowed :
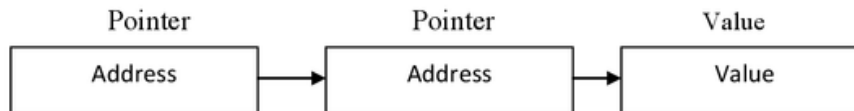
25

- Addition of two pointers

- Multiplication of two pointer variables
- Division of two pointer variables

15.9 Multiple indirection

C compiler allows creating a pointer to a pointer. We can have a pointer which points to another pointer that will point to the target value. This situation is called multiple indirection, or pointer to pointer.

a) Single indirection

b)Multiple indirection

From the above fig , the value of a normal pointer is the address of the object that contains the desired value. In case of pointer to pointer, the first pointer contains the address of the second (pointer), which points to the object that contains the desired value. Pointer to a pointer is declared by placing an additional asterisk in front of the pointer variable name.

Example   float **amt;

Here amt is a pointer to a pointer of type **float.** It is important to note that amt is not a pointer to a floating point number but rather a pointer to a **float pointer**.

Example

void main()

{

  int N,*P, **Q; // P is a pointer to integer, Q is pointer to a pointer to an integer.

N = 50;

P = &N;

Q = *P;

printf("\n %d", **Q); // print the value of N

}

Output

50

Example program

#include<stdio.h>

void main()

{

  int *p, num ;

p = #

*p = 100;

printf("\n %d",num);

(*p)++;

printf("\n %d",num);

(*p)--;

printf("\n %d",num);

}

Output

100

101

100

15.10 Pointers and Arrays

        Pointers and Arrays are interlinked interestingly. We know that array elements are located continuously in memory and array name is really a pointer to the first element in the array. This brings up an interesting relationship between array and pointers. When an array is declared, the compiler allocates a base address and enough memory to store all the elements of the array in contiguous memory locations. When array is simply referred by its name without any subscript,

it specifies a pointer to its base address which is nothing but the location of the first element of the array.

Example

int A[5] = { 2,4,6,8,10};

Consider the base address of A is 2000. Here the array is declared as int array, so it needs 2 byte memory for storage. Totally 10 bytes of required for the entire array.

A[0] A[1] A[2]   A[3] A[4]   element

2	4	6	8	10

2000   2002 2004 2006 2008   address

Simply the array name A means, it is constant pointer pointing to the first element, A[0] and therefore the value of A is address of A[0], i.e 2000.

A = &A[0] = 2000

So array names are easily assigned to a pointer of the same type. If we declare Ptr as an integer pointer, then we can do pointer assignment as follows

int *Ptr, A[5];

Ptr = A;

This is equivalent to   Ptr = &A[0];

Now every value of the array A can be accessed through pointer Ptr as follows

Ptr = &A[0];   (address = 2000)

Ptr+1 = &A[1];   (address = 2002)

Ptr+2 = &A[2];   (address = 2004)

Ptr+3 = &A[3];   (address = 2006)

Ptr+4 = &A[4];   (address = 2008)

Address of A[3] = base address + 3 * scale factor of int)

= 2000 + (3 * 2) = 2006

Example Program

```c
#include<stdio.h>

int Array[]={1,3,5,7,9,11,13};

int *ptr;

void main()

{

int i;

ptr = &Array[0];

printf("\n");

for ( i =0 ; i < 7 ; i++)

{

printf( "\n Array[%d] = %d", i , Array[i]);

printf("\t ptr + %d = %d",i,*(ptr+i));

}

}
```

Output

```
Array[0] = 1        ptr+0=1

Array[1] = 3        ptr+1=3

Array[1] = 5        ptr+1=5

Array[1] = 7        ptr+1=7

Array[1] = 9        ptr+1=9

Array[1] = 11        ptr+1=11

Array[1] = 13        ptr+1=13
```

Example program to add all the elements of an array using pointers

```c
void main()
{
int *ptr, tot, i;
int A[5] = {2,4,6,8,10};
i = 0;
ptr = A;
printf("\n Element     Value    Address ");
while(i<5)
{
printf(" A[%d] %d %u\n",i,*ptr);
tot = tot + *ptr;
i++; p++;
}
printf("\n Total =  %d", tot);
printf("\n  &A[0] = %u",&A[0]);
printf("\n  ptr = %u",ptr);
}
```

Output

Element	Value	Address
A[0]	2	200
A[1]	4	202
A[2]	6	204
A[3]	8	206

A[4]   10   208

Tot = 30

&A[0] = 200

ptr = 210

15.11 Pointer and two dimensional arrays

Pointers can also be used to manipulate two dimensional arrays.   In case of one dimensional array A, the pointer p holds the base address of an array, then the expression

*(A+i) or *(p+i)   is valid. Which represents the element A[i].

The same concept is used in two dimensional arrays also.

((A+i) + j)   or *(*(p+i) + j)

```
          0     1     2     3     4

    0   ┌─────┬─────┬─────┬─────┬─────┐   ←   p
        │     │     │     │     │     │
    1   ├─────┼─────┼─────┼─────┼─────┤   ←   p+1
        │     │     │     │     │     │
    2   ├─────┼─────┼─────┼─────┼─────┤   ←   p+2
        │     │     │     │     │     │
    3   ├─────┼─────┼─────┼─────┼─────┤   ←   p+3
        │     │     │     │     │     │
    4   ├─────┼─────┼─────┼─────┼─────┤   ←   p+4
        │     │     │     │     │     │
        └─────┴─────┴─────┴─────┴─────┘
```

p   ───────►   pointer to first row

p+i   ───────►   pointer to ith row

*(p+i)   ───────►   pointer to first element in the ith row

*(p+i) +j) ─────────►   pointer to the jth element in the ith row

((p+i) + j) ───────►   value stored in the cell(i,j)

The base address of an array A is &A[0][0]. Take this address as starting address, the compiler allocate continuous memory for all the elements in row wise. That is, the first element of second row is stored immediately after the last element of the first row, and so on.

Example

$$int \ a[3][4] = \{ \ \{1,1,1\},$$

$$\{2,2,2\},$$

$$\{3,3,3\} \ ,$$

$$\{4,4,4\}$$

$$\};$$

The elements are stored in computer memory as follows

Row 0			Row 1			Row 2			Row 3		
1	1	1	2	2	2	3	3	3	4	4	4

Address = &a[0][0]
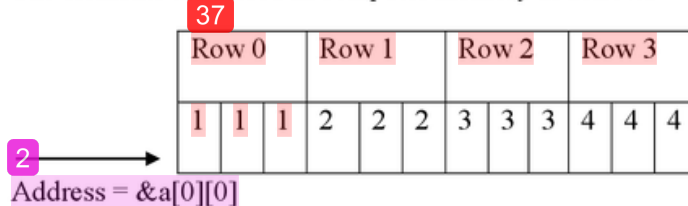
If we declare p as an int pointer with initial address of &a[0][0], then

$$A[i][j]= *(p+4 * i+j)$$

It can be noticed that, if we increment i by 1, the pointer p is incremented by 6 bytes, the size of each row. This is the reason, when two dimensional arrays are declared; it needs to specify the size of row, so that the compiler can determine the storage mapping.

```c
#include<stdio.h>
#include<stdlib.h>
int main(void)
{
int a[10][10],b[10][10],c[10][10],n=0,m=0,i=0,j=0,p=0,q=0,k=0;
   int *pt1,*pt2,*pt3;
printf("Enter size of 1st Matrix : ");
scanf("%d %d",&n,&m);
   for(i=0;i<n;i++)
{
    for(j=0;j<m;j++)
      {
      printf("Enter element no. %d %d :",i,j);
scanf("%d",&a[i][j]);
}
```

```c
        }
        printf("Enter size of 2nd Matrix : ");
        scanf("%d %d",&p,&q);
        for(i=0;i<p;i++)
        {
        for(j=0;j<q;j++)
            {
        printf("Enter element no. %d %d :",i,j);
        scanf("%d",&b[i][j]);
            }
        }
        if(m!=p)
            {
        printf("Multiplication cannot be done\n");
        exit (0);
        }
        pt1=&a[0][0];
        pt2=&b[0][0];
        pt3=&c[0][0];
        for(i=0;i<n;i++)
            {
            for(k=0;k<q;k++)
                {
                *(pt3+(i*10+k))=0;
                for(j=0;j<m;j++)
        {
        *(pt3+(i*10+k))+=*(pt+(i*10+j))**(pt1+(j*10+k));
                }
            }
        }
        Printf("\n  Resultant Matrix\n");
        for(i=0;i<n;i++)
            {
        printf("\n "};
        for(j=0;j<q;j++)
                {
                printf("    %d ",c[i][j]);
            }
        printf("\n");
        }
        return 0;
        }
```

Output

Enter size of 1st Matrix : 2 2

Enter element no. 0 0 : 2

Enter element no. 0 1 : 2

Enter element no. 1 0 : 2

Enter element no. 1 1 : 2

Enter size of 2nd Matrix : 2 2

Enter element no. 0 0 : 2

Enter element no. 0 1 : 2

Enter element no. 1 0 : 2

Enter element no. 1 1 : 2

Resultant Matrix

  8 8

  8 8

15.12 Array of Pointers

Pointers can be effectively used to handle table of strings. When arrays are used to represent list of strings it has a drawback.

char name[3][20];

the above declaration statement allocates (3*20) 60 bytes of memory to store the list of strings represented by name variable. The memory allocation is as follows.

The name table containing 3 names, each with a maximum length of 20 characters(including NULL) . the total storage allocated for name variable is 60 bytes. During execution all the three strings are not always equal in size. So some part of a memory will be unused. In order to reduce the memory wastage, pointers are utilized. Here array of pointers are declared to allocate proper amount of memory as per the original requirement during execution.

char *name[3] = { "New Delhi",

                "America",

"India"

};

The above declares **name** to be an **array of three pointers** to characters, each pointer pointing to a particular name.

name[0]   ⟶   "New Delhi"

name[1]   ⟶   "America"

name[2]   ⟶   "India"

The system allocates only 24 bytes.

N	e	w		D	e	l	h	i	\0
A	m	e	r	i	c	a	\0		
I	n	d	i	a	\0				

The following program segment will read and display all the three name in the allotted memory locations.

```
for (i=0; i<3; i++)

    scanf("%s", name[i]);

for (i=0; i<3; i++)

    printf("\n  %s",name[i]);
```

to access the jth character in the ith name ,

```
    *(name[i]+j);
```

Note :   *p[3] and (*)p[3] , these two are two different notation.

         *p[3] declares p as an **array of three pointers**.

         (*)p[3] declares p as a **pointer to an array of three elements**.

Since * has lower precedence that [].

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Program for sorting of strings C language using pointers

```c
#include<30o.h>
3include<string.h>
void main()
{
 int i,j,n;
 char str[20][20],temp[20];
 printf("Enter the no. of string to be sorted");
 scanf("%d",&n);
 10tf("\n Enter the string one by one");
 for(i=0;i<=n;i++)
    gets(str[i]);
 for(i=0;i<=n;i++)
    for(j=i+1;j<=n;j++)
{

     if(strcmp(str[i],str[j])>0)
      {
        strcpy(temp,str[i]);
        strcpy(str[i],str[j]);
        strcpy(str[j],temp);
       }

    }
printf("The sorted string\n");
for(i=0;i<=n;i++)
   puts(str[i]);
return 0;
}
```

Output

Enter the no. of string to be sorted   5

Enter the string one by one

   Ram

   Aakash

   Mani

   Siva

   Divya

The sorted string

Aakash

Divya

Mani

Ram

Siva

15.13 Pointers and functions

       While passing array elements in to a function, pointers play a vital role. When an array is passed to a function as an argument, only the address of the first element of the array and the number of elements in the array is enough. The starting address, the nature of the array, and number of elements in the array, are useful to find the block of memory allocated to an array based on the scale factor. Any modification done by the called function will affect the original values stored in the locations.

       Example program to sort N elements using pointer to an array

In this example, the function parameters are declared as pointers. The dereferenced pointers are used in the function body. When the function is called, the addresses are passed as actual arguments.

```
#include<stdio.h>

#include<conio.h>

void sort(int  int *);

void main()

{

int  i, n,*arr;

printf("\n Enter number of elements in an array ");

sacnf("%d",&n);

printf("\n Enter the elements one by one ");

for( i =0 ; i<n; i++)

scanf(" %d',arr+i);
```

```c
printf("\n Unsorted Array elements ....");

for( i =0 ; i<10; i++)

printf("\n %d',*(arr+i));

sort( n , *arr); // sort function invocation with the signature of one int and a pointer to an int array

printf("\n Sorted Array elements ....");

for( i =0 ; i<10; i++)

printf(" %d',*(arr+i));

}

void sort(int m, int *x)

{

  int i,j,temp;

  for ( i=0;i<m; i++)

  {   for ( j= i+1; j<m; j++)

      {    if( *(x+i) >= *(x+j))

          {    temp = *(x+i);

              *(x+i) = *(x+j);

              *(x+j) = temp;

          }

      }

}
```

Output

```
Enter number of elements in an array

5

Enter the elements one by one

44
```

22

11

55

33

Unsorted Array elements ….

44

22

11

55

33

Sorted Array elements ….

11

22

33

44

55

In the above example, void sort(int, int *) , tells the compiler that the formal argument that receive the array is a pointer, not array variable.

Pointer variables are effectively utilized while handling strings. Consider the following program segment, which copies the content of one string into another.

```
copy(chat *s1, char *s2)
{    while(( *s1++ = *s2++) != ' \0')

        ;

}
```

This copies the contents os s2 into s1.

15.14 Functions returning pointers

The main characteristic of a function is, it can return a single value or return multiple value through pointer. Since pointers are powerful data structure in C. so it is possible to return a pointer to the calling function.

Example

```c
int *largest(int *, int *) ; // function prototype

void main()
{
    int a = 10;
    int b = 20;
    int *p;
    p = largest(&a, &b);  // function call
    printf("\n  largest value  = %d",*p);
}
int *largest(int *x, int *y)
{
    if(*x > *y)
        return(x);  // address of a
    else
        return(y);  // address of b
}
```

15.15 Pointers to function

According to any C programming language, when we type the program in C editor, it occupies a particular part of memory. Each function including void main() occupies its own memory in physical storage. A function, like a variable has a type and an address location in the memory. Therefore it is possible to declare pointer to a function, which can be passed as

argument to other function. All the instructions are converted into machine readable form by the compiler and it gets stored in available memory space. During compilation, the system allocates necessary memory spaces for all the variables declared in the declaration statements. These memories only carefully handled by pointers and their initializations.

A pointer to a function is declared as follows:

type (*fptr) ();

The above instruction provides the following information to the compiler

fptr is a pointer to a function, which returns type value. The parentheses around *fptr are compulsory. We can make a function pointer point to a specific function by simply assigning the name of the function to the pointer.

Example   double multiply(int,int);

double (*mptr)();

mptr = multiply;

The above statement declares mptr as a pointer to a function of type which returns double as the data value. Multiply as a function, whose address is assigned to mptr. To call the function multiply, we can use pointer mptr with the list parameters.

(*mptr) (x,y) // function call

Example   int (*fptr)(int, int)

The above line declares a function pointer 'fptr' that can point to a function whose return type is 'int' and takes two integers as arguments.

#include<stdio.h>

int func (int a, int b)

{

printf("\n a= %d",a);

printf("\n b= %d",b);

return 0;

}

void main()

```
{
int (*fptr)(int,int); // function poiner

fptr = func; // assign address to function pointer

funct(5,8);

fptr( 7,14)

}
```

[8]

In the above example, we defined a function 'func' that takes two integers as inputs and returns an integer. In the main() function, we declare a function pointer 'fptr' and then assign value to it. Note that, name of the function can be treated as starting address of the function so we can assign the address of function to function pointer using function's name.

Output

```
a = 5

b = 8

a = 7

b = 14
```

[33]
```
#include <stdio.h>

#include <conio.h>


int sum(int x, int y)
{
return x+y;
}


int main( )
{
int (*fp)(int, int);

fp = sum;
```

```c
int s = fp(10, 15);

printf("Sum is %d",s);

getch();

return 0;

}
```

Output : 25

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