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Pointers

Agenda :

- ✔ What is pointer ?
- ✔ Usage of pointers
- ✔ Pointer Arithmetic
- ✔ Pointer and One Dimensional Arrays
- ✔ Pointer to an Array
- ✔ Array of pointers
- ✔ const qualifier
- ✔ Void pointer
- ✔ Character array

What is Pointer ?

- A pointer is a address.
- A pointer is a variable which holds the address of other variable & we can apply the dereference operator on that variable.

Declaration of pointer :

```
data-type * variable_name ;
```

Initialization (or definition) of pointer :

```
int a;
int *p = &a;
```

Assigning the address to a pointer variable:

```
int a;
int *p;
p = &a;
```

Example:

```
int main (void)
{
        int x = 10;
        int *p = NULL;
        p = &x;

        printf (“*p = %d, x = %d \n”, *p, x);

        *p = 15;

        printf (“*p = %d , x = %d \n”, *p, x);

        return 0;
}
```

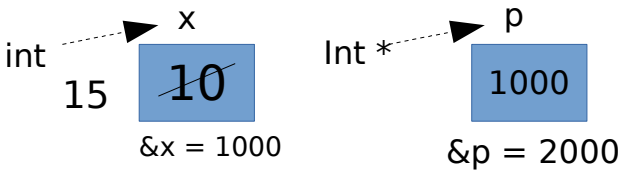

Fig 1 : Integer pointer

Usage of pointers :

- Accessing array elements.
- Returning more than one value from a function.
- Accessing dynamically allocated memory.
- Implementing data structures like linked lists, trees.

Pointer Arithmetic :

- Fetching (or accessing) the data through pointer, inserting the data using pointer & increment/decrement operation on pointer depends on the size of pointer data type.

- Size of pointer for any data type is 4 bytes for 32bit compiler & 8 bytes for 64 bit compiler .

```
Ex:   int a = 5, *pi = &a;        //&a = 1000
      char c = 'x', *pc = &c;     //&c = 5000

      pi++;                       //pi = 1000 + 1 * 4 = 1004    (since int is 4 bytes)
      pi = pi – 3;                //pi = 1004 – 3 * 4 = 992
      pi = pi + 5;                //pi = 992 + 5 * 4 = 1012
      pi--; (or)      --pi;       //pi = 1012 – 1 * 4 = 1008
      pc++; (or) ++pc;            //pc = 5000 + 1 * 1 = 5001    (since char is 1 byte)
      pc = pc – 3;                //pc = 5001 – 3 * 1 = 4998
      pc = pc + 5;                //pc = 4998 + 5 * 1 = 5003
      pc--;                       //pc = 5003 – 1 * 1 = 5002
```

Ex 1:

```
int main (void)
{
    char buf[64];
    int *n = NULL:
    buf[40] = '2';
    n = (int *)buf;
    printf ("%c \n", n[10]);
    return 0;
}
```

Ex 2:

```
int main(void)
{
        int x = 10, y = 20;
        int *p = &x;
        int *q = &y;
        int *ptr = p + q;

        printf (“%p \n”, ptr);
        return 0;

}
```

Ex 3:

```
int main (void)
{
        int a = 320;
        char *ptr = (char *)&a;
        printf ("%d \n", *ptr);

        return 0;
}
```

(320)d = 00000000 00000000 00000001 01000000

Pointer comparisons:

- Relational operators (==, !=, <, <=, >, >=) can be used with pointers

1) ==, !=

- If both pointers are NULL (or) both contain address of same variable.
- Between void pointer & other pointer.

2) >, < , <= , >=

- Valid between pointers of same type.
- Both pointers point to elements of arrays of same data type.

```
int main(void)
{
    int *i = NULL;
    float *f = NULL;
    char *c = NULL;
    void *v;

    int a = 10;

    v = &a;
    c = &a;
    f = &a;

    if (f == c)  //true - but with warnings
        printf ("true \n");
    else
        printf ("false \n");
    return 0;
 }
```

```
    if (v  !=  i)    //true - but with warnings

        printf ("false \n");

    else
        printf ("true \n");


if (v >= c){
        printf ("%d, %d", *(int*)v, *c);

        printf ("true \n");
    }else
        printf ("false \n");
```

Pointer to pointer:

```
int a = 5;
int *pa = &a;
int **ppa = &pa;
```

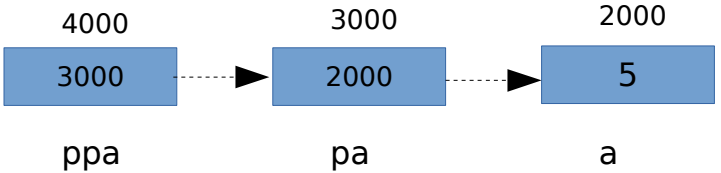

Fig 2 : Visualization of pointer to pointer

Table 1 : Illustration of pointer to pointer

Value of a	a	*pa	**ppa	5
Addresss of a	&a	pa	*ppa	2000
Value of pa	&a	pa	*ppa	2000
Address of pa		&pa	ppa	3000
Value of ppa		&pa	ppa	3000
Address of ppa			&ppa	400

Pointer & One dimensional Arrays:

- Three main points.

```
int arr[5] = {1, 2, 3, 4, 5};
int *p;
p = arr;
```

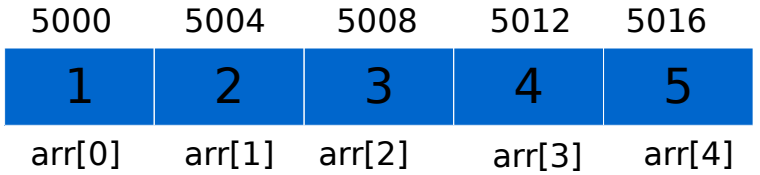

Fig 3 : Array of 5 elements

p[i] ----> *(p + i) ----> value at i^{th} position

&p[i] ----> (p + i) ----> address at i^{th} position

- a[i] = *(a + i) = *(i + a) = i[a]
- &a[i] = &*(a + i) = (i + a) = &i[a]

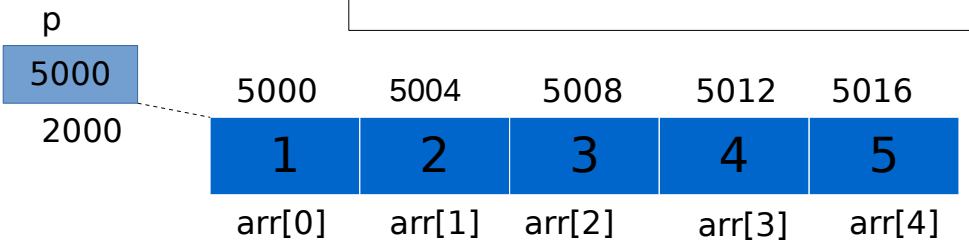

Fig 4 : Assigning the address of an array to pointer

Pointer to an Array :

int (*ptr)[5];

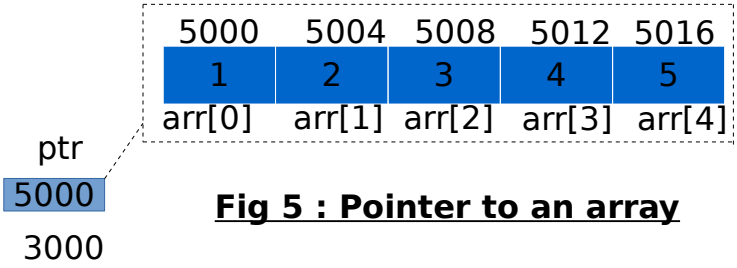

Fig 5 : Pointer to an array

Array of Pointers :

int *a[ ] = {arr, arr + 1, arr + 2, arr + 3, arr + 4};

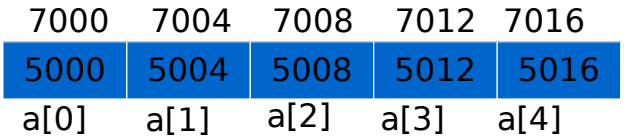

Fig 6: Array of Pointers

Example :

```
int main(void)
{
   int arr[ ] = {1, 2, 3, 4, 5};    //initialization of array

   int *p = arr;                    //assigning address of array to pointer

   int (*ptr)[5] = &arr;                    //pointer to an array

   int *a[ ] = {arr, arr + 1, arr + 2, arr + 3, arr + 4};//array of pointers

   printf ("arr = %p, p = %p, ptr = %p,a[0] = %p \n", arr, p, ptr, a[0]);
   printf ("*a[0] = %d \n", *a[0]);

   p++;
   ptr++;

   printf ("arr + 1 = %p, p = %p, ptr = %p,a[1] = %p \n", arr + 1, p, ptr, a[1]);

   return 0;
}
```

Const Qualifier:

There are three types of declarations of pointers using the qualifier const :

1. Pointer to constant data.
2. Constant pointer.
3. Constant pointer to constant data.

Ex 1 :
```
const int a = 2, b = 6;
const int *p1 = &a;

*p1 = 9;     //invalid
p1 = &b;     //valid
```

Ex 2 :
```
int a = 2, b = 6;
int *const p2 = &a;

*p2 = 9;     //valid
p = &b;      //invalid
```

Ex 3 :
```
const int a = 2, b = 6;
const int * const p3 = &a;

*p3 = 9;     //invalid
p3 = &b;     //invalid
```

Void Pointer :

- Generic pointer.
- Before de-referencing, it should be type cast to proper data type.

Ex:

```
int main(void)
{
   int a = 3;
   float b =3.4;
   void *vp;
   vp = &a;
   printf ("value of a = %d \n", *(int *)vp);
   *(int *)vp = 12;
   printf ("value of a = %d \n", *(int *)vp);
   vp = &b;
   printf ("value of b = %f \n", *(float *)vp);
   return 0;
}
```

Character Array:

```
char buf [8] = {'a', 'b', 'c', 'd', 'e'};
char arr[ ] = “array”;
char *str = “string”;
```

Ex :

```
int main (void)
{
        char buf [8] = {'a', 'b', 'c', 'd', 'e'};
        char arr[ ] = “array”;
        char *str = “string”;

        buf[3] = ‘z’;
        arr[3] = ‘y’;
        str[3] = ‘x’;          //invalid

        str = “hello”;                  //valid
        arr[ ] = “world”;   //invalid

        return 0;
}
```

‘a’	‘b’	‘c’	‘d’	‘e’	‘\0’

‘a’	‘r’	‘r’	‘a’	‘y’	‘\0’

Fig 7 : character Array

‘s’	‘t’	‘r’	‘i’	‘n’	‘g’	‘\0’

Fig 8 : String

Table 2: Difference between Character constant & String constant

Character constant	String constant
A character constant is enclosed within single inverted commas.	A sequence of characters enclosed in double quotes.
The maximum length of a character constant can be one character.	A string constant can be any length.
A single character constant has an equivalent integer value.	A single string constant does not have an equivalent integer value.
The character constant ‘A’ consists of only character A.	The string constant "A" consists of character A and \0.
A single character constant occupies one byte.	A single string constant occupies two bytes.
Every character constant does not end up with a NULL character.	Every string constant ends up with a NULL character which is automatically assigned (before the closing double quotation mark) by the compiler.

Any queries.....?

Output.. ?

1) printf (“%d %d \n”, sizeof(‘A’), sizeof(“A”));

2)int main (void)
```
{
    char str[50] = “global edge”;
    printf (“str = %s \n”, str);
    printf (“str = %s \n” + 1, str);
    printf (“str = %s \n”, str + 1);

    printf (“%d \n” + 1, 123);
    return 0;
}
```

3) int main (void)
```
{
    int arr[ 5 ];

    printf (“%d \n”, ((arr + 2) – (arr + 1));
    return 0;
}
```

4) int main (void)
```
{
    Int *p = 10;
    printf (“%u \n”, (unsigned)p);

    return 0;
}
```

5) int main (void)
```
{
  int arr[ ] = {95, 12.....,20,30};

  /* your code to print array elements
    without using sizeof operator*/

  return 0;
}
```

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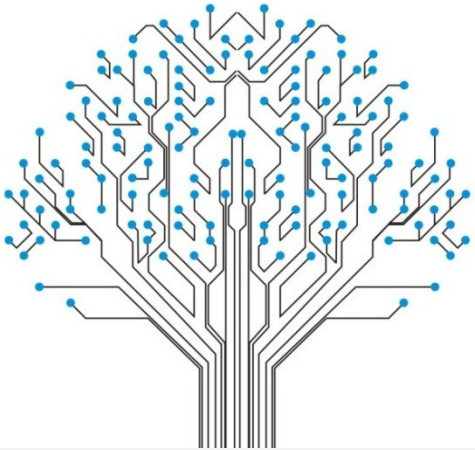

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