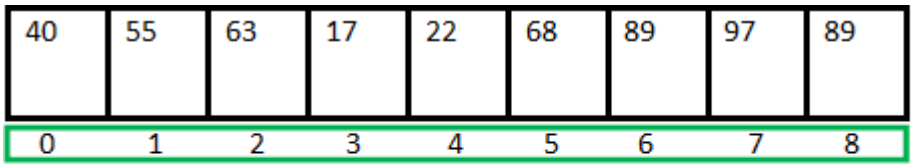
4.2.DYNAMIC MEMORY ALLOCATION

Dynamic Memory Allocation in C using malloc(), calloc(), free() and realloc()

Since C is a structured language, it has some fixed rules for programming. One of them includes changing the size of an array. An array is a collection of items stored at contiguous memory locations.



Array Length = 9
First Index = 0
Last Index = 8

As can be seen, the length (size) of the array above is 9. But what if there is a requirement to change this length (size)? For example,

If there is a situation where only 5 elements are needed to be entered in this array. In this case, the remaining 4 indices are just wasting memory in this array. So there is a requirement to lessen the length (size) of the array from 9 to 5.

Take another situation. In this, there is an array of 9 elements with all 9 indices filled. But there is a need to enter 3 more elements in this array. In this case, 3 indices more are required. So the length (size) of the array needs to be changed from 9 to 12.

This procedure is referred to as **Dynamic Memory Allocation in C**.

Dynamic memory allocation using **malloc()**, **calloc()**, **free()**, and **realloc()** is essential for efficient memory management in C.

Dynamic Memory Allocation can be defined as a procedure in which the size of a data structure (like Array) is changed during the runtime.

C provides some functions to achieve these tasks. There are 4 library functions provided by C defined under **<stdlib.h>** header file to facilitate dynamic memory allocation in C programming. They are:

1. malloc()

2. calloc()
3. free()
4. realloc()

1. **malloc ( ) METHOD**

The **"malloc"** or **"memory allocation"** method in C is used to dynamically allocate a single large block of memory with the specified size. It returns a pointer of type void which can be cast into a pointer of any form. It doesn't Initialize memory at execution time so that it has initialized each block with the default garbage value initially.

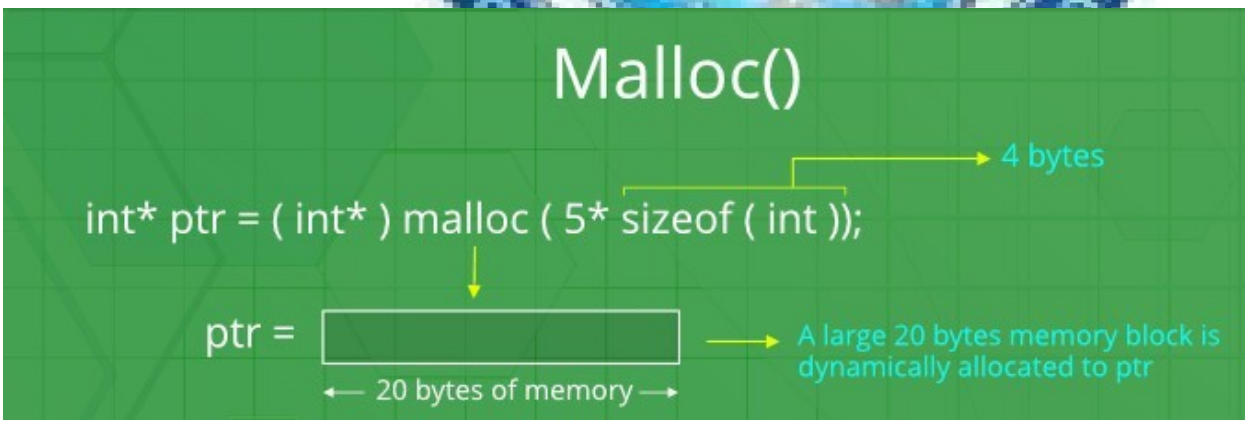
Syntax of malloc() in C

```
ptr = (cast-type*) malloc(byte-size)
```

For Example:

ptr = (int*) malloc(100 * sizeof(int));

Since the size of int is 4 bytes, this statement will allocate 400 bytes of memory. And, the pointer ptr holds the address of the first byte in the allocated memory.



If space is insufficient, allocation fails and returns a NULL pointer.

Example of malloc() in C

```
#include   <stdio.h>
#include  <stdlib.h>
int main()
{
   // This pointer will hold the
   // base address of the block created
   int* ptr;
   int n, i;
   // Get the number of elements for the array
   printf("Enter number of elements:");
   scanf("%d",&n);
   printf("Entered number of elements: %d\n", n);
   // Dynamically allocate memory using malloc()
```

```
    ptr = (int*)malloc(n * sizeof(int));
    // Check if the memory has been successfully
    // allocated by malloc or not
    if (ptr == NULL) {
        printf("Memory not allocated.\n");
        exit(0);
    }
    else {
        // Memory has been successfully allocated
        printf("Memory successfully allocated using malloc.\n");
        // Get the elements of the array
        for (i = 0; i < n; ++i)
            { ptr[i] = i + 1;
        }
        // Print the elements of the array
        printf("The elements of the array are: ");
        for (i = 0; i < n; ++i) {
            printf("%d, ", ptr[i]);
        }
    }
    return 0;
}
```

Output

```
Enter number of elements:7
Entered number of elements: 7
Memory successfully allocated using malloc.
The elements of the array are: 1, 2, 3, 4, 5, 6, 7,
```

2). <u>calloc() method</u>

1. **"calloc"** or **"contiguous allocation"** method in C is used to dynamically allocate the specified number of blocks of memory of the specified type. it is very much similar to malloc() but has two different points and these are:

2. It initializes each block with a default value ‘0’.
3. It has two parameters or arguments as compare to malloc().

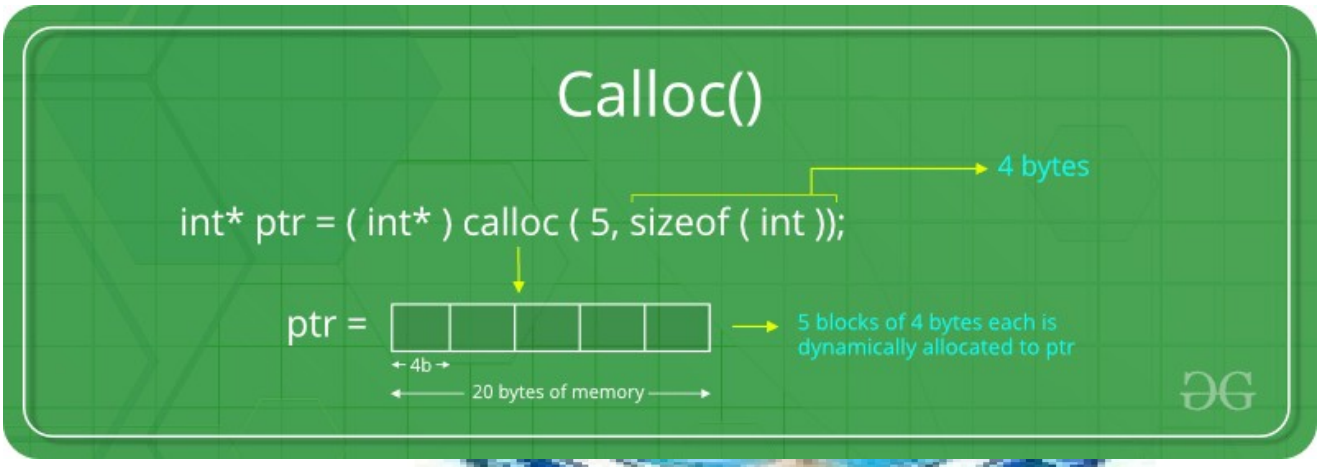
Syntax of calloc() in C

```
ptr = (cast-type*)calloc(n, element)
here, n is the no. of elements and element-size is the size of each element.
```

For Example:

ptr = (float*) calloc(25, sizeof(float));

This statement allocates contiguous spa



If space is insufficient, allocation fails and returns a NULL pointer.

Example of calloc() in C

```
// This pointer will hold the
// base address of the block created
int* ptr;
int n, i;
// Get the number of elements for the array
n = 5;
printf("Enter number of elements: %d\n", n);
// Dynamically allocate memory using calloc()
ptr = (int*)calloc(n, sizeof(int));
```

```
    // Check if the memory has been successfully
    // allocated by calloc or not
    if (ptr == NULL) {
        printf("Memory not allocated.\n");
        exit(0);
    }
    else {
        // Memory has been successfully allocated
        printf("Memory successfully allocated using calloc.\n");
        // Get the elements of the array
        for (i = 0; i < n; ++i)
            { ptr[i] = i + 1;
        }
        // Print the elements of the array
        printf("The elements of the array are: ");
        for (i = 0; i < n; ++i) {
            printf("%d, ", ptr[i]);
        }
    }
    return 0;
}
```

Output

```
Enter number of elements: 5

Memory successfully allocated using calloc.

The elements of the array are: 1, 2, 3, 4, 5,
```

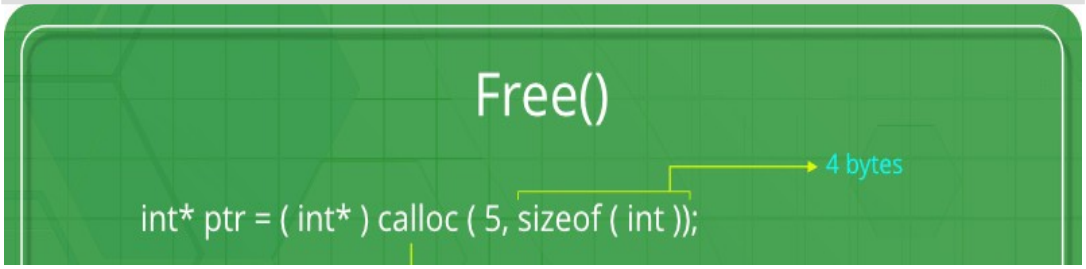
3) <u>free() method</u>

"free" method in C is used to dynamically **de-allocate** the memory. The memory allocated using functions malloc() and calloc() is not de-allocated on their own. Hence the free() method is used,

whenever the dynamic memory allocation takes place. It helps to reduce wastage of memory by freeing it.

Syntax of free() in C

```
free(ptr);
```



Example of free() in C

```
#include  <stdio.h>
#include <stdlib.h>
int main()
{
   // This pointer will hold the
   // base address of the block created
   int *ptr, *ptr1;
   int n, i;
   // Get the number of elements for the array
   n = 5;
   printf("Enter number of elements: %d\n", n);
   // Dynamically allocate memory using malloc()
```

```
    ptr = (int*)malloc(n * sizeof(int));
    // Dynamically allocate memory using calloc()
    ptr1 = (int*)calloc(n, sizeof(int));
    // Check if the memory has been successfully
    // allocated by malloc or not
    if (ptr == NULL || ptr1 == NULL)
        { printf("Memory not allocated.\n");
        exit(0);
    }
    else {
        // Memory has been successfully allocated
        printf("Memory successfully allocated using malloc.\n");
        // Free the memory
        free(ptr);
        printf("Malloc Memory successfully freed.\n");
        // Memory has been successfully allocated
        printf("\nMemory successfully allocated using calloc.\n");
        // Free the memory
        free(ptr1);
        printf("Calloc Memory successfully freed.\n");
    }
    return 0;
}
```

Output

```
Enter number of elements: 5

Memory successfully allocated using malloc.

Malloc Memory successfully freed.

Memory successfully allocated using calloc.

Calloc Memory successfully freed.
```

4). realloc() method

"realloc" or **"re-allocation"** method in C is used to dynamically change the memory allocation of a previously allocated memory. In other words, if the memory previously allocated with the help of malloc or calloc is insufficient, realloc can be used to **dynamically re-allocate memory**. re-allocation of memory maintains the already present value and new blocks will be initialized with the default garbage value.

Syntax of realloc() in C

```
ptr = realloc(ptr, newSize);
```

```
#include   <stdio.h>
#include  <stdlib.h>
int main()
{
   int index = 0, i = 0, n,
      *marks; // this marks pointer hold the base address
            // of  the block created
   int ans;
   marks = (int*)malloc(sizeof(
```

```
    int)); // dynamically allocate memory using malloc
// check if the memory is successfully allocated by
// malloc or not?
if (marks == NULL) {
    printf("memory cannot be allocated");
}
else {
    // memory has successfully allocated
    printf("Memory has been successfully allocated by "
        "using malloc\n");
    printf("\n marks = %pc\n",
        marks); // print the base or beginning
            // address of allocated memory
    do {
        printf("\n Enter Marks\n");
        scanf("%d", &marks[index]); // Get the marks
        printf("would you like to add more(1/0): ");
        scanf("%d", &ans);

        if (ans == 1) {
            index++;
            marks = (int*)realloc(
                marks,
                (index + 1)
                    * sizeof(
                        int)); // Dynamically reallocate
                            // memory by using realloc
            // check if the memory is successfully
            // allocated by realloc or not?
            if (marks == NULL) {
                printf("memory cannot be allocated");
            }
```

```
            else {
                printf("Memory has been successfully "
                    "reallocated using realloc:\n");
                printf(
                    "\n base address of marks are:%pc",
                    marks); ////print the base or
                            ///beginning address of
                            ///allocated memory
            }
        }
    } while (ans == 1);
    // print the marks of the students
    for (i = 0; i <= index; i++) {
        printf("marks of students %d are: %d\n ", i,
            marks[i]);
    }
    free(marks);
  }
  return 0;
}
```