

CSE101-Lec#28-29

Dynamic memory management

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Outline

- Dynamic Memory management
 - `malloc()`
 - `calloc()`
 - `realloc()`
 - `free()`



Dynamic Memory Allocation

- The statement:

```
int marks[100];
```

allocates block of memory to 100 elements of type `int` and memory is also contiguous. If one `int` requires 4 bytes of memory, a total of 400 bytes are allocated.

Why this approach of declaring array is not useful?

- This may lead to wastage of memory if all allocated memory is not utilized.

- Dynamic memory allocation allows a program to obtain more memory space, while running or to release space when no space is required.
- There are 4 library functions under "**stdlib.h**" for dynamic memory allocation.

Function	Use of Function
malloc()	Allocates requested size of bytes and returns a pointer first byte of allocated space
calloc()	Allocates space for an array elements, initializes to zero and then returns a pointer to memory
free()	deallocate the previously allocated space
realloc()	Change the size of previously allocated space

malloc()

- The name malloc stands for "memory allocation".
- The `malloc()` function allocates a block of memory of specified size from the memory heap.

- Syntax:

```
void * malloc(size);
```

- Here size is the number of bytes of storage to be allocated.
- If memory is allocated successfully , it returns a **pointer to first location** of newly allocated block of memory.
- If memory is not allocated i.e. no enough space exists for new block or some other reason, returns **NULL**.

malloc ()

- Return type of `malloc ()` is void pointer , it has to be **cast** to the type of data being dealt with.
- memory allocated by `malloc ()` by default contain the **garbage values**.
- Example:

```
int *p;  
p=(int*)malloc(n*sizeof(int)) ;
```
- In the above example, p is **pointer** of type integer
- `int*` tells to what type it will be pointing. `int` tells that the `malloc ()` function is type casted to return the address of integer variable.
- `n` is the number of elements



Program to allocate memory to integers.

```
#include <stdio.h>
#include <stdlib.h> /*required for dynamic
memory*/
int main()
{
    int number, *ptr, i;
    printf("How many ints would you like store?");
    scanf("%d", &number);
    ptr = (int *)malloc(number*sizeof(int));
    /*allocate memory*/
    for(i=0 ; i<number ; i++) {
        *(ptr+i) = i;
    }
    for(i=0 ; i<number ; i++){
        printf("%d\n", *(ptr + i));
    }
    return 0;
}
```




How many ints would you like store? 3

0

1

2

calloc()

- The name calloc stands for "contiguous allocation".
- It provides access to memory, which is available for dynamic allocation of variable-sized blocks of memory.
- Syntax:

```
void *calloc(size_t nitems, size_t size);
```

- calloc is similar to malloc, but the main **difference** is that the values stored in the allocated memory space is **zero** by default. With malloc, the allocated memory could have any garbage value.
- calloc() requires **two arguments**.
 1. The **first** is the number of variables you'd like to allocate memory for.
 2. The **second** is the size of each variable.

calloc ()

- If memory is allocated successfully, function `calloc ()` returns a pointer to the first location of newly allocated block of memory otherwise returns NULL
- Memory allocated by `calloc ()` by default contains the zero values.
- E.g. If we want to allocate memory for storing `n` integer numbers in contiguous memory locations

```
int *p;  
p=(int*) calloc (n, sizeof(int) );
```



Program to show calloc() function

```
#include<stdio.h>
#include<stdlib.h>
void main()
{
    float *x;
    int i,n;
    printf("how many elements do u want?");
    scanf("%d",&n);
    x=(float*)calloc(n,sizeof(float));
    if(x!=NULL)
    {
        printf("data is=\n");
        for(i=0;i<n;i++)
            printf("\n x[%d]=%d ",i,* (x+i));
    }
    else
        printf("calloc failed");
    getch();
}
```



how many elements do u want 3

x[0]=0

x[1]=0

x[2]=0

Difference between `malloc()` and `calloc()`

	<code>calloc()</code>	<code>malloc()</code>
Function:	Allocates a region of memory large enough to hold "n elements" of "size" bytes each.	Allocates "size" bytes of memory.
Syntax:	<code>void *calloc</code> <code>(number_of_blocks,</code> <code>size_in_bytes);</code>	<code>void *malloc</code> <code>(size_in_bytes);</code>
No. of arguments:	2	1
Contents of allocated memory:	The allocated region is initialized to zero.	The contents of allocated memory are not changed. i.e., the memory contains garbage values.
Return value:	void pointer (void *). If the allocation succeeds, a pointer to the block of memory is returned.	void pointer (void *). If the allocation succeeds, a pointer to the block of memory is returned.



realloc()

- Now suppose you've allocated a certain number of bytes for an array but later find that you want to add values to it. You could copy everything into a larger array, which is inefficient, or you can allocate more bytes using `realloc()`, without losing your data.
- `realloc()` takes **two** arguments.
 1. The **first** is the pointer referencing the memory.
 2. The **second** is the total number of bytes you want to reallocate.
- Passing zero as the second argument is the equivalent of calling `free`.
- Syntax:

```
void *realloc(pointerToObject, newsize);
```


`realloc()`

- If memory is allocated successfully, function `realloc()` returns a pointer to the first location of newly allocated block of memory which may be at same site or at new site and copy the contents from previous location to a new location if required , otherwise returns `NULL`.

This example
uses calloc to
allocate
memory
then realloc

```
#include<stdio.h>
#include <stdlib.h>
int main()
{
    int *ptr, i;
    ptr = (int *)calloc(5, sizeof(int));
    *ptr = 1;
    *(ptr+1) = 2;
    ptr[2] = 4;
    ptr[3] = 8;
    ptr[4] = 16;
    ptr = (int *)realloc(ptr, 7*sizeof(int));
    printf("Now allocating more memory... \n");
    ptr[5] = 32; /* now it's legal! */
    ptr[6] = 64;
    for(i=0 ; i<7 ; i++){
        printf("ptr[%d] holds %d\n", i, ptr[i]);
    }
}
```



Now allocating more memory...

```
ptr[0] holds 1
ptr[1] holds 2
ptr[2] holds 4
ptr[3] holds 8
ptr[4] holds 16
ptr[5] holds 32
ptr[6] holds 64
```

free ()

- Deallocates a memory block allocated by previous call to `malloc()`, `calloc()` or `realloc()` and return it to memory to be used for other purposes.
- Syntax:

```
void *free(void *block);
```
- The argument of function `free()` is the pointer to block of memory which is to be freed.

`free ()`

- The `realloc ()` function can behave the same as `free ()` function provided the second argument passed to `realloc ()` is 0.

`free (ptr) ;`

which is equivalent to

`realloc (ptr, 0) ;`

Memory Leak

- A condition caused by a program that does not free up the extra memory it allocates.
- It occurs when the dynamically allocated memory is no longer needed but it is not freed.
- If we continuously keep on allocating the memory without freeing it for reuse, the entire heap storage will be exhausted.
- In such circumstances, the memory allocation functions will start failing and program will start behaving unexpectedly



Next Class: Derived Types

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