SC1007
Data Structures and Algorithms

Dynamic Data Structure

&

Linked Lists

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N4-02B-69A

Overview

- Definition of Pointers and Structures
- Static Data Structure and Dynamic Data Structure
- Computer Memory Layouts
- Memory Allocation
- Memory Deallocation
- Examples and Common Mistakes

- Concepts of Linked Lists

C Programming - Quick Recap

Basic C Programming:

1. **Read Input: scanf()**
2. **Write Output: printf()**
3. **Arithmetic: +,-,*,/,%**
4. **Logic: &&, ||, !, ==, !=, >,<,>=,<= etc.**
5. **Control Structure:**
    1. **Sequence Structure**
    2. **Selection Structure: if… else…, switch and break, goto, ? :**
    3. **Repetition Structure: while, do… while, for loop**

1. **Function**
2. **Pointer – * and &**
3. **Array**
4. **Character String**
5. **Structure**
6. **Recursion**

Static Data Structure and Dynamic Data Structure

Static Data Structure: the allocated memory size is fixed at compile time. You are not able to change the size while you are running it.

Built-in Data Types

Scalar variables	char, int, long, float, double
Array	char name[64]; int a[8][8];

Derived Data Type

C Structs	**typedef struct node {** **int age;** **float height;** **}student_t;** **student_t s1;** **struct node s2;**
	struct node { int age; float height; }student;

Dynamic Data Structure: the memory allocation is done during execution time. You have some ways to change the size during the program is running.

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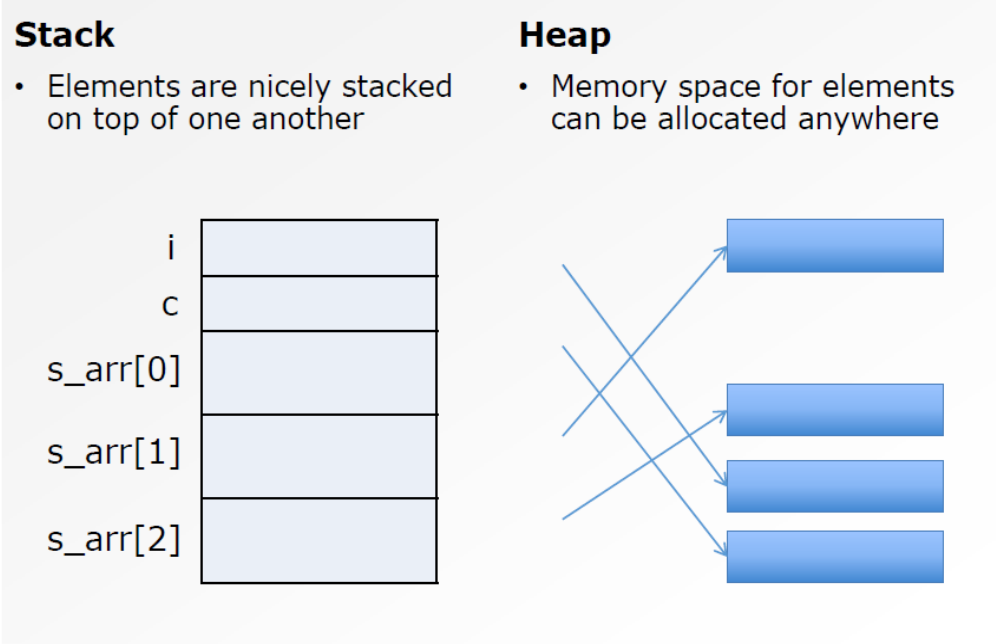

Memory Allocation

3 scenario

1. **Known the data size before compile**
2. **Known the data size at the beginning**
3. **Unknown the data size. The size can be increased or decreased over the time while the program is running**

1. **Static Data Allocation (in stack memory)**
2. **Dynamic Data Allocation (in heap memory)**
3. **Dynamic Data with linked list structure**

Dynamic Memory Allocation and Deallocation

```
#include <stdlib.h>
malloc() and free()
```

- `malloc()` takes an argument of the number of bytes to be allocated and returns a **`void`** pointer `to the allocated memory.`
- `sizeof()` can be used to determine the size of a structure in bytes

```
Eg. int *array = (int *) malloc(sizeof(int)*5);
```

- `free() deallocates memory but freed pointer is not NULL.`

Extra Information

- malloc() does not “clear” the data in the memory.
- If you would like to initialize the elements as zero,
  1. Write a loop to initialize them to zero
  2. Use calloc()

  Eg. int *array = (int *) calloc(5,sizeof(int));
- free() is still required to deallocate memory
- realloc() allows user change the size of the allocated memory.

```c
#include <stdio.h>
#include <stdlib.h>                                     //include library for malloc() and free()

int main(void)
{
      int i;
      double* item;                                     //declare two pointers
      char* string;
      item = (double *) malloc(10*sizeof(double));      //dynamically memory allocation for 10 elements each
      string = (char *) malloc(10*sizeof(char));

      for(i=0;i<10;i++)                                 //Read 10 floating numbers
      {
            scanf("%lf",&item[i]);
      }
      scanf("%*c");                                     //skip the last '\n'

      i=0;                                              //Read 9 character + null character to stop
      char *stringP=string;
      while(i++<9)
            scanf("%c",stringP++);
      *stringP='\0';
      printf("%s\n",string);                            //Print the string

      double* itemP=item;                               //Print the numbers in item
      for(i=0;i<10;i++,itemP++)
            printf("%.2lf ",*itemP);
      printf("\n");

      free(item);                                       //free the allocated memory
      free(string);
      return 0;
}
```

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Linked List

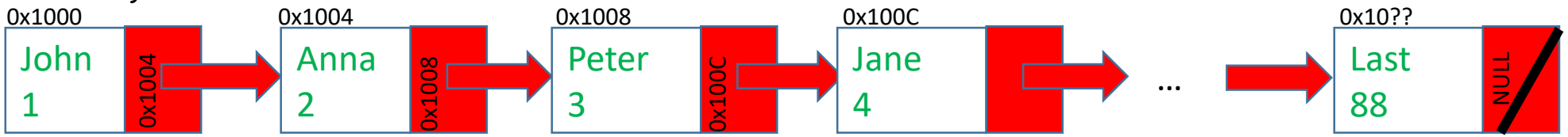
Memory Address	Name	Matric No
0x1000	John	0001
0x1004	Anna	0002
0x1008	Peter	0003
0x100C	Jane	0004
	…	…

- **Structure**: a collection of variables with different types:

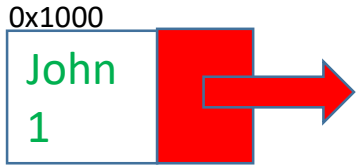
```
struct student{
        char Name[15];
        int matricNo;
}
```

- **Self-referential structure:** a pointer member that points to a structure of the same structure type

```
struct node{
        char Name[15];
        int matricNo;
        struct node *nextPtr;   //link
}
```

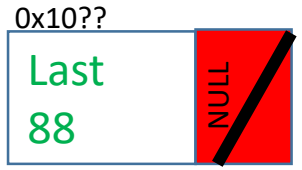


Linked List




```
struct node{
          char Name[15];
          int matricNo;
          struct node *nextPtr;  //link
}
```

1. **Each node contains data and link**
2. **The link contains the address of next node**
3. **If user knows the address of first node, the next node can be found from the link.**
4. **The link of the last node is a NULL pointer**



5. **The example is known as singly-linked list**
   - **There is only ONE link in the node**

Summary

- Static Structure Definition

```
typedef struct node {
        int age;
        float height;
   }student_t;
student_t s1;
struct node s2;
```

- Dynamic Memory Allocation/Deallocation

```
#include <stdlib.h>
item = (double *) malloc(10*sizeof(double));
free(item);
```

- Concepts of Linked Lists

```
struct node{
        char Name[15];
        int matricNo;
        struct node *nextPtr;  //link
    }
```

Overview of Next Lecture

1. **What is the linked list?**
2. **How to create a linked list?**
3. **How to use the linked list?**
4. **Why do you need a linked list?**

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