Object Oriented Programming Using C++

Day 1

Quick Review of C programming language

History

- Inventor: Dennis Ritchie
- Location: At&T Bell Lab
- Development Year: 1969-1972
- Operating System: Unix
- Hardware: PDP-11
- C is statically type checked as well as strongly type checked language.
- C is a general purpose programming language.
- Extension: .c
- Standardization: ANSI
    - C89
    - C95
    - C99
    - C11
    - C17
    - C23

Data Type

- Data Type Describe following things:
    - Size: How much memory is required to store the data.
    - Nature: Which type of data is allowed to stored inside memory
    - Operation: Which operations are allowed to perform on the data stored inside memory
    - Range: How much data is allowed to store inside memory
- Types:
    - Fundamental Data Types(5)
        - void
        - char
        - int
        - float
        - double
    - Derived Data Types
        - Array
        - Function
        - Pointer
    - User Defined Data Types
        - Structure

        - Union
- Type Modifiers
    - short
    - long
    - signed
    - unsigned
- Type Qualifiers
    - const
    - volatile

Entry Point Function

- According to ANSI specification, entry point function should be "main".
- Syntax: 1

```
int main( int argc, char *argv[ ], char *envp[ ] ){
  return 0;
}
```

- Syntax: 2

```
void main( int argc, char *argv[ ], char *envp[ ] ){

}
```

- Syntax: 3

```
int main( int argc, char *argv[ ] ){
  return 0;
}
```

- Syntax: 4

```
void main( int argc, char *argv[ ] ){

}
```

- Syntax: 5

```
int main( void ){
  return 0;
}
```

- Syntax: 6

```
void main( void ){

}
```

- Syntax: 7

```
void main(  ){

}
```

- main is user defined function.
- Calling main function is a responsibility of operating system. Hence it is called as callback function.
- main function must be global function.
- We can define only one main function per project. If we do not define main function then linker generates error.

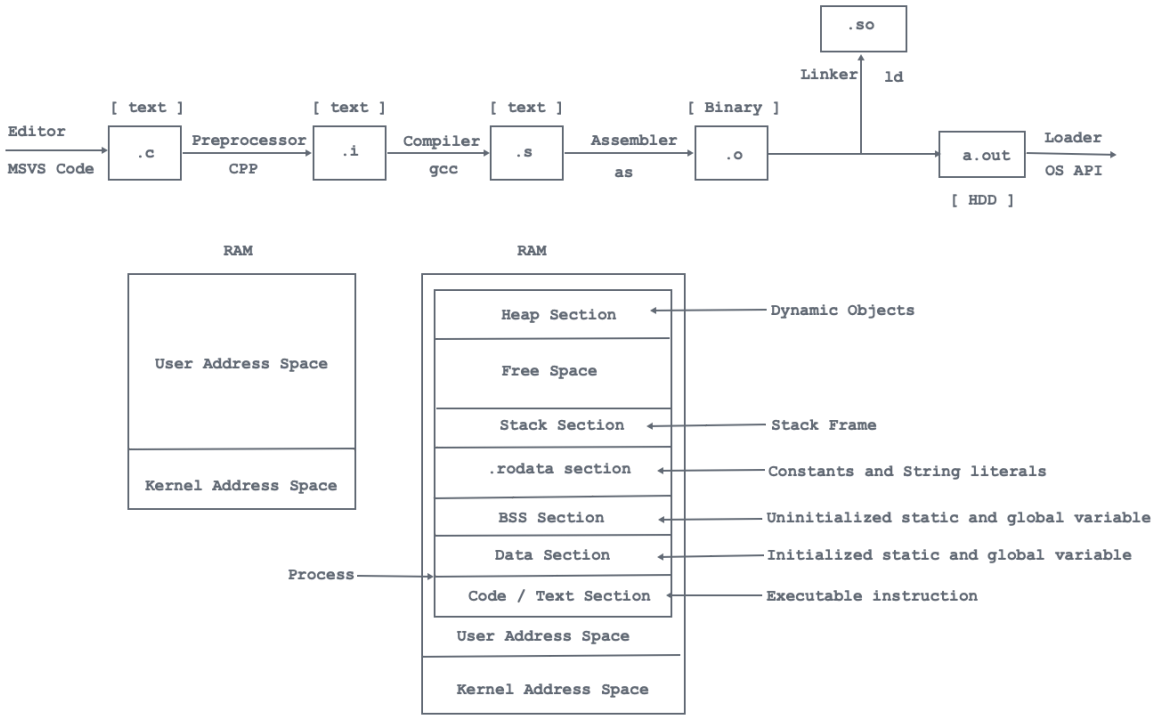
Software Development Kit

- SDK = Development tools + Documentation + Runtime Environment + Supporting Libraries
- Development tools
  - Editor
    - It is used to create/edit source file(.c/.cpp)
    - Example:
      - MS Windows: Notepad, Notepad++, Edit Plus, MS Visual Studio Code, Wordpad etc.
      - Linux: vi, vim, TextEdit, MS Visual Studio Code etc.
      - Mac OS: vi, vim, TextEdit, MS Visual Studio Code etc.
  - Preprocessor
    - It is a system program whose job is:
      - To remove the comments
      - To exapand macros
    - Example: CPP(C/C++ Pre Processor)
    - Preprocessor generates intermediate file(.i /.ii)
  - Compiler
    - It is a system program whose job is:
      - To check syntax

            - To convert high level code into low level(Assembly code)
        - Example:
            - Turbo C: tcc.exe
            - MS Visual Studio: cl.exe
            - Linux: gcc
        - Compiler generates .asm / .s file.
    - Assembler:
        - It is a system program which is used to convert low level code into machine level code.
        - Example:
            - Turbo C: Tasm
            - MS Visual Studio: Masm
            - Linux: as
        - It generates .obj / .o file.
    - Linker
        - It is a program whose job is to link machine code to library files.
        - It is responsible for generating executable file.
        - Example:
            - Turbo C: Tlink.exe
            - MS Visual Studio: link.exe
            - Linux: ld
    - Loader:
        - It is an OS API.
        - It is used to load executable file from HDD into primary memory(RAM).
    - Debugger:
        - Logical error is also called as bug.
        - To find the bug we should use debugger
        - Example
            - Linux: gdb, ddd
- Documentation
    - It can be in the form of html / pdf / text format.
    - Example: https://en.cppreference.com/w/c/language
- Runtime Environment
    - It is responsible for managing execution of application
    - Example: C Runtime

Flow Of Execution

- Reference: https://www.tenouk.com/ModuleW.html



Comments

- If we want to maintain documentation of the source code then we should use comments.
- Comments in C/C++
  - Single Line Comment

```
//This is single line comment
```

  - Multiline / Block Comment

```
/*
  This is multiline comment
*/
```

- "-save-temps" Save intermediate compilation results

Local Function Declaration

```
int main( void ){//Calling Function
  int sum( int num1, int num2 );  //Local Function Declaration: OK
  int result = sum( 10, 20 ); //Function Call
  return 0;
}
int sum( int num1, int num2 ){  //Called Function
```

```
  int result = num1 + num2;
  return result;
}
```

Global Function Declaration

```
int sum( int num1, int num2 );  //Local Function Declaration: OK
int main( void ){//Calling Function
  int result = sum( 10, 20 ); //Function Call
  return 0;
}
int sum( int num1, int num2 ){  //Called Function
  int result = num1 + num2;
  return result;
}
```

Function Definition as a Declaration

```
//Treated as declaration as well as definition
int sum( int num1, int num2 ){  //Called Function
  int result = num1 + num2;
  return result;
}
int main( void ){//Calling Function
  int result = sum( 10, 20 ); //Function Call
  return 0;
}
```

Linker Error

- Without definition, If we try to use function then linker generates error.

```
int sum( int num1, int num2 );  //Function Declaration
int main( void ){//Calling Function
  int result = sum( 10, 20 ); //Function Call
  return 0;
}
//Output: Linking Error
```

Argument versus Parameter

- During function call, if we use variable or constant value then it is called as argument.
- Example 1

```
int main( void ){
  int result = sum( 10, 20 );   //Here 10 and 20 are arguments
  return 0;
}
```

- Example 2

```
int main( void ){
  int num1 = 50;
  int num2 = 60;
  int result = sum( num1, num2 );   //Here num1 and num2 are arguments
  return 0;
}
```

- Example 3

```
int main( void ){
  int num1 = 110;
  int result = sum( num1, 120 );   //Here num1 and 120 are arguments
  return 0;
}
```

- During function definition, if we use variables then it is called as function parameter or simply parameter.
- Example 1:

```
//Here num1 and num2 are parameters
int sum( int num1, int num2 ){
  int result = num1 + num2;
  return result;
}
```

Declaration and Definition

- Declaration refers to the term where only nature of the variable is stated but no storage is allocted.
- Definition refers to the place where memory is assigned / allocated.
- Example 1

```
int main( void ){
  //Uninitialized non static local variable
  int num1; //Declaration as well as definition
```

```
  return 0;
}
```

- Example 2

```
int main( void ){
  //Initialized non static local variable
  int num1 = 10; //Declaration as well as definition
  return 0;
}
```

- Example 3

```
  //Initialized non static global variable
int num1 = 10; //Declaration as well as definition
int main( void ){
  printf("Num1  : %d\n", num1);
  return 0;
}
```

- Example 4

```
int main( void ){
  extern int num1;  //Declaration
  printf("Num1  : %d\n", num1);
  return 0;
}
//Initialized non static global variable
int num1 = 10; //Declaration as well as definition
```

- Example 5

```
int main( void ){
  extern int num1;  //Declaration
  printf("Num1  : %d\n", num1); //Linker Error
  return 0;
}
```

Initialization and Assignment

- During declaration, process of storing value inside variable is called as initialization.
- Consider example:

```
```

```
int number = 10;  //Initialization
```

- We can do initialization of variable only once.

```
int number = 10;  //Initialization: OK
int number = 20;  //Not OK
```

- After declaration, process of storing value inside variable is called as assignment.
- Example 1:

```
int number;
number = 10;  //Assignment
```

- Example 2:

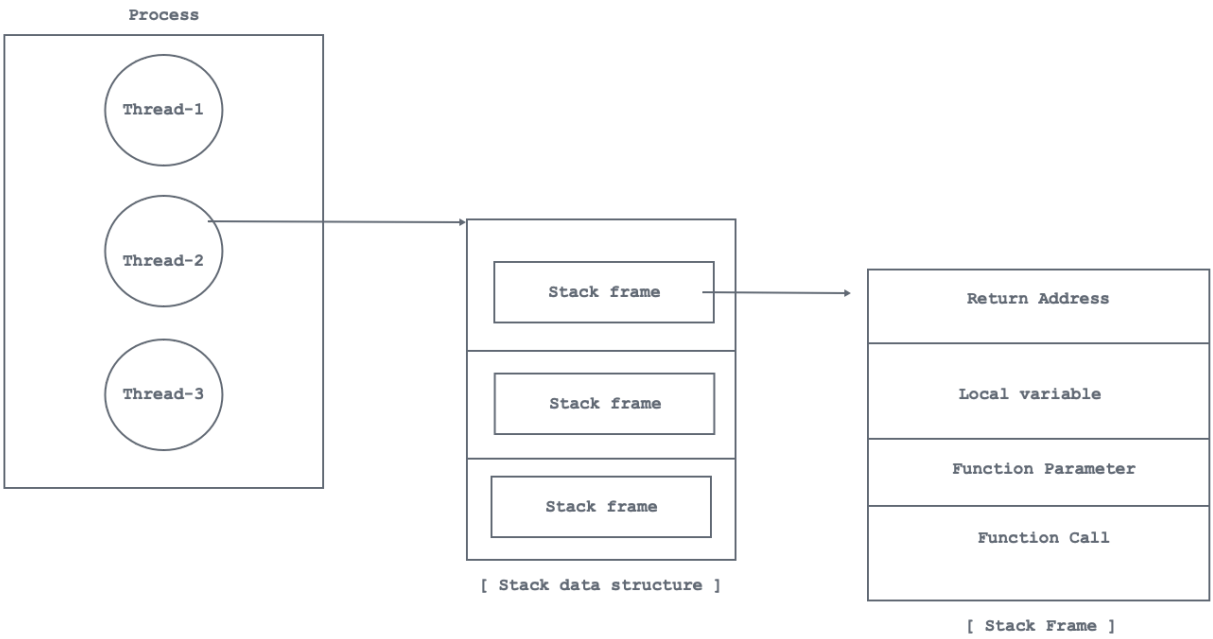
```
int number = 10;  //Initialization
number = 20;  //Assignment
```

- We can do assignment multiple times.
- Example 3:

```
int number = 10;  //Initialization
number = 20;  //Assignment
number = 30;  //Assignment
```

Day 2

Function Activation Record



Pointer

- Variable Definition:
  - An entity whose value can be change is called as variable.
  - Named memory location / name given to memory location is called as variable.
  - Variable is also called as identifier.
- Assignement:
  - Identify the rules for variable/identifier name.
- Pointer is a variable which is designed to store address of another variable.
- Size of pointer:
  - 16-bit : 2 bytes
  - 32-bit : 4 bytes
  - 64-bit : 8 bytes
- Pointer Declaration:
  - Example 1

```
int* ptrNumber; //OK
```

  - Example 2

```
int * ptrNumber; //OK
```

  - Example 3

```
int *ptrNumber; //OK: Recommended
```

- Example 4

```
int main( void ){
  //Uninitialied non static local pointer variable
  int *ptrNumber; //Wild Pointer
  return 0;
}
```

- Uninitialied pointer is called as wild pointer.
- NULL is a macro whose value is 0.

```
#define NULL 0
```

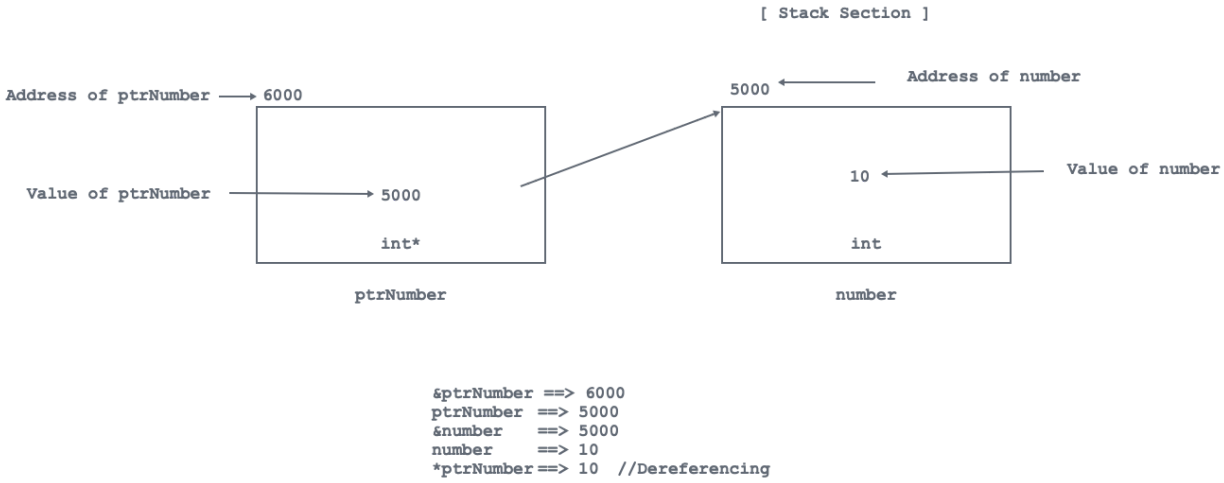
- To initializer pointer or to avoid dangling pointer we should use NULL;
  - Example 4

```
int main( void ){
  //NULL is a macro
  int *ptrNumber = NULL;
  //ptrNumber is a NULL pointer
  return 0;
}
```

- If pointer contains NULL value then it is called as Null pointer

- Pointer Initialization

```
int number = 10;  //Initialzation
int *ptrNumber = &number; //Initialization
//How will you print value 10
printf("Value : %d\n", number);
printf("Value : %d\n", *ptrNumber); //10
```

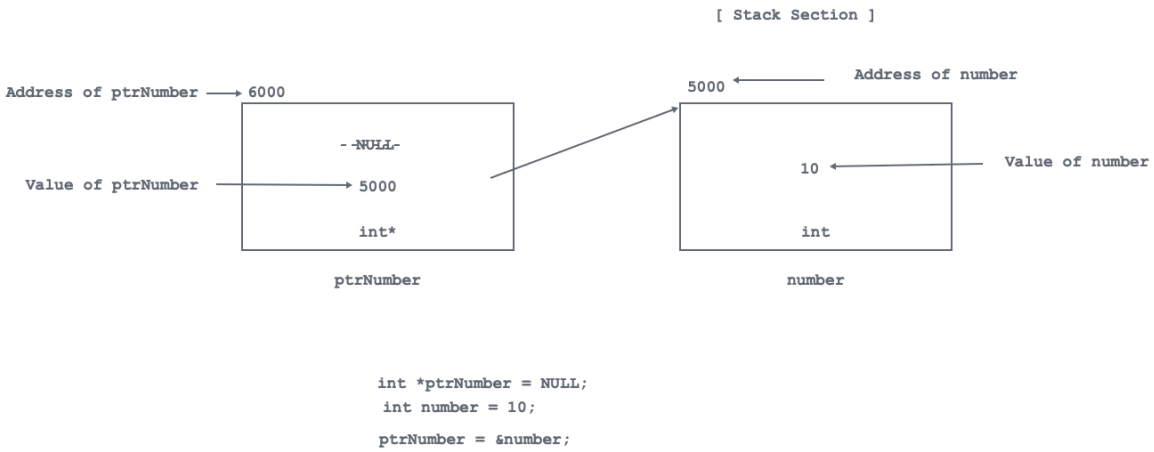



```
&ptrNumber ==> 6000
ptrNumber  ==> 5000
&number    ==> 5000
number     ==> 10
*ptrNumber ==> 10  //Dereferencing
```

- Pointer Assignment

```c
int *ptrNumber = NULL; //Initialzation
int number = 10;  //Initialzation
ptrNumber = &number;  //Assignment
//How will you print value 10
printf("Value : %d\n", number);
printf("Value : %d\n", *ptrNumber); //10
```

- We should not derefer Null pointer. Behaviour will be unpredictable.



Constant Qualifier

- const is a keyword in C/C++ and it is consider as type qualifier.
- Example 1

```
#include<cstdio>
int main( void ){
  int number = 10;  //Initialization
  printf("Number    :   %d\n", number); //10
  number = number + 5;
  printf("Number    :   %d\n", number); //15
  return 0;
}
```

- If we dont want to modify value of the variable then we should use const qualifier.
- Example

```
#include<cstdio>
int main( void ){
  const int number = 10;    //Initialization
  printf("Number    :   %d\n", number); //10
  //number = number + 5;    //Not OK
  return 0;
}
```

- We can not modiy value of constant variable but we can read its value. Hence it is called as read-only variable.

Constant and Pointer combinations

int *ptrNumber

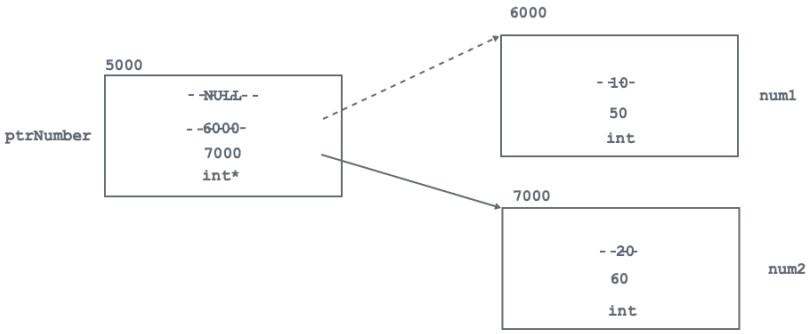
- Here ptrNumber is non constant pointer variable which can store address of non constant integer variable.
- Example:

```c
int main( void ){
  int *ptrNumber = NULL;

  int num1 = 10;
  ptrNumber = &num1;
  //num1 = 50;  //OK
  *ptrNumber = 50;  //Dereferencing

  printf("Num1  :   %d\n", num1);   //50
  printf("Num1  :   %d\n", *ptrNumber); //50: Dereferencing


  int num2 = 20;
  ptrNumber = &num2;
  //num2 = 60;  //OK
  *ptrNumber = 60;  //Dereferencing
  printf("Num2  :   %d\n", num2);   //60
  printf("Num2  :   %d\n", *ptrNumber); //60:Dereferencing
  return 0;
}
```



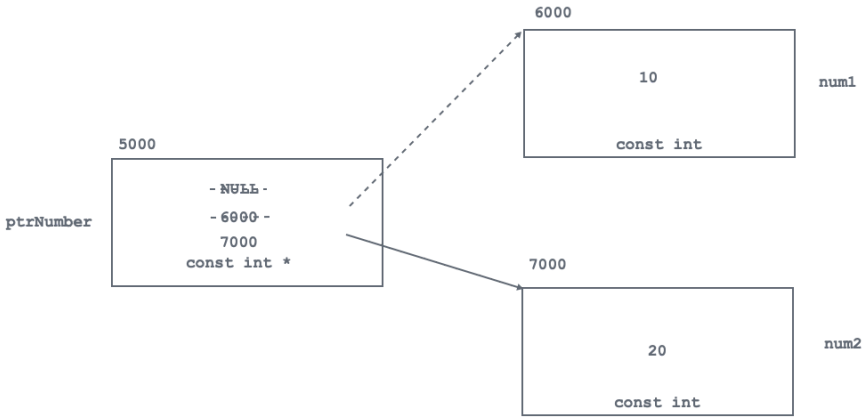
const int *ptrNumber

- Here ptrNumber is non constant pointer variable which can store address of constant integer variable.
- Example:

```
int main( void ){
  const int *ptrNumber = NULL;  //OK

  const int num1 = 10;
  ptrNumber = &num1;    //OK
  //num1 = 50;  //Not OK
  //*ptrNumber = 50;    //Not OK
  printf("Num1  :   %d\n", num1);   //10
  printf("Num1  :   %d\n", *ptrNumber); //10: Dereferencing

  const int num2 = 20;
  ptrNumber = &num2;    //OK
  //num2 = 60;  //Not OK
  //*ptrNumber = 60;    //Not OK
  printf("Num2  :   %d\n", num2);   //20
  printf("Num2  :   %d\n", *ptrNumber); //20: Dereferencing
  return 0;
}
```



int const *ptrNumber

- const int *ptrNumber and int const *ptrNumber are same.

const int const *ptrNumber

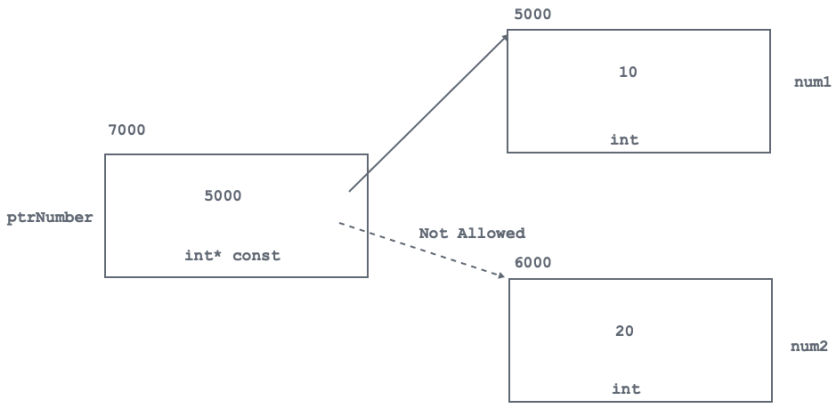
- const int *ptrNumber, int const *ptrNumber and const int const *ptrNumber are same.
- warning: duplicate 'const' declaration specifier

int *const ptrNumber

- Here, ptrNumber is constant pointer variable, which can store address of non constant integer variable.

```c
int main( void ){
  int num1 = 10;
  int *const ptrNumber = &num1;
  //num1 = 50;  //OK
  *ptrNumber = 50;
  printf("Num1  :   %d\n", num1);   //50
  printf("Num1  :   %d\n", *ptrNumber); //50: Dereferencing

  int num2 = 20;
  //ptrNumber = &num2;  //Not OK
  return 0;
}
```



int *ptrNumber const

- It is invalid syntax.

const int *const ptrNumber

- Here ptrNumber is constant pointer variable which can store address of constant integer variable.
- Example:

```
int main( void ){
  const int num1 = 10;  //OK
  const int *const ptrNumber = &num1;

  //num1 = 50;  //Not OK
  //*ptrNumber = 50;    //Not OK:Dereferencing
  printf("Num1  :   %d\n", num1);   //10
  printf("Num1  :   %d\n", *ptrNumber); //10: Dereferencing

  const int num2 = 20;  //OK
  //ptrNumber = &num2;  //Not OK
  return 0;
}
```

int const *const ptrNumber

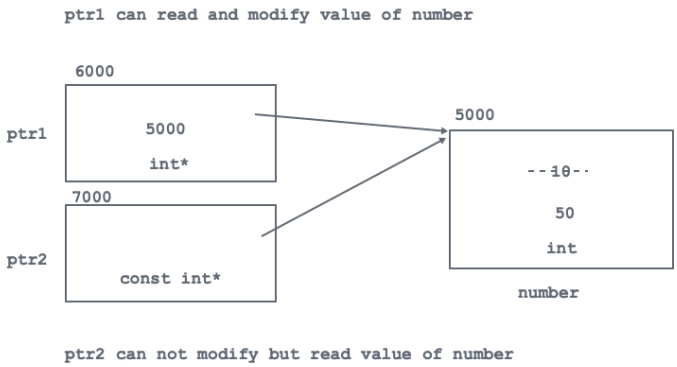
- const int *const ptrNumber and int const *const ptrNumber are same.

Consider following Pointer Example

```
int main( void ){
    int number = 10;
    int *ptr1 = &number;
    *ptr1 = 50; //OK: Dereferencing
    printf("Number  :   %d\n", number); //50
    printf("Number  :   %d\n", *ptr1);  //50: Dereferencing

    printf("---------\n");

    const int *ptr2 = &number;
    //*ptr2 = 60;   //Not OK
    printf("Number  :   %d\n", number); //50
    printf("Number  :   %d\n", *ptr2);  //50: Dereferencing
    return 0;
}
```



Consider following Pointer Example

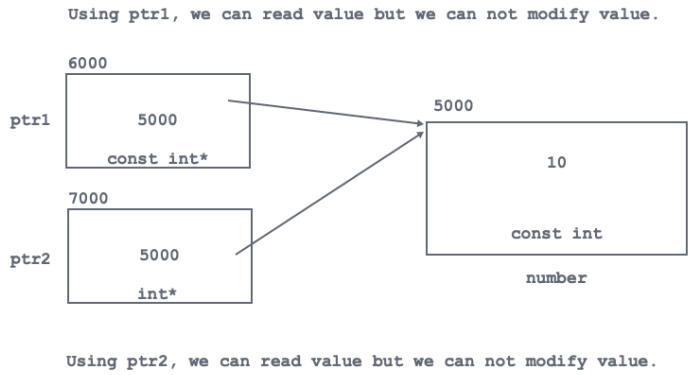
```
int main( void ){
    const int number = 10;

    const int *ptr1 = &number;
    //*ptr1 = 50;   //Not OK
    printf("Number  :   %d\n", number);//10
```

```c
    printf("Number  :   %d\n", *ptr1);//10: Dereferencing

    printf("---------\n");

    int *ptr2 = (int *)&number;
    *ptr2 = 50;
    printf("Number  :   %d\n", number);//10
    printf("Number  :   %d\n", *ptr2);//50: Unexpected behavior
    return 0;
}
```



Lab Assignment

- Write a menu driven program to test accept/print employee record.
- Define structure:
  - Employee:
    - name: char[30]
    - empid: int
    - salary: float
- Create object and test the functionality
  - int main(void)
  - void accept_record(struct Employee *ptr);
  - void print_record(struct Employee *ptr);

Structure

- Structure is derived data type in C/C++. But generally it is called as user defined data type.

- If we want to group related data elements together then we should use structure.
- Consider below examples
    - name:char[30], empid:int, salary:float: Employee
    - number:int, balance:float, type:char[30]: BankAccount
    - day:int, month:int, year:int: Date
    - hour:int, minute:int, second:int : Time
    - red:int , green:int, blue:int : Color
- struct is keyword in C/C++.
- To declare structure and to create object of the structure we must use struct keyword.
- Example 1:

```
struct Employee{
  char name[ 30 ];  //structure member
  int empid;  //structure member
  float salary;  //structure member
};
struct Employee emp;
//struct Employee : Type Name
//emp: object
```

- If we want to give another name to the existing data type then we should use typedef.
- typedef is a keyword.
- Example 2:

```
struct Employee{
  char name[ 30 ];  //structure member
  int empid;  //structure member
  float salary;  //structure member
};
typedef struct Employee Employee_t;
struct Employee emp1; //OK
Employee_t emp2;  //OK
struct Employee_t emp3;  //NOT OK
```

- Example 3:

```
typedef struct Employee{
  char name[ 30 ];  //structure member
  int empid;  //structure member
  float salary;  //structure member
}Employee_t;
```

```
  struct Employee emp1; //OK
  Employee_t emp2;  //OK
```

- Consider following example:

```
int main( void ){
  char name[ 30 ];
  int empid;
  float salary;

  printf("Name    :   ");
  scanf("%s",name);
  printf("Empid   :   ");
  scanf("%d",&empid);
  printf("Salary  :   ");
  scanf("%f", &salary);


  printf("Name    :   %s\n", name);
  printf("Empid   :   %d\n", empid);
  printf("Salary  :   %f\n", salary);

  //printf("%-30s%-5d%-10.2f\n", name, empid, salary);
  return 0;
}
```

- Consider following example:

```
int main( void ){
  //Local structure
  struct Employee{
    char name[ 30 ];
    int empid;
    float salary;
  };

  struct Employee emp;
  //struct Employee: Data type
  //emp: object

  printf("Name  :   ");
  scanf("%s",emp.name);
  printf("Empid :   ");
  scanf("%d",&emp.empid);
  printf("Salary    :   ");
  scanf("%f", &emp.salary);


  printf("Name  :   %s\n", emp.name);
```

```
  printf("Empid :   %d\n", emp.empid);
  printf("Salary    :   %f\n", emp.salary);

  //printf("%-30s%-5d%-10.2f\n", name, empid, salary);
  return 0;
}
```

- We can declare structure inside function. It is called as local structure.
- We can not create object/pointer of local structure outside function.
- If we create, object of the structure then all the members declared inside structure get space inside object.
- Using object, If we want to access members of structure then we should use dot / member selection operator.
- Using pointer, If we want to access members of structure then we should use arrow operator.
- Consider following example:

```
int main( void ){
  //Local structure
  struct Employee{
    char name[ 30 ];
    int empid;
    float salary;
  };

  struct Employee emp;
  struct Employee *ptr = &emp;

  printf("Name  :   ");
  scanf("%s",ptr->name);
  printf("Empid :   ");
  scanf("%d",&ptr->empid);
  printf("Salary    :   ");
  scanf("%f", &ptr->salary);


  printf("Name  :   %s\n", ptr->name);
  printf("Empid :   %d\n", ptr->empid);
  printf("Salary    :   %f\n", ptr->salary);
  return 0;
}
```

Day 3

Limitations with C programming languages

- In C languages, all the functions are global. Any global function can access any global data. Hence achieving data security is difficult.
- There is no string data type in C hence string memory managment is difficult
- If number of lines gets increased then code management becomes difficult.

C++ History

- Inventor: Bjarne Stroustrup
- Development Year: 1979
- Initial name : C with Classes
- Renamed in 1983 by ANSI: C++
- Standardization: ISO Working Group
- C++ Standards:
  - C++98
  - C++03
  - C++11
  - C++14
  - C++17
  - C++20
  - C++23
  - C++26
- C++ is object oriented programming language.
- C++ is derived from C and Simula(First object oriented programming language).
- C++ is also called as hybrid programming language.
- C++ is statically as well as strongly type checked language.

Data Types

- Fundamental Data Types(7)
  - void
  - bool
  - char
  - wchar_t (typedef unsigned short wchar_t)
  - int
  - float
  - double
- Derived Data Types(4)
  - Array
  - Function
  - Pointer
  - Reference
- User Defined Data Types(3)
  - Structure
  - Union
  - Class

Type Modifiers

- short
- long
- signed
- unsigned

Type Qualifiers

- const
- volatile

Execution Flow

- cfront is translator developed by Bjarne strostrup. It was used to convert C++ source code into C source code.
- Name of the C++ compiler for linus is g++.

Access Specifier

- If we want to control visibility of the members of structure/class then we should use access specifier.
- Access specifiers in C++:
    - private
    - protected
    - public

Access Specifier	Same Class	Derived Class	Outsid Class / Global funtion
private	A	NA	NA
protected	A	A	NA
public	A	A	A

Structure in C++

- We can define function inside structure.
- To create object of structure keyword struct is optional.
- Structure members are by default considered as public.
- Structure is not an object oriented concept.

What is the difference between structure and class?

- structure members are by default public whereas class members are by default private.

Data Member

- Variable declared inside class / structure is called as data member.

```
class Employee{
private:
  char name[ 30 ];  //Data member
  int empid;        //Data member
  float salary;     //Data member
};
```

- Data member is also called as property / field / attribute.

Member Function

- A function implemented / defined inside class / structure is called as member function.

```
class Employee{
public:
  void accept_record( void ){   //Member function
    printf("Name    :   ");
    scanf("%s", name );
    printf("Empid   :   ");
    scanf("%d", &empid );
    printf("Salary  :   ");
    scanf("%f", &salary );
  }

  void print_record( void ){    //Member function
    printf("Name    :   %s\n", name);
    printf("Empid   :   %d\n", empid);
    printf("Salary  :   %f\n", salary);
  }
};
```

- Member function is also called as method / operation / behaviour / message
- Member function of the class which is having body is called as concrete method.
- Member function of the class which do not have body is called as abstract method.

Class

- A class is collection of data member and member function.
- Inside class, we can define:

    - Nested type
        - enum
        - union
        - structure
        - class
    - Data member
        - non static
        - static
    - Member function
        - static
        - non static
            - const
            - virtual
    - Constructor
    - Destructor
- A class from which we can create object/instance is called as concrte class.
- A class from which we can not create object/instance is called as abstract class.

Object

- Variable of a class is called as object.
- Object is also called as instance.

```
class Employee emp1; //OK

Employee emp; //OK
```

- Process of creating object from class is called as instantiation;
    - C:
        - struct Structure_Name object_name;
    - C++
        - Structure_Name object_name;
        - Class_Name object_name;
    - Java:
        - Class_name reference_name = new Class_name( );

```
Employee emp;   //Here class Employee is instantiated and name of the
instance is emp.
```

Message Passing

- Process of calling member function on object is called as message passing.

```
```

```
int main( void ){
  Employee emp; //Here class Employee is instantiated and name of the
instance is emp.

  emp.acceptRecord( );  //acceptRecord() function is called  on object
emp;

  emp.printRecord( );       //printRecord() function is called  on
object emp;

  return 0;
}
```

- Consider following code:

```
int main( void ){
  Employee emp;

  //:: is called as scope resolution operator

  emp.Employee::acceptRecord( );    //OK

  emp.Employee::printRecord( ); //OK

  return 0;
}
```

Syntax to define member function global

```
ReturnType ClassName::functionName( ){
  //TODO
}
```

Header guard / Include guard

```
#ifndef EMPLOYEE_H_
#define EMPLOYEE_H_
  //TODO: Declaration
#endif /* EMPLOYEE_H_ */
```