Embedded System Design & Application

Embedded C Language

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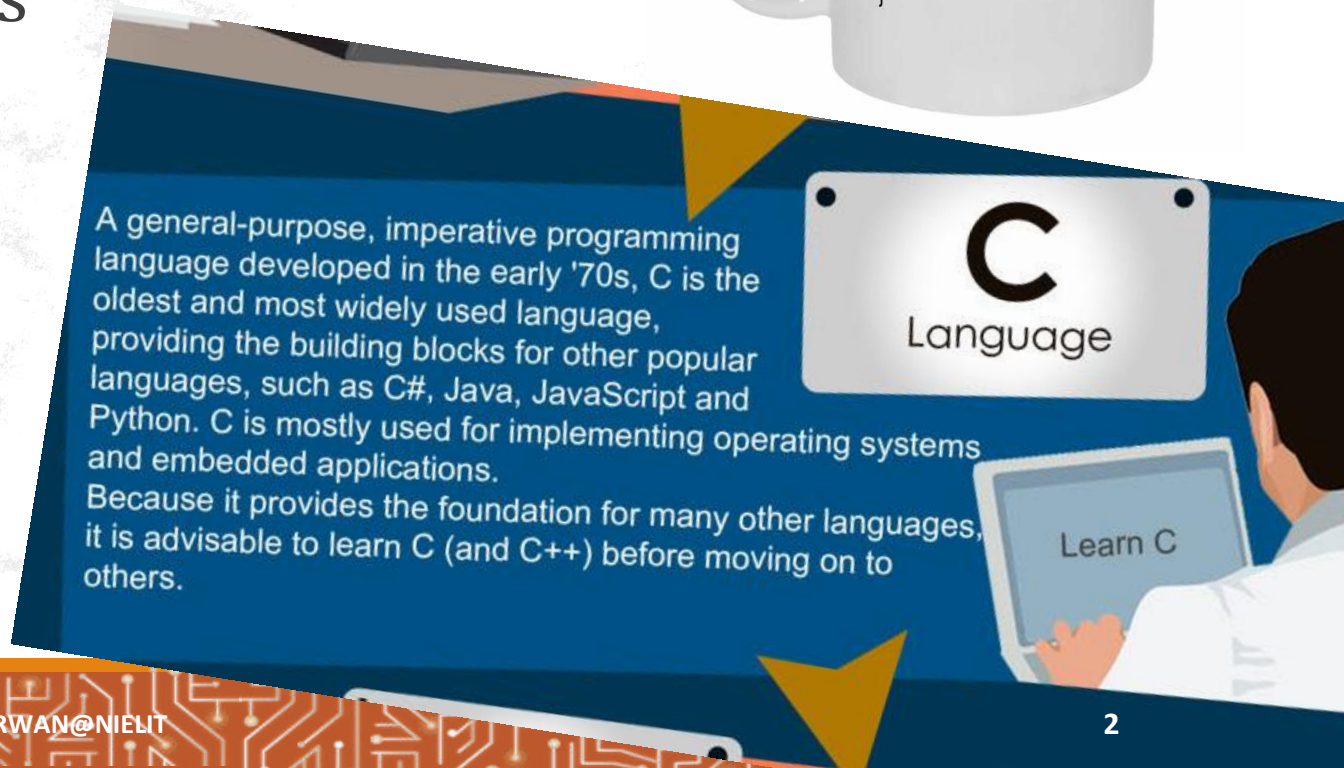
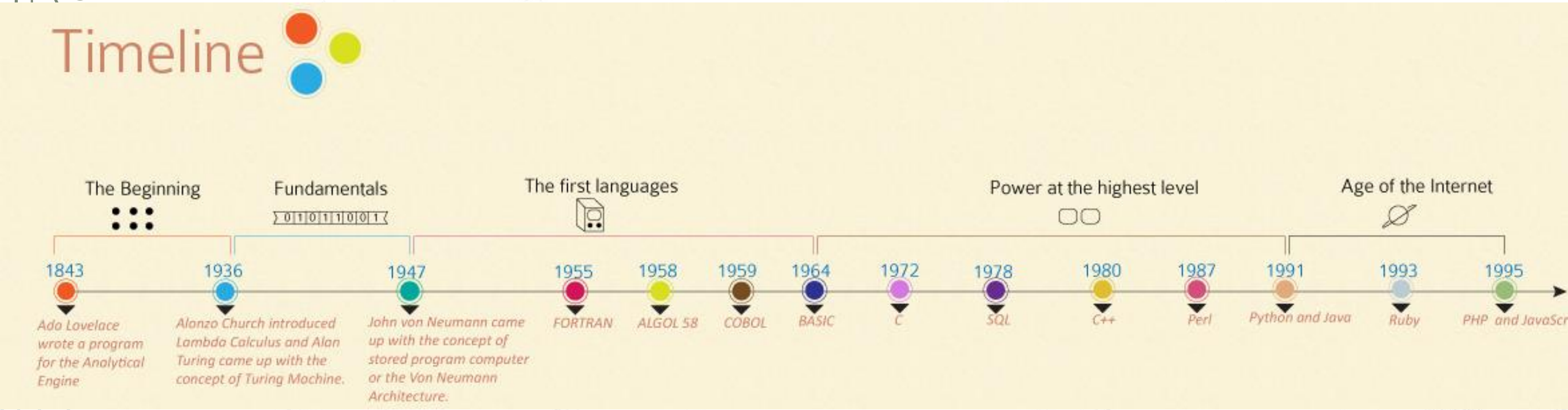
agenda

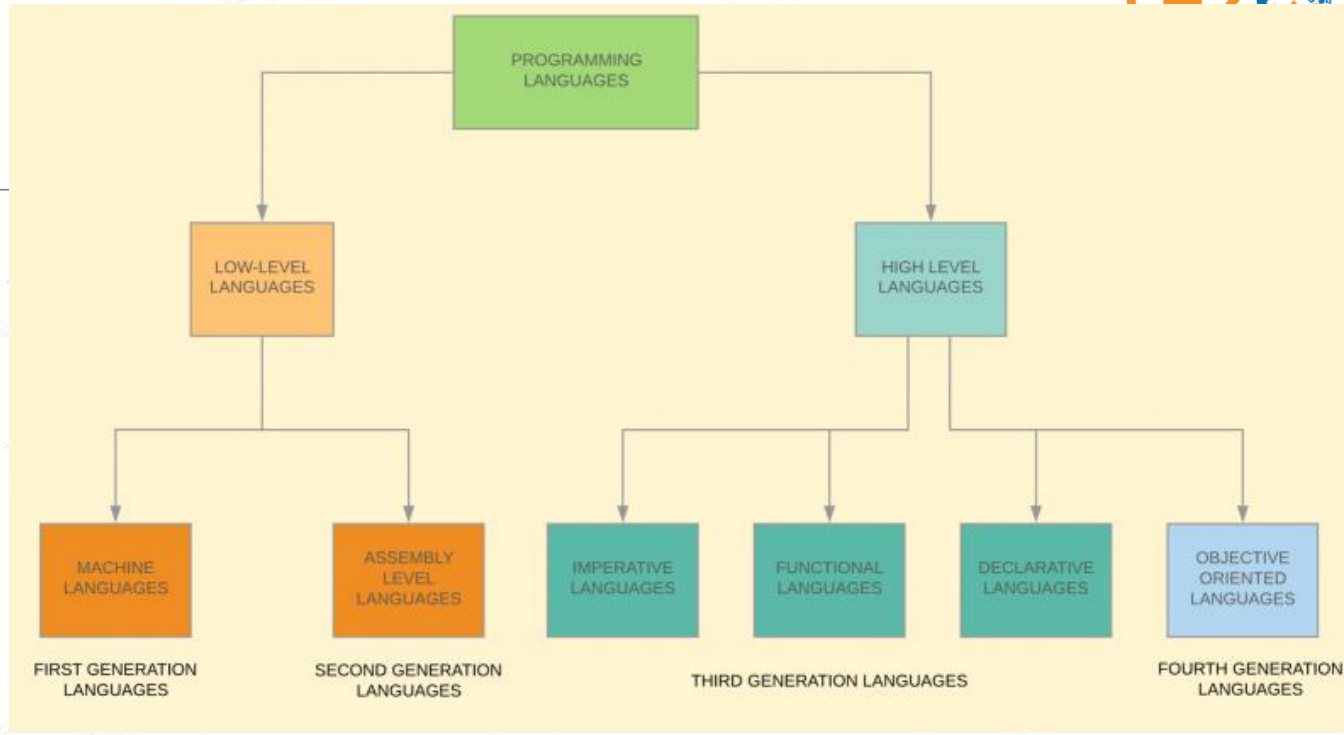
- Need of computing languages
- C language – history, uses, applications
- C language- data type, operators
- Flow and control statements
- Functions
- Header files

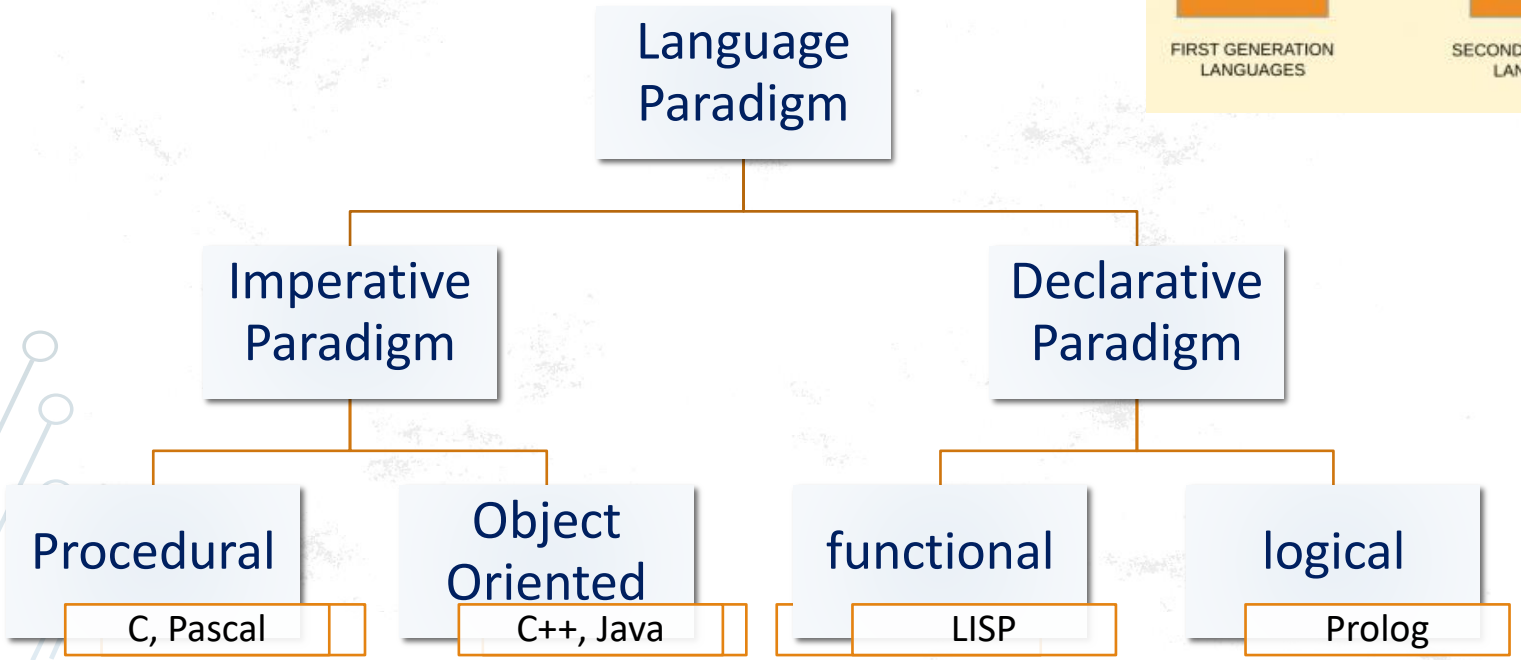


World of programming



Classification of Programming Languages





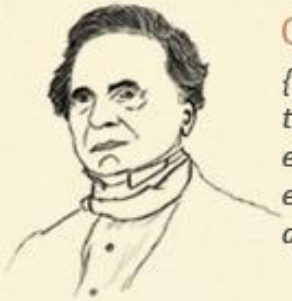
THE WORLD OF

PROGRAMMING

Pioneers

Facts & Algos

Stats



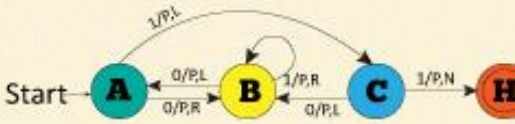
Charles Babbage

{He first came up with the idea of difference engine & analytical engine and is regarded as father of computer}

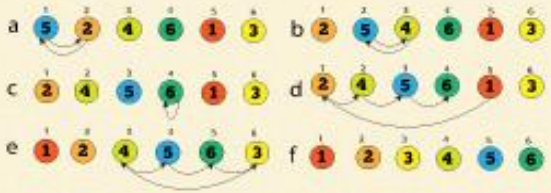
// A Punch Card

Alan Turing

{He is well known for the Halting problem, Turing machines, crypto-analysis of Enigma & Turing test. Turing award is given annually for exceptional work in the field of computing}



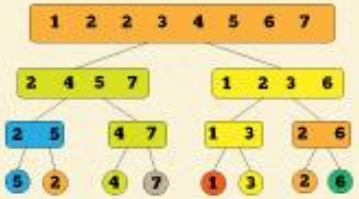
// 3 state busy beaver machine



// Insertion Sort algorithm

Ada Lovelace

{Wrote a program to calculate sequence of Bernoulli's number using analytical engine. Regarded as World's first programmer}



// Merge sort algorithm

John von Neumann

{He came up with the concept ofstored program computer that uses a CPU and a separate storage to hold both instructions and data. This is also known as von Neumann architecture}

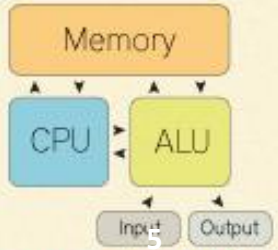
Dennis Ritchie

{He is the creator of C programming language and was also amongst the key developers of UNIX operating system. He received the Turing award in 1983}

// Dijkstra's algorithm

Edsger Dijkstra

{He is known for Dijkstra's algorithm, which is a graph search algorithm that solves the single-source shortest path problem for a graph with nonnegative edge

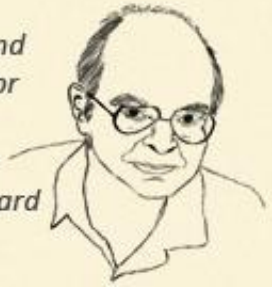


// Von Neumann Architecture

// B-Tree

Donald Knuth

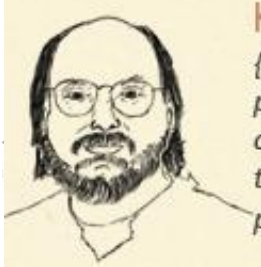
{He is the creator of TEX and MMIX and is well known for the "Art of computer programming"book series. He received the Turing Award in 1974}



// Binary Search Tree

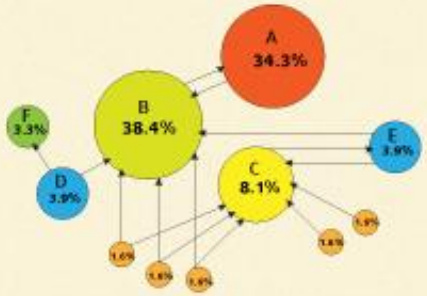
John Backus

{He is well known for the development of FORTRAN and ALGOL. He is also the inventor of Backus-Naur form and has also helped to popularize functional level programming}



Ken Thompson

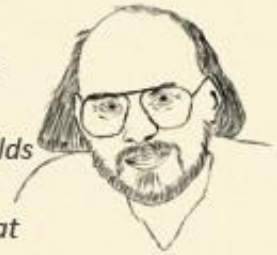
{He is well known as the principal creator of the UNIX operating system and is also the co-creator of the Go programming language}

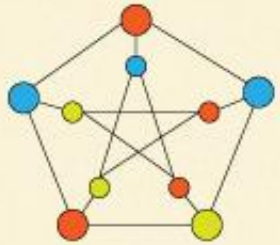


// Google PageRank Algorithm

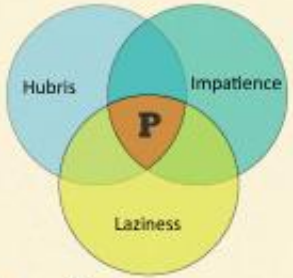
Bjarne Stroustrup

{He is well known for the creation and development of C++programming language and currently holds the college of engineering chair in computer science at Texas A&M.}





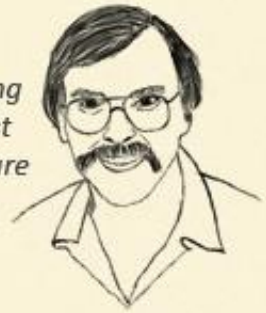
// Graph Coloring Algorithm

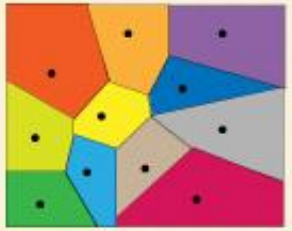


// 3 virtues of a Programmer - Impatience, Laziness and Hubris

Larry Wall

{He is well known for the creation of Perl programming language and is also the first recepient of the Free Software Foundation Award for the Advancement of Free Software}

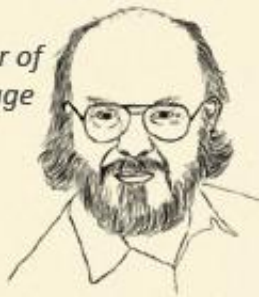




// Sweep line algorithms can be used for generating a Voronoi diagram

James Gosling

{ He is known as the father of Java programming language and is also the creator of Gosmacs, which was the first Emacs to run under UNIX}



Guido van Rossum

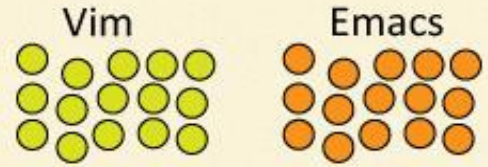
{He is well known as the author of Python programming language and is currently employed by Google}

```
>++++++++++>+>+[
  [+++++[>++++++++<-]>.<++++++[>-------<-]+<<<]>.>>[
    [-]<[>+<-]>>[<<+>+>-]<[>+<-[>+<-[>+<-[>+<-[>+<-[>+<-
      [>+<-[>+<-[>+<-[>[-]>+>+<<<-[>+<-]]]]]]]]]]]+>>>
  ]<<<
]
```

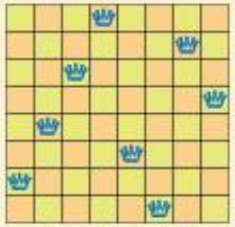
// Infinite Fibonacci sequence in Brainfuck language

Richard Stallman

{He is the creator of Emacs editor and the lead architect and organizer of the GNU project. He has been actively involved in the free software movement}



// Vim and Emacs are the two most popular editors amongst "Real Programmers"



// A solution to the Eight Queen Problem

Linus Torvalds

{He is best known for having initiated the development of Linux Kernel and the Git revision control system. He is also a strong supporter of Open Source software}

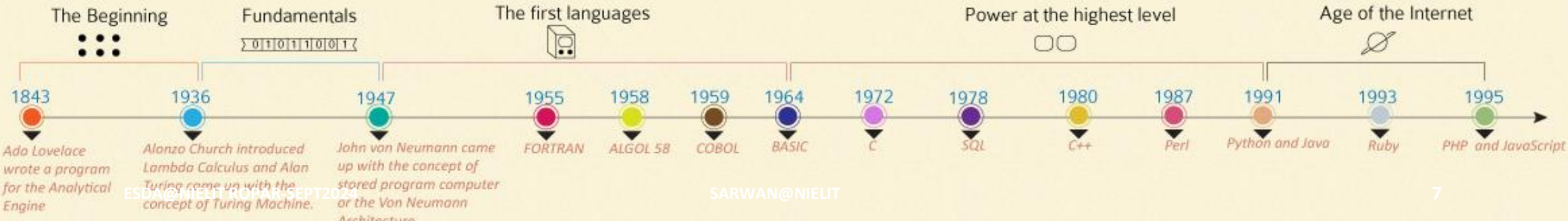
1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	

// 15 puzzle - A version of the classic n-puzzle

Bill Joy

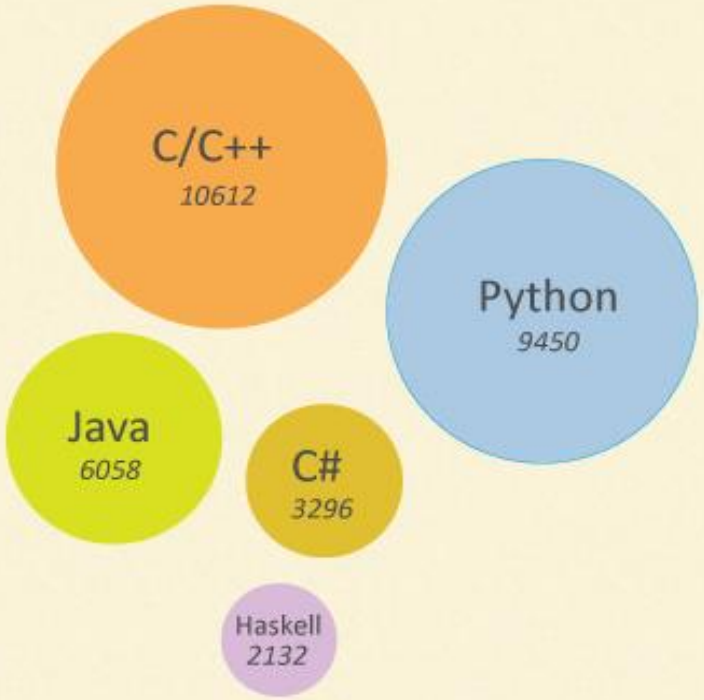
{He is the co-founder of Sun Microsystems and is also the creator of vi editor,csh and NFS. He was also a primary figure in the development of Java programming language}

Timeline



Project Euler

Project Euler is a series of challenging mathematical/computer programming problems. Following stat depicts the top five programming languages by most number of users.



StackOverflow

Stack Overflow is a website featuring questions and answers on a wide range of topics in computer programming. Following stat depicts the top three programming languages by most numbers of questions asked.

C# - 73906

```
using System;
class ExampleClass
{
    static void Main()
    {
        Console.WriteLine("Hello, world!");
    }
}
```

Java - 43034

```
public class HelloWorld {
   public static void main(String args[]) {
      System.out.println("Hello, world!");
   }
}
```

PHP - 35390

```
<?php
    echo "Hello World";
 ?>
```

Tiobe Index

The TIOBE Programming Community index gives an indication of the popularity of programming languages. The index is updated once a month. Following stat depicts the top three programming languages for April 2010.

Source: smashingmagazine.com

C Language

1960	Algol	• International Group
1967	BCPL	• Martin Richards
1970	B	• Ken Thomson
1972	Traditional C	• Dennis Ritchie
1978	K&R C	• kernighan & Ritchie
1989	ANSI C	• ANSI Commitee
1990	ANSI/ISO C	• ISO Commitee
1999	C99	• Standerd Commitee

- Creator of C Programming lang. and Creator of UNIX operating System
- 1941-2011
- Harvard Graduate

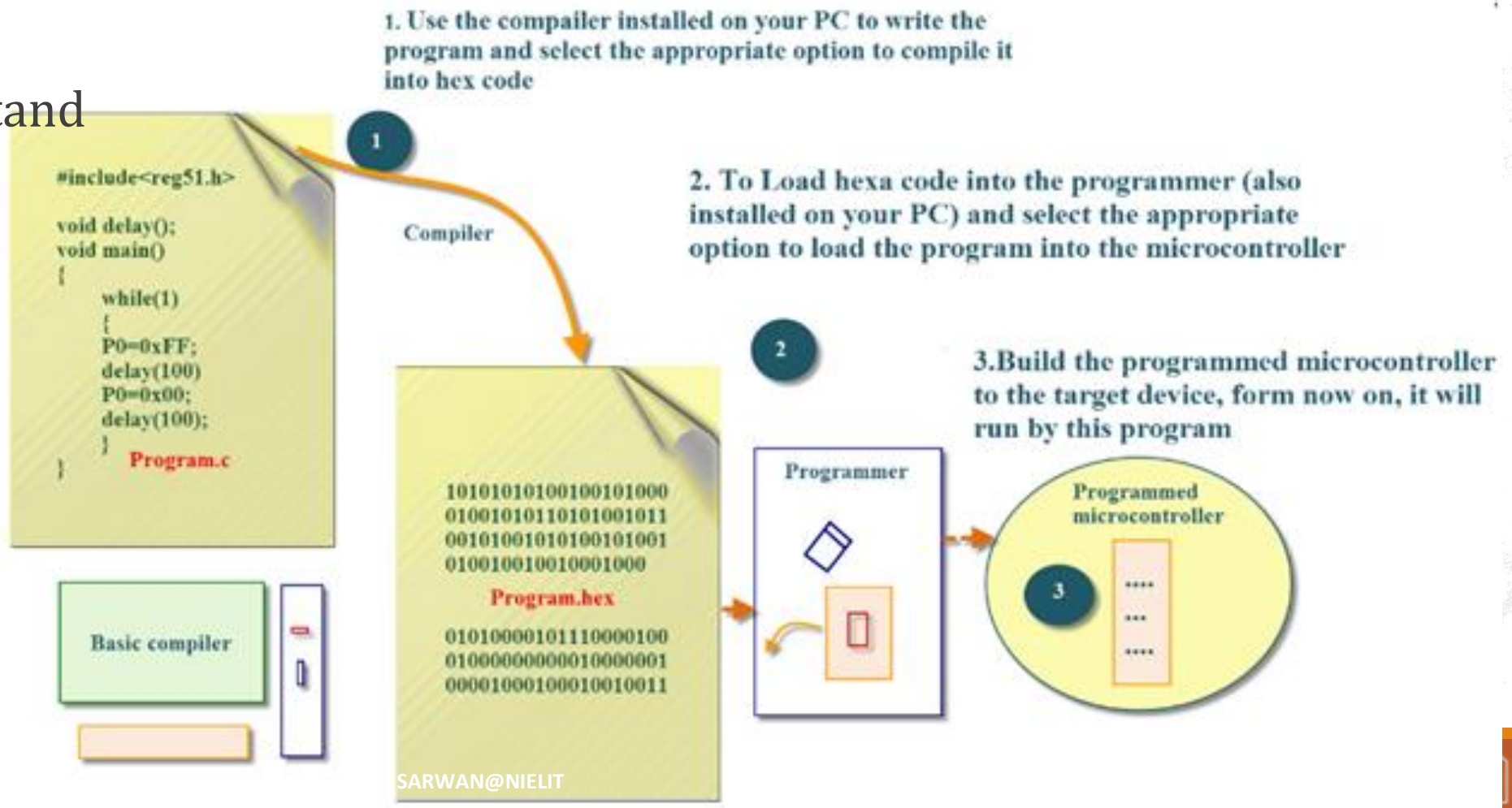
Dennis Ritche : With Ken Thompson (Creator of BCPL)

Embedded system programming

- Most embedded devices used by us, uses microcontroller that are programmed by embedded C

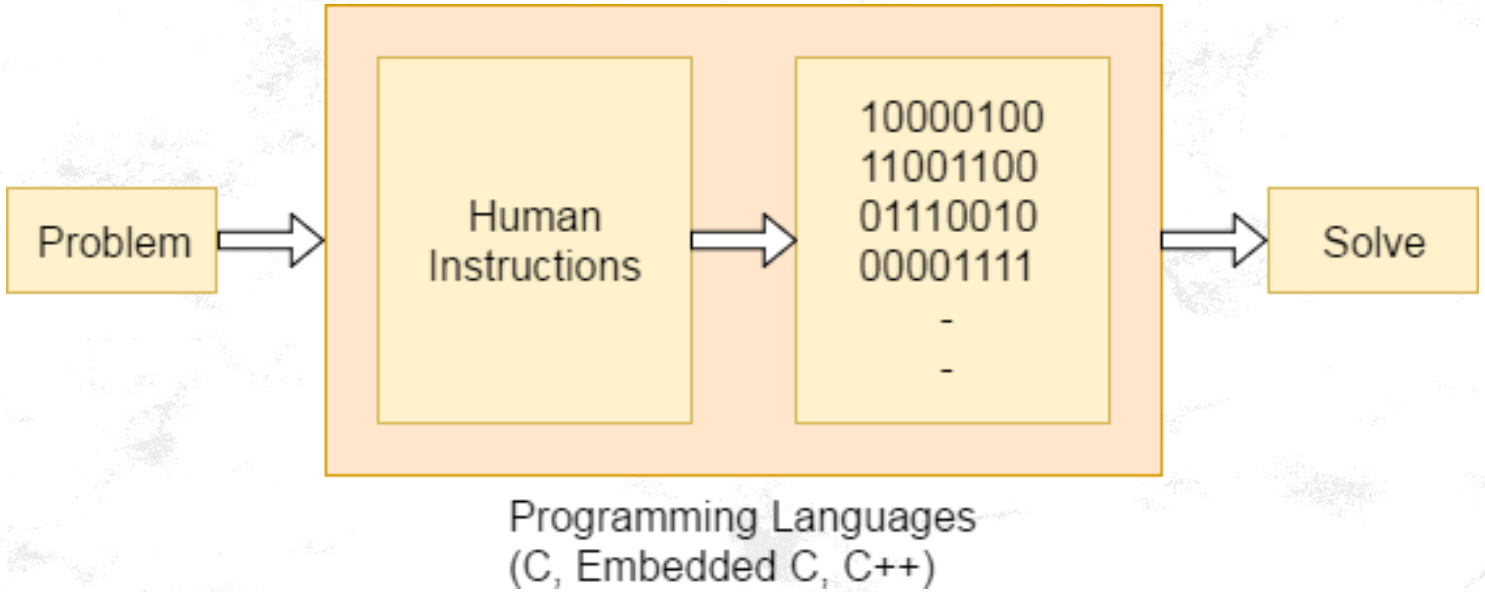
Advantages

- Easy to understand
- High Reliability
- Portability
- Scalability



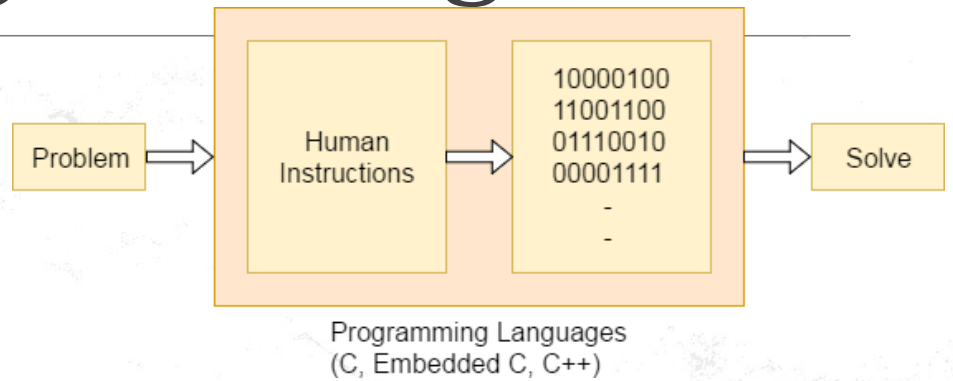
Embedded system programming

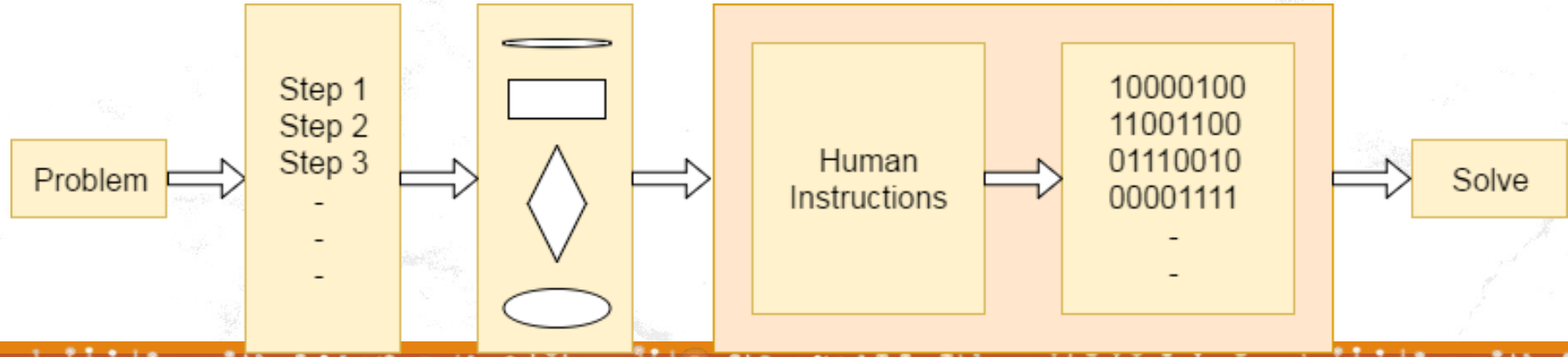
- block diagram of Embedded C Programming development
- The C language programming is designed for function with variables, character set, data types, keywords, expression and so on



Embedded system programming

The microcontroller programming is different for each type of operating system. Even though there are many operating system are exist such as Windows, Linux, RTOS, etc

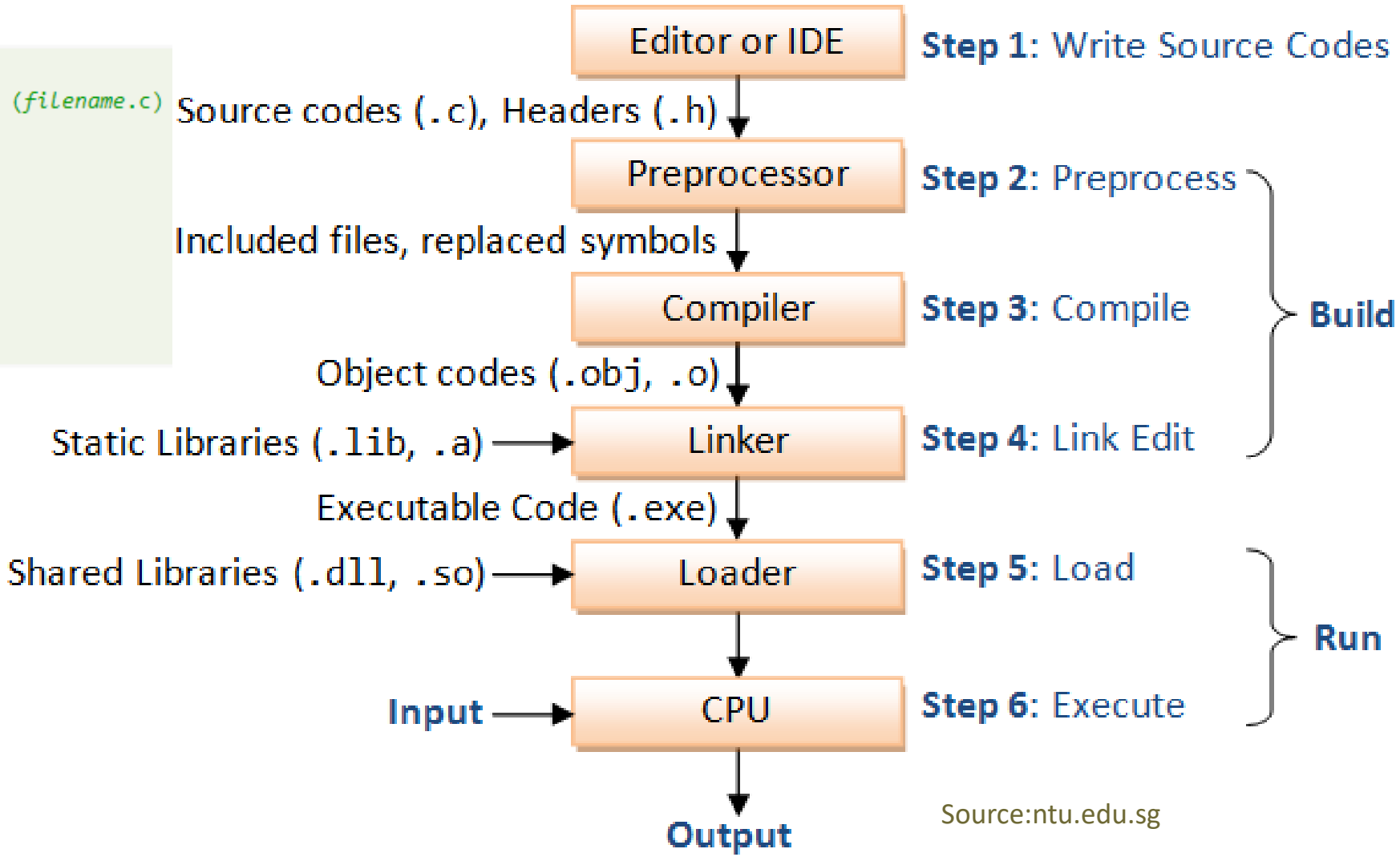




The Process of Writing a C Program

- Program template

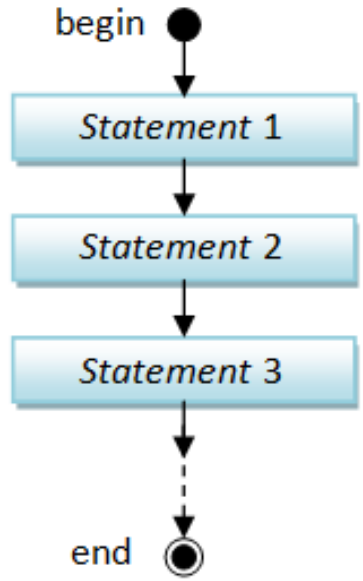
```c
/*
 * Comment to state the purpose of this program (filename.c)
 */
#include <stdio.h>

int main() {
   // Your Programming statements HERE!

   return 0;
}
```



Source:ntu.edu.sg

What is a program

- A *program* is *a sequence of instructions* (called *programming statements*), executing one after another - usually in a *sequential* manner, as illustrated in the previous example and the following flow chart.
- C is case sensitive language
- Each declaration statement is terminated with a semi-colon (;).
- In multiple-variable declaration, the names are separated by commas (,)



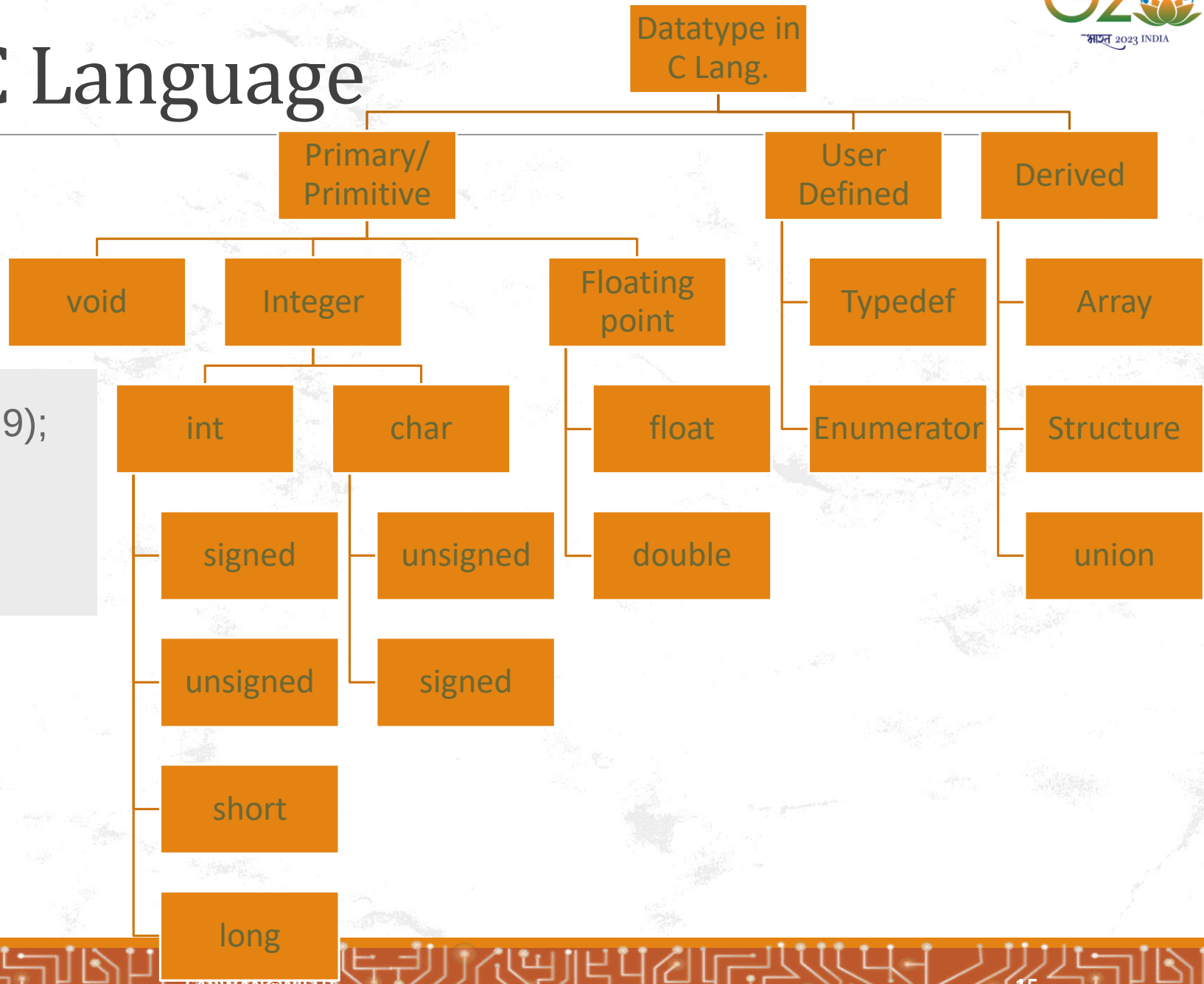
Sequential

Source:ntu.edu.sg

Datatype in C Language

```
typedef int numbers;
numbers a=1;
```

```
enum prime (2,3,5,7,11,13,17,19);
enum prime a,b;
a=5;
b=19;
```



Datatype in C Language

Data type	Size	Range	Description
char signed char	1 byte	-128 to 127	A character
unsigned char	1 byte	0 to 255	A character
short signed short signed short int	2 bytes	–32,767 to 32,767	Short signed integer of minimum 2 bytes
unsigned short unsigned short int	2 bytes	0 to 65,535	Short unsigned integer of minimum 2 bytes
int signed int	2 or 4 bytes	-32,768 to 32,767 or -2,147,483,648 to 2,147,483,647	An integer (Both positive as well as negative)
unsigned int	2 or 4	0 to 65,535 or 0 to	An unsigned integer

Datatype in C Language

Data type	Size	Range	Description
long signed long signed long int	4 bytes	-2,147,483,648 to 2,147,483,647	Long signed integer of minimum 4 bytes
unsigned long unsigned long int	4 bytes	0 to 4,294,967,295	Long unsigned integer of minimum 4 bytes
float	4 bytes	1.2E-38 to 3.4E+38	Single precision floating point number
double	8 bytes	2.3E-308 to 1.7E+308	Double precision floating point number
long double	12 bytes	3.4E-4932 to 1.1E+4932	Double precision floating point number

Qualifier-Modifier

- **register-** Local variable are stored in register instead of RAM
- **static** defined local variables do not lose their value between function calls.
- **typedef** used to create new type
- **extern** used to declare global variable
- **volatile** variable values might keep on changing without any explicit assignment by the program

Group	Qualifiers (Modifier)	Default Qualifiers (Modifier)
1	auto, register, static, extern, typedef	auto
2	signed, unsigned	signed
3	Short, long	Not Short, not long
4	Const	Not Const
5	Volatile	Not Volatile

Embedded c datatypes

- **sbit:** This data type is used in case of accessing a single bit of SFR register.
  - sbit a=P2^1;
- **Bit**: This data type is used for accessing the bit addressable memory of RAM (20h-2fh).
  - bit c;
- **SFR:** This data type is used for accessing a SFR register by another name. All the SFR registers must be declared with capital letters.
  - SFR port0=0x80;

Name	Funtion
sbit	Accessing of single bit
bit	Aceessing of bit addressable memory of RAM
sfr	Accessing of sfr register by another name

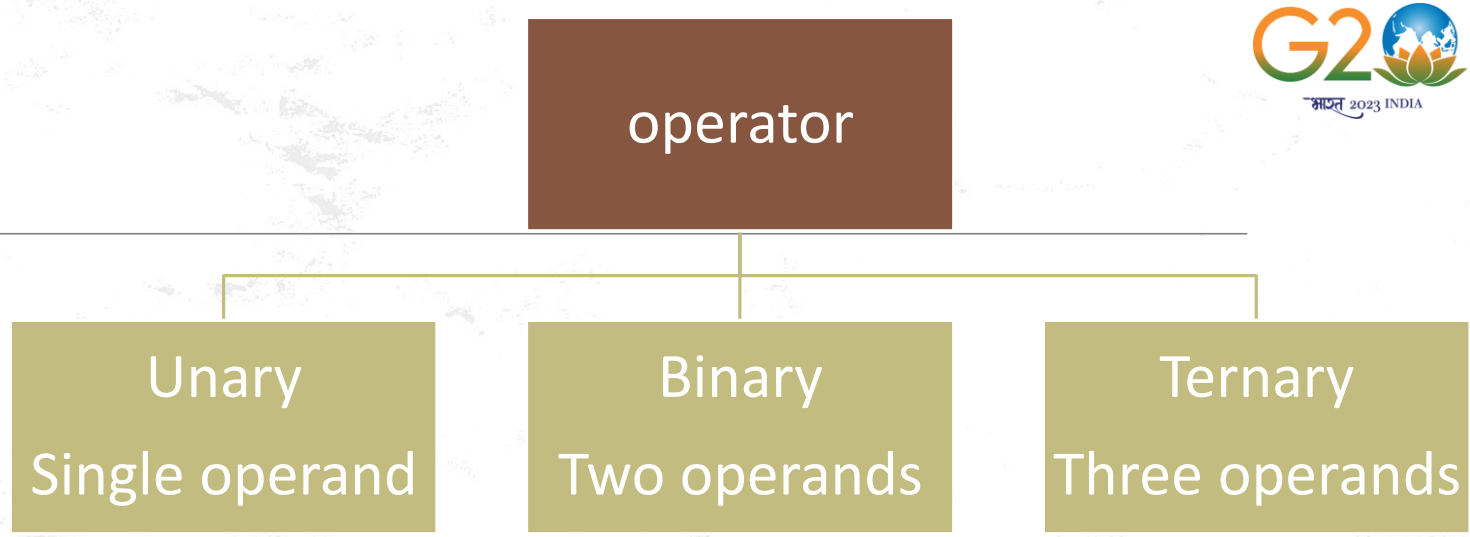
SFR Register: The SFR stands for **'Special Function Register'.**
Microcontroller 8051 has 256 bytes of RAM memory.
This RAM is divided into two parts:

- the first part of 128 bytes is used for data storage, and
- the other of 128 bytes is used for SFR registers.

All peripheral devices like I/O ports, timers and counters are stored in the SFR register, and each element has a unique address.

Source:elprocus.com

Operator

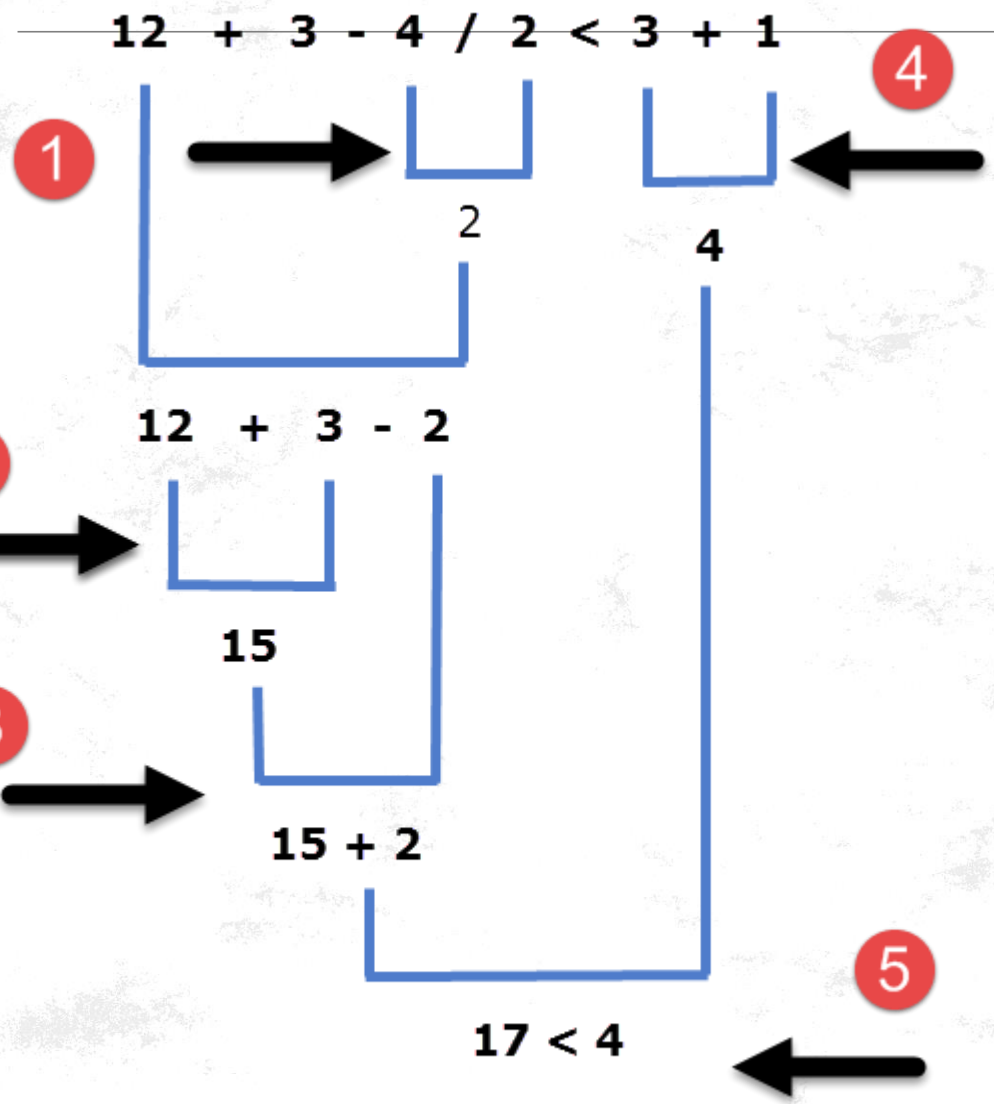


unary operator →	+ +, - -	Unary operator
Binary operator	+, -, *, /, %	Arithmetic perator
	<, <=, >, >=, ==, !=	Relational operator
	&&, ||, !	Logical operator
	&, |, <<, >>, ~, ^	Bitwise operator
	=, +=, - =, *=, /=, %=	Assignment operator
Ternary operator →	?:	Ternary or conditional operator

Precedence & Associativity

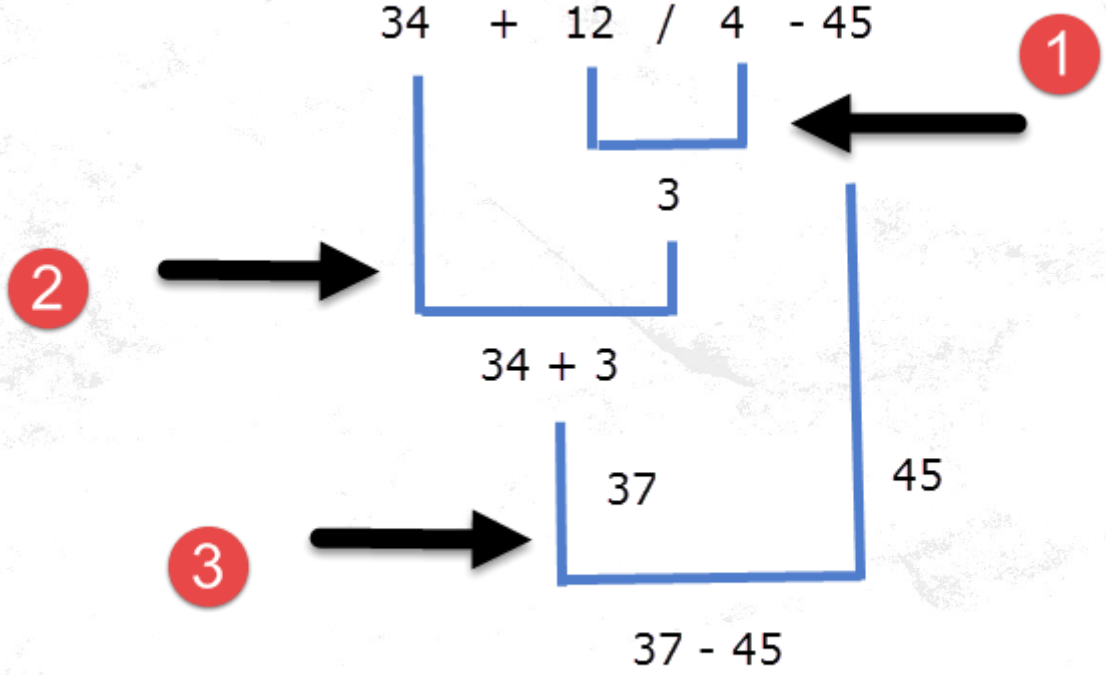
Operator	Description	Associativity
() [] . -> ++ --	Parentheses or function call Brackets or array subscript Dot or Member selection operator Arrow operator Postfix increment/decrement	left to right
++ -- + - ! ~ (type) * & sizeof	Prefix increment/decrement Unary plus and minus not operator and bitwise complement type cast Indirection or dereference operator Address of operator Determine size in bytes	right to left
* / %	Multiplication, division and modulus	left to right
+ -	Addition and subtraction	left to right
<< >>	Bitwise left shift and right shift	left to right
< <= > >=	relational less than/less than equal to relational greater than/greater than or equal to	left to right
== !=	Relational equal to and not equal to	left to right
&	Bitwise AND	left to right
^	Bitwise exclusive OR	left to right
|	Bitwise inclusive OR	left to right
&&	Logical AND	left to right
||	Logical OR	left to right
? :	Ternary operator	right to left
= += -= *= /= %= &= ^= |= <<= >>=	Assignment operator Addition/subtraction assignment Multiplication/division assignment Modulus and bitwise assignment Bitwise exclusive/inclusive OR assignment	right to left
,	Comma operator	left to right

= 12 + 3 - 4 / 2 < 3 + 1



Ans: 0

= 34 + 12/4 - 45



Ans : -8

Bitwise operator

- Bitwise AND operator &
- Bitwise OR operator |
- Bitwise XOR operator ^
- Bitwise complement operator ~
- Bitwise left shift operator <<
- Bitwise right shift operator >>

Bitwise operator

Write a C program using bitwise operator

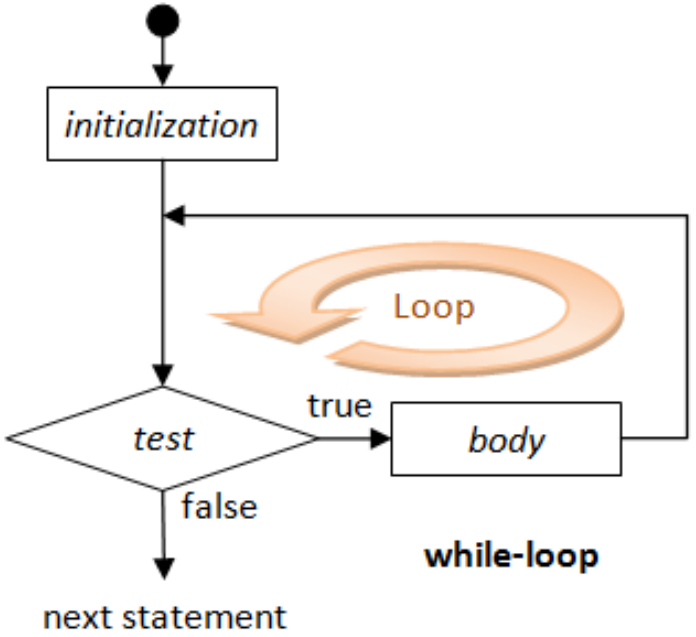
- to check Least Significant Bit (LSB) / Most Significant Bit (MSB) of a number is set or not.
- to get / set nth bit of a number.
- to clear nth bit of a number.
- to toggle nth bit of a number.
- to get highest / lowest set bit of a number.
- to count trailing / leading zeros in a binary number.
- to flip bits of a binary number using bitwise operator.
- to count total zeros and ones in a binary number.
- to convert decimal to binary number system using bitwise operator.
- to swap two numbers using bitwise operator.
- check whether a number is even or odd using bitwise operator.

Loop – *to perform repetitive task*

```
initialization-statement;
while (test) {
   loop-body;
}
next-statement;
```

Other variants :

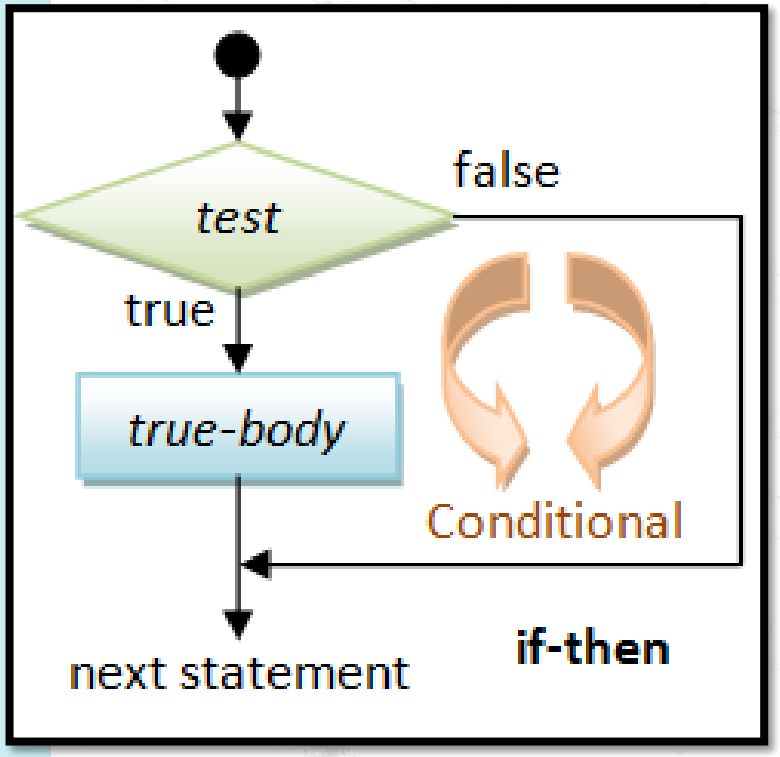
```
do {   ....  } while (condition )
for( initialization ; condition ; inc/dec) {  ....}
```

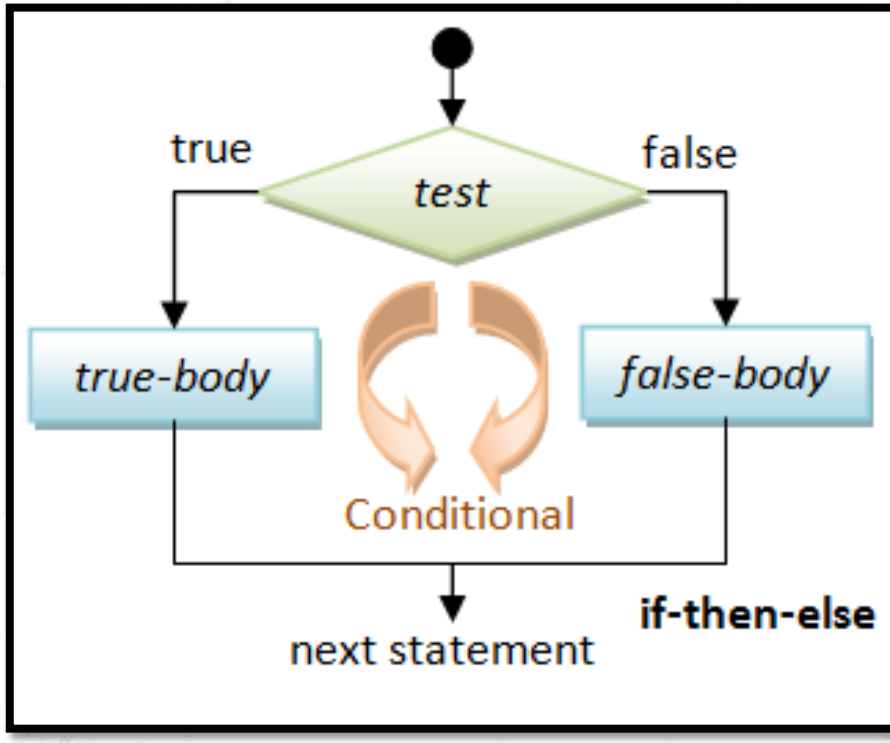


Source: ntu.edu.sg

Control statement - *conditional (or decision)*

```
// if-then
if ( test )
{ true-body; }
// if-then-else
if ( test )
{ true-body; }
else
{ false-body; }
```





Other variant

- switch case

Function / method

- Reduces code duplication
- Repetitive task can be represented in form of method
- Make code modular
- provide abstraction

```
// A function that takes two integers as
// parameters and returns an integer
int max(int, int);

// A function that takes a int pointer and an
//int variable as parameters
// and returns an integer of type int
int *swap(int*,int);

// A function that takes a char and an int as
// parameters and returns an integer
int fun(char, int);
```

question

- Write a one line C function to round floating point numbers

```
int roundNo(float num)
{
    return num < 0 ? num - 0.5 : num + 0.5;
}
```

Header files

- Header file is a file that contains function declaration and macro definition for C in-built library functions.
- All C standard library functions are declared in many header files which are saved as file_name.h.