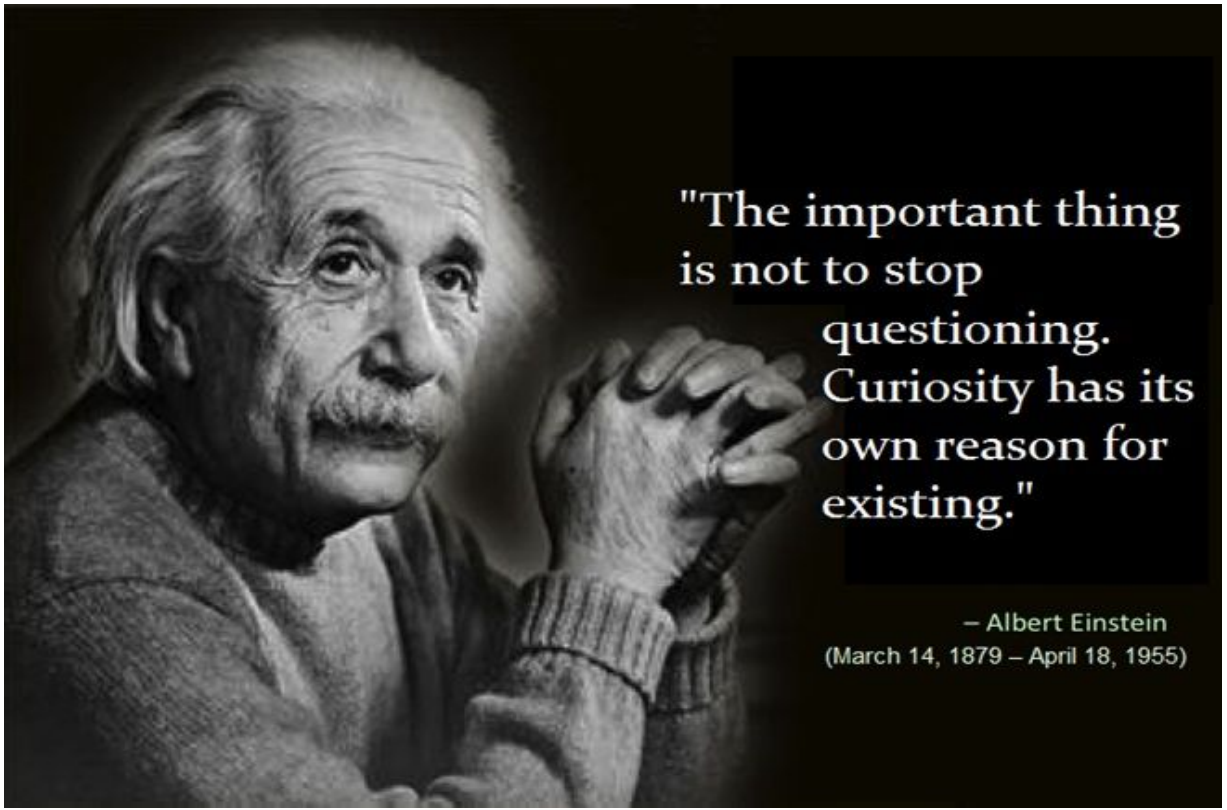
Counting to Computing

Jaynarayan T Tudu
Computer Science and Engg
IIT Tirupati

Our Curiosity: We want to solve problem



When we see a bird we say there is one bird!

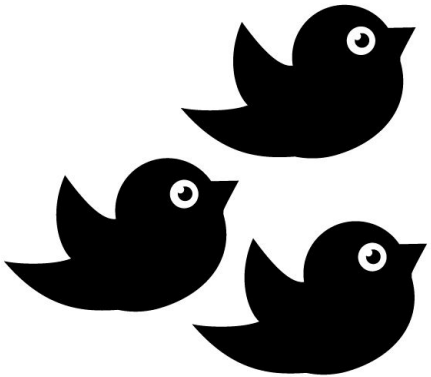
When we see two birds…… three birds…. four birds…. five birds….. 99 birds….

What are we doing?

Counting!

Our Curiosity: We want to solve problem

When we see something like this…. We often start to think in terms of number, how many birds?



3 + 2 = 5

Calculate!

Calculation/Counting: How easy it is?

1 + 2 = ?
3 + 4 = ?
7 + 8 = ?
15 + 16 = ?
31 + 32 = ?
63 + 64 = ?
127 + 128 = ?
255 + 256 = ?
511 + 512 = 1023
……
……
……

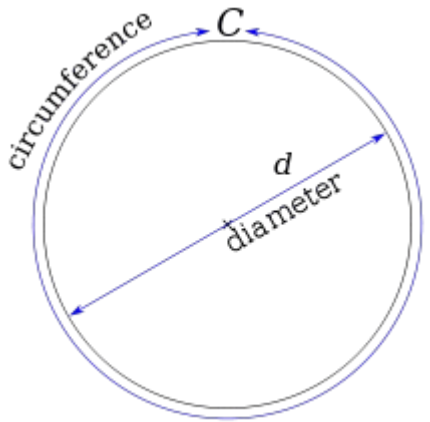
How many minutes u need?

2^n - 1 + 2^n = ? for n = 20

2^20 - 1 + 2^20 = ?

(1024 * 1024) -1 + (1024 * 1024) = ?

Little difficult in terms of time!



C = pi * d

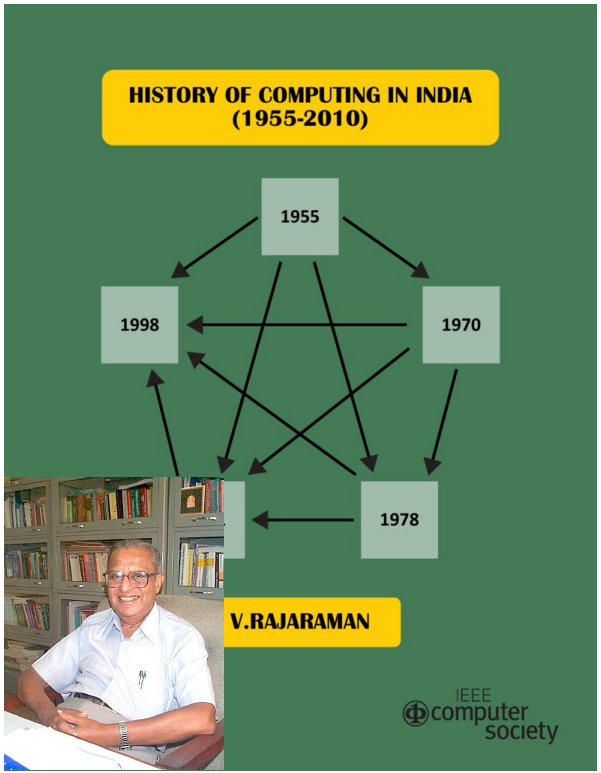
3.14159 26535 89793 23846 26433
83279 50288 41971 69399 37510
58209 74944 59230 78164 06286
20899 86280 34825 34211
7067……
……still computing

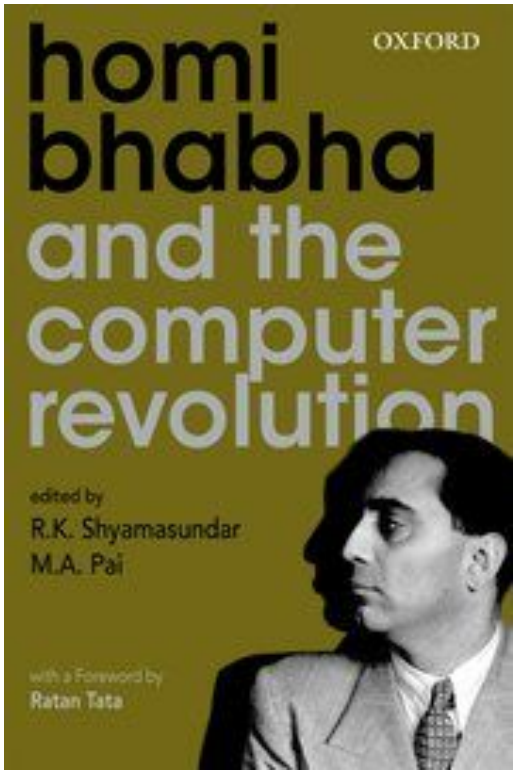
Need of Machine: How it started?

2400 BC:
Abacus was used by Babylonians for +, -.

1642: Pascaline, invented by Blaise Pascal to help his father for tax accounting.

History of Computing in INDIA





The three Cs

Counting

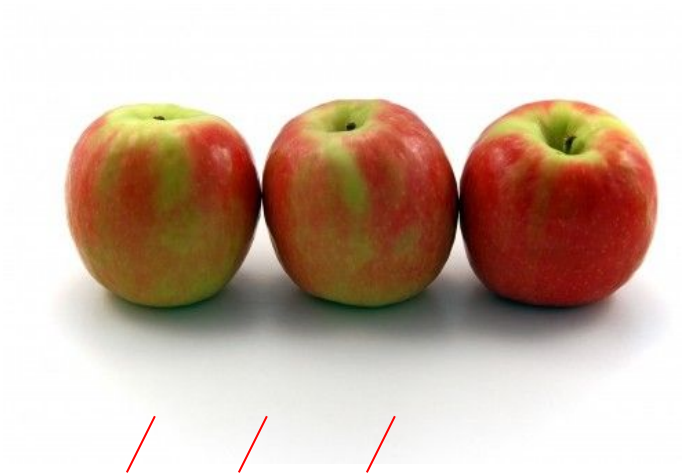
Calculating

Computing

Next is for YOU?

Trails of Computing Mind: thoughts of modern computer

+



5

1936: A-Machine

R/w first-number : [*] * + * * * { 0}

R/w -first-number : * [*] + * * * { 1}

R/w first-number : * * [+] * * * { 2}

R/w second-number: * * * [*] * * { 3}

R/w second-number: * * * * [*] * { 4}

R/w second-number: * * * * * [*] { 5}

R/w second-number: * * * * * *[_] { 6}

Override-last-* : * * * * * [*] _ { 7}

R/w beginning : * * * * [*] _ _ { 8}

R/w beginning : * * * [*] * _ _ { 9}

R/w beginning : * * [*] * * _ _ {10}

R/w beginning : * [*] * * * _ _ {11}

R/w beginning : [*] * * * * _ _ {12}

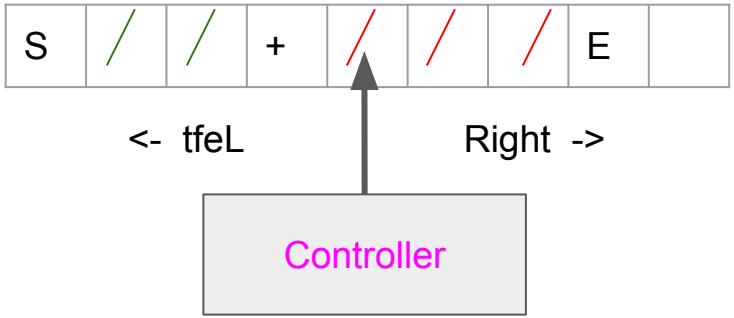
R/w beginning : [_] * * * * * _ _ {13}

HALT : _[*] * * * * _ _ {14}

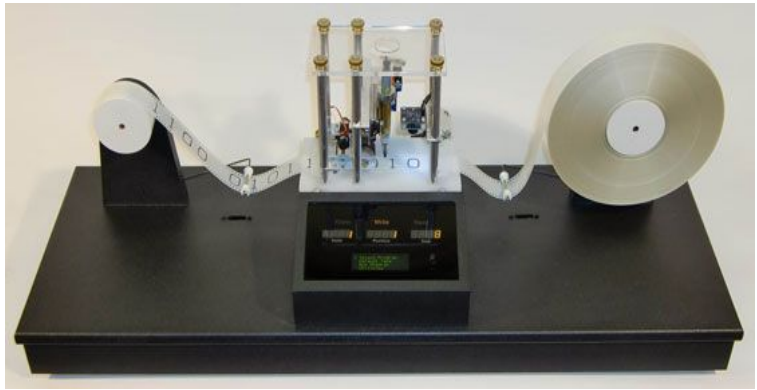
Alan J Turing (Mathematician and Computer Scientist)

Turing Machine (A-Machine)

Someone who can store: We call it Tape



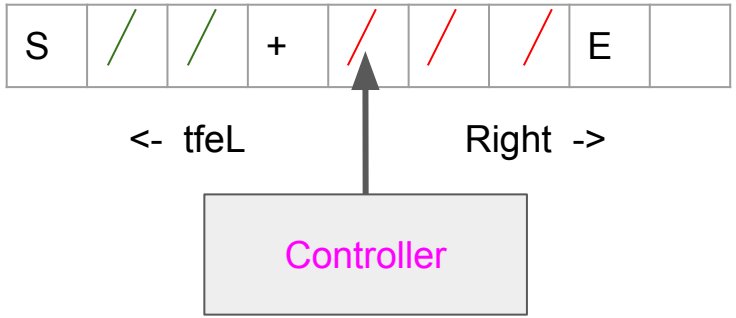
Theoretical Description of Turing Machine



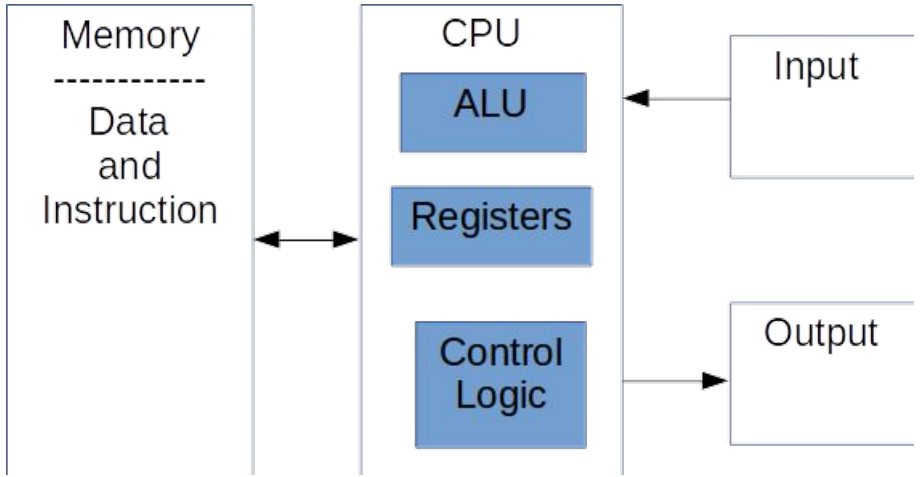
Physical Implementation of Turing Machine
Image source: http://aturingmachine.com/

1945: von Neumann Architecture

Someone who can store: We call it Tape

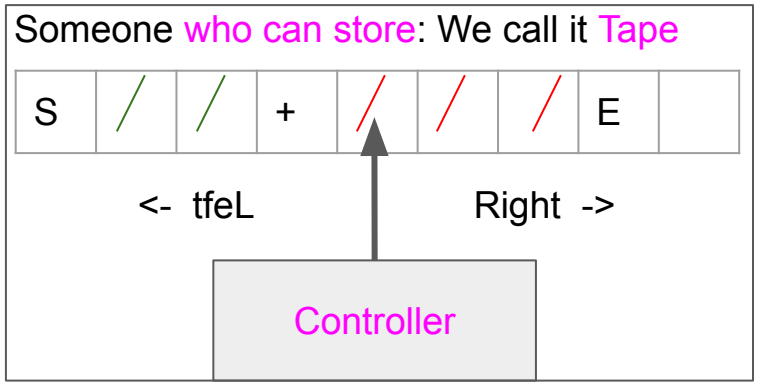


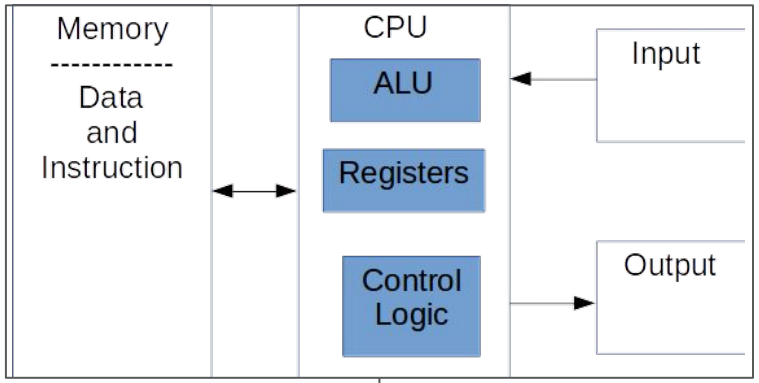
Turing Machine



Memory, Register	Tape
Control Logic	Controller (FSM)
Data and Instruction	Symbols
Arithmetic and Logic Unit	Addition (+) etc...

The Two Ideas





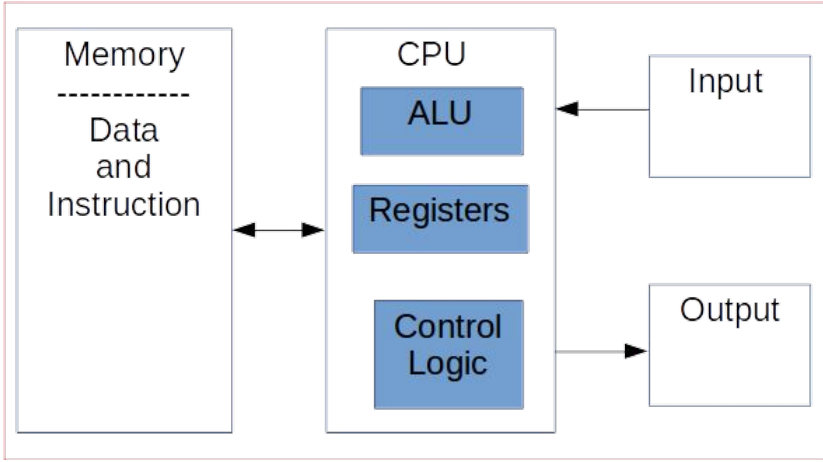
Theory
of Computer Science

System
of Computer Engg

Software
of Computer Engg

Hardware
of Computer Engg

The Next Set of Thoughts...



von Neumaan Architecture
(Princeton Architecture)

Stored Program Concept

HOW the storing and programing can be performed in physical machine

First requirement:
Representation of Data or Information

Data Representation

The human way:

Decimal system [0, 1, 2, 3, 4, 5, 6, 7, 8, 9]

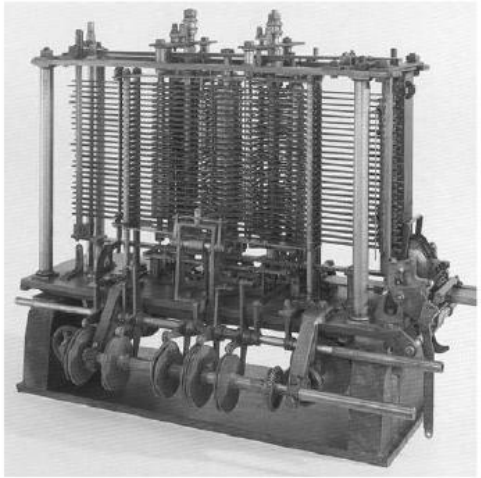
The possible operations:

+, - , * , / etc…..

The Difficulty:

It was very difficult to represent the 0 - 9 digits physically.

Therefore, people needed a much simpler representation



1871: Analytical Engine
(based on decimal system)

Who designed?

Binary System - Digital System

The Binary System and Boolean Algebra

Use only two things and represents the whole universe! (the physical world has duality).

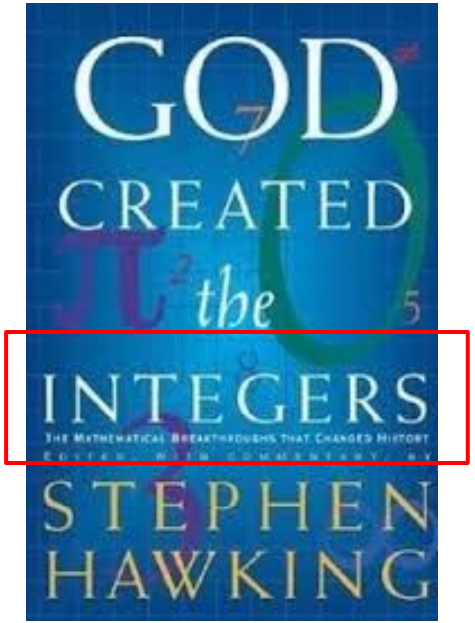
Lets the two things be: 0 and 1

Integers in decimal:

0	10	20	30 …….. 90
1	11	21	31 ……
2	12	22	32
3	13	23	33
4	14	24	34
5	15	25	35
6	16	26	36
7	17	27	37
8	18	28	38
9	19	29	39……..99

Integers in binary:

0	10	100	1000	…….
1	11	101	1001	
		110	1010	
		111	1011	
			1100	
			1101	
			1110	
			1111	……..



The Binary System and Boolean Algebra

How to perform operations?

2 + 3 = 5

10 + 11 = 101

```
  1 0   +
  1 1
-------
  1 0 1
```

Similarly other operations can be performed!

Integers in decimal:

0	10	20	30 …….. 90
1	11	21	31 ……
2	12	22	32
3	13	23	33
4	14	24	34
5	15	25	35
6	16	26	36
7	17	27	37
8	18	28	38
9	19	29	39……..99

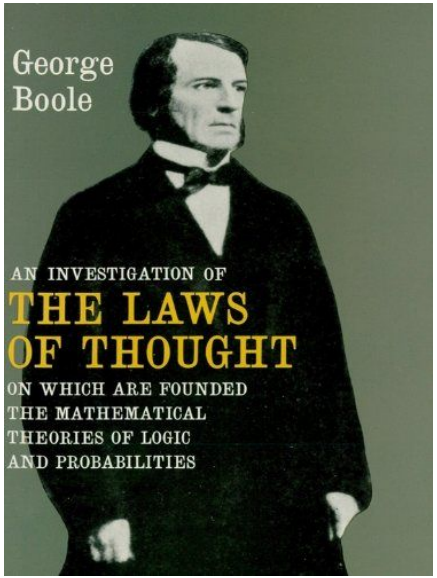
Integers in binary:

0	10	100	1000	…….
1	11	101	1001	
		110	1010	
		111	1011	
			1100	
			1101	
			1110	
			1111	……..

The Binary System and Boolean Algebra

Two questions:

1) How do we represent ZERO and ONE physically?
2) How do we perform operations?



George Boole, The laws of thought.

ZERO - FALSE - OFF - OPEN

ONE - TRUE - ON - CLOSE

AND OR NOT

XOR NOR NAND XNOR

Input	Output
A	A′
0	1
1	0

The Binary System and Boolean Algebra

One questions:

1) How to map logical operation with arithmetic operations?

ADDITION
SUBTRACTION

MULTIPLICATION
DIVISION

AND OR NOT

XOR NOR NAND
XNOR

Arithmetic

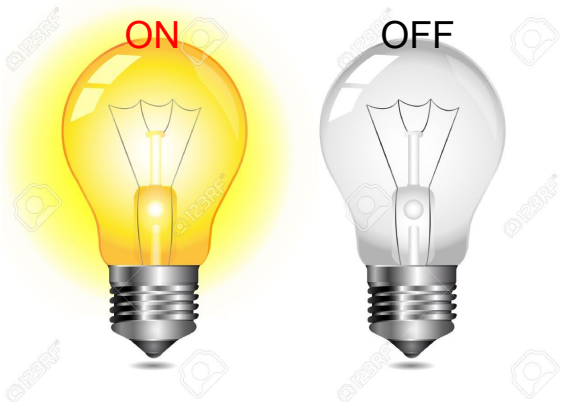
Logic

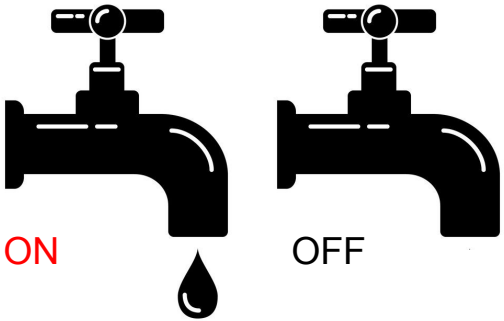
Truth Table			
Input		Output	
A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

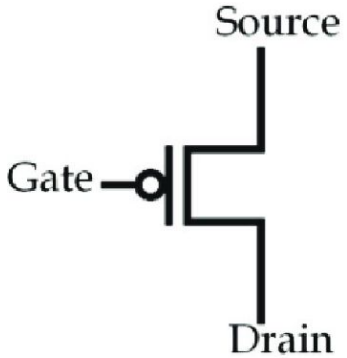
Example: Addition of two bits

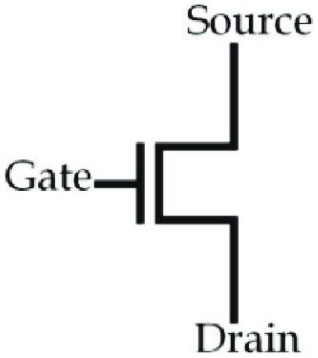
Arithmetic and logic unit (ALU)

Binary System | Boolean Algebra | Device



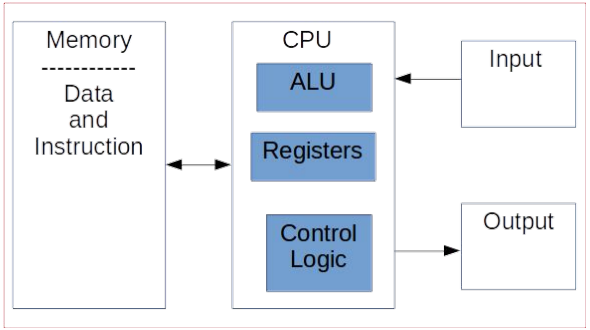




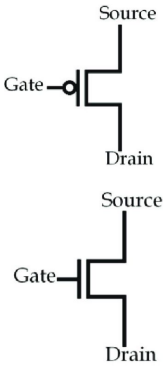


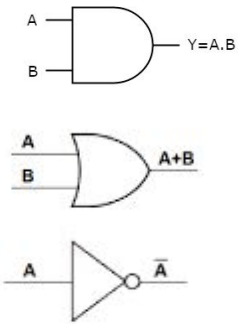
From Device to von Neumaan Architecture

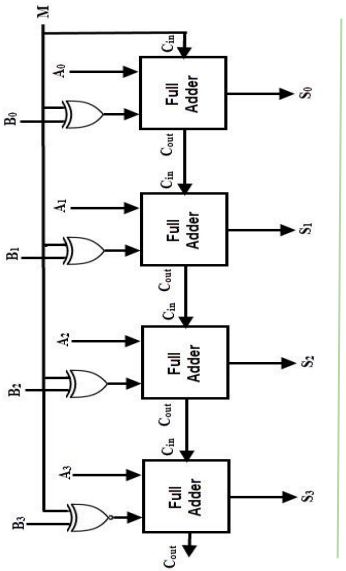
Goal: to build a computer



Transistor -> Gates -> Component -> System







Von Neumaan kind of machine

How to Talk with the Machine!

How do you talk with a Chinese friend?

Scenario 1:

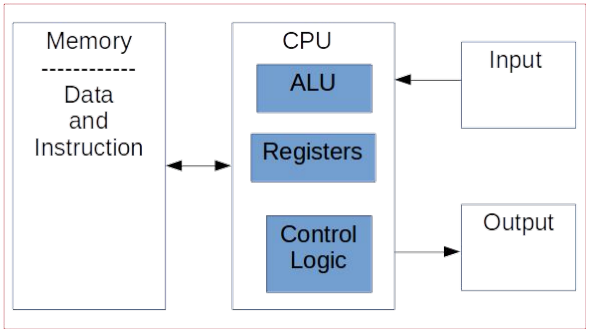
Balaji: Only Telugu
Tiang: Only Chinese

Solution: Baltiang: Telugu + Chinese

Third person

Computer understand only ZEROs and ONEs

How to Talk with Machine



01010
10101

Programming
Language

Telugu
Sanskrt
English

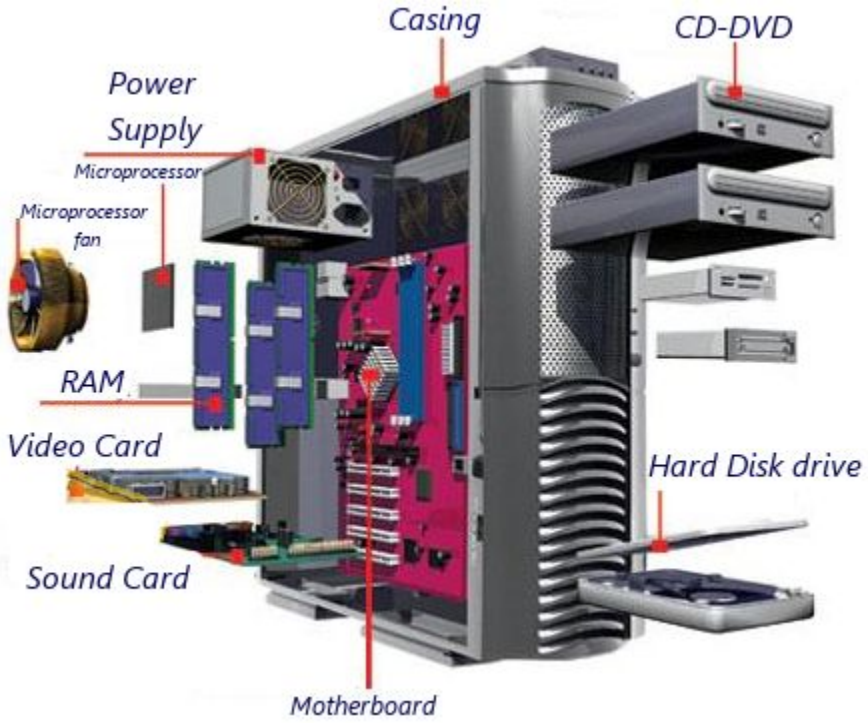
The Modern Computer: Outside

A computer system is fitted with several Components.

- CPU
- Monitor, touch screen
- Keyboard
- Smart pad
- Audio devices
- Printer, Scanner, Camera

- Magnetic Disk, Pendrive, External HD
- There could be many more…..

The Modern Computer: Inside

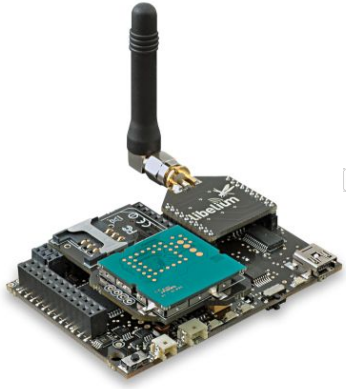


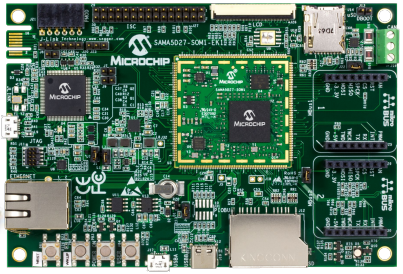
My suggestion for your purchase:

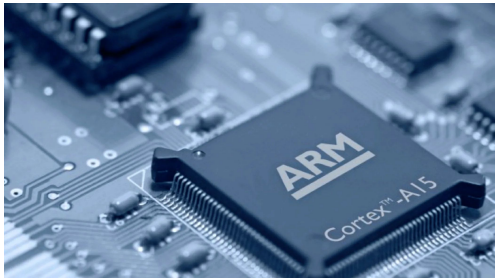
- Go for a Laptop
- Price range: 30K - 70K
- Processor: Intel i5 - i7
  (Don't go for i9)
- : AMD A series A6-A8
- : ARM Cortex A series
- Clock: 1.4 GHz - 3 GHz
- (risky to go for 4GHz)
- RAM (DDR4, 8 - 16GB)
- Hard Disk: 500 GB is enough
- Battery: removable with 8 - 10 hrs backup.

The Bigger and Smaller: Variety of system

From micro-controller to super-computer!







Summit has 4,356 nodes, Each Node = Two 22-core **Power9** CPUs,

Graphics: six **NVIDIA Tesla V100 GPUs**

Each V100 **= 640 Tensor Cores**
+ 5120 CUDA cores

most cases: users are from non-computer science background.

The Bigger and Smaller

Why so many different computers?

Explosion modeling

Fluid dynamics

Biomedical imaging: optical tomography with finite elements

Physics: relativity

Regional ocean modeling

Molecular dynamics

Home Appliances

Weather forecasting

Social Networking

Road traffic

Data collection (surveillance camera)

You Tube

The Current Status: World, India and IITT

- Better and faster is the human need! (need of research)
- World is looking for Quantum Computer
- AI and Machine Learning! (at least once in a day you will hear abt this)
- To explore Neuromorphic Computer

- India needs own Computing capabilities
- Example: Shakti processor is developed indigenously at IITM
- And, IIT Tirupati certainly need to contribute for India

Suggestions

Everyone must learn to use some computer :)

Every one must learn Programming: C/C++ and Python

Good programmer: C/C++, Python + Data Structure and Algorithm

Very Good programmer: Good Programmer + Computer Architecture

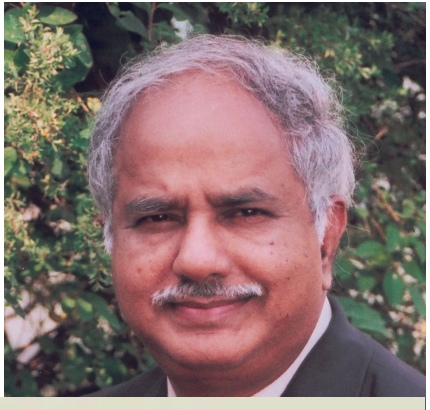
Very very good programmer: Do BTech in Computer Science :)

Suggestions

Online Learning:

- Participate in online competitions
- Credit online courses
- Join online group discussion
- Subscribe to online technical journals and news
- Keep track of various events in other IITs as well as around the world university.
- For any thing else talk with your seniors and faculty advisor or to any faculty you find in corridor

Career and Future



Career and Future

We have plenty of place to work….

You can create more….

The world

of Computer Science and Engineering