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?

"The important thing is not to stop questioning. Curiosity has its own reason for existing."

— Albert Einstein

(March 14, 1879 – April 18, 1955)

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 \times 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

Computing

Calculating

Next is for YOU?
Trails of Computing Mind: thoughts of modern computer
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

\[
\begin{array}{ccccccc}
S & / & / & + & / & / & E \\
\end{array}
\]

<- tfeL Right ->

Controller

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

S / / + / / E

<s>- tfeL</s> Right <=>

Controller

Turing Machine

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

Someone who can store: We call it Tape

S+E

<- tfeL  

Controller

---

Theory of Computer Science

System of Computer Engg

Software of Computer Engg

Hardware of Computer Engg

-----

Memory
Data and Instruction

CPU
ALU
Registers
Control Logic

---------

Input

Output
The Next Set of Thoughts...

von Neumann 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

Binary System - Digital System

1871: Analytical Engine (based on decimal system)

Who designed?
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

<table>
<thead>
<tr>
<th>Integers in decimal:</th>
<th>Integers in binary:</th>
</tr>
</thead>
<tbody>
<tr>
<td>0  10  20  30 ......... 90</td>
<td>0  10  100  1000 .........</td>
</tr>
<tr>
<td>1  11  21  31 .........</td>
<td>1  11  101  1001</td>
</tr>
<tr>
<td>2  12  22  32</td>
<td>110  1010</td>
</tr>
<tr>
<td>3  13  23  33</td>
<td>111  1011</td>
</tr>
<tr>
<td>4  14  24  34</td>
<td>1100</td>
</tr>
<tr>
<td>5  15  25  35</td>
<td>1101</td>
</tr>
<tr>
<td>6  16  26  36</td>
<td>1110</td>
</tr>
<tr>
<td>7  17  27  37</td>
<td>1111 .........</td>
</tr>
<tr>
<td>8  18  28  38</td>
<td></td>
</tr>
<tr>
<td>9  19  29  39 ......... 99</td>
<td></td>
</tr>
</tbody>
</table>
The Binary System and Boolean Algebra

How to perform operations?

2 + 3 = 5

10 + 11 = 101

\[
\begin{array}{c}
10 \\
+ \\
11 \\
\hline
101
\end{array}
\]

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.

<table>
<thead>
<tr>
<th>ZERO</th>
<th>FALSE</th>
<th>OFF</th>
<th>OPEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>ONE</td>
<td>TRUE</td>
<td>ON</td>
<td>CLOSE</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AND</th>
<th>OR</th>
<th>NOT</th>
<th>XOR</th>
<th>NOR</th>
<th>NAND</th>
<th>XNOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

George Boole
The Binary System and Boolean Algebra

One question:
1) How to map logical operation with arithmetic operations?

<table>
<thead>
<tr>
<th>Arithmetic</th>
<th>Logic</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADDITION</td>
<td>AND</td>
</tr>
<tr>
<td>SUBTRACTION</td>
<td>OR</td>
</tr>
<tr>
<td>MULTIPLICATION</td>
<td>NOT</td>
</tr>
<tr>
<td>DIVISION</td>
<td>XOR</td>
</tr>
<tr>
<td></td>
<td>NOR</td>
</tr>
<tr>
<td></td>
<td>NAND</td>
</tr>
<tr>
<td></td>
<td>XNOR</td>
</tr>
</tbody>
</table>

Arithmetic and logic unit (ALU)

Truth Table

<table>
<thead>
<tr>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Example: Addition of two bits
Binary System | Boolean Algebra | Device
From Device to von Neumaan Architecture

Goal: to build a computer

Transistor -> Gates -> Component -> System
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

Computer understand only ZEROs and ONEs

Telugu
Sanskrt
English

01010
10101
How to Talk with Machine

01010
10101
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
- Physics: relativity
- Molecular dynamics
- Social Networking
- Fluid dynamics
- Home Appliances
- Regional ocean modeling
- Weather forecasting
- Data collection (surveillance camera)
- You Tube
- Biomedical imaging: optical tomography with finite elements
- Road traffic
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

You can create more....

We have plenty of place to work....
The world of Computer Science and Engineering