# Application of Electronics in Modern Computer Science

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***Abstract:*** The chip design of CPU was majorly started by MSI chip at an early stage of development gradually it moved towards VLSI. Major fields developed due to impact of electronics in computer science are Computer Organization and Architecture. CMOS circuit which has been used in CPU has become an old concept and getting replaced by Memristor Crossbar a futuristic concept. In digital electronics, NAND flash memory has been default storage component in embedded system. Cache Memory is one of the important part of computer and flash memory is the backbone of it .Shortage of space in circuit led to the development of nanotechnology which is widely used now. IoT (Internet of Things) is the next big thing in future and asynchronous circuits are becoming increasingly important in this system design for IoT.

***Index Terms:*** Memristor Crossbar, IoT, CMOS improvisation using Machine Learning

## I. Introduction

The development of computer science industry was totally guided by the electronics industry. The digital circuit and central processing unit developed from the aspects of Very Large Scale Integration (VLSI) to digital design and computer organization and architecture. Logic gates are also used in this .CMOS can be designed with using different voltages using the traditional 5 V to low power CMOS (3.3V, 2.5V, 1.8V). [1]

In modern field CMOS technology is fading away due to challenges felt such as saturated performance gain, increased leakage power consumption. CMOS computers are suffering from memory bottleneck. To address this difficulties many alternative technology has been checked and among them Memristor Crossbar is the most promising among them seeing in terms of scalability, high integration density and non volatility etc. [2]

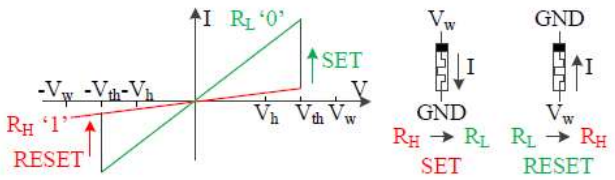



Fig. 1: Ideal Memristor Model.

Source: Xei, Hoang Anh Du Nguyen, Mottaqiallah Taouil, Said Hamdioui, Koen Bertels, 2017

NAND- flash- based mobile device have gained a ground in the recent past. Flash translation layer (FTL) is proposed to translate logical page number (LPNs) into physical page numbers (PPNs) due to erase-before-write constraint. Embedded flash storage device are equipped with very limited embedded RAM because of hardware budget and power consumption. [3]

The extensive use of computer and shortage of space led to the development of nanotechnology. Using nanotechnology we can design and manufacture electronic components and devices that can used to build smaller and faster computer. [4]

In the period of ever increasing transistor integration coupled circuits high power density and temperature is creating a huge impact on cores of chip problems leading to temperature hotspots. This effect can slow down current performance speed and scaling generations. Thus nowadays modern techniques are used to eliminate this problem and Machine Learning (ML) technique is most beneficial. [5]

Internet-of-Things (IoT) is now the technical backbone of smart cities envisioned to cope up with the rapid urbanization. IoT is build using various components including electronics, sensors, actuators, controller, network etc. But the current existing electronics can't cope up with the complexity of the IoT circuits. The existing Computer Aided Design (CAD) or electronic automation system are not enough to meet diverse challenges. The development of real time and ultralow power plays an important role. [6]

**II. Detailed Study**

A mapping methodology of Boolean logic circuit on memristor crossbar to enable the implementation of large logic circuit for multi bit adder. Some of the targets to introduce Memristor crossbar in place of CMOS circuit are as follows:

- Using Memristor crossbar to enable large scale logic circuits.
- Design of CMOS peripheral circuit which act as the control engine.
- To optimize area, delay, power consumption.

Here Boolean logic has been proposed for the working then the implementation of the primitive logic operator is given to build one full-bit adder.

*A. Memristor Model*

The memristor model has 2 resistive states that is High ($R_H$) and Low ($R_L$) resistive states. The memristor switches from one state to another when the absolute value of the voltage across device is greater than threshold voltage $V_{th}$, otherwise it stays in the previous state. It requires two different states from low to high resistance (RESET) and high to low (SET).

B. *Working Principle of Boolean Logic*

The Boolean Logic design is implemented to solve logic function using format of sum-of-product. Where $m_i$ is the minterm and n is the (i.e., $\bar{f} = m_1 + \cdots + m_i + \cdots + m_n = \overline{m_1 \cdot \cdots \cdot m_i \cdot \cdots \cdot m_n}$) number of minterms. By ANDing all the NAND gates which consist of multiple memristor crossbars the output f is obtained. The input and output latches are composed of several memritors depending on number of input and output.

Memristor-based logic design requires a CMOS circuit to control the crossbar part there are 7 states and discussed below.

- INA: Initialize all the memristor to $R_H$. This state requires RESET operation.
- RIN: Receive Inputs , these state requires SET,RESET, or copy operators
- CFM: Configure all the minterms state. All the minterms are configured simultaneously using copy operation.
- EVM: Evaluate all minterms state it's evaluated by NAND operation.
- GER: Generate Result, these state needs and AND operation.
- INR: Invert result state
- SOU: Send Output state here results are stored and copy operation employed. [7]

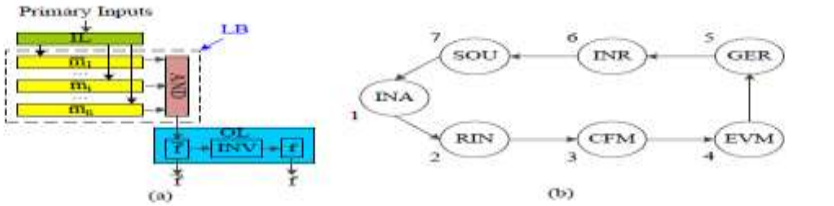



Fig. 2: Working Principle of Boolean Logic: (a) Computing Element, (b) State Machine.

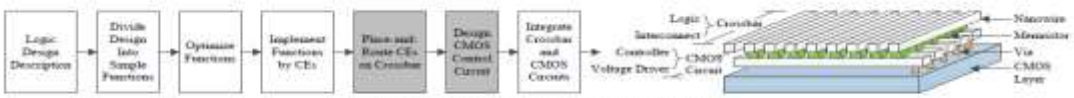


Fig. 5: Mapping Flow and Implementation.

Source: Xei, Hoang Anh Du Nguyen, Mottaqiallah Taouil, Said Hamdioui, Koen Bertels, 2017

NAND based storage device have been widely deployed in various computing systems. It gives the additional advantage over traditional hard-disks in terms of superior performance and shock resistance. A flash drive cannot be overwritten until and unless residing block has been erased. It occurs due to erase-before-write constraint. Lowering of free pages free pages faced a shortage and garbage collection gathers there and it has a negative impact on the storage.

In the digital world the capacity of flash storage is increasing exponentially with limited RAM becoming a challenge. To reduce the space –overhead problem, map caching schemes are proposed.

A. *Performance Model*

1) *Storage Access Time*

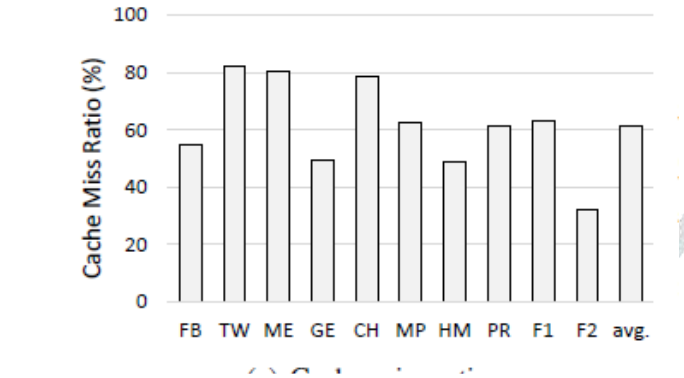
A mapping cache is generally adopted by a page-mapping FTL to translate LPN to PPN with limited RAM space.

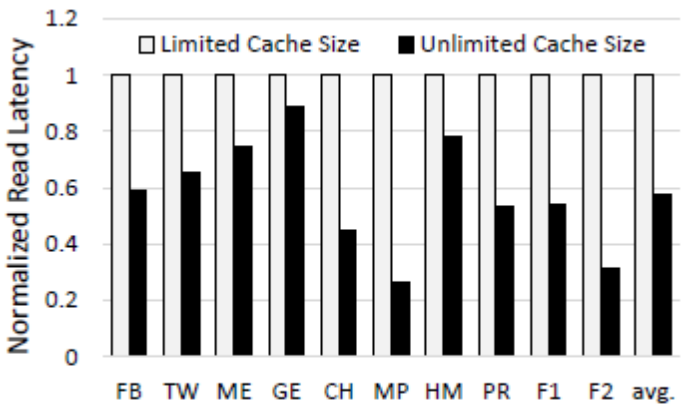
2) *Waiting Time*

The latency request consists of two parts: The storage access part and the waiting time. The waiting time of a request is the time duration between the arrival and dispatch of the request. The latency of a request *i* is:

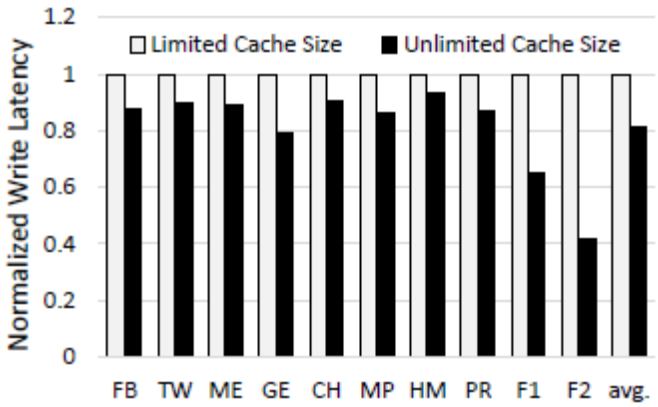
$$T^i_{latency} = T^i_{wait} + T^i_{access}$$

Some Graphical Results are given in Comparison of a fixed-sized cache and an unlimited sized cache in terms of cache miss ratio, read latency, and writes latency.




(b) Read latency




(c) Write latency

Source: Ji, Li-Pin Chang, Chao Wu, Liang Shi, Chun Jason Xue, 2017

3) *Mapping Cache Verification on Embedded Flash Storage Device*

Demand based map caching is the new trend nowadays and its popular design for flash based memory system.

IoT is already started to bring revolutionary change to the automated world and electronics played a vital role in designed the modern circuits. This remote control of application is possible through embedded system.

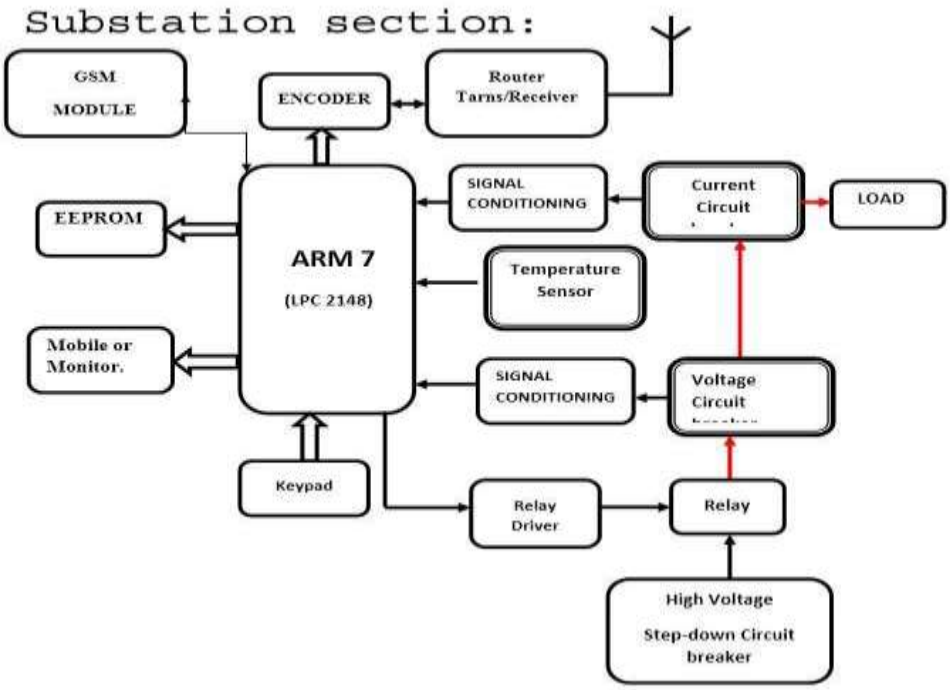
Circuit breaker is an important part of transmission and distributive system. Monitoring circuit breaker condition online can prevent faults that can lead to costly repairs and result in a loss of service. [9]

However the existing electronic circuit and designing system can't cope up with the ever increasing demand in automation industry. It will fail to cater time-to-market and complexity. [10]

Distribution of circuit breaker is currently monitored manually. But this type of checking can't give information about occasional overload and heating.

Now to check this using modern automated technology of IoT microcontroller will be used and it will continuously keep on monitoring various parameters such as Output Current, output Voltage and temperature of circuit breaker. All the outputs will be feeded in the computer using VB based software.

A BLOCK Diagram is been showed on how the automated circuit breaker will work:




Source: Bhagwan Kharat, Durvankurn Sarwade, Dhananjay Bidgar, Bhusan Kadu, 2017

The various parts of the block diagram has been explained below with the working mechanism.

1. *Microcontroller ARM 7*

The LPC2148 microcontroller are based on 16/32 bit ARM7 with real time emulation and trace support, that combines microprocessor with 32 kb, 64 kb, for embedded high speed flash memory

2. *LCD Display*

Cheap and easy way to get text display for embedded system. Display is set to 6 to 20 characters

3. *RF Trans/Receiver*

Its shirt ranged remote control where low cost and longer range is required.

4. *Keypad*

It's used to change set of parameters.

5. *Signal Conditioning*

The process of performing operation on signals to covert in suitable form for interfacing other circuit called signal conditioning.

6. *Temperature Sensor*

In this circuit the temperature sensor which is used is LM35. It includes 3 pins the input voltage pin ($V_i$), the output voltage pin ($V_o$), and the ground pin (GND). If the temperature rises over the desired temperature, cooling fan automatically starts and reduces the temperature.

7. *Voltage Transformer*

The general purpose of the voltage transformer is just like a step down transformer. Primary of the transformer is connected either to the phase or ground depending upon requirement. For acting as stepping down transformer the secondary part has lower number of winding or turns in it.

8. *Current Transformer*

It act's as basic principle of electrical power transformer but here the primary current or system current transforms into secondary current or burden current .

i. ADVANTAGES

- Low cost design and low power consuming
- Real time monitoring
- Integrate with your facilities computerized maintenance management software

ii. USES

- This system can be used to monitoring and controlling the home appliances.
- This system can be used in industries. [11]

Microprocessor is an important part of circuit nowadays and power supply has now primary constraint to design it. Reducing supply voltage is a popular way to meet power budgets with minimal performance impact and it is achieved by either decreasing nominal supply with technology scaling or applying runtime power saving technique as dynamic voltage scaling.

To address this challenge various methodologies has been tried and tested. To detect voltage emergencies and save the microprocessor both digital and analogue ways can be used. But two major challenges come up one is the *Sensor Placement* problem, where there is an over head on-chip design and its back draws are chip area problem and calibration problem.

The second problem is of noise sensors which occupy certain amount of chip size and may not be placed in the exactly functional area resulting in mismatch between the sensor reading and voltage to be monitored; such mismatch incurs error in *voltage emergency detection.*

Thus it's desirable to be able to make a full chip prediction based on limited number of sensor reading to predict voltage emergencies not only in the location near sensors but far from it also. Machine learning is used recently to sort out this type of problems recently used to solve high level synthesis, circuit test and physical design. The development of noise-sensor based voltage system using machine learning can save all the problems. [12]

**III. Conclusion**

Electronics has been the integral part during the development of age old computers to the most modern concepts.

The introduction of Memristor Crossbar over CMOS system will certainly give some advantages on the terms of scalability it will able to scale a large circuit and automation which is the next thing in the smart world. [13]

The NAND flash memory storage with a small mapping cache is implemented to resolve the storage issues without any cache miss. Batches of requests are re-ordered to optimize the waiting time. [14]

In modern control centers system gets all the notification of usage in real time. And to get the information regarding circuit breakdown will certainly help to minimize the time taking action and IoT is the backbone for this. [15]

Usage of machine learning to figure out power and thermal management on single core and multi core processors. It will result in improved management decisions of power management methods. [16]

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