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Low Area and Low Power CMOS technology based RAM and Ternary CAM memory design

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Abstract - Ternary content addressable memory (TCAM) is an associative memory or associative array for very high speed searching applications. It compares input search data (tag) against a table of stored data and returns the address of matching data. Several custom computers were built to implement TCAM. In this paper the system proposed an XOR based content addressable memory. Data matching process is applicable to match line sense amplifier (MLSA). Given an input tag the proposed architecture computes a few possibilities for the location of the matched tag and performs the comparisons on them to locate a single valid match. Proposed method is to design the CMOS based RAM and CAM memory architecture design. This design is used to find match line data effectively and to reduce the leakage power level for match line process. The proposed system is mainly focused by the matched line sense amplifier process and to compare the content data between the data register and 4x4 TCAM cell design. Ternary CAM design is used to consume less power and also to reduce the leakage power of CMOS transistors. This design is used to reduce the delay time as well as to increase the speed in ML search process.
Keywords - Content Addressable Memory(CAM), Ternary CAM, XOR type CAM cell, Static Random Access Memory (SRAM), Low Power.

I.   INTRODUCTION

Standard computer memory such as random access memory (RAM) in which the user supplies a memory address and the RAM returns the data word stored at that address. TCAM is designed such that the user supplies a data word and the TCAM searches its entire memory to see if that data word is stored anywhere in it [2]. If the data word is found the TCAM returns a list of one or more storage addresses where the word was found. Numerous devices have been produced by Integrated Device Technology, Cypress Semiconductor, IBM, Broadcom and others to the Look-aside interface agreement [6]. Binary CAM is the simplest type of TCAM which uses data search words consisting entirely of 1s and 0s [1]. Ternary TCAM (TCAM) allows a third matching state of "X" or "don't care" for one or more bits in the stored data word thus adding flexibility to the search [2]. For example a ternary CAM might have a stored word of "10XX0" which will match any of the four search words "10000", "10010", "10100" or "10110".
The added search flexibility comes at an additional cost over binary CAM as the internal memory cell must now encode three possible states instead of the two of binary CAM [4]. This additional state is typically implemented by adding a mask bit such as "care" or "don't care" bit to every memory cell. In modern computer memory a sense amplifier is one of the elements which make up the circuitry on a semiconductor memory chip. A sense amplifier is part of the read circuitry that is used when data is read from the memory its role is to sense the low power signals from a bit line that represents a data bit 1 or 0 stored in a memory cell and amplify the small voltage swing to recognizable logic levels so the data can be interpreted properly by logic outside the memory [2]. Modern sense amplifier circuit consists of two to six usually four transistors [7]. Sense amplifiers for core memory sometimes contained thirteen transistors. There is one sense amplifier for each column of memory cells so there are usually hundreds or thousands of identical sense amplifiers on a modern memory chip. As such sense amplifiers are one of the only analog circuits in a computer memory subsystem. In this paper TCAM refers to binary CAM (BCAM) with don't care [2]. The CAM array is divided into several equally sized sub blocks which can be activated independently. For a previously trained network and given an input tag the classifier only uses a small portion of the tag and predicts very few sub blocks of the TCAM to be activated. Once the sub blocks are activated the tag is compared against the few entries in them while keeping the rest deactivated and thus lowers the dynamic energy dissipation as well as to reduce the power consumption.

II. PROPOSED SYSTEM ARCHITECTURE

In proposed system the content addressable memory is a XOR logic gate based cell design [2]. Data matching process is used in the

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match line sense amplifier (MLSA). The proposed system can do a fast match line (ML) selection process. In this paper first of all the system design of 6T based static random access memory (SRAM) CMOS design [Fig.4]. This design is to store the single bit value. This design consists of two inverter cross connection is used to maintain the given input data. Then the system design of 8T based XOR Ternary CAM design [Fig.2]. It consists of selection line (SL) and the bit line (BL) to control the TCAM cell. This process used to find the address bit location. Then the scan based enable process is to find the TCAM cell array result. The XOR gate function to match the SRAM data and TCAM data and to invert the activation result. The match line process is to check the CAM data register. The clock function is to control the output matched line row then it will get the content address [Fig.1].
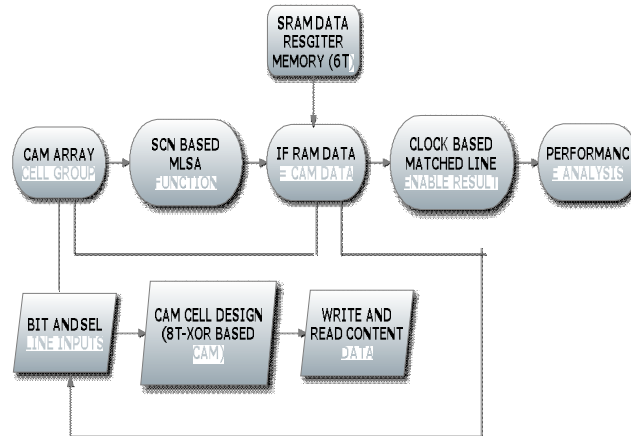

Fig. 1 Proposed system flow diagram

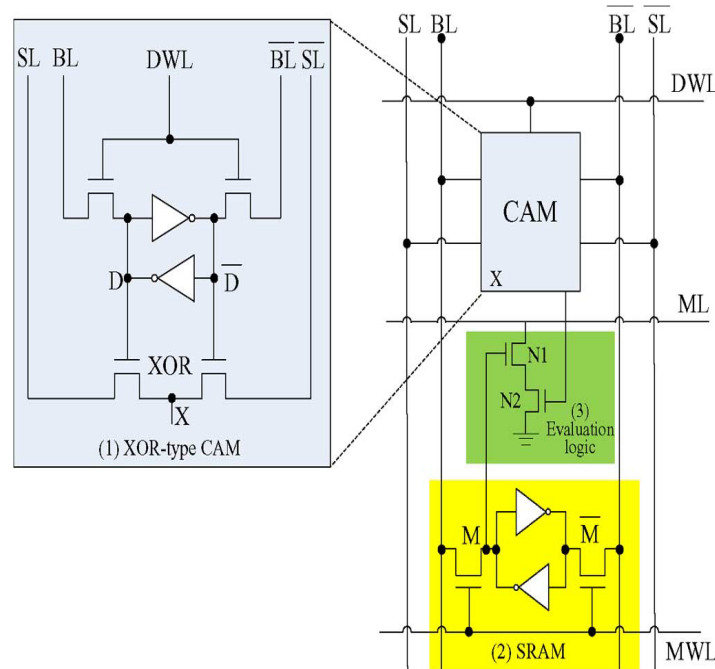If the write line is set to '1', then to get the data to cross inverter circuit connection.

Fig. 2 XOR type Single CAM cell

Proposed design having the 8T based XOR TCAM CMOS design. This design is consist of two control lines. Selection line (SL) and the bit line (BL) are the control lines of the TCAM cell [2]. This process is used to find the address bit location and to check the address level and apply the evaluation logic function.

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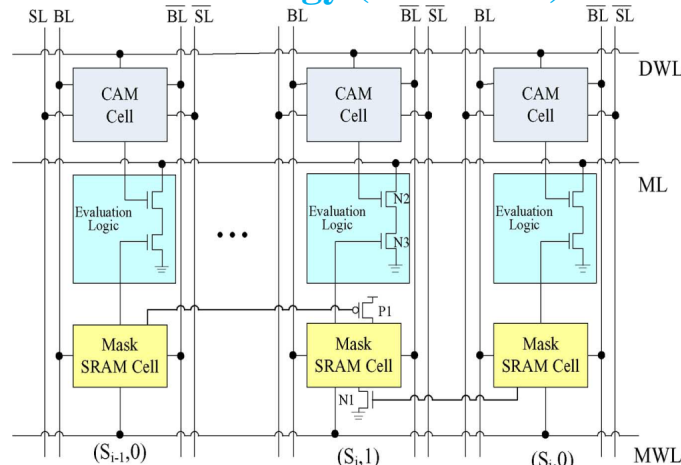

Fig. 3 Two-Side Self-Gating Ternary CAM array

The scan based enable process is to find the TCAM cell array result and to apply the CAM and RAM data. The XOR gate function to match the SRAM data and TCAM data and to invert the activation result [2]. To check the all the row CAM data to data register input data bit then to activate the ML function.
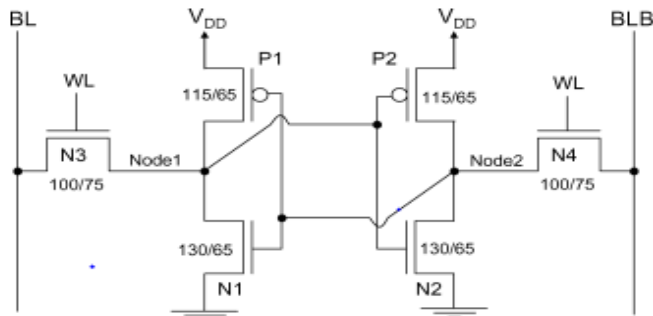

Fig. 4 Proposed circuit of 6T based SRAM

The match line process is to check the CAM data register and RAM data register value. The clock function is to control the output matched line row and to get the content address [4]. This matched line process is mainly focused by the TCAM cell array input data storage [5]. The final output is to identify the content address effectively and to increase the ML check process time. Then to consider the power consumption level and to check the match line delay time also. Area consumption is depends on optimization of MOS transistors count level.

III.   RESULT ANALYSIS

Proposed system is implemented using TANNER version 13.0 back-end EDA tool is used for simulation. S-Edit (Schematic Entry), W-Edit (Waveform view and analysis) and T-Spice (Tanner Spice) is used for circuit simulation.
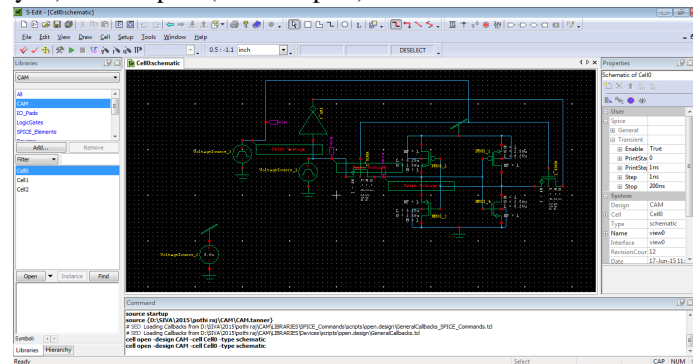

Fig. 5 Schematic entry of 6T based SRAM design

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This fig.5 represented as schematic entry of six transistors based Static RAM design using S-Edit of TANNER version 13.0 simulator.
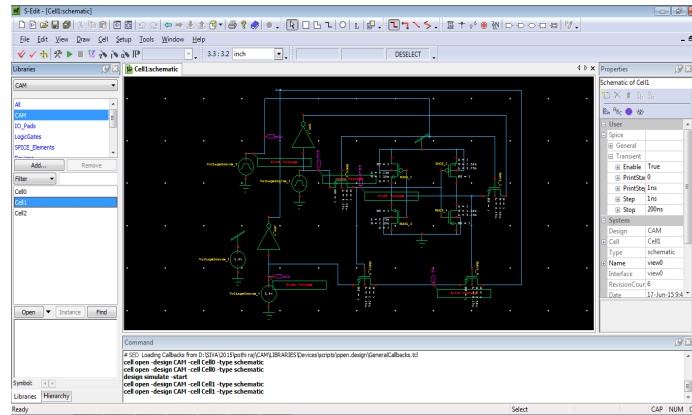

Fig. 6 Schematic entry of 8T based Ternary CAM design

⬜⬜⬜⬜⬜⬜n fig.6 denoted as schematic entry of eight transistors based Ternary CAM memory design using S-Edit of TANNER version 13.0 simulator.
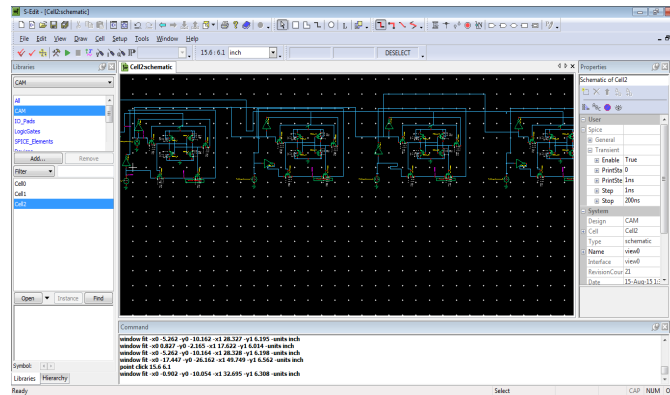

Fig. 7 Schematic entry of 4x1 TCAM array cell

In fig.7 represented as schematic design of 4x1 ternary content addressable memory cell using S-Edit of TANNER version 13.0 simulator.
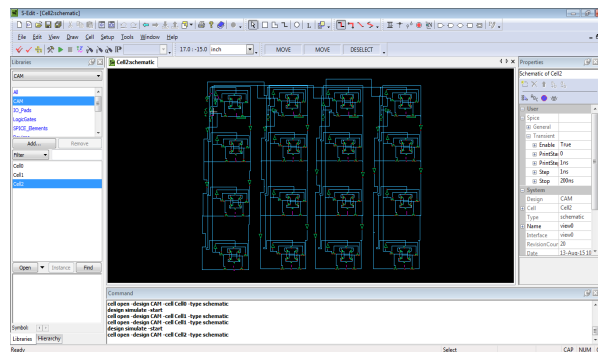

Fig. 8 Schematic entry of 4x4 TCAM cell array

In fig.8 implies as schematic design of 4x4 ternary content addressable memory cell array using S-Edit of TANNER version 13.0 simulator.

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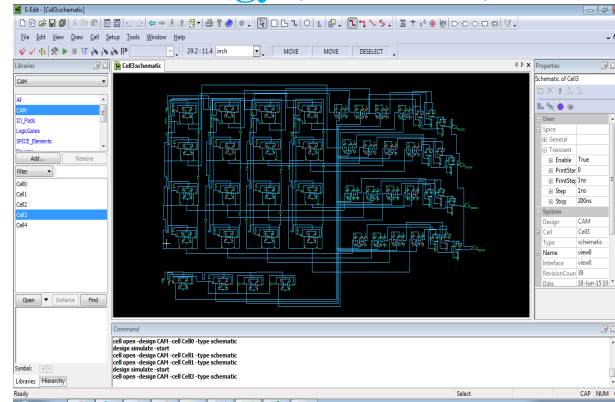

Fig. 9 Schematic entry of 4x4 TCAM with MLSA

In fig.9 conclude as a schematic design of 4x4 ternary content addressable memory cell array with match line sense amplifier and scan based enable function using S-Edit of TANNER version 13.0 simulator.
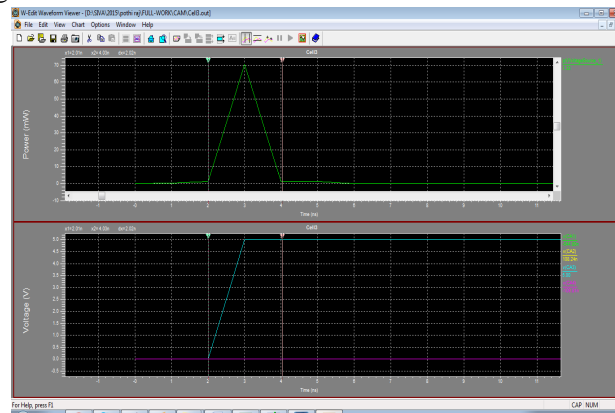

Fig.10 Output - Power consumption of 4x4TCAM

IV.   PERFORMANCE COMPARISIONS

Parameters of Simulation (Units)	Existing System	Proposed System
Supply Voltage (V)	1.8	5
Optimization of MOS transistors count level (~ numbers)	512	400
Power consumption (mw)	94	70
Delay time (ns)	7	2.42
Area consumption (mm^2)	4.83	0.320

V.   CONCLUSION

In this paper design of XOR based content addressable memory (CAM) has been presented. It is a very low power Ternary content addressable memory (TCAM) cell. Ternary content addressable memory (TCAM) is suitable for low power applications where frequent and parallel look-up operations are required [2]. In a conventional TCAM array each entry consists of a tag that if matched with the input points to the location of a data word in a static random access memory (SRAM) block. The actual data of interest are stored in the SRAM and a tag is simply a reference to it. Therefore when it is required to search for the data in the SRAM it suffices to search for its corresponding tag. Consequently the tag may be shorter than the SRAM data and would require fewer bit comparisons. Simple and fast updates can be achieved without retraining the network entirely. Depending on the application non

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uniform inputs may result in higher power consumption but does not affect the accuracy of the final result. NOR type architecture was also implemented in the same process technology.

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