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Fast and Low Power Nonvolatile TCAM as Filter-based Search Engines Used in Big-Data Processing

大數據時代之節能快速的非揮發性過濾式搜尋引擎

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作品摘要

此研究將結合高密度、高低阻態比值大的非揮發性記憶體元件－電阻式記憶體和電晶體所組成的非揮發性三元內容循址儲存器，將可以解決傳統靜態隨機存取記憶體為基底的三元內容循址記憶體其待機漏電的耗能，並且在相同容量下能夠有更小的面積，而此單一巨集的非揮發性三元內容遁址記憶體更能加速開關機的速度且可以節省開關機時資料搬動的耗能。此次研究目標除了研發新的非揮發性三元內容遁址記憶體其記憶胞外，更要突破近年來國際論文所發表的非揮發性三元內容遁址記憶體所遇到的問題，達到比先前架構更小的記憶胞面積、更快的搜尋速度和更低的非揮發性記憶體元件改寫所需耗能，且要能解決先前架構配對線長度受限制的瓶頸。

The development of embedded systems and wireless technology has led to a wide range of applications; however, the storage of data associated with these applications presents serious difficulties, particularly when dealing with long standby time and discontinuous power supply. This has led to the development of cloud servers and databases; however the transmission of invalid data between the cloud and local devices plays a major role in overall power consumption. By implementing a filter capable of identifying the input data, devices can reduce the amount of data that must be sent to the cloud, and further reduce the overall power consumption.

TCAM is meant to address the needs for more speed and large storage. However, for the feature of normally-off, we need the Nonvolatile Memory to reduce large standby power companying with large storage. The implementation of non-volatile memory in TCAM generally involves a 2-macro solution, which includes a SRAM-based TCAM macro with a nonvolatile memory macro, such as flash. In power-off mode, the TCAM macro stores data within a nonvolatile memory macro. In power-on mode, the data is restored from the nonvolatile memory macro. Unfortunately, limited I/O bandwidth can produce large delays and induce large energy consumption associated with the movement of data in power-on and power-off operations.

This study developed a single macro solution, which is capable of reducing area overhead, minimizing store/restore energy, and speeding up store/restore operations. The proposed method does not require the movement of data and enables immediate power-on/off switching, based on the fact that only logic-based peripheral circuits need to be woken up.

This study proposed a bi-directional voltage divider control (BVDC) 3T1R nonvolatile TCAM (nvTCAM) which can reach:

1. 1/4 times smaller than traditional 16T SRAM-based TCAM, and 4 times larger capacity with same area.
2. Fast and low power wake-up and backup operations.
3. 1.33 times smaller NVM device write energy than other 2R-based nvTCAM.

The capacity of implemented macro is 4kbits, and 0.96ns search time is achieved. The measured search speed is the most fast one compared with other published nvTCAM.

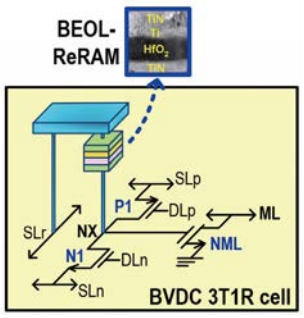

圖 1 / 提出電路架構 Proposed cell structure

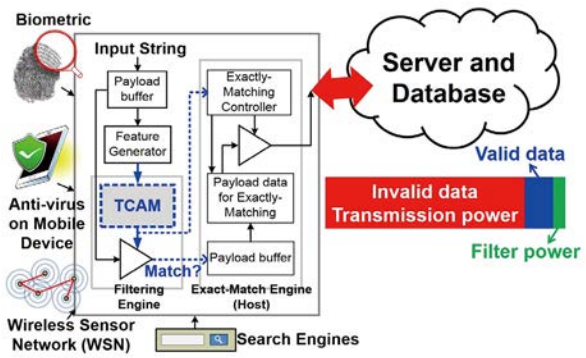

圖 2 / 三元內容遁址記憶體為基底的過濾器
TCAM-based Filter