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**SELF STUDY PAPER ON**

**Understanding NAND’s intrinsic characteristics critical role in Solid State Drive (SSD) design**

Introduction:

With increasing demand of placing the servers in the same area as the user for better performance with their portable devices and other technology gadgets. The new data centers are using the SSD (Solid State Drives) for better user experience and low latency with consistent performance at lesser cost and voltage requirements. Enterprise SSDs must be available at low cost with increased power efficiency and higher storage density which reduces the overall Operation expenses. To achieve this SSD designers have decided to compare the workload requirements with the available Flash memory techniques and NAND memory behavior is the best suited for this.

Study:

This paper summarizes the importance that NAND’s memory behavior and its inbuilt technique it has in achieving high performing SSD. Which is the most used technique for the enterprise data center applications. Paper also Explains how we can achieve enterprise data center’s requirement of high performance, low latency, consistent reliability and low power consumption by also ensuring a sufficient durability. This paper only concentrates on these fields, though there are other factors and requirements of enterprise data centers.

Performance of the data center is measured by the number of input and output operations per second (IOPS). Data center is used by clients who require 24/7 service, that demands for a consistent reliable performance than unusual peak performance. FOB (Fresh out of box) measurement in data center expects consistent behavior. There are 3 states in which the state can be in,

* **FOB state**: A drive reaches this state when there is very limited or completely no user data. When all the NAND cells are capable of receiving new data. Here we can write in SLC mode i.e. we can write in one cell at a time.
* **Transition State**: From FOB the drive enters transition state where there would be a consistent and steady decrease in performance.
* **Steady State**: It next enters the steady state which is the state where the enterprise data center operational tasks are carried out. In this state, we test the IOPS.

Enterprise Data centers needs efficient working round the clock. They need SSD which are capable of 0.1 to 3 SSD drive fills per day. NAND memory being non-volatile and cost effective are considered most efficient. Reliability standards for the Enterprise SSD are JEDEC specifications in JESD 218. The testing is done based on the test endurance test method of JESD 219. The testing is done by an activity trace which imitates the actual workflow and exact usage of the enterprise modules. By performing the test in similar environment and limiting the drive fills we can measure the reliability over the drives lifetime.

Three regions are tested during the measure of reliability:

* RDT (Reliability Demonstration Testing): This is done in the early region and in low-level events. It measures the Mean Time to Failure(MTTF).
* TBW (Total Bytes Written): This gives the expected life of the drive and the retention data post the TBW phase. It uses the Short Stroke technique to ensure low volume and higher cycle counts.
* Cycle- To- Death: This measures the endurance post TBW. It specifies the End- Of –Life margin and behavior. This helps to predict the EOL cycling error rates.

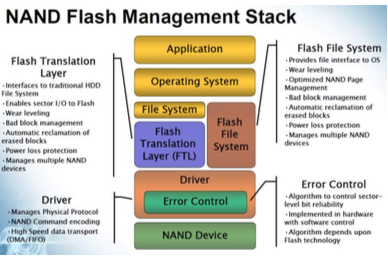
NAND memory, Firmware and controller contributions help the SSD to meet the enterprise reliability requirements.

The Data centers requirements of reliability, performance and latency can be found in the NAND memory design choices. The design of NAND’s cell, page and block and manufacturing mechanisms determines the specifications for the page reads, block erase and cyclic based raw bit error rate.

NAND is determined and designed in way that all of its block functionality and attributes are balanced. Which has a significant impact on its performance. As permanent writes or Lithography are decreasing, Design tradeoff between the product parameters can help elevate the performance and reduce the cost and voltage consumption. The solutions for the parameters can come from Process technology, NAND Die features or System level features. All the parameters have an impact on the program read and erase times. NANDS array structure and internal programing ability dealing with reliability and maximize cycle help to perform tprog.

A collection of NAND blocks is a plane. As the number of pages and planes increase from SLC to TLC. With the increase now larger erase and writes have to be handled. Transfer of valid bit is also necessary to perform garbage collection. To Overcome this problem one system technique is to perform overlapping plane operations. These parallel operations for the plane are standard for the SSDs.

Combining the NAND to form an SSD is done by flash transaction layer (FTL) and firmware which is embedded within the SSD. The SSD is also responsible for the file control, error handling and also the Driver interface to NAND. Error correction of SSD is based on the Flash memory technology and for NANDs MLC and TLC BCH and low-density parity check are used.



Conclusion:

Data centers are embedding new technology as demand in growth of data on cloud and customers requirement of on-demand data. Enterprise data centers with SSDs that have been designed by taking advantage of NANDs intrinsic features will gain sufficient mileage in the market. The key for better SSDs is to understand the workload and optimize NAND behavior with appropriate flash management algorithms.

References:

[1] Will Akin. Understanding NAND’s intrinsic characteristics critical role in Solid State Drive (SSD) design: IEEE International Memory Workshop, 2015