Understanding Implications of Trim, Discard, and Background Command for eMMC Storage Device

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***Abstract*—Recently, eMMC is widely being used in mobile devices because of its characteristics such as low cost, small size, and low power consumption. In this paper, we analyze features of eMMC based on commands such as Trim, Discard, and Background to investigate how do commands affect the random write performance and lifetime of the NAND flash memory. Also, we propose a method that uses the Background command to improve the random write performance of eMMC. Our experimental results clearly show that our method outperforms the normal power-off method, on average, by 173% in terms of the random write performance.**

***Keywords*—Performance and Lifetime of eMMC; Trim command; Discard Command; Background command**

I. Introduction

The eMMC, which consists of the NAND flash memory, is widely adopted in mobile devices, such as smartphones and tablets. This is because eMMC offers several attractive features compared with Solid State Disk (SSD). However, problems of eMMC such as the random write performance and lifetime remain to be solved because eMMC manufactures scale down their flash density to store multiple bits in each cell for reducing manufacturing cost[1]. To address the above problems, we explore two approaches. One is the extension of hardware(e.g., DRAM and SRAM). However, the hardware extension of eMMC is restricted because eMMC must satisfy various requirements, such as low cost, small size, and low power consumption. Another is the adoption of software approach that collaborates between host and eMMC. The Trim, Discard, and Background command are a representative of the way for collaboration. The Trim and Discard command are used to notify eMMC that pages are no longer valid and it leads to eliminate unnecessary copy operations in eMMC[2]. If eMMC receives these commands from the host, the FTL marks pages as invalid and invalid pages are deleted by Garbage Collection (GC)[3][4]. The Background command is another feature of eMMC that can promptly handle many pending jobs, such as Garbage Collection and Wear Leveling, when host wants to handle them[2]. Unfortunately, the research on Background command is insufficient and related literatures are also very scarce because most research has focused on SSD[3][4][5]. Furthermore, existing file systems do not consider not only the characteristics of eMMC but also commands of that because they have been designed to consider the characteristics of Hard Disk Drive (HDD) [5]. In this paper, we analyze the characteristics of eMMC by using the Trim and Discard command, and find unique characteristics of eMMC features. We also propose a method to improve the random write performance of eMMC on mobile device environments.

II. Proposal Method

A. Understanding of Trim/Discard command

It is generally known that the Trim and Discard command are used to improve the random write performance and lifetime of eMMC[3][4]. When a file is deleted, the file system issues Trim or Discard command with the data of deleted file to eMMC. If eMMC receives the Trim and Discard command, the FTL marks pages, which belong to Trim or Discard command, as invalid. As a result, the Trim and Discard command significantly reduce Garbage Collection cost as well as extend lifetime of eMMC. This is because pages marked as invalid are not copied to another place during Garbage Collection. Fig.1 shows how to use the Trim and Discard command with data that has been deleted by the host in the middle of writing data to eMMC. Especially, it is important for the Trim and Discard command to ensure that pages are aligned at a boundary of a multiple of page size. The main reason of alignment is that the misaligned pages increase Garbage Collection cost by generating the additional copy operations for valid pages. Therefore, the misaligned pages decrease the effectiveness of Trim and Discard command.

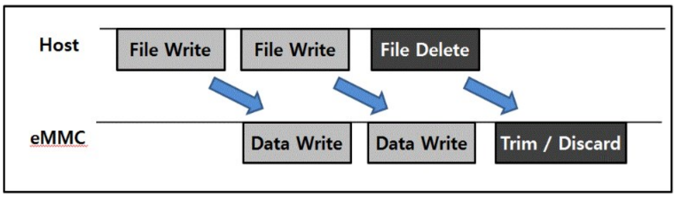


Fig. 1. How to use the Trim and Discard command

B. Proposal method based on Background Command

In order to improve the random write performance, we propose a method that issues the Background command to eMMC whenever the mobile devices turn off eMMC power. There are two reasons. First, the Background command can perform pending jobs of FTL that can secure free pages in advance (e.g., Garbage Collection). However, it must be performed when there are no I/O requests. Second, the mobile devices frequently turn off eMMC power for saving their power consumption. The proposed method significantly reduces the number of Garbage Collection and Garbage Collection cost by performing pending jobs periodically. As a result, Garbage Collection is rarely performed when the write operations are received from host because the FTL already has enough free pages. Fig. 2 shows the sequence of our method.

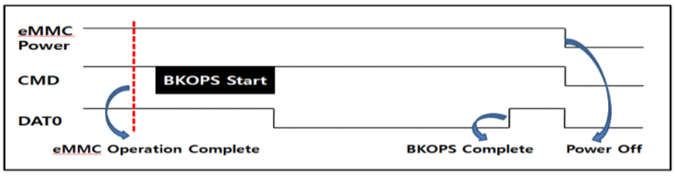
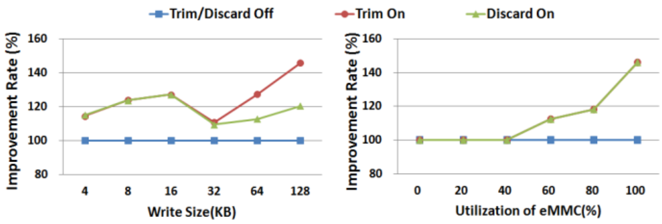


Fig. 2. How to use the Background command before eMMC Power-off

III. EXPERIMETAL RESULTS

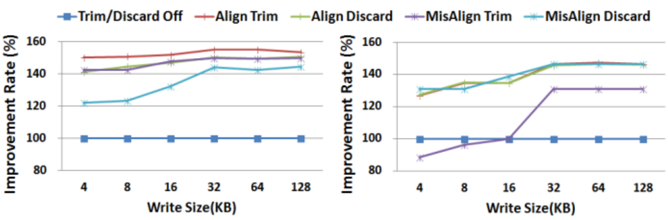
We performed our experiments on state-of-the-art smartphones such as Galaxy S3 and Galaxy S4, and we used syntactic workloads. To eliminate the effect of buffer cache and file system, we also directly issued all requests to eMMC. In this paper, we only present the results of one smartphone because experimental results of two eMMC show very similar patterns. We first measured the random write performance and lifetime to study features of eMMC. As shown in Fig. 3(a), we can see the random write performance impact of the Trim and Discard command. Specifically, when the Trim and Discard command are issued, the random write performance is improved, on average, by 25% and 18%, respectively. Fig. 3(b) shows that the lifetime is extended, on average, 8% when the Trim and Discard command are used. This is because the Trim and Discard command mark invalid pages and it leads to decrease the copy overhead by ignoring copy of invalid pages.



(a) Random Write performance (b) Lifetime

Fig. 3. Comparison on the using of Trim and Discard command

We also study the effectiveness of page alignment and compare the random write performance and lifetime of eMMC to examine the impact of the alignment. In case of aligned page with the Trim and Discard command, the random write performance and lifetime of eMMC are improved more than in case of misaligned page. Specifically, the random write performance is improved, on average, by 10% (Fig. 4(a)) and the lifetime is extended, on average, by 13% (Fig. 4(b)).



(a) Random Write performance (b) Lifetime

Fig. 4. Comparison by the use conditions of Trim and Discard command

Fig. 5 presents the effects of our method according to utilization of eMMC. Fig. 5 clearly shows that our method improves the random write performance, on average, by 173% because it periodically issues the Background command to eMMC when eMMC power is turned off by power consumption policy of mobile device. As a result, our method significantly reduces possibility that performs the Garbage Collection caused by lack of free pages because it already takes enough free pages.

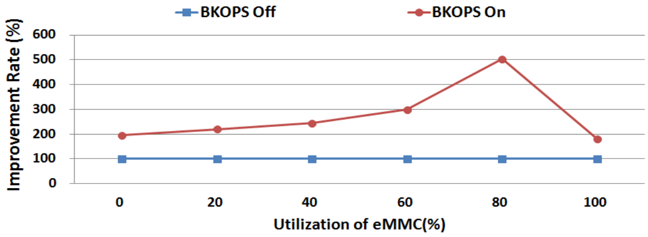


Fig. 5. Comparison on the using of Background command

IV. CONCLUSION

In this paper, we analyzed the collaboration method between host and eMMC to improve the random write performance and lifetime of eMMC. As a result, we found two performance characteristics. First, the Trim and Discard command improve the random write performance and lifetime of eMMC simultaneously. Second, the alignment with Trim and Discard command is a important factor in the random write performance and lifetime of eMMC. We also proposed a method using the Background command to improve the random write performance of eMMC. As a result, we confirmed that our method improves the random write performance of eMMC, on average, by 173%. We are sure that the our analysis and the proposed method can be used by an OS designer to optimize the random write performance and lifetime of eMMC.

ACKNOWLEDGMENT

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