Introduction of eMMC

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Product Planning & Application

Samsung Electronics

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Contents

eMMC4.4

eMMC4.41

eMMC4.5

Multi Partition

- **eMMC 4.3 → 2 boot partitions and 1 user data partition**
- **eMMC 4.4 → RPMB partition is added**
 - **→ 4 general purpose partitions and enhanced user data area can be set in normal user data area**

General Purpose Partition

| Boot 1 | Boot 2 | RPMB (Secure Data) | | | | | Enhanced User data area(SLC mode) | |

Normal User Data Area
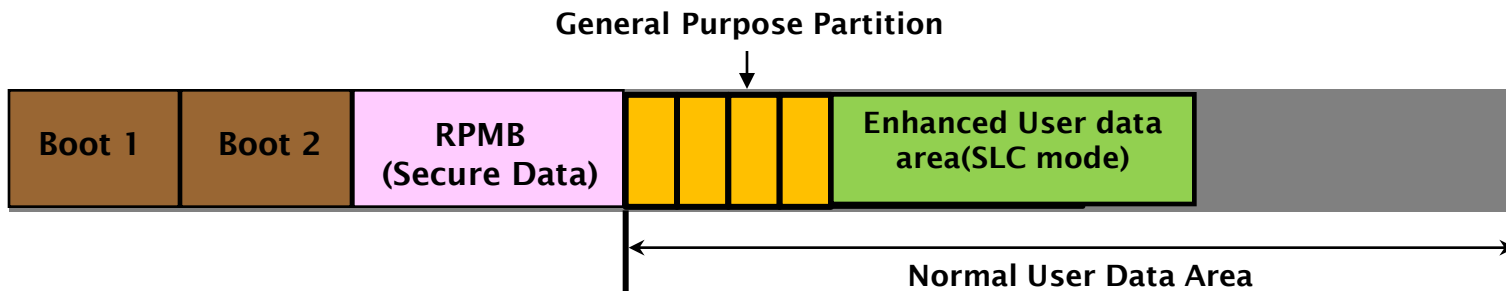
Partitions		NAND type	Default Size	Remarks
Boot Area Partition 1		SLC Mode	128KB	Size as multiple of 128KB (max. 32MB)
Boot Area Partition 2		SLC Mode	128KB	Size as multiple of 128KB (max. 32MB)
RPMB Area Partition		SLC Mode	128KB	Size as multiple of 128KB (max. 32MB)
General Purpose Partitions		MLC "or" Enhanced Area	0KB	Available size can be seen by following: $(EXT\_CSD[145]* 8^2 + EXT\_CSD[144]* 8^1 + EXT\_CSD[143]) * HC\_WP\_GPR\_SIZE*HC\_ERASE\_GPR\_SIZE * 512KB$ byte
User Data Area	Enhanced Area	SLC Mode	0KB	Start address → multiple of Write Protect Group size
	Default Area	MLC	93.1%	

RPMB(Replay Protect Memory Block)

- **Prevents illegal data copy or access**
  - **Only handled by security key (SHA-256)**
  - **When host tries to access to RPMB,**
    a) Host reads key the counter value to generate MAC (token) using SHA-256 algorithm
    b) The host sends the generated MAC to eMMC controller
    c) eMMC controller reads the key which was pre-loaded by host and the counter value to generate MAC using SHA-256
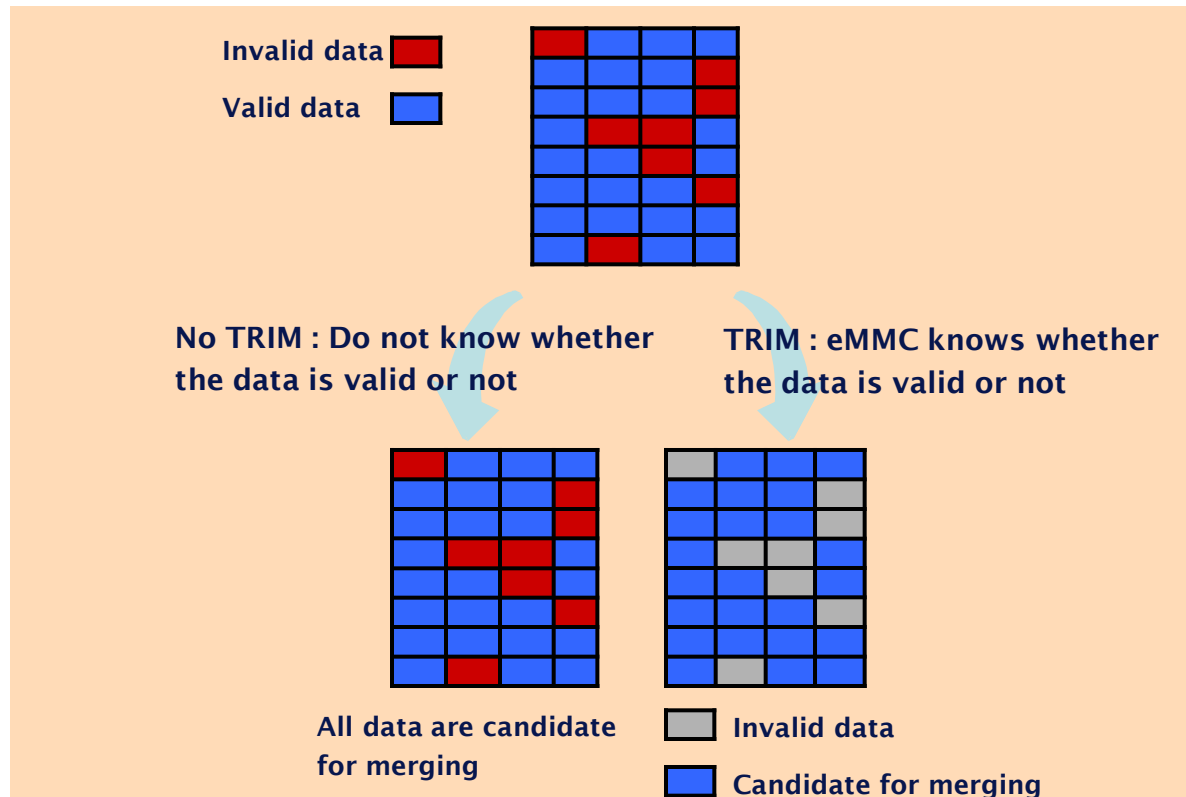   d) Compares two MAC. If two keys are identical, RPMB access is allowed
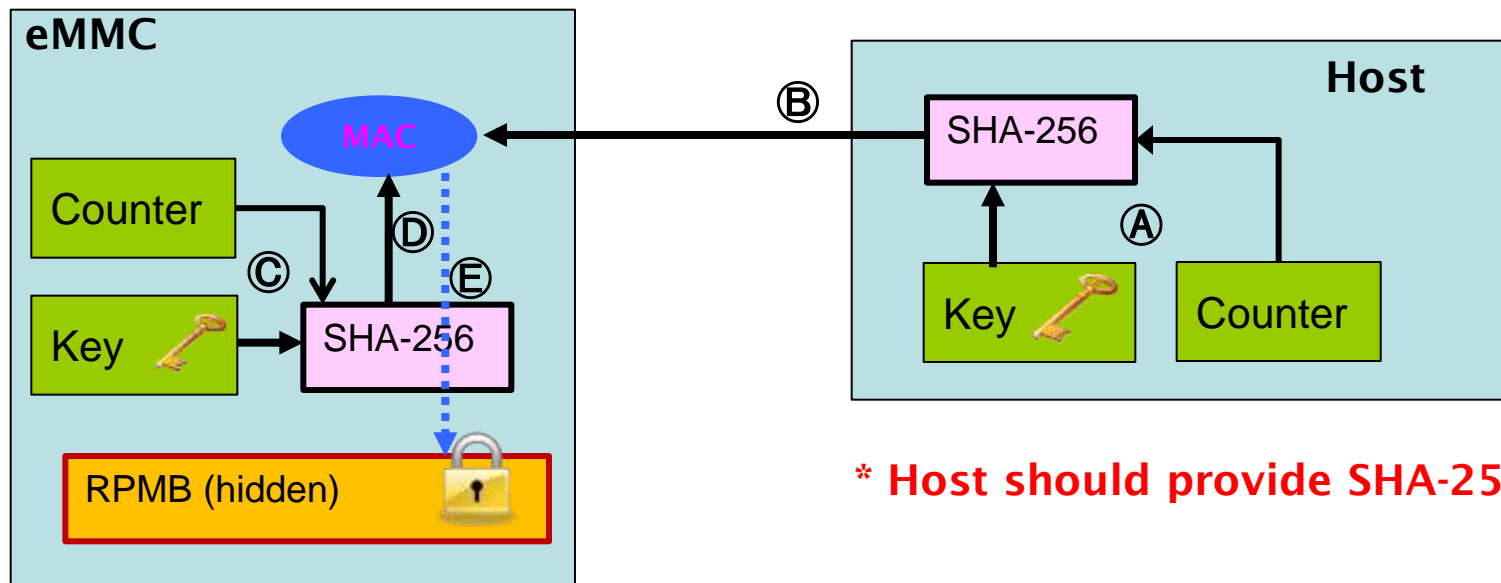
* **Host should provide SHA-256**
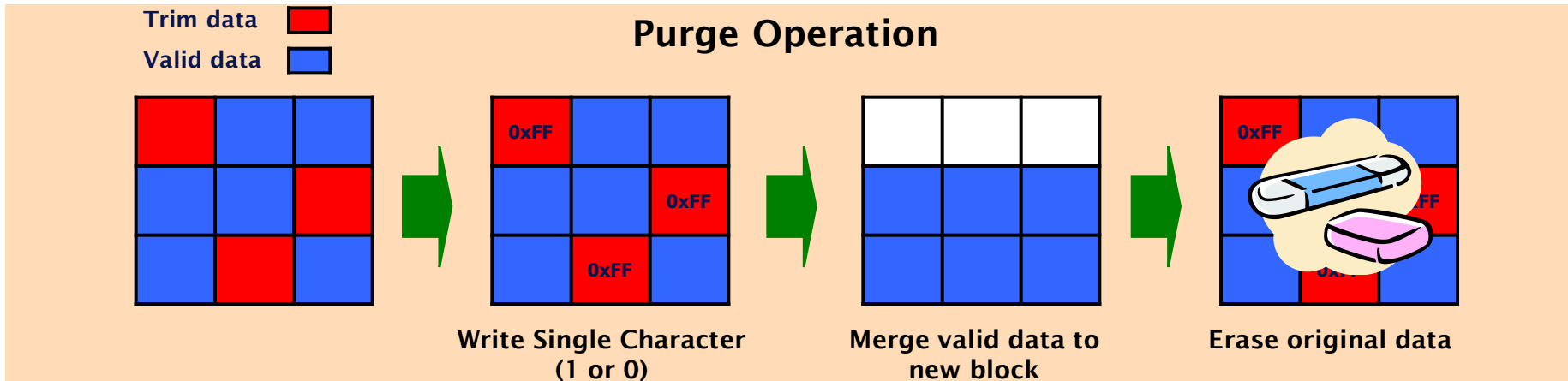
* Each counter includes the # of success to access RPMB

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■ **Mark data that is invalid.**

- Similar to STL_Delete()
- Trim data should be shown as "0" or "1" (by JEDEC) [SAMSUNG] trim data is shown as "0"

Invalid data 🟥

Valid data 🟦

No TRIM : Do not know whether the data is valid or not

TRIM : eMMC knows whether the data is valid or not

All data are candidate for merging

🟨 Invalid data

🟦 Candidate for merging

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Secure TRIM/Erase → Sanitize

Secure Trim/Erase

- ### Step 1: marks data which is logically deleted
- ### Step 2 : Actual secure purge operation is executed
  → secure purge: overwrite single character not only to trimed blocks but also to data which was generated by internal operation like wear-leveling, and then erase physically

Trim data ▮ (red)
Valid data ▮ (blue)

Purge Operation

0xFF		
		0xFF
	0xFF	

Write Single Character (1 or 0)

Merge valid data to new block

Erase original data

→ **The more data in step 1, the longer step 2.**

* Between step 1 and step 2, other operations can be executed

- ### Secure Trim and Secure Erase are identical except operation unit
  - Secure Erase: erase unit is Erase Group size (512KB)
  - Secure Trim : step1: sector based size(512byte)
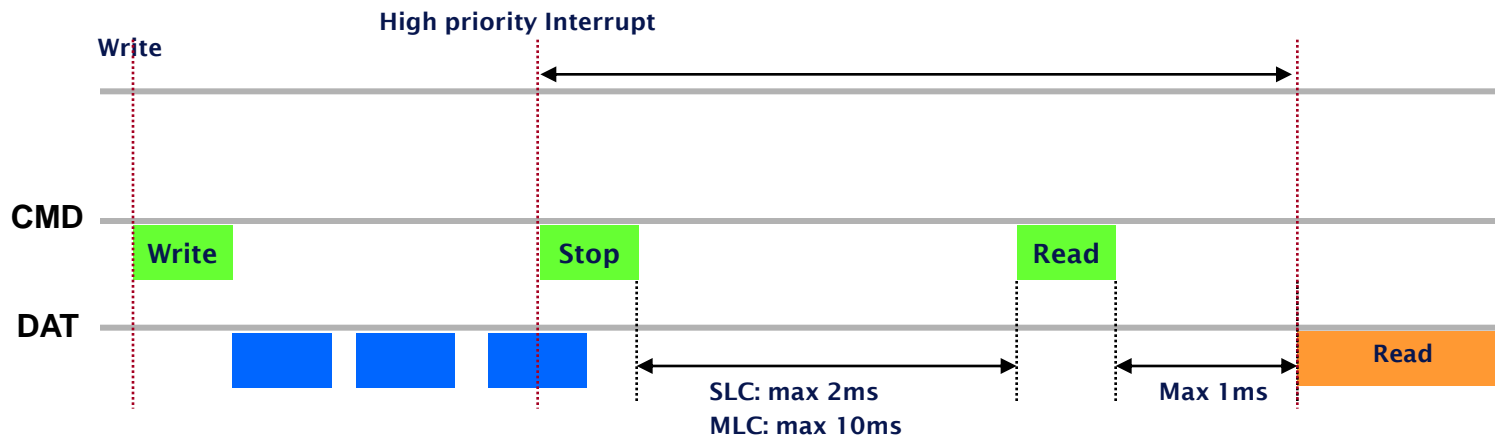   step2: purge unit is Write Group size(512KB)

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eMMC Version Comparison

- **Remarkable changes in eMMC4.4 : Performance and Security**
- **Additional features of performance and reliability in eMMC 4.5**

			eMMC4.41	eMMC4.5
Clock Frequency			**~ 52MHz DDR (104MB/s)**	**~ 200MHz (SDR)**
Pin Count (w/o Power pin)			**11**	**11**
H/W reset			**Yes**	**Yes**
Alternative Boot			**Yes**	**Yes**
Multi-Partition			**Yes**	**Yes**
Simultaneous Partition Access			**No**	**No**
Performance		Trim	**Yes**	**Yes**
		Discard	**No**	**Yes**
Security		RPMB	**Yes**	**Yes**
		Secure Erase	**Yes**	**Sanitizer**
		Secure Trim	**Yes**	
Performance		High Priority Interrupt	**Yes**	**Yes**
		Back Ground Operation	**Yes**	**Yes**
		Packed CMD	**No**	**Yes**
		Data Tag	**No**	**Yes**
		Context ID	**No**	**Yes**
		Cache Operation	**No**	**Yes**
Reliability		Dynamic Capacity	**No**	**Yes**

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eMMC4.4

eMMC4.41

eMMC4.5

HPI(High Priority Interrupt)

- **stops ongoing write operation and then read data within a specific time**

- **aborts ongoing writing operation by CMD 12**
  - [SAMSUNG] Reliable Write, Write, Secure Trim, Trim, Secure Erase, Erase can be interrupted by HPI

- **If read/ write partition is different, additional partition switching time is needed for changing partition**

High priority Interrupt

Write

CMD

| Write | Stop | Read |

DAT

Read

SLC: max 2ms
MLC: max 10ms

Max 1ms

Background Operation

- **Host gives free time to the device. During this time device can do housekeeping like merge operation.**
  - Host should check that necessity (4 levels) of background operation
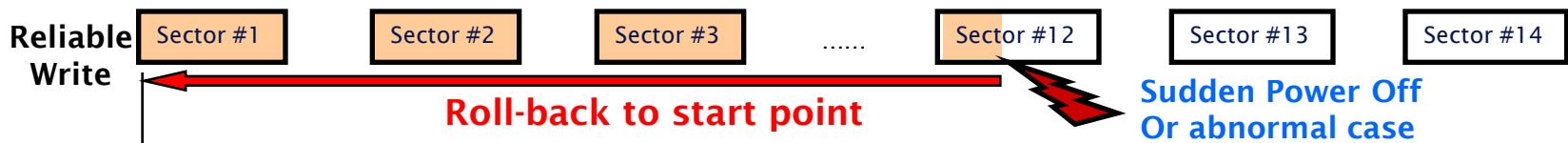- **Helps to improve performance**

[Background operation]

Level	Descriptions
0	No operation required
1	Background operation which is not critical
2	Background operation which impacts on performance
3	Background operation which is critical

Not operating   **Doing Maintenance**
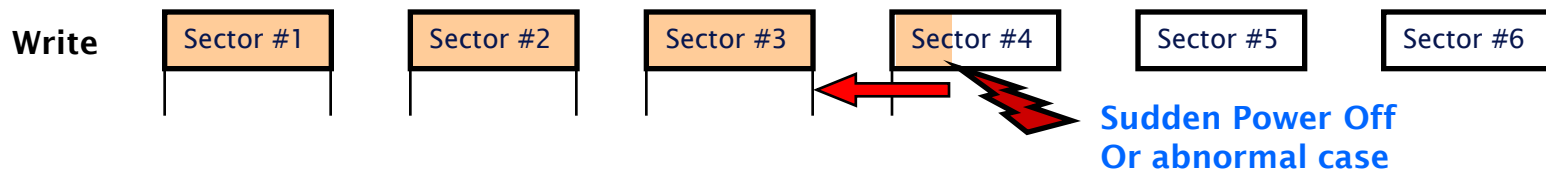
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Data Atomicity

- ## Normal Reliable Write (eMMC4.4)
  - The old data that logical address point must retain unchanged until a new data is successfully written to the same logical address
  - Reliable write sector (EXT_CSD[222]) : 1 or 255

Reliable Write | Sector #1 | Sector #2 | Sector #3 | ...... | Sector #12 | Sector #13 | Sector #14

Roll-back to start point

Sudden Power Off Or abnormal case

- ## Enhanced Reliable Write – Sector based Atomicity (eMMC4.41)

Write | Sector #1 | Sector #2 | Sector #3 | Sector #4 | Sector #5 | Sector #6

Sudden Power Off Or abnormal case

- ## SAMSUNG eMMC supports both eMMC 4.4 and eMMC4.41
  - Flexible "reliable write sector count" support : from 1 to 255

- eMMC4.4
- eMMC4.41
- **eMMC4.5**

eMMC Feature Summary

- **Basic features for mass storagea + base memory for mobile environment**
    - **High performance – DDR, HS200, packed command, cache**
    - **Low latency – HPI, background op, cache**
    - **Low cost (unified storage) – boot, partition**
    - **Hint – trim, discard, data tag, partition attribute, power-off notification, RTC, dynamic capacity**
    - **Security – RPMB, secure trim/erase, sanitize**

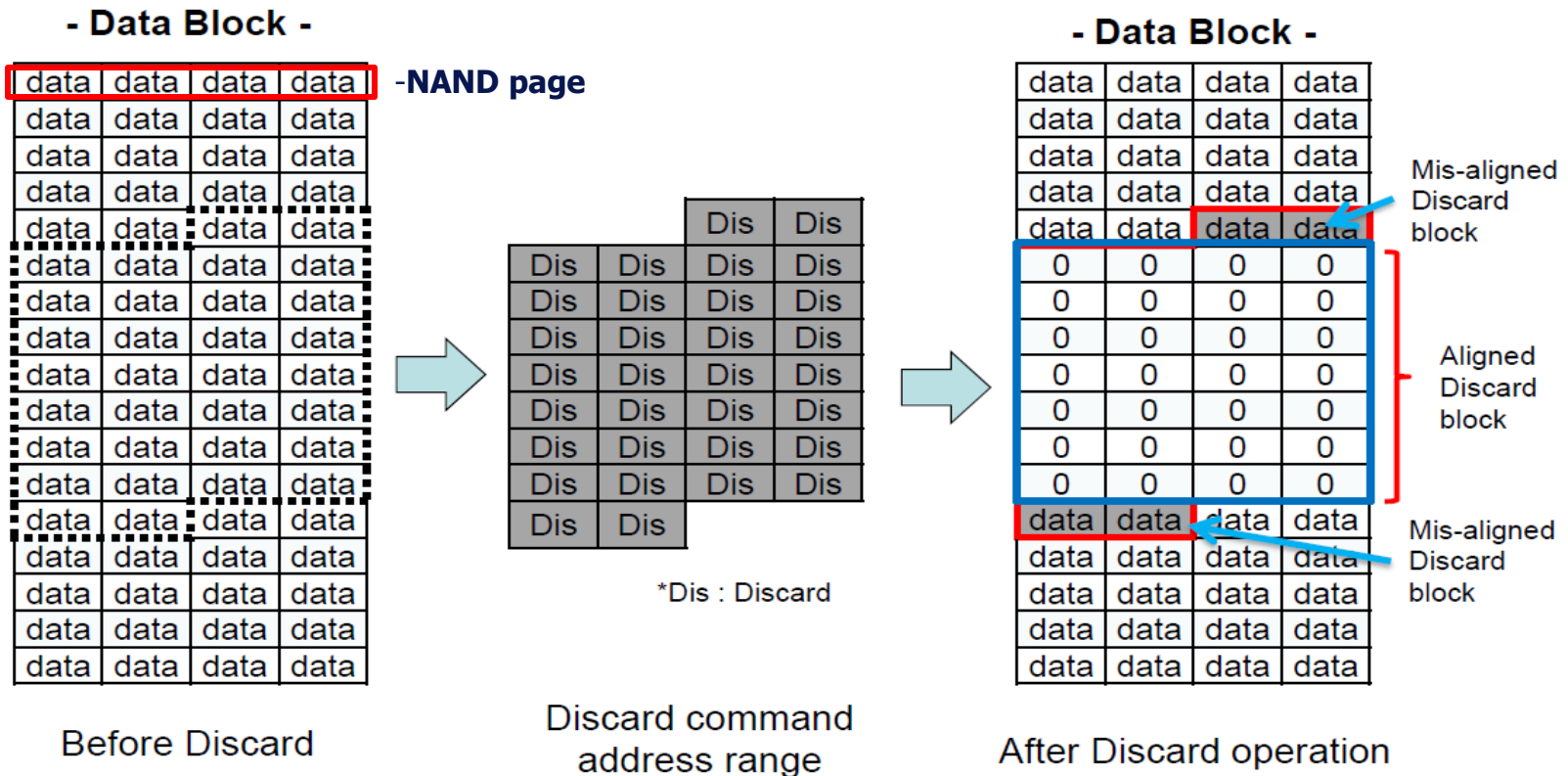| Version	Features
4.3	Booting, sleep, reliable write
4.4	DDR mode, partition, trim, security enhancement
4.41	Background operation, HPI (High Priority Interrupt)
4.5	Higher data rate (SDR 200MHz), data tag, partition attribute, discard, power-off notification, RTC, dynamic capacity, packed command, cache, sanitize

eMMC 4.5 Features

■ **Most features can be utilized by host & need host driver support**

| Category	Features	Meaning	Where to change
Performance	HS200	MMC interface speed increases (104→200Mbps)	HW
	Packed CMD	Vectored read/write command (ex. readv/writev)	D/D
	Cache	Write-back & flush like HDD	D/D
Hint	Discard	Mark unused LBA without zero-filling (ex. Deleted files)	D/D
	Context ID	Specify context ID for write command (ex. File, task)	App, FS, D/D
	Data tag	Specify data tag for write command (ex. FS meta)	App, FS, D/D
	Partition type	Specify GPAP type (system code, non-persistent)	D/D
	Power-off notify	Host shall not intentionally power-off device without notification	D/D
	RTC	Send RTC info to device	(App,) D/D
	Dynamic capacity	Device request host for capacity reduction	FS, D/D
Security	Sanitize	Purge all unused LBA	App, D/D

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- **Benefits**
  - **Reduce write timeout by reducing garbage collection cost**
  - **Level 3 over-provision**
- **Trim vs. Discard – misalignment handling**

- Data Block -

-NAND page

Before Discard

Discard command address range

*Dis : Discard

- Data Block -

Mis-aligned Discard block

Aligned Discard block

Mis-aligned Discard block

After Discard operation

Effectiveness of Trim

- **Trim is useful both for higher throughput and for reducing performance fluctuation**
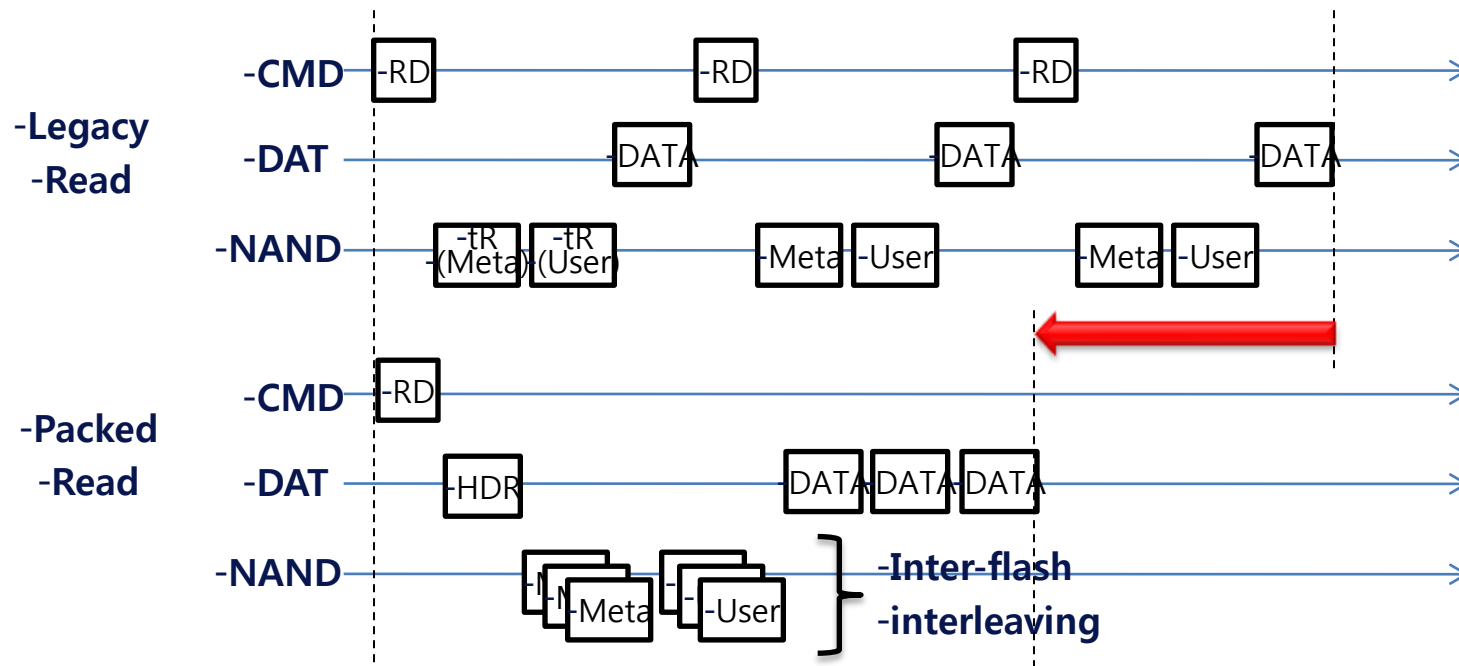 - **Write timeout will be shorter if trim is used well**

-<**Write Performance Fluctuation** >
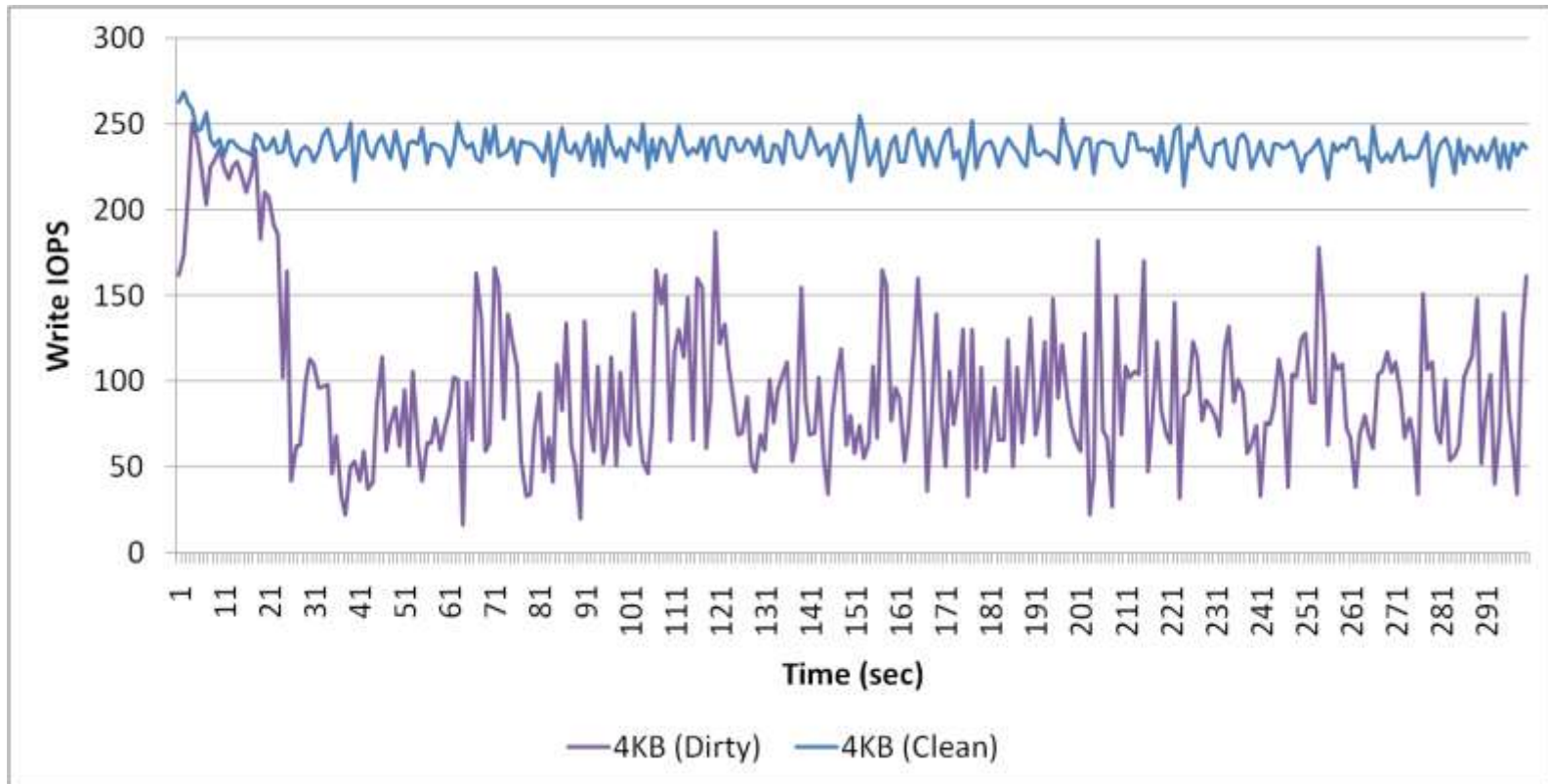
- ## Benefits
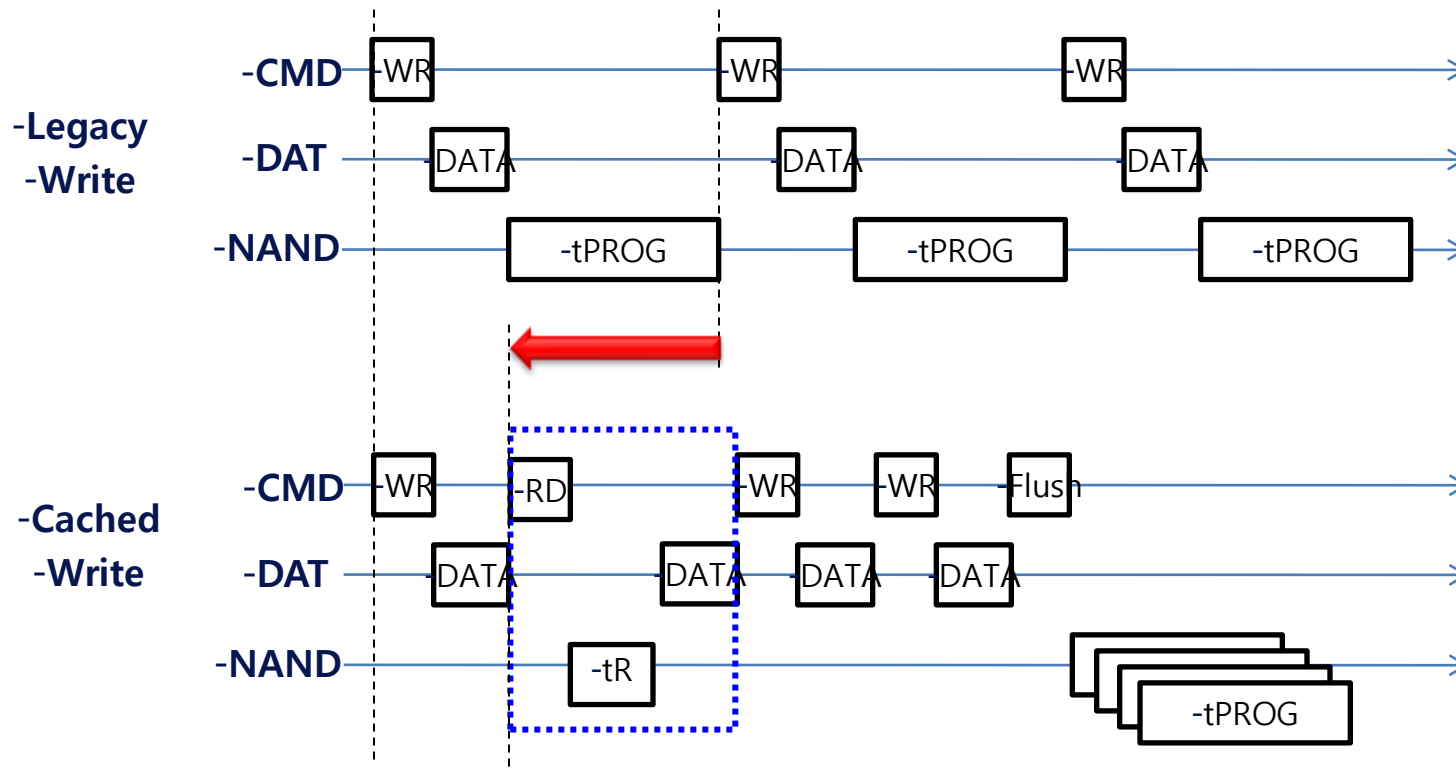 - ### Reduces # of discrete I/O CMD processing (usually random pattern) → higher read and write IOPS
- ## Example of Packed read
  - ### Internal data processing can be pipelined if there are multiple flash chips that can operate in parallel

Benefits

- **Buffers write operations that usually come in burst → higher write IOPS, shorter write latency**

- **May interleave read I/O if there is no ongoing flush operation**

-Legacy
-Write

-CMD	-WR		-WR		-WR
-DAT	DATA		DATA		DATA
-NAND		-tPROG		-tPROG		-tPROG

-Cached
-Write

-CMD	-WR	-RD	-WR	-WR	Flush
-DAT	DATA	DATA	DATA	DATA
-NAND		-tR			-tPROG

- ## Power-off notification
  - ### eMMC FW could use power-off signal for
    - marking where the last write operation happened
    - flushing dirty metadata of FW into nonvolatile memory
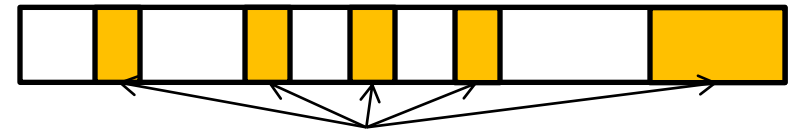 - ### As a result, eMMC initialization process could be shortened
- ## Sanitize
  - ### Secure erase/trim (4.4) – mark data to be securely deleted and purge at once
  - ### Sanitize (4.5) – purge unused data at once → may take huge time for completion
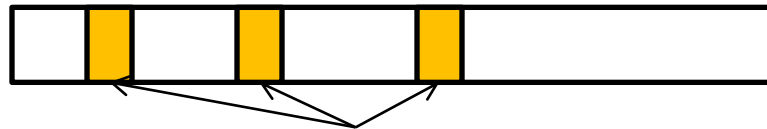
-Step 1. mark secure erase/trim

-Unused user space (trim/erase)

-Step 2. purge

-Step 1. sanitize

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SAMSUNG eMMC 4.5 Schedule

- **ES sample will be ready in early Dec '12 w/o SDR200.**
- **ES sample w/ SDR200 will be ready in the end of 1Q '12.**
- **CS sample w/ SDR200 will be ready in 2Q '12.**

Year	2011		2012			
	Nov	Dec	1Q	2Q	3Q	4Q
SAMSUNG ELECTRONICS		● 4.5 ES (w/o SDR200)	● 4.5 ES (w/SDR200)	● 4.5 CS (w/SDR200)		

Λlign with your imagination

Thank you

Questions to yejin.moon@samsung.com

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TURN ON TOMORROW