

UNT IN-DEPTH RELIABILITY CHARACTERIZATION OF NAND FLASH BASED SOLID STATE DRIVES IN HIGH PERFORMANCE COMPUTING SYSTEMS

MOTIVATIONS

NAND flash based solid state drives (SSD) have been widely used in high performance computing (HPC) systems due to their better performance compared with the traditional hard disk drives. However, little is known about the reliability characteristics of SSDs in production systems.

DATA

SSD-SMART data files are pulled from a active production system.

- Window size is 6 months
- Hourly recored
- Over 500,000 record
- Contains 20 SMART attributes
- All data are raw values

ID NO.	NAME	DESCRIPTION					
Environmental Attributes							
9	РОН	Power On Hour					
12	PCC	Power Cycle Count					
194	TC	Temperature Celsius					
Performance Attributes							
5	RSC	Reallocated Sector Count					
166	MWEC	Min Write/Erase Count					
167	MBB	Min Bad Block/Die					
168	MEC	Max Erase Count					
169	TBB	Total Bad Block					
171	PFC	Program Fail Count					
172	EFC	Erase Fail Count					
173	AWEC	Average Write/Erase Count					
174	UPLC	Unexpected Power Lost Count					
187	RU	Reported Uncorrect					
212	SPE	SATA PHY Error					
230	PWEC	Percentage Write/Erase Count					
232	PARS	Percentage Avaliable Reserved Space					
233	TNWG	Total NAND Write(GB)					
241	TWG	Total Write(GB)					
242	TRG	Total Read(GB)					
243	Unknown	N/A					

FUTURE RESEARCH

• Investigate the reliability degradation process of SSDs

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METHODS & PROCESS

SMART Attributes Analysis

SSD Characteristics Analysis

SSD Health Status Analysis

RESULTS 1

Pearson's coefficient reveals that write and erase operations appear strong linear correlations to each other.

НОЧ	1	-0.099	0.032	0.0021	0.097	0.019	0.11	-0.46	-0.6	0.14	0.11	0.13	-0.22		0.9
PCC	-0.099	1	0.027	-0.018	0.02	0.055	-0.012	0.8	0.13	-0.011	-0.012	-0.14	-0.41		
MWEC	0.032	0.027	1	0.012	0.019	0.017	0.0073	0.013	-0.0079	0.006	0.0073	0.0082	0.0008		
	0.0021	-0.018	0.012	1	-0.079	0.8	-0.096	0.025	0.059	-0.096	-0.098	-0.092	-0.055		0.6
MEC	0.097	0.02	0.019	-0.079	1	-0.038	0.95	-0.041	-0.14	0.95	0.95	0.9	0.076		
TBB	0.019	0.055	0.017	0.8	-0.038	1	-0.052	0.047	0.02	-0.05	-0.054	-0.075	-0.12		0.3
AWEC	0.11	-0.012	0.0073	-0.096	0.95	-0.052	1	-0.072	-0.14	0.99	1	0.95	0.093		
UPLC A	-0.46	0.8	0.013	0.025	-0.041	0.047	-0.072	1	0.59	-0.083	-0.073	-0.13	-0.17		
TC	-0.6	0.13	-0.0079	0.059	-0.14	0.02	-0.14	0.59	1	-0.17	-0.14	-0.13	0.044		0.0
PWEC	0.14	-0.011	0.006	-0.096	0.95	-0.05	0.99	-0.083	-0.17	1	0.99	0.95	0.088		
TNWG PI	0.11	-0.012	0.0073	-0.098	0.95	-0.054	1	-0.073	-0.14	0.99	1	0.95	0.093		-0.3
TWG TN	0.13	-0.14	0.0082	-0.092	0.9	-0.075	0.95	-0.13	-0.13	0.95	0.95	1	0.35		
TRG	-0.22	-0.41	0.0008	-0.055	0.076	-0.12	0.093	-0.17	0.044	0.088	0.093	0.35	1		
	DOLL	DOG	MMEC	MDD	MEG	TDD	114/50		TO	DWEC	THINKS	THE	TRO		

Figure 4: Pearson Correlation Coefficient

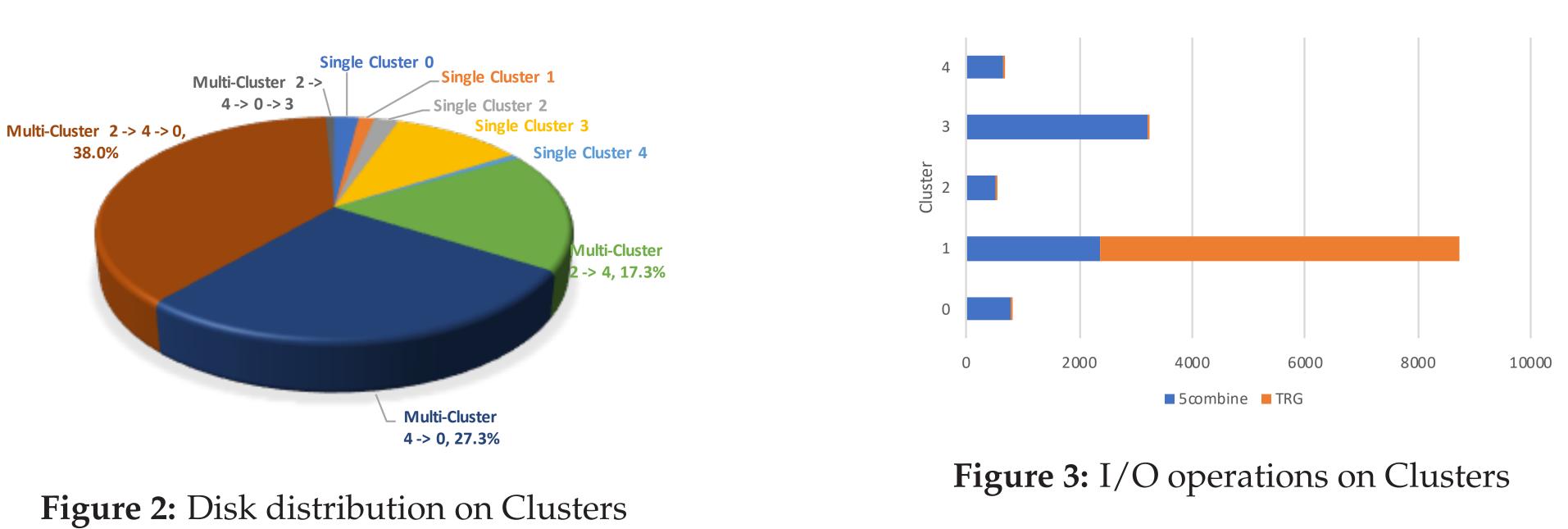
Other results includes:

- I/O operations may distribute unevenly.
- Environmental related attributes are not directly contribute to the disk health status.
- No evidence proof that I/O operations will lead to back block increase in SSDs.

• Accurate model this process for a better characterization of SSD's reliability

RESULTS 2

- SSDs in Cluster 1 experience I/O intensive operations.
- SSDs in Cluster 3 experience the highest number of write and erase operations, while the number of read operations is the average.
- Clusters 0, 2 and 4 include the majority of SSDs which experience the average number of I/O operations.
- SSDs in the three clusters have reliability degradation following the same transition pattern



CONCLUSION

We explore SSDs SMART data from a real world production system. Our research found that:

- The volume of I/O operations and cycles has a major influence on the wear level of SSD.
- Write and erase related attributes display a strong correlation.
- Read operation is relatively independent and is not evenly distributed in among the drives.
- Observe many health status transitions.

REFERENCES

[1] Song Huang, Song Fu, Quan Zhang, and Weisong Shi. Characterizing disk failures with quantified disk degradation signatures: An early experience. In *Proceeding of IISWC*, pages 150–159. IEEE, 2015.

ACKNOWLEDGMENT

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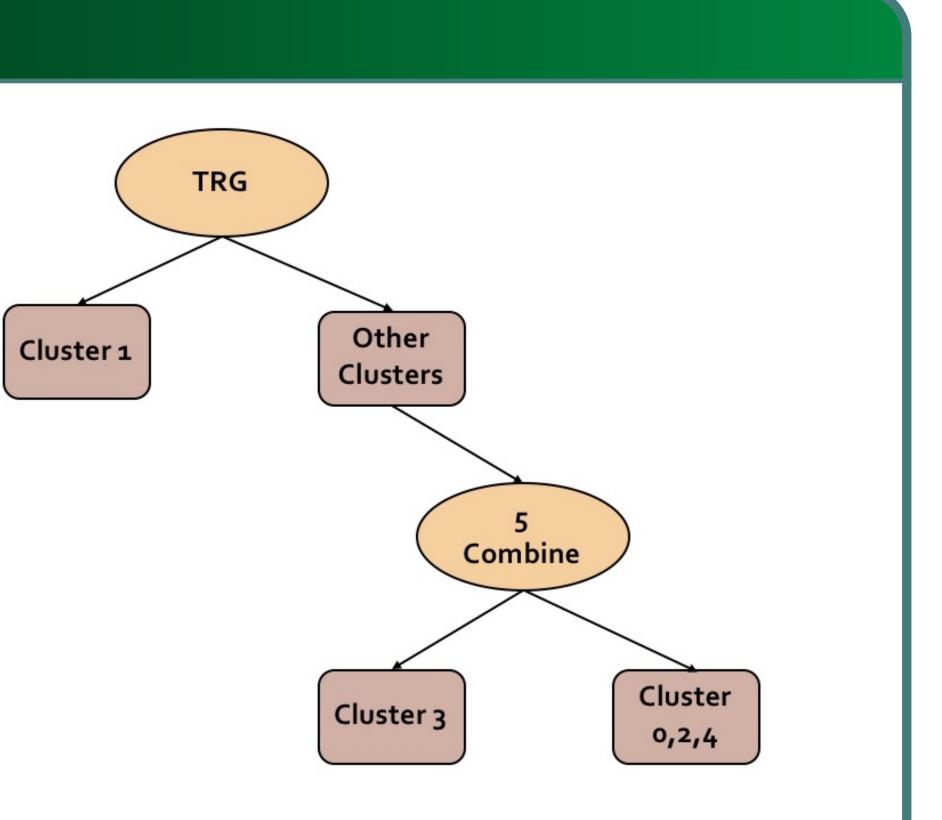


Figure 1: Cluster Distinguished by Wear Level

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