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Benchmarking Issues

- Benchmark Problems
 - Synthetic tests are not always real world indicators
 - Most focus on isolated situations
 - Typically use only worst case data entropy
 - Some use Mebibyte/s (MiB/s) vs. Megabyte/s (MB/s)
 - Do not require the drive to be in a "used" state (preconditioned)

"What is preconditioning?"

- Operator Errors
 - Not manually preconditioning or doing it incorrectly
 - Misunderstanding results like data entropy
 - Not testing other relevant data
 - Power per GB written
 - Battery life
 - Write amplification
 - Background vs. foreground garbage collection

"I don't precondition because it takes too long"

Most benchmark results only show part of the bigger picture

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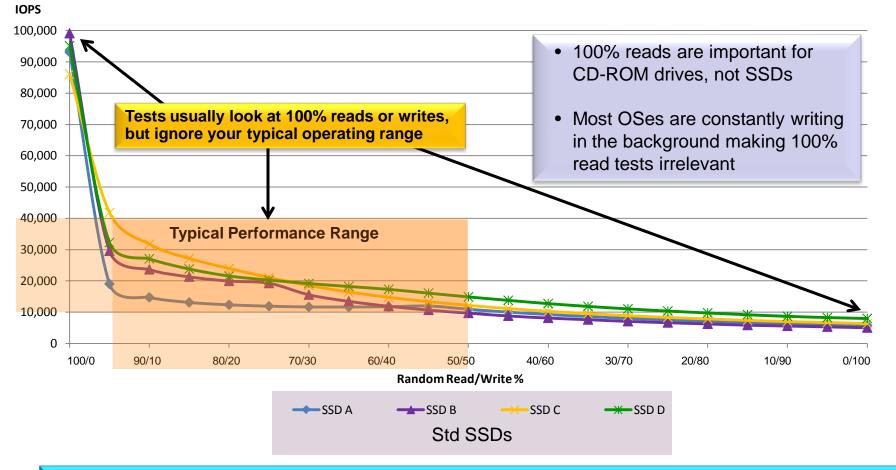
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Synthetic Tests Often Highlight Unrealistic Data

True performance measurements mix reads and writes



With just 5% writes typical SSDs lose 50-80% performance

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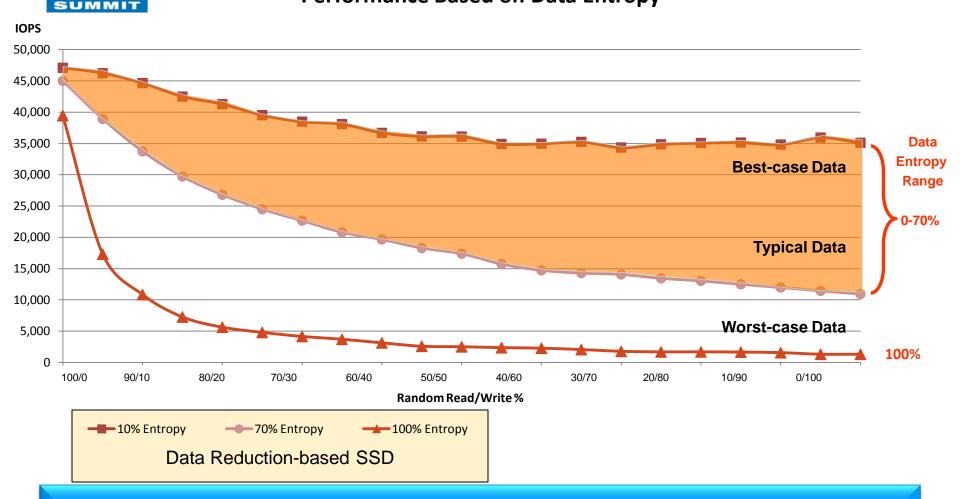
SUMMI



Random IOPS after Random Writes preconditioning; data collected using VDBench

Why Does Entropy Testing Matter?

Performance Based on Data Entropy



Performance increases with lower entropy for data reduction technology like DuraWrite[™]

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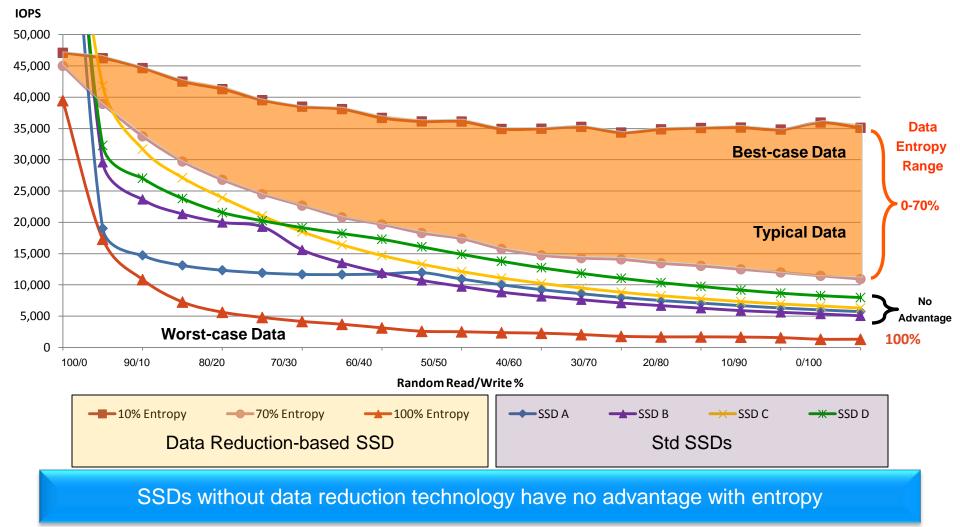
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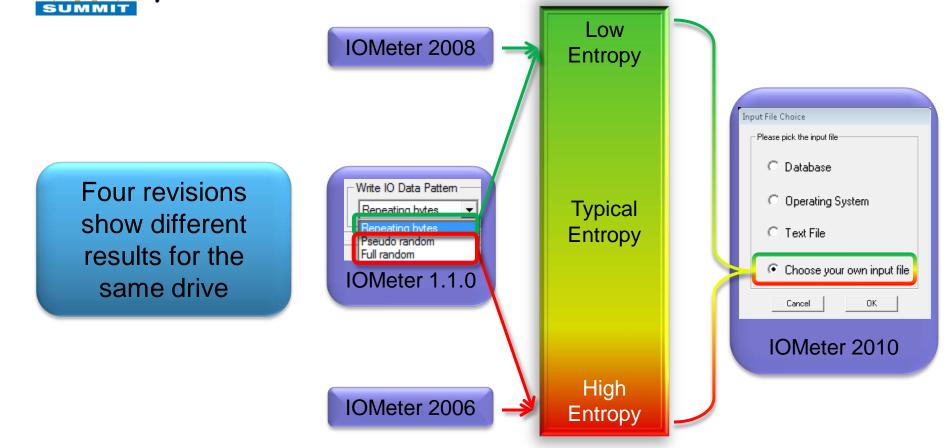
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Random IOPS after Random Writes preconditioning; data collected using VDBench



IOMeter – Multiple Versions Available Entropy is the primary difference



IOMeter 2010 permits entropy testing for typical data







Does Preconditioning Really Matter?



- All NAND SSDs perform Garbage Collection (GC)
 - Starts after writing one full capacity worth of data
 - Represents >99.9% of the SSD's life
 - Mainly affects write performance

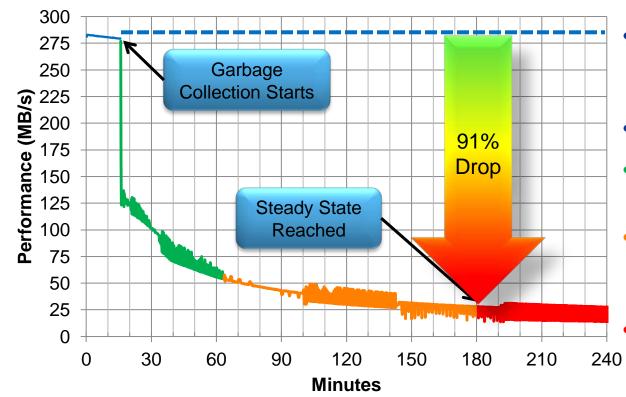
Just How Much Can Preconditioning Matter?







Preconditioning Impact on an SSD



From FOB to Random Steady State

Secure erase SSD for Fresh-Out-of-Box (FOB)

- After 16 minutes drive wrote 256GB (one full capacity write)
- Garbage Collection starts
- After ~62 minutes it wrote 2x capacity
- After ~3 hours it wrote 3x capacity, and finally hit steady state
- Now you can run drive tests to represent reality

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Properly precondition before random tests for true-life results

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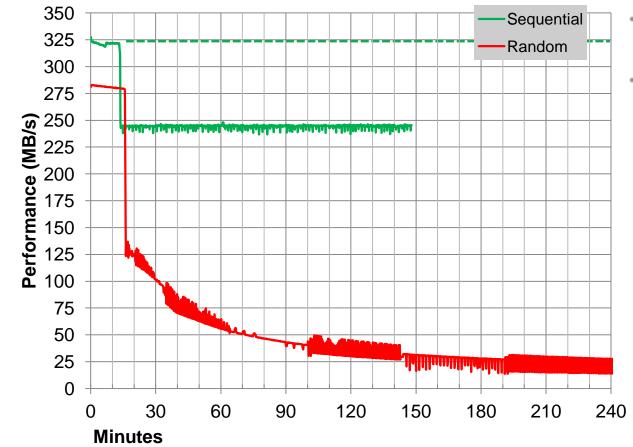


IOMeter Test Parameters:

- Transfer size and access type: 4K random write
- Test duration: 240 minutes



Sequential vs. Random Preconditioning FOB to Steady-state Write Performance Compared



- Sequential precon generally hits steady-state very quickly
- Random precon can take over 10x longer

Don't use only sequential preconditioning because it is convenient

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The Benchmarks

Before and After Proper Preconditioning



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Commonly Used Benchmarks



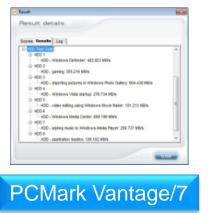
Anvil's Storage Utilities

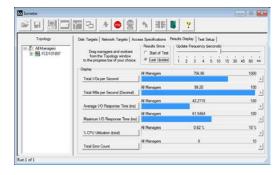




ATTO Disk Benchmark

CrystalDiskMark 3.0.1 < All 0x00, 0Fill> File Edit Theme Help Language 5 • 1000MB • D: 0% (0/238GB) Read [MB/s] Write [MB/s] 511.4 503.4 455.6 490.5 35.86 72.43 238.5 321.7 **Crystal Disk Mark**







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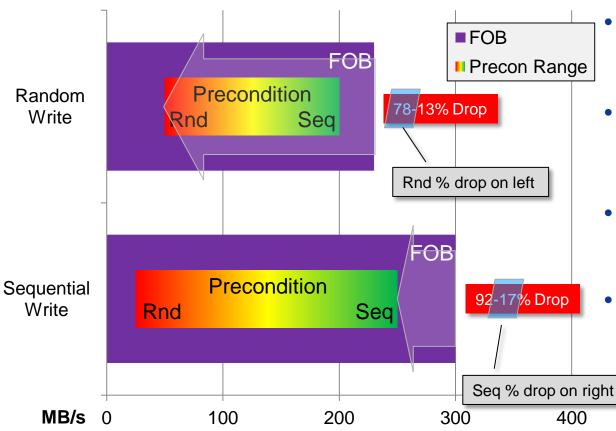


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How to Read the Charts

Before and After Preconditioning



FOB Rnd Seq Precon Precon 230 Rnd 50 200 Write Seq 300 25 250 Write

Purple shows Fresh-**Out-of-Box performance**

- Max, but not real
- True performance range
 - Green is sequential
 - Red is random
- Random test results would use the **red** precon zone results
- Sequential test results would use the green precon zone results

This might seem complicated, but it is critical to proper measurements



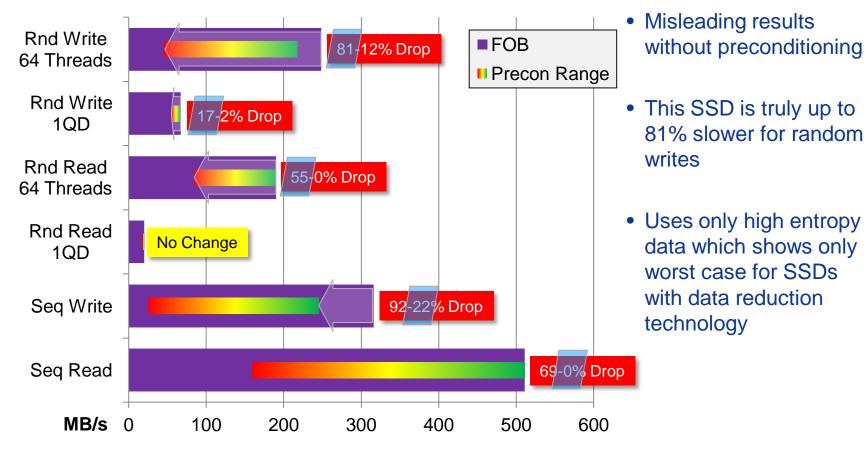






AS SSD Before and After Preconditioning

L A.M. Lauf and State	Children +	
ATA 6070 sd0xxx-04 1004.K-04 223.17.56	Read:	Write:
8 Seq	509.64 MB/s	316.03 MB
8 4K	19.34 MB/s	66.92 MB/s
# 4K-64Thrd	187.47 MB/s	248.23 MB/s
Acc time	0.135 ms	0.284 ms
Score:	258	347
	733	
		1



Up to 81% reduction in performance after preconditioning

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Seq 4K

Read

Seq 128K

Read

Seq 4K

Write

Seq 128K

Write

ATTO Before and After Preconditioning



- All sequential tests; generally only look at sequential precondition
 - Sequential operations are not greatly impacted by preconditioning except when randomly preconditioned
 - ATTO was the only test that did not show performance indicative of other tests

Tests only sequential performance, but results are questionable

400

27% Drop

■ FOB

Precon Range2

No Change

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MB/s 0

100

200



No Change

No Change

300



500



600



Rnd Write

4K QD32

Rnd Write

4K 1QD

Rnd Read

4K QD32

Rnd Read

4K 1QD

Seq Write

Seq Read

Crystal Disk Mark (CDM) Before and After Preconditioning

10-9% Drop

3-0% Drop

100

200

300

3-0% Drop

54-14% Drop

■ FOB

Precon Range

500

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1.000	Theme Help Language	0% (0/22468)
All	Read [MB/s]	
Seq	506.5	502.0
512K	442.1	486.5
410	32.36	77.15
4%	108.1	341.4

- Misleading results
 without preconditioning
- SSD is truly up to 54% slower for random writes
- Default uses only high entropy data which shows only worst case for SSDs with data reduction

Up to 54% reduction in performance after preconditioning

400

23-14% Drop

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MB/s 0





No Change

600





Rnd Write

4K QD32

Rnd Write

4K 1QD

Rnd Read

4K QD32

Rnd Read

4K 1QD

Seq Write

Seq Read

Anvil Before and After Preconditioning

63-0% Drop

No Change

100

200

85-7% Drop

No Change

85-4%/Drop

300

■ FOB

Precon Range

500

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49-0% Drop

600



- Misleading results without preconditioning
- SSD is truly up to 85% slower for random writes
- Provides a number of entropy options to match user environment



400

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MB/s 0







Defender

Gaming

Import

Pictures

OS Startup

Movie Maker

Media Center

Media Player

App Load

PC Mark Vantage Before and After Preconditioning



- Misleading results
 without preconditioning
- SSD is truly up to 74% slower for the App Load test
- Real-world results would vary based on more random or sequential data already present on SSD



49-19% Drop

45-43% Drop

200

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MB/s 0

100



300



■ FOB

74-66<mark>% Drop</mark>

400

32-29% Drop

27-24% Drop

49-33% Drop

39-17% Drop

500

Precon Range

32-29% Drop





Precondition Procedure Used

- Secure erase
- Create partition
- Quick format* NTFS
- Default allocation size
- Open IOMeter
 - If entropy testing use IOMeter 2010 and select extracted Anvil entropy file (0%, 46%, 100%) as data type
 - Set LBA count to capacity of drive minus 10GB
 - Simulates full drive with 10GB free
 - Select created partition as target

- Precondition sequentially until steady-state
- Run GUI benchmarks and record all results
 - Close each GUI benchmark before moving on to next GUI test to clear temporary GUI data on drive
- Repeat IOMeter step with Random preconditioning until steady-state
- Rerun GUI tests and record all results

Note range of results for each test

SATA trace shows OS Format sends TRIM and removes all preconditioning

*Do not format after preconditioning because it TRIMs drive to empty state





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- Optimizing Flash Controller Technology for Next-Gen Flash
- Greg Huff, LSI Senior Vice President and CTO

Visit us at <u>booth #402</u>

- Experience new LSI flash storage innovations
- See live demos of LSI SandForce Driven SSDs
- Enter to win SandForce Driven SSDs from Adata, Mushkin and Kingston
 - Drawings held on Wednesday 12-2pm & 5-7pm, Thursday 12-2pm
 - Up to 3 winners every 30 minutes!





Test Equipment

- CPU
 - Intel Core i5-3550 @ 3.70 GHz
- RAM
 - 8 GB RAM 1333 MHz
- Motherboard
 - Intel Z77 Express Chipset
- Host Driver
 - Intel RST 11.7.0.1013 (AHCI Enabled)

- Operating System
 - Windows 7
 - Vista
- SSDs
 - Various SandForce Driven and non-LSI controller based SSDs with 256GB flash





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