StorScore
Microsoft's System for SSD Qualification

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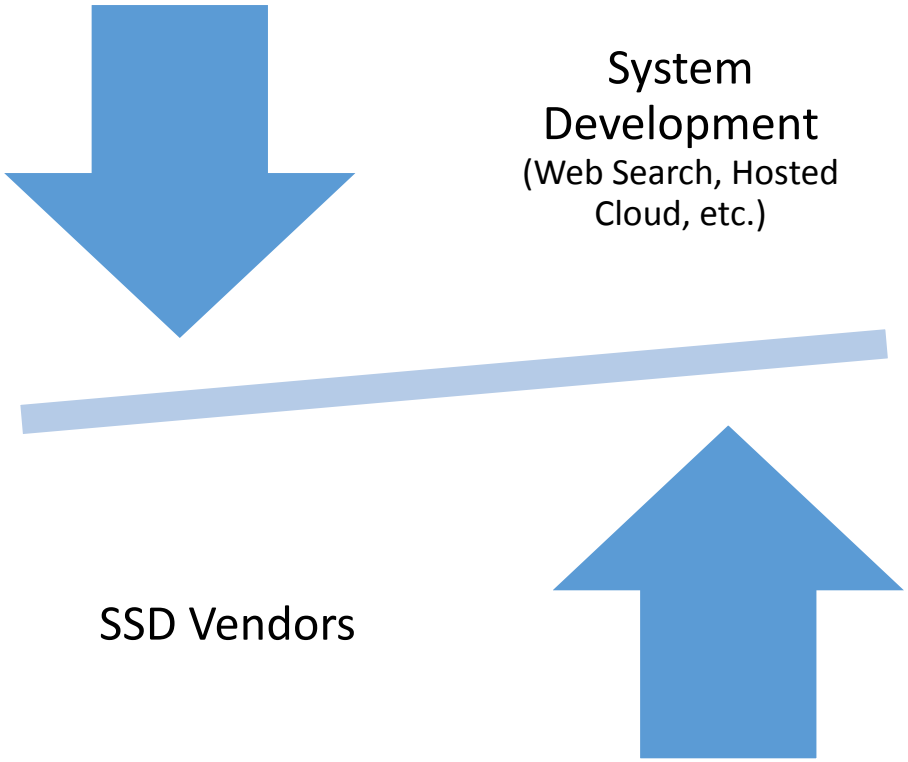
Microsoft

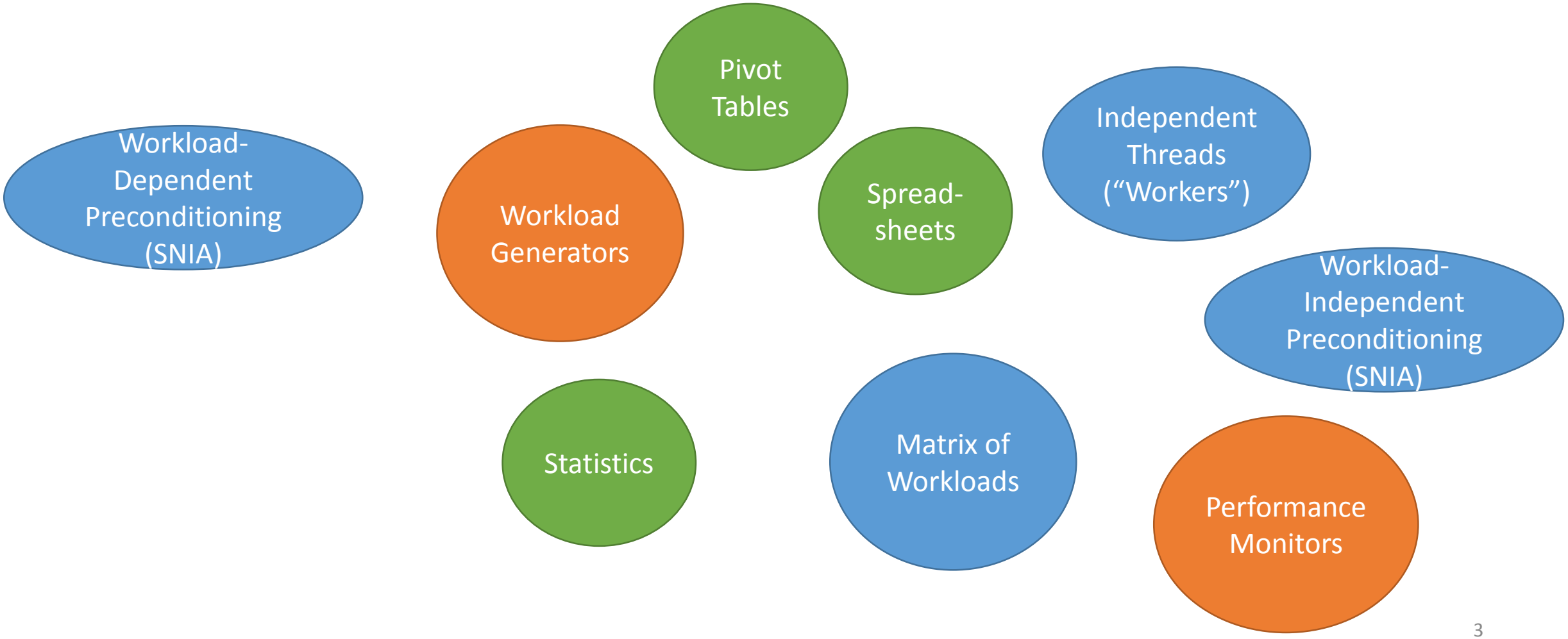
Who are we?



Unique Needs & Opportunities

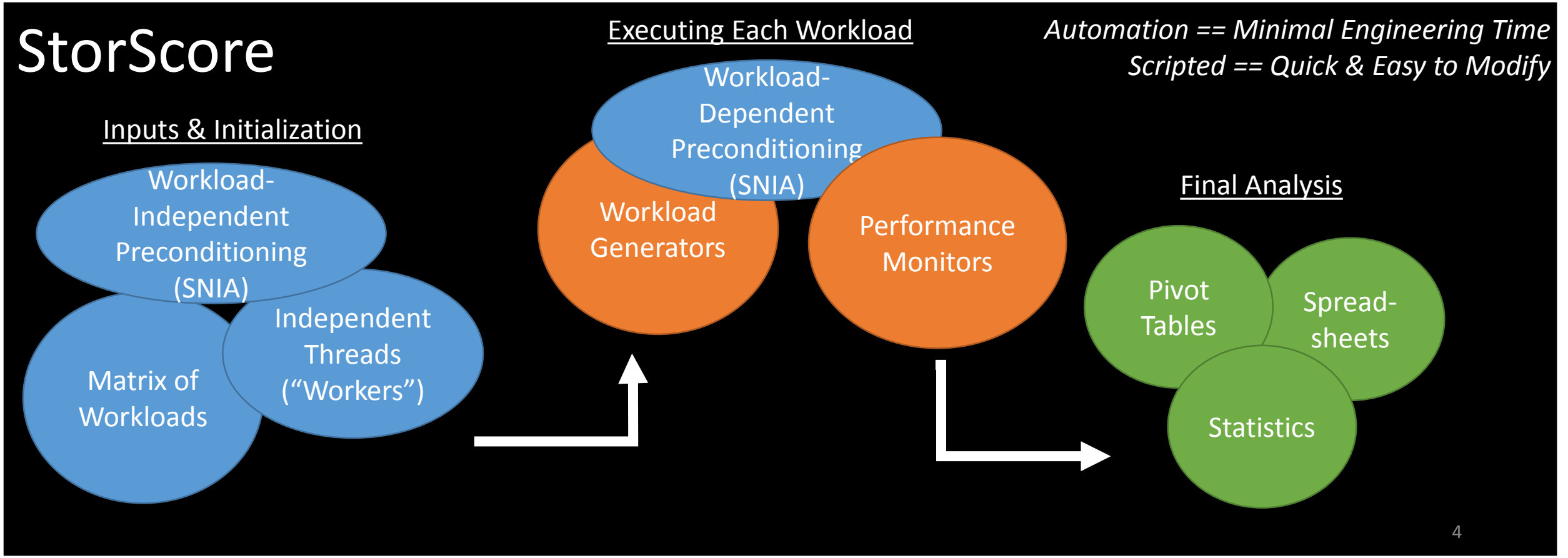
- Microsoft's platform
- Workloads: Variety and Quantity
- Flexibility to modify stack
- Iterate on designs with vendors
- Wide variety of expertise
- Additional metrics

Many Resources & Concepts



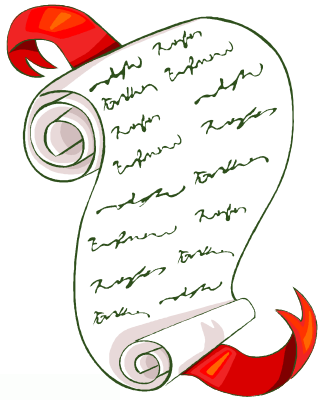
What is StorScore?

StorScore is a script wrapper that automates industry-wide best practices for SSD performance testing, existing tools that are under active development for Windows and modern tools and techniques for data analysis.

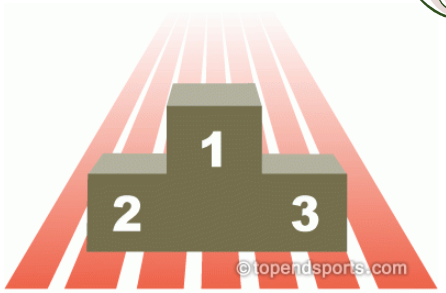


Outline

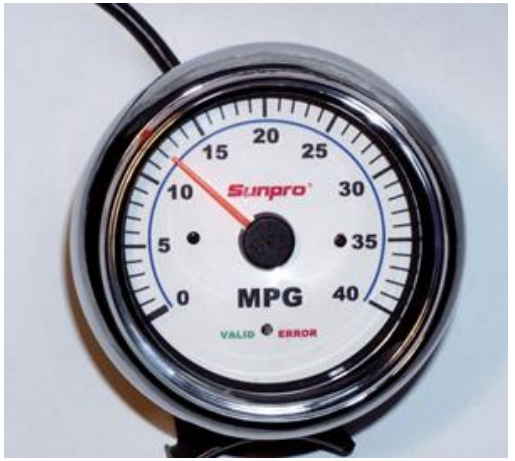
- ***Recipes***: Defining the Test Suite



- ***Scores***: Managing the Output



- ***Endurance***: Quantifying the Consumable



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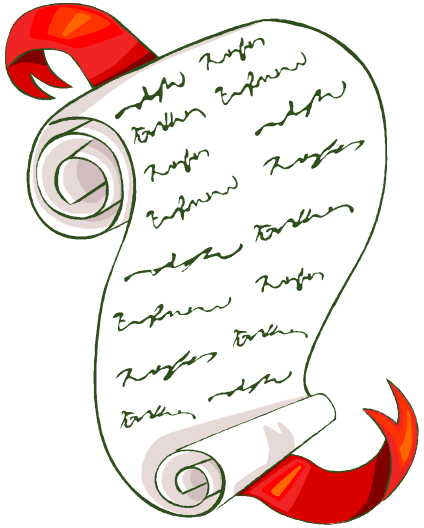

A Single Test

```
test(
    name_string          => 'foo',
    write_percentage     => 0,
    access_pattern       => 'random',
    block_size           => '8K',
    queue_depth          => 32,
    warmup_time          => 60,
    run_time             => 3600
);
```

- The entire contents of single.rcp
- Reference the file from the cmd line:
  `$> StorScore --recipe=single.rcp`
- Reads like English

A Matrix of Tests

```
# vim: set filetype=perl:
require 'matrix.rpm';

do_matrix(
    access_patterns     => [qw( sequential random )],
    write_percentages   => [qw( 100 30 0 )],
    block_sizes         => [qw( 2M 1M 512K 64K 16K 8K 4K 1K )],
    queue_depths        => [qw( 256 64 16 4 1 )],
    warmup_time         => 60,
    run_time            => 3600
);

include 'targeted_tests.rcp';
```

- Mimics Test designer's whiteboard sketch
- "include" statements combine test files
- Full functionality of Perl

```
do_workload( "Targeted Test Read Baseline" );

bg_exec( "smart_loop.cmd $gc{'target_physicaldrive'}" );
do_workload( "Targeted Test SMART Read Data " );
bg_killall();
```

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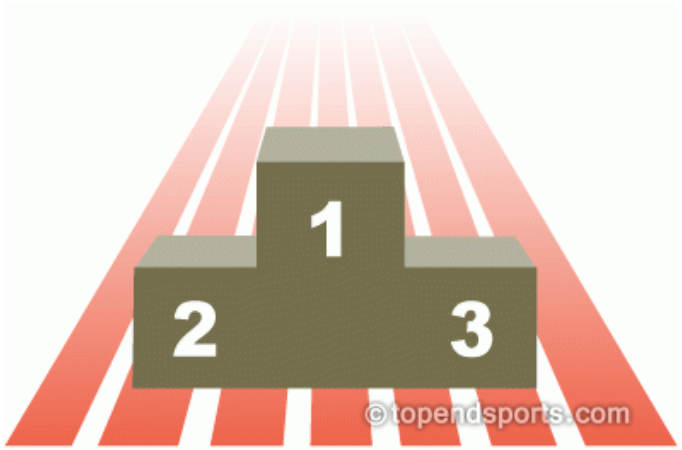


Results Parser

- Raw Output Files → One Excel File
  (24 SSDs x 218 Workloads = 5,232 Files)
- Detects and highlights outliers
- Generate Pivot Tables & Graphs
- Still too much data
  (5,232 Files x 23 Metrics = 120k Data Pts.)

Display Name	Write Mix	Access Size (kB)	Access Type	Queue Depth	Bandwidth (MB/s)	Average Latency (ms)
Device A	100%	16	random	1	54.32	1.04
Device B	100%	16	random	1	15.05	0.29
Device A	30%	16	random	1	20.01	1.39

Example Policy:
Bandwidth matters a lot, latency matters a little

Device A scores 72/100
Device B scores 65/100

Putting the "Score" in StorScore

- Goal: Enable data-driven decisions throughout the company
- Reduce data to one score per drive
  - Explainable
  - Repeatable
  - Representative
- Method: a weighted average of all the metrics for each workload

Display Name	Write Mix	Access Size (kB)	Access Type	Queue Depth	Bandwidth (MB/s)	Average Latency (ms)
Device A	100%	16	random	1	Z_AX0	Z_AX1
Device B	100%	16	random	1	Z_BX0	Z_BX1
Device A	30%	16	random	1	Z_AY0	Z_AY1

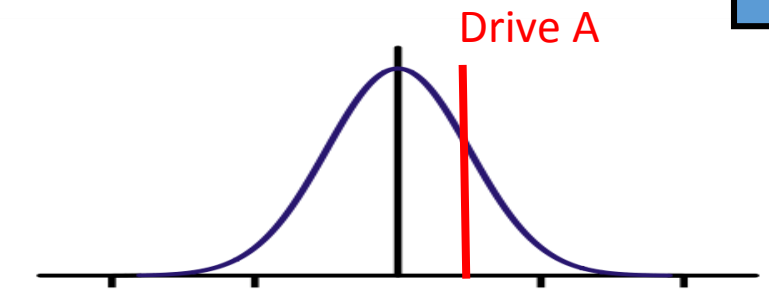
Step 1:
Convert each value to z-score

Calculating Each Z-Score

A z-score (or standard score) is the number of standard deviations from the mean.

Drive: A
Wkld: X (4k, rand, QD = 1, 100% writes)
Metric: 0 (Read Latency)

z_{AX0}



Distribution of
- all drives
- workload X
- metric 0

- One z-score for each data point
- Positive = better than average
- Negative = worse than average
- Based on cohort of drives

Calculating the Weighted Average

General Policy:

Throughput Metrics

Latency Metrics

50% x $Z_{A(n+m)i}$ **+ 50% x** $Z_{A(n+m)j}$ **= 70 / 100**

Drive A
Wkld range 0 to (n+m)
Metric range 0 to i

Score for Drive A

- Can apply multiple policies at once
- Can use any kind of weight system (stay consistent within single policy)

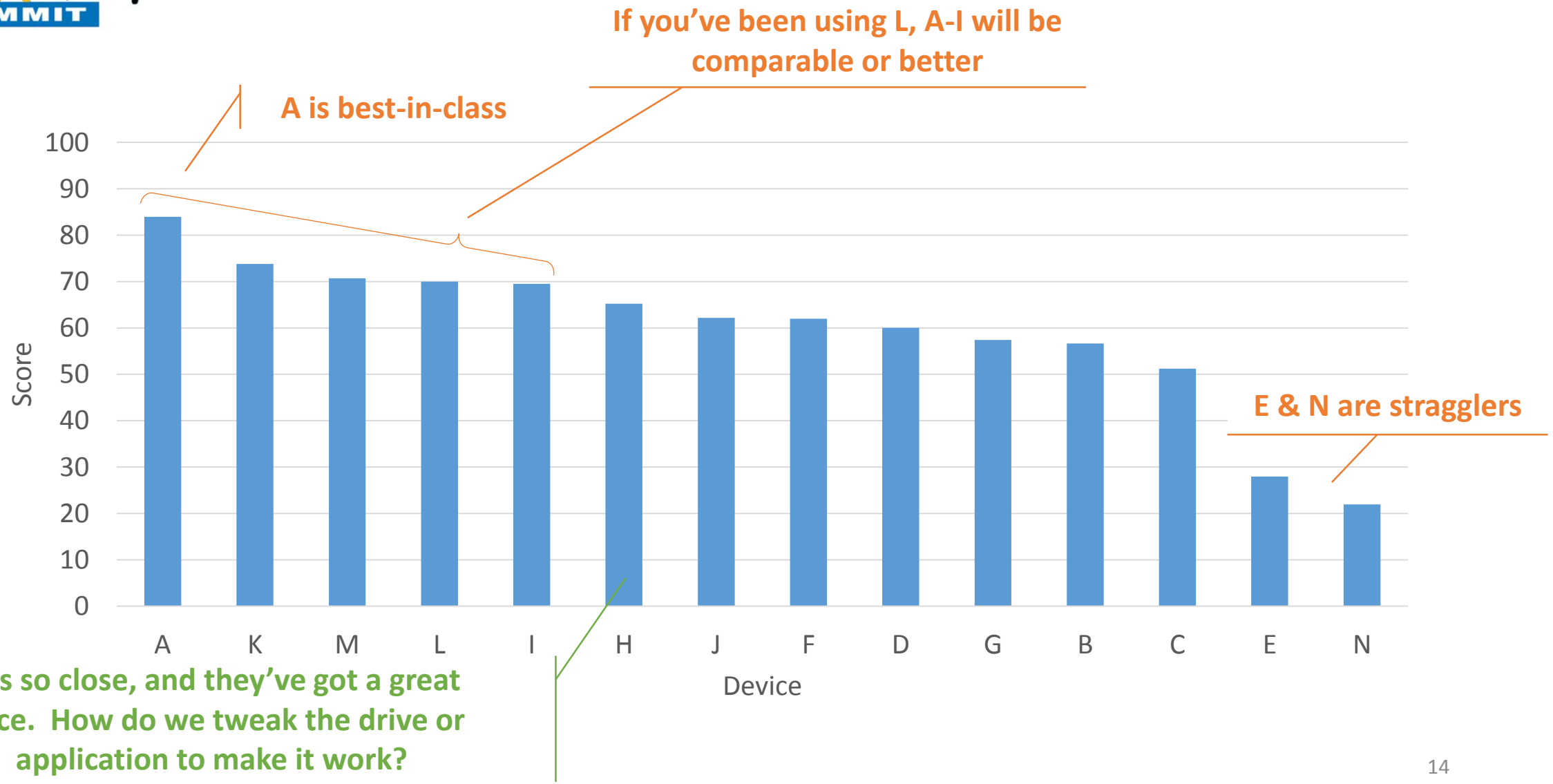
Policy to Favor Mixed Workloads:

70/30 Read/Write Mix Workloads

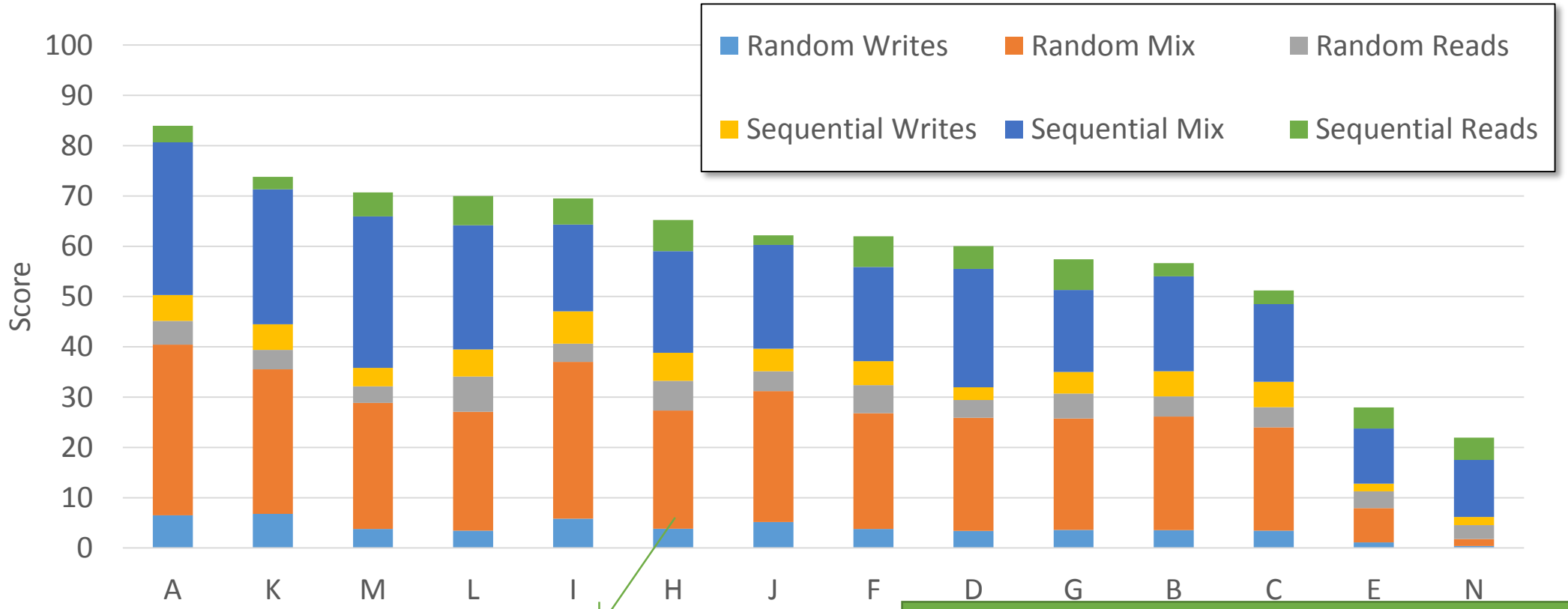
100% Read & 100% Write Workloads

5 x $Z_{An(i+j)}$ **+ 1 x** $Z_{Am(i+j)}$ **= 65 / 100**

Scores


If you've been using L, A-I will be comparable or better
A is best-in-class
E & N are stragglers
100
90
80
70
60
50
40
30
20
10
0
Score
A
K
M
L
I
H
J
F
D
G
B
C
E
N
Device
H is so close, and they've got a great price. How do we tweak the drive or application to make it work?

Scores' Breakdown



H is so close, and they've got a great price. How do we tweak the drive or application to make it work?

Answer:
Drive should improve random mix (not seq. mix), or
App should favor sequential mix (not random mix)

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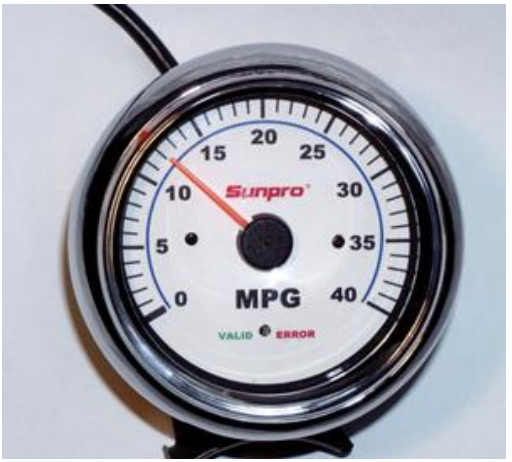
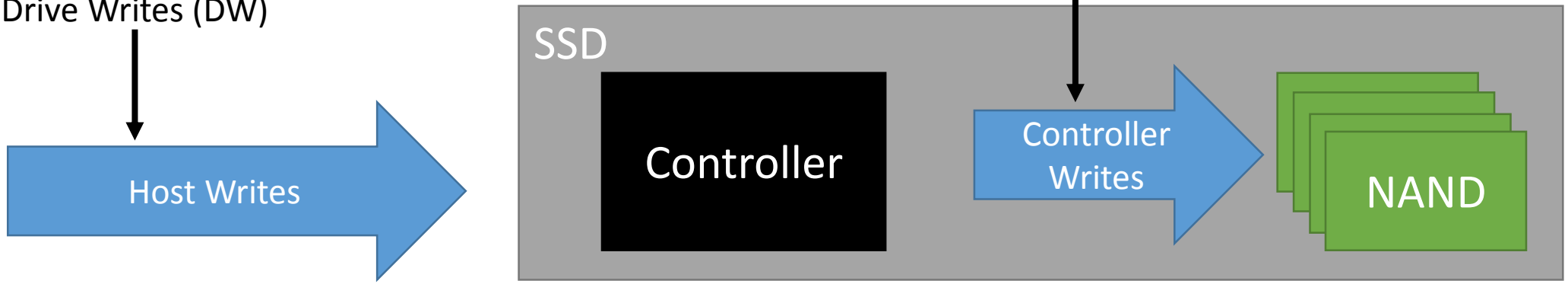


SSD Failure Mechanism: Writes

Drive Writes Per Day (DWPD)
Total Bytes Writes (TBW)
Drive Writes (DW)

Program / Erase Cycles (P/E Cycles, or PEC)
Write / Erase Cycles (W/E Cycles)

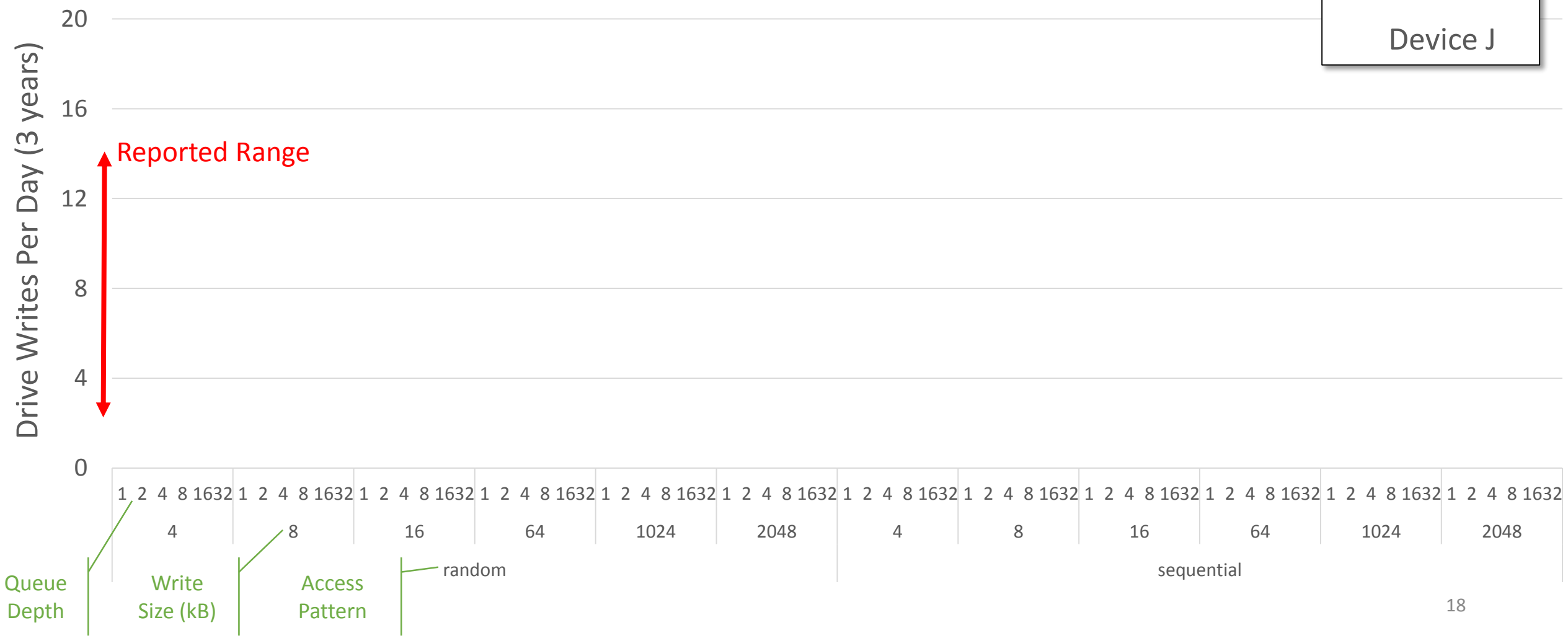


Total Drive Writes **x** **Write Amplification Factor** **=** **P/E Cycles**

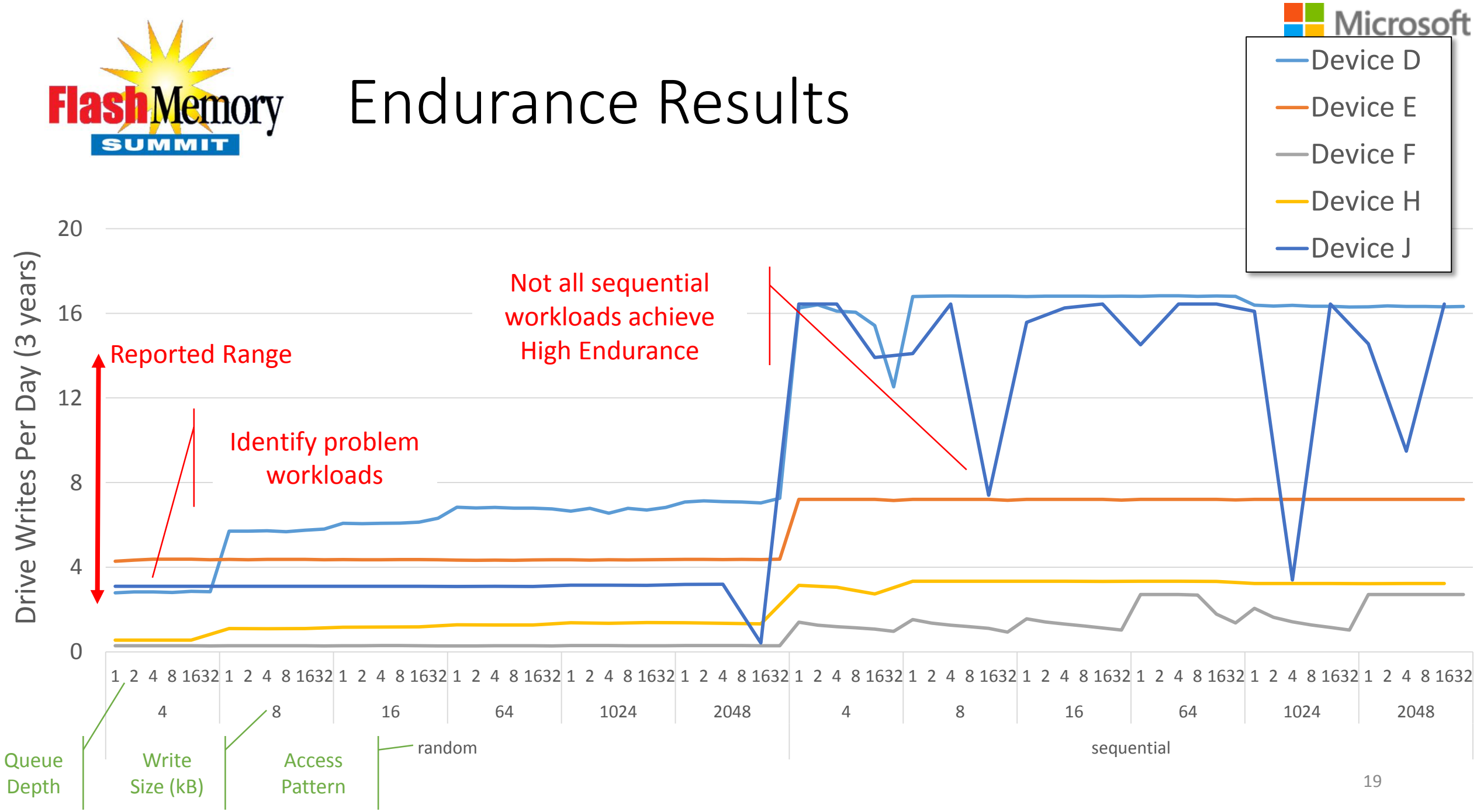
Workload Dependent,
Vendor Reported, Implementation Specific

Previously Available	New Telemetry
SMART "Media Wear Indicator"	SMART "Controller Writes"
Reported in **units of 1%** (300 TB for 30k, 1TB drive)	Reported in units of **sectors or GB**
4.7 months for 1 workload	1,700 workloads in 4.7 months

Endurance Results



Endurance Results



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Conclusion

- How StorScore brings together existing work & concepts
- Simplicity of defining the inputs
- Spectrum of analysis tools
  - Directly and interactively with excel & pivot charts
  - Automated Score generation
  - Burrowing down into portions of the score
- Measuring endurance on many workloads

StorScore
enables data-driven decision making process for Microsoft cloud applications

Thanks! Questions?

You may download StorScore for free at:

http://aka.ms/storScore