Optimizing SSDs for Multiple Tenancy Use

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Overview

• Is physical data separation everything?
  – NVM Sets: A write to one set does not impact a read from another.

• Can we improve performance & endurance of multi-tenancy SSDs without physical data separation?

• Show how we can improve random write speeds for multi-tenancy variable active workloads by using a feature available in some Western Digital SSDs.
Multiple Tenancy Requirements

- SSDs used in cloud computing...
  - Multiple customers (tenants) per SSD.

- New protocol to support multiple tenants:
  - NVM sets, Namespaces.

- Customers want...
  - Consistency of service.
  - High Quality of Service (QoS).

- Cloud providers want...
  - High endurance & performance.
  - Consistency.
  - Lower costs (i.e. lower OP / TCO).

- Reality is...
  - Tenants can change behavior over time.
  - Makes consistency and lower cost harder to achieve.

- Using NVMe, tenants’ data can be separated according to namespace/stream.
Logical & Physical Separation

- **Logical / block separation**: Drive is separated into distinct partitions each used by a different tenant.
  - **Pros**:
    - Simple
  - **Cons**:
    - Potential for tenant’s data mixing within die.
    - Lower QoS due to contention between tenants.

- **Physical die separation**:
  - **Pros**:
    - No die contention between tenants. Better QoS.
  - **Cons**:
    - Lower maximum per tenant bandwidth.
    - Die failure has higher cost.
    - Cannot use unutilized resources for other tenants.

### Example Random write workload on 7% OP drive:

<table>
<thead>
<tr>
<th>Tenant</th>
<th>Write Rate</th>
<th>Logical Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Ra</td>
<td>La</td>
</tr>
<tr>
<td>B</td>
<td>Rb &lt; Ra</td>
<td>Lb &gt; La</td>
</tr>
<tr>
<td>C</td>
<td>Rc &lt; Rb</td>
<td>Lc &gt; Lb</td>
</tr>
</tbody>
</table>

### Logical / Block Separation
- OP shared across drive.
- Tenants written to different NAND blocks.
- Tenants share die.

### Physical Die Separation
- OP different (tuned) for each tenant.
- Tenants data written to different die.
Fix It Automatically in the SSD...

- Tenant’s with different write patterns create a non-uniform workload.
- But all tenants have the same OP for logical separation on a standard SSD.
- Physical separation have pre-determined OP per tenant that cannot change.

- Is there another way to approach the problem?
- What if the SSD could always give the OP to where it was needed?
Non-Uniform Workload in an SSD

• Write Amplification (WA) is a function of Over-Provisioning (OP).

• Incorrectly apportioned OP:
  – Higher Write Amplification (worse than uniform random).
  – Lower Performance.
  – Poorer Quality of Service.
  – Lower Endurance.

• Track “temperature” of all logical pages.

• Western Digital Guardian Technology Platform dynamically calculates optimal OP and assigns that OP across the drive.

• The write amplification is reduced and performance increased.
### What can be achieved?

#### Endurance Benefit (PEs)

<table>
<thead>
<tr>
<th>Region</th>
<th>LBA Regions Active</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Active</td>
</tr>
<tr>
<td>B</td>
<td>Active</td>
</tr>
<tr>
<td>C</td>
<td>Active</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Endurance Benefit (PEs)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical</strong></td>
</tr>
<tr>
<td>2x</td>
</tr>
<tr>
<td><strong>Dynamic OP</strong></td>
</tr>
<tr>
<td>1.95x</td>
</tr>
</tbody>
</table>

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Wrap Up: Guardian Technology™ Platform

- Off the shelf drive with Dynamic OP allocation better than physical separation as tenants alter behaviour over time.
- Wear levelling always maintained across all physical blocks.
- Endurance of SSD improved.
- TCO improved.
- Power reduced due to lower GC.
- Performance increased due to lower GC.
- QoS improved compared to standard SSD.
- Guardian Technology™ benefits any non-uniform workload, not just multi-tenancy use.
- Note: Guardian Technology™ Dynamic OP allocation is not yet available in all Western Digital SSDs.