Flexible Data Placement (FDP) Benefits in QLC SSD: A Case Study

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FMS the Future of Memory and Storage

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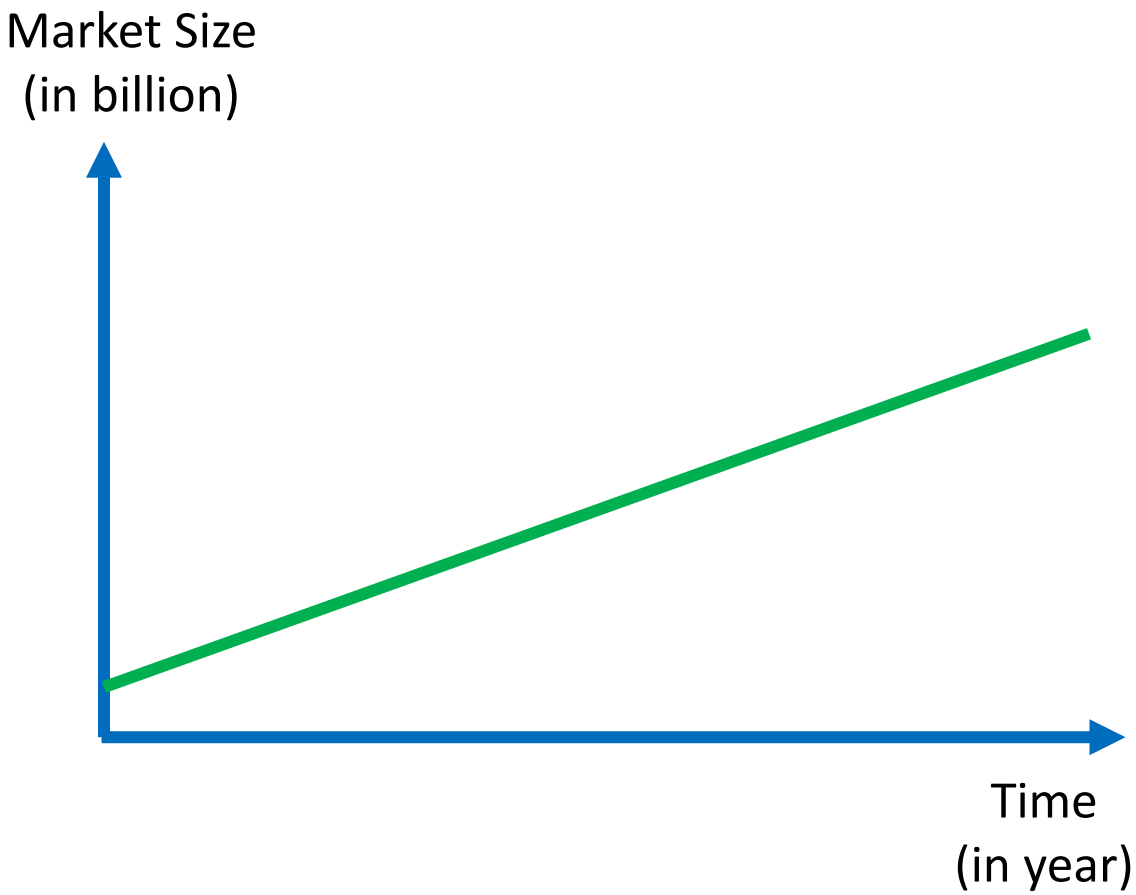
Agenda

- Artificial Intelligence Fueling High-Capacity Storage Growth
- QLC NAND Enabled High-Capacity SSD
- Flexible Data Placement (FDP) Benefits QLC SSD
- QLC SSD with FDP Cast Study
- Measured Test Result Showing Benefits of FDP in QLC SSD
- Multi-Tenant Quality-of-Service (QoS) Improvement Technology
- Summary

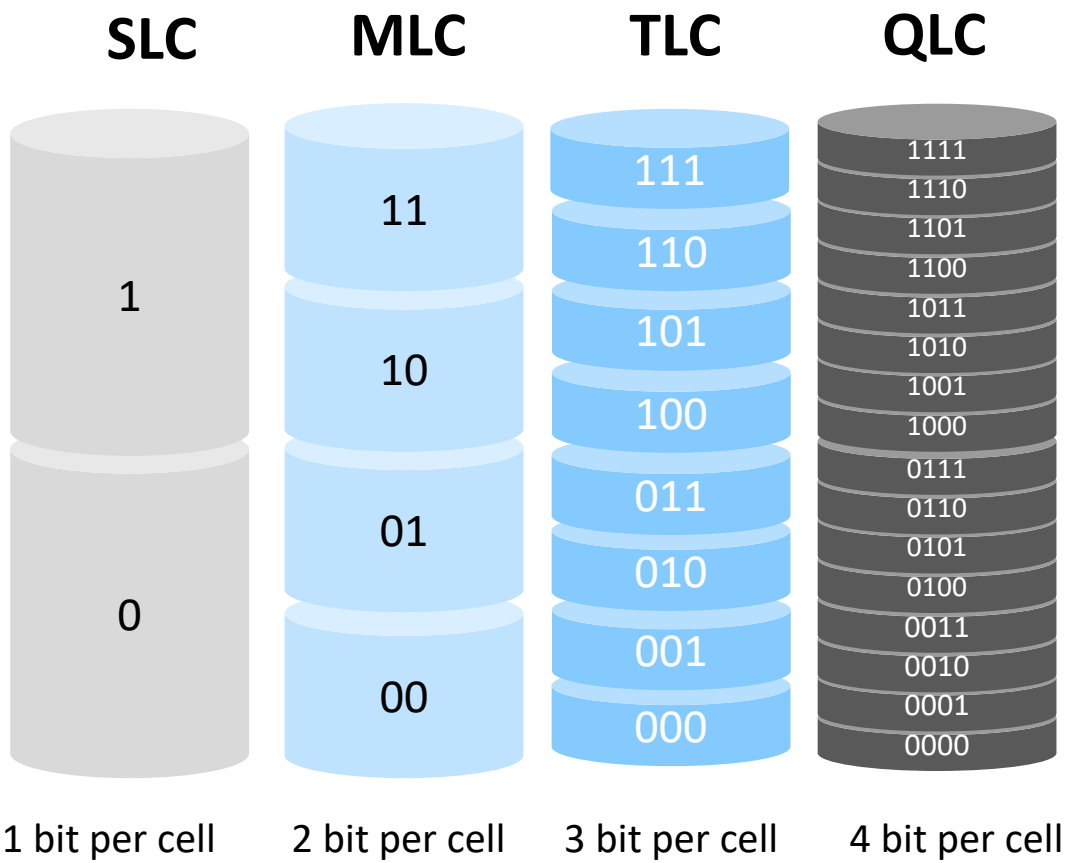
Artificial Intelligence Fueling High-Capacity Storage Growth

- AI-powered storage market expected to reach $200+ billion by 2033 with a 20+% CAGR
- Enterprise sector and Solid-state drive (SSD) expected to dominate AI-powered storage market

→ Demand for high-capacity SSD grows rapidly

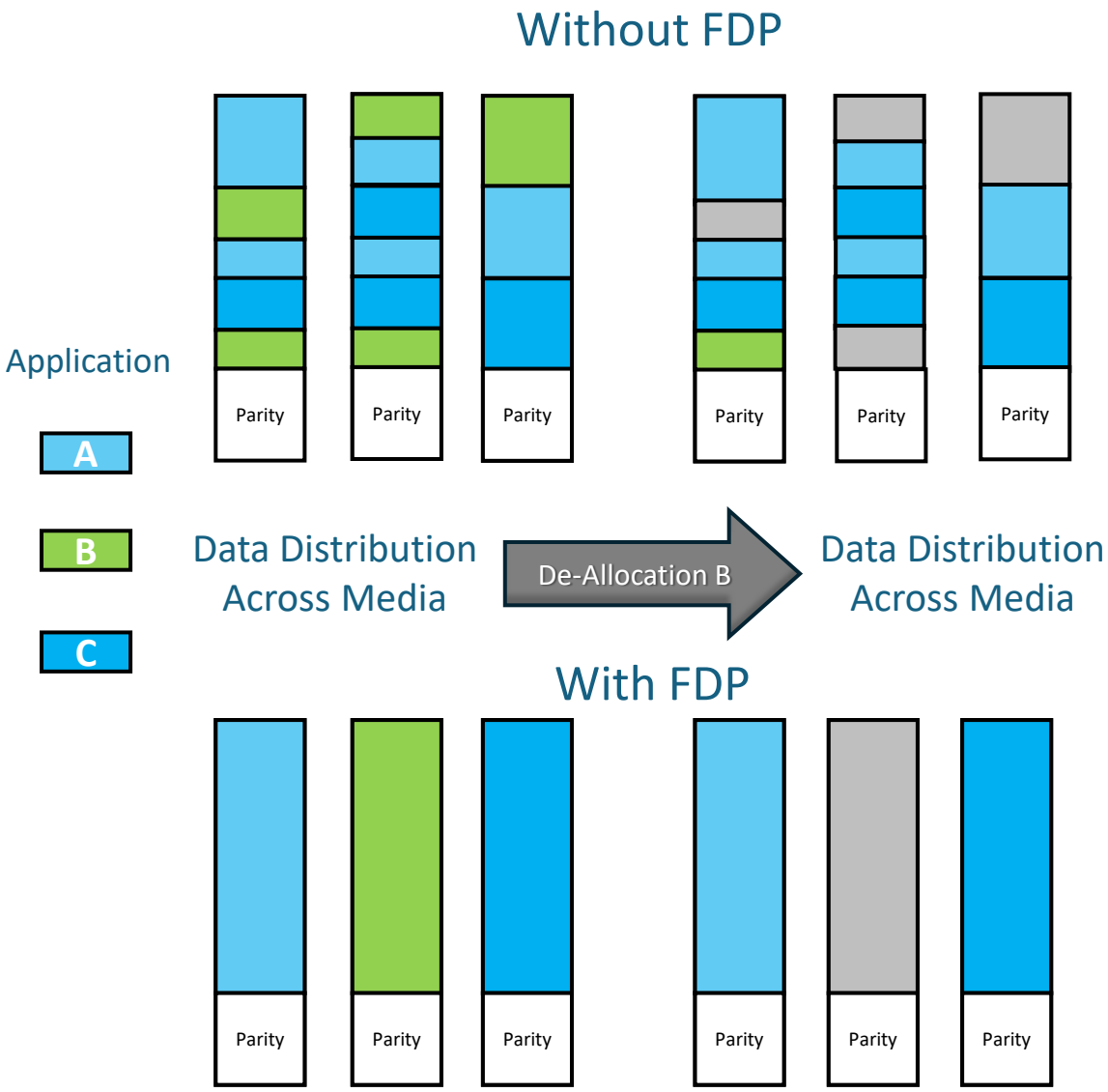


QLC NAND Enabled High-Capacity SSD



- QLC is the latest NAND technology
- QLC advantages
  - Higher NAND die density
  - Higher SSD capacity
  - Lower cost per GB
- QLC disadvantages
  - More difficult programming
  - Lower endurance (DWPD)
  - Lower P/E cycle
- QLC is perfect for high-capacity SSD applications in AI era
- To extend life of QLC NAND, advanced data placement technologies like FDP and ZNS can be used

Flexible Data Placement (FDP) Benefits QLC SSD



- FDP allows host to provide hint on where to place data
- With hint from host, data can be placed in separate regions for isolation
- Advantages of FDP
  - Reduce write amplification (WAF)
  - Reduce garbage collection (GC)
  - Improve write performance
  - Improve endurance
- FDP benefits all NAND type and is perfect for QLC NAND SSD

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QLC SSD with FDP Cast Study

- Test configuration:
  - SSD hardware : Silicon Motion 16TB Enterprise SSD with Micron N48R QLC NAND in U.2 Form factor
  - SSD firmware : FDP enabled with 8 RUHs and 8 Namespaces vs FDP disabled with 8 Namespaces
  - Test platform : ASUS PRIME Z690-P (I5-12500 16GB)
  - Test program : FIO
  - Test workload : 8 FDP sequential write jobs comparing with 8 non-FDP sequential write jobs

* Picture from ASUS website

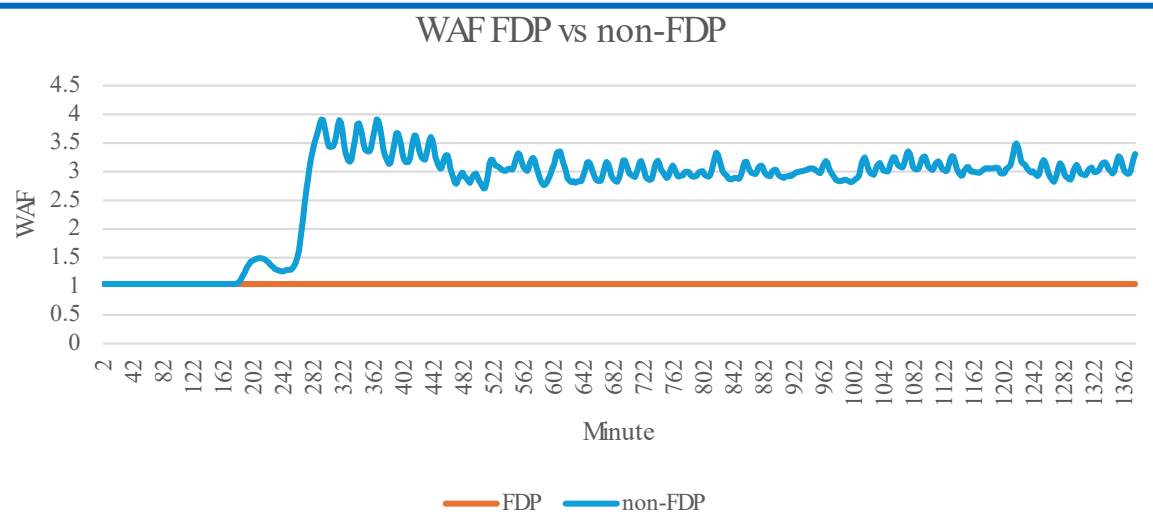
Measured Test Result Showing Benefits of FDP in QLC SSD

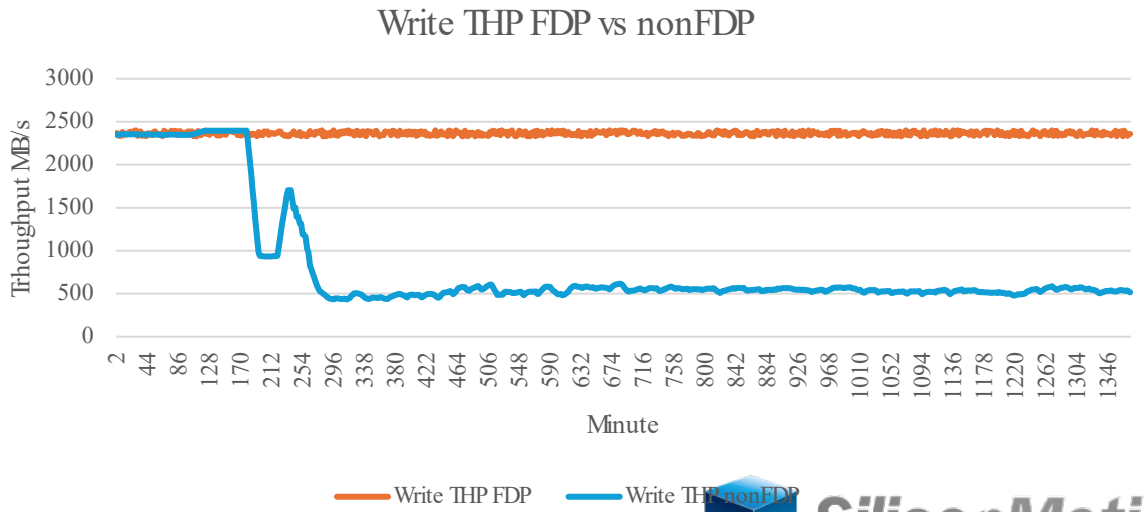
TestB FDP default Handle

Workloads	BS	data temp.		NS		FDP RUHs
fio0 seqwrite	16K	1/4 BW	→	NS0	LBA All	NS0.plid0 RUH0
fio1 seqwrite	32K	1/16 BW	→	NS1	LBA All	NS1.plid0 RUH1
fio2 seqwrite	64K	1/16 BW	→	NS2	LBA All	NS2.plid0 RUH2
fio3 seqwrite	256K	1/8 BW	→	NS3	LBA All	NS3.plid0 RUH3
fio4 seqwrite	16K	1/4 BW	→	NS4	LBA All	NS4.plid0 RUH4
fio5 seqwrite	32K	1/16 BW	→	NS5	LBA All	NS5.plid0 RUH5
fio6 seqwrite	64K	1/16 BW	→	NS6	LBA All	NS6.plid0 RUH6
fio7 seqwrite	256K	1/8 BW	→	NS7	LBA All	NS7.plid0 RUH7

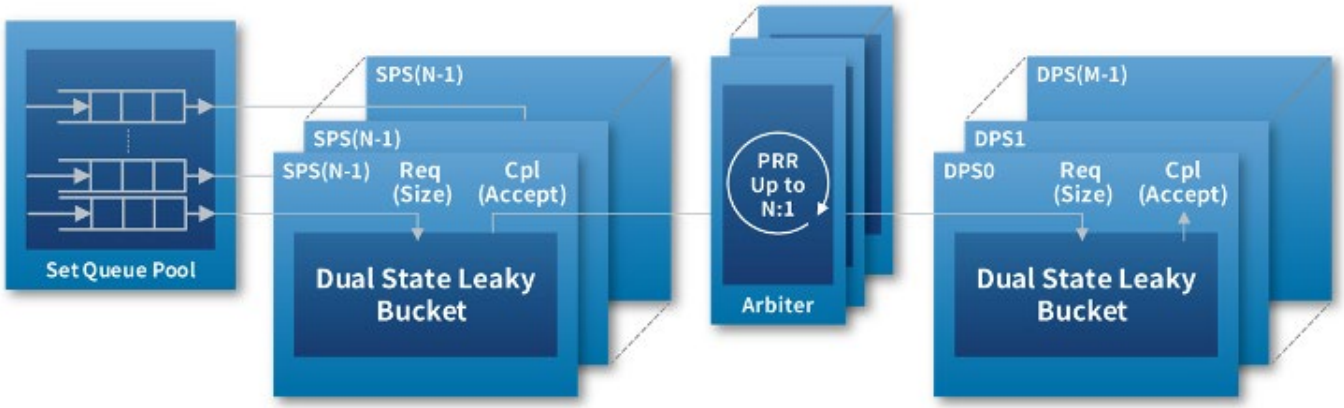
TestB non-FDP

fio0 seqwrite	16K	1/4 BW	→	NS0	LBA All
fio1 seqwrite	32K	1/16 BW	→	NS1	LBA All
fio2 seqwrite	64K	1/16 BW	→	NS2	LBA All
fio3 seqwrite	256K	1/8 BW	→	NS3	LBA All
fio4 seqwrite	16K	1/4 BW	→	NS4	LBA All
fio5 seqwrite	32K	1/16 BW	→	NS5	LBA All
fio6 seqwrite	64K	1/16 BW	→	NS6	LBA All
fio7 seqwrite	256K	1/8 BW	→	NS7	LBA All





Multi-Tenant Quality-of-Service (QoS) Improvement Technology



- To further enhance QLC SSD QoS in multi-tenant environment, QoS management techniques can be deployed together with FDP
- PerformaShape™, as an example for QoS management, is developed based on “Dual State Leaky Bucket” algorithm where each QoS set is assigned with two token buckets and IO traffic flows when token is available
- PerformaShape™ benefits
  - Smooth out fluctuations
  - Isolate noisy neighbors
  - Fully utilize the SSD bandwidth

Summary

- AI revolution changes storage industry by demanding high-capacity SSD
- QLC SSD is best for high-capacity applications but has limitations
- FDP helps QLC SSD adoption
  - Extends QLC NAND life by reducing WAF and GC
  - Improves write performance
- PerformaShape™ technology further improves QoS in multi-tenant applications
- High Capacity QLC AI SSDs enabled by FDP and PerformaShape™ technologies is the perfect solution for AI storage applications

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