Flash Memory Summit

# *Fast* Integration and *Furious* Performance with Zoned Flash drives

Robert Lercari

V.P. Engineering

Radian Memory Systems, Inc.

# Legal

This presentation and/or accompanying oral statements by Radian Memory Systems, Inc. (“RMS”) representatives collectively, the “Presentation”, is intended to provide information concerning Flash memory technology. While RMS strives to provide information that is accurate and up-to-date, this Presentation may nonetheless contain inaccuracies or omissions. As a consequence, RMS does not in any way guarantee the accuracy or completeness of the information provided in this Presentation.

This Presentation may include forward-looking statements, including, but not limited to, statements about any matter that is not a historical fact; statements regarding RMS’ intentions, beliefs or current expectations concerning, among other things, market prospects, technological developments, growth, strategies, and the industry in which RMS operates; and statements regarding products or features that are still in development. By their nature, forward-looking statements involve risks and uncertainties, because they relate to events and depend on circumstances that may or may not occur in the future. RMS cautions you that forward looking statements are not guarantees of future performance and that the actual developments of RMS, the market, or industry in which RMS operates may differ materially from those made or suggested by the forward-looking statements in this Presentation.

In addition, even if such forward-looking statements are shown to be accurate, those developments may not be indicative of developments in future periods.

# Agenda

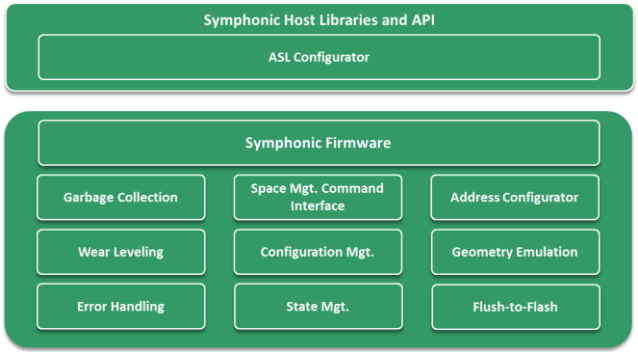
- Cooperative Flash Management (CFM) and Zoned Flash
- Zone Configuration and Address Space Layout (ASL)
- Solutions for Strict Write Pointers
- ‘Apples to Apples’ Performance Benchmark:
  Zoned Flash vs. FTL SSD

# Cooperative Flash Management (CFM)

*Redistribution of Flash Management between Host/Device*

Host System Software

- Data Placement
- Leverages host segment cleaning for Garbage Collection
- Scheduling

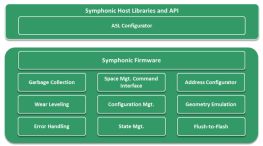



- Wear Leveling
- NAND Maintenance
- Maintains device state

- Idealized Flash
- Configurable Addressing
- Offload process execution

Standard NVMe API plus vendor specific extensions

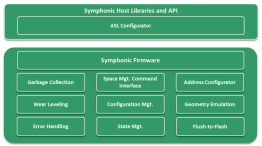
# Cooperative Flash Management (CFM)




2014

Symphonic™ v1
Cooperative Flash Management

Demo'd CFM to leading Flash Fabs



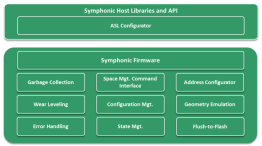

2015

Symphonic™ v2
Cooperative Flash Management

Won FMS

CFM and SMR

SDC
STORAGE DEVELOPER CONFERENCE
SNIA SANTA CLARA, 2015




2017

SMERF Drive
SMR-F SSD

Zoned Flash

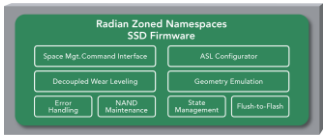

2018

Implementation for OC2


2018

Symphonic™ v3
Cooperative Flash Management

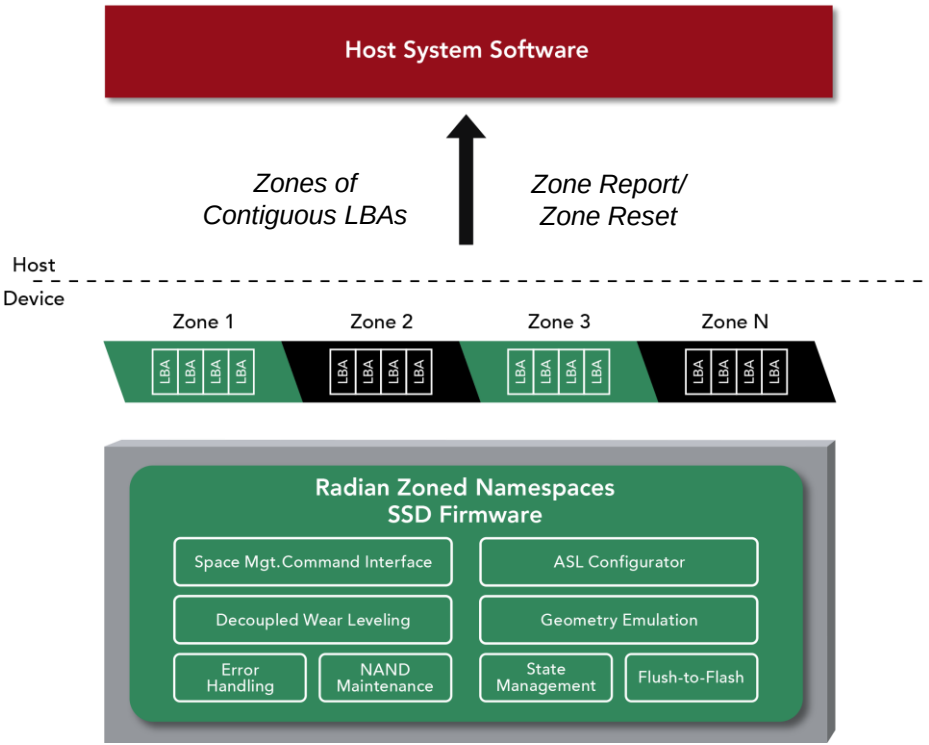
'*All Firmware*' implementation




2019

Zoned Flash

# Zoned Flash

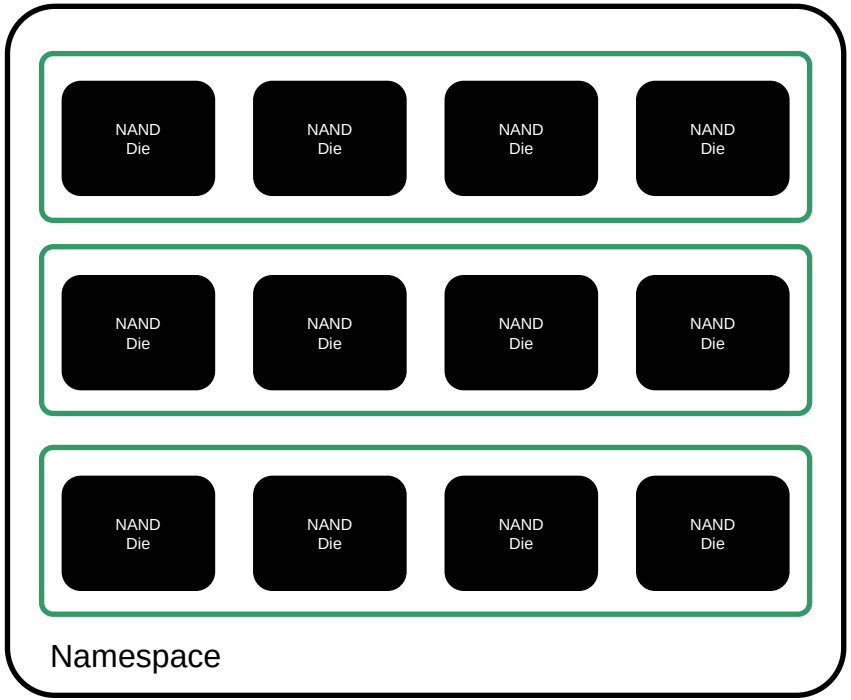



- Idealized Flash
- ASL Configurator
- Decoupled Wear Leveling and NAND Maintenance
- Back Channel*
- Delegated Move offload*
- Zone Append*
- Relaxed Write Pointer

**Optional feature*

# Configurability

## Address Space Layout (ASL)




- Performance
- Endurance
- Capacity

**Iso-Region**
Dies form discrete, physically isolated regions

**Iso-Box**
One or more iso-regions that can be associated with a namespace

# Configurability

- Zones and Application Segments: Write Amp
- Write Stripes: Bandwidth/Latency

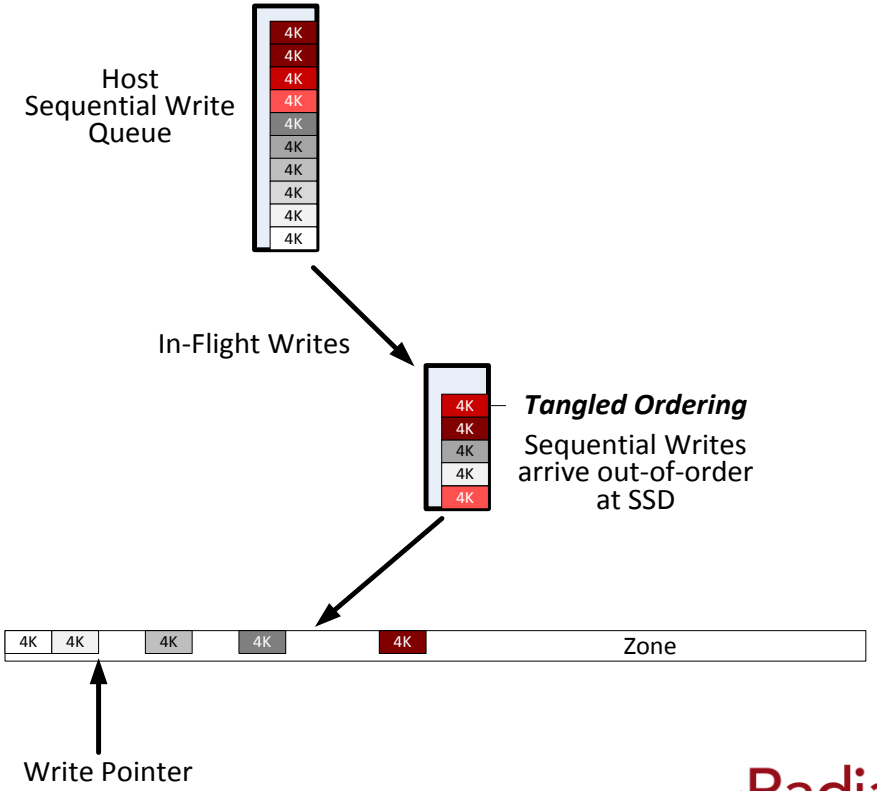
NAND Erase Units (blocks) from dies from within the same iso-region

NAND pages from within Erase Units (blocks) within a zone.


- Zone Report command

# Strict Write Pointer

- NAND requires sequential programming
- Tangled Ordering
- Performance Impact



# Zone Append

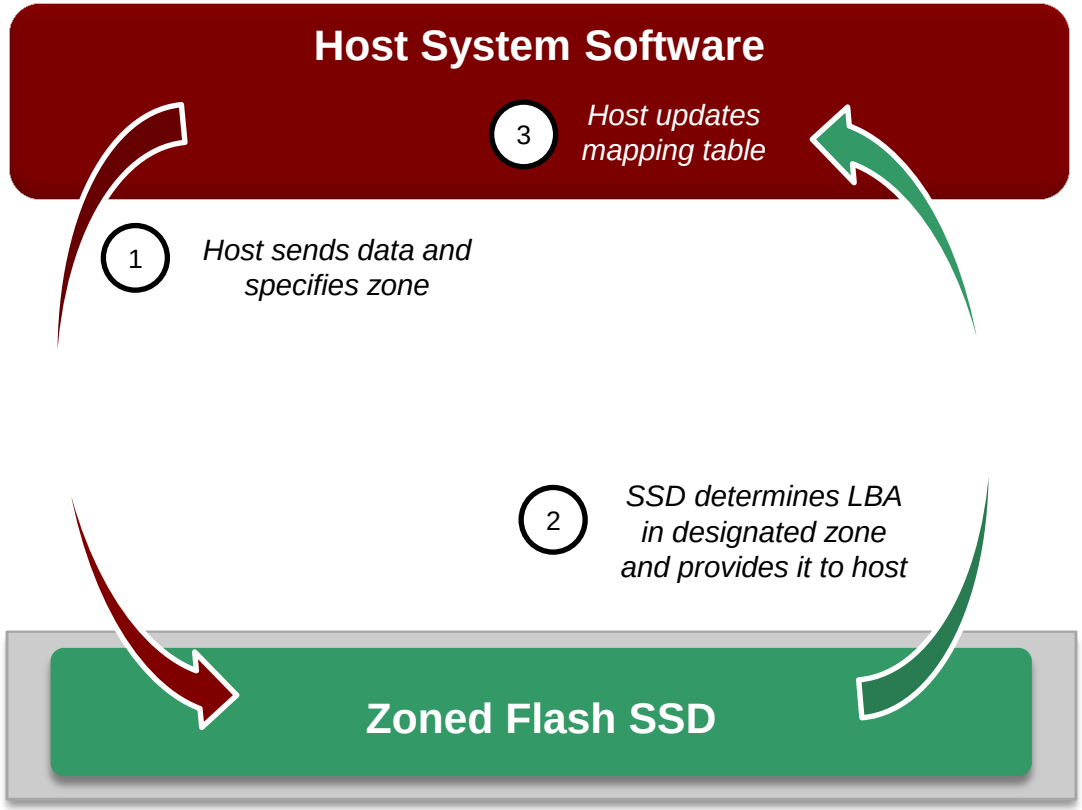
***Pros***

- No Strict Write Pointer requirement
- Overcomes NAND addressing anomalies, geometry or vendor specific attributes
- No FTL L2P storage requirements .1%, 1GB mapping space for 1TB capacity

***Cons***

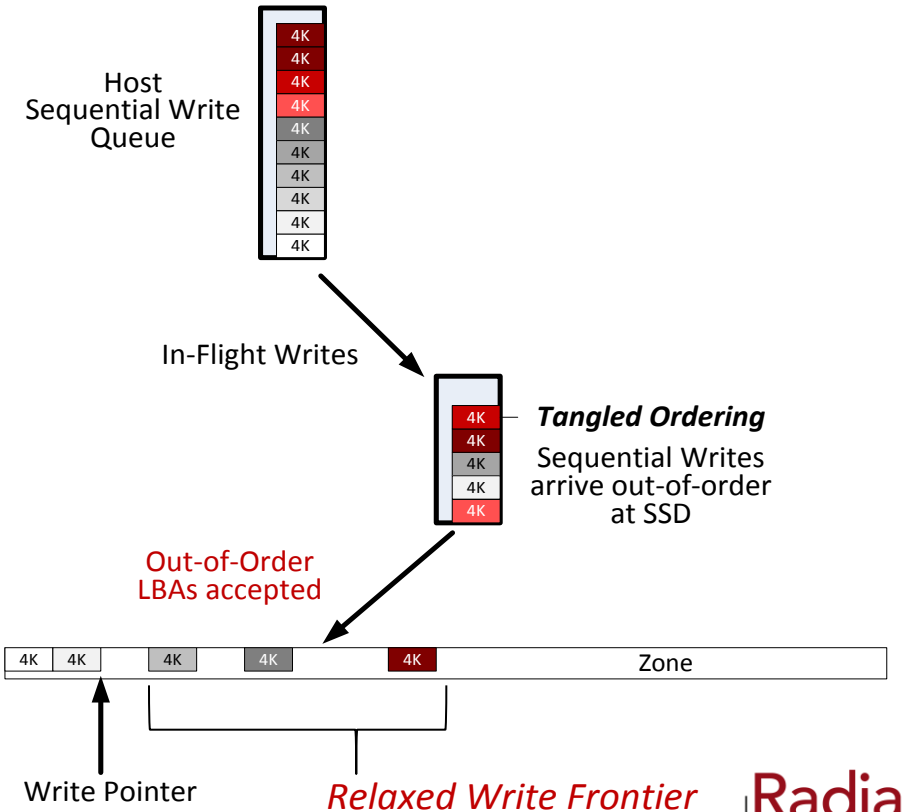
- Modifications to host system software
- New consistency models
- Potential latency impact

***Radian's Zone Append can support multiple, concurrent append request/completions***

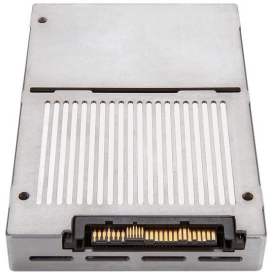


# Relaxed Write Pointer

- Overcomes Tangled Ordering if host attempts to write sequentially
- No modifications to host software, no new consistency models or additional latency
- Minimal SSD memory (***not*** 0.1% like L2P tables)



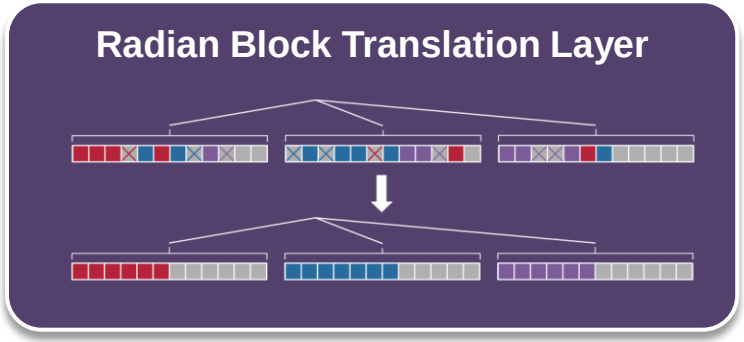
# Testing Zoned SSDs



RMS-350

**Zoned Flash U.2 NVMe SSD**

- 2TB -16TB TLC Flash
- Two different NAND vendors/fabs
- User NV-RAM
- Single or Dual Port




- Provides support for in-place overwriting of zones (Conventional Zones)
- Log Structured design serializes random overwriting workload
- Performs segment cleaning (garbage collection) with Zone Reset

## *How to test…*

- Garbage Collection
- Endurance and Data Retention (e.g., JESD219 workloads)
- HA/Fault Tolerance (e.g., dual port, shorn writes)
- Performance and Comparative Performance Testing

# Apples to Apples Comparison

Zoned Flash
U.2 NVMe SSD
RMS-350

## Identical Silicon

- **Same SSD Processor**
- **Same Flash Array**
  3D TLC NAND
  Dies/Package
  # of Channels
  # of Packages/Channel
  4.6TB Raw capacity
- **Same DDR4 array**
  DDR4
  # of Devices

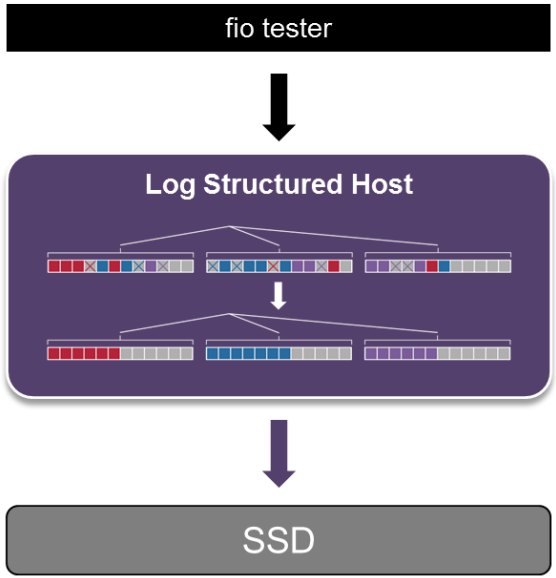

FTL
U.2 NVMe SSD

# System Test Configuration

Application Workload

- 70/30 Mix
- 4K Random Read
- 4K Random Write
- SSD Queue Depth = 32
  4 worker threads
  IOD = 8/thread

*Measuring at the system level*



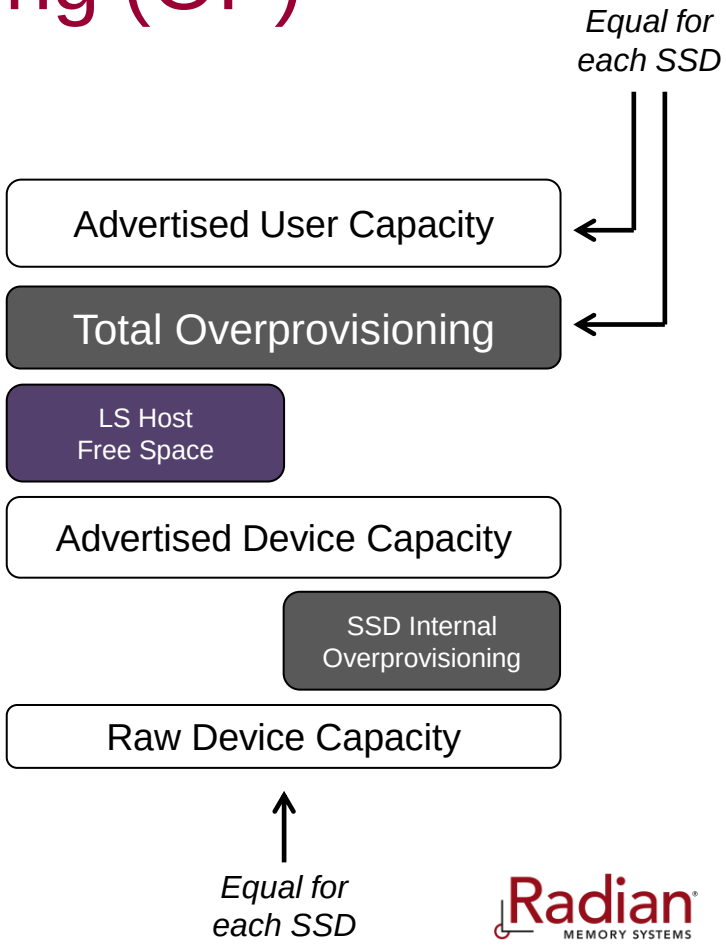

- Emulates typical SDS and All-Flash Array storage stacks
- Serializes random, overwriting workload

- Performs segment cleaning (garbage collection)
- Creates *Log-on-Log*

# Overprovisioning (OP)

| | FTL SSD | Zoned SSD |
|---|---|---|
| Advertised User Capacity | 3.23TB | 3.23TB |
| Total OP | 30% | 30% |
| LS Host Free Space | ***13%*** | ***27%*** |
| Advertised Device Capacity | 3.84TB | 4.49TB |
| SSD Internal OP | 17% | 3% |
| Raw Capacity | 4.62TB | 4.62TB |

*Log-on-Log*

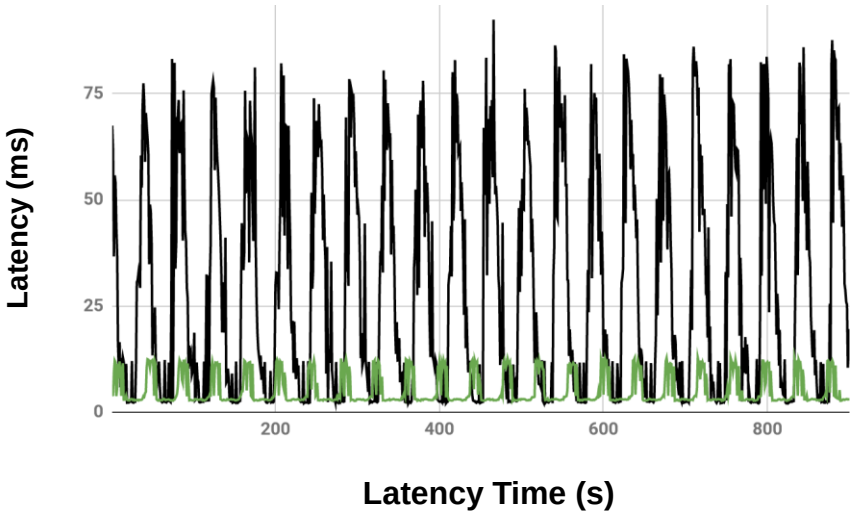


- 70/30 Mix
- 4K Random Read
- 4K Random Write

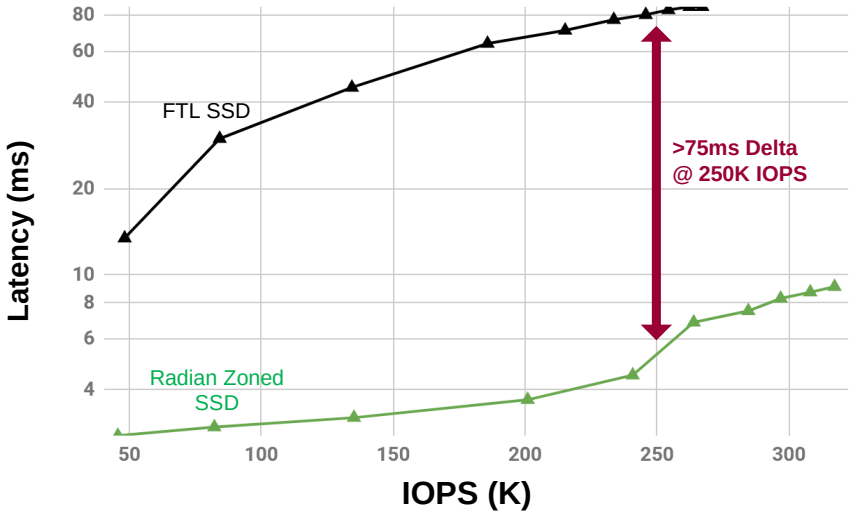
- SSD Queue Depth = 32
  4 worker threads
  IOD = 8/thread

- Total Overprovisioning = 30%
- Single Namespace

## 99.99% Latency Over Time




## 99.99% Latency @ IOPS



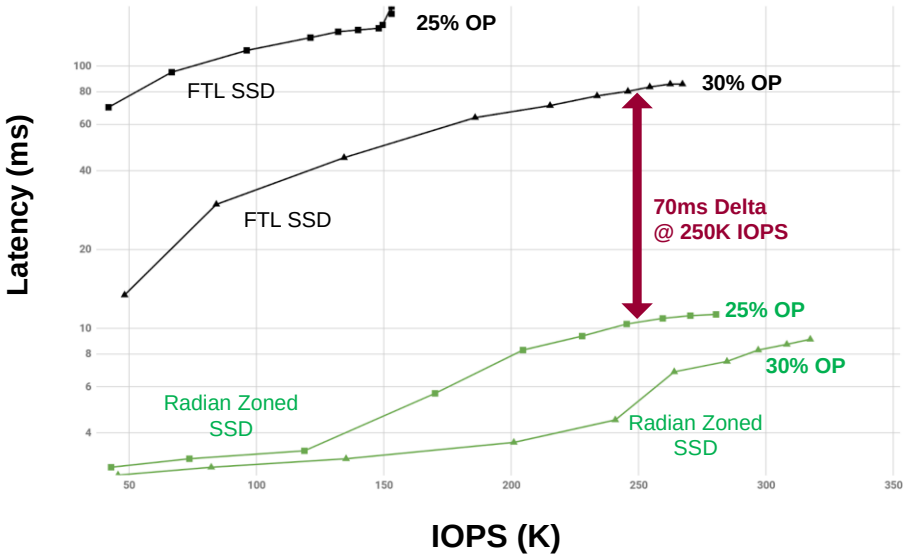

**FTL SSD**

**Radian Zoned SSD**

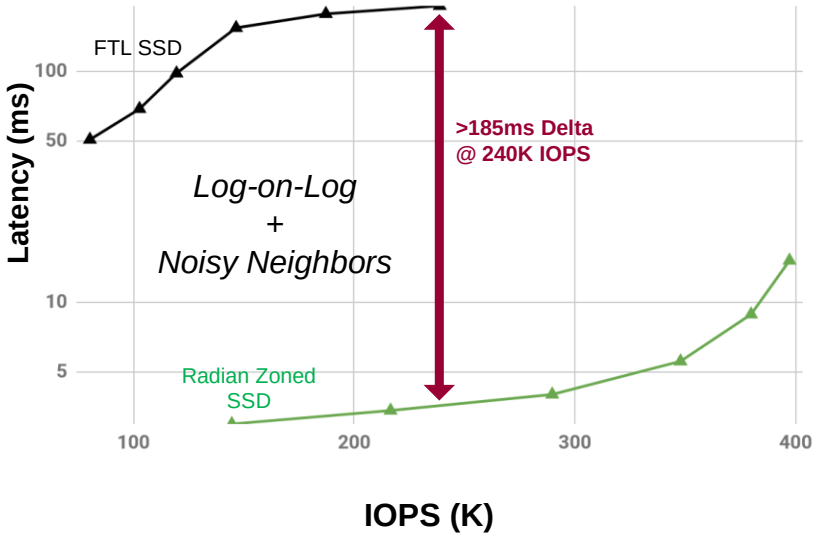
- 70/30 Mix
- 4K Random Read
- 4K Random Write

- SSD Queue Depth = 32

## 99.99% Latency @ IOPS
## Single Namespace, 25% OP and 30% OP




## 99.99% Latency @ IOPS
## Sixteen Namespaces, 30% OP




**FTL SSD**

**Radian Zoned SSD**