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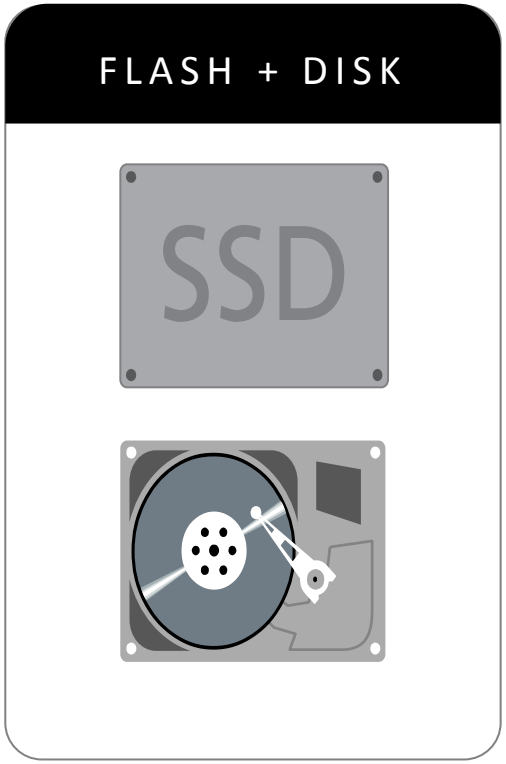
2013 OFA Developer Workshop

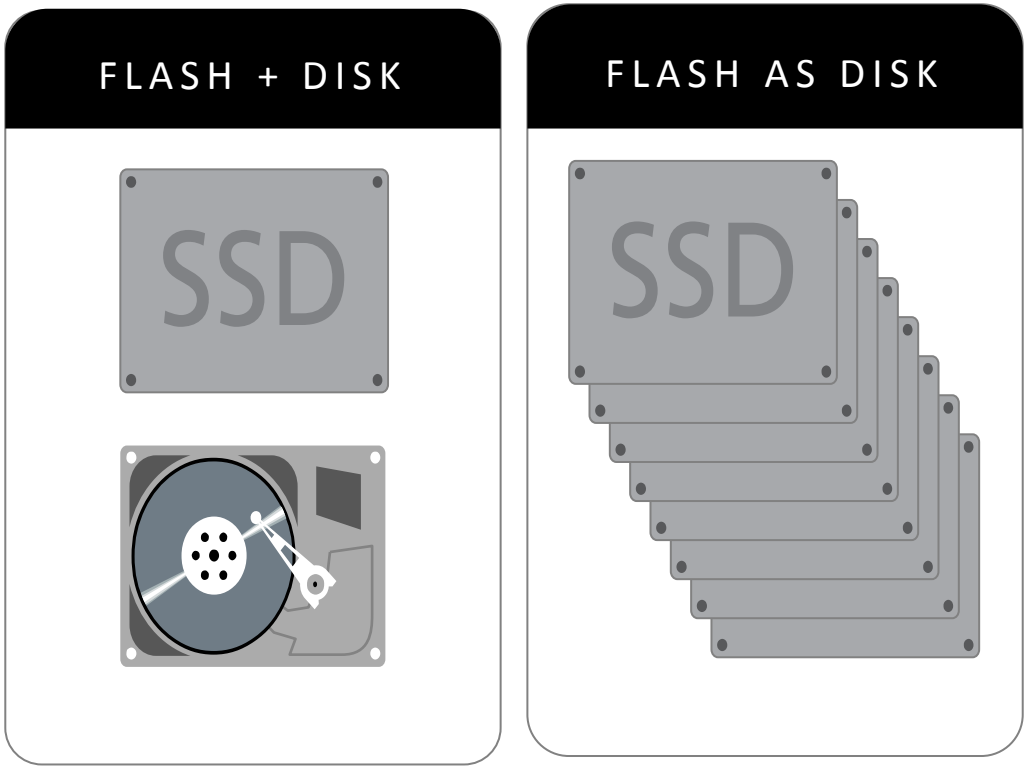
Standardizing New NVM Software Architectures and Architectures

Walt Hubis, Storage Standards Architect, Fusion-io

Evolution of Flash Adoption



Evolution of Flash Adoption



Evolution of Flash Adoption

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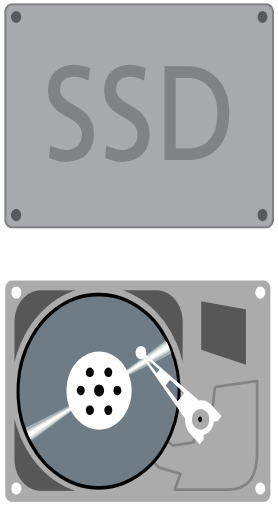
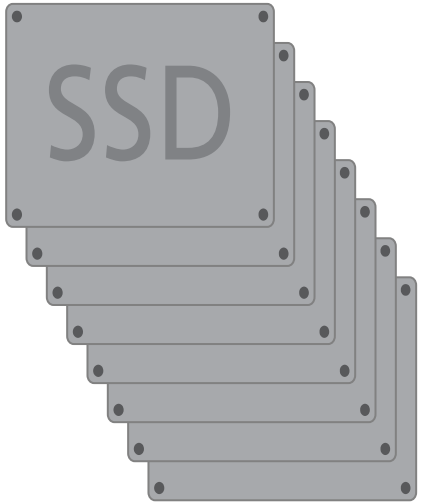
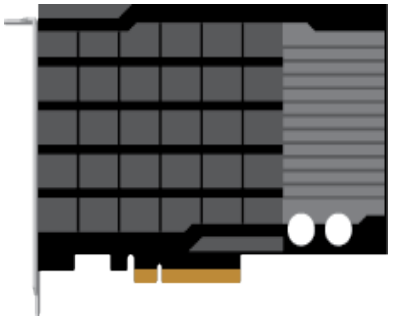
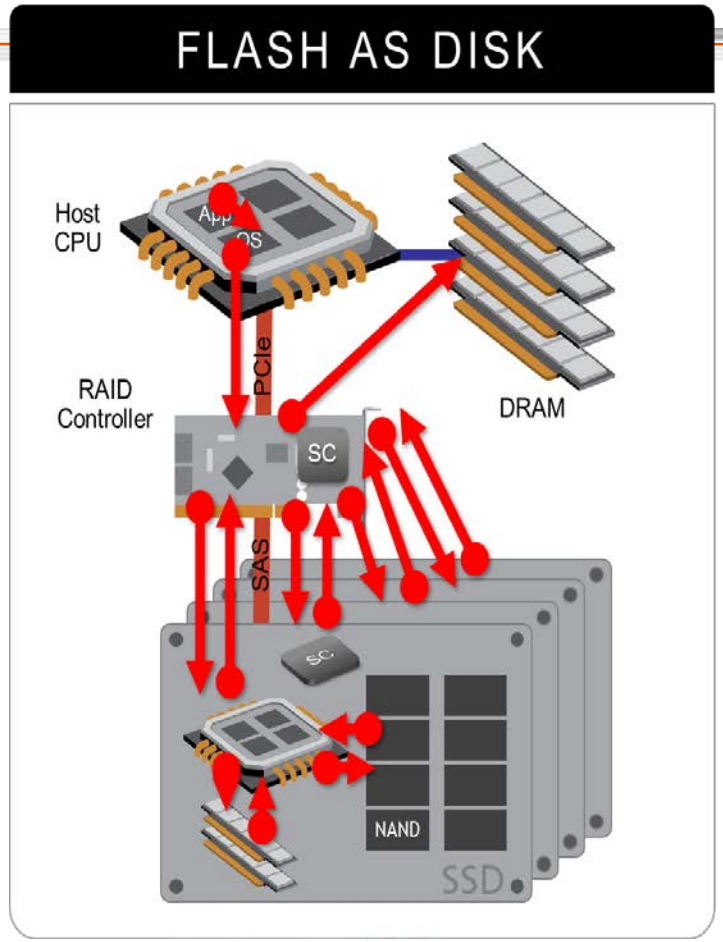
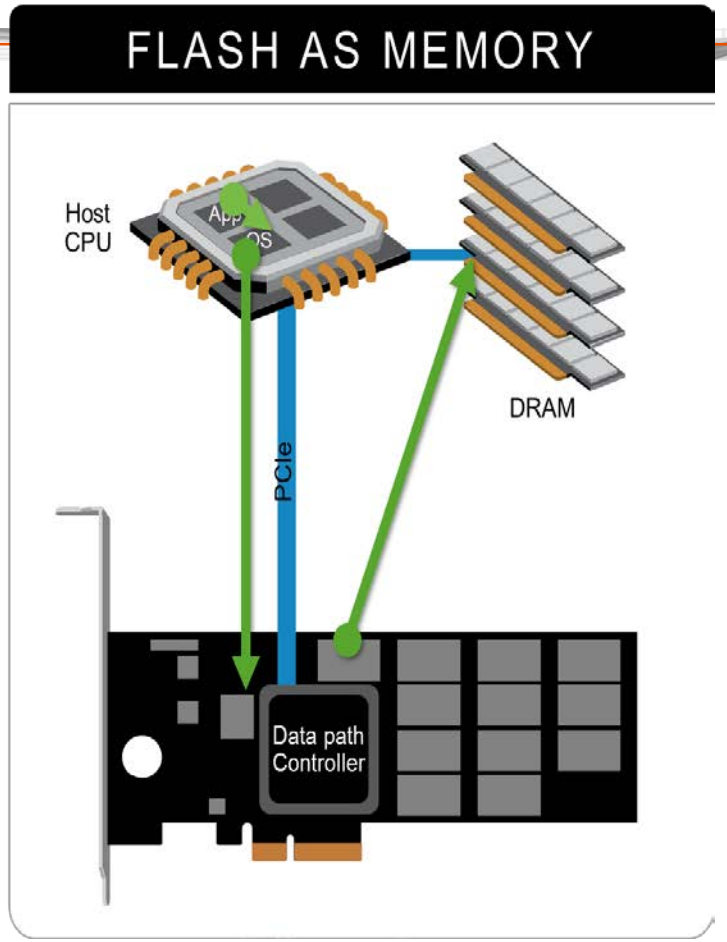
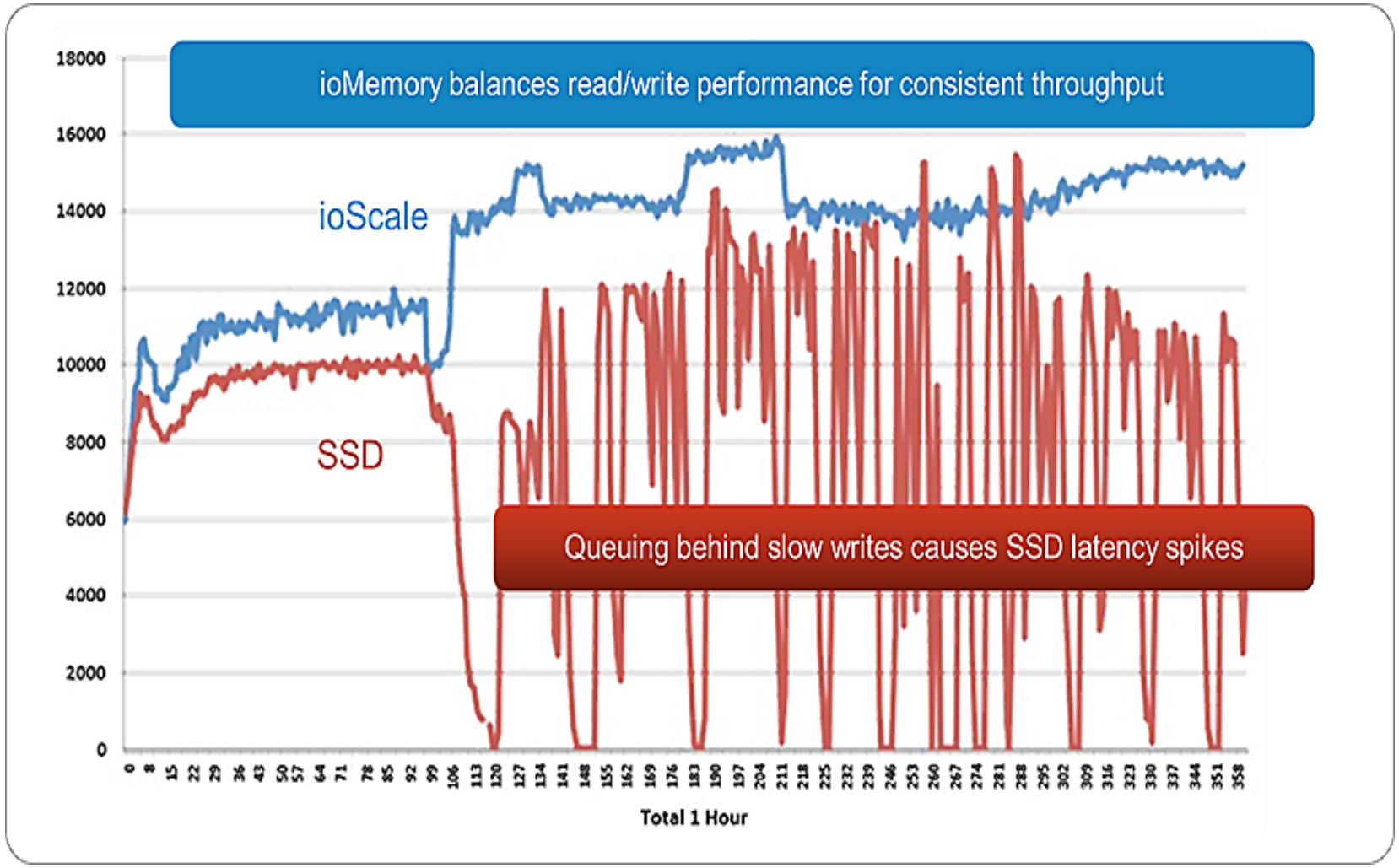
FLASH + DISK	FLASH AS DISK	FLASH AS MEMORY
		

Flash Architectures

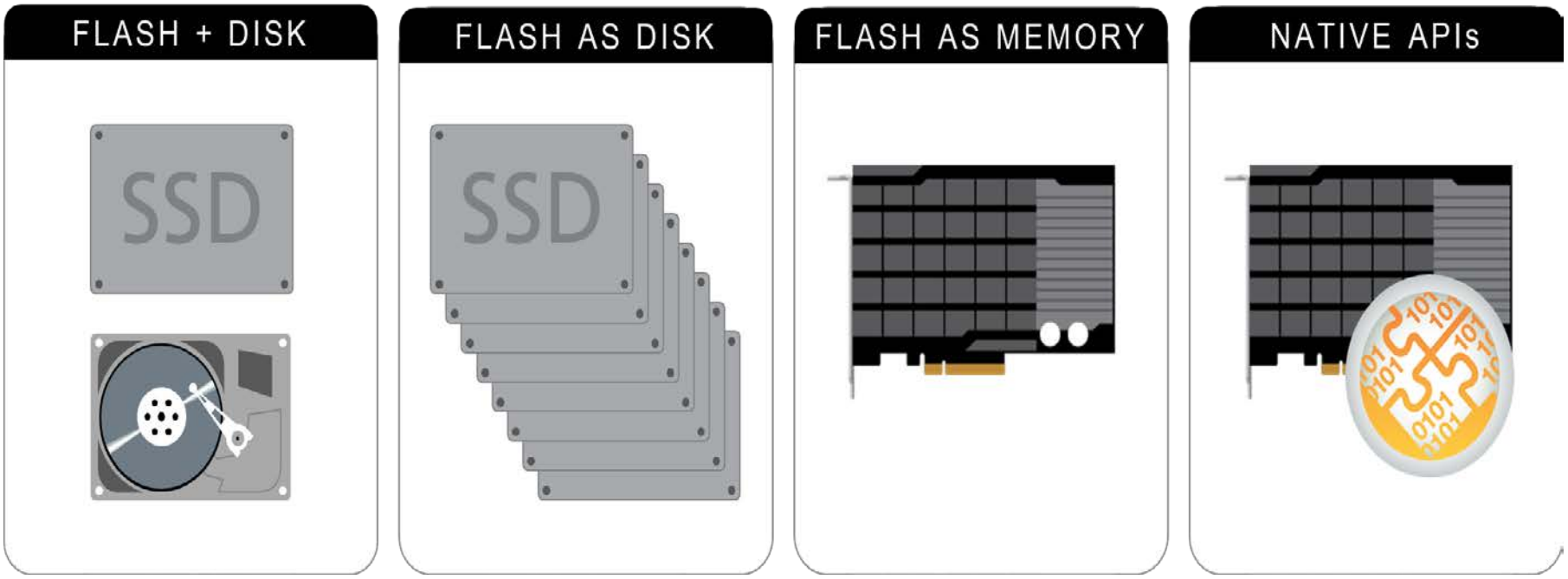




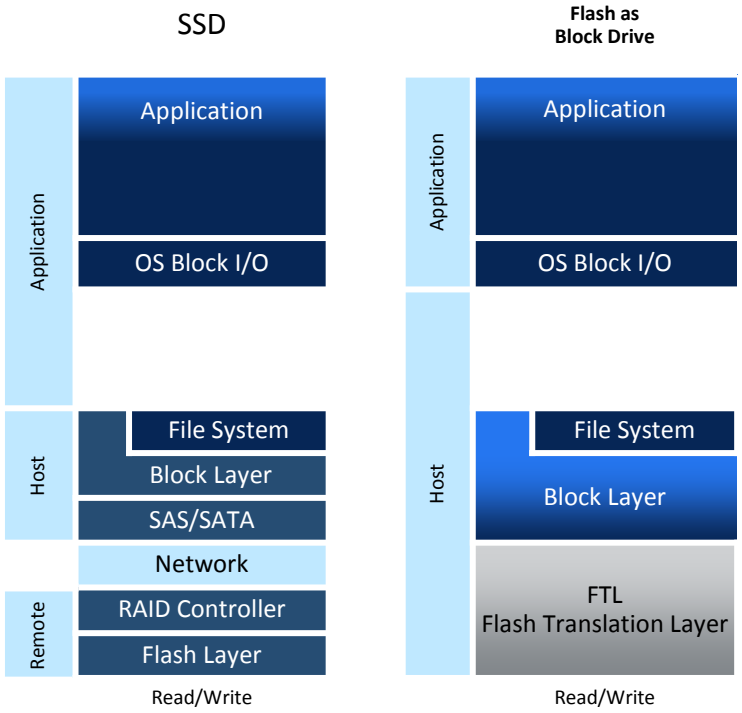
Balanced Performance Affects Throughput



Evolution of Flash Adoption



Non-Volatile Memory Evolution



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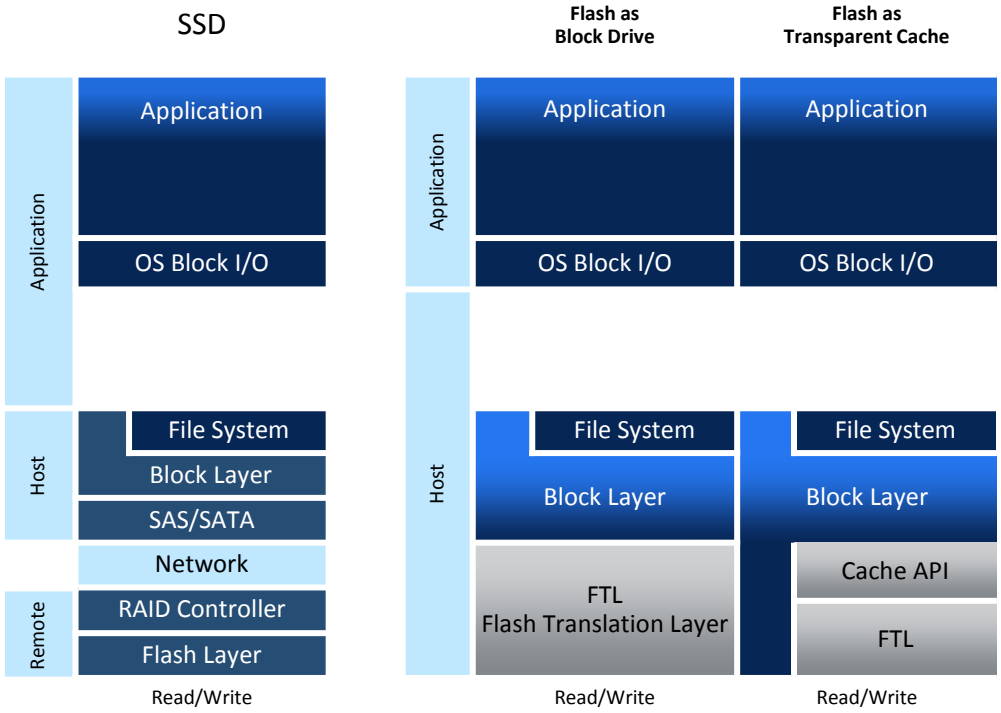

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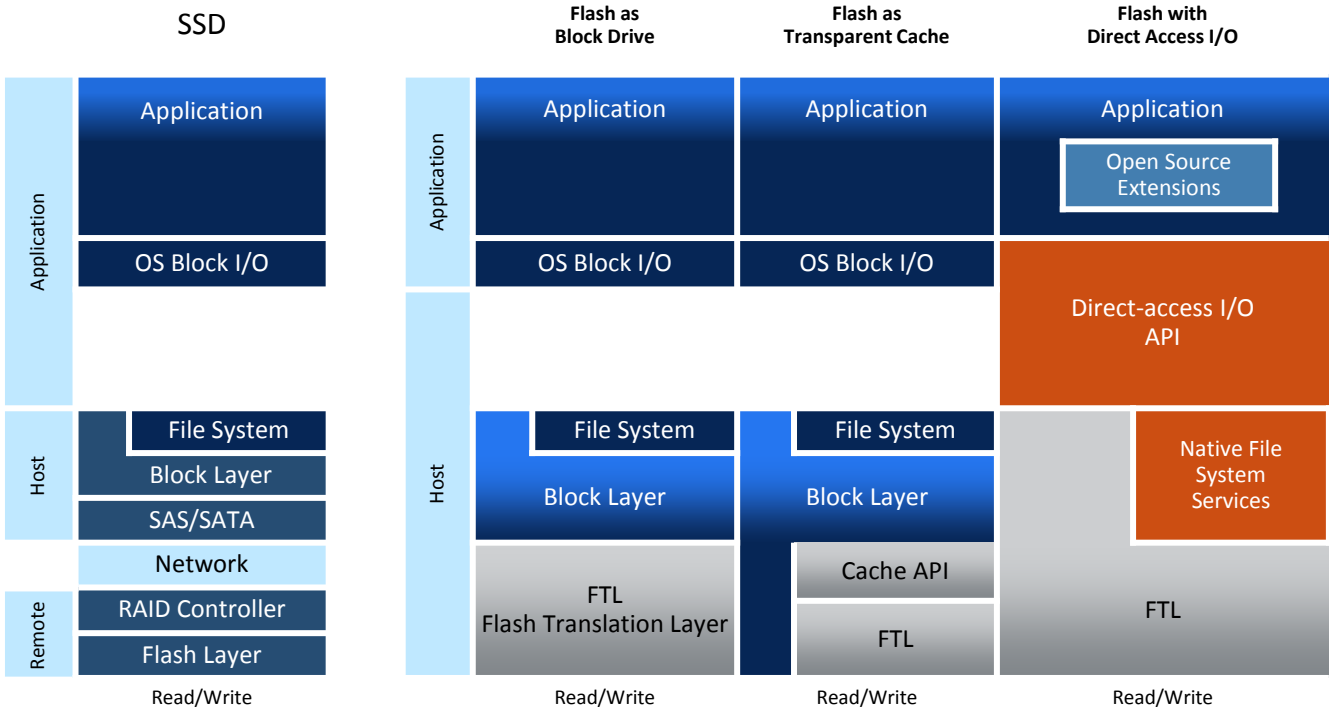

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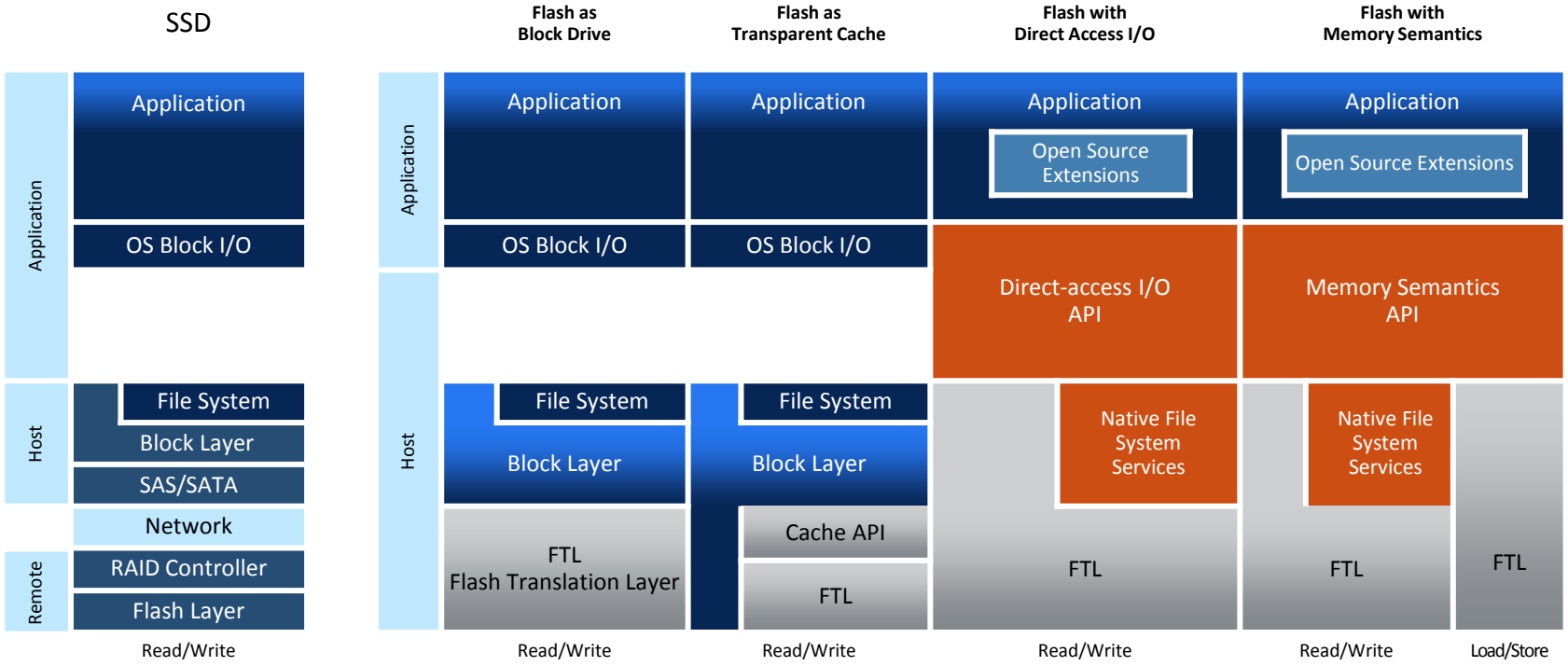

Comparing I/O and Memory Access Semantics

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I/O	I/O semantics examples: • Open file descriptor – open(), read(), write(), seek(), close() • (New) Write multiple data blocks atomically, nvm_vectored_write() • (New) Open key-value store – nvm_kv_open(), kv_put(), kv_get(), kv_batch_*()
Memory Access **(Volatile)**	Volatile memory semantics example: • Allocate virtual memory, e.g. malloc() • memcpy/pointer dereference writes (or reads) to memory address • (Improved) Page-faulting transparently loads data from NVM into memory
Memory Access **(Non-Volatile)**	Non-volatile memory semantics example: • (New) Allocate and map Auto-Commit Memory™ (ACM) virtual memory pages • memcpy/pointer dereference writes (or reads) to memory address • (New) Call checkpoint() to create application-consistent ACM page snapshots • (New) After system failure, remap ACM snapshot pages to recover memory state • (New) De-stage completed ACM pages to NVM namespace • (New) Remap and access ACM pages from NVM namespace at any time

New Primitives for a New Type of Media

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Tape	Open, read, write, rewind, close.
Disk	Open, read, write, seek, close.
SSD	Open, read, write, seek, close.
ioMemory NVM	Open, read, write, seek, close. *Plus, new primitives to exploit characteristics of non-volatile memory* Basic write + atomic write, conditional write. Basic write + TTL expiry for auto-deletion. Basic mmap + crash-safety, versioning.

ATOMIC I/O Primitives: Sample Uses and Benefits

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Databases

Transactional Atomicity:
Replace various workarounds implemented in database code to provide write atomicity (double-buffered writes, etc.)

Filesystems

File Update Atomicity:
Replace various workarounds implemented in filesystem code to provide file/directory update atomicity (journaling, etc.)

- 99% performance of raw writes
  Smarter media now natively understands atomic updates, with no additional metadata overhead.
- 2x longer flash media life Atomic Writes increase the life of flash media up to 2x due to reduction in write-ahead-logging and double-write buffering.
- 50% less code in key modules
  Atomic operations dramatically reduce application logic, such as journaling, built as work-arounds.

SNIA Non-Volatile Memory (NVM) Program Problem Statement

- NVM features and performance are outgrowing the existing storage model
- Sending block reads/writes down the traditional IO stack is insufficient and becoming inefficient
  - OK if NVM to be represented as a traditional disk
  - Not OK for higher order NVM operations
- NVM technology is evolving less as storage, more as memory
  - Need a programming model for storage memory usage
- Critical need to collaborate cross-industry to define and implement this new programming model
- SNIA creates NVM Technical Working Group June 2012

SNIA NVM Programming TWG Formation

- Charter: Develop specifications for new software programming models for use of NVM
  - Scope:
    - Programming models for applications and OS components
    - Each model covers NVM extensions for block storage, file access, and memory access models
- Operating System (OS) Specific APIs
  - SNIA defines the programming model specification
  - Each OS Vendor codes the programming models to the specific OS
    - Discussion with Linux community underway

NVM Accessed as Memory

- Samples of behavior to be covered in specification
  - Discover available NVM devices
  - Discover their characteristics and support for optional features:
    - Examples : Atomic operations, provisioning, etc…
  - Assign a region of NVM to a process memory address
    - Same region has to map the same way across reboots
  - How to read/write to NVM
    - How to commit changes to NVM
    - Use of behavior to assure durability and consistency (flush, …)

NVM Programming Model Exclusions

- The programming model is tied to other kernel behavior
  - Access control and ownership
  - Device discovery and naming
    - Frameworks related to storage
    - Events
    - SW install/upgrade
    - Device management
- Vendor Unique Behaviors
  - Flash maintenance and grooming
  - Implementation of FTL and associated services
  - Certain types of error conditions

TWG Status

- Weekly calls
  - Tuesdays at 4:00PM Pacific
- Two Day Face to Face Meetings
  - Quarterly at SNIA Symposia
- See me if you are interested in attending
- Current work
  - Use Cases
  - Actions
  - Glossary
- Deliverable Schedule TBD

Open Interfaces and Open Source

- Primitives: Open Interface
- API Libraries: Open Source, Open Interface
- INCITS SCSI (T10) active standards proposals:
  - SBC-4 SPC-5 Atomic-Write
    http://www.t10.org/cgi-bin/ac.pl?t=d&f=11-229r6.pdf
  - SBC-4 SPC-5 Scattered writes, optionally atomic
    http://www.t10.org/cgi-bin/ac.pl?t=d&f=12-086r3.pdf
  - SBC-4 SPC-5 Gathered reads, optionally atomic
    http://www.t10.org/cgi-bin/ac.pl?t=d&f=12-087r3.pdf
- SNIA NVM-Programming TWG

Thank You