OPEN Compute Summit

March 10–11, 2015
San Jose

OPEN Compute Summit

SMR

The Future of Cheap and Deep

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Why Shingled Magnetic Recording?

Large capacity gains are increasingly requiring advanced technologies

- SMR
- HAMR
- BPM

SMR is currently the most cost-effective technology to meet these required capacity gains for the next several years

- Currently, SMR provides ~25% capacity gain with no other required changes

Lowest $/GB in Enterprise

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Agenda

- Very quick basic refresh of SMR
- Drive Managed SMR
- Host Aware SMR
- Moving Forward with SMR

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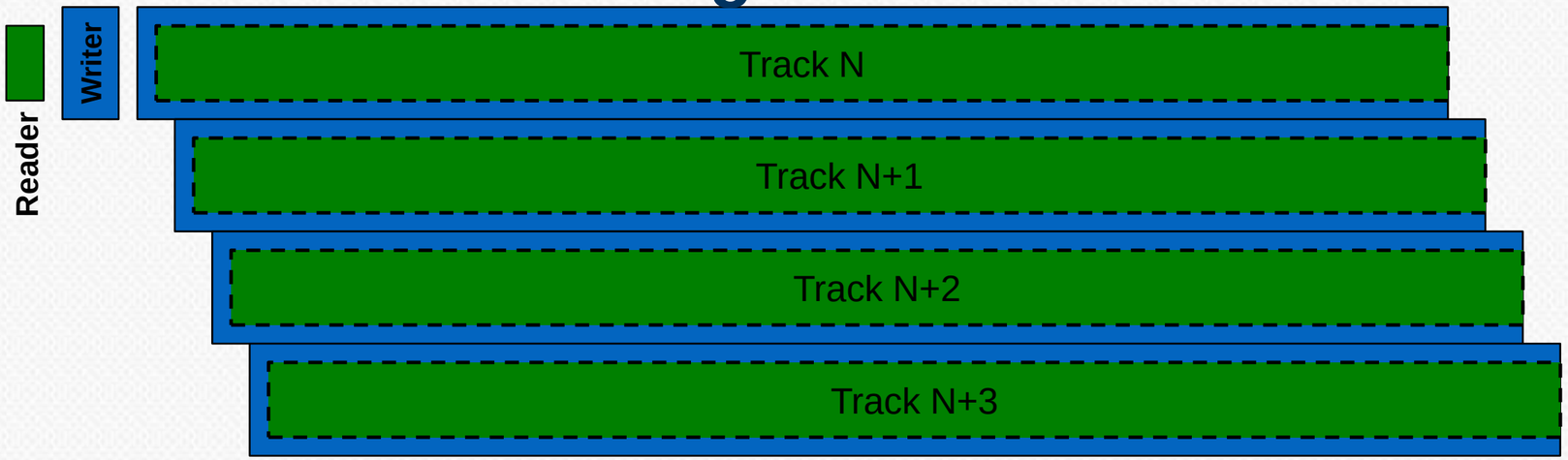
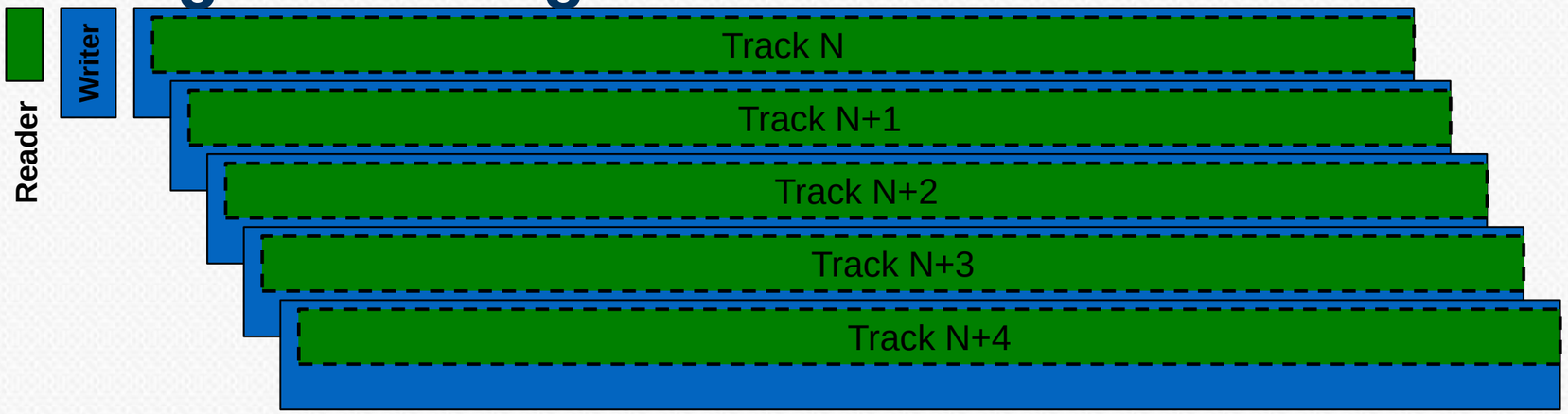
SMR Basics

Conventional versus SMR Writing

Conventional Writing



Shingled Writing



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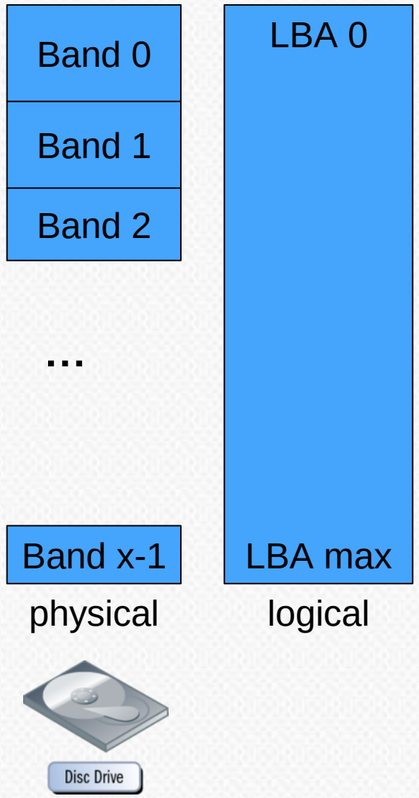
Drive Managed SMR

A disk as a set of bands

- SMR Bands
  - Physical Construct
  - Boundaries not known outside of drive



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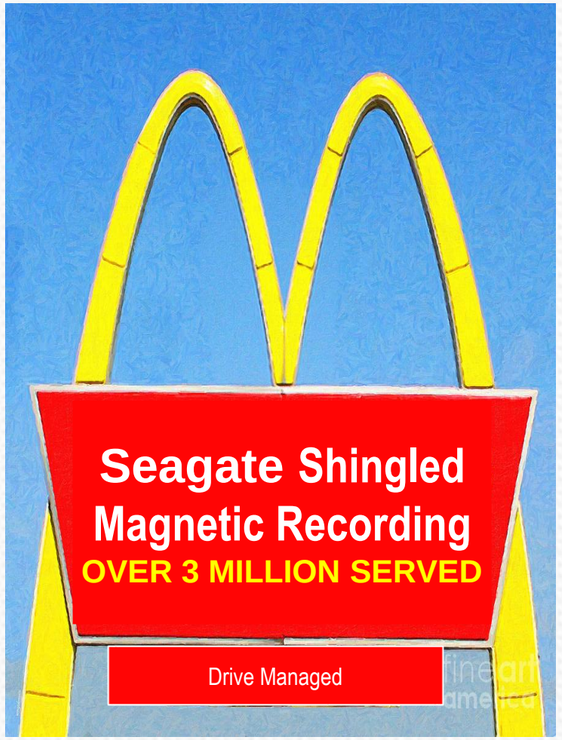
Drive Managed SMR

- The first SMR drive type
- Makes architectural details of SMR transparent to the host.
- Backward compatible



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Drive Managed SMR

- Benefits
  - No host changes required
  - Extremely effective in Personal Compute and in some Enterprise applications (Ex: Archive)
  - Reads (seq, rndm) typically achieve conventional performance
  - Large write-back disk cache
  - Write-around for sequential writes = conventional performance

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Drive Managed SMR

- Challenges
  - Disk cache is a limited resource
    - Full cache can degrade random write performance
    - Larger cache has areal density cost
    - Read performance impact if reads are fragmented
  - Cache Cleaning is complex
    - Potentially large command latency tails
  - Write-around is limited
    - Sequential detection is non-trivial
      - Multiple streams versus random
      - Long inter-command time versus end of stream
      - Multiple tracks needed: write one track after the next track is buffered or queued

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Drive Managed SMR

- Best practices to achieve optimal performance
  - Idle time allows cache to clear and minimize fragmentation conditions
  - Truly Sequential writes
  - Writes with high transfer length and queue depths
    - Maintains sequential streaming mode
  - Limit and concentrate random writes

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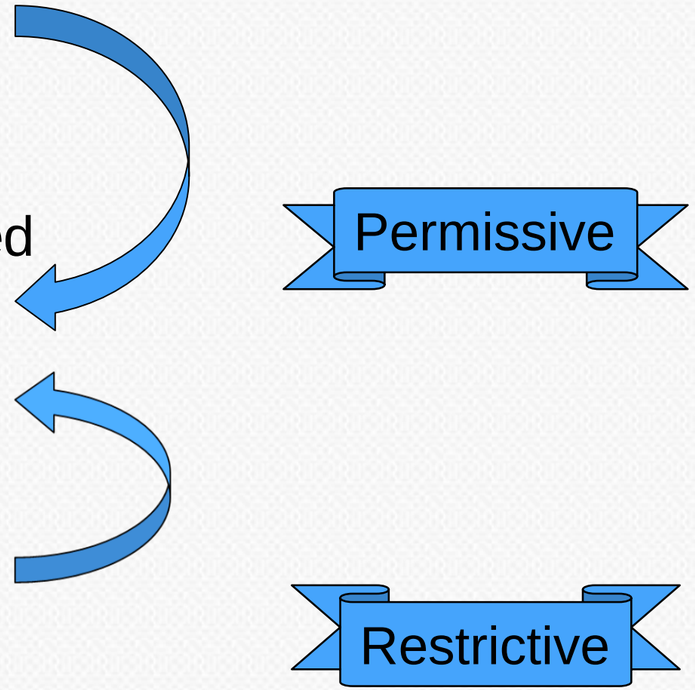
SMR Drive Types

- Drive Managed
  - Drive autonomously manages all SMR operations
  - Backward compatible
- Host Aware
  - Superset of Drive Managed and Host Managed
  - Backward compatible
  - Extensions to ATA and SCSI command sets
- Host Managed
  - Extensions to ATA and SCSI command sets
  - Error conditions for some reads and writes
  - Not backward compatible
  - New device type



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Host Aware SMR

Host Aware SMR Solution

Goals

- Performance parity vs conventional disks
  - Broadened use cases over Drive Managed
  - Trivial sequential detection
- Minimal interface changes
  - A few new commands and parameters
  - No changes to Read and Write commands
- Enable more markets
- Grow beyond Archive

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Host Aware SMR Solution

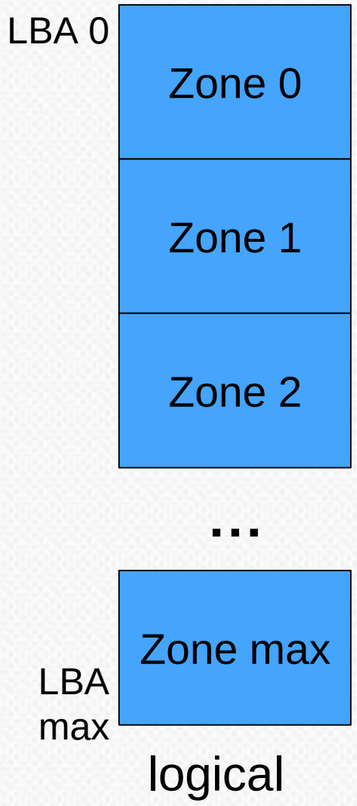
Achieving the goals

Goals

- Parity with conventional disks
- Minimal interface changes
- Enable more markets
- Grow beyond Archive

Methodology

- Zones
  - Logical address ranges exposed to host
- Write Pointers
  - Location of sequential writing
- Host controls zone usage
  - Tell drive what sectors are not in use, “unwritten”
- Leverage device capabilities
  - Number of active sequential streams at full performance
  - Amount of random write space at full performance



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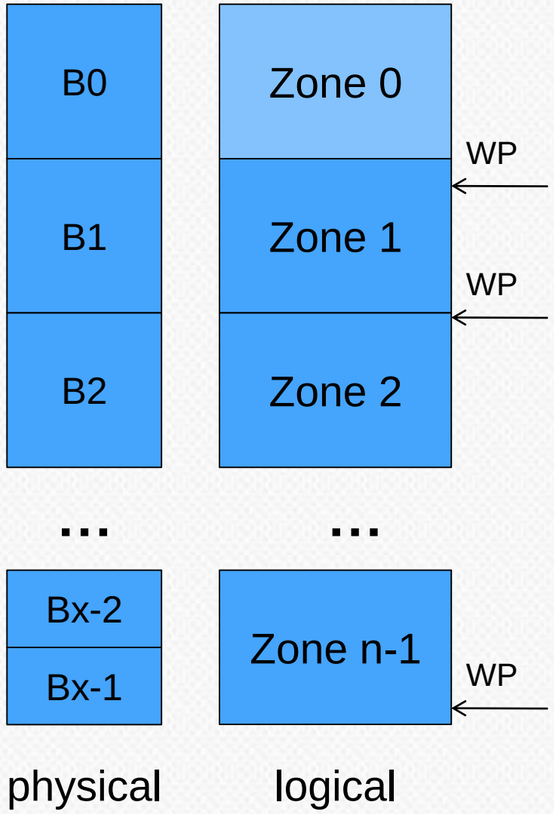
Host Aware SMR Solution

Zones

- SMR Bands
  - Physical construct
  - Boundaries are not known outside the drive
- Zones
  - Logical space is divided into zones
    1. Conventional zones
    2. Write pointer zones
       - *"Sequential Write Preferred"*
       - Each zone has its own Write Pointer
       - Each zone has its own state



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Host Aware SMR Solution

Write Pointer Zones

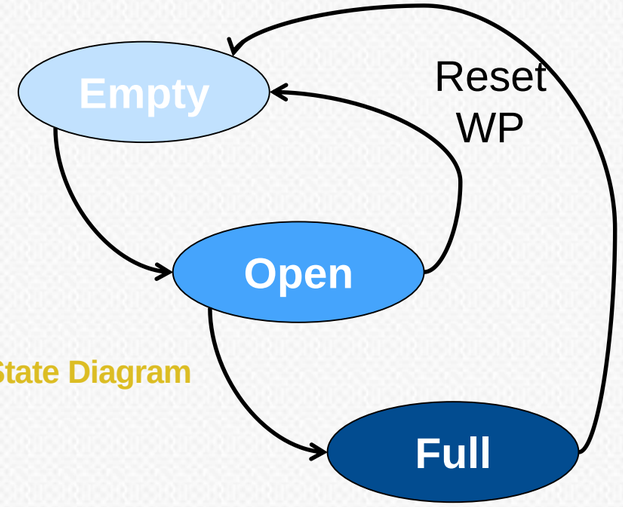
Writes at the write pointer have conventional performance

- Write pointer automatically advances

Writes not at the write pointer handled like Drive Managed

- Write pointer may or may not advance

Issue *"Reset Write Pointer"* before re-writing



Simplified State Diagram

Empty

- Write pointer is at start of zone

Open

- Write pointer is mid-zone

Full

- No write pointer value

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Host Aware SMR Solution

Intended Usage Model

1. Use **REPORT ZONES** and parameters to determine configuration

2. (*Judiciously*) Assign random write zones as needed
   - Limit to the device's Random Zones capabilities
   - Don't care about Write Pointer values
   - Don't issue Reset Write Pointer
   - Not preconfigured from factory
   - Can change during operation

3. Use the rest of the zones for sequential writing
   - Write Pointer is implicitly known

4. Control the number of Open zones
   - Limit to the device's Open zones capability

5. Garbage collect to evacuate zones for re-use
   i. Copy non-stale data to an open zone
   ii. Issue Reset Write Pointer
   iii. Move zone to free pool

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Moving Forward with SMR

Host Aware SMR Solution

Considerations for adopting Host Aware

- Do you understand your Workload (from a drive's perspective)?
  - How close to "best practices"?
- What SW development resources are available to you?
  - App modifications
  - File System optimizations
  - Implementing ZAC/ZBC features, commands, HA intended usage model
- Familiarize yourself with ZAC/ZBC via T10, T13 website content / specs
  - ZBC rev. 2 is in letter ballot review
  - ZAC is in spec development
- Obtain drive samples, initiate a POC

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Resources

t10.org	ZBC: SCSI Zoned Block Commands letter ballot review, now
t13.org	ZAC: Zoned-device ATA Commands spec development, now
github.com/hgst/libzbc	Linux user space libraries for ZBC emulation
github.com/Seagate/SMR_FS-EXT4	SMR Friendly Filesystem upgrades to ext4 See announcement at Linux Vault Conference March 11-12, 2015, Boston

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Summary

- The most cost-effective near-term capacity gains require SMR
- Some applications run well on Drive Managed
  - “Don’t know until you try it”
- Host Aware broadens SMR’s appeal to a wider range of applications
  - Leveraging the intended usage model
- Understand your environment and look for opportunities to adopt Host Aware SMR

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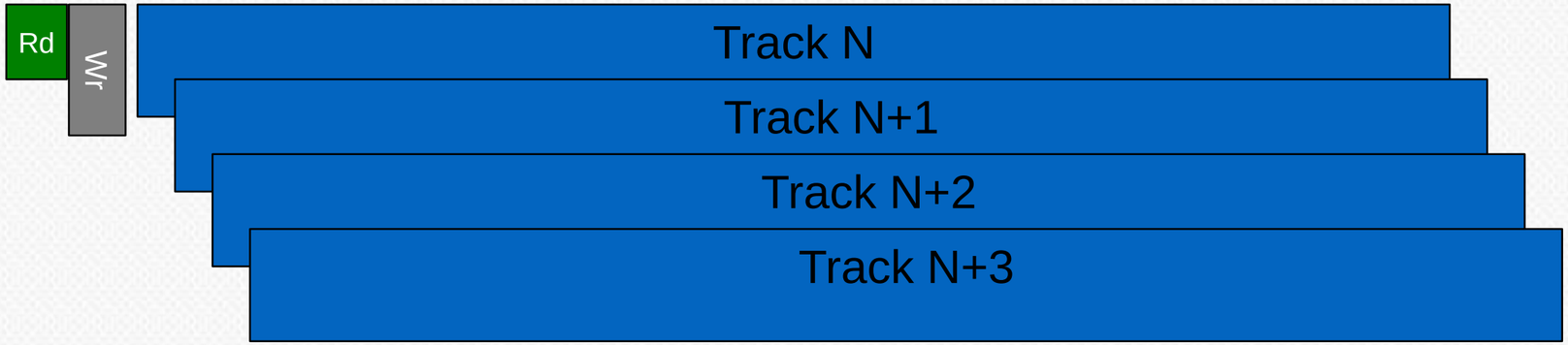
THANK YOU!

BACKUP

SMR Basics

Updating a band with new data



Data Buffer

Old Track N Data
Old Track N+1 Data
Old Track N+2 Data
Old Track N+3 Data

1. Read old data

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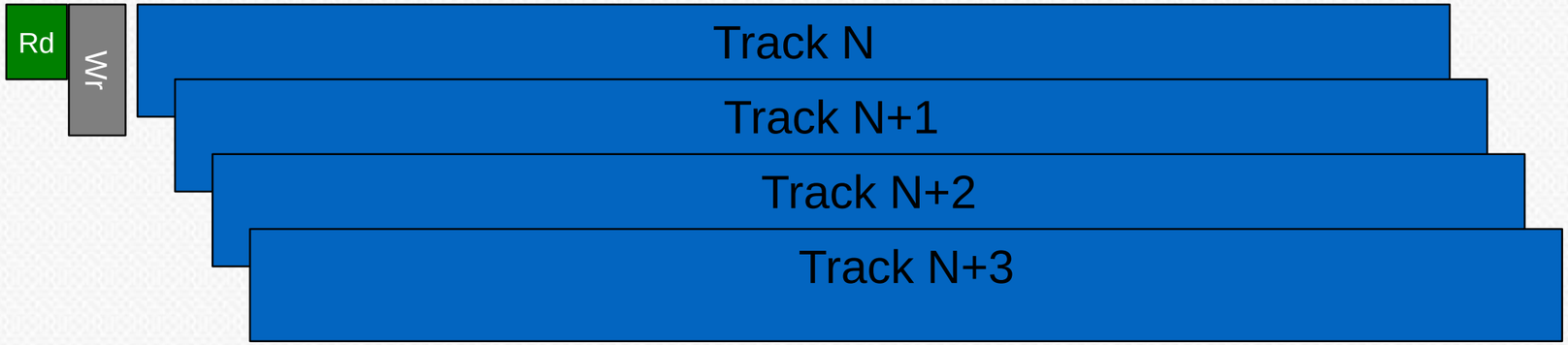
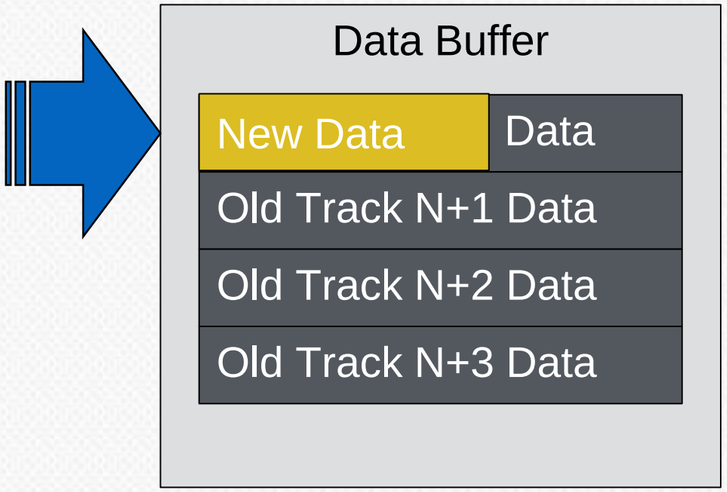
SMR Basics

Updating a band with new data





1. Read old data
2. Merge with new data

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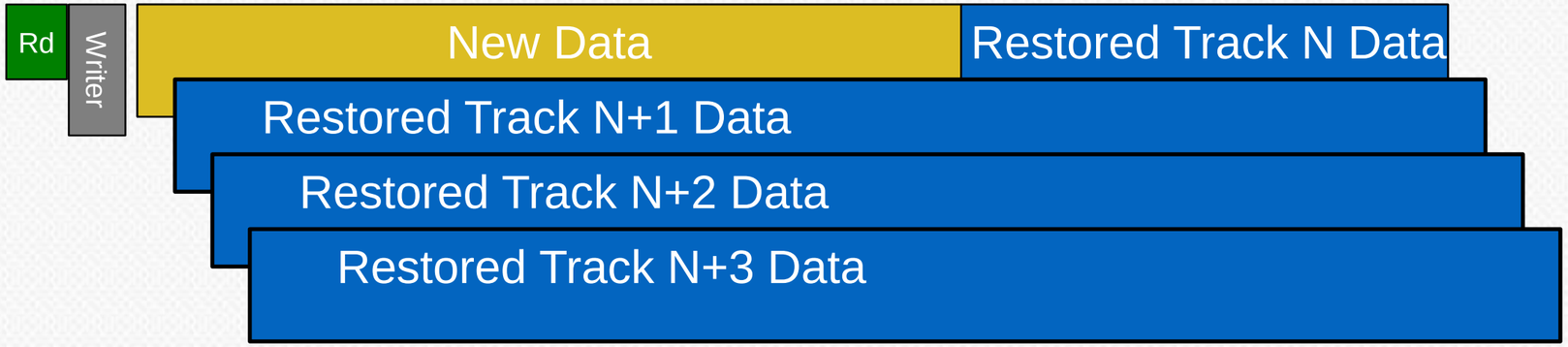
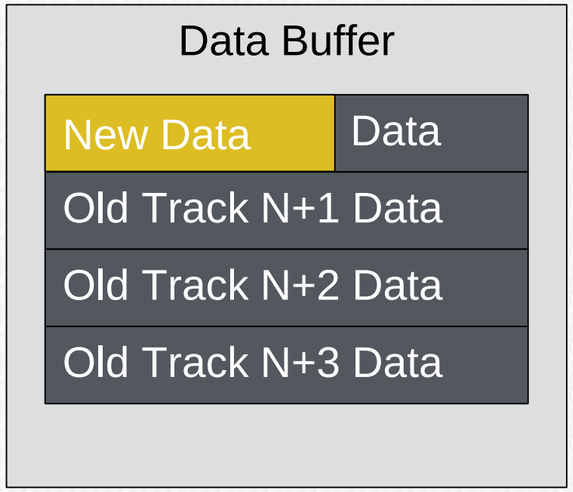
SMR Basics

Updating a band with new data





1. Read old data
2. Merge with new data
3. Write new data, refreshing old data

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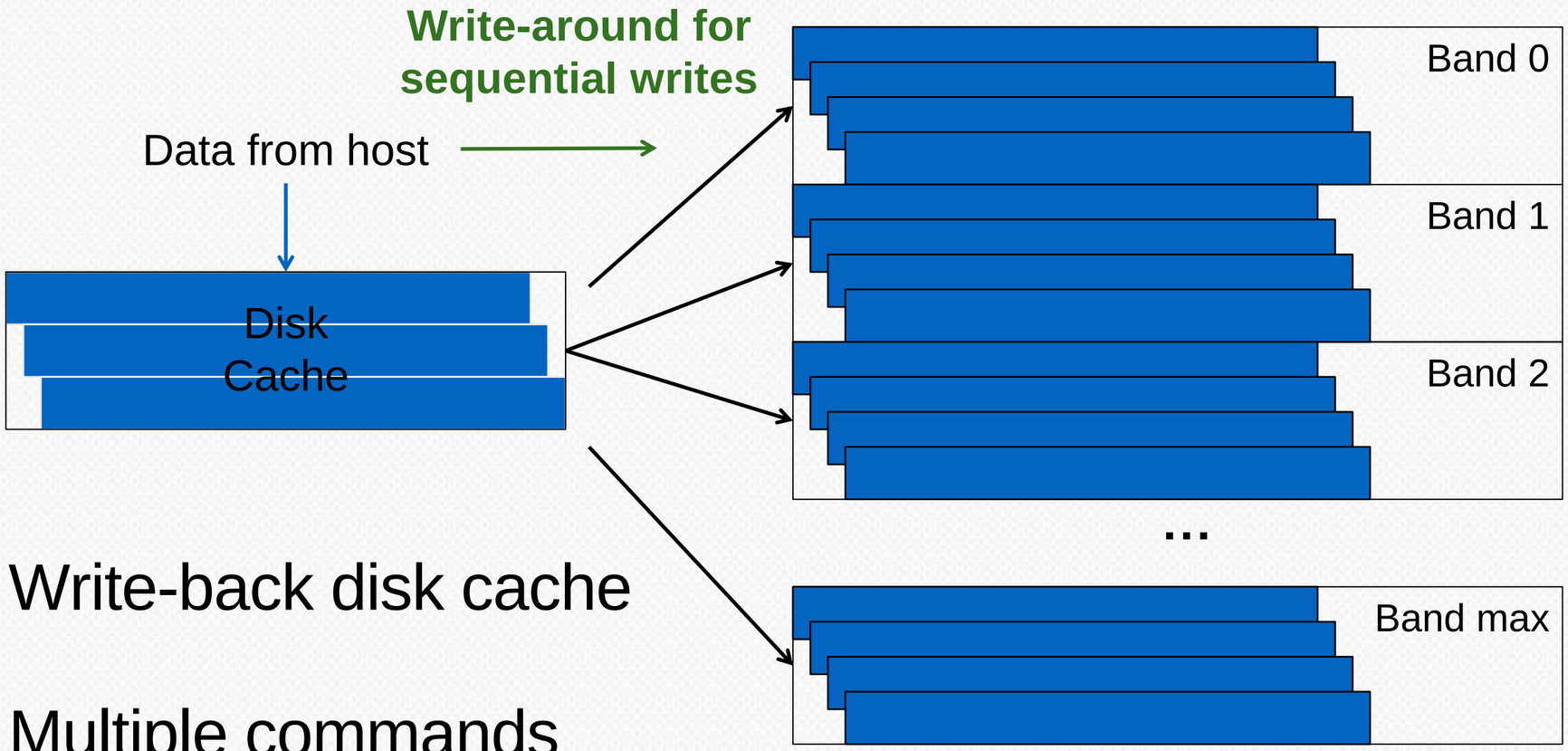
SMR Basics

Improving Write Performance



Write-back disk cache

Multiple commands cleaned during a band update

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