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CSAL with Core Scaling for RAID5F: Revolutionizing Cloud Storage Performance and Reliability

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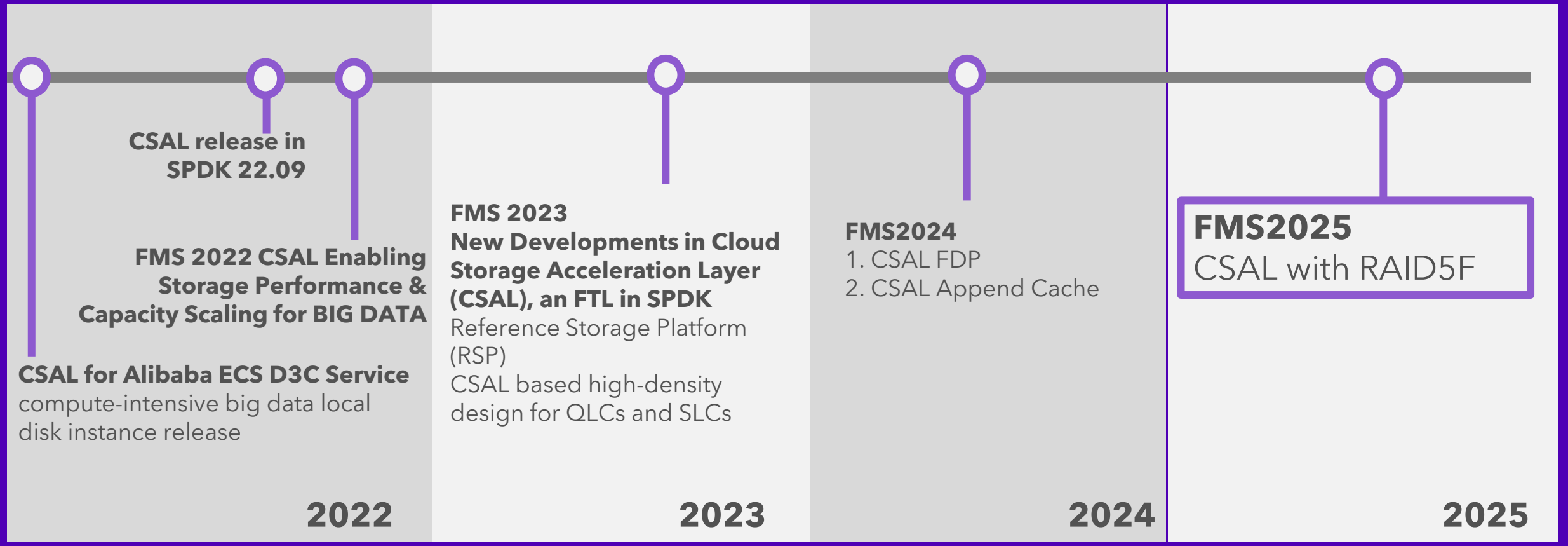
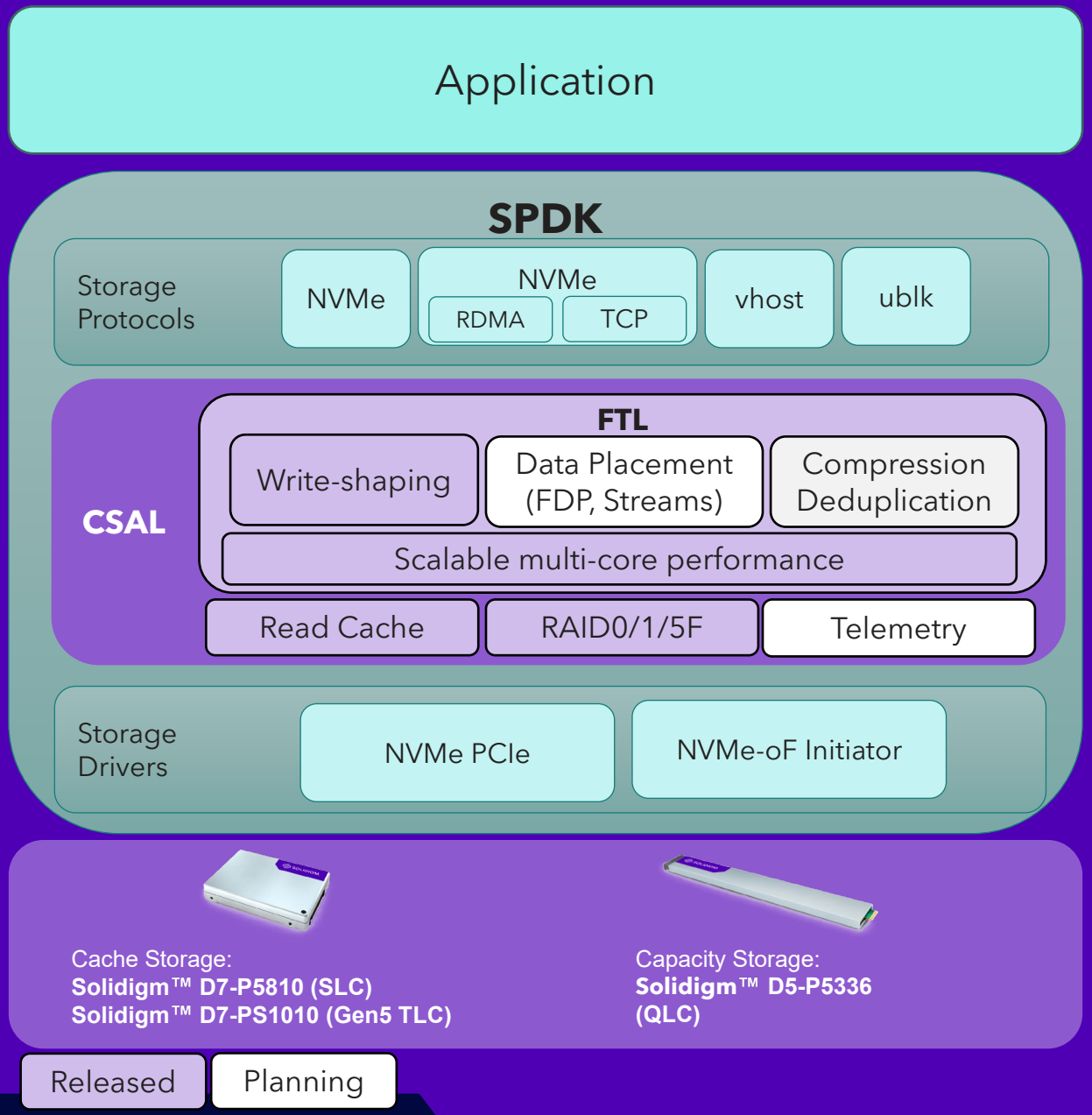
CSAL Evolution



Cloud Storage Acceleration Layer (CSAL)

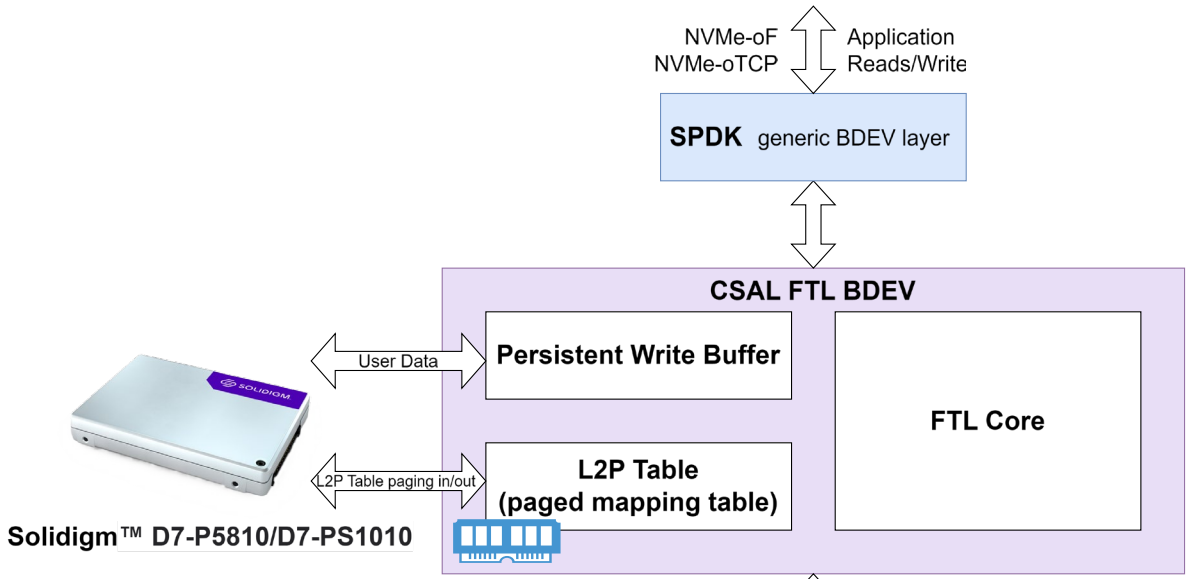
- **Built on SPDK**
  - Modular extensions enhancing SPDK's core
- **Write shaping**
- **Append-cache**
- **RAID0/1/5F/10**
- **Features in planning**: data placement, compression, deduplication, management, analytics



Write shaping

- CSAL provides transparent block device to the upper application
- Ultra-fast cache and write shaping tier to improve performance and endurance to scale QLC value
- Consistent performance in multi-tenant environment
- Flexible scaling of NAND performance and capacity to the user/workload needs

Cloud Storage Acceleration Layer (CSAL)



Solidigm™ D7-P5810/D7-PS1010

- Persistent Write Buffer
- Metadata and L2P Table
- Early write acknowledgement
- Power fail safety
- Write reduction
- Write aggregation to optimal write size
- High performance SSD

Solidigm™ D5-P5336 (QLC)
Capacity Storage

- High density SSD

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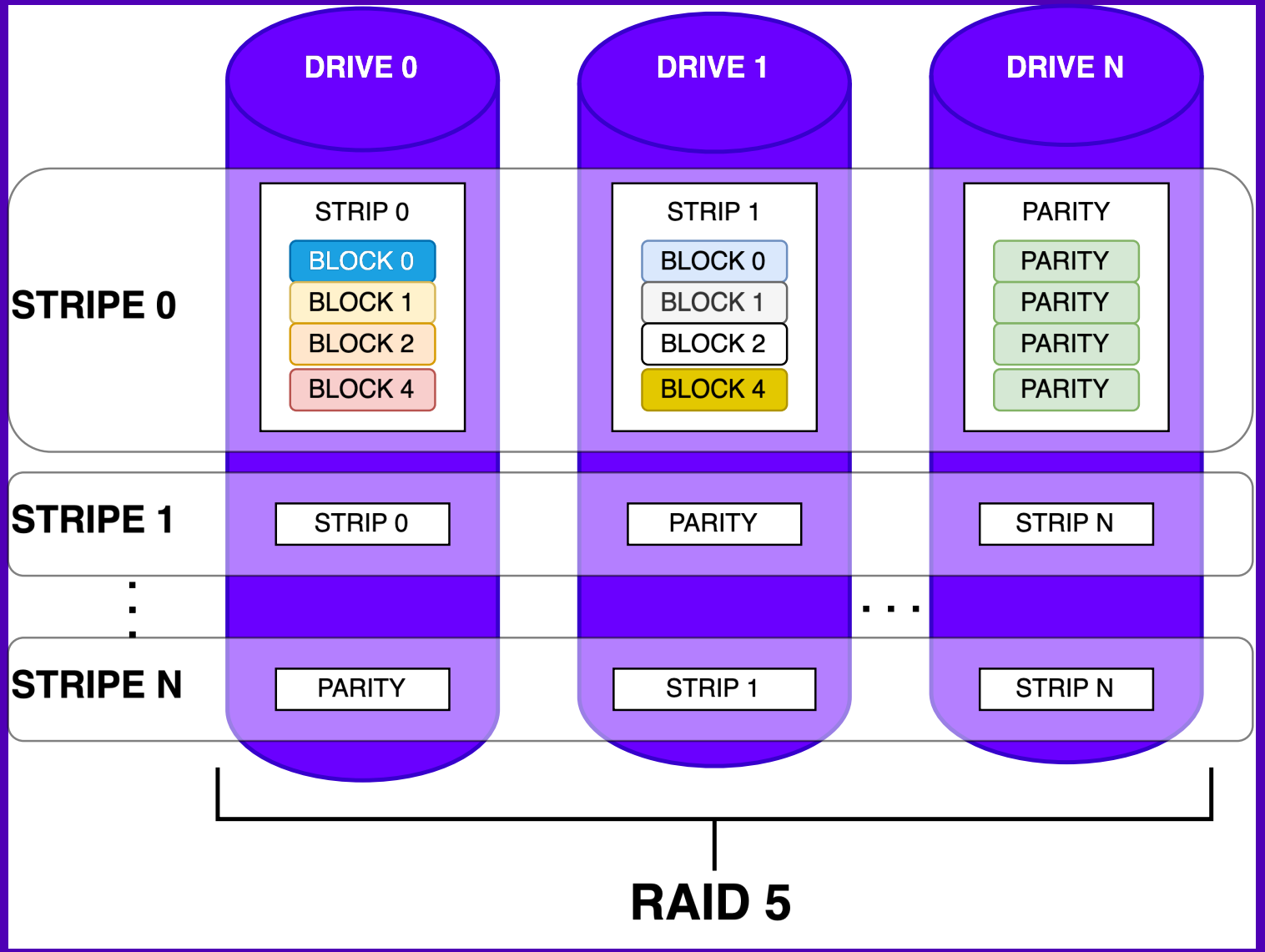
The Problem with Traditional RAID5

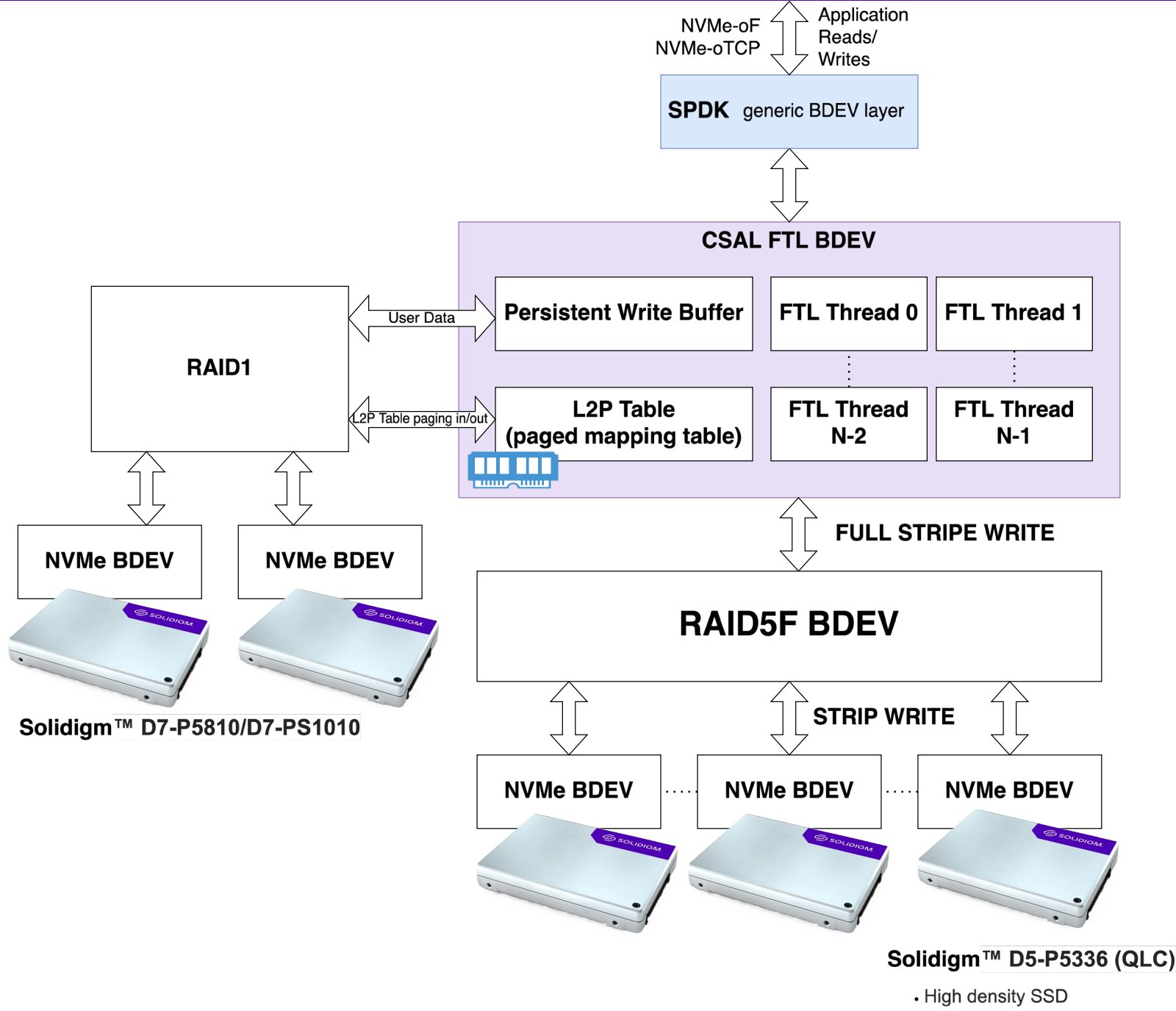
RAID 5 writes are often not aligned to a full stripe.

- Involves updating:
  - One or more data blocks
  - Parity block
- Requires read-modify-write cycle:
  - Read old data + parity
  - Compute new parity
  - Write new data + new parity
- Inconsistency risk between data and parity during update if power loss or crash occurs
  - Old parity with new data
  - New parity with old data



Introducing CSAL RAID5F

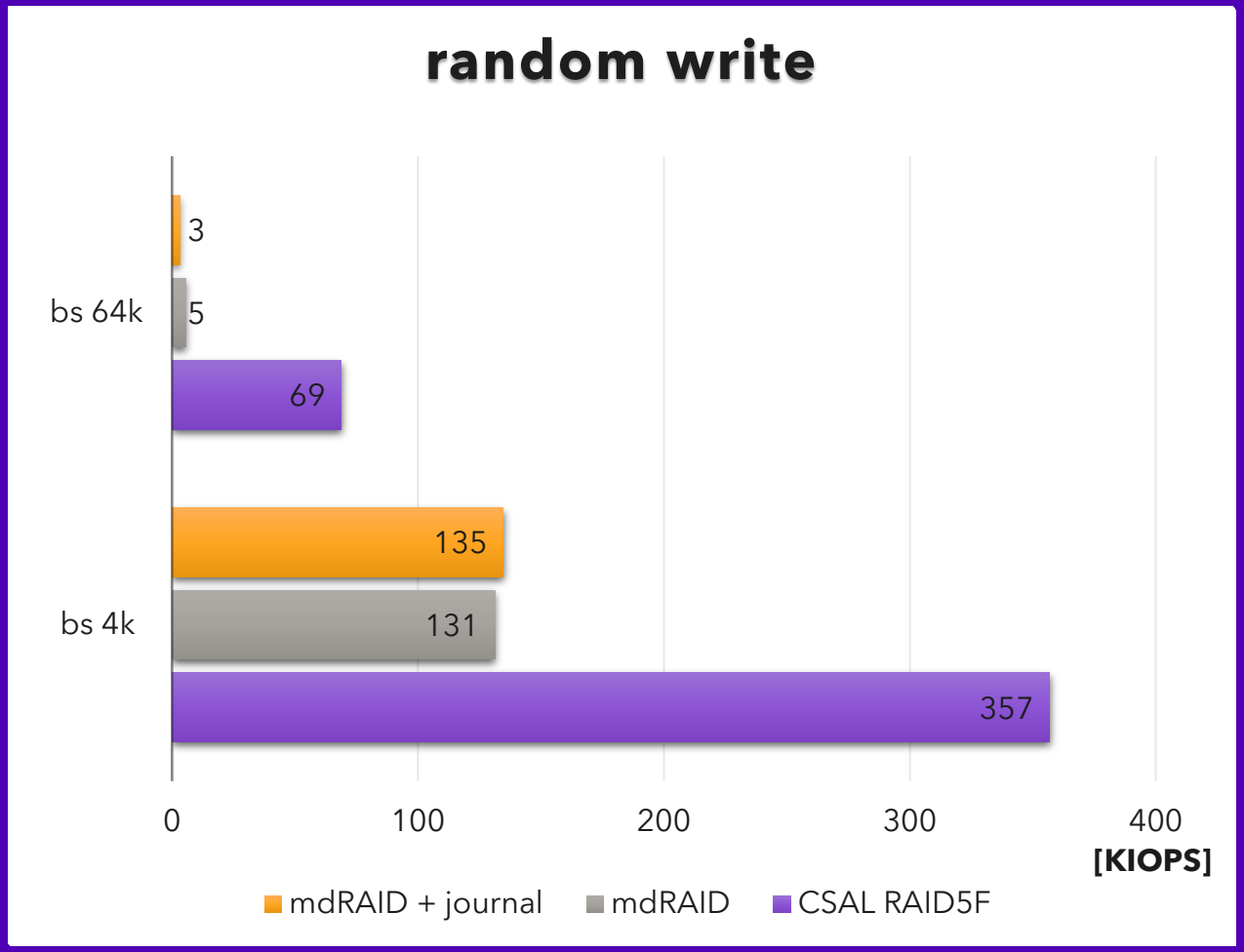
- Combining CSAL FTL write shaping future with new RAID5F BDEV
- Full-stripe atomic write
  - lack of costly read-modify-write
  - better performance
- No write hole
  - lack of silent data corruption
- Lower WAF
  - increased NAND endurance

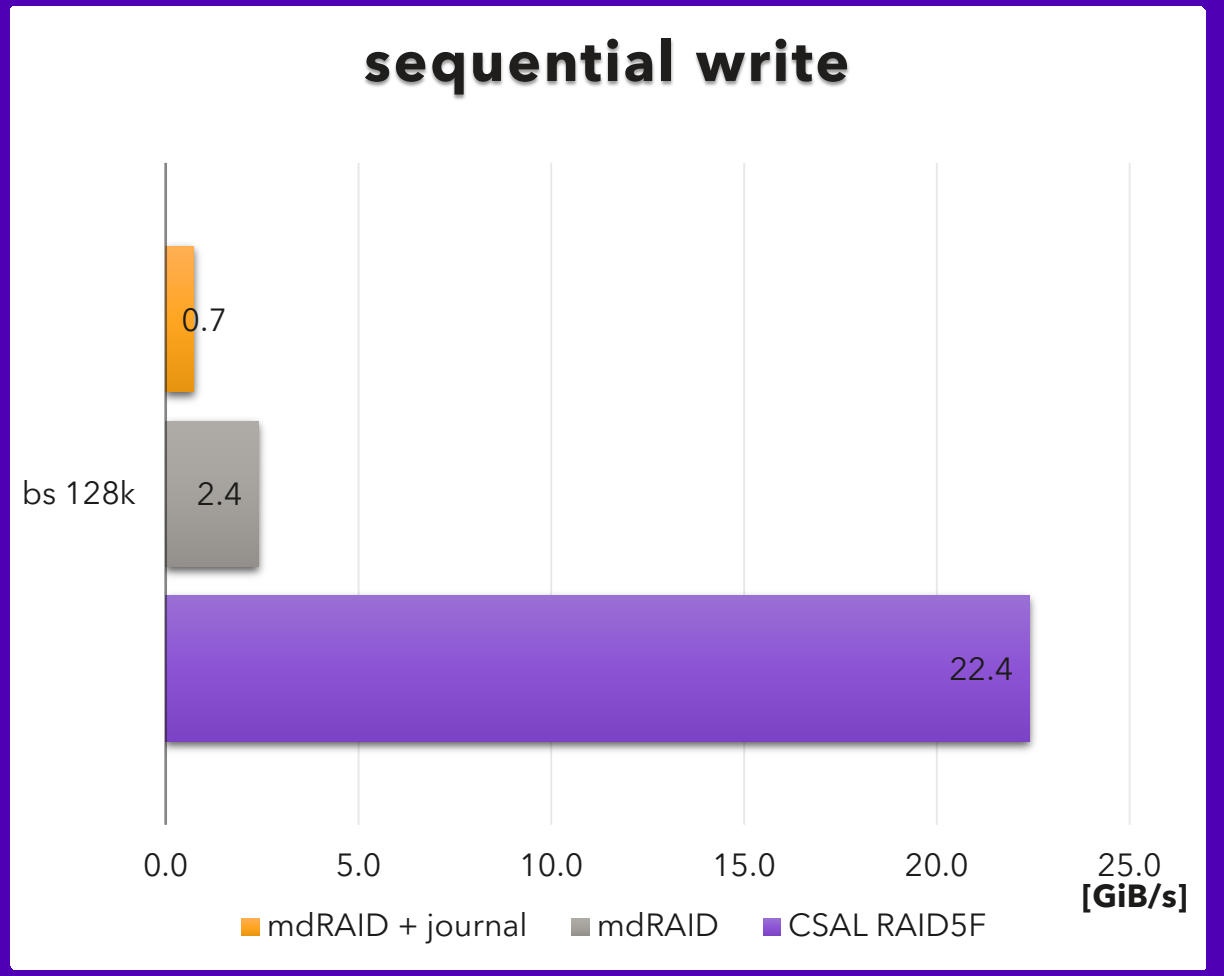


Evaluation - CSAL RAID5F vs Linux Software RAID (mdRAID)

- **Workloads & Parameters:**
  - Sequential Write:
    - Block size: 128K
    - I/O depth: 128
  - Random Write:
    - Block size: 4 KiB, 64 KiB
    - I/O depth: 128
- **Preconditioning:**
  - Full-drive sequential write pass across all partitions before test (to eliminate fresh-block bias)
- **Test Environment:**
  - Storage Backend (RAID5 with strip size 128K):
    - 9 × Solidigm D5-P5336 (QLC, 15.36 TB each)
    - Total usable capacity: ~123 TB
  - Write Cache (RAID10):
    - 8 × Solidigm D7-P5810 (SLC, 800GB each)
    - 5% of total usable capacity
  - Server: AMD EPYC 9534 (64 cores) – 8 cores dedicated for RAID logic
  - Operating System: Fedora 41, Kernel: 6.13.4-200.fc41.x86_64

CSAL RAID5F vs mdRAID write performance comparison





Unlock 4×–20× better performance with CSAL RAID5F, compared to traditional Linux software RAID.

Conclusion

CSAL offers a feature-rich, robust, QLC-friendly RAID solution – unlocking high-density, high-performance deployments.

Key Advantages:

- No RMW overhead
- Built-in write hole protection
- Scales across CPU cores
- 4×–20× better performance vs MDRAID with journal
- Improved SSD endurance

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Q&A
Cloud Storage Acceleration Layer RAID5F

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