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Optimize Redis with NextGen NVM

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Agenda

- Redis introduction
- NVM introduction
- Scenario 1: Use NVM to increase Redis capacity
- Scenario 2: Use NVM to improve the performance of Redis persistency
- Completed features support of Redis on NVM
  - LRU & Defrag
  - Linux Copy-on-Write on NVM
- Summary

Redis Introduction

Redis is an open-source in-memory K-V database that offers high performance, replication, and a unique data model with optional durability.

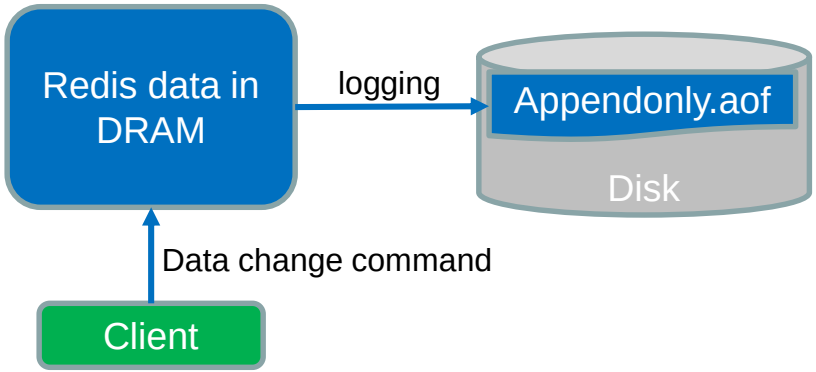

Fig1. Redis persistency - AOF

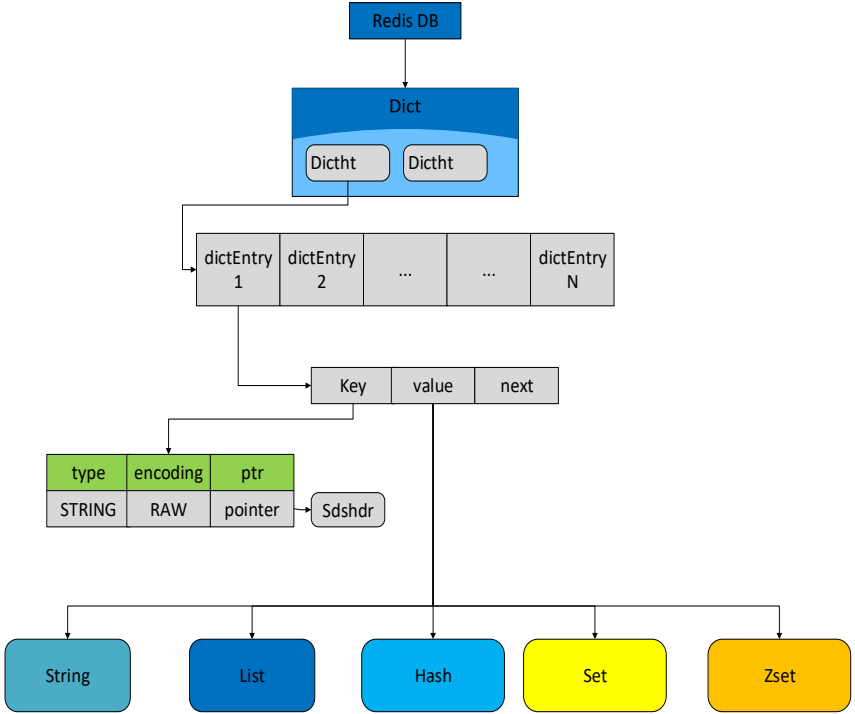

Fig2. Redis data structures

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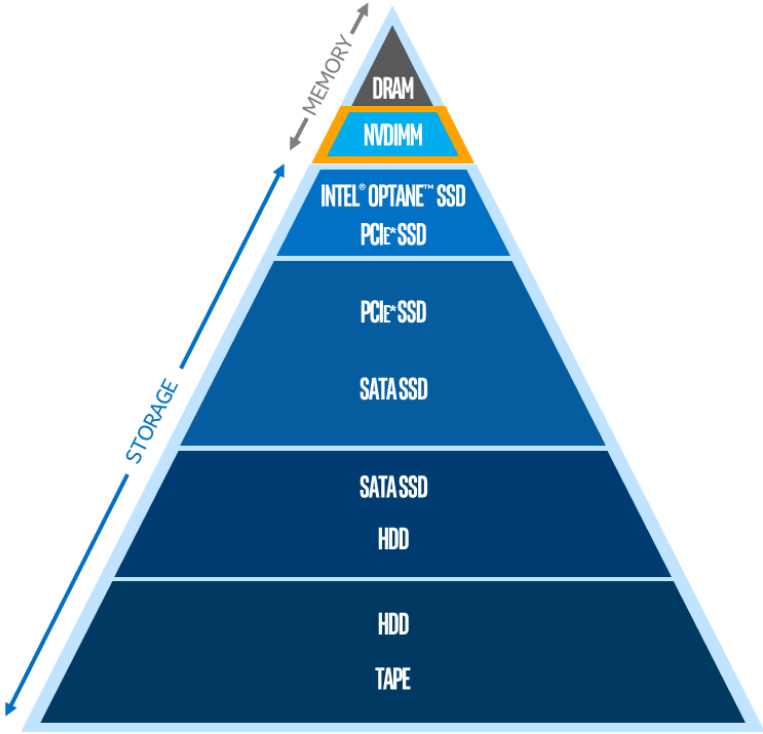
NVM Highlight

- Large capacity
- Lower $ / GB
- Close to DRAM throughput and latency
- Persistency - may or may not use



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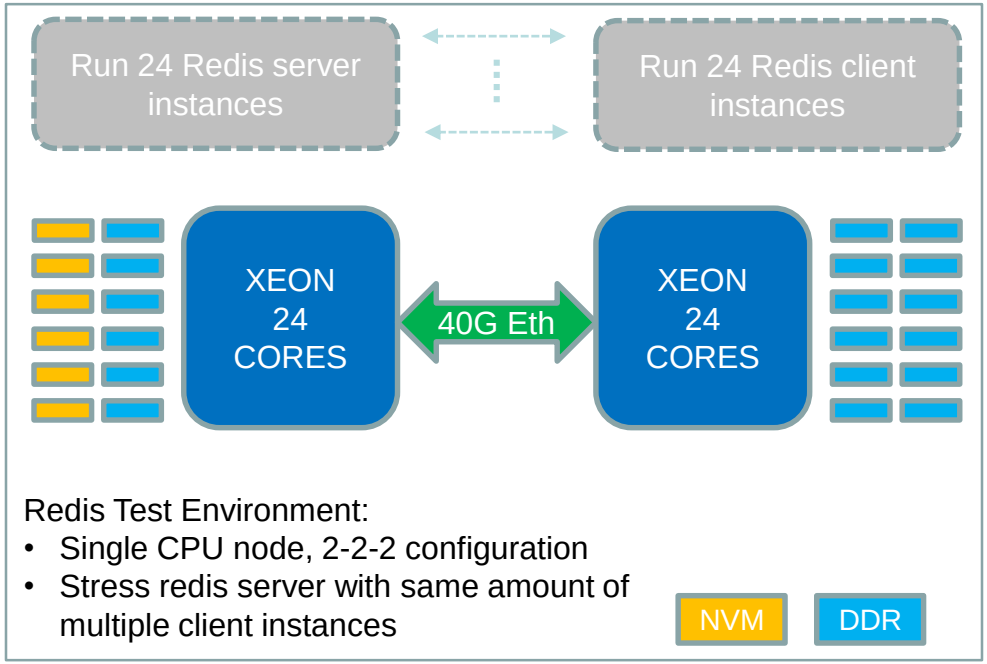
Use NVM to increase Redis capacity

- Design Option #1 - Store all heap data in NVM
  - Replace jemalloc by libmemkind
  - Minimum Redis code change needed



Use NVM to increase Redis capacity

Design option #1 - Store all heap data in NVM

- Performance optimization opportunity:
  - Big and sequential data access pattern has better performance than small and random data access pattern in NVM
  - Meanwhile in Redis, a lot of management data structures are small and usually be accessed randomly

Use NVM to increase Redis capacity

Design option #2 - Store most of heap data in NVM

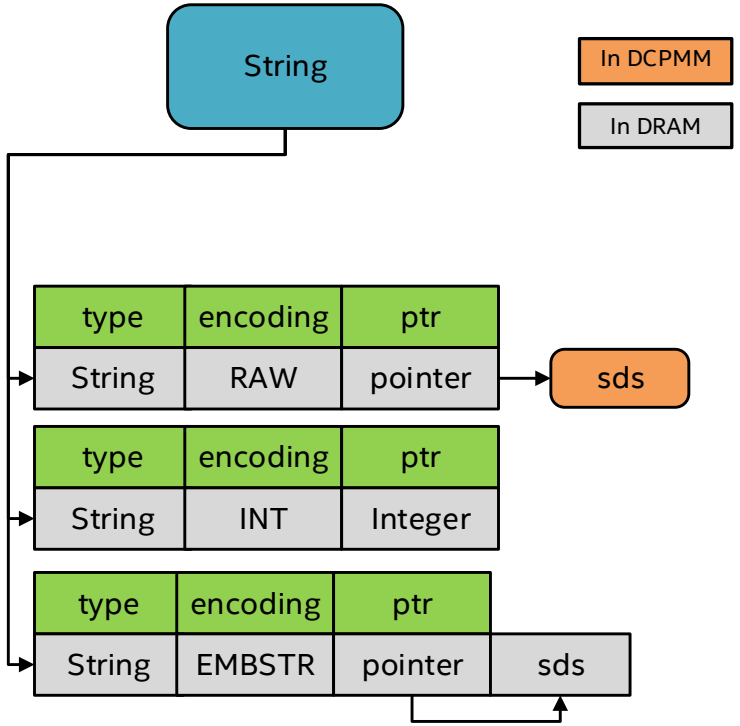
- Only store large value in NVM (>64 byte by default)
  - Keep Redis management data structures in DRAM
  - Optimize the data placement strategy for each data type

Performance:

- Close to Redis performance run on DRAM
- URL: https://github.com/pmem/pmem-redis

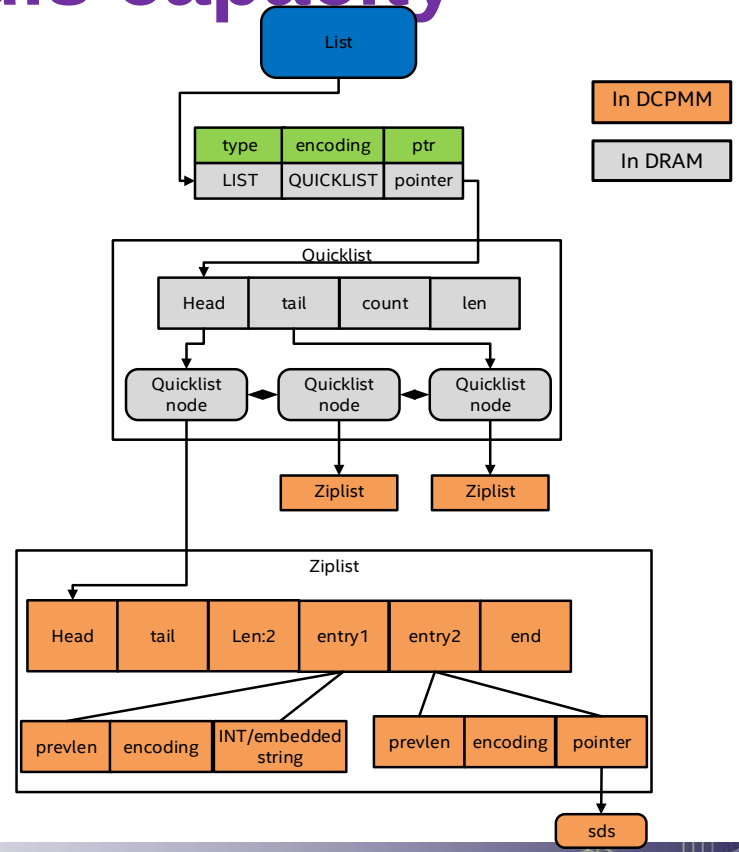
Use NVM to increase Redis capacity

- Implementation details:
- Encoding to STRING:
  - RAW: Store value (>threshold) in DCPMM and store SDS pointer in DRAM.
  - INT: Store in the DRAM
  - EMBSTR: Store in the DRAM



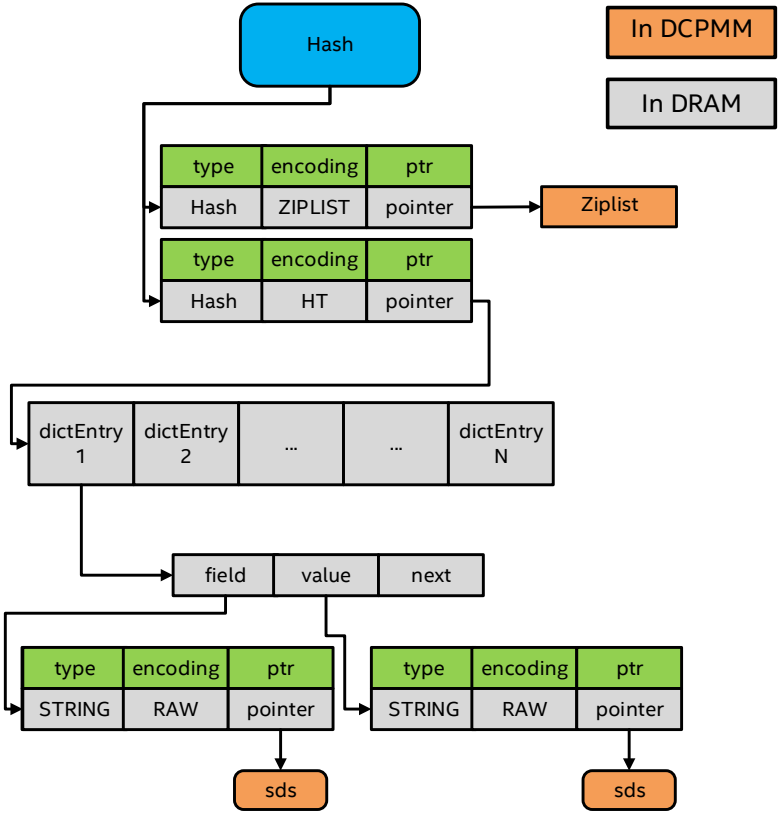
Use NVM to increase Redis capacity

- Implementation details:
- Encoding to LIST: QUICKLIST
  - After Redis-3.2.7, quicklist is used to implement the list data type. Each quicklist node contains a ziplist structure.
  - ziplist is to save memory usage for small items like int/embedded string
  - Store value (>threshold) in DCPMM and store the pointer in ziplist



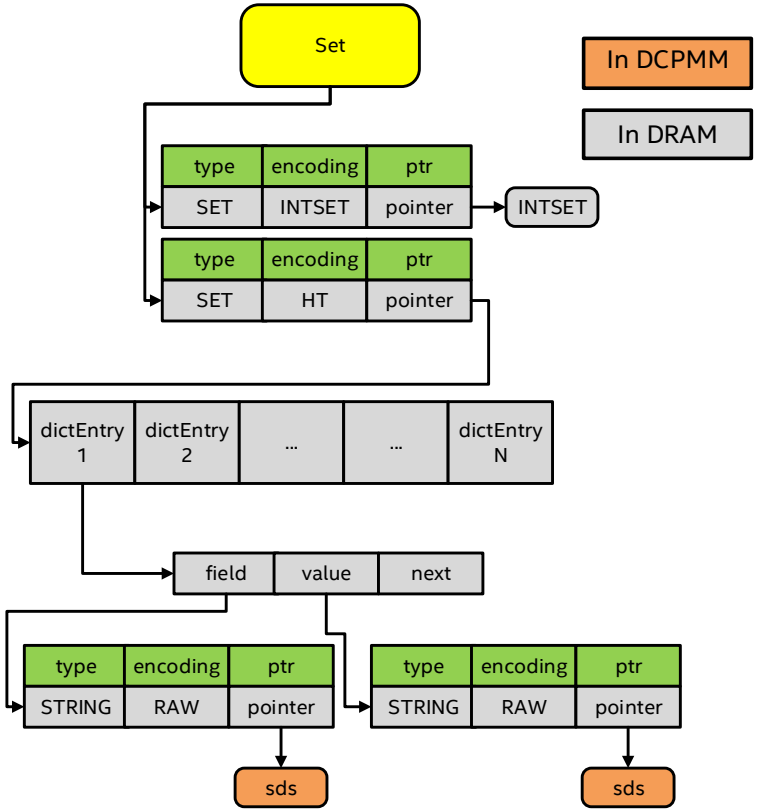
Use NVM to increase Redis capacity

- Implementation details:
- Encoding to HASH:
  - ZIPLIST: Store value (>threshold) in DCPMM and store the pointer in ziplist
  - HASHTABLE: Store value (>threshold) in DCPMM and store the pointer in hashtable



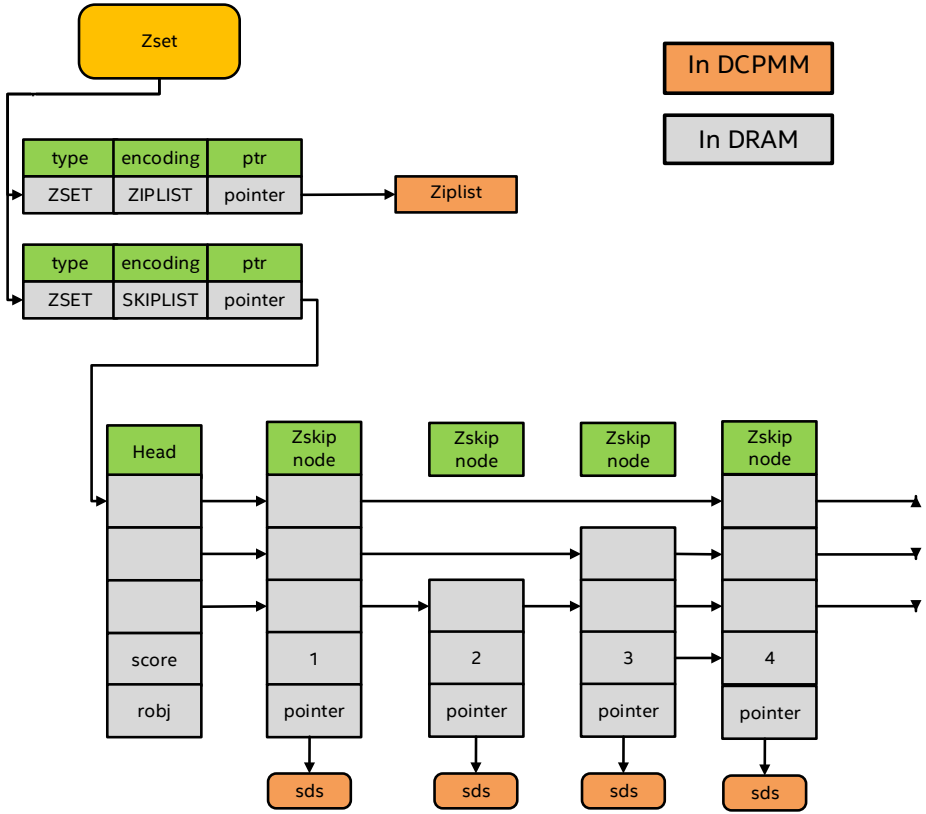
Use NVM to increase Redis capacity

- Implementation details:
- Encoding to SET
  - INTSET: It is unnecessary to move intset into DCPMM due to its small size
  - HASHTABLE: Store value (>threshold) in DCPMM and store the pointer in hashtable



Use NVM to increase Redis capacity

- Implementation details:
- Encoding to ZSET
  - ZIPLIST: Value (>threshold) stored in DCPMM and the pointer stored in ziplist
  - SKIPLIST: Value (>threshold) stored in DCPMM and the pointer stored in skiplist



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Use NVM to improve the performance of Redis persistency

Design option #1 – Persist everything in NVM

- Use libpmemobj to store data and its mgmt. structures in NVM

Source:

- URL: https://github.com/pmem/redis/tree/3.2-nvml

Use NVM to improve the performance of Redis persistency

Design option #2 – Pointer based AOF

- Store key in DDR and AOF (same to Open Source Redis)
- Store value in NVM (for persistency) and only store its pointer in AOF(for recover)
- Leverage AOF to guarantee data integrity

Performance:

- Much better than Open Source Redis AOF (sync=always)
- URL: https://github.com/pmem/pmem-redis

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Completed features support of Redis on NVM

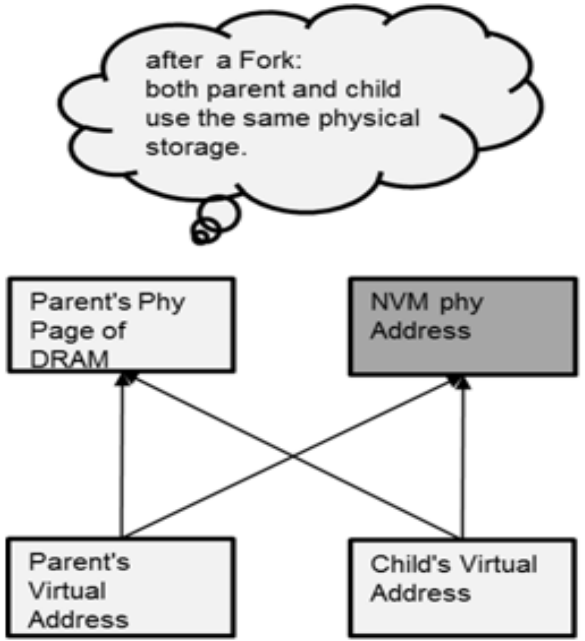
Besides data movement optimization, also covers below features for NVM adoption:

- Data retirement support: LRU on NVM
  - Evict the objects only when both DDR and NVM are full
  - Support to evict objects in NVM
- Defragmentation on NVM
  - In Redis 4.0, leverage jemalloc to support defrag the space in NVM

Completed features support of Redis on NVM

- Pitfall – Linux Copy-on-Write is not supported on NVM

- Problem Statement
  - Redis leverages CoW to do RBD snapshot, replication, etc.
  - The NVM space doesn't support CoW, because it is based on a memory mapped file. Hence the parent and child process share the same NVM address space, which may cause data corrupt during COW.
- Solution
  - During CoW, duplicate objects in parent process of Redis
  - Introduce two hash tables to help the parent process to decide if it needs to duplicate the object or not



Summary

Optimized Redis with Next Gen NVM can achieve:

- Full compatible API and Functionality
  - Compatible with open source Redis 4.0+
- Higher capacity per instance with lower TCO
  - Way to use NVM as a volatile device to provide larger capacity for in-memory database
- Higher Perf on persistency
  - Novel design to use NVM for high performance persistency on Redis

Reference

- Persistent Memory Development Kit http://pmem.io/pmdk/libpmem/
  - Libmemkind https://github.com/memkind/memkind
  - Libpmem http://pmem.io/pmdk/libpmem/
- Open Source Redis download https://redis.io/
- Optmized PMEM Redis Repo https://github.com/pmem/pmem-redis