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Converged Storage Technology

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Abstract

- **Converged Storage Technology**
  - This SNIA Tutorial discusses the concept of object store and key-value storage, next generation key-value converged storage solutions, and what has been done to promote the key-value standard.

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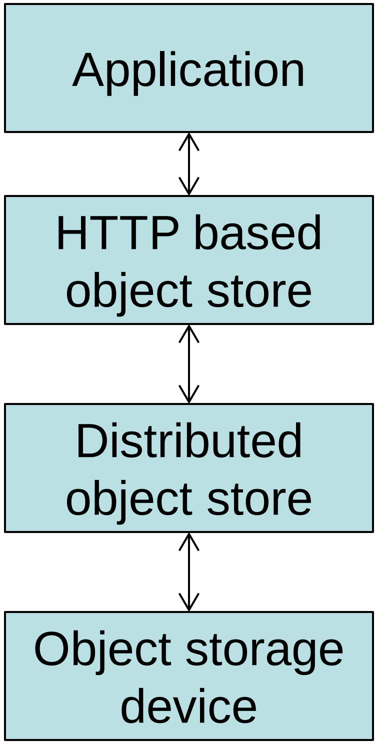
Background: Object Store

- The Device based object store
  - Originated in CMU NASD project, Garth Gibson
  - ANSI INCITS T10, OSDv2 (SCSI extension)
- Distributed object store
  - Ceph Rados
  - Google GFS
  - Azure Storage Stream Layer
- The HTTP based object store
  - Amazon Web Service S3
  - Openstack Swift
  - Ceph Object Gateway



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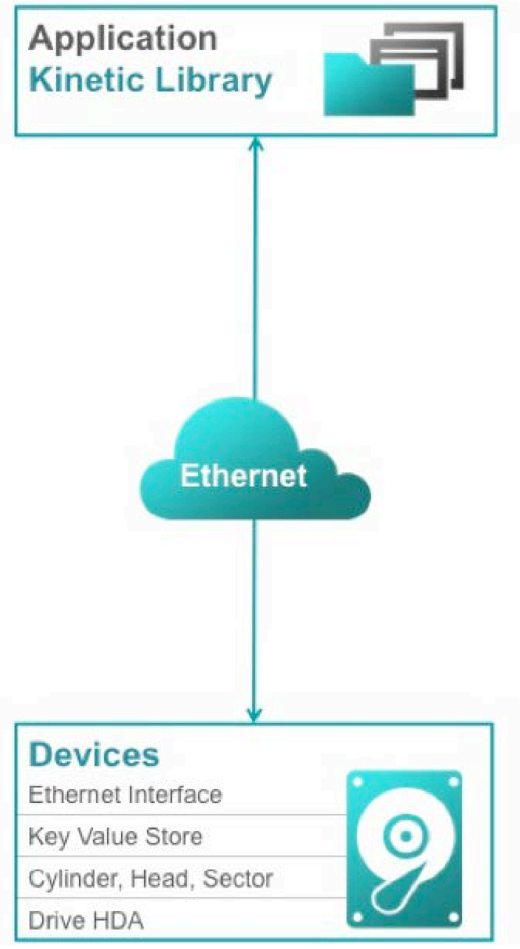
Background: Device based object store

- Software
  - Ceph OSD
  - Lustre OSS
  - Panasas OSD
- Hardware
  - IP Disk
- Standard organization
  - Linux Foundation, KINETIC Open Storage Project



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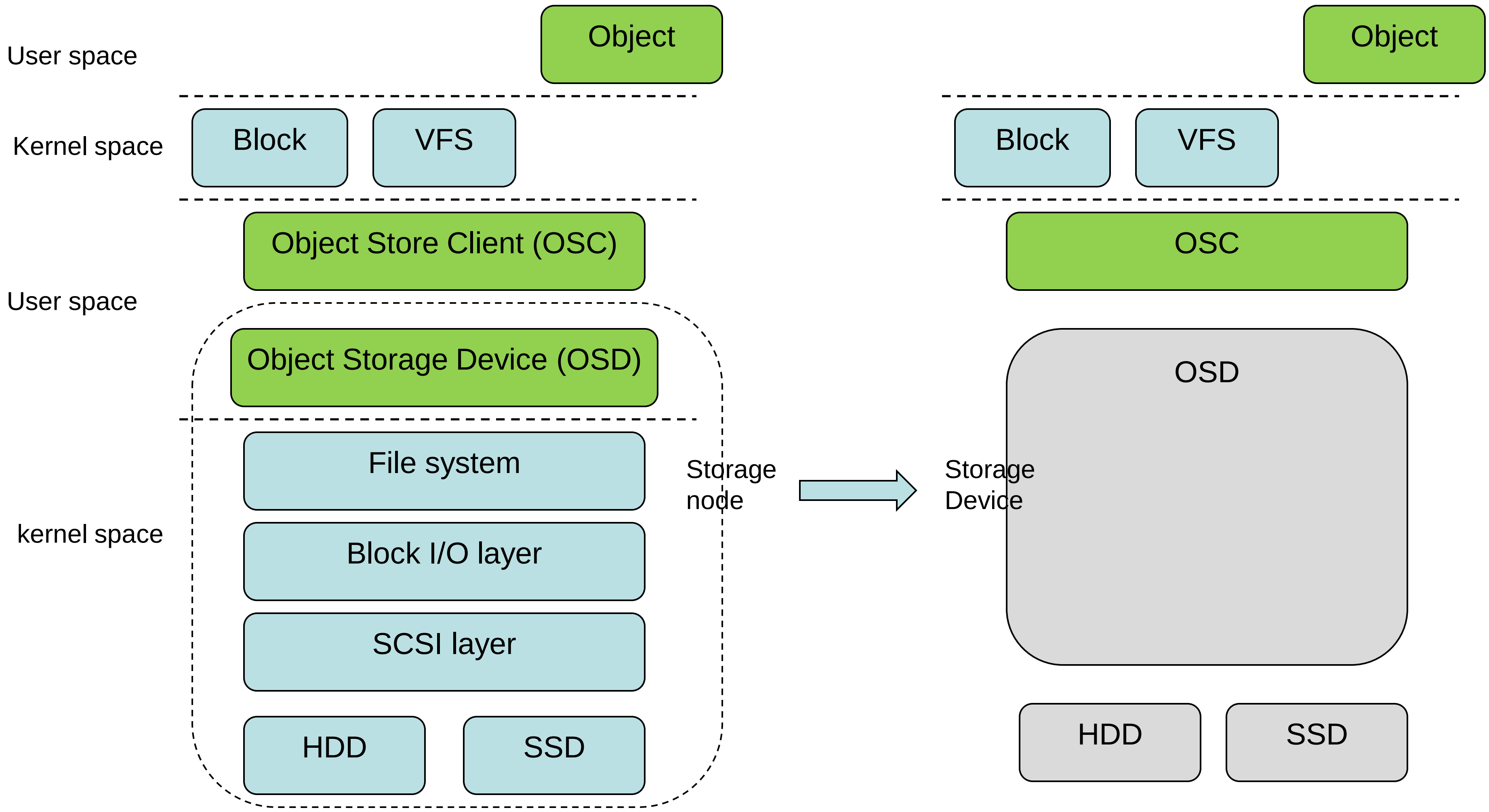
Background: object store stack



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Background: Device based key-value store

- Disk optimized key-value store
  - BerkeleyDB
  - MongoDB
  - LevelDB
- Flash optimized key-value store
  - LevelDB
  - SILT – SOSP 2011
  - FlashStore – VLDB 2010
  - FAWN-KV – SOSP 2009
  - NVMKV – co-designed with FTL, HotStorage 2014

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Background: Device based key-value store

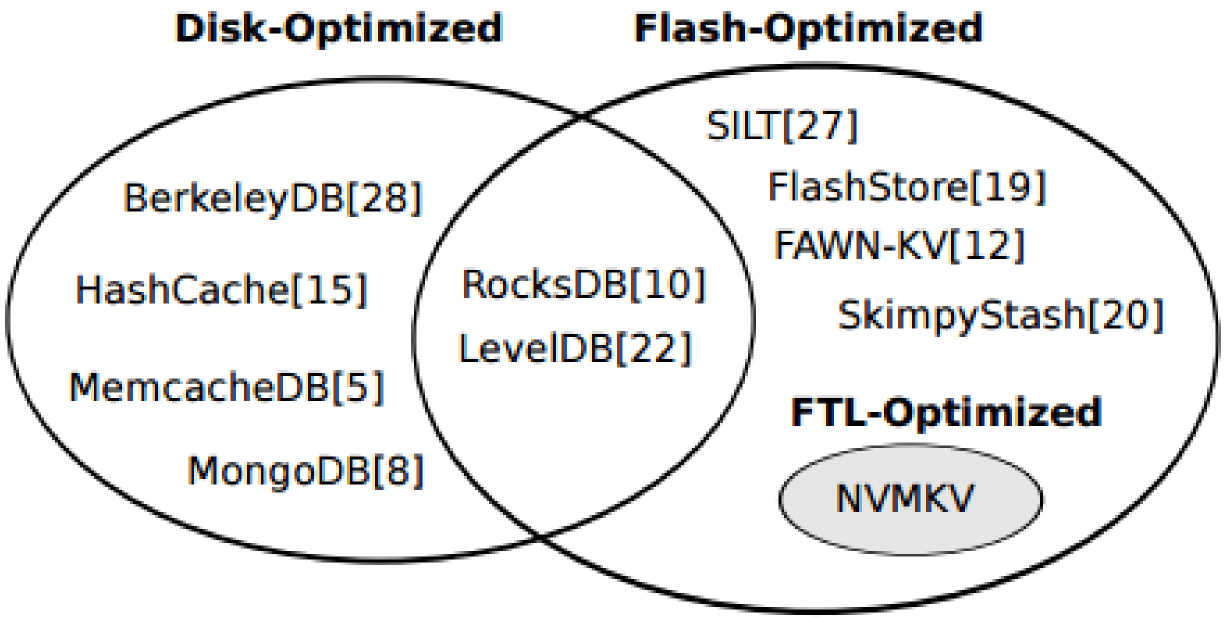

Figure 2: **Categorizing Existing KV stores.** *This figure shows a broad categorization of existing KV stores based on primarily being hard-disk- or flash-optimized and on leveraging capabilities surfaced by modern FTLs.*

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Background: Distributed Key-value Store

- Distributed key-value store / NoSQL DB
  - Google Bigtable
  - HBase
  - Azure Partition Layer
  - Amazon DynamoDB
  - Cassandra
  - Redis

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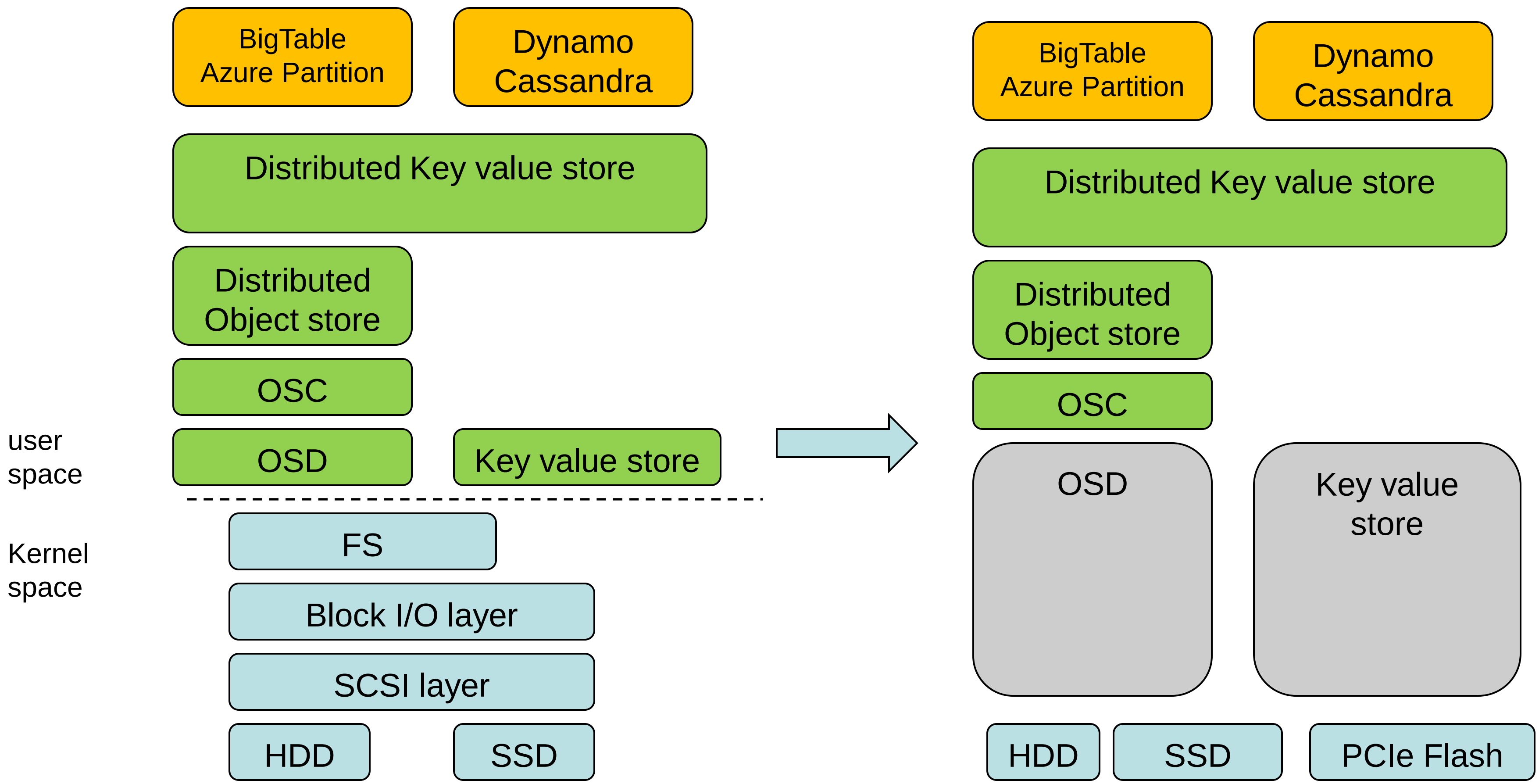
Back ground: Key-value Store stack



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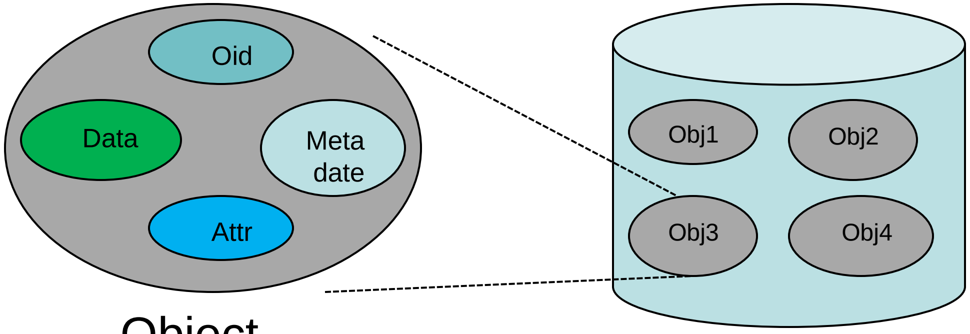
Background:
KV Store vs Object Store

- Key value store and object store are similar, but they do have differences.

	Object Store	Key value store
Key type	Positive integer	Any string
Attribute	Need	Not need
Data size	Big	Small
Metadata	Need	Not need



Object

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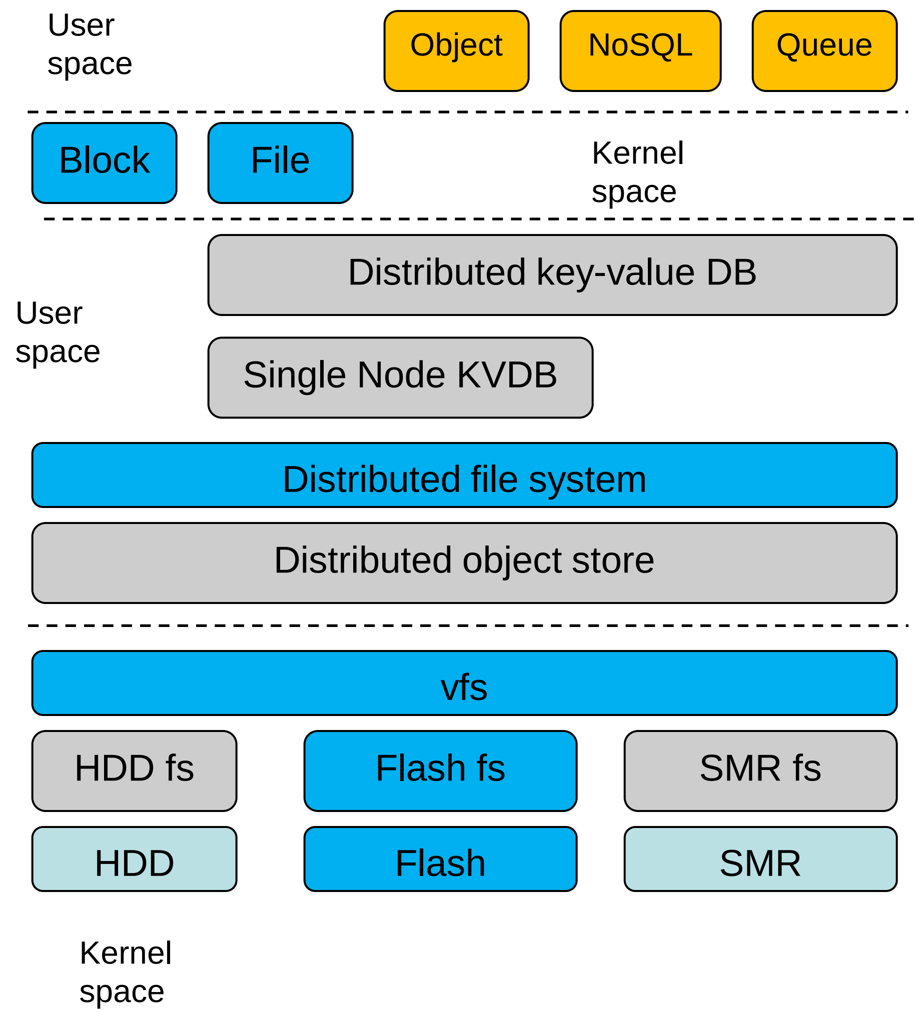
A typical converged storage architecture

- Converged storage
  - Integrate all kinds of Storage device to provide all kinds of storage service
- Device layer
  - Use local FS to manage the physical space
- Distributed object store
  - Distributed Replication or EC
  - Checksum, Failover
- Distributed key-value DB
  - Unified abstraction of storage services



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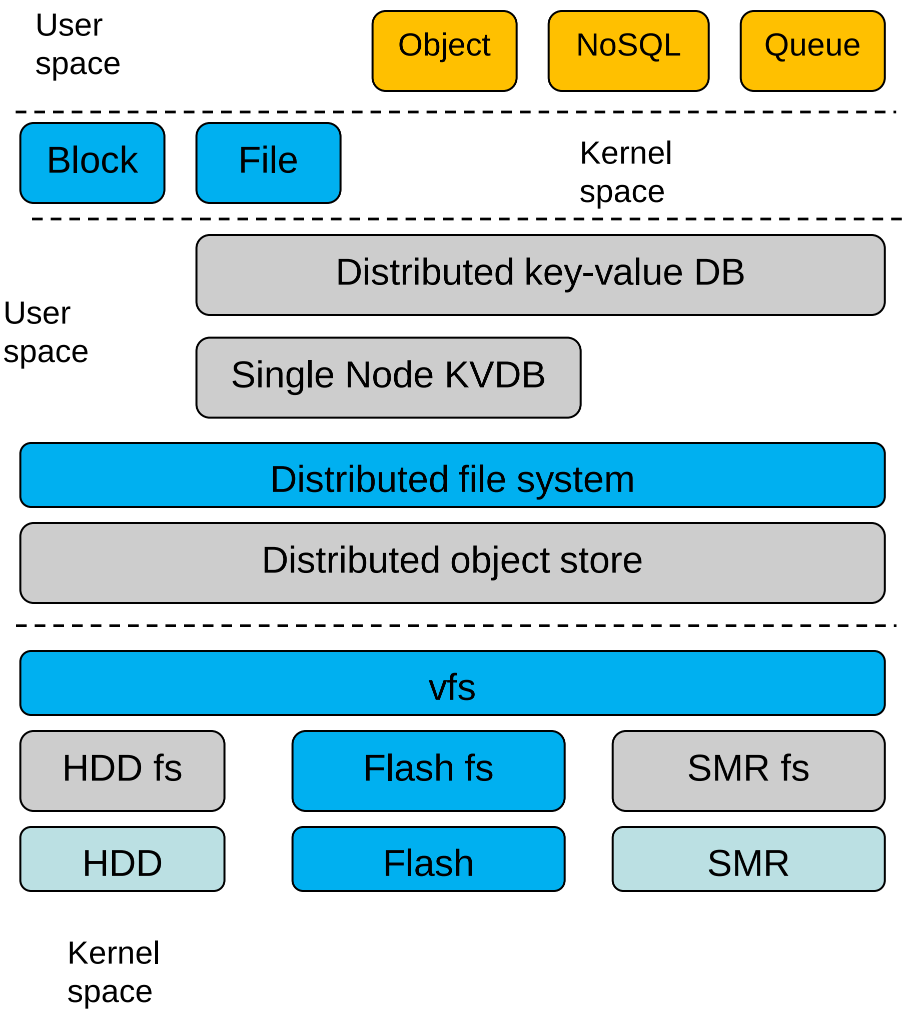
Problem 1

- **Complicated**
  - VFS is good for abstraction, but too complicated.
  - We only need an object store
    - flat namespace
    - space management.
- **Flash Performance**
  - User-space & kernel space transition
  - Performance wasted by OS
  - Upper layer cannot use the features of flash
    - Atomic batch write
    - Atomic batch trim



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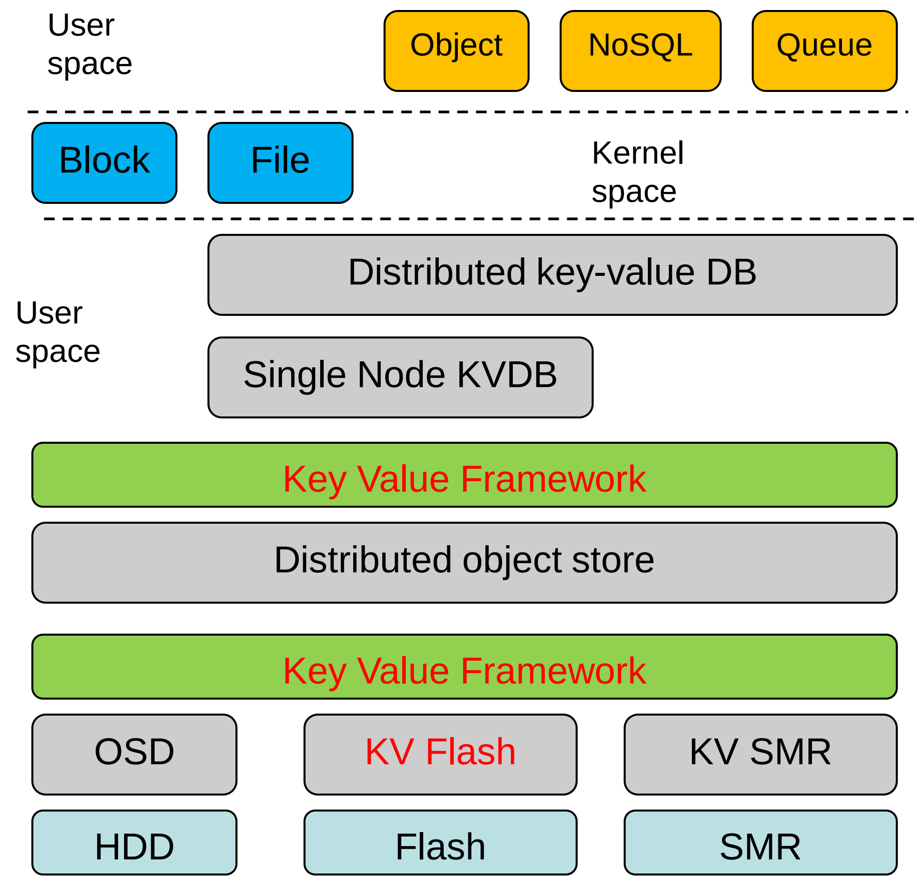
Solve the problem

- Key-value framework (KVF)
  - User-space key-value library
  - User-space key-value storage device
  - IP-device for remote access
  - Interface like VFS
    - General interface for common application
    - Extended interface for flash
  - Make the lower level and high level the same interface



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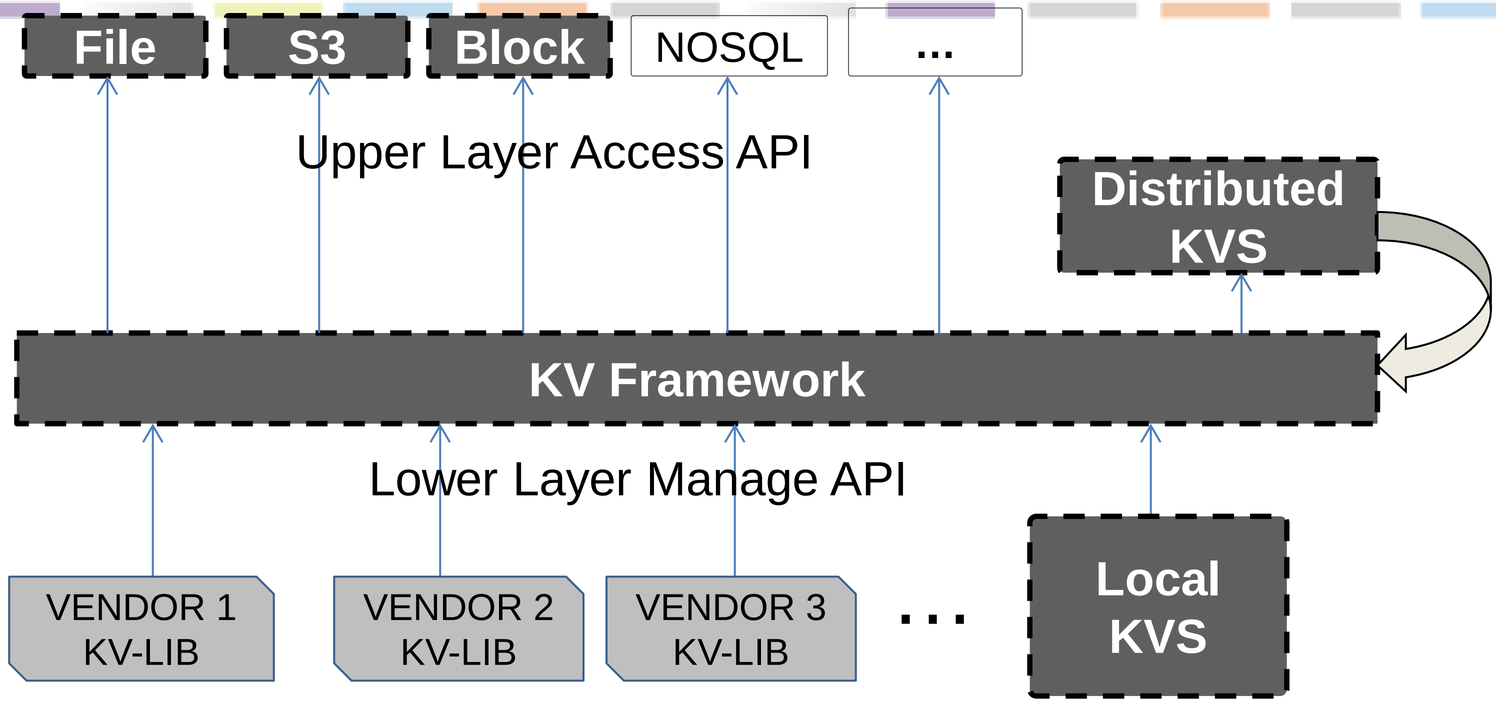
The KVF architecture



- KVF is a interface framework (like VFS), KVS is the actual store (like FS).
- Low level management interface: Let vendor device register in.
- Up level access interface: Let upper services to access the KVS, they can based on local KVS or Distributed KVS.
- Distributed KVS can base on local KVS and register into KVF again, like many distributed file system do.

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The key value framework

- What & why
  - Storage vendors offload the simple KV operation (put/ get/ delete/ iterator) to the storage medium. Which make the higher level simple, high performance, low TCO.
  - All KV store have similar interface, but there is no unified standard.

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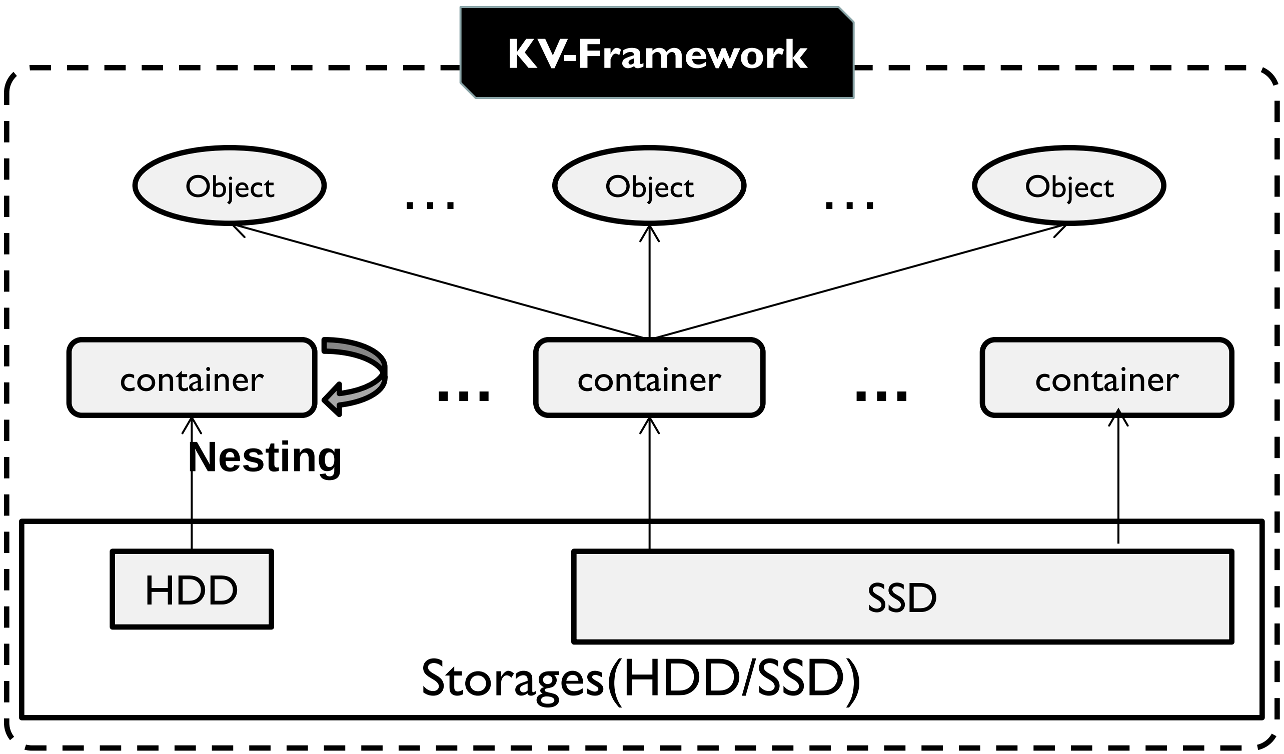
KVF data model



- KVS can provide different kind of containers (some vendor called pools), based on storage medium.
- On top of container, we can provide object, which can access by KV interface
- Container can nest to provide distributed container.

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A kind of KVF interface

```
s32 kvf_register(kvf_type_t * t);
s32 kvf_unregister(kvf_type_t * t);
kvf_type_t* get_kvf(const char* name);
```

Register interface

```
typedef struct kvf_operations {
s32 (*init)(const char* config_file);
s32 (*shutdown)();
s32 (*set_prop)(const char* name, char* value);
s32 (*get_prop)(const char* name, char* value);
void* (*alloc_buf)(u32 size, s32 flag);
void (*free_buf)(void** buf);
const char* (*get_errstr)(s32 errcode);
s32 (*get_stats)(kvf_stats_t * kvfstats);
s32 (*trans_start)(kv_trans_id_t** t_id);
s32 (*trans_commit)(kv_trans_id_t* t_id);
s32 (*trans_abort)(kv_trans_id_t* t_id);
} kvf_operations_t;
```

Vendor capability interface

```
typedef struct pool_operations {
s32 (*create)(const char* name, const char* config_file, pool_id_t* pid);
s32 (*destroy)(const char* name);
s32 (*open)(const char* name, u32 mod, pool_id_t* pid);
s32 (*close)(const pool_id_t pid);
s32 (*set_prop)(const pool_id_t pid, u64 prop, const char buf[MAX_PROP_LEN]);
s32 (*get_prop)(const pool_id_t pid, u64 prop, char buf[MAX_PROP_LEN]);
s32 (*get_stats)(const pool_id_t pid, pool_stats_t* stats);
s32 (*xcopy)(const pool_id_t src, const pool_id_t dest, s32 flags, void* regex, s32 regex_len);
s32 (*list)(pool_id_t** pid, s32* num);
} pool_operations_t;
```

Container interface

KVF interface

```
typedef struct kv_operations {
        s32 (*put)(const pool_id_t pid, const key_t* key, const value_t* value,
                const kv_props_t* props, const put_options_t* putopts);
        s32 (*get)(const pool_id_t pid, const key_t* key, value_t* value, const kv_props_t* props,
                const get_options_t* getopts);
        s32 (*del)(const pool_id_t pid, const key_t* key, const kv_props_t* props,
        s32 (*mput)(pool_id_t pid, const kv_array_t* kvarray, const kv_props_t* props,
                const put_options_t* putopts);
        s32 (*mget)(pool_id_t pid, kv_array_t* kvarray, const kv_props_t* props,
                const get_options_t* getopts);
        s32 (*mdel)(pool_id_t pid, const kv_array_t* kvarray, const kv_props_t* props,
                const del_options_t* delopts);
        s32 (*async_put)(pool_id_t pid, const key_t* key, const value_t* value,
                const kv_props_t* props, const put_options_t* putopts, async_crud_cb put_fn);
           s32 (*async_get)(pool_id_t pid, const key_t* key, value_t* value,
                const kv_props_t* props, const get_options_t* getopts, async_crud_cb  get_fn);
        s32 (*async_del)(pool_id_t pid, const key_t* key,
                const kv_props_t* props, const del_options_t* delopts, async_crud_cb
del_fn);
        s32 (*iter_open)(const pool_id_t pid, s32 flags, void* regex, s32 regex_len, s32 limit,
iter_id_t* itid);
        s32 (*iter_next)(const pool_id_t pid, iter_id_t itid, kv_array_t* kvarray);
        s32 (*iter_close)(const pool_id_t pid, iter_id_t itid);
} kv_operations_t;
```

Object access KV interface

https://github.com/huaweistorage/ananas

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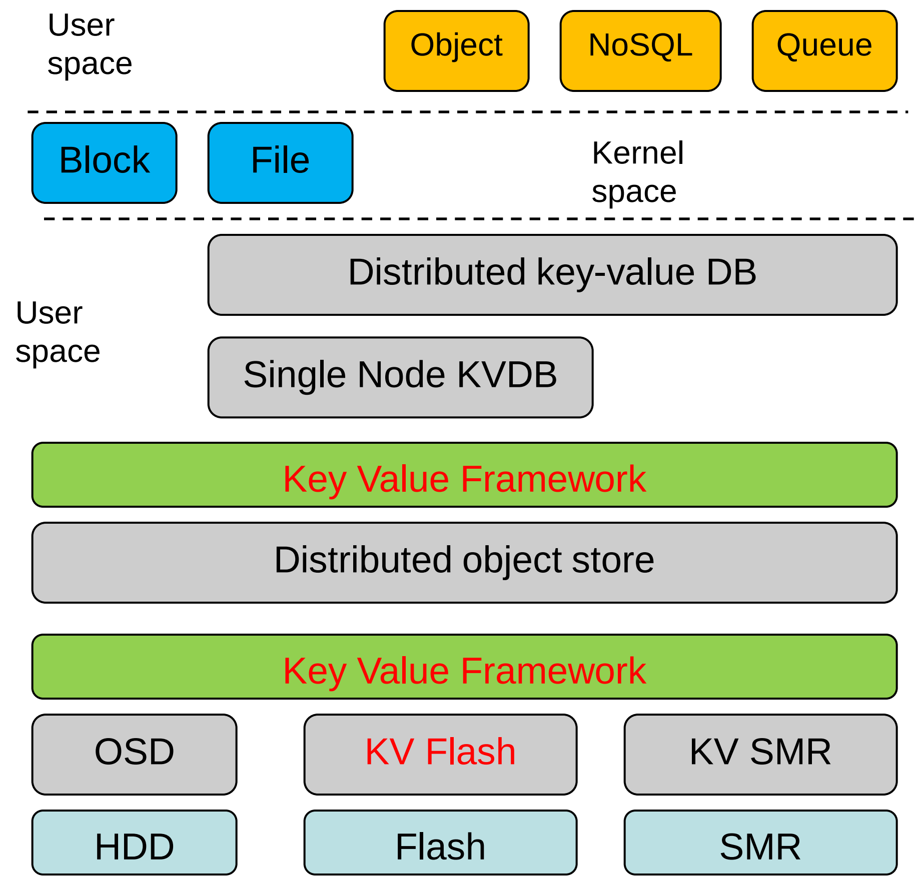
Problem 2

- **Distributed layer performance**
  - Kernel space block & file protocol
    - Not easy to transplant
    - Not easy to develop
    - Performance problem
  - Network package cross the OS many times, degrade performance



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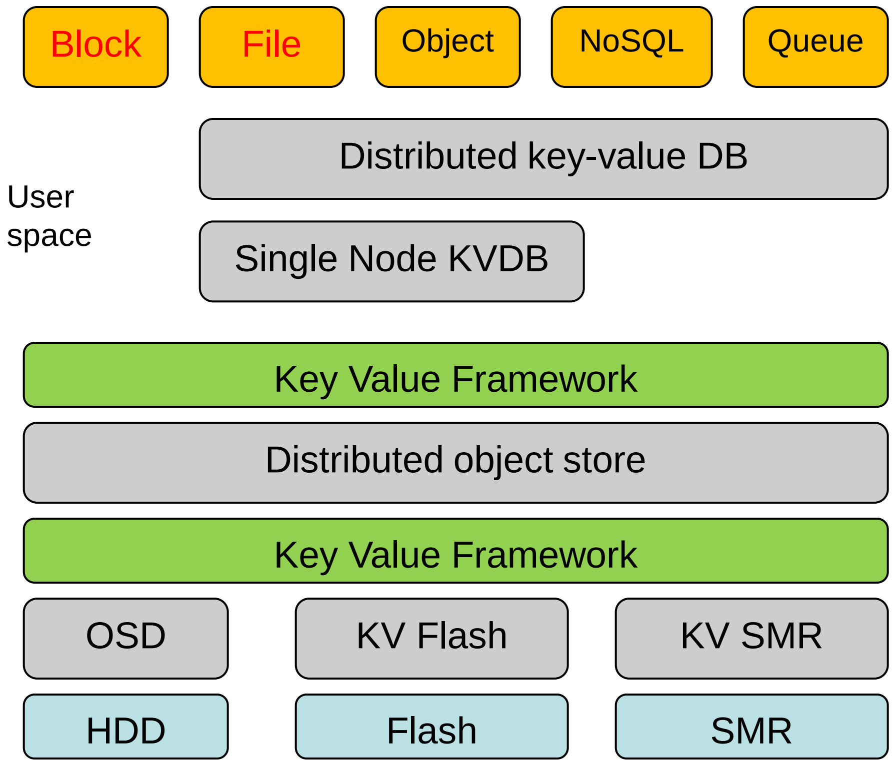
Solve the problem

- User-space protocol
  - User-space iscsi，Linux tgt
  - User-space NFS，Ganesha
- User-space network stack
  - Intel DPDK
  - FreeBSD Netmap
  - InfiniBand, user-space RDMA
  - …
- End-to-end user-space I/O stack



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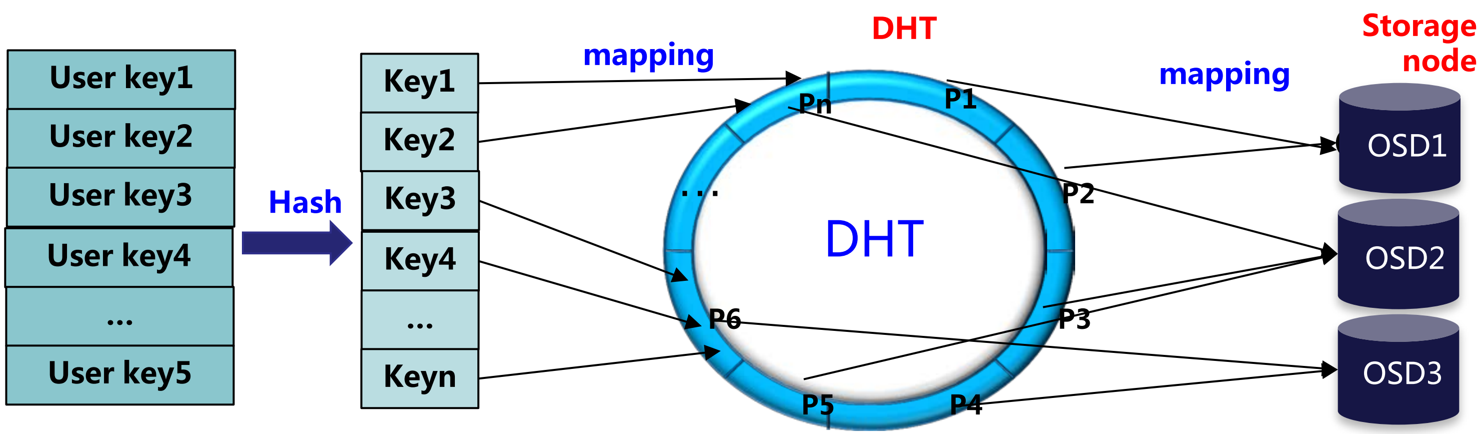
Distributed object store

- Distributed Hash Table: Sheepdog, Swift, etc
  - Less metadata, easy to scale-out,
  - Loss data locality
  - Difficult to provide performance isolation
  - Not easy to support policy



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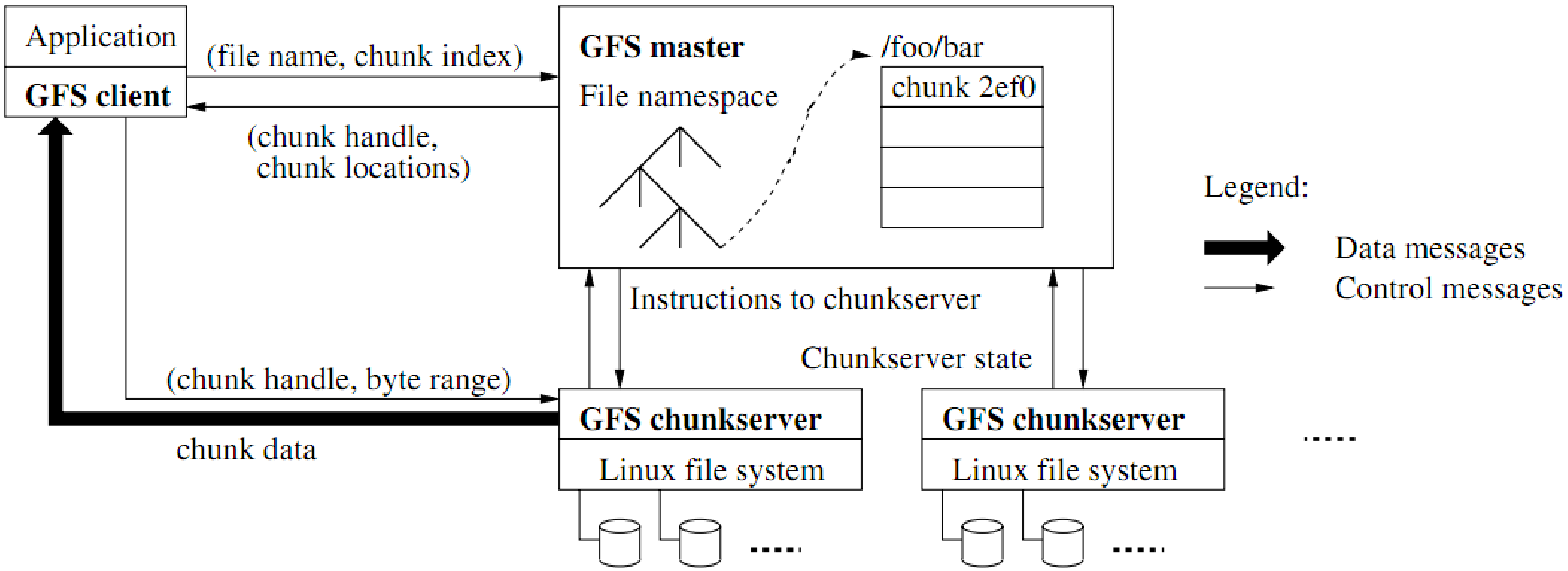
Distributed object store

- Master record object location: GFS, Azure Stream Layer, etc
  - Metadata bottle-neck
  - Easy to support policy
  - Keep data locality



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Distributed key value DB

- DHT: Dynamo, Cassandra, etc
  - Easy to scale out
  - Loss key-value locality
  - Easy aggregate performance
- Range Partition: Bigtable, Azure partition layer, etc.
  - Easy to scale out
  - Keep locality
  - Easy to isolate performance

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Other concerns

- Lock service
  - Zookeeper
  - Chubby
- Transaction support
  - Local transaction
  - Distributed transaction
- Cross datacenter in one region
  - Sync replication
- Cross region
  - Asynchronous Geo-replication

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The SNIA Education Committee thanks the following Individuals for their contributions to this Tutorial.

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