KV Userspace Driver
(OpenMPDK-uNVMe)

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Today's topic

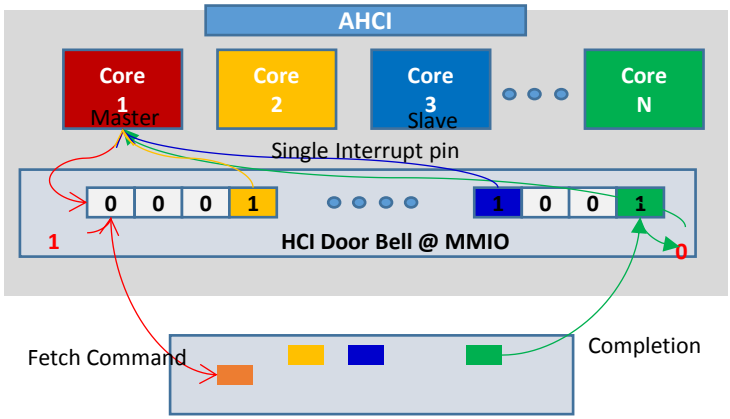
KeyValue NVMe?

Userspace Driver?

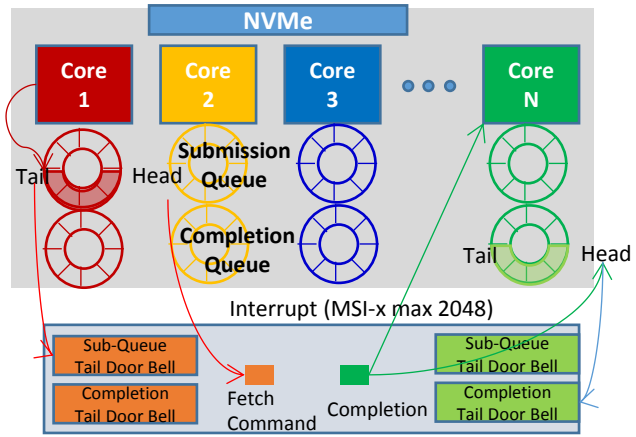
NVMe – High performance storage bus interface

- Scalable storage bus interface over PCI-e controller, emerged in the era of multi core and higher performance SSD

- **SATA(ACHI): Master/Slave architecture**
  - ✓ IO Submission : performance limitation when slave core issue commands
  - ✓ IO Completion : performance limitation due to Broadcasting interrupt from master to slave core



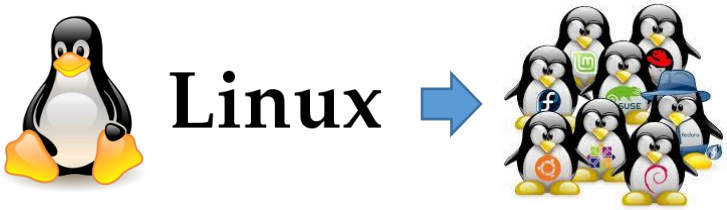
- **NVMe: Parallelism**
  - ✓ Per CPU Queuing : minimum lock contention / maximum cache hit ratio
  - ✓ Paired Queuing : IO Submission and Completion Q is separated
  - ✓ Interrupt balancing with MSI-X : maximum 2048 interrupts can be balanced on all cores



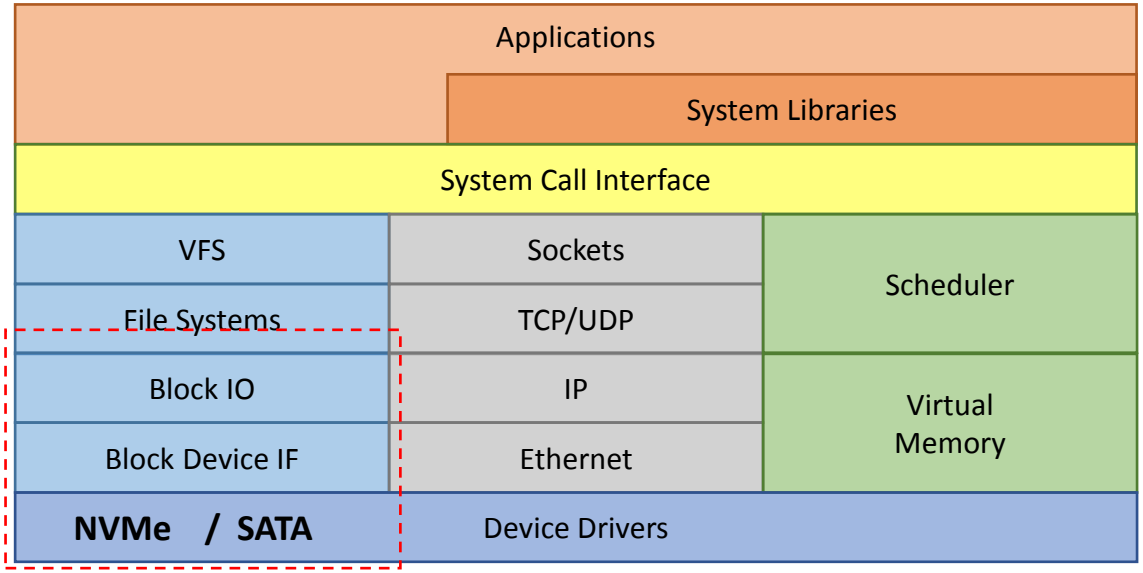
	UFS (AHCI)	SATA (AHCI)	NVMe
Queue : CPU mapping	1:N	1:N	1:1 (per cpu)
Maximum Queue Count	1	1	64K
Maximum Queue Depth	32	32	Max 64K (host/ssd negotiation)
Maximum Interrupt handler	1	1	2048(MSI-X)

Kernel and Userspace Driver

- POSIX OS consists of kernel sub components such as VM, scheduler, network, file system, and block layer
- Kernel device driver for NVMe storage located beneath block layer



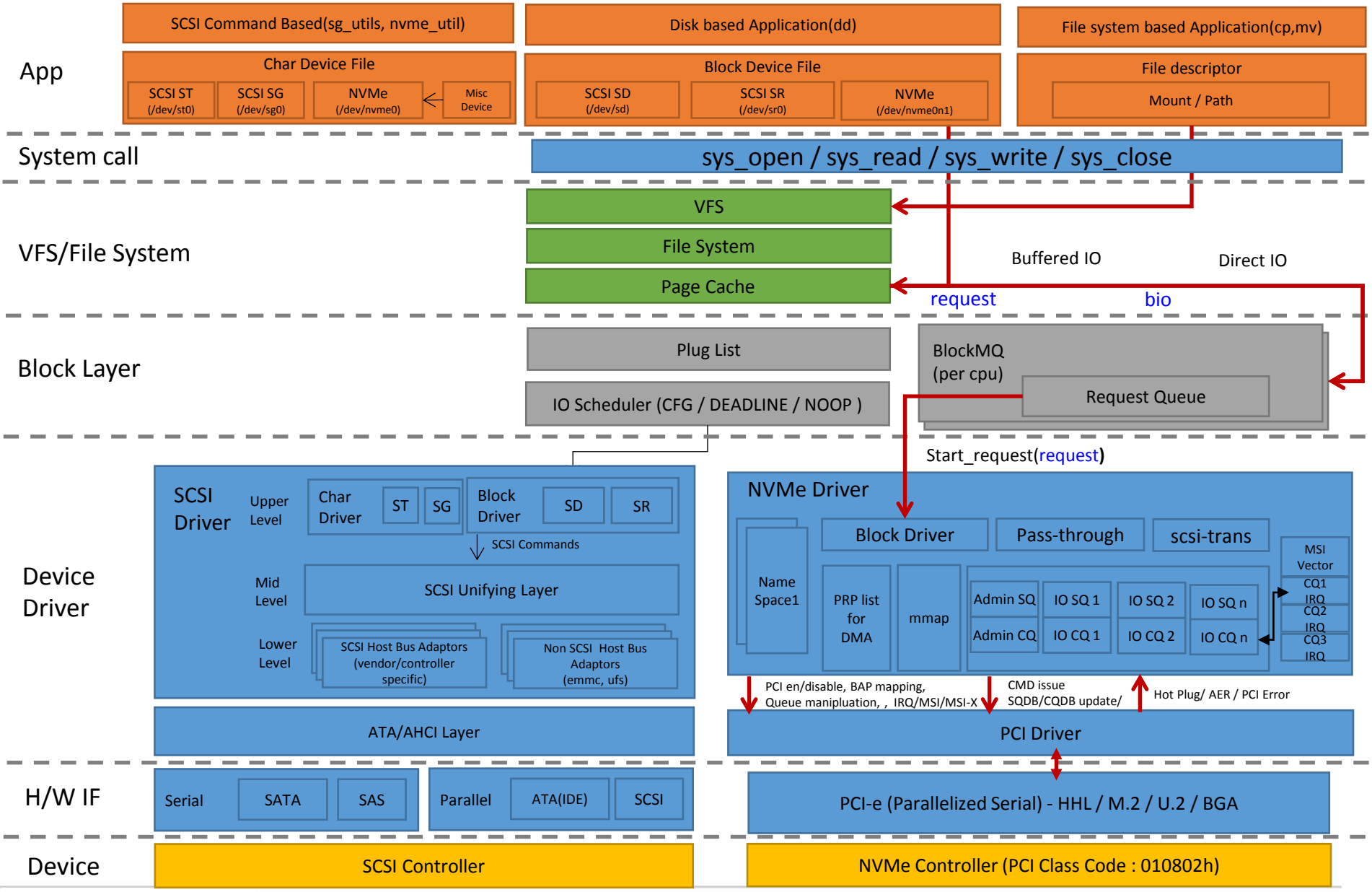
various distros…
redhat, ubuntu, debian, centos, fedora, suse, and so on



NVMe SSD

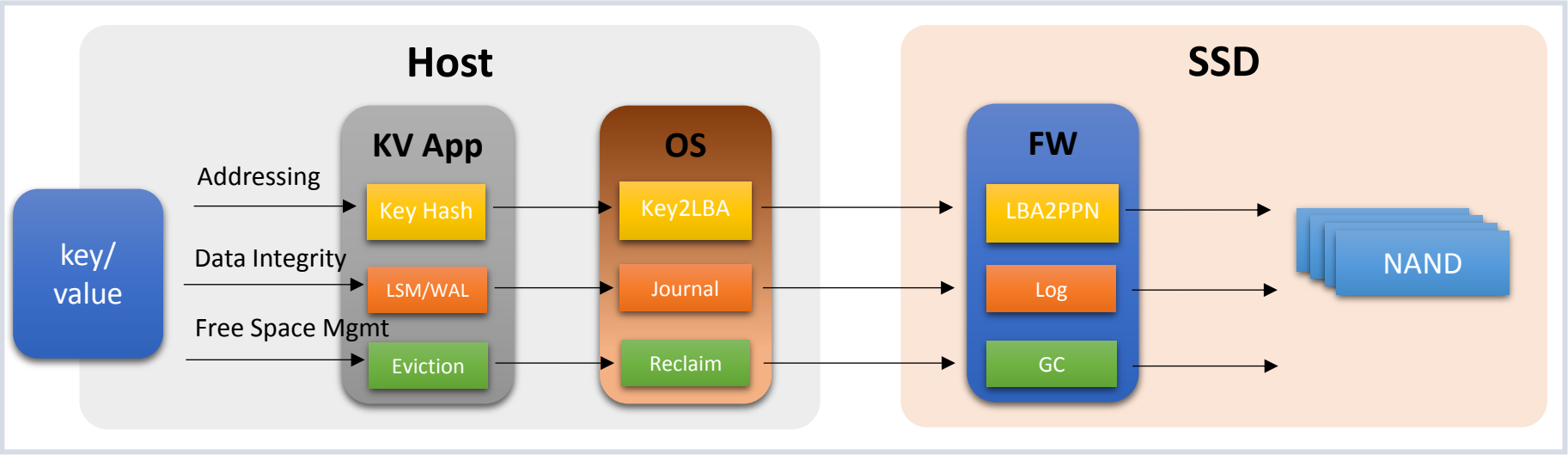
SATA SSD

Kernel Driver - NVMe IO Path



KV User Driver Background - KV SSD Premise

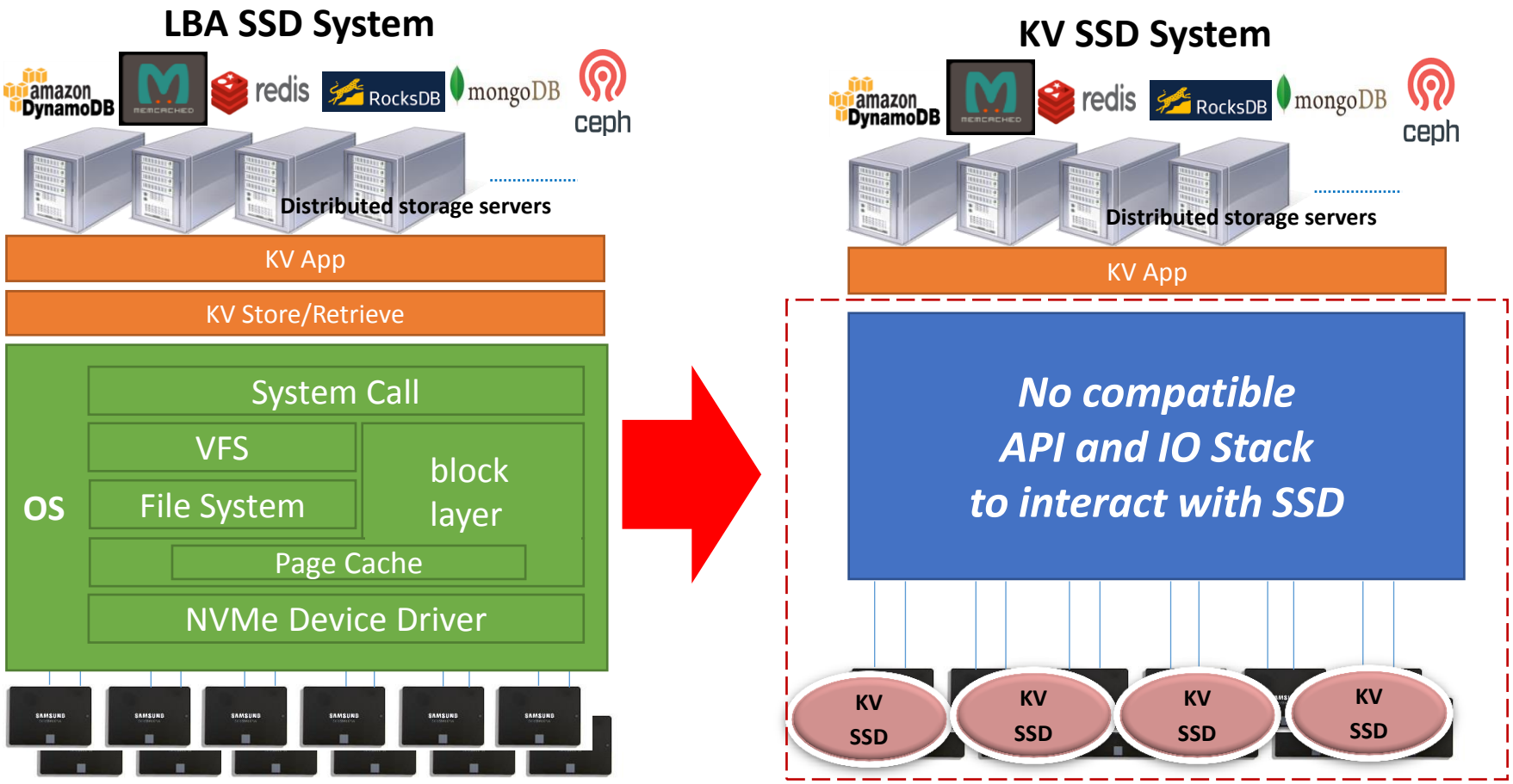
- KV SSD benefits are originated from eliminating functional **redundency** ranging from host application to SSD internal
  - **Addressing , Data Integrity, and Free Space Management**
- Especially, data integrity redundency causes increased WAF/RAF, which makes SSD longevity worse and app IO latency longer, consuming more host cpu/memory resources



- KV SSD introduces new NVMe commands such as iterate and interfacing protocol to deal with dynamic size key/value pair via host driver

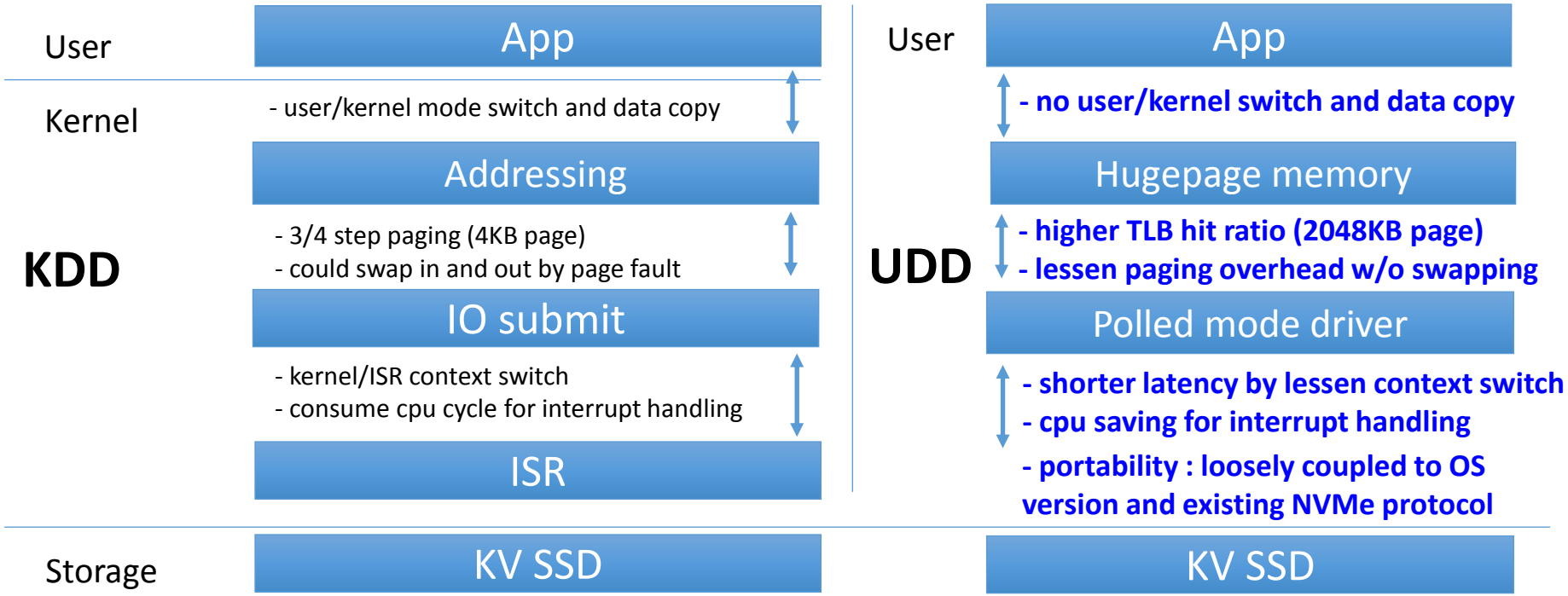
KV User Driver Background - KV SSD System

- Accordingly, KV SSD system is designed to bypass typical operating system storage stack as many as possible. Also, the modified storage protocol requires changes in device driver



KV Userspace Driver: OpenMPDK-uNVMe

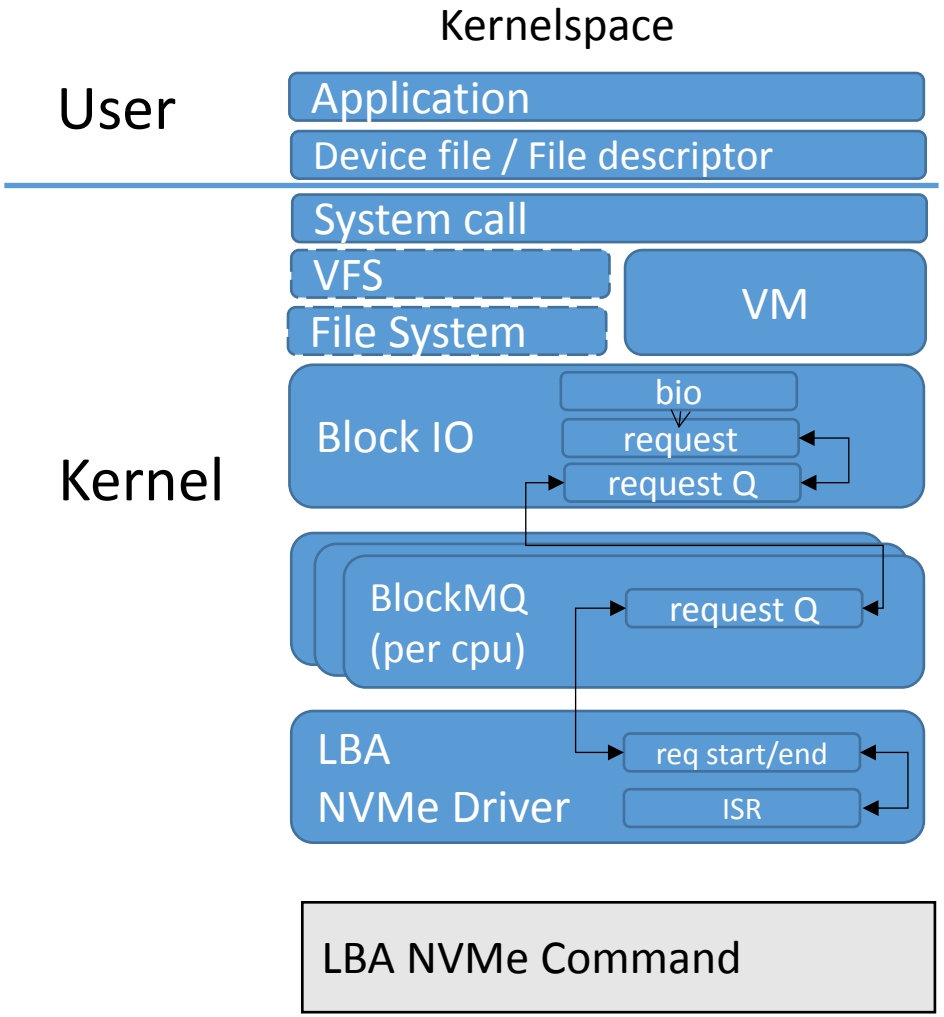
- **Why Userspace driver?** UDD can provides an optimized IO stack with smaller OS overhead and dependency

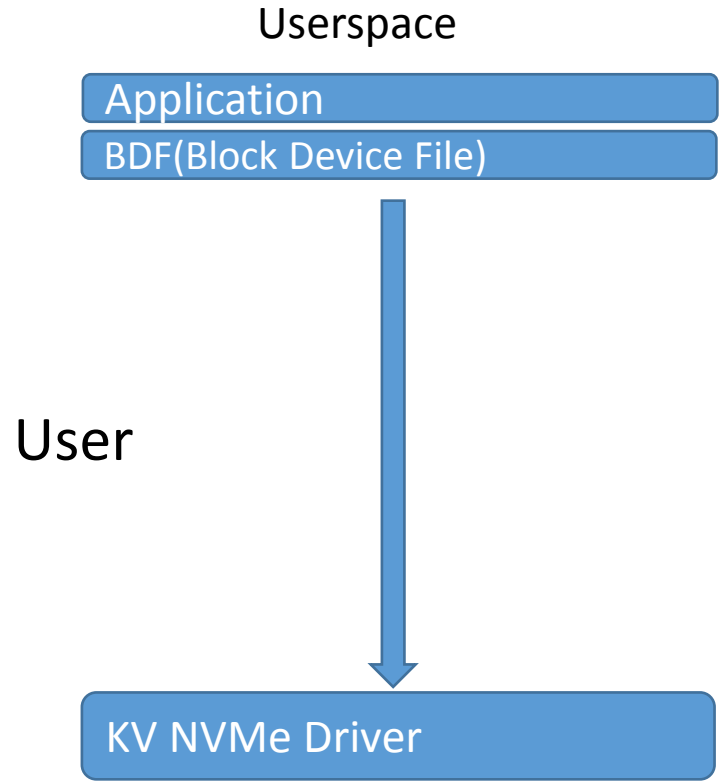


➔ For the reasons, uNVMe has been implementing as extension of *Intel SPDK.* uNVMe further provides means to optimize host cpu/dram usage and cope with diverse IO characteristics

- Apparently, KDD is worthwhile in that it covers various IO pattern out of real world application over commercial systems and a fundamental approach to widespread KV SSD echo system. Thus, Samsung provides both KDD and UDD

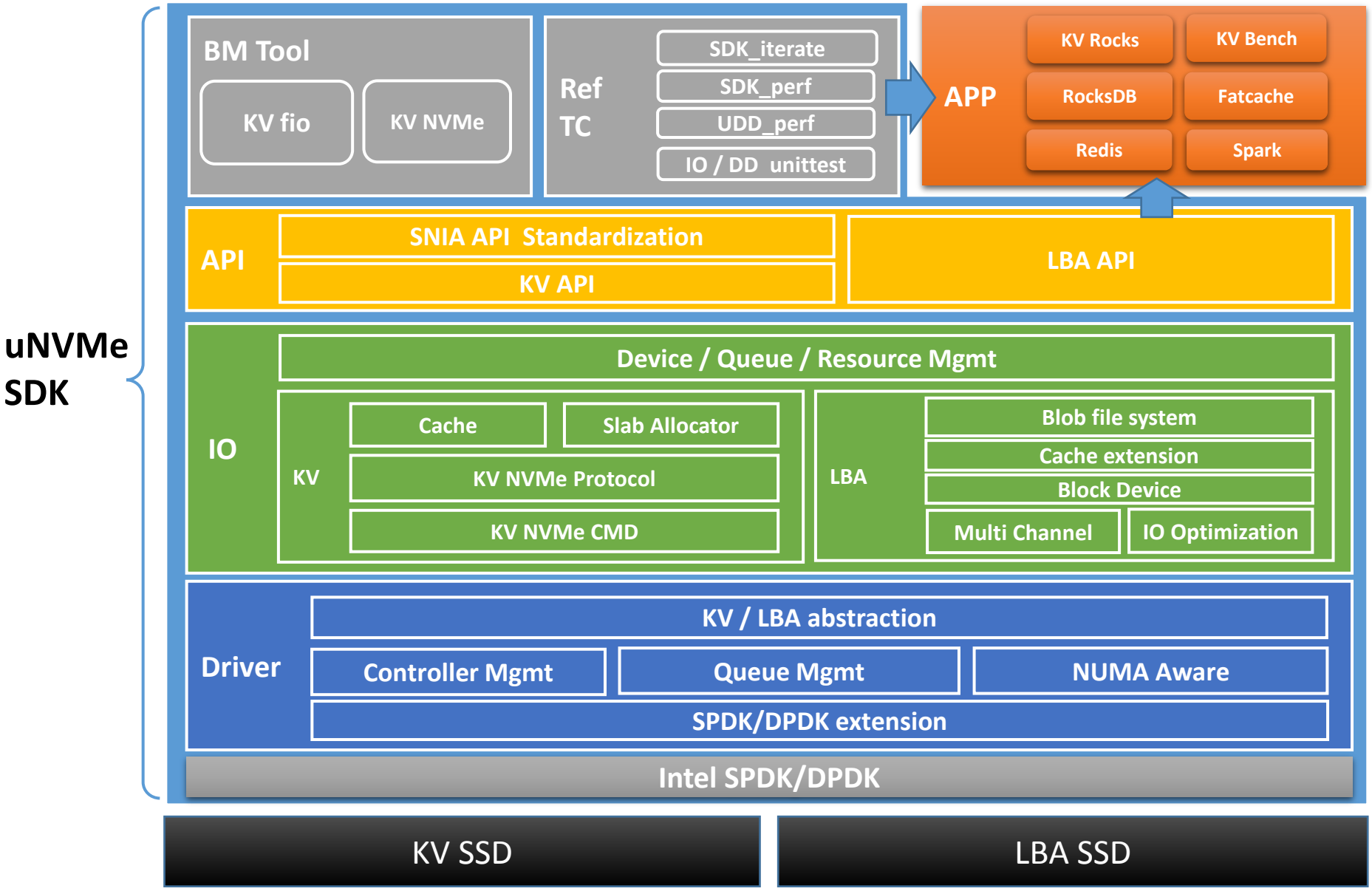
Kernel / Userspace IO Flow





KV NVMe Command			
Key size	Value size	Key space	Command
4~255B	0~2048KB	Multiple Keyspace	Store (Put)
			Retrieve (Get)
			Delete
			Iterate Request
			Iterate Read
			Exist
			Utilization / WAF / Iterate-info / etc

uNVMe SDK – Oct 2018



Programming Syntax Change(1)

IO on LBA SSD

Application

fd = open(“path,,)

KV to Buffer

write/read(fd, buffer)

Buffer to KV

close(fd)

IO on KV SSD

Application

write/read(KV)

Programming Syntax Change(2)

- **uNVMe primary API and data structures below**
- **Please be aware that SNIA API standardized is also provided**

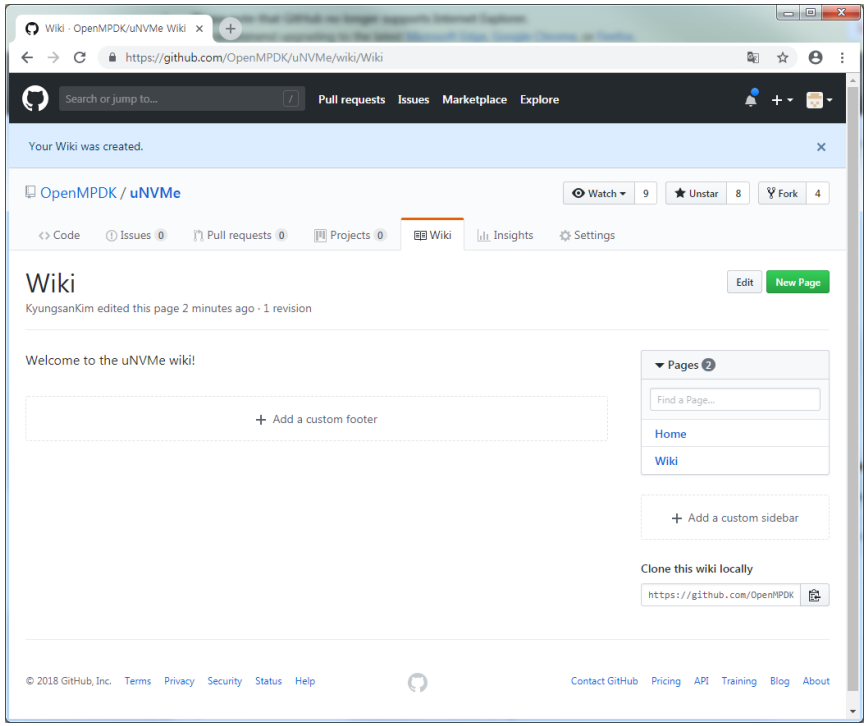
```
/** SDK init / finalize **/
int kv_sdk_init(int init_from, void *option);
int kv_sdk_load_option(kv_sdk *sdk_opt, char* log_path);
int kv_sdk_finalize(void);
void kv_sdk_info(void);


/** KV SSD IO **/
int kv_store(uint64_t handle, kv_pair *kv);
int kv_store_async(uint64_t handle, kv_pair *kv);
int kv_retrieve(uint64_t handle, kv_pair *kv);
int kv_retrieve_async(uint64_t handle, kv_pair*kv);
int kv_delete(uint64_t handle, kv_pair *kv);
int kv_delete_async(uint64_t handle, kv_pair *kv);
uint32_t kv_iterate_open(uint64_t handle, const uint8_t keyspace_id, const
uint32_t bitmask, const uint32_t prefix, const uint8_t iterate_type);
int kv_iterate_close(uint64_t handle, const uint8_t iterator);
int kv_iterate_read(uint64_t handle, kv_iterate* it);
int kv_iterate_read_async(uint64_t handle, kv_iterate* it);
int kv_iterate_info(uint64_t handle, kv_iterate_handle_info* info, int nr_handle);
int kv_exist(uint64_t handle, kv_pair* kv);
int kv_exist_async(uint64_t handle, kv_pair* kv);
int kv_format_device(uint64_t handle, int erase_user_data);


/** Utilities **/
uint64_t kv_get_total_size(uint64_t handle);
uint64_t kv_get_used_size(uint64_t handle);
uint64_t kv_get_waf(uint64_t handle);
uint32_t kv_get_sector_size(uint64_t handle);
int kv_get_log_page(uint64_t handle, uint8_t log_id, void* buffer, uint32_t
buffer_size);
```

```
/**  * @brief A pair of structures of key, value, and kv_param. */
typedef struct {
    uint8_t keyspace_id;
    kv_key key;
    kv_value value;
    kv_param param;
} kv_pair;

typedef struct {
    void *key;              /**< a pointer to a key */
    uint16_t length;        /**< key length in byte unit */
} kv_key;

/**  * @brief A value consists of a buffer pointer and its length  */
typedef struct {
    void *value;        /**< buffer address for value */
    uint32_t length;    /**< value buffer size in byte unit for input and the retuned value
length for output*/
    uint32_t actual_value_size;     /* full value size that is stored in disk (only applied on KV
SSD, not on LBA SSD) */
    uint32_t offset;        /**< offset for value */
} kv_value;

/** * @brief A structure which contains I/O option, and callback function(for async I/O)  */
typedef struct {
    void (*async_cb)();         /**< async notification callback (valid only for async I/O) */
    void* private_data;         /**< private data address used in callback (valid only for async
I/O) */
    union {
        int store_option;
        int retrieve_option;
        int delete_option;
        int iterate_request_option;
        int iterate_read_option;
        int exist_option;
    }io_option;             /**< options for operations */
} kv_param;
```

Extra materials

Guide Document

- uNVMe/doc/uNVMe2.0_SDK_Programmung_Guide_v1.1.pdf
- uNVMe/doc/uNVMe2.0_SDK_Evaluation_Guide_v1.1.pdf



https://github.com/OpenMPDK/uNVMe

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KVSSD

KV SSD host software package

C 4 5 Updated 10 days ago

uNVMe

C++ 8 4 Updated on 6 Jul

HPBDriver

HPB (Host-aware Performance Booster)

2 Updated on 5 Jul

Top languages

C++ C

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