# 实验三、bdev原理和源码分析

## 实验目的

- 学习bdeb原理和基本接口操作

## 实验内容

- 配置bdev运行环境
- 运行hello_bdev程序并分析源码
- 通过bdev接口写入数据并读取

## 实验过程和步骤

### 运行hello_bdev示例

#### 启动虚拟机

```
./start.sh ssd
```

#### 初始化环境

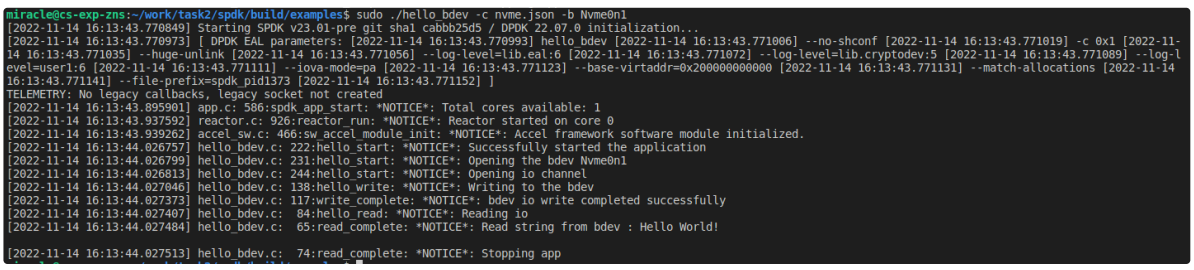
```
sudo scripts/setup.sh
```

#### 生成配置文件

```
./scripts/gen_nvme.sh --json-with-subsystems > ./build/examples/nvme.json
```

#### 运行hello_bdev

```
cd build/examples/
sudo ./hello_bdev -c nvme.json -b Nvme0n1
```

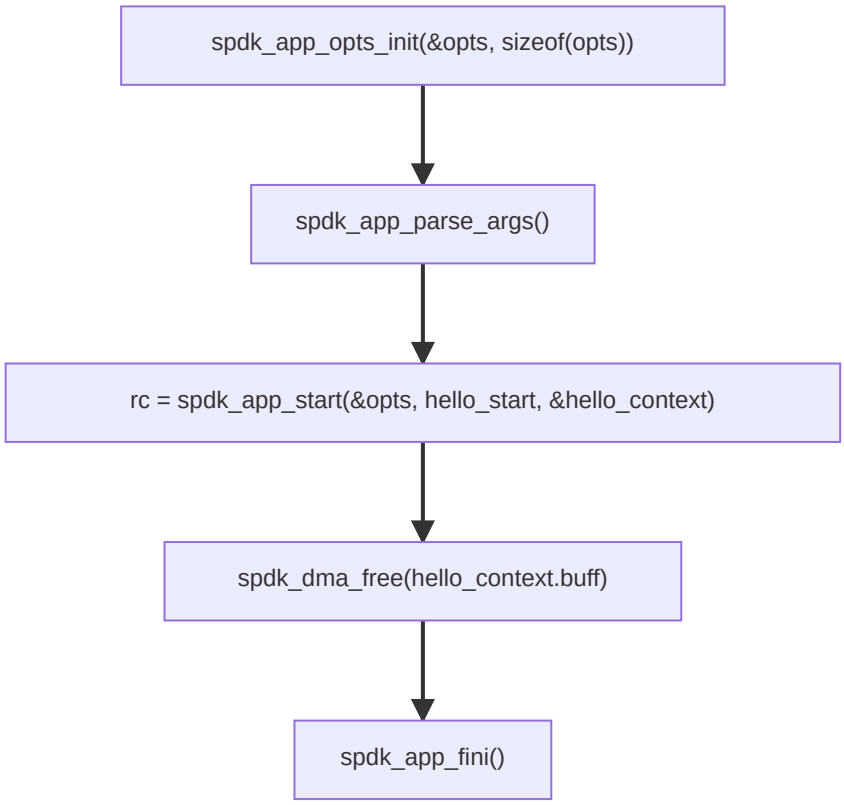


## 分析hello_bdev.c源码

### `main()` 主函数

```
int main(int argc, char **argv)
{
    struct spdk_app_opts opts = {};
    int rc = 0;
    struct hello_context_t hello_context = {};

    /* Set default values in opts structure. */
    spdk_app_opts_init(&opts, sizeof(opts));
    opts.name = "hello_bdev";

    /*
     * Parse built-in SPDK command line parameters as well
     * as our custom one(s).
     */
    if ((rc = spdk_app_parse_args(argc, argv, &opts, "b:", NULL,
hello_bdev_parse_arg,
                      hello_bdev_usage)) != SPDK_APP_PARSE_ARGS_SUCCESS) {
        exit(rc);
    }
    hello_context.bdev_name = g_bdev_name;

    /*
     * spdk_app_start() will initialize the SPDK framework, call
hello_start(),
     * and then block until spdk_app_stop() is called (or if an
initialization
     * error occurs, spdk_app_start() will return with rc even without
calling
     * hello_start().
     */
    rc = spdk_app_start(&opts, hello_start, &hello_context);
    if (rc) {
        SPDK_ERRLOG("ERROR starting application\n");
    }

    /* At this point either spdk_app_stop() was called, or spdk_app_start()
     * failed because of internal error.
     */

    /* When the app stops, free up memory that we allocated. */
    spdk_dma_free(hello_context.buff);

    /* Gracefully close out all of the SPDK subsystems. */
    spdk_app_fini();
    return rc;
}
```

主要流程为




其中：

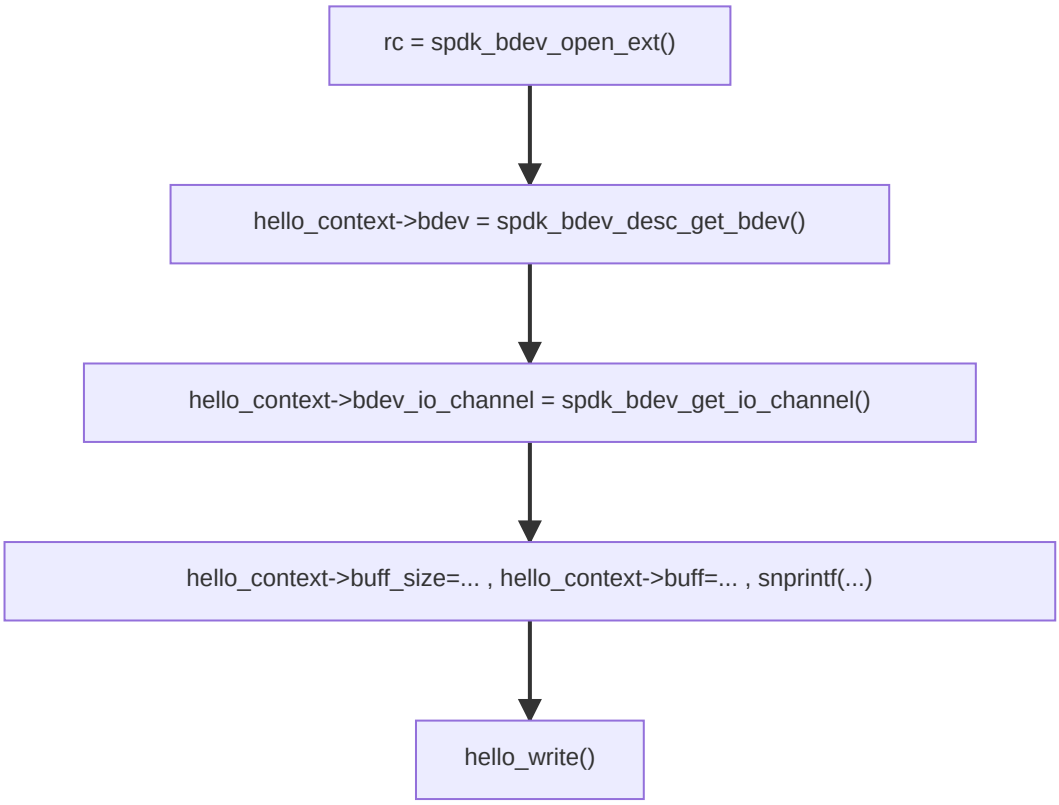
- `spdk_app_opts_init()` 初始化opts参数
- `spdk_app_parse_args()` 载入spdk默认参数和用户自定义参数（如：`-c nvme.json` 等）
- `rc = spdk_app_start(&opts, hello_start, &hello_context)` 载入SPDK框架，调用 `hello_start` 函数，并在调用 `spdk_app_stop()` 后返回状态值
- `spdk_dma_free()` 释放分配的空间
- `spdk_app_fini()` 关闭所有SPDK子系统

### `hello_start()` 主任务函数

```
static void hello_start(void *arg1)
{
    struct hello_context_t *hello_context = arg1;
    uint32_t buf_align;
    int rc = 0;
    hello_context->bdev = NULL;
    hello_context->bdev_desc = NULL;

    SPDK_NOTICELOG("Successfully started the application\n");

    /*
     * There can be many bdevs configured, but this application will only use
     * the one input by the user at runtime.
     *
     * Open the bdev by calling spdk_bdev_open_ext() with its name.
     * The function will return a descriptor
     */
    SPDK_NOTICELOG("Opening the bdev %s\n", hello_context->bdev_name);
    rc = spdk_bdev_open_ext(hello_context->bdev_name, true,
hello_bdev_event_cb, NULL,
```

```
                &hello_context->bdev_desc);
    if (rc) {
        SPDK_ERRLOG("Could not open bdev: %s\n", hello_context->bdev_name);
        spdk_app_stop(-1);
        return;
    }

    /* A bdev pointer is valid while the bdev is opened. */
    hello_context->bdev = spdk_bdev_desc_get_bdev(hello_context->bdev_desc);


    SPDK_NOTICELOG("Opening io channel\n");
    /* Open I/O channel */
    hello_context->bdev_io_channel = spdk_bdev_get_io_channel(hello_context-
>bdev_desc);
    if (hello_context->bdev_io_channel == NULL) {
        SPDK_ERRLOG("Could not create bdev I/O channel!!\n");
        spdk_bdev_close(hello_context->bdev_desc);
        spdk_app_stop(-1);
        return;
    }

    /* Allocate memory for the write buffer.
     * Initialize the write buffer with the string "Hello World!"
     */
    hello_context->buff_size = spdk_bdev_get_block_size(hello_context->bdev)
*
                   spdk_bdev_get_write_unit_size(hello_context->bdev);
    buf_align = spdk_bdev_get_buf_align(hello_context->bdev);
    hello_context->buff = spdk_dma_zmalloc(hello_context->buff_size,
buf_align, NULL);
    if (!hello_context->buff) {
        SPDK_ERRLOG("Failed to allocate buffer\n");
        spdk_put_io_channel(hello_context->bdev_io_channel);
        spdk_bdev_close(hello_context->bdev_desc);
        spdk_app_stop(-1);
        return;
    }
    snprintf(hello_context->buff, hello_context->buff_size, "%s", "Hello
World!\n");

    if (spdk_bdev_is_zoned(hello_context->bdev)) {
        hello_reset_zone(hello_context);
        /* If bdev is zoned, the callback, reset_zone_complete, will call
hello_write() */
        return;
    }

    hello_write(hello_context);
}
```

主要流程为




其中：

- `spdk_bdev_open_ext()` 通过设备名（如运行程序是附加的参数 `-b Nvme0n1` ）打开bdev，返回一个descriptor
- `spdk_bdev_desc_get_bdev()` 通过descriptor获取bdev指针
- `spdk_bdev_get_io_channel()` 通过descriptor获取I/O通道
- `hello_context->buff_size=... , hello_context->buff=... , snprintf(...)` 为写入buffer分配空间并写入字符串
- `hello_write()` 调用写入函数

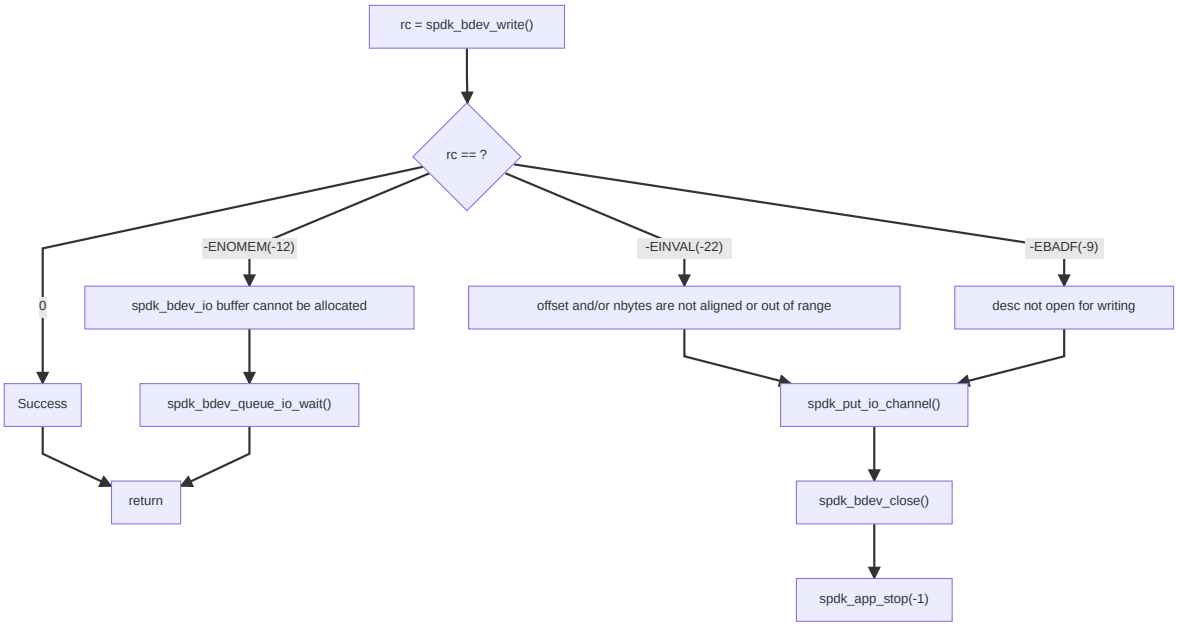
## `hello_write()` 写入函数

下面对写入函数进行分析

```
static void hello_write(void *arg)
{
    struct hello_context_t *hello_context = arg;
    int rc = 0;

    SPDK_NOTICELOG("Writing to the bdev\n");
    rc = spdk_bdev_write(hello_context->bdev_desc, hello_context-
>bdev_io_channel,
                hello_context->buff, 0, hello_context->buff_size,
write_complete,
                hello_context);

    if (rc == -ENOMEM) {
        SPDK_NOTICELOG("Queueing io\n");
        /* In case we cannot perform I/O now, queue I/O */
        hello_context->bdev_io_wait.bdev = hello_context->bdev;
        hello_context->bdev_io_wait.cb_fn = hello_write;
```

```
        hello_context->bdev_io_wait.cb_arg = hello_context;
        spdk_bdev_queue_io_wait(hello_context->bdev, hello_context-
>bdev_io_channel,
                    &hello_context->bdev_io_wait);
    } else if (rc) {
        SPDK_ERRLOG("%s error while writing to bdev: %d\n", spdk_strerror(-
rc), rc);
        spdk_put_io_channel(hello_context->bdev_io_channel);
        spdk_bdev_close(hello_context->bdev_desc);
        spdk_app_stop(-1);
    }
}
```

主要流程为



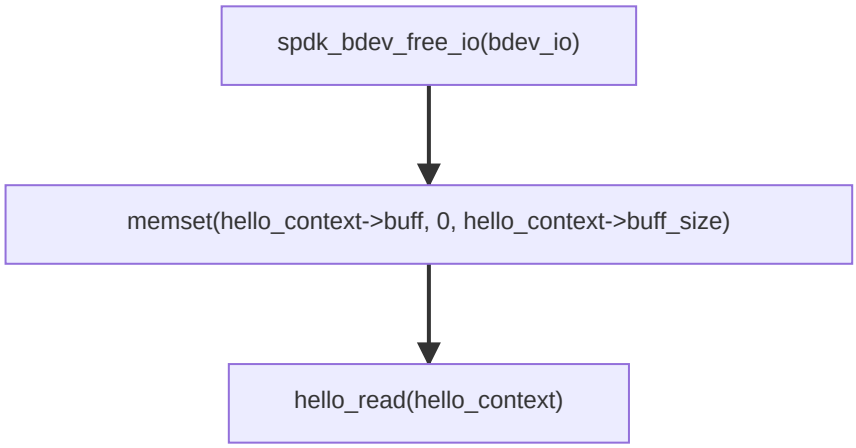

其中：

- `spdk_bdev_write()` 向bdev写入，并在完成后调用相应回调函数
- `spdk_bdev_queue_io_wait()` 加入I/O等待队列
- `spdk_put_io_channel()` 释放I/O通道，并在释放最后一个通道后调用销毁回调函数
- `spdk_bdev_close()` 关闭块设备（bdev，block device）

### `write_complete()` 写入回调函数

```
static void write_complete(struct spdk_bdev_io *bdev_io, bool success, void
*cb_arg)
{
    struct hello_context_t *hello_context = cb_arg;

    /* Complete the I/O */
    spdk_bdev_free_io(bdev_io);

    if (success) {
        SPDK_NOTICELOG("bdev io write completed successfully\n");
    } else {
        SPDK_ERRLOG("bdev io write error: %d\n", EIO);
        spdk_put_io_channel(hello_context->bdev_io_channel);
        spdk_bdev_close(hello_context->bdev_desc);
        spdk_app_stop(-1);
        return;
    }

    /* Zero the buffer so that we can use it for reading */
    memset(hello_context->buff, 0, hello_context->buff_size);

    hello_read(hello_context);
}
```

主要流程为




其中：

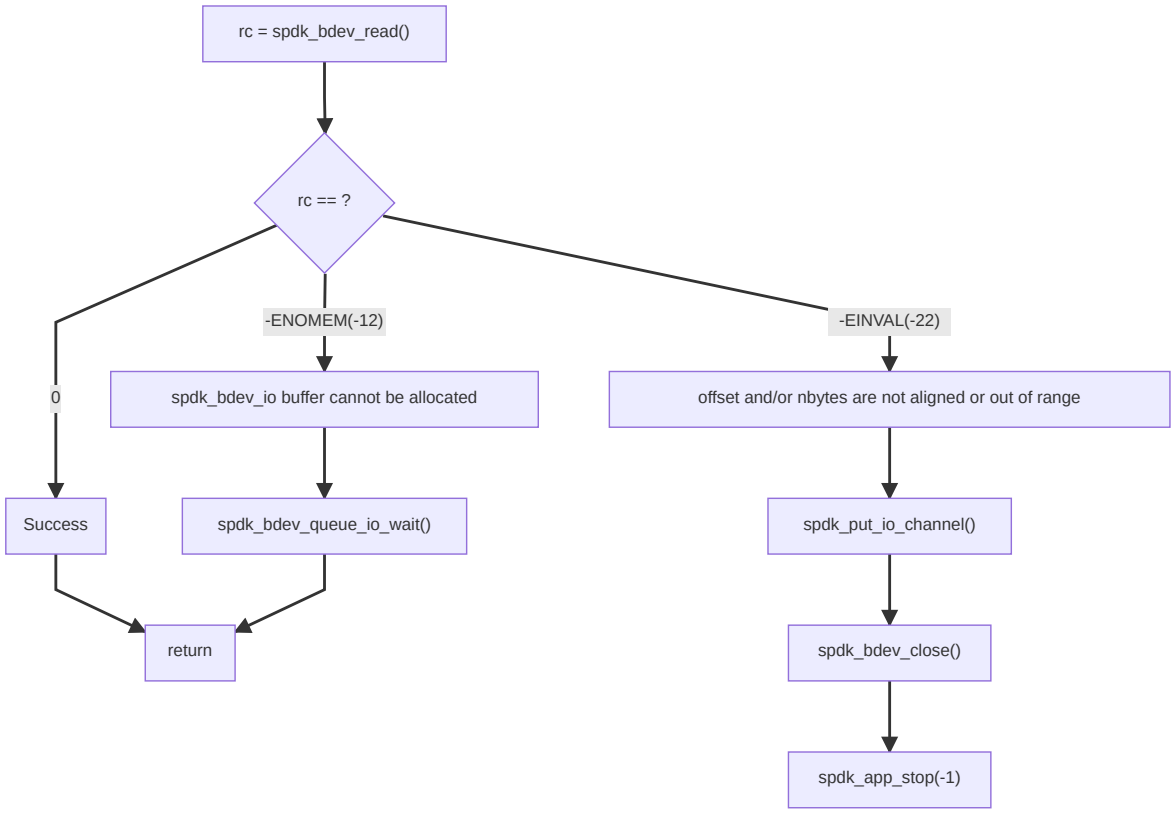
- `spdk_bdev_free_io()` Free an I/O request
- `memset(...)` 将buffer置为0,便于后续存储读取的数据
- `hello_read()` 调用读取函数

### `hello_read()` 读取函数

```
static void hello_read(void *arg)
{
    struct hello_context_t *hello_context = arg;
    int rc = 0;
```

```
    SPDK_NOTICELOG("Reading io\n");
    rc = spdk_bdev_read(hello_context->bdev_desc, hello_context-
>bdev_io_channel,
                hello_context->buff, 0, hello_context->buff_size,
read_complete,
                hello_context);

    if (rc == -ENOMEM) {
        SPDK_NOTICELOG("Queueing io\n");
        /* In case we cannot perform I/O now, queue I/O */
        hello_context->bdev_io_wait.bdev = hello_context->bdev;
        hello_context->bdev_io_wait.cb_fn = hello_read;
        hello_context->bdev_io_wait.cb_arg = hello_context;
        spdk_bdev_queue_io_wait(hello_context->bdev, hello_context-
>bdev_io_channel,
                    &hello_context->bdev_io_wait);
    } else if (rc) {
        SPDK_ERRLOG("%s error while reading from bdev: %d\n", spdk_strerror(-
rc), rc);
        spdk_put_io_channel(hello_context->bdev_io_channel);
        spdk_bdev_close(hello_context->bdev_desc);
        spdk_app_stop(-1);
    }
}
```

主要流程为




其中：

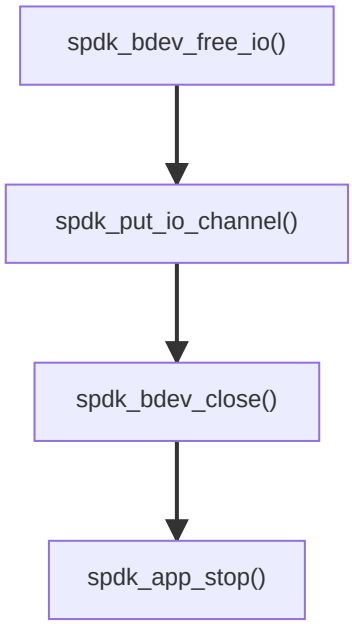
- `spdk_bdev_write()` 从bdev读取，并在完成后调用相应回调函数

### `read_complete()` 读取回调函数

```
static void read_complete(struct spdk_bdev_io *bdev_io, bool success, void
*cb_arg)
{
    struct hello_context_t *hello_context = cb_arg;

    if (success) {
        SPDK_NOTICELOG("Read string from bdev : %s\n", hello_context->buff);
    } else {
        SPDK_ERRLOG("bdev io read error\n");
    }

    /* Complete the bdev io and close the channel */
    spdk_bdev_free_io(bdev_io);
    spdk_put_io_channel(hello_context->bdev_io_channel);
    spdk_bdev_close(hello_context->bdev_desc);
    SPDK_NOTICELOG("Stopping app\n");
    spdk_app_stop(success ? 0 : -1);
```

```
}
```

主要流程为




## 修改hello_bdev.c，实现自定义字符串读写

生成256KB字符串数据，修改hello_bdev.c源码将字符串数据通过bdev写入，之后再读取，验证结果是否正确

`miracle_bdev.c`

```c
#include "spdk/stdinc.h"
#include "spdk/thread.h"
#include "spdk/bdev.h"
#include "spdk/env.h"
#include "spdk/event.h"
#include "spdk/log.h"
#include "spdk/string.h"
#include "spdk/bdev_zone.h"
#include <math.h>

static char *g_bdev_name = "Nvme0n1";

const int DATA_LENGTH = 256*1024;

struct my_context
{
    struct spdk_bdev *bdev;
    struct spdk_bdev_desc *bdev_desc;
    struct spdk_io_channel *bdev_io_channel;
    char *buff;
    uint32_t buff_size;
    char *bdev_name;
    struct spdk_bdev_io_wait_entry bdev_io_wait;
```

```
};

static char *generate_str(void)
{
    char *str = (char *)malloc(DATA_LENGTH * 8);
    memset(str, 0, DATA_LENGTH*8);
    if (str)
    {
        int i;
        for (i = 0; i < DATA_LENGTH; ++ i)
        {
            str[i] = '0'+(i%10);
        }
        return str;
    }
    else
    {
        return NULL;
    }
}

static void save_data(const char *file_path, char *str)
{
    FILE *fp = fopen(file_path, "w");
    fprintf(fp, "%s", str);
    fclose(fp);
}

static int miracle_bdev_parse_arg(int ch, char *arg)
{
    switch (ch)
    {
    case 'b':
        g_bdev_name = arg;
        break;
    default:
        return -EINVAL;
    }
    return 0;
}

static void miracle_bdev_usage(void)
{
    printf(" -b <bdev>                 name of the bdev to use\n");
}

static void bdev_event_cb(enum spdk_bdev_event_type type, struct spdk_bdev
*bdev, void *event_ctx)
{
    SPDK_NOTICELOG("Unsupported bdev event: type %d\n", type);
}

static void read_complete(struct spdk_bdev_io *bdev_io, bool success, void
*cb_arg)
```

```
{
    struct my_context *p = cb_arg;

    if (success)
    {
        SPDK_NOTICELOG("Reading Successfully, Saveing to data.out!!\n");
        save_data("./data.out", p->buff);
    }
    else
    {
        SPDK_ERRLOG("bdev io read error\n");
    }

    spdk_bdev_free_io(bdev_io);
    spdk_put_io_channel(p->bdev_io_channel);
    spdk_bdev_close(p->bdev_desc);
    SPDK_NOTICELOG("Stopping app\n");
    spdk_app_stop(success ? 0 : -1);
}

static void start_read(void *arg)
{
    struct my_context *p = arg;
    int rc = 0;

    SPDK_NOTICELOG("Reading io\n");
    rc = spdk_bdev_read(p->bdev_desc, p->bdev_io_channel, p->buff, 0, p-
>buff_size, read_complete, p);

    if (rc == -ENOMEM)
    {
        SPDK_NOTICELOG("Queueing io\n");
        p->bdev_io_wait.bdev = p->bdev;
        p->bdev_io_wait.cb_fn = start_read;
        p->bdev_io_wait.cb_arg = p;
        spdk_bdev_queue_io_wait(p->bdev, p->bdev_io_channel, &p-
>bdev_io_wait);
    }
    else if (rc)
    {
        SPDK_ERRLOG("%s error while reading from bdev: %d\n", spdk_strerror(-
rc), rc);
        spdk_put_io_channel(p->bdev_io_channel);
        spdk_bdev_close(p->bdev_desc);
        spdk_app_stop(-1);
    }
}

static void write_complete(struct spdk_bdev_io *bdev_io, bool success, void
*cb_arg)
{
    struct my_context *p = cb_arg;

    spdk_bdev_free_io(bdev_io);
```

```
    if (success)
    {
        SPDK_NOTICELOG("bdev io write completed successfully\n");
    }
    else
    {
        SPDK_ERRLOG("bdev io write error: %d\n", EIO);
        spdk_put_io_channel(p->bdev_io_channel);
        spdk_bdev_close(p->bdev_desc);
        spdk_app_stop(-1);
        return;
    }

    memset(p->buff, 0, p->buff_size);
    start_read(p);
}

static void start_write(void *arg)
{
    struct my_context *p = arg;
    int rc = 0;

    SPDK_NOTICELOG("Writing to the bdev\n");
    rc = spdk_bdev_write(p->bdev_desc, p->bdev_io_channel, p->buff, 0, p-
>buff_size, write_complete, p);

    if (rc == -ENOMEM)
    {
        SPDK_NOTICELOG("Queueing io\n");
        p->bdev_io_wait.bdev = p->bdev;
        p->bdev_io_wait.cb_fn = start_write;
        p->bdev_io_wait.cb_arg = p;
        spdk_bdev_queue_io_wait(p->bdev, p->bdev_io_channel, &p-
>bdev_io_wait);
    }
    else if (rc)
    {
        SPDK_ERRLOG("%s error while writing to bdev: %d\n", spdk_strerror(-
rc), rc);
        spdk_put_io_channel(p->bdev_io_channel);
        spdk_bdev_close(p->bdev_desc);
        spdk_app_stop(-1);
    }
}

static void miracle_bdev(void *arg)
{
    struct my_context *p = arg;
    uint32_t buf_align;
    uint32_t block_size;
    int rc = 0;
    p->bdev = NULL;
    p->bdev_desc = NULL;
```

```
    SPDK_NOTICELOG("Successfully started the application\n");

    SPDK_NOTICELOG("Opening the bdev %s\n", p->bdev_name);
    rc = spdk_bdev_open_ext(p->bdev_name, true, bdev_event_cb, NULL, &p-
>bdev_desc);
    if (rc)
    {
        SPDK_ERRLOG("Could not open bdev: %s\n", p->bdev_name);
        spdk_app_stop(-1);
        return;
    }

    p->bdev = spdk_bdev_desc_get_bdev(p->bdev_desc);

    SPDK_NOTICELOG("Opening io channel\n");
    p->bdev_io_channel = spdk_bdev_get_io_channel(p->bdev_desc);
    if (p->bdev_io_channel == NULL)
    {
        SPDK_ERRLOG("Could not create bdev I/O channel!!\n");
        spdk_bdev_close(p->bdev_desc);
        spdk_app_stop(-1);
        return;
    }

    block_size = spdk_bdev_get_block_size(p->bdev);
    buf_align = spdk_bdev_get_buf_align(p->bdev);

    p->buff_size = ceil((double)(DATA_LENGTH+1)/block_size)*block_size;
    p->buff = spdk_dma_zmalloc(p->buff_size, buf_align, NULL);
    if (!p->buff)
    {
        SPDK_ERRLOG("Failed to allocate buffer\n");
        spdk_put_io_channel(p->bdev_io_channel);
        spdk_bdev_close(p->bdev_desc);
        spdk_app_stop(-1);
        return;
    }

    SPDK_NOTICELOG("Generating Data\n");
    char *str = generate_str();
    if (str){
        snprintf(p->buff, p->buff_size, "%s", str);
        free(str);
        SPDK_NOTICELOG("Saving Data to ./data.txt\n");
        save_data("./data.in", p->buff);
        start_write(p);
    }
    else{
        SPDK_ERRLOG("Could not generate data!!\n");
        spdk_put_io_channel(p->bdev_io_channel);
        spdk_bdev_close(p->bdev_desc);
        spdk_app_stop(-1);
        return;
```

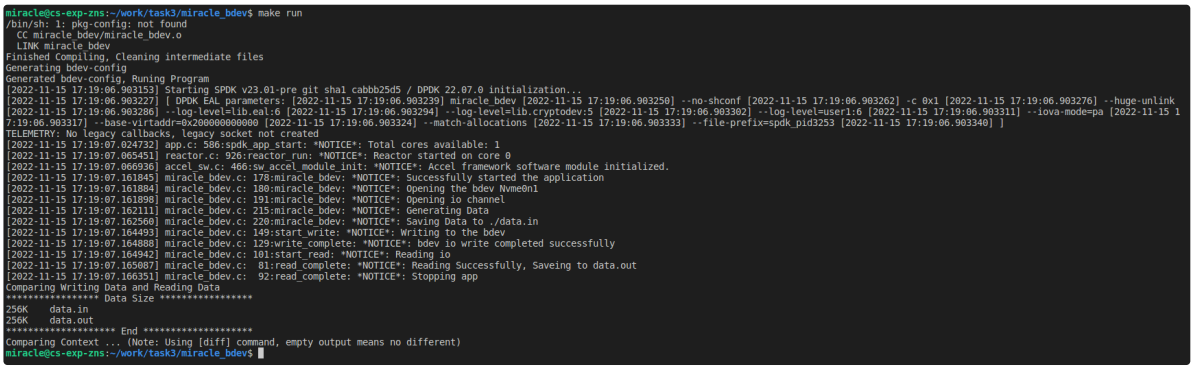
```
    }
}

int main(int argc, char **argv)
{
    struct spdk_app_opts opts = {};
    int rc = 0;
    struct my_context context = {};

    spdk_app_opts_init(&opts, sizeof(opts));
    opts.name = "miracle_bdev";
    rc = spdk_app_parse_args(argc, argv, &opts, "b:", NULL,
miracle_bdev_parse_arg, miracle_bdev_usage);
    if (rc != SPDK_APP_PARSE_ARGS_SUCCESS)
    {
        exit(rc);
    }
    context.bdev_name = g_bdev_name;

    rc = spdk_app_start(&opts, miracle_bdev, &context);
    if (rc)
    {
        SPDK_ERRLOG("ERROR starting applicatoin\n");
    }

    spdk_dma_free(context.buff);
    spdk_app_fini();

    return rc;
}
```

**Makefile**

```
SPDK_ROOT_DIR := /home/miracle/work/task2/spdk
include $(SPDK_ROOT_DIR)/mk/spdk.common.mk
include $(SPDK_ROOT_DIR)/mk/spdk.modules.mk

APP = miracle_bdev

C_SRCS := miracle_bdev.c

SPDK_LIB_LIST = $(ALL_MODULES_LIST) event event_bdev

include $(SPDK_ROOT_DIR)/mk/spdk.app.mk

run: all
    @ echo "Finished Compiling, Cleaning intermediate files"
    @ rm -f miracle_bdev.d miracle_bdev.o
    @ echo "Generating bdev-config"
    @ $(SPDK_ROOT_DIR)/scripts/gen_nvme.sh --json-with-subsystems >
./miracle_bdev.json
    @ echo "Generated bdev-config, Runing Program"
    @ sudo ./miracle_bdev -c ./miracle_bdev.json
```

```
	@ echo "Comparing Writing Data and Reading Data"
	@ echo "****************** Data Size ******************"
	@ du -h data.*
	@ echo "********************* End *********************"
	@ echo "Comparing Context ... (Note: Using [diff] command, empty output
means no different)"
	@ diff data.in data.out
```

### 运行结果




# 实验结论和心得体会

本次实验配置了bdev运行环境，运行并分析了hello_bdev程序，并最终独立编写实现了通过bdev接口的数据写入与读取。