lab2 实验报告

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一、实验内容

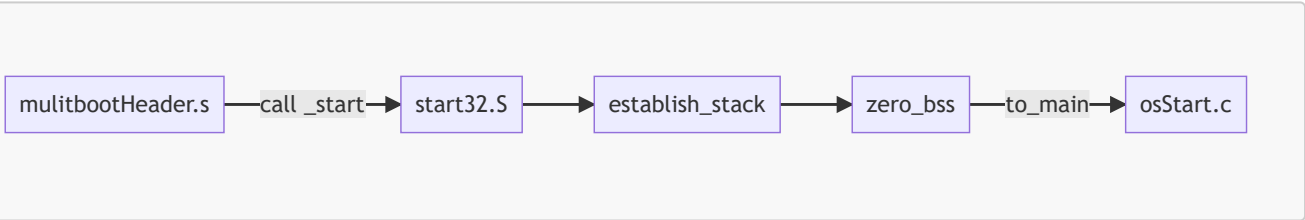
- 【必须】在源代码的语言层面，完成从汇编语言到 C 语言的衔接
- 【必须】在功能上，实现清屏、格式化输入输出，设备包括 VGA 和串口，接口符合要求
- 【必须】在软件层次和结构上，完成 multiboot_header、myOS 和 userApp 的划分，体现在文件录组织和 Makefile 组织上
- 【必须】采用自定义测试用例和用户（助教）测试用例相结合的方式进行验收
- 【必须】提供脚本完成编译和执行

二、实验原理

- 软件的架构(框图)

三、实验过程

1. 代码的主流程及其实现



2. 主要功能模块及其实现

- `vga.c`

    1. 设置光标位置

        直接使用`outb()`函数写入对应的端口

        ```
        void set_cursor_pos(unsigned short int pos)
        {
            unsigned char row = (pos & 0xff00) >> 8;
            unsigned char col = pos & 0xff;
            outb(CURSOR_INDEX_PORT, CURSOR_LINE_REG);
            outb(CURSOR_DATA_PORT, row);
            outb(CURSOR_INDEX_PORT, CURSOR_COL_REG);
            outb(CURSOR_DATA_PORT, col);
        }
        ```

    2. 获取光标当前所在位置

使用`outb()`和`inb()`获取行号和列号，用位运算获取位置信息

```
unsigned short int get_cursor_pos(void)
{
    unsigned short int pos = 0;
    unsigned short int row, col;
    outb(CURSOR_INDEX_PORT, CURSOR_LINE_REG);
    row = inb(CURSOR_DATA_PORT);
    outb(CURSOR_INDEX_PORT, CURSOR_COL_REG);
    col = inb(CURSOR_DATA_PORT);
    pos += col;
    pos += (row) << 8;
    return pos;
}
```

3. 滚屏

直接使用指针修改显存，除开最后一行的内存直接改为向后偏移八十个单位的值，最后一行，设置为底色黑色空白，最后将光标移动到最后一行开始的位置

```
void scroll_screen(void)
{
    for (int i = 0; i < VGA_SCREEN_HEIGHT * VGA_SCREEN_WIDTH -
VGA_SCREEN_WIDTH; i++)
    {
        unsigned short int *p, *q;
        p = (unsigned short int *)(i * 2 + VGA_BASE);
        q = (unsigned short int *)((i + 80) * 2 + VGA_BASE);
        *p = *q;
    }
    for (int i = VGA_SCREEN_HEIGHT * VGA_SCREEN_WIDTH -
VGA_SCREEN_WIDTH; i < VGA_SCREEN_HEIGHT * VGA_SCREEN_WIDTH; i++)
    {
        unsigned short int *p;
        p = (unsigned short int *)(i * 2 + VGA_BASE);
        unsigned char blank = ' ';
        int color = 10;
        unsigned short int data = 0;
        data += color << 8;
        data += blank;
        *p = data;
    }
    set_cursor_pos(VGA_SCREEN_HEIGHT * VGA_SCREEN_WIDTH -
VGA_SCREEN_WIDTH);
}
```

4. 向 vga 的特定光标位置 pos 输出一个字符

直接修改当前光标位置显存的值，将光标的位置向后 $+1$

```
void put_char2pos(unsigned char c, int color, unsigned short int pos)
{
    unsigned short int data = 0;
    data += color << 8;
    data += c;
    unsigned short int *p;
    p = (unsigned short int *)(pos * 2 + VGA_BASE);
    *p = data;
    set_cursor_pos(pos + 1);
}
```

5. 清屏

将整个屏幕设置为底色黑色，内容空白，光标移到屏幕最开始

```
void clear_screen(void)
{
    for (int i = 0; i < VGA_SCREEN_HEIGHT * VGA_SCREEN_WIDTH; i++)
    {
        unsigned short int *p;
        p = (unsigned short int *)(i * 2 + VGA_BASE);
        unsigned char blank = ' ';
        int color = 10;
        unsigned short int data = 0;
        data += color << 8;
        data += blank;
        *p = data;
    }
    set_cursor_pos(0);
}
```

6. 向 vga 的当前光标位置输出一个字符串，并移动光标位置到串末尾字符的下一位

遍历字符串，调用输出一个字符的函数，对换行符号进行特判，每次输出字符前获取当前光标所在的位置，如果获取的光标位置超过了屏幕显示范围，则向上滚动一行

```
void append2screen(char *str, int color)
{
    /* todo */
    int len = strlen(str);
    for (int i = 0; i < len; i++)
    {
        unsigned short int pos = get_cursor_pos();
        if (pos >= VGA_SCREEN_HEIGHT * VGA_SCREEN_WIDTH)
```

```
            {
                scroll_screen();
                pos = get_cursor_pos();
            }
            if (*(str + i) == '\n')
                set_cursor_pos((pos / 80 + 1) * 80);
            else
                put_char2pos(*(str + i), color, pos);
        }
        unsigned short int pos = get_cursor_pos();
        if (pos >= VGA_SCREEN_HEIGHT * VGA_SCREEN_WIDTH)
            scroll_screen();
    }
```

- uart.c

    1. 向串口输出一个字符

    直接向串口对应的端口，使用 outb 函数输出

    ```
    void uart_put_char(unsigned char ch)
    {
        outb(UART_PORT, ch);
    }
    ```

    2. 向串口输出一个字符串

    遍历字符串，调用输出一个字符的函数uart_put_char(unsigned char ch)

    ```
    void uart_put_chars(char *str)
    {
        int len = strlen(str);
        for (int i = 0; i < len; i++)
            uart_put_char(*(str + i));
    }
    ```

- vsprintf.c

需要编写或移植一个格式串处理函数，这里选择编写一个可以处理基本的几种格式的转换

```
unsigned char hex_tab[] = {'0', '1', '2', '3', '4', '5', '6', '7', '8', '9',
'a', 'b', 'c', 'd', 'e', 'f'};

int outc(const char c, char *buf, int index)
{
    *(buf + index) = c;
    index++;
```

```
    return index;
}

int outs(const char *s, char *buf, int index) //输出字符串
{
    while (*s != '\0')
    {
        *(buf + index) = *s;
        index++;
        s++;
    }
    return index;
}

int out_num(long n, int base, char lead, int maxwidth, char *buff, int
index)
{
    unsigned long m = 0;
    char buf[500], *s = buf + sizeof(buf);
    int count = 0, i = 0;
    *--s = '\0';
    if (n < 0)
        m = -n;
    else
        m = n;
    do
    {
        *--s = hex_tab[m % base];
        count++;
    } while ((m /= base) != 0);
    if (n < 0)
        *--s = '-';

    return outs(s, buff, index);
}
int vsprintf(char *buf, const char *fmt, va_list args)
{
    /* todo */
    char lead = ' ';
    int maxwidth = 0;
    int index = 0;
    int argv = 0;
    for (; *fmt != '\0'; fmt++)
    {
        if (*fmt != '%')
        {
            *(buf + index) = *fmt;
            index++;
            continue;
        }

        fmt++;
        argv++;
```

```
        if (*fmt == '0')
        {
            lead = '0';
            fmt++;
        }

        while (*fmt >= '0' && *fmt <= '9')
        {
            maxwidth *= 10;
            maxwidth += (*fmt - '0');
            fmt++;
        }

        switch (*fmt)
        {
        case 'd':
            index = out_num(va_arg(args, int), 10, lead, maxwidth, buf,
index);
            break;
        case 'o':
            index = out_num(va_arg(args, unsigned int), 8, lead, maxwidth,
buf, index);
            break;
        case 'u':
            index = out_num(va_arg(args, unsigned int), 10, lead, maxwidth,
buf, index);
            break;
        case 'x':
            index = out_num(va_arg(args, unsigned int), 16, lead, maxwidth,
buf, index);
            break;
        case 'c':
            index = outc(va_arg(args, int), buf, index);
            break;
        case 's':
            index = outs(va_arg(args, char *), buf, index);
            break;

        default:
            index = outc(*fmt, buf, index);
            break;
        }
    }
    *(buf + index) = '\0';
    return argv;
}
```

- myPrintk.c 直接调用已经封装好的串口输出和 vga 输出函数

```
char kBuf[400];
int myPrintk(int color, const char *format, ...)
```

```
{
    va_list args;

    va_start(args, format);
    int cnt = vsprintf(kBuf, format, args);
    va_end(args);

    uart_put_chars(kBuf);
    append2screen(kBuf, color);

    return cnt;
}
char uBuf[400];
int myPrintf(int color, const char *format, ...)
{
    va_list args;

    va_start(args, format);
    int cnt = vsprintf(uBuf, format, args);
    va_end(args);

    uart_put_chars(uBuf);
    append2screen(uBuf, color);

    return cnt;
}
```