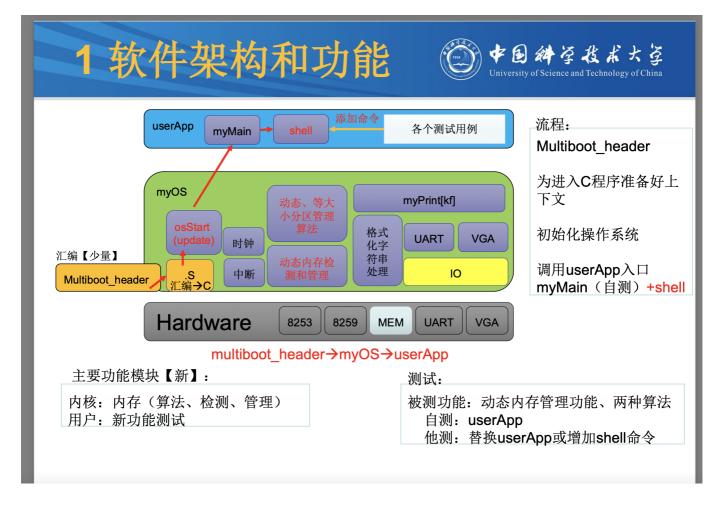
Lab4实验报告

1. 软件框图



- 1. 本次实验与之前实验相仿,首先进入从multibootHeader进入OS_Start,然后再运行相关编写的指令;
- 值得指出的是本次实验在操作系统正式启动前加入了内存初始化的步骤,分别初始化了内核内存与用户内存,将用户内存与内核内存相隔离;
- 3. 系统正式启动后,可以在shell()程序中调用各种用户程序;

2. 源代码说明

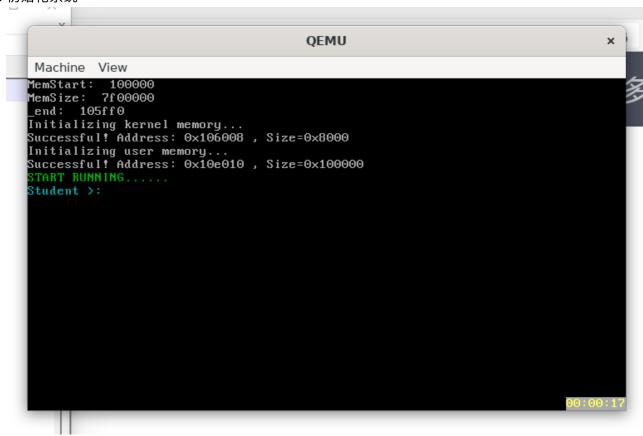
- 1. 本次实验着重编写了.../myOS/kernel/mem部分的内容;
- 2. pMemInit模块在系统启动的时候检测电脑的内存情况,统计出总共有多少内存,并且在检测完成后调用相关的接口,初始化内存并且对内核内存和用户内存分别初始化;
- 3. dPartition模块进行了写了动态分配的相关代码,本次实验采用的是FirstFit 逻辑,该模块是本次实验工作量最大的模块,需要进行大量地Debug,后期bug也重点集中在这一部分,该模块编写了动态内存分配初始化,动态内存分配与释放逻辑,需要考虑到许多极端情况;
- 4. eFPartition模块编写了固定地址分配的相关程序,该模块提供了Init, Malloc以及Free的相关指令,该模块较为简单,在代码中有详细的注释,就不在此赘述;
- 5. malloc模块进行了相关内核以及用户态的malloc和free指令的编写;

- 6. MemTestCase我们添加了两条指令用来测试相关的Umalloc和Ufree指令是否工作正常
- 7. shell部分我们完善了addNewCmd指令,该函数用于添加新的自定义的应用程序到我们的shell当中;
- 8. 值得一提的是,我们在OS_Start模块更改了相关的程序,我们加入了初始化内核内存以及用户内存的步骤,我们将内核内存与用户内存分开管理,更利于我们管理内存;

3. 程序编译以及运行结果

我们编译以及运行的指令是由老师提供的source2img.sh文件,下面依次解释各个测试用例的作用:

1. 初始化系统:



我们进入系统,首先检测可用内存的大小,从1M的地址开始检测,以0x1000为步长测试,发现系统可用的内存大小是7f00000;然后我们再初始化内核内存,我们为内核内存初始化了0x8000大小,即8k的大小,创建成功后去创建了用户内存,用户内存可以在UserApp的编写中自行设定,本次实验我们设定为1M内存;然后我们的系统就可以正式启动了;

2. testMalloc1

```
OEMU
                                                                                         ×
 Machine View
EMB(start=0\times10e738, size=0\times f0, nextStart=0\times0)
Student >:test
UNKOWN command: test
Student >:cmd
list all registered commands:
command name: description
         free: Free the space!
      malloc: Malloc a space!
     testeFP: Init a eFPatition. Alloc all and Free all. testdP3: Init a dPatition(size=0x100) A:B:C:- ==> A:B:- ==> A:- ==> - . testdP2: Init a dPatition(size=0x100) A:B:C:- ==> -:B:C:- ==> -:C:- ==> -
     testdP1: Init a dPatition(size=0x100) [Alloc,Free]* with step = 0x20
maxMallocSizeNow: MAX MALLOC SIZE always changes. What's the value Now?
 testMalloc2: Malloc, write and read.
 testMalloc1: Malloc, write and read.
        help: help [cmd] cmd: list all registered commands
Student >:testMalloc1
Student >:
```

该测试用例申请了两个buffer,分别是19字节和24字节,并且测试了对他们写入相关字节,发现可以正常写入,并且读取成功,那么就说明我们申请的相关内存是正确的;

3. testMalloc2

```
QEMU
                                                                                ×
Machine View
command name: description
        free: Free the space!
     malloc: Malloc a space!
    testeFP: Init a eFPatition. Alloc all and Free all. testdP3: Init a dPatition(size=0x100) A:B:C:- ==> A:B:- ==> A:- ==> - . testdP2: Init a dPatition(size=0x100) A:B:C:- ==> -:B:C:- ==> -:C:- ==> -
     testdP1: Init a dPatition(size=0x100) [Alloc,Free]* with step = 0x20
maxMallocSizeNow: MAX_MALLOC_SIZE always changes. What's the value Now?
testMalloc2: Malloc, write and read.
testMalloc1: Malloc, write and read.
       help: help [cmd] cmd: list all registered commands
Student >:testMalloc1
BUF2(size=24, addr=0×10e743) filled with 22(#): #################################
Student >:testMalloc2
Student >:_
```

该测试用例与上个测试用例相仿,申请了两个9字节和24字节的内存地址,并进行了相仿的实验,写入和读取均正常,并且我们可以注意到这次申请的地址与上例中的地址相同,这说明了我们在上例中free的操作运

行正常;

4. testeFP

```
We had successfully malloc() a small memBlock (size=0x9c, addr=0x10e684);
It is initialized as a very small ePartition;
eFPartition(start=0x10e684, totalN=0x9c, perSize=0x20, firstFree=0x10e690)
EEB(start=0x10e690, next=0x10e6b4)
EEB(start=0x10e6b4, next=0x10e6d8)
EEB(start=0x10e6d8, next=0x10e6fc)
EEB(start=0x10e6fc, next=0x0)
Alloc memBlock A, start = 0x10e694: 0xaaaaaaaa
eFPartition(start=0x10e684, totalN=0x9c, perSize=0x20, firstFree=0x10e6b4)
EEB(start=0x10e6b4, next=0x10e6d8)
EEB(start=0x10e6d8, next=0x10e6fc)
EEB(start=0x10e6fc, next=0x0)
Alloc memBlock B, start = 0x10e6b8: 0xbbbbbbbb
eFPartition(start=0x10e684, totalN=0x9c, perSize=0x20, firstFree=0x10e6d8)
EEB(start=0x10e6d8, next=0x10e6fc)
EEB(start=0x10e6fc, next=0x0)
Alloc memBlock C, start = 0x10e6dc: 0xccccccc
eFPartition(start=0x10e684, totalN=0x9c, perSize=0x20, firstFree=0x10e6fc)
EEB(start=0x10e6fc, next=0x0)
Alloc memBlock D, start = 0x10e700: 0xdddddddd
eFPartition(start=0x10e684, totalN=0x9c, perSize=0x20, firstFree=0x0)
Alloc memBlock E, failed!
eFPartition(start=0x10e684, totalN=0x9c, perSize=0x20, firstFree=0x0)
Now, release A.
eFPartition(start=0x10e684, totalN=0x9c, perSize=0x20, firstFree=0x10e690)
EEB(start=0x10e690, next=0x0)
Now, release B.
eFPartition(start=0x10e684, totalN=0x9c, perSize=0x20, firstFree=0x10e6b4)
EEB(start=0x10e6b4, next=0x10e690)
EEB(start=0x10e690, next=0x0)
Now, release C.
eFPartition(start=0x10e684, totalN=0x9c, perSize=0x20, firstFree=0x10e6d8)
EEB(start=0x10e6d8, next=0x10e6b4)
EEB(start=0x10e6b4, next=0x10e690)
EEB(start=0x10e690, next=0x0)
Now, release D.
eFPartition(start=0x10e684, totalN=0x9c, perSize=0x20, firstFree=0x10e6fc)
EEB(start=0x10e6fc, next=0x10e6d8)
EEB(start=0x10e6d8, next=0x10e6b4)
EEB(start=0x10e6b4, next=0x10e690)
EEB(start=0x10e690, next=0x0)
Student >:
```

注意:EEB代表的是当前空闲的可用的memBlock,并且我们在每次分配后将当前的EEB打印下来,方便 后期调试

该测试用例测试了等大小分配机制,因为该测试用例在VGA上不能完整展示,我们使用了UART上的截图,可以看出来我们首先初始化了一个具有4个内存块的memBlock;其中每个memBlock可用的字节数为31,因为考虑到对齐以及最大化内存使用率,所以我们采用了4字节对齐的方式,也就是说我们为每个memBlock分配了32+EEB_Size(EEB_Size=4)个字节的内存;我们也可以从图中看出我们相邻的两个EEB的地址间距是36,符合我们的预期;

并且我们将他们依次分配出去,并且收回,观察EEB模块是否分配正确,我们发现EEB分配均符合预期;为了编写程序的方便,我们优先分配第一块EEB,收回的时候也优先将他们发在EEB首位,所以我们会发现最后的EEB排序与开始的排序不相同,这并不是程序错误导致的,这只是一个feature,并不影响我们内存机制的使用;

5. testdP1

```
We had successfully malloc() a small memBlock (size=0x100, addr=0x10e728);
It is initialized as a very small dPartition;
dPartition(start=0x10e728, size=0x100, firstFreeStart=0x10e738)
EMB(start=0x10e738, size=0xf0, nextStart=0x0)
Alloc a memBlock with size 0x10, success(addr=0x10e740)!.....Relaesed;
Alloc a memBlock with size 0x20, success(addr=0x10e740)!.....Relaesed;
Alloc a memBlock with size 0x40, success(addr=0x10e740)!.....Relaesed;
Alloc a memBlock with size 0x80, success(addr=0x10e740)!.....Relaesed;
Alloc a memBlock with size 0x100, failed!
Now, converse the sequence.
Alloc a memBlock with size 0x100, failed!
Alloc a memBlock with size 0x80, success(addr=0x10e740)!.....Relaesed;
Alloc a memBlock with size 0x40, success(addr=0x10e740)!.....Relaesed;
Alloc a memBlock with size 0x20, success(addr=0x10e740)!.....Relaesed;
Alloc a memBlock with size 0x10, success(addr=0x10e740)!.....Relaesed;
Student >:
```

```
QEMU
                                                                                   ×
 Machine
         View
     testdP1: Init a dPatition(size=0x100) [Alloc,Free]* with step = 0x20
maxMallocSizeNow: MAX_MALLOC_SIZE always changes. What's the value Now?
 testMalloc2: Malloc, write and read.
 testMalloc1: Malloc, write and read.
        help: help [cmd]
         cmd: list all registered commands
Student >:testdP1
We had successfully malloc() a small memBlock (size=0×100, addr=0×10e728);
It is initialized as a very small dPartition;
dPartition(start=0x10e728, size=0x100, firstFreeStart=0x10e738)
EMB(start=0x10e738, size=0xf0, nextStart=0x0)
Alloc a memBlock with size 0x10, success(addr=0x10e740)!.....Relaesed;
Alloc a memBlock with size 0x20, success(addr=0x10e740)!.....Relaesed;
Alloc a memBlock with size 0x40, success(addr=0x10e740)!.....Relaesed;
Alloc a memBlock with size 0x80, success(addr=0x10e740)!.....Relaesed;
Alloc a memBlock with size 0x100, failed!
Now, converse the sequence.
Alloc a memBlock with size 0x100, failed!
Alloc a memBlock with size 0x80, success(addr=0x10e740)!.....Relaesed;
Alloc a memBlock with size 0x40, success(addr=0x10e740)!.....Relaesed;
Alloc a memBlock with size 0x20, success(addr=0x10e740)!.....Relaesed;
Alloc a memBlock with size 0×10, success(addr=0×10e740)!.....Relaesed;
Student >:
                                                                             00:03:5
```

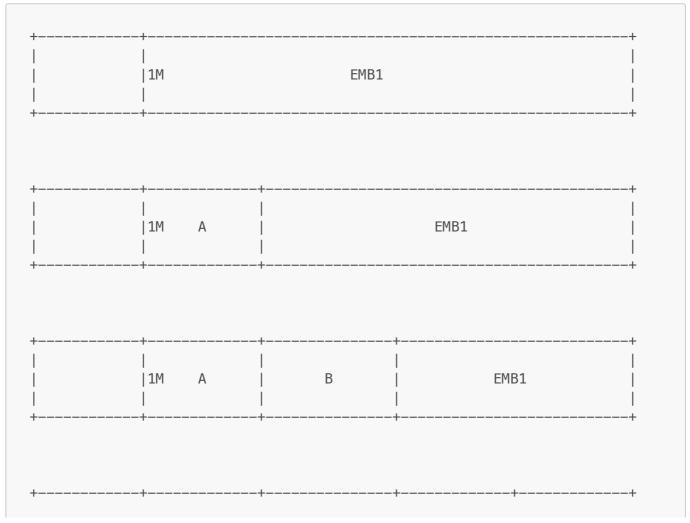
注意EMB代表的是当前空闲的memBlock,我们将其打印下来仅仅是为了方便调试;

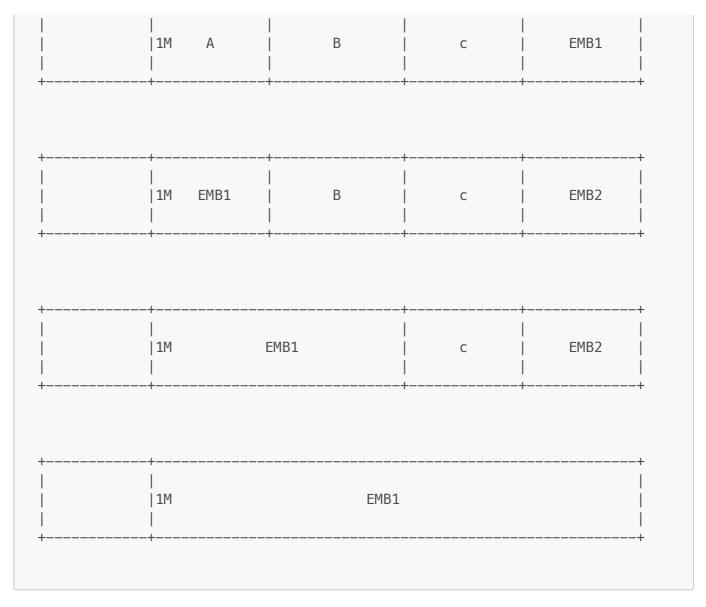
该测试用例测试的是动态分配机制,注意到我们虽然Init的时候虽然分配了0x100大小的内存,但是因为分配机制本身的消耗,所以我们在申请0x100大小的内存的时候必然会产生内存大小不够,无法分配的错误,但是我们在申请以及释放其他大小的内存时均可以正常分配;实验结果符合我们的预期;

6. testdP2

```
We had successfully malloc() a small memBlock (size=0x100, addr=0x10e728);
It is initialized as a very small dPartition;
dPartition(start=0x10e728, size=0x100, firstFreeStart=0x10e738)
EMB(start=0x10e738, size=0xf0, nextStart=0x0)
Now, A:B:C:- ==> -:B:C:- ==> -:C- ==> - .
Alloc memBlock A with size 0x10: success(addr=0x10e740)!
dPartition(start=0x10e728, size=0x100, firstFreeStart=0x10e750)
EMB(start=0x10e750, size=0xd8, nextStart=0x0)
Alloc memBlock B with size 0x20: success(addr=0x10e758)!
dPartition(start=0x10e728, size=0x100, firstFreeStart=0x10e778)
EMB(start=0x10e778, size=0xb0, nextStart=0x0)
Alloc memBlock C with size 0x30: success(addr=0x10e780)!
dPartition(start=0x10e728, size=0x100, firstFreeStart=0x10e7b0)
EMB(start=0x10e7b0, size=0x78, nextStart=0x0)
Now, release A.
dPartition(start=0x10e728, size=0x100, firstFreeStart=0x10e738)
EMB(start=0x10e738, size=0x10, nextStart=0x10e7b0)
EMB(start=0x10e7b0, size=0x78, nextStart=0x0)
Now, release B.
dPartition(start=0x10e728, size=0x100, firstFreeStart=0x10e738)
EMB(start=0x10e738, size=0x38, nextStart=0x10e7b0)
EMB(start=0x10e7b0, size=0x78, nextStart=0x0)
At last, release C.
dPartition(start=0x10e728, size=0x100, firstFreeStart=0x10e738)
EMB(start=0x10e738, size=0xf0, nextStart=0x0)
```

该测试用例测试了相关分配以及释放机制的正确性,我们依次申请A、B、C三个memBlock,我们需要注意的是释放他们的时候需要将相邻的两个空闲的EMB链接到一个EMB,下图清晰地反应了这个test所完成的事情;



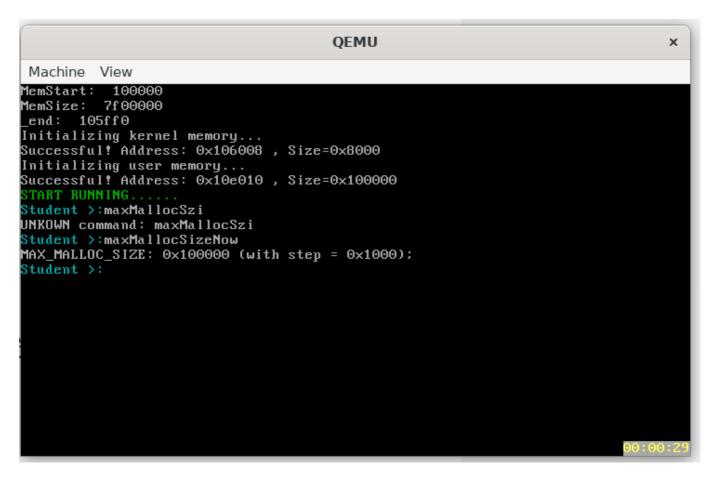


7. testdP3

```
We had successfully malloc() a small memBlock (size=0x100, addr=0x10e728);
It is initialized as a very small dPartition;
dPartition(start=0x10e728, size=0x100, firstFreeStart=0x10e738)
EMB(start=0x10e738, size=0xf0, nextStart=0x0)
Now, A:B:C:- ==> -:B:C:- ==> -:C- ==> - .
Alloc memBlock A with size 0x10: success(addr=0x10e740)!
dPartition(start=0x10e728, size=0x100, firstFreeStart=0x10e750)
EMB(start=0x10e750, size=0xd8, nextStart=0x0)
Alloc memBlock B with size 0x20: success(addr=0x10e758)!
dPartition(start=0x10e728, size=0x100, firstFreeStart=0x10e778)
EMB(start=0x10e778, size=0xb0, nextStart=0x0)
Alloc memBlock C with size 0x30: success(addr=0x10e780)!
dPartition(start=0x10e728, size=0x100, firstFreeStart=0x10e7b0)
EMB(start=0x10e7b0, size=0x78, nextStart=0x0)
At last, release C.
dPartition(start=0x10e728, size=0x100, firstFreeStart=0x10e778)
EMB(start=0x10e778, size=0xb0, nextStart=0x0)
Now, release B.
dPartition(start=0x10e728, size=0x100, firstFreeStart=0x10e750)
EMB(start=0x10e750, size=0xd8, nextStart=0x0)
Now, release A.
dPartition(start=0x10e728, size=0x100, firstFreeStart=0x10e738)
EMB(start=0x10e738, size=0xf0, nextStart=0x0)
Student >:
```

这个test与上一个test相仿,只不过我们是逆序的方式将这些内存块释放,我们需要注意的是将他们与相邻的内存块合并;

8. maxMallocSizeNow



这个是测量最大可分配的内存大小,采用从0开始以 0×1000 为步长,依次累加测试,本次实验我们用户态内存仅分配了 0×100000 与测试结果相符合;

如果我们使用了自行编写的malloc指令进行内存分配,那我们的maxMallocSizeNow将相应地缩小;

2022/5/28

```
QEMU
                                                                               ×
Machine View
MemStart: 100000
MemSize: 7f00000
end: 105ff0
Initializing kernel memory...
Successful! Address: 0x106008 , Size=0x8000
Initializing user memory...
Successful! Address: 0x10e010 , Size=0x100000
START RUNNING.
Student >:maxMallocSzi
UNKOWN command: maxMallocSzi
Student >:maxMallocSizeNow
MAX_MALLOC_SIZE: 0×100000 (with step = 0×1000);
Student >:malloc 8912
Suceessful! Address = 0x10e684
dPartition(start=0x10e010, size=0x100000, firstFreeStart=0x110954)
EMB(start=0x110954, size=0xfd6bc, nextStart=0x0)
Student >:maxMallocSizeNow
MAX_MALLOC_SIZE: 0xfe000 (with step = 0x1000);
Student >:_
```

9. malloc以及free

```
_ | D | X
                                     OEMU
Machine View
MemStart: 100000
MemSize: 7f00000
_end: 105ff0
Initializing kernel memory...
Successful! Address: 0x106008 , Size=0x8000
Initializing user memory...
Successful! Address: 0x10e010 , Size=0x100000
START RUNNING.....
Student >:maxMallocSizeNow
MAX_MALLOC_SIZE: 0x100000 (with step = 0x1000);
Student >:malloc 10000
Suceessful! Address = 0x10e684
dPartition(start=0x10e010, size=0x100000, firstFreeStart=0x110d94)
EMB(start=0x110d94, size=0xfd27c, nextStart=0x0)
Student >:maxMallocSizeNow
MAX_MALLOC_SIZE: 0xfe000 (with step = 0x1000);
Student >:free 10e684
Successful!
dPartition(start=0x10e010, size=0x100000, firstFreeStart=0x10e67c)
EMB(start=0x10e67c, size=0xff994, nextStart=0x0)
Student >:maxMallocSizeNow
MAX MALLOC SIZE: 0x100000
1AX_MALLOC_SIZE: 0x100000 (with step = 0x1000);
Student >:
```

这是我自己编写的为了测试Umalloc以及Ufree指令的用户界面测试命令,这个命令旨在测试User_Memory的分配情况,我们将用户界面和内核界面相隔离,这个malloc指令调用的是系统提供的Umalloc和Ufree,我们测试以后发现在User_Memory处能够正常分配以及释放,这个起到了内核的内存与用户态内存相隔离,避免出现用户的某些操作影响系统的稳定性;

其中malloc (size), size代表的是需要分配的内存的大小,如果分配成功则给出分配好的地址,如果分配失败,则给出相关的提示;

free (address), 应给出相应的address地址,需要释放相应位置的内存,成功则提示成功,失败则返回相关原因;

需要注意的是free命令对应的应该是基于16进制的地址;

我们在测试的时候也使用了maxMallocSize的命令,来判断是不是内存模块被真正地释放了;