实验二 磁盘存储空间的分配和回收

1、实验内容

模拟 UNIX 系统的空闲块成组链接法，实现磁盘存储空间的管理。

2、基本思想

基本思想是使用块状链表实现内存的分配与回收。这种方法具有使用链表分配的几乎所有特点，例如可以动态地离散地分配，没有外部碎片但有内部碎片。比起直接使用链表法进行分配内存，这种方法的优势我还没有想出来，就不在这里叙述了。这种磁盘管理方法利用了将磁盘的空余空间组织成组，每组第一块描述了下一组空闲空间的信息，包括下一组有多少空余空间，下一组中空闲块的块号是什么等等，而第一组的描述信息放在内存中。磁盘空间的分配和回收类似于一般的链表，不同点在于这种算法使用了类似堆栈的分配和回收，即后进先出，而非一般链表法采用的队列的先进先出的分配和回收法。

在这个模拟程序中，我使用了一个动态分配的数组模拟磁盘空间，并且专门实现了一个函数用来定位第 i 块内存在数组中的位置。在块状链表中插入和删除的算法和提示中基本一致，具体见下图。显示空余块的方法相当于遍历这个链表，由于实在太简单没什么好写的，就不在这里描述了。
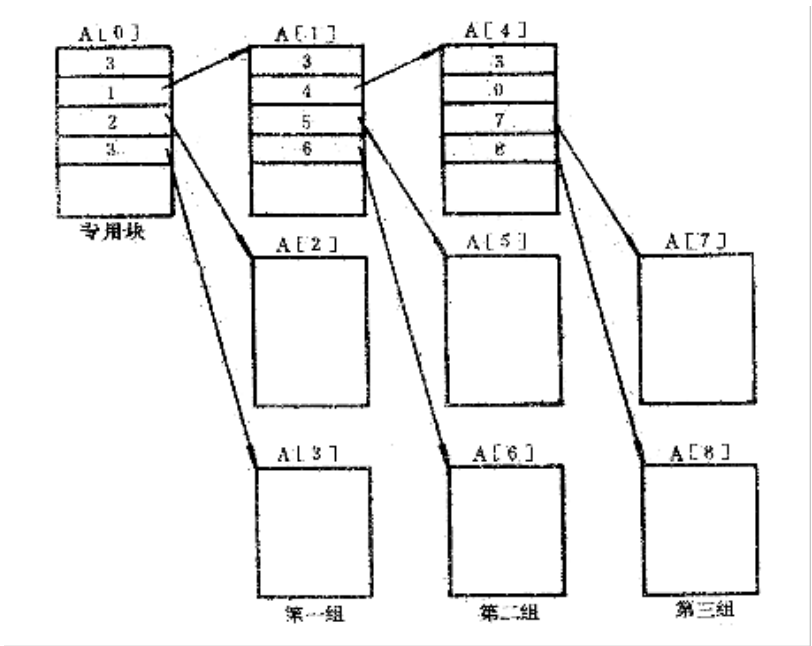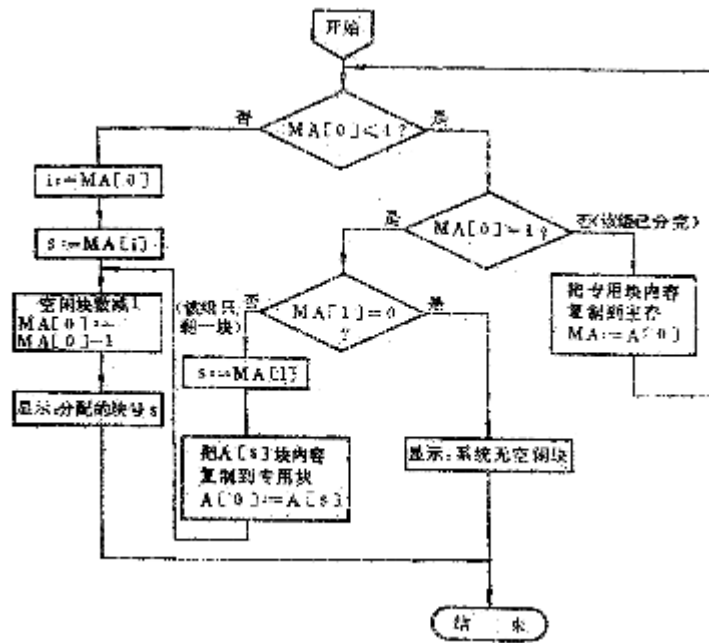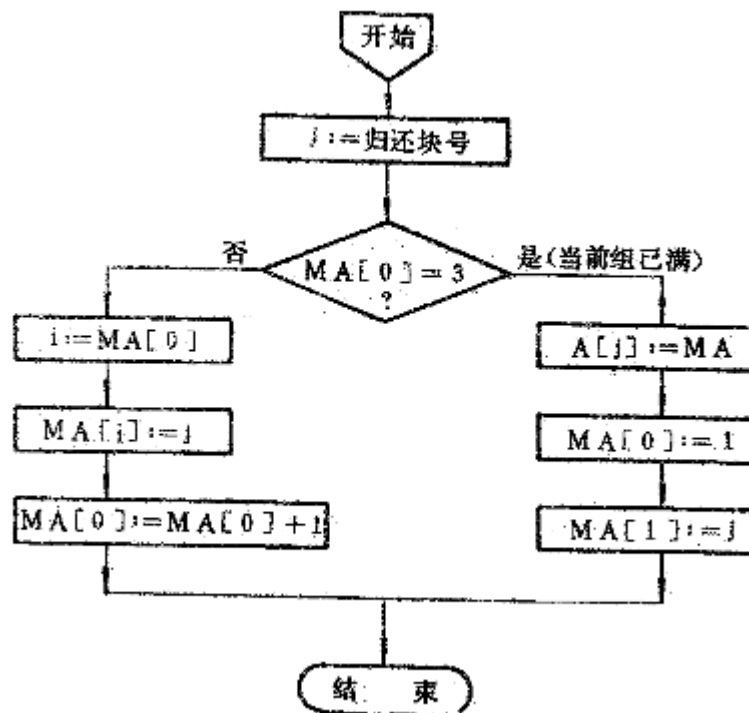

Illustration 1: 空余块的块状链表存储方法

Illustration 2: 空余块的分配

Illustration 3: 已用块的回收

3、实验平台及软件

Debian Linux 4.1.1-21 with Linux Kernel 2.6.18-6-686, GCC version 4.1.2 and GDB version 6.4.90

4、调试过程

(1)输入数据

```
8 4              //指定块数目及每块的大小
1 6              // 分配 6 块内存
1 2              // 分配 2 块内存
2 7              // 回收 7 号内存
2 8              // 回收 8 号内存
2 4              // 回收 4 号内存
2 5              // 回收 5 号内存
2 6              // 回收 6 号内存
2 1              // 回收 1 号内存
2 2              // 回收 2 号内存
2 3              // 回收 3 号内存
1 4              // 分配 4 块内存
2 2              // 回收 2 号内存
2 6              // 回收 6 号内存
1 3              // 分配 3 块内存
2 1              // 回收 1 号内存
2 5              // 回收 5 号内存
0                // 退出模拟程序
```

Drawing 1: 输入数据

输出数据

Drawing 3: 输出样例，第一部分

```
Please input the size of the disk in blocks:8
Please input the size of each block(>=3):4


There are still 6 byte space available.
1---Allocate Disk Space
2---Dispose Disk Space
3---Display free blocks
0---Exit
Please input your choice:1
How many bytes do you want to allocate:6
The blocks allocated are:
1 2 3 4 5 6

All free blocks will be displayed in group below:
Group 1 has 2 free blocks, and this group is the last group.
        Block 8 is free.
        Block 7 is free.



There are still 2 byte space available.
1---Allocate Disk Space
2---Dispose Disk Space
3---Display free blocks
0---Exit
Please input your choice:1
How many bytes do you want to allocate:2
The blocks allocated are:
7 8

All free blocks will be displayed in group below:
Group 1 has 0 free blocks, and this group is the last group.
```

Drawing 2: 输出样例，第二部分

```
There are still 0 byte space available.
1---Allocate Disk Space
2---Dispose Disk Space
3---Display free blocks
0---Exit
Please input your choice:2
Which block do you want to free:7
All free blocks will be displayed in group below:
Group 1 has 1 free blocks, and this group is the last group.
        Block 7 is free.


There are still 1 byte space available.
1---Allocate Disk Space
2---Dispose Disk Space
3---Display free blocks
0---Exit
Please input your choice:2
Which block do you want to free:8
All free blocks will be displayed in group below:
Group 1 has 2 free blocks, and this group is the last group.
        Block 7 is free.
        Block 8 is free.


There are still 2 byte space available.
1---Allocate Disk Space
2---Dispose Disk Space
3---Display free blocks
0---Exit
Please input your choice:2
Which block do you want to free:4
All free blocks will be displayed in group below:
Group 1 has 0 free blocks, and block 4 is the pointer to group 2.
Group 2 has 2 free blocks, and this group is the last group.
        Block 7 is free.
        Block 8 is free.
```

There are still 2 byte space available.
1---Allocate Disk Space
2---Dispose Disk Space
3---Display free blocks
0---Exit
Please input your choice:2
Which block do you want to free:5
All free blocks will be displayed in group below:
Group 1 has 1 free blocks, and block 4 is the pointer to group 2.
        Block 5 is free.
Group 2 has 2 free blocks, and this group is the last group.
        Block 7 is free.
        Block 8 is free.

There are still 3 byte space available.
1---Allocate Disk Space
2---Dispose Disk Space
3---Display free blocks
0---Exit
Please input your choice:2
Which block do you want to free:6
All free blocks will be displayed in group below:
Group 1 has 2 free blocks, and block 4 is the pointer to group 2.
        Block 5 is free.
        Block 6 is free.
Group 2 has 2 free blocks, and this group is the last group.
        Block 7 is free.
        Block 8 is free.

There are still 4 byte space available.
1---Allocate Disk Space
2---Dispose Disk Space
3---Display free blocks
0---Exit
Please input your choice:2
Which block do you want to free:1
All free blocks will be displayed in group below:
Group 1 has 0 free blocks, and block 1 is the pointer to group 2.
Group 2 has 2 free blocks, and block 4 is the pointer to group 3.
        Block 5 is free.
        Block 6 is free.
Group 3 has 2 free blocks, and this group is the last group.
        Block 7 is free.
        Block 8 is free.

There are still 4 byte space available.
1---Allocate Disk Space
2---Dispose Disk Space
3---Display free blocks
0---Exit
Please input your choice:2
Which block do you want to free:2
All free blocks will be displayed in group below:
Group 1 has 1 free blocks, and block 1 is the pointer to group 2.
        Block 2 is free.
Group 2 has 2 free blocks, and block 4 is the pointer to group 3.
        Block 5 is free.
        Block 6 is free.
Group 3 has 2 free blocks, and this group is the last group.
        Block 7 is free.
        Block 8 is free.

There are still 5 byte space available.
1---Allocate Disk Space
2---Dispose Disk Space
3---Display free blocks
0---Exit
Please input your choice:2
Which block do you want to free:3
All free blocks will be displayed in group below:
Group 1 has 2 free blocks, and block 1 is the pointer to group 2.

Drawing 4: 输出样例，第三部分

Block 2 is free.
        Block 3 is free.
Group 2 has 2 free blocks, and block 4 is the pointer to group 3.
        Block 5 is free.
        Block 6 is free.
Group 3 has 2 free blocks, and this group is the last group.
        Block 7 is free.
        Block 8 is free.

There are still 6 byte space available.
1---Allocate Disk Space
2---Dispose Disk Space
3---Display free blocks
0---Exit
Please input your choice:1
How many bytes do you want to allocate:4
The blocks allocated are:
3 2 1 6

All free blocks will be displayed in group below:
Group 1 has 1 free blocks, and block 4 is the pointer to group 2.
        Block 5 is free.
Group 2 has 2 free blocks, and this group is the last group.
        Block 7 is free.
        Block 8 is free.

There are still 3 byte space available.
1---Allocate Disk Space
2---Dispose Disk Space
3---Display free blocks
0---Exit
Please input your choice:2
Which block do you want to free:2
All free blocks will be displayed in group below:
Group 1 has 2 free blocks, and block 4 is the pointer to group 2.
        Block 5 is free.
        Block 2 is free.
Group 2 has 2 free blocks, and this group is the last group.
        Block 7 is free.
        Block 8 is free.

There are still 4 byte space available.
1---Allocate Disk Space
2---Dispose Disk Space
3---Display free blocks
0---Exit
Please input your choice:2
Which block do you want to free:6
All free blocks will be displayed in group below:
Group 1 has 0 free blocks, and block 6 is the pointer to group 2.
Group 2 has 2 free blocks, and block 4 is the pointer to group 3.
        Block 5 is free.
        Block 2 is free.
Group 3 has 2 free blocks, and this group is the last group.
        Block 7 is free.
        Block 8 is free.

There are still 4 byte space available.
1---Allocate Disk Space
2---Dispose Disk Space
3---Display free blocks
0---Exit
Please input your choice:1
How many bytes do you want to allocate:3
The blocks allocated are:
6 2 5

All free blocks will be displayed in group below:
Group 1 has 0 free blocks, and block 4 is the pointer to group 2.
Group 2 has 2 free blocks, and this group is the last group.
        Block 7 is free.
        Block 8 is free.

Drawing 5: 输出样例，第四部分

```
There are still 2 byte space available.
1---Allocate Disk Space
2---Dispose Disk Space
3---Display free blocks
0---Exit
Please input your choice:2
Which block do you want to free:1
All free blocks will be displayed in group below:
Group 1 has 1 free blocks, and block 4 is the pointer to group 2.
          Block 1 is free.
Group 2 has 2 free blocks, and this group is the last group.
          Block 7 is free.
          Block 8 is free.

There are still 3 byte space available.
1---Allocate Disk Space
2---Dispose Disk Space
3---Display free blocks
0---Exit
Please input your choice:2
Which block do you want to free:6
All free blocks will be displayed in group below:
Group 1 has 2 free blocks, and block 4 is the pointer to group 2.
          Block 1 is free.
          Block 5 is free.
Group 2 has 2 free blocks, and this group is the last group.
          Block 7 is free.
          Block 8 is free.

There are still 4 byte space available.
1---Allocate Disk Space
2---Dispose Disk Space
3---Display free blocks
0---Exit
Please input your choice:0
```

Drawing 6: 输出数据，第五部分

这个程序也存在一些不足，问题在于，当待分配的内存比较大时，程序会出现段错误，例如当内存有 1000000 个块，并且每个块的大小为 4000 个字节时就会出错。另外，当模拟程序运行完退出释放之前动态申请的内存时 glibc 有时会报错。目前这两个问题没有解决，产生问题的原因也还没搞清楚。

5、总结
在本次试验中，我对 Unix 系统中使用的硬盘空间的分配和回收机制有了一定的认识，并且实现了一个采用这种算法的模拟分配机制，与此同时实现了块状链表这种数据结构。

6、参考文献
黄水松，黄干平，曾平，李蓉蓉。（2003）。《计算机操作系统》。武汉：武汉大学。