操作系统(D)

项目 4

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调度算法

一 C 语言实现版本

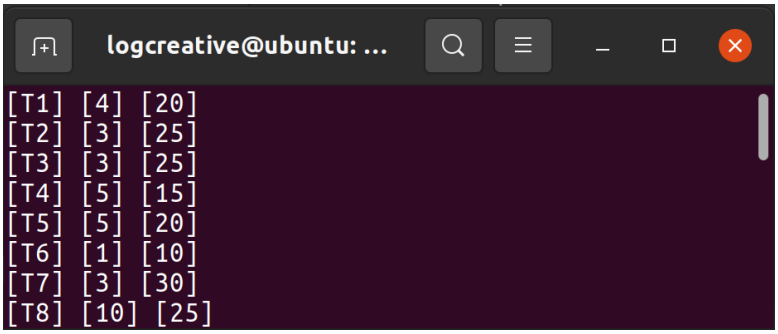
1. FCFS

Listing 1: src/posix/schedule_fcfs.c

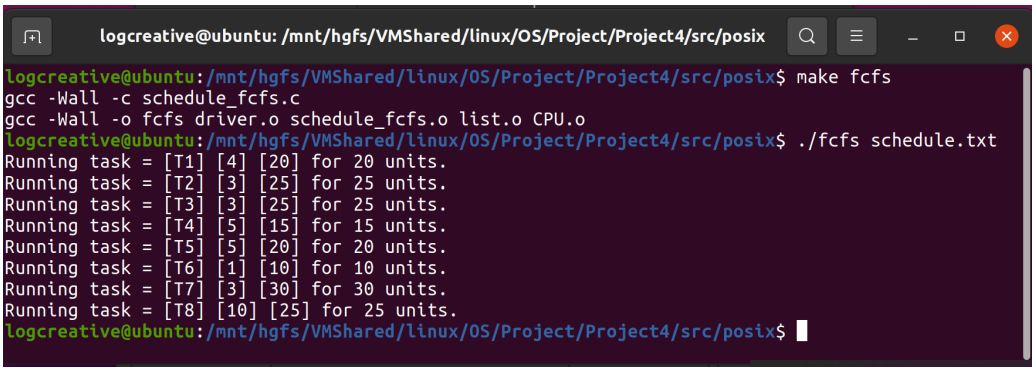
```c
#include "schedulers.h"
#include "list.h"
#include "cpu.h"
#include <stdio.h>
#include <stdlib.h>

struct node* taskList = NULL;
int value = 0;

void add(char *name, int priority, int burst){
    Task* newTask = (Task*) malloc(sizeof(Task));
    newTask->name = name;
    newTask->priority = priority;
    newTask->burst = burst;
    newTask->tid = __sync_fetch_and_add(&value,1);
    newTask->exec = 0;

    if(!taskList){
        taskList = malloc(sizeof(struct node));
        taskList->task = newTask;
        taskList->next = NULL;
    } else {
        struct node* temp = taskList;
        while(temp->next) temp = temp->next;
        insert(&temp->next,newTask);
    }

}

void schedule(){

    // traverse(taskList);
```

```
    struct node *temp = taskList;
    while(temp){
        Task* thisTask = temp->task;
        run(thisTask,thisTask->burst);
        delete(&taskList, thisTask);
        temp = temp->next;
    }
}
```

将输入的任务按照先后次序形成链表，注意第一个任务插入的时候特别进行了处理，之后按照给定的链表方法使用地址输入需要被替代位置的元素，之后顺移。遍历结果如下图所示：



之后按照 FCFS 的规则遍历该链表运行即可，运行完成后就会把链表上对应的元素删除。



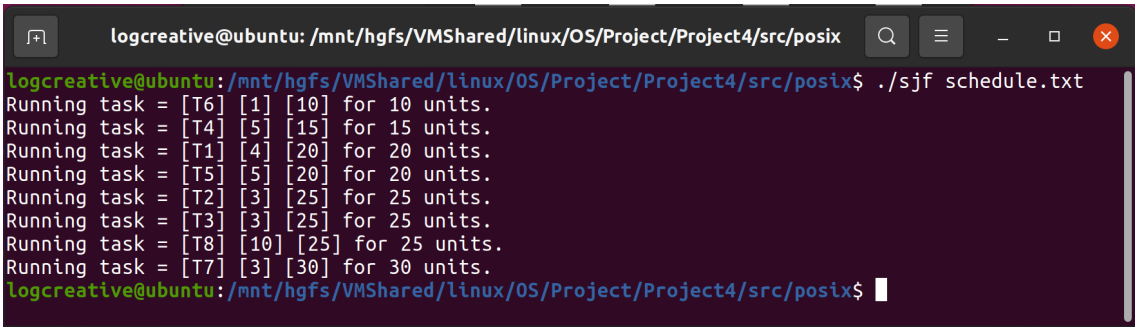
2. SJF

Listing 2: src/posix/schedule_sjf.c

```
#include "schedulers.h"
#include "list.h"
#include "cpu.h"
#include <stdio.h>
#include <stdlib.h>

int value = 0;
struct node* taskList = NULL;

void add(char *name, int priority, int burst){
    Task* newTask = (Task*) malloc(sizeof(Task));
    newTask->name = name;
    newTask->priority = priority;
    newTask->burst = burst;
```

```
    newTask->tid = __sync_fetch_and_add(&value,1);
    newTask->exec = 0;

    if(!taskList){
        taskList = malloc(sizeof(struct node));
        taskList->task = newTask;
        taskList->next = NULL;
    } else {
        struct node* temp = taskList;
        while(temp->next) temp = temp->next;
        insert(&temp->next,newTask);
    }

}

void schedule(){
    while(taskList){
        struct node *minNode = taskList;

        struct node *pivot = taskList;
        while(pivot){
            if(pivot->task->burst<minNode->task->burst)
                minNode = pivot;
            pivot = pivot->next;
        }

        Task* thisTask = minNode->task;
        run(thisTask,thisTask->burst);
        delete(&taskList, thisTask);
    }
}
```

SJF 算法要求首先处理运行时间短的任务。这里采用了调度时寻找时间最短任务方法。每次对链表进行最小值搜索，存入 minNode 中，使用小于号即可保证取的是同最小值的最先值。



3. RR

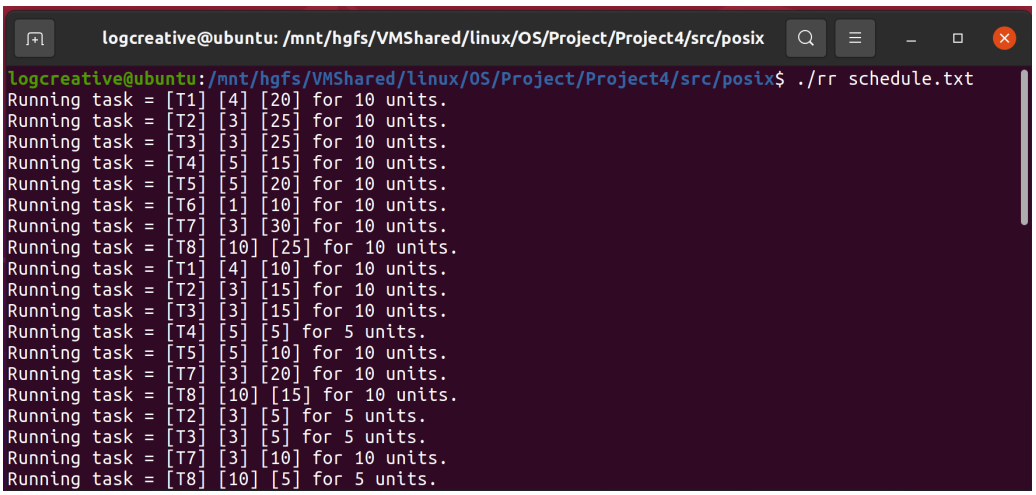
Listing 3: src/posix/schedule_rr.c

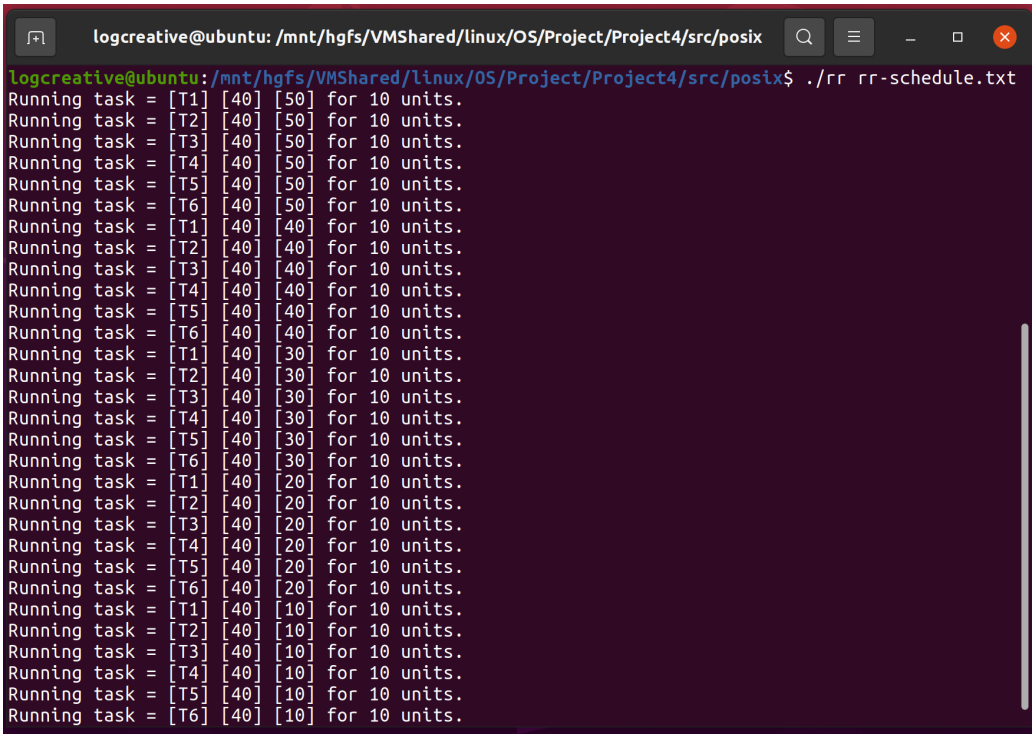
```
#include "schedulers.h"
#include "list.h"
#include "cpu.h"
#include <stdio.h>
#include <stdlib.h>
```

```
int value = 0;
struct node* taskList = NULL;

void add(char *name, int priority, int burst){
    Task* newTask = (Task*) malloc(sizeof(Task));
    newTask->name = name;
    newTask->priority = priority;
    newTask->burst = burst;
    newTask->tid = __sync_fetch_and_add(&value,1);
    newTask->exec = 0;

    if(!taskList){
        taskList = malloc(sizeof(struct node));
        taskList->task = newTask;
        taskList->next = NULL;
    } else {
        struct node* temp = taskList;
        while(temp->next) temp = temp->next;
        insert(&temp->next,newTask);
    }

}

void schedule(){
    struct node *pivot = taskList;
    while(pivot){
        Task* thisTask = pivot->task;
        int slice = thisTask->burst>QUANTUM? QUANTUM : thisTask->burst;
        run(thisTask, slice);

        delete(&taskList, thisTask);
        if(thisTask->burst > 0){
            struct node* temp = taskList;
            while(temp->next) temp = temp->next;
            insert(&temp->next,thisTask);
        }
        pivot = pivot->next;
    }
}
```

轮转调度使用 FCFS 按照顺序让每一个任务运行一个时间量 `QUANTUM` 的时间，一个未运行结束的程序会被插入到列表的最后。使用一个 `pivot` 的指针追踪正在进行的任务。

该算法在标准集和特集上的运行情况分别如下：





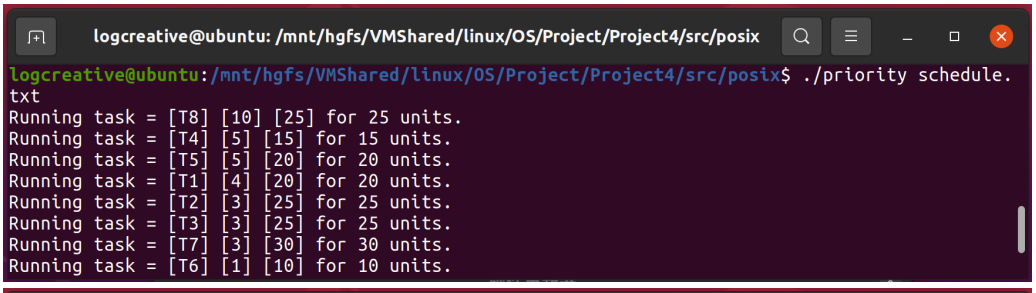
4. 优先级调度

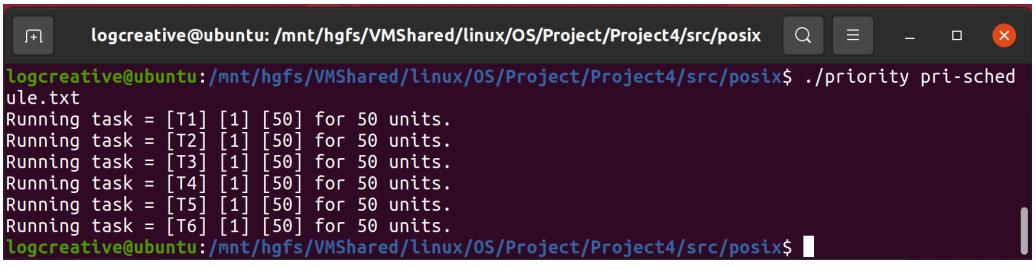
Listing 4: src/posix/schedule_priority.c

```c
#include "schedulers.h"
#include "list.h"
#include "cpu.h"
#include <stdio.h>
#include <stdlib.h>

int value = 0;
struct node* taskList = NULL;

void add(char *name, int priority, int burst){
    Task* newTask = (Task*) malloc(sizeof(Task));
    newTask->name = name;
    newTask->priority = priority;
    newTask->burst = burst;
    newTask->tid = __sync_fetch_and_add(&value,1);
```

```
    newTask->exec = 0;

    if(!taskList){
        taskList = malloc(sizeof(struct node));
        taskList->task = newTask;
        taskList->next = NULL;
    } else {
        struct node* temp = taskList;
        while(temp->next) temp = temp->next;
        insert(&temp->next,newTask);
    }

}

void schedule(){
    while(taskList){
        struct node *maxpriNode = taskList;

        struct node *pivot = taskList;
        while(pivot){
            if(pivot->task->priority>maxpriNode->task->priority)
                maxpriNode = pivot;
            pivot = pivot->next;
        }

        Task* thisTask = maxpriNode->task;
        run(thisTask,thisTask->burst);
        delete(&taskList, thisTask);
    }
}
```

类似于 SJF，只不过是比较的任务中优先级的最大值，同优先级取最先进行的。该算法在标准集与特集上的运行结果分别如下：





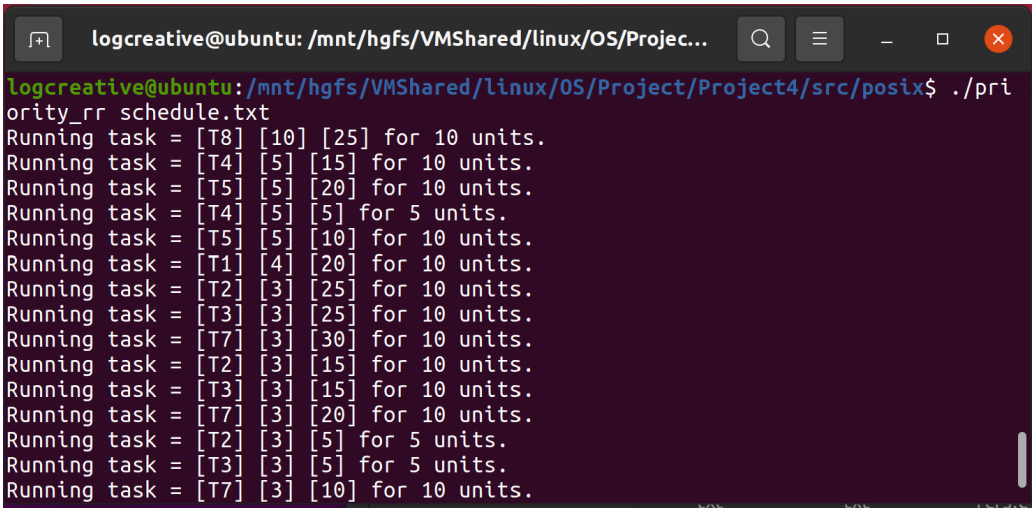
5. 优先级–轮转调度

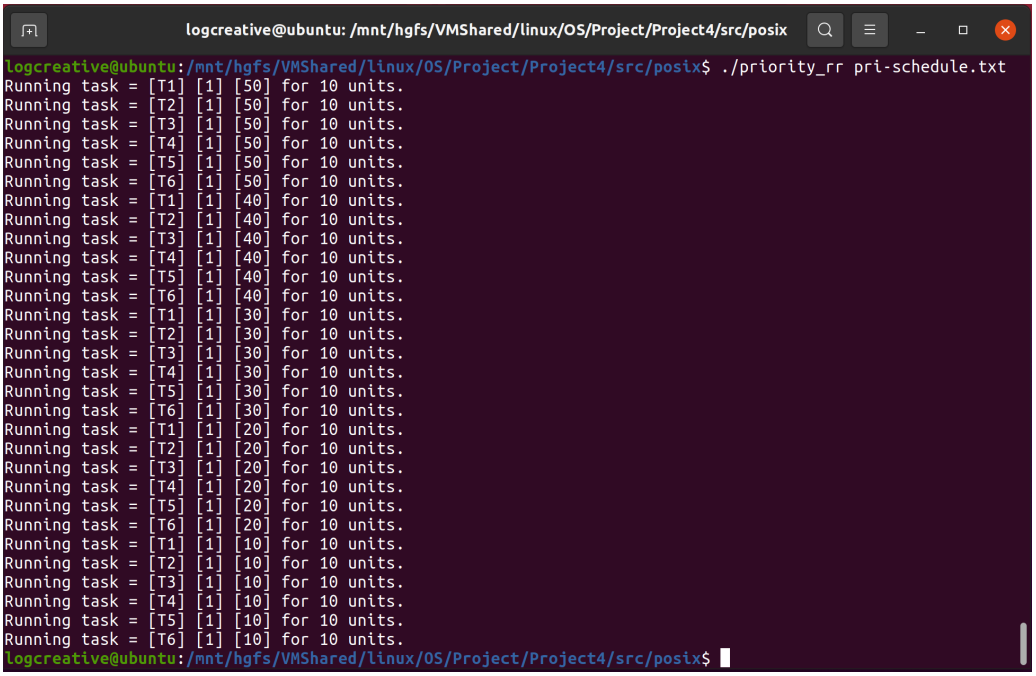
Listing 5: src/posix/schedule_priority_rr.c

```
#include "schedulers.h"
#include "list.h"
```

```c
#include "cpu.h"
#include <stdio.h>
#include <stdlib.h>

int value = 0;
struct node* taskList = NULL;

void add(char *name, int priority, int burst){
    Task* newTask = (Task*) malloc(sizeof(Task));
    newTask->name = name;
    newTask->priority = priority;
    newTask->burst = burst;
    newTask->tid = __sync_fetch_and_add(&value,1);
    newTask->exec = 0;

    addTask(newTask);
}

void addTask(Task* newTask){
    if(!taskList){
        taskList = malloc(sizeof(struct node));
        taskList->task = newTask;
        taskList->next = NULL;
    } else {
        struct node* temp = taskList;
        while(temp->next && temp->next->task->priority >= newTask->priority)
            temp = temp->next;

        if(temp == taskList && temp->task->priority < newTask->priority){
            taskList = malloc(sizeof(struct node));
            taskList->task = newTask;
            taskList->next = temp;
        }
        else if(!temp->next){
            struct node* newNode = malloc(sizeof(struct node));
            newNode->task = newTask;
            newNode->next = NULL;
            temp->next = newNode;
        }
        else insert(&temp->next,newTask);
    }
}

void schedule(){
    struct node *pivot = taskList;
    while(pivot){
        Task* thisTask = pivot->task;
        int slice = thisTask->burst>QUANTUM? QUANTUM : thisTask->burst;
        run(thisTask, slice);

        delete(&taskList, thisTask);
        if(thisTask->burst > 0)
            addTask(thisTask);
        pivot = pivot->next;
    }
}
```

优先级–轮转调度需要同时考虑两者，则在开始的加入 add 的时候就会对优先级进行排序，然后不断在本优先级轮转，运行完毕后会同样调用 add 函数插入，轮转本优先级后轮转下一优先级，直到所有的任务都被执行完毕。这里插入需要考虑更多的情况，仅仅基于给定的 list 实现方法。该算法在标准集和特集上的运行结果分别如下：





二 Java 语言实现版本

“may be completed in either C or Java”，所以只需要使用一种语言完成即可。

三

1. 增加原子整数的 tid。在 schedule 外添加

```
int value = 0;
```

在新建任务时，添加

```
newTask->tid = __sync_fetch_and_add(&value,1);
```

即可，以上的程序皆按照这种方式修复。运行正常。

2. 为了计算周转时间、等待时间和相应时间，需要修改一些文件的定义。

   添加 task 类型的一个属性 exec 用于计算上一次运行结束的时刻，初始会在相应的初始化阶段被赋值为 0。

Listing 6: src/posix/task.h

```
/**
 * Representation of a task in the system.
 */

#ifndef TASK_H
#define TASK_H

// representation of a task
typedef struct task {
    char *name;
    int tid;
    int priority;
    int burst;
    int exec;
} Task;

#endif
```

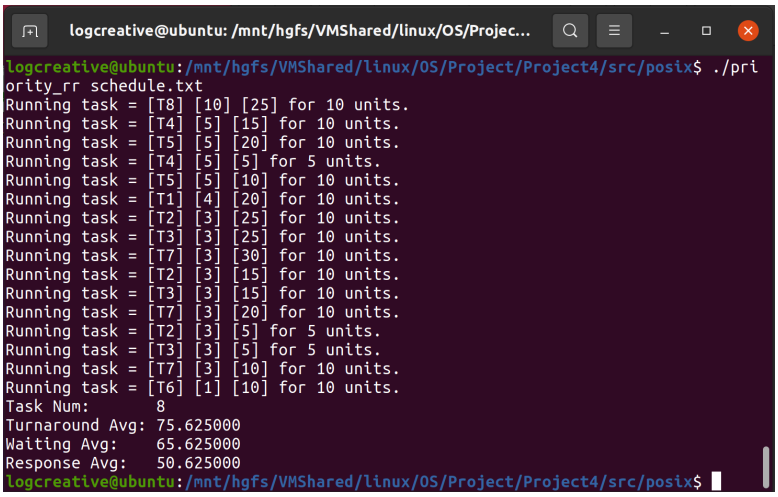
重点修改 CPU 部分的定义。添加 CPU 时钟 clock，当一个任务即将运行的时候，如果从未运行过，也即 exec 是 0，就会添加任务数，并且计入相应时间。等待时间是当前时刻与上一时间片执行完毕时刻的差值。执行完毕后，增加时钟时间，修改剩余时间，赋值该事件片执行结束时间，如果没有剩余时间，就将当前的时钟时间计入周转时间。

Listing 7: src/posix/cpu.c

```
/**
 * "Virtual" CPU that also maintains track of system time.
 */

#include <stdio.h>

#include "task.h"

int clock = 0;

int tasknum = 0;

int turnaround = 0;
int waiting = 0;
int response = 0;

// run this task for the specified time slice
void run(Task *task, int slice) {

    if(task->exec==0){
```

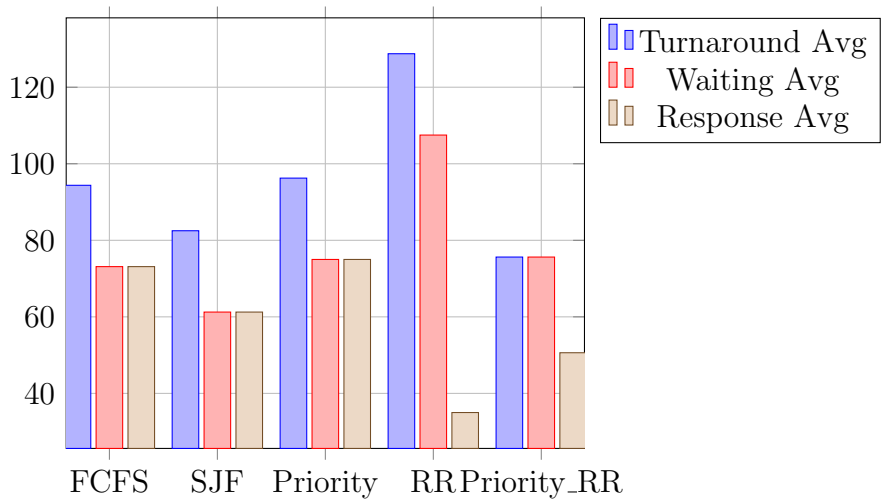
```
        tasknum++;
        response += clock;
    }
    waiting += clock - task->exec;

    printf("Running task = [%s] [%d] [%d] for %d units.\n",task->name, task->priority, task->burst,
         slice);

    clock += slice;
    task->burst -= slice;
    task->exec = clock;
    if(task->burst==0) turnaround += clock;

}

void printAvg(){
    printf("Task Num:\t%d\n", tasknum);
    printf("Turnaround Avg:\t%2f\n", (double) turnaround / tasknum);
    printf("Waiting Avg:\t%2f\n", (double) waiting / tasknum);
    printf("Response Avg:\t%2f\n", (double) response / tasknum);
}
```

修改 driver.c 在 schedule() 结束后调用 printAvg() 函数，打印对应的时间。运行示例如下：



所有的算法在标准集上的结果如下：

算法	周转时间	等待时间	响应时间
FCFS	94.375	73.125	73.125
SJF	82.500	61.250	61.250
优先级	96.250	75.000	75.000
轮转	128.750	107.500	35.000
优先级–轮转	75.625	65.625	50.625


120
100
80
60
40
Turnaround Avg
Waiting Avg
Response Avg
FCFS
SJF
Priority
RR
Priority_RR