ICS143B Project1 Process and Resource Manager - Final Document

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1. Introduction

Design/implement a simplified process and resource manager. The basic operations include create/destroy process, request/release resource, time-out interrupt, I/O processing and schedule processes.

2. Data Structure

a. Process Control Block(PCB)

```
+-----+
| PID |
+-----+
| RList |->|R1|->|R2|->... |Rn|->NULL
+-----+
| Status.Type |, | Status.List |->|N1|->|N2|->... |Nn|->NULL
+-----+
| CreationTree.Parent |->|Parent1|,
| CreationTree.Children |->|Child1|->|Child2|->... |Childn|->NULL
+-----+
| Priority |
+-----+
```

The PCB is a structure having Process ID, Resource List - RList, Process Status, Priority, CreationTree including Parent and Children. “RList” is a pointer to the linked list of resources this PCB is using and is used by the process manager to update the resource usage list. Status.Type indicates the status of the process and Status.list is a pointer to the linked list of “Ready List” when the status is ‘ready’ while it’s a pointer to the linked list of “Waiting List” when the status is ‘wait’. “Parent” is a pointer to the parent process of current process. And “Children” is a pointer to the linked list of the children processes of current process. The creation tree need to be updated when some updates occur in this PCB. “Priority” indicates the priority of this PCB, such as 0, 1 or 2.

b. Resource Control Block(RCB)

```
+-----+
| RName |
+-----+
| Available |, | Used |
+-----+
| Waiting List |->|PCB1|->|PCB2|->... |PCBn|->NULL
+-----+
```

The RCB is a structure having Resource Name, a counter for remaining available resources, a counter for used resources and a pointer named “Waiting List”, which points to the linked list of the PCBs which are waiting to use these resources. Two counters will be updated when the PCB succeeds to request the resources. While the failed PCB will be added to the **end** of the “Waiting List” of this RCB.

c. Ready List(RL)

```
+-----+
| Priority-2 |->|PCB1|->|PCB2|->... |PCBn|->NULL
+-----+
| Priority-1 |->|PCB1|->|PCB2|->... |PCBn|->NULL
+-----+
| Priority-0 |->|PCB1|->|PCB2|->... |PCBn|->NULL
+-----+
```

The RL is a structure having three linked list. Each one maps to a pointer to the Ready List of PCBs in the particular priority. PCB will be added to the **end** of the corresponding linked list when this PCB succeeds to request all the required resources.

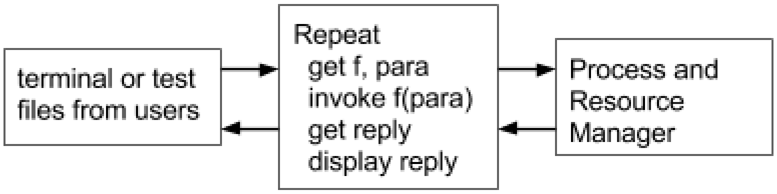
d. Process and Resource Manager(PRManager)

```
+-----+
| Running_Process |->|PCB|
+-----+
| All Resources |->|RCB1|->|RCB2|->... |RCBn|->NULL
+-----+
| Ready List |->|PCB1|->|PCB2|->... |PCBn|->NULL
+-----+
```

The PRManager is a structure having the running process, a pointer to the linked list of all resource and a pointer to the “Ready List”. There is always only one process in the running status. “All Resources” is used to find the particular RCB using rid. The running process can be picked up from “Ready List” when rescheduling.

3. System Architecture

a. Overall Organization


terminal or test files from users
Repeat
get f, para
invoke f(para)
get reply
display reply
Process and Resource Manager

The terminal or test files give the input. **Main function** reads the input command line by line and calls the corresponding function in **Process and Resource Manager(PRManager)** with parameters. After operation, **PRManager** gives reply to **main function**, and then **main function** displays reply to users.

b. Important functions in PRManager:

(1): Create Process

- Describe: create a new PCB data structure, initialize PCB using parameters, link PCB to creation tree, insert new process at the end of the corresponding RL
- Call Hierarchy: PRManager.createProcess(pid) -> new PCB(pid) -> PCB.initiate() -> RL.insert(PCB) -> PRManager.scheduler()
- What data structures may be changed? PRManager.runningProcess(when this PCB has highest priority), PRManager.ReadyList(otherwise)

(2) Destroy Process:

- Describe: find the corresponding PCB using pid, recursive kill the children of this particular PCB and itself including free using resources, delete PCB and update all pointers to this PCB

hint: process can be destroyed by any of its ancestors or by itself (exit).

- Call Hierarchy: PRManager.destroyProcess(pid) -> PRManager.getPCB(pid) -> PCB.killTree(pid) -> RCB.release() -> PRManager->RL.remove(pid) -> PCB.killSelf()-> PRManager.scheduler()
- What data structures may be changed? PRManager.runningProcess, PCBs, RCBs, PRManager.RL

(3) Request Resource:
- Describe: find the corresponding RCB using rid, check its status, (1). if the status is ‘free’, then change this RCB’s status to ‘allocated’ and insert this RCB to the end of RList of current process; (2). otherwise, then change the status of current process to ‘blocked’, remove current process from “Ready List” and insert current process to the “Waiting List” of this RCB. In the end, call rescheduler.
hint: all requests are satisfied in strict FIFO order.
- Call Hierarchy: case1: PRManager.requestResource(rid) -> PRManager.getRCB(rid) -> RCB.status = ‘allocated’ -> PRManager.runningProcess.RList.insert(RCB)
case2: PRManager.requestResource(rid) -> PRManager.getRCB(rid) -> PRManager.runningProcess.status = ‘waiting’ -> PRManager->runningProcess = NIL -> RCB.waitingList.add(PCB) -> PRManager.scheduler()
- What data structures may be changed? PRManager.runningProcess, PRManager->RL, RCB

(4) Release Resource:
- Describe: find the corresponding RCB using rid, remove this RCB from RList of current process. (1). if the “Waiting List” of this RCB is NULL, then change the RCB’s status to ‘free’; (2) otherwise, remove the first process q of RCB’s “Waiting List”, change q->status.type to ‘ready’ and q->status.list pointing to this RCB, remove current process from “Ready List” and insert current process to the “Waiting List” of this RCB. In the end, call rescheduler.
- Call Hierarchy: case1: PRManager.releaseResource(rid) -> PCB.RList.remove(RCB) -> RCB.status = ‘free’
case2: PRManager.releaseResource(rid) -> PCB.RList.remove(RCB) -> RCB.removeFirstFromWaitingList() -> PRManager->RL.add(pid) -> PRManager.scheduler()
- What data structures may be changed? PRManager, PCB.RList, RCB

(5) Scheduler:
- Describe: if some conditions are satisfied, change status of p to running and output the name of the running process.
- Call Hierarchy: PRManager.scheduler() -> PRManager.runningPrcess.change() -> PCB.changeStatus() -> PRManager.RL.add(PCB)
- What data structures may be changed? PRManager.runningProcess, PRManager.RL

(6) Time Out:
- Describe: use this function to simulate time-sharing. Find the running process q, change q->status.type to ‘ready’, insert q into “Ready List”, and call rescheduler finally.
- Call Hierarchy: PRManager.timeOut() -> RL.insert(pid) -> PRManager.scheduler()
- What data structures may be changed? PRManager.runningProcess, PRManager.RL

4. Test Cases/Results

a. Create Process
(1) basic case:

```
shell> cr A 1
*A is running
shell> cr B 2
*B is running
```

```
shell> cr C 1
*B is running
```

(2) create duplicate processes:

```
shell> cr A 1
*A is running
shell> cr A 2
*error
```

b. Destroy Process

(1) basic case:

```
shell> cr A 1
*A is running
shell> de A
*Init is running
```

(2) delete whole tree:

```
shell> cr A 2
*A is running
shell> cr B 1
*A is running
shell> cr C 1
*A is running
shell> de A
*Init is running
```

(3) delete subtree:

```
shell> cr D 1
*D is running
shell> cr A 2
*A is running
shell> cr B 1
*A is running
shell> cr C 1
*A is running
shell> de A
*D is running
```

(4) test if destroy releases the resource

```
shell> cr A 1
*A is running
shell> cr B 1
*A is running
shell> to
*B is running
shell> req R1
*B is running
shell> to
```

```
*A is running
shell> req R1
*B is running
shell> de B
*A is running
```

(5) delete non-existed process

```
shell> cr A 1
*A is running
shell> de B
*error
```

c. Request Resource

(1) basic case:

```
shell> cr A 1
*A is running
shell> req R1
*A is running
shell> cr B 1
*A is running
shell> to
*B is running
shell> req R1
*A is running
```

(2) request more than existed resources

```
shell> cr A 1
*A is running
shell> req R1
*A is running
shell> req R1
*error
```

(3) request non-existed resource

```
shell> cr A 1
*A is running
shell> req R5
*error
```

d. Release Resource

(1) basic case:

```
shell> cr A 1
*A is running
shell> req R1
*A is running
shell> cr B 1
*A is running
shell> to
```

```
*B is running
shell> req R1
*A is running
shell> rel R1
*A is running
shell> to
*B is running
```

(2) release non-existed resource

```
shell> cr A 1
*A is running
shell> rel R1
*error
```

(3) check if context switch to the process with higher priority when release resource to the process with higher priority

```
shell> cr A 1
*A is running
shell> req R1
*A is running
shell> cr B 2
*B is running
shell> req R1
*A is running
shell> rel R1
*B is running
```

e. Time Out

(1) Recycle:

```
shell> cr A 1
*A is running
shell> cr B 1
*A is running
shell> cr C 1
*A is running
shell> to
*B is running
shell> to
*C is running
shell> to
*A is running
```

f. Request IO and IO Completion

```
shell> cr A 1
*A is running
shell> rio
*Init is running
shell> ioc
```

```
*A is running
```

g. Complex Test Case

(1). Sample.txt

```
cr x 2
cr y 1
to
cr z 2
to
req R1
to
req R1
de z
rel R1
de x

init
cr x 1
cr p 1
cr q 1
cr r 1
to
req R2
to
req R3
to
req R4
to
to
req R3
req R4
req R2
to
de q
to
to
quit
```

Result:

```
Init is running
x is running
x is running
x is running
x is running
z is running
z is running
x is running
z is running
```

```
x is running
x is running
Init is running


Init is running
x is running
x is running
x is running
x is running
p is running
p is running
q is running
q is running
r is running
r is running
x is running
p is running
q is running
r is running
x is running
x is running
x is running
p is running
x is running
Process terminated
```

(2). Sample2.txt

```
cr A 1
req R1
cr B 1
to
req R1
cr C 1
to
req R1
cr D 1
rel R1
to
de A
```

Result:

```
Init is running
A is running
A is running
A is running
B is running
A is running
```

```
A is running
C is running
A is running
A is running
A is running
D is running
error
```

(3). Sample3.txt

```
cr A 1
req R1
cr B 1
to
req R1
cr C 1
to
req R1
cr D 1
rel R1
to
to
to
de A
```

Result:

```
Init is running
A is running
A is running
A is running
B is running
A is running
A is running
C is running
A is running
A is running
A is running
D is running
B is running
A is running
Init is running
```

5. Pseudo Code

a.

```
Create(initialization parameters){
        create PCB data structure
        initialize PCB using parameters
        link PCB to creation tree
        insert(RL, PCB, priority)
        Scheduler()
}
insert(RL, PCB, priority){
        find the “Ready List” with the particular priority
        insert this PCB to the end of this linked list
}
```

b.

```
Destroy (pid) {
        p = Get_PCB(pid)
        Kill_Tree(p)
        Scheduler()
}
Kill_Tree(p) {
        for all child processes q Kill_Tree(q){
                Free_Resources()
                delete PCB and update all pointers
        }
}
Get_PCB(pid){
        Search from current process to its children process until getting the pointer p to PCB with the
        particular pid
}
Free_Resources(){
        for all resources in the RList of current process{
                Release(rid)
        }
}
```

c.

```
Request(rid) {
        r = Get_RCB(rid);
        if (r->Status == 'free') {
                r->Status = 'allocated‘;
                insert(self->RList, r);
        }
  } else {
        self->Status.Type = 'blocked';
        self->Status.List = r;
        remove(RL, self);
        insert(r->Waiting_List, self);
        Scheduler();
  }
}
Get_RCB(rid){
        search from All_Resource until getting the RCB with the particular rid
}
```

d.

```
Release(rid) {
    r = Get_RCB(rid);
    remove(self->RList, r);
    if (r->Waiting_List == NIL} {
        r->Status = 'free';
    } else {
        remove(r->Waiting_List, q);
        q->Status.Type = 'ready';
        q->Status.List = RL;
        insert(q->RList, r); //missing in book
        insert(RL, q);
        Scheduler();
    }
}
```

e.

```
Scheduler() {
    find highest priority process p
    if (self->priority < p->priority ||
        self->Status.Type != 'running' ||
        self == NIL)
        preempt(p, self)
}
```

f.

```
Time_out() {
    find running process q;
    remove(RL, q);
    q->Status.Type = 'ready';
    insert(RL, q);
    Scheduler();
}
```

g.

```
Request_IO() {
    self->Status.Type = 'blocked';
    self->Status.List = IO;
    remove(RL, self);
    insert(IO->Waiting_List, self);
    Scheduler();
 }
```

h.

```
IO_completion() {
    remove(IO->Waiting_List, p);
    p->Status.Type = 'ready';
    p->Status.List = RL;
    insert(RL, p);
    Scheduler();
}
```