CS543

Homework #4

SUBMITTED BY:

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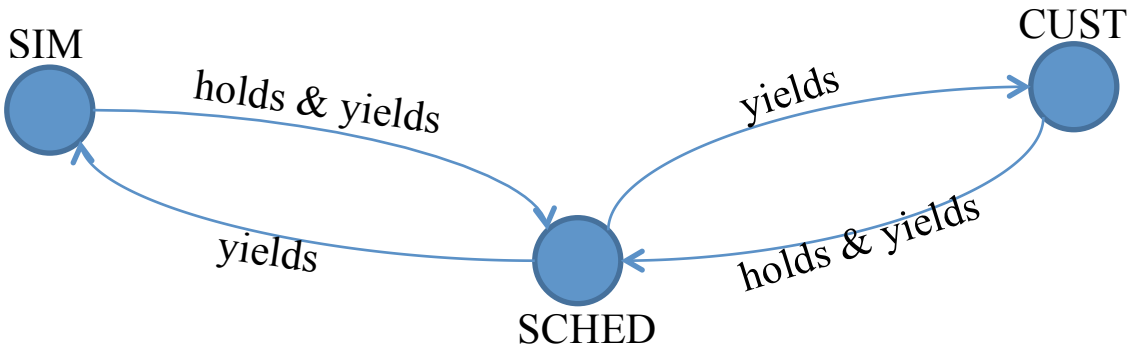
1. Briefly sketch the design of a threads-based discrete-event simulator.

(1) Using pictures, try to explain how the language CSIM implements the transfer of control between "sim" and "cust" in the simulation of the single-server queue.



(2) Explain how the "hold" operation is implemented

Assuming process executing the hold function has activation record E and the current simulation time is E.time = clock. The hold function advance the event occurrence time to t (time to hold) in the future, and insert event E back to the calendar, then yield to the scheduler function.

```
void hold (float t)
{
    E.time = clock + t;
    Insert E in simulation calendar;
    yield (scheduler);
}
```

(3) Explain what you will use as an event-activation record

Activation record E:

E.thread (process which is given control at E.time)
E.time (time of event occurrence)

(4) You will need to provide a "create-wrapper" (to be invoked by the simulator user) which envelopes the actual create primitive, or you will use CSIM's approach and provide a "create" function.

The simulation process:

```
FACILITY f;
EVENT done;
sim ()
{
    int i; float t;
```

```
    create("sim");
    f = facility("facility");
    done = event ("done");
    for (i=0; i<1000; i++) {
        cust ();
        hold(expon(seed, mean));
    }
    wait(done);
    print statistics;
}
cust ()
{
    create("cust");
    reserve(f);
    hold(expon(seed, mean));
    release(f);
    if (cust is #1000)
        set done = true;
}
```

2. Implement a threads-based C-language discrete-event simulator. Use pthreads for this project; you will only need the three basic thread operations:

create(x): create a thread whose name is x

yield(x): yield to thread x

setpri(x; j): set the priority of thread x to an integer j, 1<= j <=2. Note that at any given time only the highest priority thread can run. If x = SELF, the invoking thread sets its own priority.

Write a library of functions that will support a facility with a single server and a fcfs queueing discipline, just as done in CSIM. The facility will support reserve and release methods. Also implement an event with set, clear and wait methods.

Objects:

(1) Calendar – record future activity of threads
(2) Facility – serve the customers
(3) Simevent – only the "done" event in this simulation
(4) Asim – the thread operations

Functions:

(1) Calendar

- init():
  - initialize all the entries in the calendar with a thread id NULL and occur time INF

(2) Facility

- init():

- initialize the facility status into FREE
- empty the waiting list for the facility
- clear the statistics (queue length, delay etc.)

- reserve():
  - if the facility is FREE, change it to OCCUPIED
  - else the thread itself to the waiting list and call yield()
- release():
  - if the waiting list is not empty, extract the first thread on the queue and put it in the calendar
  - else change the facility status to FREE
- notice_arrive():
  - record the current simulation time as the arrival time of the thread
- notice_leave():
  - record the current simulation time as the depart time of the thread
- report():
  - print the statistics (queue length, delay etc.)

(3) Simevent

- init():
  - initialize the event status to 0
- set():
  - set the event status to 1
- clear():
  - set the event status to 0
- wait():
  - busy wait until event status is 1

(4) Asim

- create(funcname):
  - create a thread with function funcname and set its priority to MINPRIO
  - insert the created thread to calendar
- yield (tid):
  - set SELF priority to MINPRIO
  - set tid priority to MAXPRIO
  - call sched_yield()
- setpri (tid, pri):
  - if tid == SELF, set pthread_self() priority to pri
  - else set tid priority to pri
- hold(t):
  - calculate thread_time = simclock + t;
  - insert the SELF thread back into calendar with occur time thread_time
  - yield to scheduler

Simulation Process:

```
main() {
    create the “sim” thread with maximum priority;
    create the “scheduler” thread with maximum priority;
    pthread_join(“sim” thread);
    pthread_join(“scheduler” thread);
    pthread_exit(NULL);
}
```

```
sim() {
    s = new asim;
    f = new facility;
    done = new simevent;
    done->clear();
    for (i = 0; i < NARS; i++) {
        s->create(cust);
        s->hold(IATM);
    }
    done->wait();
    f->report();
}
```

```
cust() {
    f->notice_arrive();
    f->reserve();
    s->hold(SVTM);
    f->release();
    cnt --;
    f->notice_leave();
    if (cnt == 0) {
        done->set();
    }
}
```

```
scheduler() {
    while(1) {
        if (calendar is not empty) {
                remove the thread with earliest time stamp from calendar;
                change the thread’s priority into MAXPRIO;
        }
        sched_yield();
    }
}
```

Simulation Result:

In the demonstration simulation, there are two customers arriving with inter-arrival time 5 and service time 3, the simulation result is shown below:

```
Thread 3078843248 creat thread 3062057840 to excecute cust() at time 0
Thread 3078843248 holds 5
scheduler resumed thread 3062057840 at time 0
Thread 3062057840 arrives at arrtme[0] = 0
thread 3062057840 gets facility at time 0
Thread 3062057840 holds 3
scheduler resumed thread 3062057840 at time 3
thread 3062057840 releases facility at time 3
Thread 3062057840 departs at deptime[0] = 3
scheduler resumed thread 3078843248 at time 5
Thread 3078843248 creat thread 3053665136 to excecute cust() at time 5
Thread 3078843248 holds 5
scheduler resumed thread 3053665136 at time 5
Thread 3053665136 arrives at arrtme[1] = 5
thread 3053665136 gets facility at time 5
Thread 3053665136 holds 3
scheduler resumed thread 3053665136 at time 8
thread 3053665136 releases facility at time 8
Thread 3053665136 departs at deptime[1] = 8
scheduler resumed thread 3078843248 at time 10

=============== Report ===============
Total number of customers served is 2
Mean delay in system is 3
```