Lab2 Report by Enzuo Zhu and Shixun WU

This report describes our work on Lab 2. Section 1, 2, 3 describes our implementation of Part 1, 2, 3, respectively. Here is the link to our video https://drive.google.com/file/d/1tfDxuuGesUYgBNltttsX1xB672o0Gp48/view?usp=sharing.

Enzuo Zhu and Shixun Wu contribute to this project equally.

Part 1:

We first add four int32 variables, namely `tick`, `tickets`, `stride`, and `pass` into the PCB struct as follows:

```
// Per-process state
struct proc {
  struct spinlock lock;

  // p->lock must be held when using these:
  enum procstate state;        // Process state
  void *chan;                  // If non-zero, sleeping on chan
  int killed;                  // If non-zero, have been killed
  int xstate;                  // Exit status to be returned to parent's wait
  int pid;                     // Process ID

  // wait_lock must be held when using this:
  struct proc *parent;         // Parent process

  // these are private to the process, so p->lock need not be held.
  uint64 kstack;               // Virtual address of kernel stack
  uint64 sz;                   // Size of process memory (bytes)
  pagetable_t pagetable;       // User page table
  struct trapframe *trapframe; // data page for trampoline.S
  struct context context;      // swtch() here to run process
  struct file *ofile[NOFILE];  // Open files
  struct inode *cwd;           // Current directory
  char name[16];               // Process name (debugging)
  int num_syscall;

  // Lab2 Schedule
  int tick;
  int tickets;
  int stride;
  int pass;
};
```

These values are initialized in function `allocproc` as follows:

```
found:
  p->pid = allocpid();
  p->state = USED;
  p->num_syscall = 0;
  p->tick = 0;
  p->tickets = 10000;
  #if defined (STRIDE)
  p->stride = 1;
  p->pass = 0;
  #endif
```

The system call `sched_statistics()` and `sched_tickets` are initialized with syscall number `24` and `25`, respectively. The implementations of `sched_statistics()` and `sched_tickets` are as follow:

```
uint64 sys_sched_statistics(void){
  struct proc *p;
  for(p = proc; p < &proc[NPROC]; p++){
     if(p->state == UNUSED)
        continue;
      if(p->state >= 0 && p->state < NELEM(states) && states[p->state])
    printf("%d(%s): tickets: %d, ticks: %d\n", p->pid, p->name, p->tickets, p-
>tick);
  }
  return 0;
}
```

```
#define stride_K 10000
uint64 sys_sched_tickets(void){
  int value_tickets;
  argint(0, &value_tickets);
  if(value_tickets > 10000) return -1;
  struct proc *p = myproc();
  p->tickets = value_tickets;
  #if defined(STRIDE)
  p->stride = stride_K / p->tickets;
  #endif
  return 0;
}
```

Part 2:

We add the following code inside the loop of function `scheduler()` in `proc.h`. We paste our code snippet below.

Lottery Scheduling

Our lottery scheduling has the following logic. First, the total number of tickets among all processes, `tot_tickets`, is computed by looping over the PCB array. After that, a random ticket `rand_lottery` is sampled by calling `rand() % tot_tickets`. Finally, an iteration over processes subtracts `rand_lottery` by the number of tickets of each iterated process until `rand_lottery` is less than zero. The last process in the iteration will be scheduled.

Stride Scheduling

Our stride scheduling first finds the process with the minimum pass. Then we update the pass with the stride of the selected pass and schedule the selected process.

```
void
scheduler(void)
{
  struct proc *p;
  struct cpu *c = mycpu();

  c->proc = 0;
  // int flag = 1;
  for(;;){

    // Avoid deadlock by ensuring that devices can interrupt.
    intr_on();
    // acquire(&proc_lock);
    #if defined(LOTTERY)
    int tot_tickets = 0;
    for(p = proc; p < &proc[NPROC]; p++) {
      acquire(&p->lock);
      if(p->state == RUNNABLE) {
        tot_tickets += p->tickets;
      }
      release(&p->lock);
    }
    // if (flag > 0){printf("LOTTERY\nNumOfTickets::%d\n",tot_tickets);flag--;}
    int rand_lottery = rand();

    rand_lottery = rand_lottery % tot_tickets;
    // int init_lottery = rand_lottery;
    for(p = proc; p < &proc[NPROC]; p++) {

      acquire(&p->lock);
      if(p->state == RUNNABLE) {

        if(rand_lottery < p->tickets){

          p->tick++;
          p->state = RUNNING;
          c->proc = p;
          // printf("pid: %d, ticks: %d\n", p->pid, p->tick);
          // printf("NumOfTickets:%d, init_lottery: %d,, cur_lottery:
%d\n",tot_tickets, init_lottery, rand_lottery);
          swtch(&c->context, &p->context);
```

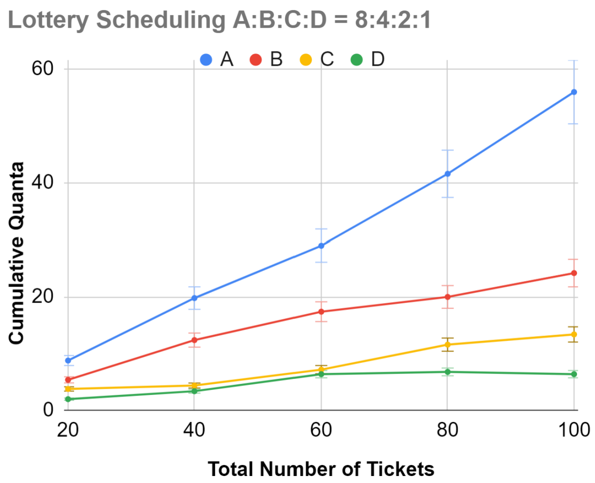
```
          // Process is done running for now.
          // It should have changed its p->state before coming back.
          c->proc = 0;
          release(&p->lock);
          break;
        }
        else{
          rand_lottery -= p->tickets;
        }
      }
      release(&p->lock);
    }

    #elif defined(STRIDE)
    // if (flag > 0){printf("STRIDE\n");flag--;}
    int min_pass = 2147483647;
    for(p = proc; p < &proc[NPROC]; p++) {
      acquire(&p->lock);
      if (p->state == RUNNABLE){
        if (p->pass < min_pass) min_pass = p->pass;
      }
      release(&p->lock);
    }
    for(p = proc; p < &proc[NPROC]; p++) {

      acquire(&p->lock);
      if(p->state == RUNNABLE) {
        if(p->pass == min_pass){

          p->tick++;
          p->pass += p->stride;
          p->state = RUNNING;
          c->proc = p;
          // printf("pid: %d, ticks: %d\n", p->pid, p->tick);
          // printf("NumOfTickets:%d, init_lottery: %d,, cur_lottery:
%d\n",tot_tickets, init_lottery, rand_lottery);
          swtch(&c->context, &p->context);

          // Process is done running for now.
          // It should have changed its p->state before coming back.
          c->proc = 0;
          release(&p->lock);
          break;
        }
      }
      release(&p->lock);
    }
    #else
    for(p = proc; p < &proc[NPROC]; p++) {
      acquire(&p->lock);
      if(p->state == RUNNABLE) {
        // Switch to chosen process.  It is the process's job
        // to release its lock and then reacquire it
```

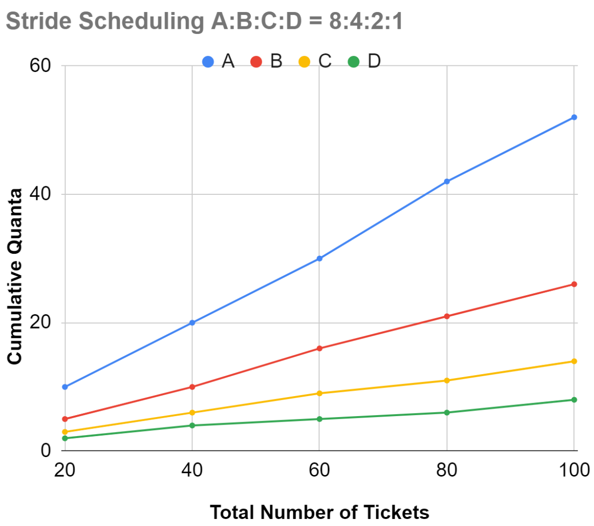
```
            // before jumping back to us.
            // printf("pid: %d, ticks: %d\n", p->pid, p->tick);
            p->tick++;
            p->state = RUNNING;
            c->proc = p;
            swtch(&c->context, &p->context);

            // Process is done running for now.
            // It should have changed its p->state before coming back.
            c->proc = 0;
          }
          release(&p->lock);
        }
      #endif
      // release(&proc_lock);
    }
  }
```

Part 3: Experiments

A:B:C:D = 8:4:2:1

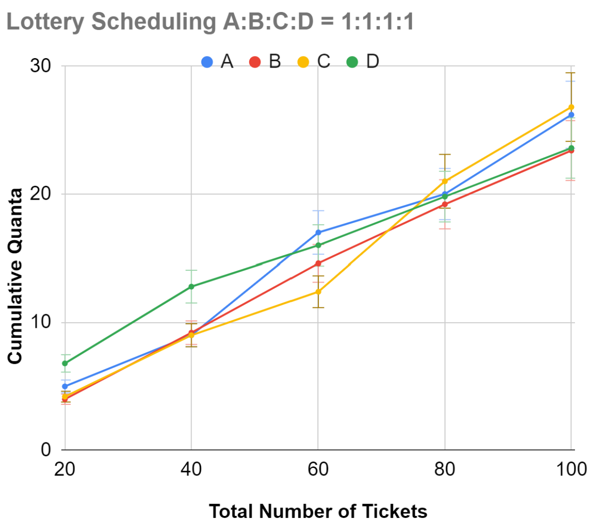
Simulation results for four clients, A, B, C, and D, with a 8:4:2:1 allocation. The following two figures are allocations by randomized lottery scheduler and deterministic stride scheduler. The lottery scheduer shows significant variability while deterministic stride scheduler exhibits precise periodic behavior. The lottery scheduler has high variance for small ticket values.

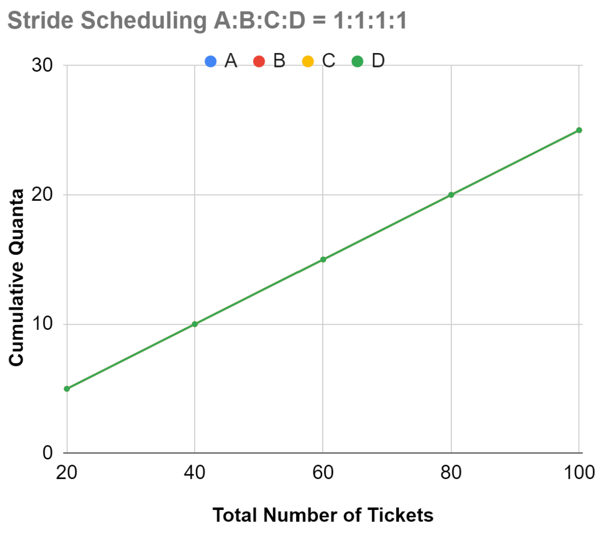




A:B:C:D = 1:1:1:1

Simulation results for four clients, A, B, C, and D, with a 1:1:1:1 allocation. The following two figures are allocations by randomized lottery scheduler and deterministic stride scheduler. The lottery scheduer shows significant variability while deterministic stride scheduler exhibits precise periodic behavior. The lottery scheduler has high variance for small ticket values.


Lottery Scheduling A:B:C:D = 1:1:1:1
A
B
C
D
Cumulative Quanta
0
10
20
30
20
40
60
80
100
Total Number of Tickets


Stride Scheduling A:B:C:D = 1:1:1:1
A
B
C
D
Cumulative Quanta
0
10
20
30
20
40
60
80
100
Total Number of Tickets