Scheduler

Scheduler – in most simple terms

- Selects a process to execute and passes control to it !
  - The process is chosen out of “READY” state processes
  - Saving of context of “earlier” process and loading of context of “next” process needs to happen
- Questions
  - What are the different scenarios in which a scheduler called ?
  - What are the intricacies of “passing control”
  - What is “context” ?

Steps in scheduling scheduling

- Suppose you want to switch from P1 to P2 on a timer interrupt
- P1 was doing

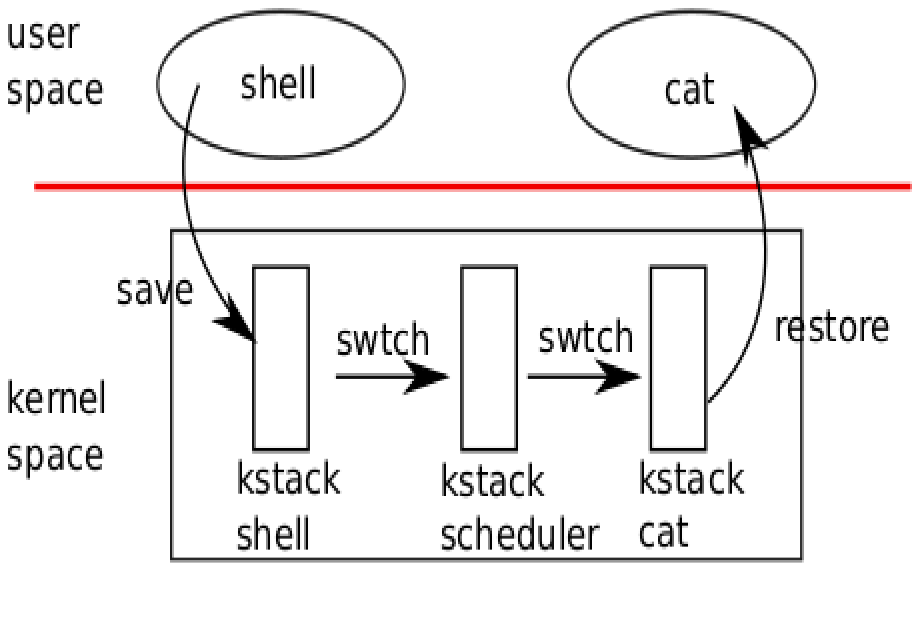
  F() { i++; j++;}

- P2 was doing

  G() { x--; y++; }

- P1 will experience a timer interrupt, switch to kernel (scheduler) and scheduler will schedule P2

4 stacks need to change!



- **User stack of process -> kernel stack of process**
  - **Switch to kernel stack**
  - **The normal sequence on any interrupt !**
- **Kernel stack of process -> kernel stack of scheduler**
  - **Why?**
- **Kernel stack of scheduler -> kernel stack of new process . Why?**
- **Kernel stack of new process -> user stack of new process**

scheduler()

- Disable interrupts
- Find a RUNNABLE process. Simple round-robin!
- c->proc = p
- switchuvm(p) : Save TSS of scheduler’s stack and make CR3 to point to new process pagedir
- p->state = RUNNING
- swtch(&(c->scheduler), p->context)

swtch

```
swtch:
  movl 4(%esp), %eax
  movl 8(%esp), %edx

  # Save old callee-saved registers
  pushl %ebp
  pushl %ebx
  pushl %esi
  pushl %edi

  # Switch stacks
  movl %esp, (%eax)
  movl %edx, %esp

  # Load new callee-saved registers
  popl %edi
  popl %esi
  popl %ebx
  popl %ebp
  ret
```

scheduler()

- swtch(&(c->scheduler), p->context)
- Note that when scheduler() was called, when P1 was running
- After call to swtch() shown above
  - The call does NOT return!
  - The new process P2 given by ‘p’ starts running !
  - Let’s review swtch() again

swtch(old, new)

- The magic function in swtch.S
- Saves callee-save registers of old context
- Switches esp to new-context’s stack
- Pop callee-save registers from new context

  ret

  - where? in the case of first process – returns to forkret() because stack was setup like that !
  - in case of other processes, return where?
    - Return address given on kernel stack. But what’s that?
    - The EIP in p->context
    - When was EIP set in p->context ?

scheduler()

- Called from?
  - mpmain()
  - No where else!
- sched() is another scheduler function !
  - Who calls sched() ?
    - exit() - a process exiting calls sched ()
    - yield() - a process interrupted by timer calls yield()
    - sleep() - a process going to wait calls sleep()

sched()

```
void
sched(void)
{
  int intena;
  struct proc *p = myproc();
  if(!holding(&ptable.lock))
    panic("sched ptable.lock");
  if(mycpu()->ncli != 1)
    panic("sched locks");
  if(p->state == RUNNING)
    panic("sched running");
  if(readeflags()&FL_IF)
    panic("sched interruptible");
  intena = mycpu()->intena;
  swtch(&p->context, mycpu()->scheduler);
/*A*/  mycpu()->intena = intena;
}
```

- get current process
- Error checking code (ignore as of now)
- get interrupt enabled status on current CPU (ignore as of now)
- call to swtch
  - Note the arguments’ order
  - p->context first, mycpu()->scheduler second
- swtch() is a function call
  - pushes address of */*A*/* on stack of current process p
  - switches stack to mycpu()->scheduler. Then pops EIP from that stack and jumps there.
  - when was mycpu()->scheduler set? Ans: during scheduler()!

sched() and schduler()

sched() {

...

  swtch(&p->context, mycpu()->scheduler); /* X */

}

scheduler(void) {

...

    swtch(&(c->scheduler), p->context); / * Y */

}

- scheduler() saves context in c->scheduler, sched() saves context in p->context
- after swtch() call in sched(), the control jumps to Y in scheduler
  - Switch from process stack to scheduler's stack
- after swtch() call in scheduler(), the control jumps to X in sched()
  - Switch from scheduler's stack to new process's stack
- Set of co-operating functions

sched() and scheduler() as co-routines

- In sched()

  swtch(&p->context, mycpu()->scheduler);

- In scheduler()

  swtch(&(c->scheduler), p->context);

- These two keep switching between processes
- These two functions work together to achieve scheduling
- Using asynchronous jumps
- Hence they are co-routines

To summarize

- On a timer interrupt during P1
  - trap() is called. Stack has changed from P1's user stack to P1's kernel stack
  - trap()->yield()
  - yield()->sched()
  - sched() -> swtch(&p->context, c->scheduler()
  - Stack changes to scheduler's kernel stack.
  - Switches to location "Y" in scheduler().
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- Now the loop in scheduler()
  - calls switchkvm()
  - Then continues to find next process (P2) to run
  - Then calls switchuvm(p): changing the page table to the P2's page tables
  - then calls swtch(&c->scheduler, p2's->context)
  - Stack changes to P2's kernel stack.
  - P2 runs the last instruction it was was in ! Where was it?
    - mycpu()->intena = intena; in sched()
    - Then returns to the one who called sched() i.e. exit/sleep, etc
    - Finally returns from it's own "TRAP" handler and returns to P2's user stack and user code