CS 3305A

CPU Scheduling – Multiprocessor

Lecture 11

Oct 21 2019

Multiple-Processor Scheduling

- So far, we've only dealt with a single processor
- CPU scheduling more complex when multiple CPUs are involved

Multiple-Processor Scheduling

- Asymmetric multiprocessing (master)
- There is one processor that makes the decisions for
  - Scheduling, I/O processing, system activities
  - Other processor(s) execute only user code.
- This is a simple approach due to master-slave model / centralized command model
- Master CPU: Load sharing

Multiple-Processor Scheduling

- Symmetric Multiprocessing (SMP)
- Here, each processor is self-scheduling.
- Share a common ready queue or each processor may have its own private queue of ready processes.
- Most modern operating systems support SMP including Windows XP, Solaris, Linux, and Mac OS X.

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Process Synchronization - I

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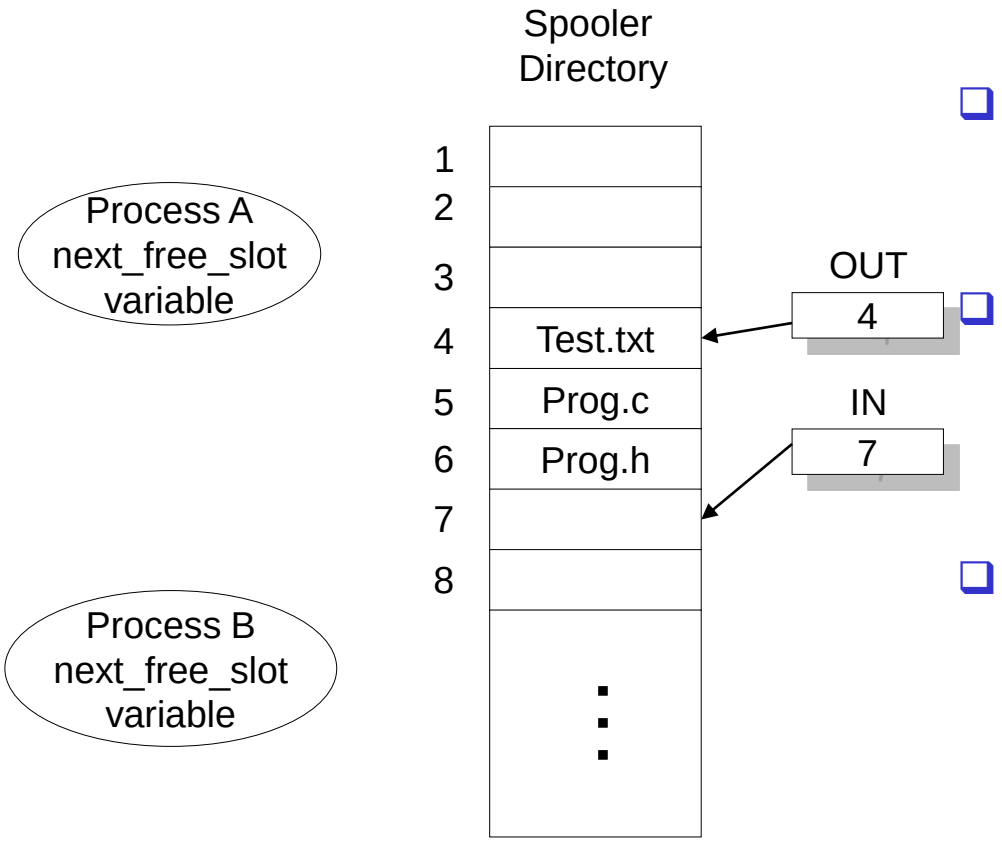
Process Synchronization

- Race Condition
- Critical Section
- Mutual Exclusion
- Peterson's Solution
- Disabling Interrupts
- Test and Lock Instruction (TSL)
- Semaphores
- Deadlock

Race Condition Example (1)

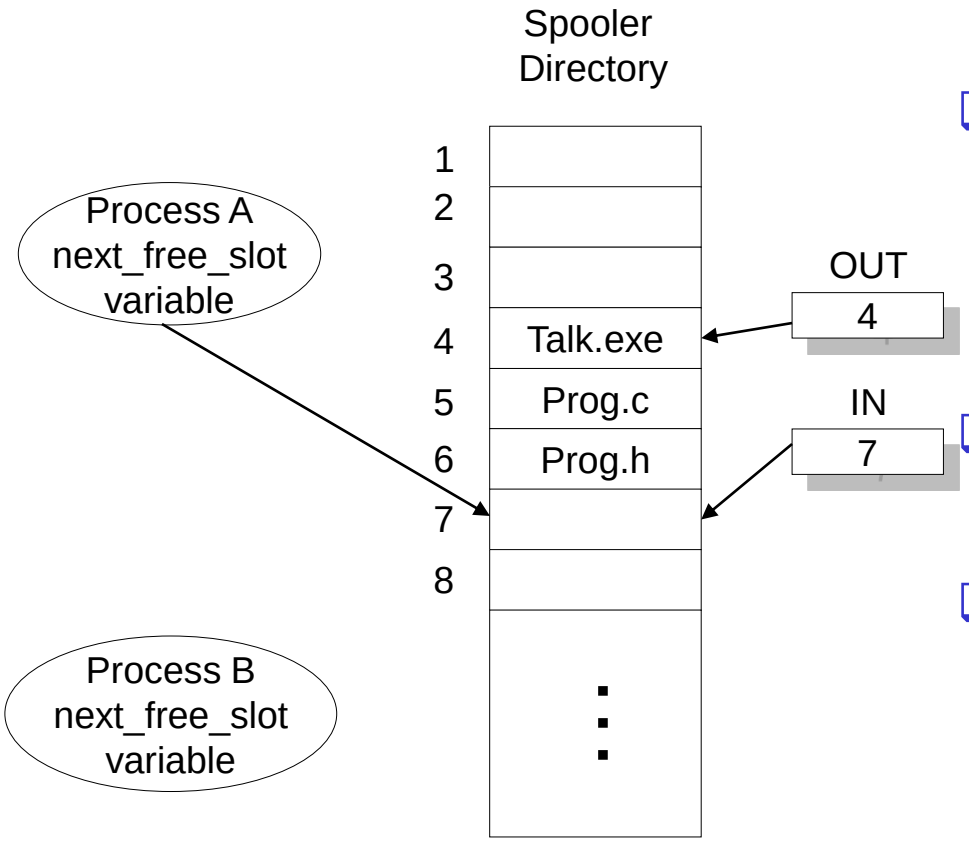
- Assume a spooler directory array (in shared memory) has a number of slots
  - Numbered 0, 1, 2…
  - Each slot has a file name
- Two other variables:
  - In points to the first empty slot where a new filename can be entered.
  - Out points to the first non-empty slot, from where the spooler will read a filename and print the corresponding file.

Race Condition Example (1)



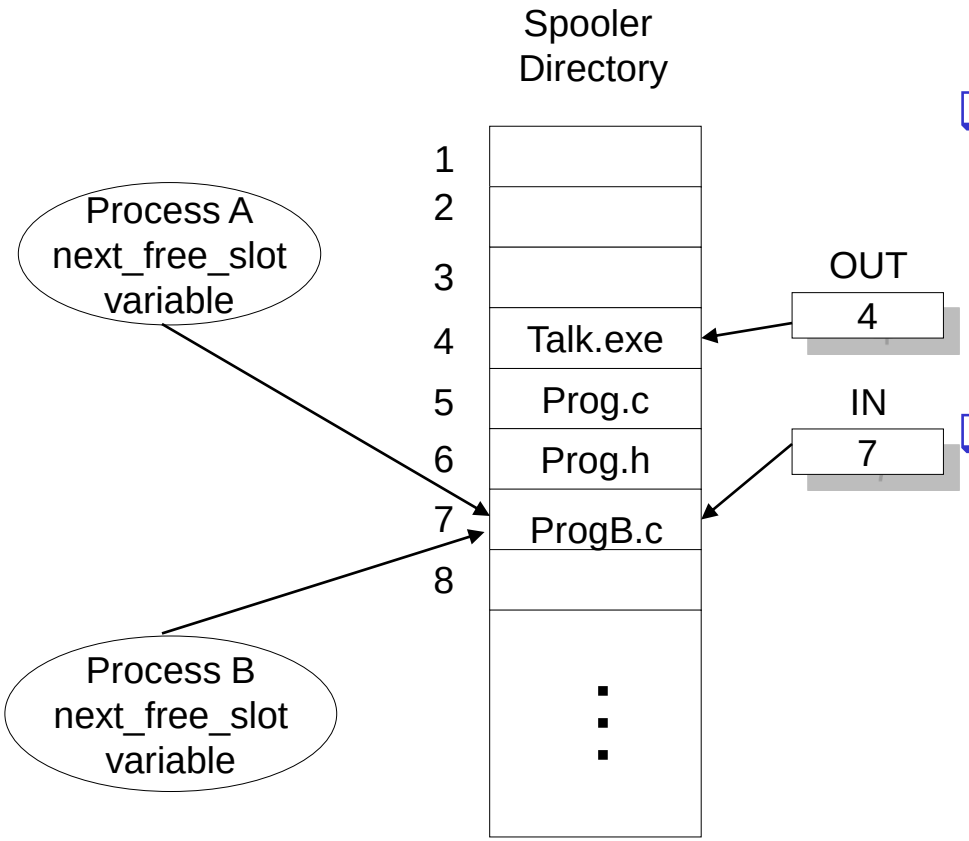
- Slots 1,2,3 are empty indicating the files in those slots have printed
- Each process has a local variable next_free_slot representing an empty slot
- Assume both process A and B want to print files.
  - Each wants to enter the filename into the first empty slot in spooler directory

Race Condition Example (1)



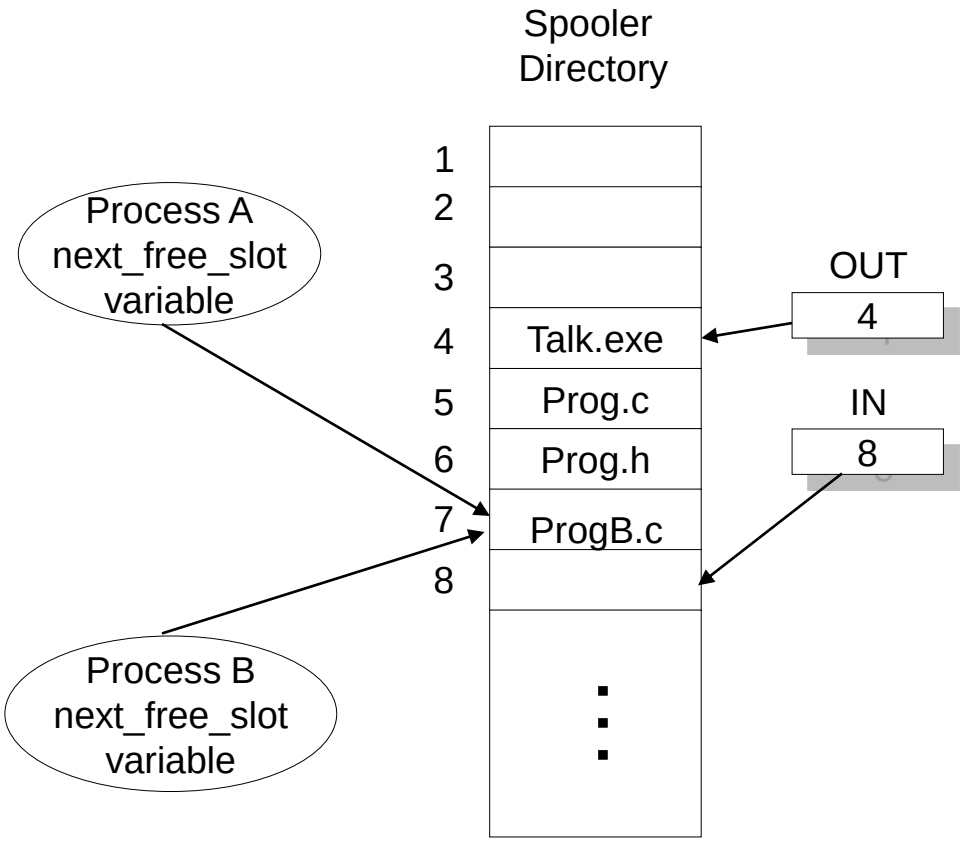
- Process A reads IN and stores the value 7 in its local variable, next_free_slot
- Process A's time quanta expires
- Process B is picked as the next process to run

Race Condition Example (1)



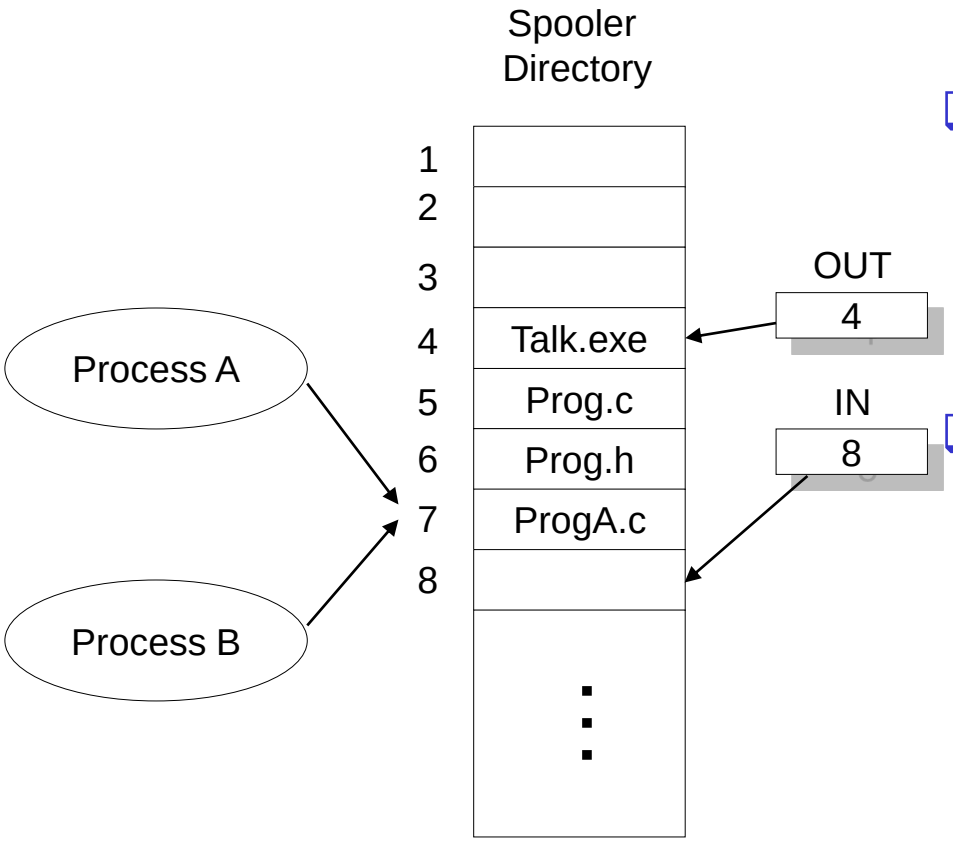
- Process B reads IN and stores the value 7 in its local variable, next_free_slot
- Process B writes a filename to slot 7

Race Condition Example (1)



- Process B then updates the In variable to 8
- Process A now gets control of the CPU

Race Condition Example (1)



- Process A writes its filename to slot 7 which erases process B's filename.
- Process B does not get its file printed.

Race Condition (2)

- Application: Withdraw money from a bank account
- Two requests for withdrawal from the same account comes to a bank from two different ATM machines
- A thread for each request is created
- Assume a balance of $1000

Race Condition (2)

```
bank_example (account, amount_to_withdraw)
{
    1.    balance = get_balance(account);

    2.    if (balance => amount_to_withdraw)
                  withdraw_authorized();
          else
                  withdraw_request_denied()

    3.    balance = balance – amount_to_withdraw;
}
```

What happens if both processes request that $600 be withdrawn?

Race Condition (2)

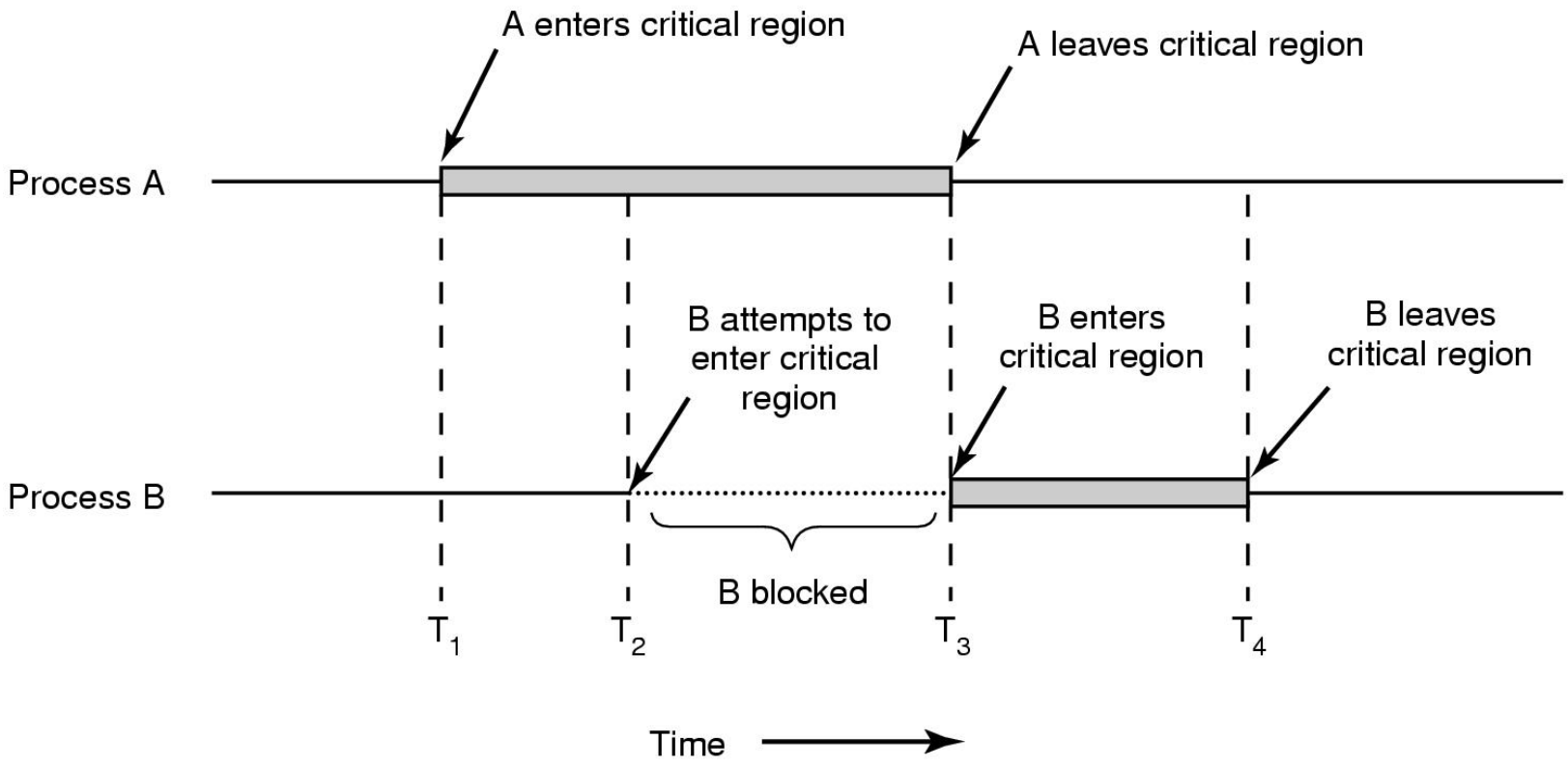
Process / Thread 1	Process / Thread 2
1. Read balance: $1000	
2. Withdraw authorized for $600 (now actual balance is $400)	
CPU switches to process 2→	3. Read Balance $1000
	4. Withdraw authorized for $600 (this is unreal!!)
5. Update balance $1000-$600 = $400	← CPU switches to process 1
CPU switches to process 2→	6. Update balance $400-$600 = $-200

Critical Sections and Mutual Exclusion

- A critical section is any piece of code that accesses shared data
  - Printer example: In, Out variables are shared
  - Bank account: Balance is shared

- Mutual exclusion ensures that only one thread/process accesses the critical section at a time i.e., No two processes simultaneously in critical section!

Mutual Exclusion in Critical Sections



General structure for Mutual Exclusion

```
Do {
        entry section
                critical section
        exit section
                remainder section
} while(1)
```