Amirkabir University of Technology
(Tehran Polytechnic)

Operating Systems

Processes-Part3

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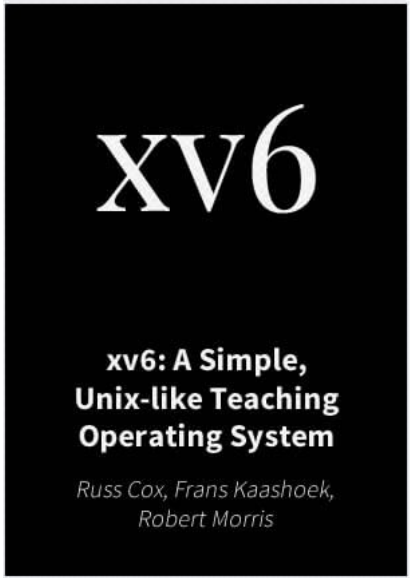
Course logistics

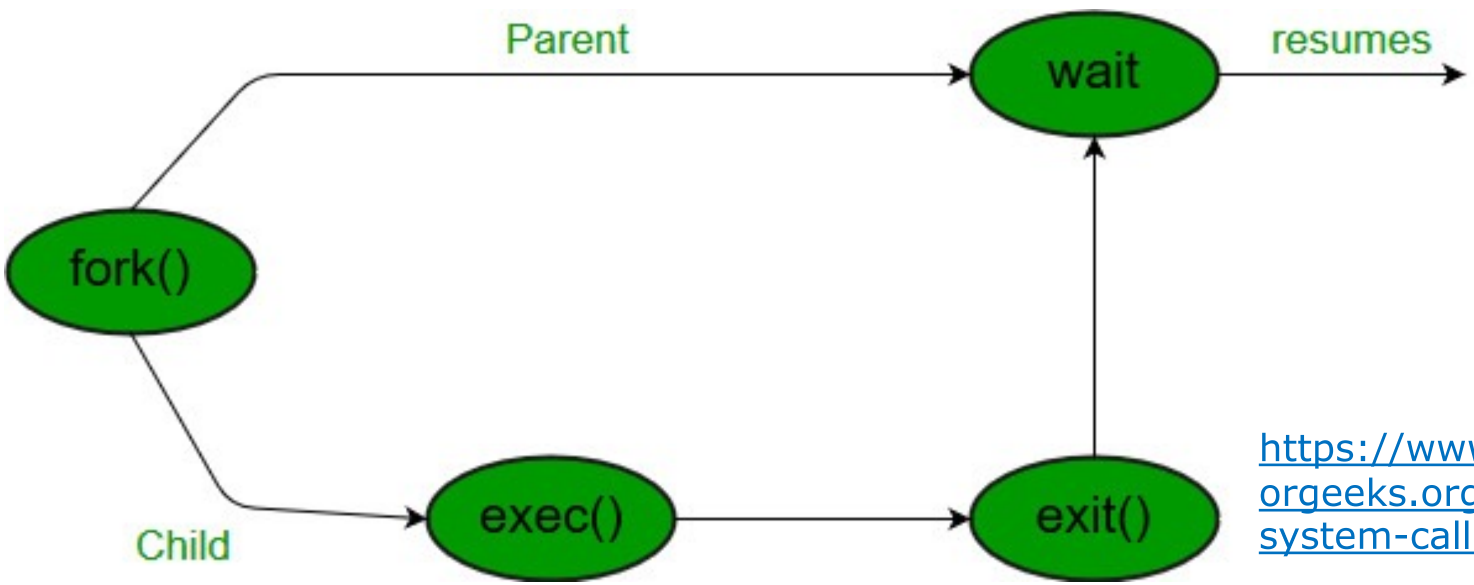
- You have **less than a week** to complete
  - Phase 1 of the project
  - Your first homework



- We will have an extra session on fork
  - The session is handled by TAs
  - It covers both theoretical aspects and how use fork in practice
  - Most probably at coming Thursday

Process Termination

- Process executes last statement and then asks the operating system to ***delete it*** using the **`exit()`** system call.
  - Returns status data from child to parent (via **`wait()`**)
  - Process' resources are deallocated by operating system.



https://www.geeksforgeeks.org/wait-system-call-c/

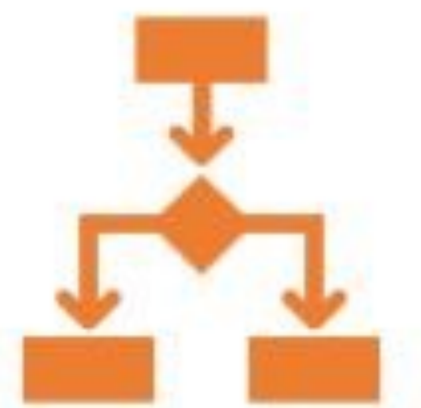
Process Termination (cont.)

- Parent may terminate the execution of children processes using the **`abort()`** system call.

- Some reasons for doing so:
  - Child has exceeded allocated resources.
  - Task assigned to child is no longer required.
  - The parent is exiting, and the operating systems does not allow a child to continue if its parent terminates.

Process Termination (cont.)

- Some OSs do not allow child to ***exists*** if its parent has terminated.
  - If a process terminates, then all its children must also be terminated.
  - **Cascading termination:** All children, grandchildren, etc., are terminated.
  - The termination is initiated by the operating system.



Process Termination (cont.)

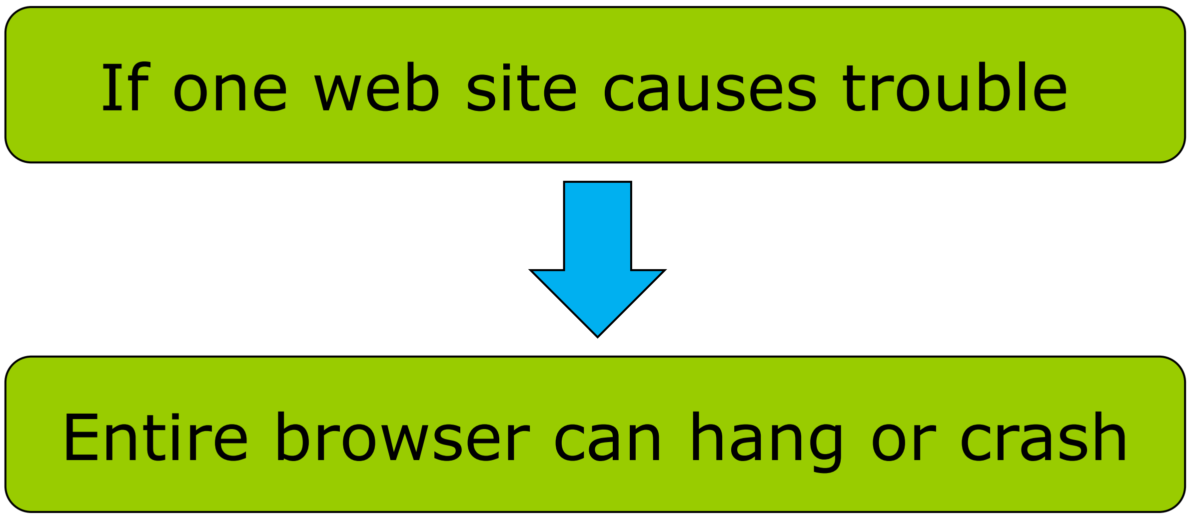
- The parent process may wait for termination of a child process by using the ***wait()*** system call.
  - The call returns status information and the pid of the terminated process.

pid = wait(&status);

- If no parent waiting (did not invoke wait()), process is a zombie.
- If parent terminated without invoking wait(), process is an orphan.

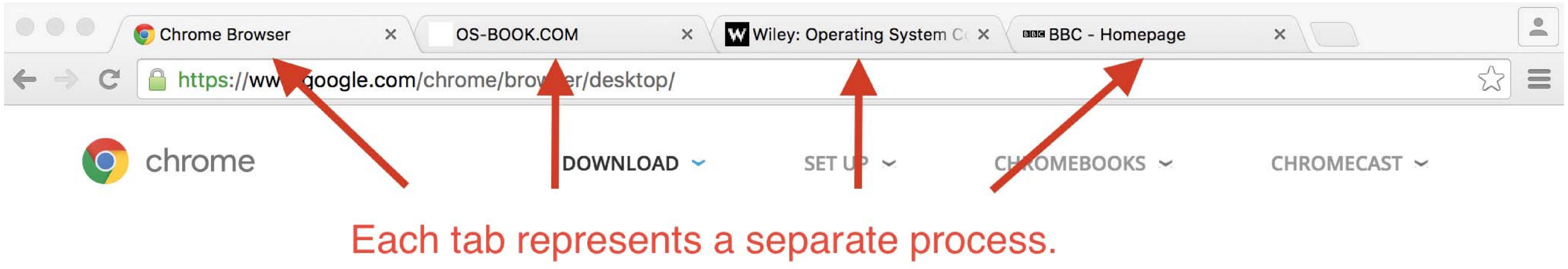
Multiprocess Architecture – Browser

- Many web browsers ran as single process (some still do)



Multiprocess Architecture – Chrome Browser (cont.)

- Google Chrome is multiprocess with 3 different types of processes:
  - Browser process manages user interface, disk and network I/O.
  - Renderer process renders web pages, deals with HTML, Javascript.
    - A new renderer created for each website opened
    - Runs in sandbox restricting disk and network I/O (why?)
  - Plug-in process for each type of plug-in.



Inter-Process Communication

- Processes within a system may be ***independent*** or ***cooperating***
- Cooperating process can affect or be affected by other processes, including ***sharing data***.
- Reasons for cooperating processes:
  - Information sharing
  - Computation speedup
  - Modularity
  - Convenience

Inter-Process Communication (Cont.)

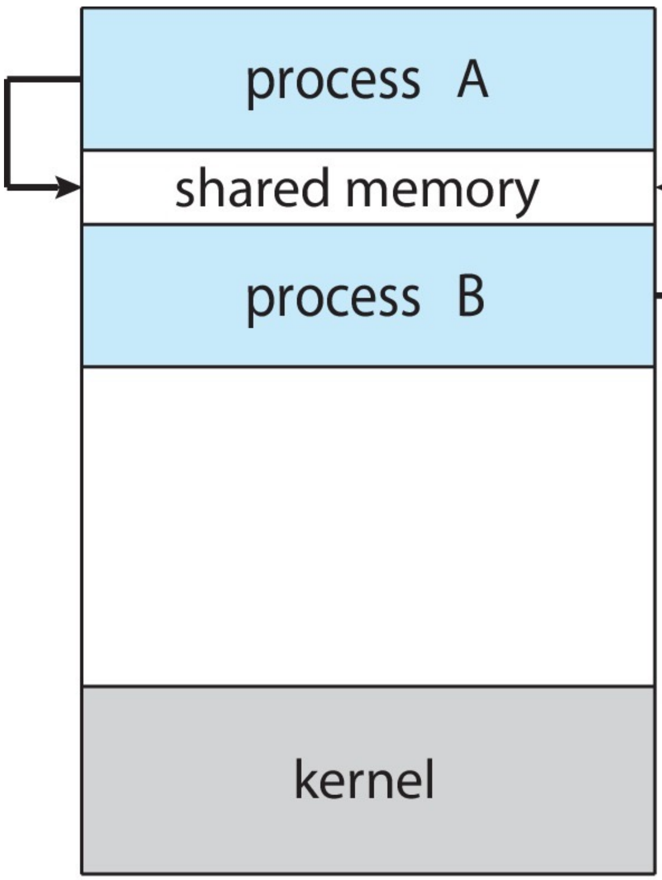
- Cooperating processes need interprocess communication (IPC)

- Two models of IPC
  - **Shared memory**
  - **Message passing**
    - **We do not cover this.**

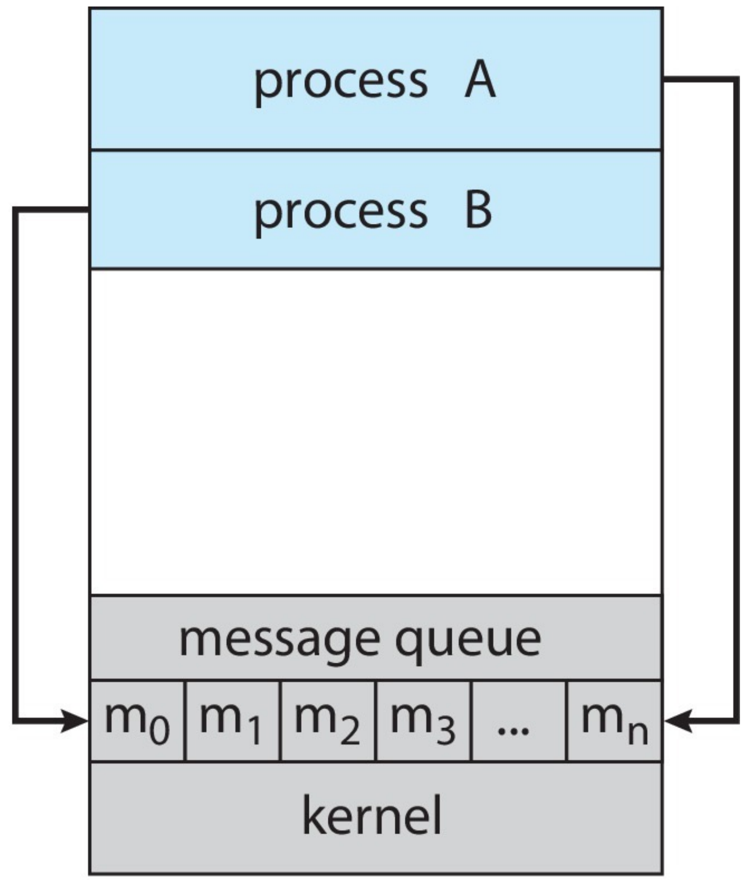
Communications Models

(a) Shared memory.

(b) Message passing.



(a)



(b)

Producer-Consumer Problem

- Paradigm for cooperating processes:
  - **Producer** process produces information that is consumed by a **consumer** process.

- Two variations:
  - **Unbounded-buffer** places no practical limit on the size of the buffer:
    - Producer never waits
    - Consumer waits if there is no buffer to consumer
  - **Bounded-buffer** assumes that there is a fixed buffer size
    - Producer must wait if all buffers are full
    - Consumer waits if there is no buffer to consume

IPC – Shared Memory

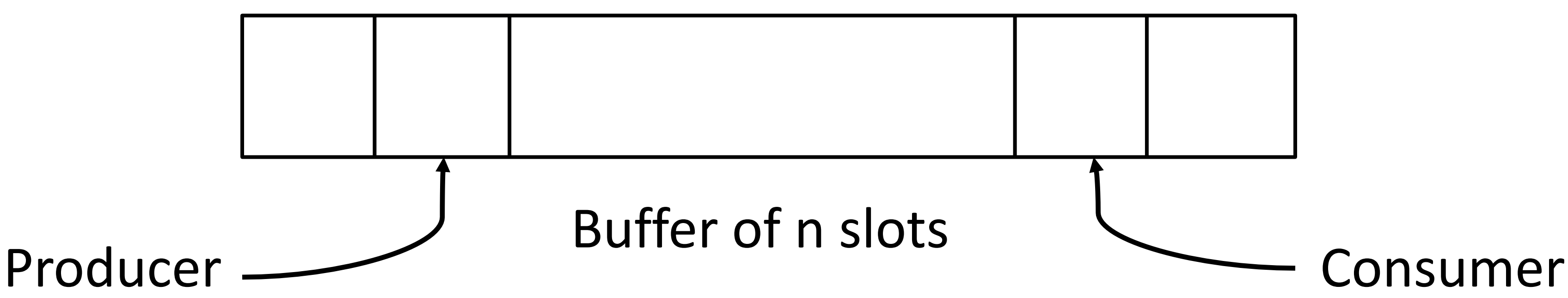
- An area of memory shared among the processes that wish to communicate.
- The communication is ***under the control of the users*** processes ***not the operating system***.
- Major issues is to provide mechanism that will allow the user processes ***to synchronize their actions*** when they access shared memory.
- Synchronization is discussed in great details in Chapters 6 & 7.

Bounded-Buffer – Shared-Memory Solution

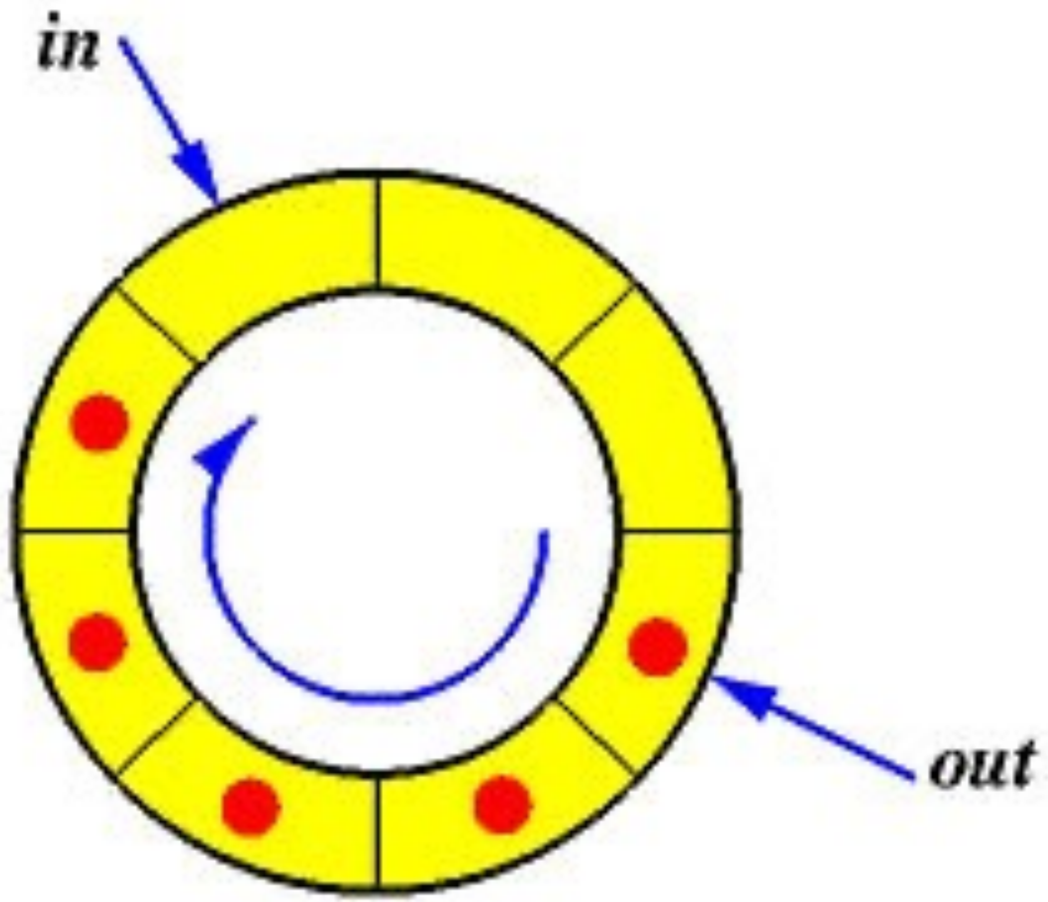
- Shared data

```
#define BUFFER_SIZE 10
typedef struct {
  . . .
} item;
item buffer[BUFFER_SIZE];
int in = 0;
int out = 0;
```

- Solution is correct but can only use **BUFFER_SIZE - 1** elements.



Circular Bounded-Buffer



Source: https://pages.mtu.edu/~shene/NSF-3/e-Book/SEMA/TM-example-buffer.html

Producer Process – Shared Memory

```
item next_produced;

while (true) {
   /* produce an item in next produced */
   while (((in + 1) % BUFFER_SIZE) == out)
      ; /* do nothing */
   buffer[in] = next_produced;
   in = (in + 1) % BUFFER_SIZE;
}
```

Consumer Process – Shared Memory

```
item next_consumed;

while (true) {
      while (in == out)
            ; /* do nothing */
      next_consumed = buffer[out];
      out = (out + 1) % BUFFER_SIZE;

      /* consume the item in next consumed */
}
```

What about Filling all the Buffers?

- Suppose that we wanted to provide a solution to the consumer-producer problem that **fills all the buffers.**

- How can we do it?

What about Filling all the Buffers? (ont.)

- We can do so by having ***an integer counter*** that keeps track of the number of full buffers.
- Initially, counter is set to 0.
- The integer counter is incremented by the producer after it produces a new buffer.
- The integer counter is decremented by the consumer after it consumes a buffer.

Producer

```
while (true) {
     /* produce an item in next produced */

     while (counter == BUFFER_SIZE)
          ; /* do nothing */
     buffer[in] = next_produced;
     in = (in + 1) % BUFFER_SIZE;
     counter++;
}
```

Consumer

```
while (true) {
      while (counter == 0)
            ; /* do nothing */
      next_consumed = buffer[out];
      out = (out + 1) % BUFFER_SIZE;
          counter--;
      /* consume the item in next
consumed */
}
```

Race Condition

- **counter++** could be implemented as

```
register1 = counter
register1 = register1 + 1
counter = register1
```

- **counter--** could be implemented as

```
register2 = counter
register2 = register2 - 1
counter = register2
```

Race Condition (cont.)

- Consider this execution interleaving with "count = 5" initially:

```
S0: producer execute register1 = counter          {register1 = 5}
S1: producer execute register1 = register1 + 1  {register1 = 6}
S2: consumer execute register2 = counter          {register2 = 5}
S3: consumer execute register2 = register2 - 1  {register2 = 4}
S4: producer execute counter = register1          {counter = 6 }
S5: consumer execute counter = register2          {counter = 4}
```

Race Condition (cont.)

Question – why was there no race condition in the first solution (where at most N – 1) buffers can be filled?

More in Chapter 6.