CS343 Operating Systems

Lecture 8

Inter Process Communication

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Process Management

- Creating and deleting both user and system processes
- Suspending and resuming processes (context switching, scheduling)
- Providing mechanisms for process communication
- Providing mechanisms for process synchronization
- Providing mechanisms for deadlock handling

Process Creation

- **Parent** process create **children** processes, which, in turn create other processes, forming a **tree** of processes
- Process identified and managed via a **process identifier** (**pid**)
- Resource sharing options
  - Parent and children share all resources
  - Children share subset of parent's resources
  - Parent and child share no resources
- Execution options
  - Parent and children execute concurrently
  - Parent waits until children terminate

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
  - Process' resources are deallocated by operating system
- Parent may terminate the execution of children processes using the `abort()` system call during following cases.
  - 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

- Some OS do not allow child to exists if its parent has terminated.
- **Cascading termination:** If a process terminates, then all its children, grand children, etc. must also be terminated.
- 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**

Context Switch

- When CPU switches to another process, the system must save the state of the old process and load the saved state for the new process via a **context switch**
- **Context** of a process represented in the PCB
- Context-switch time is overhead; the system does no useful work while switching
- Time dependent on hardware support

Multitasking in Mobile Systems

- Some mobile systems allow only one process to run, others suspended
- Due to screen space limits, user interface limits OS support for
  - **Single foreground process-** controlled via user interface
  - **Multiple background processes**– in memory, running, but not on the display, and with limits
  - Limits include single, short task, receiving notification of events, specific long-running tasks like audio playback

Multi-process Application

- Many web browsers ran as single process (some still do)
  - If one web site causes trouble, entire browser can hang or crash

- Google Chrome Browser is multiprocess with 3 types of processes:
  - **Browser** process manages user interface, disk and network I/O
  - **Renderer** process renders web pages, deals with HTML, Javascript.
  - **Plug-in** process for each type of plug-in

Process Management

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- Providing mechanisms for process synchronization
- Providing mechanisms for deadlock handling

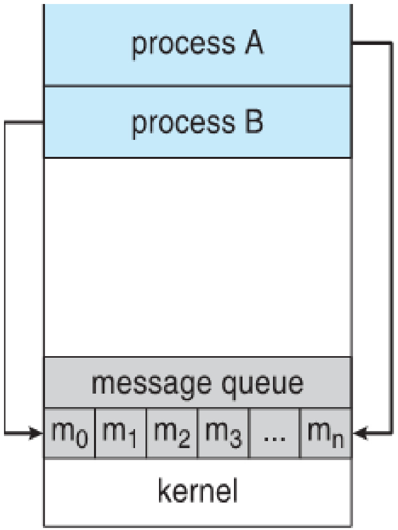
Inter-process Communication

- Processes within a system may be **independent** or **cooperating**
- **Independent process** cannot affect or be affected by the execution of another process
- **Cooperating process** can affect or be affected by other processes, including sharing data
- Reasons for cooperating processes:
  - Information sharing
  - Computation speedup
  - Modularity
  - Convenience

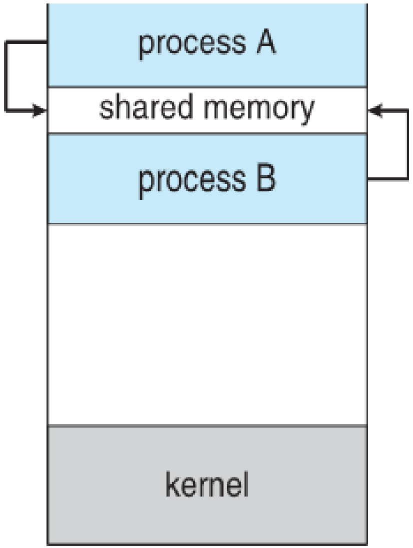
Communications Models

- Cooperating processes need **Interprocess communication** (**IPC**)
- Two models of IPC:

Message passing

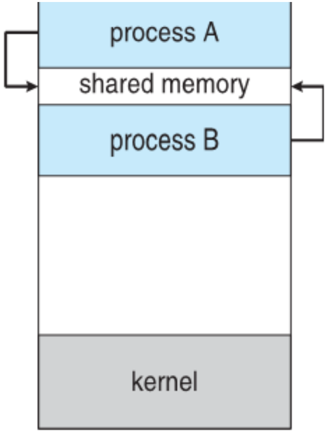


Shared memory



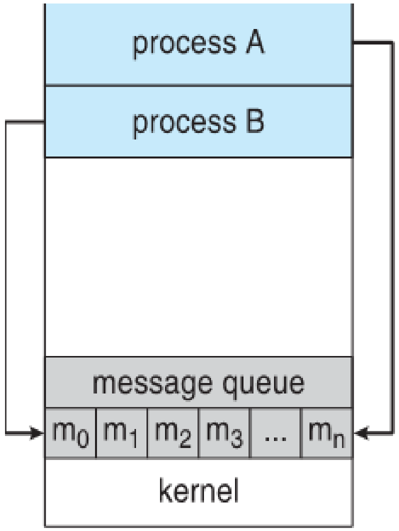
IPC – Shared Memory

- 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.



IPC – Message Passing

- Mechanism for processes to communicate and to synchronize their actions
- Message system – processes communicate with each other without resorting to shared variables
- IPC facility provides two operations:
  - **send**(message)
  - **receive**(message)
- The message size is either fixed or variable



IPC – Message Passing

- If processes P and Q wish to communicate, they need to:
  - Establish a communication link between them
  - Exchange messages via send/receive
- Implementation issues:
  - How are links established?
  - Can a link be associated with more than two processes?
  - How many links between a pair of communicating processes?
  - What is the capacity of a link?
  - Unidirectional or bi-directional link?
  - Is the size of a message in the link fixed or variable?

Direct Communication

- Processes must name each other explicitly:
  - **send** (P, message) – send a message to process P
  - **receive**(Q, message) – receive a message from process Q
- Properties of communication link
  - Links are established automatically
  - A link is associated with exactly one pair of communicating processes
  - Between each pair there exists exactly one link
  - The link may be unidirectional, but is usually bi-directional

Indirect Communication

- Messages are directed and received from mailboxes
  - Each mailbox has a unique id
  - Processes can communicate only if they share a mailbox
- Properties of communication link
  - Link established only if processes share a common mailbox
  - A link may be associated with many processes
  - Each pair of processes may share several communication links
  - Link may be unidirectional or bi-directional

Indirect Communication

- Operations
  - create a new mailbox (port)
  - send and receive messages through mailbox
  - destroy a mailbox
- Primitives are defined as:
- **send**(A, message) – send a message to mailbox A
- **receive**(A, message) – receive a message from mailbox A

Synchronization

- Message passing may be either blocking or non-blocking
- **Blocking** is considered **synchronous**
  - **Blocking send** -- the sender is blocked until the message is received
  - **Blocking receive** -- the receiver is blocked until a message is available

Synchronization

- Message passing may be either blocking or non-blocking
- **Non-blocking** is considered **asynchronous**
  - **Non-blocking send** -- the sender sends the message and continue
  - **Non-blocking receive** -- the receiver receives:
    - A valid message, or
    - Null message

Buffering

- Queue of messages attached to the link.
- Implemented in one of three ways

1. Zero capacity – no messages are queued on a link.
   Sender must wait for receiver
2. Bounded capacity – finite length of *n* messages
   Sender must wait if link full
3. Unbounded capacity – infinite length
   Sender never waits

Objectives of Process Synchronization

- To introduce the concept of process synchronization.
- To introduce the critical-section problem, whose solutions can be used to ensure the consistency of shared data
- To present both software and hardware solutions of the critical-section problem
- To examine several classical process-synchronization problems
- To explore several tools that are used to solve process synchronization problems

Producer-Consumer Problem

- Paradigm for cooperating processes, producer process produces information that is consumed by a consumer process
  - **unbounded-buffer** places no practical limit on the size of the buffer
  - **bounded-buffer** assumes that there is a fixed buffer size

Bounded-Buffer – Producer & Consumer

```
item buffer[BUFFER_SIZE]; int in = 0; int out = 0;
```

Producer

```
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

```
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 */

 }
```

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