CS 537
Lecture 4
Inter-Process Communication

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Notes

- Homework 1 due today in class, on paper
- Quiz 1 will be next Tuesday at the beginning of section
  - probably 3 questions
  - Covers up until today's lecture
    - hardware support for OS
    - system calls
    - processes
    - one question will be from book
  - Book material in first two reading assignments

Project Questions

- How was project 0?
- What was easy?
- What was hard?
- What can I teach you about?

Questions for this Lecture

- How can multiple processes cooperate?

Interprocess Communication (IPC)

- To cooperate usefully, threads must communicate with each other
- How do processes and threads communicate?
  - Shared Memory
  - Message Passing
  - Signals

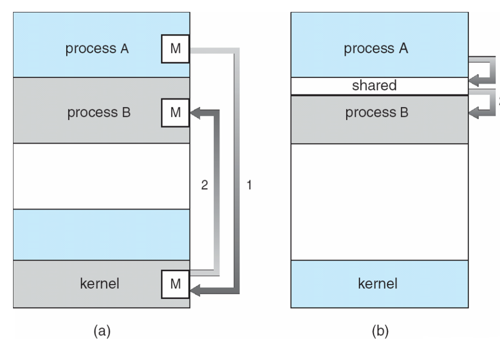
Interprocess Communication

- 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
- Cooperating processes need **interprocess communication** (**IPC**)
- Two models of IPC
  - Shared memory
  - Message passing

Cooperating Processes

- **Independent** process cannot affect or be affected by the execution of another process
- **Cooperating** process can affect or be affected by the execution of another process
- Advantages of process cooperation
  - Information sharing
  - Computation speed-up
  - Modularity
  - Convenience

Communications Models



IPC: Shared Memory

- Processes
  - Each process has private address space
  - Explicitly set up shared memory segment within each address space
- Threads
  - Always share address space (use heap for shared data)
- Advantages
  - Fast and easy to share data
- Disadvantages
  - Must **synchronize** data accesses; error prone
- Synchronization: Topic for end of semester

IPC: Signals

- Signal
  - Software interrupt that notifies a process of an event
  - Examples: SIGFPE, SIGKILL, SIGUSR1, SIGSTOP, SIGCONT
- What happens when a signal is received?
  - Catch: Specify signal handler to be called
  - Ignore: Rely on OS default action
    - Example: Abort, memory dump, suspend or resume process
  - Mask: Block signal so it is not delivered
    - May be temporary (while handling signal of same type)
- Disadvantage
  - Does not specify any data to be exchanged
  - Complex semantics with threads
  - Not implemented in Windows

IPC: Message Passing

- Message passing most commonly used between processes
  - Explicitly pass data btween **sender** (src) + **receiver** (destination)
  - Example: Unix pipes, Windows LPC
- Advantages:
  - Makes sharing explicit
  - Improves modularity (narrow interface)
  - Does not require trust between sender and receiver
- Disadvantages:
  - Performance overhead to copy messages
- Issues:
  - How to name source and destination?
    - One process, set of processes, or mailbox (port)
  - Does sending process wait (I.e., block) for receiver?
    - Blocking: Slows down sender
    - Non-blocking: Requires buffering between sender and receiver

IPC: Message Passing details

- Mechanism for processes to communicate and to synchronize their actions
- Message system – processes communicate with each other without resorting to shared variables
- If P and Q wish to communicate, they need to:
  - establish a communication link between them
  - exchange messages via send/receive
- Implementation of communication link
  - physical (e.g., shared memory, hardware bus)
  - logical (e.g., logical properties)

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 – 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

Bounded-Buffer – Producer

```
while (true) {
   /* Produce an item */
   while (((in = (in + 1) % BUFFER SIZE count)
             == out)
     ;   /* do nothing -- no free buffers */
   buffer[in] = item;
   in = (in + 1) % BUFFER SIZE;
}
```

Bounded Buffer – Consumer

```
while (true) {
     while (in == out)
        ; // do nothing -- nothing to consume
     // remove an item from the buffer
     item = buffer[out];
     out = (out + 1) % BUFFER SIZE;
     return item;
   }
```

Synchronization

- Message passing may be either blocking or non-blocking
- **Blocking** is considered **synchronous**
  - **Blocking send** has the sender block until the message is received
  - **Blocking receive** has the receiver block until a message is available
- **Non-blocking** is considered **asynchronous**
  - **Non-blocking** send has the sender send the message and continue
  - **Non-blocking** receive has the receiver receive a valid message or null

Buffering

- Queue of messages attached to the link; implemented in one of three ways
  1. Zero capacity – 0 messages
     Sender must wait for receiver (rendezvous)
  2. Bounded capacity – finite length of *n* messages
     Sender must wait if link full
  3. Unbounded capacity – infinite length
     Sender never waits