IPC

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Outline

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Independent or Cooperating Processes

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 the execution of another process
  - ▶ Information sharing
  - ▶ Computation speed-up
  - ▶ Modularity

Multiprocess Architecture

Taking advantage of *independent* or/and cooperative processes, design
multiprocess architecture applications

Example Applications

- ▶ The Chromium projects
- ▶ The instructor's Monte Carlo simulation program to estimate π
- ▶ Shell scripts

What benefits do we get by using the multiprocess architecture?

Outline

Inter-process Communication (IPC)

- ▶ Cooperative processes communicate with each other to share data.
- ▶ There are two communication *models*
  - ▶ Shared memory
  - ▶ Message passing

Shared Memory

▶ OS must provide a system call to create a shared memory region.

▶ OS must attach the shared memory region to communicating processes' address spaces.

▶ OS must remove the restriction that normally one process is prevented from accessing another process's memory.

▶ All accesses to the shared memory region are treated as routine memory accesses, and no assistance from the kernel is required.

▶ The processes are also responsible for ensuring that they are not writing to the same location simultaneously.

Message Passing

- ▶ Processes exchange messages. There is no conflict needed to be avoided.
- ▶ IPC facility provides two operations:
  - ▶ `send(message)`
  - ▶ `receive(message)`
- ▶ Processes establish a communication link between them and exchange messages via `send`/`receive`

Design Message Passing

- ▶ Physical communication link can be shared memory, hardware bus, or network.
- ▶ Logically, the communication be
    - ▶ direction or indirect communication (like mailbox)
    - ▶ Blocking or non-blocking (synchronous or asynchronous)
    - ▶ explicit buffering or implicit (automatic) buffering

Outline

Producer and Consumer Problem

The producer produces information while the consumer consumes information

Bounded Buffer via Shared Memory

Shared Buffer

```
1 #define BUFFER_SIZE 10
2 typedef struct { } item;
3
4 // The following are shared among cooperating processes
5 item buffer[BUFFER_SIZE];
6 int in = 0;
7 int out = 0;
8
```

Producer

```
1 while (true) {/* produce an item in next
        produced */
2   while (counter == BUFFER_SIZE)
3     ; /* do nothing */
4   buffer[in] = next_produced;
5   in = (in + 1) % BUFFER_SIZE;
6   counter++;
7 }
8
```

Consumer

```
1 while (true) {
2   while (counter == 0)
3     ; /* do nothing */
4   next_consumed = buffer[out];
5   out = (out + 1) % BUFFER_SIZE;
6   counter--;
7   /* consume the item in next consumed
        */
8 }
9
```

Process Synchronization

Both producer and consumer may read and write to the shared memory
concurrently ...

Producer and Consumer via Blocking Message Passing

Producer

```
1 message next_produced;
2 while (true) {
3    /* produce an item in next_produced */
4    send(next_produced); /* blocking */
5 }
6
7
```

Consumer

```
1 message next_consumed;
2 while (true) {
3    receive(next_consumed); /* blocking */

4    /* consume the item in next_consumed
         */
5 }
6
```

How aboub non-blocking message passing?

Outline

UNIX IPC

Examine the example programs

- ▶ POSIX ordinary and named pipes
- ▶ POSIX shared memory
- ▶ POSIX message passing
- ▶ Berkeley Sockets

Windows IPC

Examine the example programs

- ▶ Windows anonymous and named pipes
- ▶ Windows mail slots
- ▶ Windows shared memory

Outline

Which data sharing or IPC mechanism to use?

- Processes, or threads, or both?
- How do processes share data?
- How do threads share data?