Iter-Process Communication

UNIX IPC

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Premises

❖ Where are we?

- u01-courseIntroduction
- u02-review
- u03-cppBasics
- u04-cppLibrary
- u05-multithreading
- u06-synchronization
- u07-advancedIO
- u08-IPC

➡
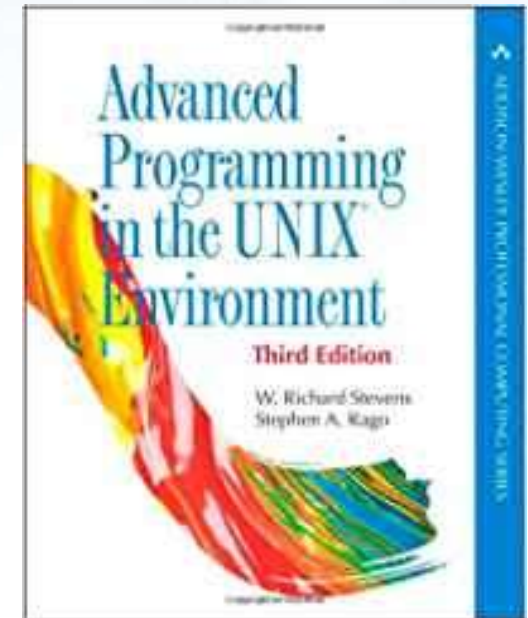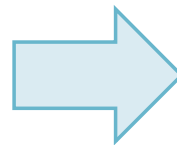
- u08s03e
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- u08s01-introduction.pdf
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- u08s03-messageQueues.pdf
- u08s04-sharedMemory.pdf
- u08s05-shockets.pdf

Advanced Programming in the UNIX Environment
Third Edition
W. Richard Stevens
Stephen A. Rago

Introduction

Processes do not share their address space: Each process in an operating system has its own separate memory space. This isolation ensures that one process cannot directly access the memory of another process, which enhances security and stability.
Copy-on-Write (CoW): This is a memory management technique used to efficiently handle the duplication of memory. When a process is forked, the parent and child processes initially share the same memory pages. Only when one of the processes modifies a shared page is the page copied, ensuring that each process has its own version of the page. This reduces the overhead of duplicating memory unnecessarily.
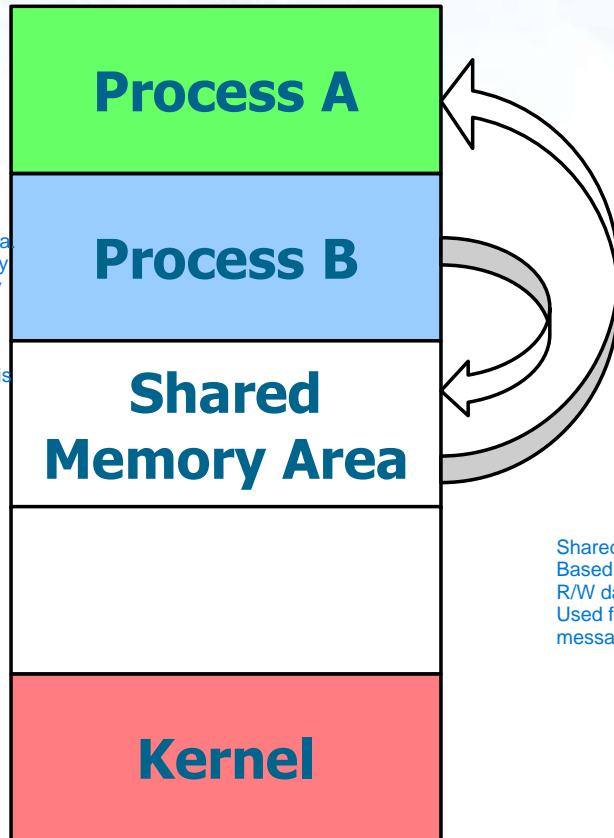
❖ **Processes do not share their address space**

➤ Copy-on-Write duplicates the memory only when strictly required

❖ Information sharing among processes is referred to as **IPC** or **I**nter **P**rocess **C**ommunication

Information sharing among processes: Since processes do not share their address space, they need mechanisms to communicate and share data. This is where IPC comes in.
IPC (Inter Process Communication): This refers to the methods and mechanisms that allow processes to exchange data and signals.

➤ Processes may need to share information when running

▪ On the same machine, **intra**-machine communication
▪ On different machines, **inter**-machine communication

➤ The communication models can be based on

▪ Message exchange
▪ Shared memory

Message exchange: Processes communicate by sending and receiving messages. This can be done using various IPC mechanisms like pipes, message queues, sockets, etc.
Shared memory: A portion of memory is shared between processes. This allows processes to read and write to the same memory space, facilitating faster communication compared to message passing.

Communication models

The diagram illustrates two processes, Process A and Process B, both accessing a shared memory area. This shared memory area is managed by the kernel, which ensures that both processes can read from and write to this common space.

Process A
Process B
Shared Memory Area
Kernel

❖ **Shared memory**

➢ Based on sharing a memory area and R/W data in this area

➢ Used for sharing a large amount of data
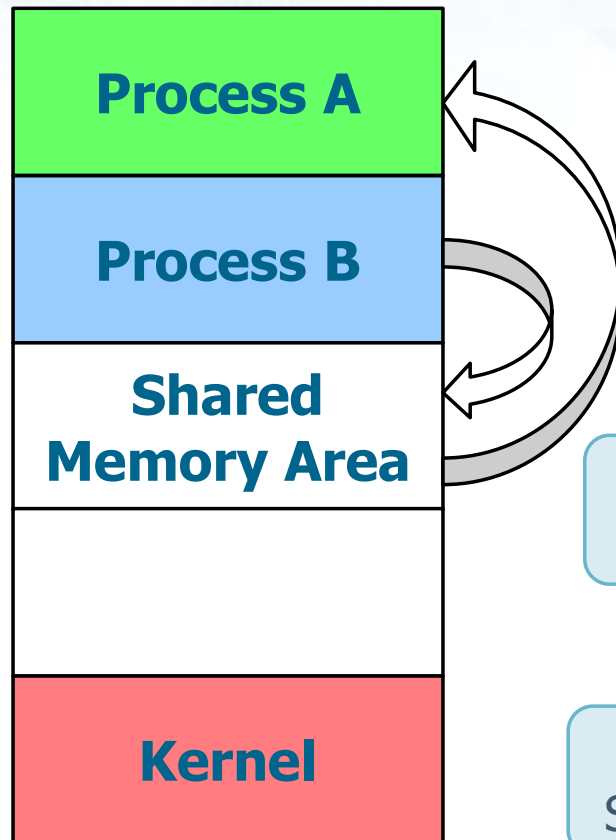
Shared Memory:
Based on sharing a memory area: This model allows multiple processes to access a common memory space.
R/W data in this area: Processes can read from and write to this shared memory area.
Used for sharing a large amount of data: Shared memory is efficient for transferring large volumes of data between processes because it avoids the overhead of message passing.

Communication models

Process A	
Process B	
Shared Memory Area	
Kernel	

❖ **Shared memory**

➢ Most common methods

- ▪ **File** sharing
  - Sharing the name or the file pointer or descriptor before fork/exec

  > Course of OS

- ▪ **File mapping**
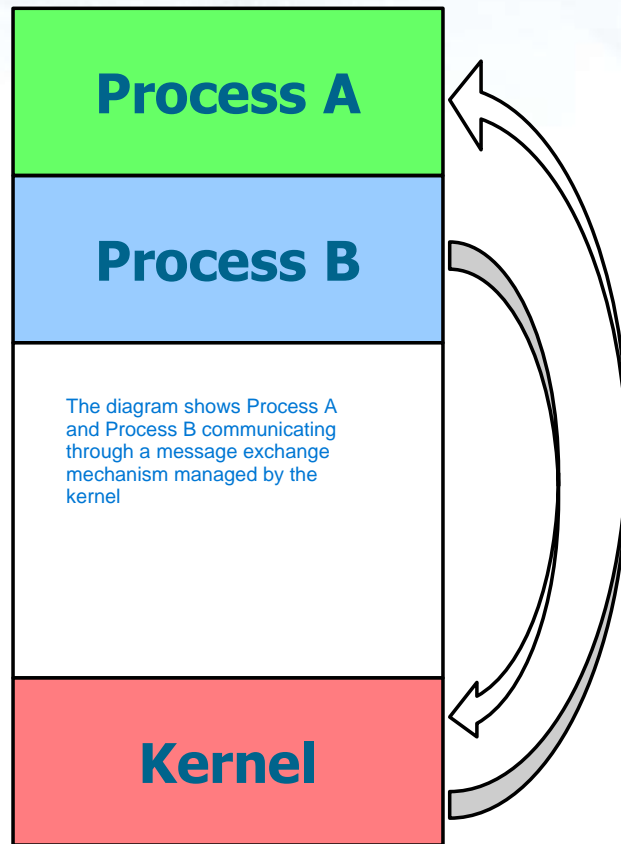 - A file is mapped into the address process space

  > Unit 07 Section 05

- ▪ **Memory sharing**
  - A chunk of memory is mapped into the address process space

  > Unit 08 Section 04

Communication models

| Process A |
| Process B |
| The diagram shows Process A and Process B communicating through a message exchange mechanism managed by the kernel |
| Kernel |

❖ **Message exchange**

➢ Communication takes place through the exchange of messages

➢ Need to setup of a communication channel

➢ Useful for exchanging limited amounts of data

➢ Uses system calls

  ▪ Require kernel intervention

  ▪ Introduce overhead

Message Exchange:
Communication takes place through the exchange of messages: Processes communicate by sending and receiving messages.
Need to set up a communication channel: A communication channel must be established between the processes to facilitate message exchange.
Useful for exchanging limited amounts of data: This method is typically used for smaller data transfers.
Uses system calls: Message exchange relies on system calls, which:
Require kernel intervention: The kernel is involved in managing the communication.
Introduce overhead: System calls can add some performance overhead due to the context switching between user mode and kernel mode.

Communication models

Process A

Process B

Kernel

Intra machine

Inter machine
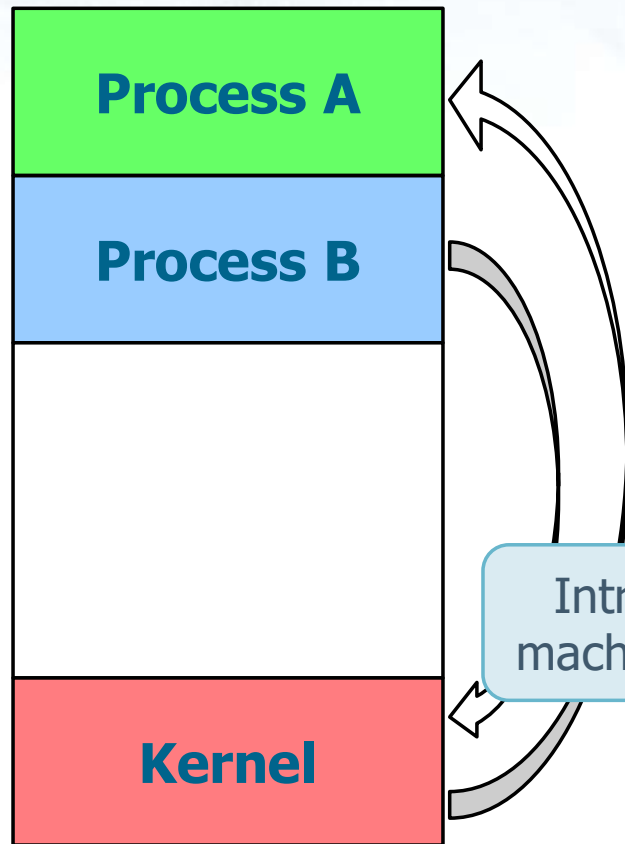
❖ **Message exchange**

➤ Most common methods

- ▪ Pipes
  - ● Basic (older) strategy

  Unit 08 Section 02

- ▪ FIFOs
  - ● Avoid a common ancestor between processes

  Unit 08 Section 03

- ▪ Message queues
  - ● Allow structured data

  Unit 08 Section 05

- ▪ Network sockets
  - ● Allow transfer (through the network) between processes running on different machines

Review: Pipes

Original pipes (or unnamed pipes):
Common form of UNIX System IPC:
Pipes are widely used in UNIX systems
for inter-process communication.
Pseudo-files linking two processes:
Pipes act as temporary files that link two
processes, allowing data to flow between
them.
Can be used only between processes
that have a common ancestor:
The pipe must be created before forking
the parent process: The parent process
creates the pipe, and then forks child
processes that inherit the pipe.
The pipe lasts only as long as the
processes last: The lifespan of the pipe
is tied to the lifespan of the processes
using it

P_1 ⇒ ⇒ P_2
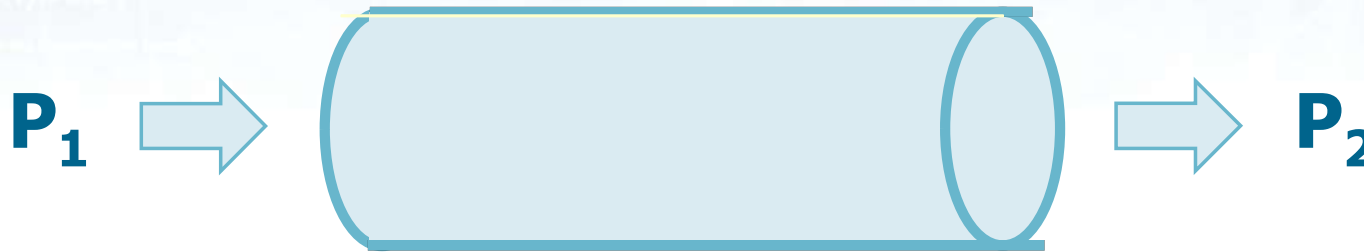
❖ Original pipes (or **unnamed** pipes)

➢ Are a common form of UNIX System IPC

➢ Are pseudo-files linking two processes

➢ Can be used only between processes that have a **common ancestor**

  ▪ The pipe must be created **before** forking the parent process

  ▪ The pipe lasts only as long as the processes last

Review: Pipes

It often has a capacity limited to 64KBytes

P₁ ➡ ➡ P₂
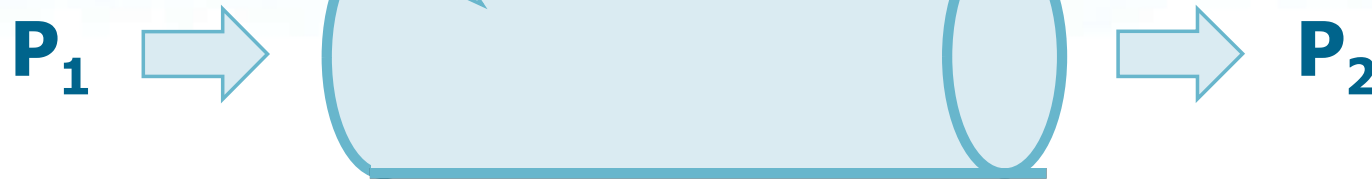
❖ Original pipes (or **unnamed** pipes)
  ➢ Are **half duplex**
    ▪ Data flows only in one direction
  ➢ Can be seen as an **unstructured** sequential files
    ▪ The communication channel is a FIFO queue
    ▪ Structured data transfers require a communication protocol
  ➢ Transfer only **limited quantity** of memory

Review: Pipes

```
int file[2];
char cR cW;
```
The direction of data flow depends on how the pipe is set up. Typically:
Parent writes, child reads: The parent process writes to the pipe, and the child process reads from it.
Child writes, parent reads: Alternatively, the child process can write to the pipe, and the parent process reads from it.
The key point is that data flows in one direction (half-duplex).

```
if (pipe(file) != 0) { ... Error ... }
pid = fork ();
if (pid == -1) { ... Error ... }

if (pid == 0) {
  // Child
  close (file[1]);
  n = read (file[0], &cR, sizeof(char));
  ...
} else {
  // Parent
  close (file[0]);
  n = write (file[1], &cW, sizeof(char));
  ...
}
```

The child reads from the pipe

The parent writes into the pipe