ECE 3574: InterProcess Communication with Pipes and Sockets

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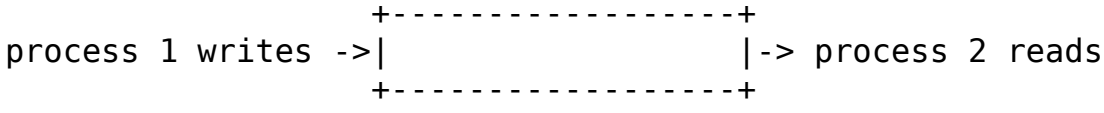
InterProcess Communication with Pipes and Sockets

- Today we are going to look at concurrent programming using multiple OS processes.
  - communicating processes
  - Unix and Windows pipes
  - Unix fork + pipes
  - Cross-platform IPC using QProcess and QLocalSocket

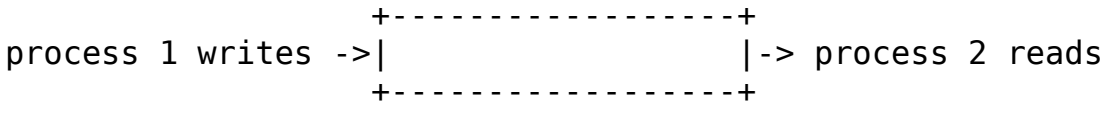
A reoccuring theme in concurrent programming is the idea of communication over a channel

- Depending on how these are implemented they go by many names:
  - Pipes, Sockets, Message Queues, Channels, Signals
- The idea is simple.

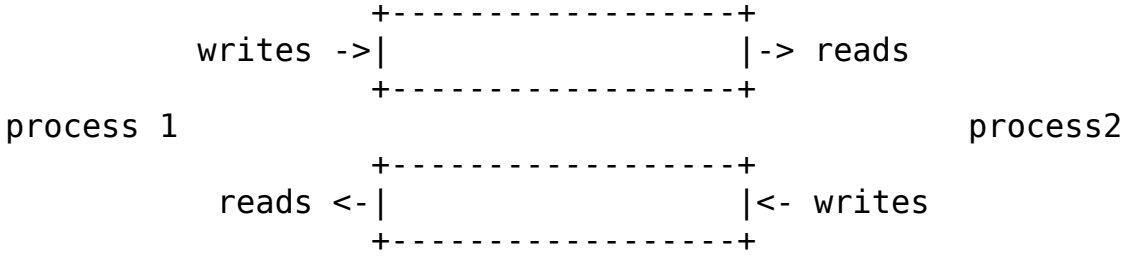


Communication may be half-duplex or full-duplex

- Half-Duplex



- Full-Duplex



The message sent over the channel can take various forms

- the message may be just text
- the message might be a binary stream (exchange serialized objects)
- the message might be a function to call (Remote Procedure Call)
- We will focus on simple messages for now and look at data serialization later.

The exact semantics of these communciation channels varies by platform

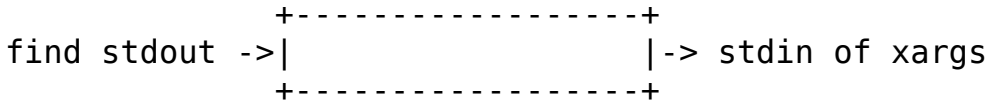
- Examples on Unix:
  - Pipes (Anonymous and Named)
  - Sockets
  - Message Queues
- Examples on Windows:
  - Pipes (Anonymous and Named)
  - Sockets
  - COM

A central tenant of Unix systems is that programs should be small and composable

- The primary way this is done is using Pipes.
- Example: search through all my CMake based projects looking for ones that expect a test to fail.
- `find ~ -name CMakeLists.txt -print | xargs grep add_test`

A central tenant of Unix systems is that programs should be small and composable

- The | character is a pipe. It connects the standard output of one program to the standard input of the next, forming a simple half-duplex channel.



Example: Unix Pipes

- `#include <unistd.h>`
- create a pipe with pipe giving two integer file descriptors
- read from one, write to the other
- See example code: `unix_pipe/`
    - pipe, pipe2 - create pipe

That's dumb, what is that good for?

- We combine that with `fork`, which makes a copy of the current process, called the *child*.
- The *parent* and *child* process communicate over shared pipe descriptors.
- See example code: `unix_fork/`, `unix_fork_pipe/`
  - fork - create a child process

A cross-platform solution using Qt

- The process on Unix using sockets is similar to pipes.
- Both have rough equivalents on Windows.
- Lets use Qt to do it cross-platform

QProcess

- `QProcess` is a Qt class that abstracts a process. You can start them, hijack stdin and stdout, and get their exit status.
- See example code: `qprocess_example/`
    - QProcess Class

QLocalSocket

- `QLocalSocket` is a class the abstracts a local socket. On Windows this is a named pipe and on Unix this is a local domain socket, but it does not matter to us. The idea is to use QProcess similar to fork and use QLocalSocket to setup the communication.
- See example code: `qlocalsocket_example/`
  - QLocalSocket Class

Case Study: Message Passing Interface (MPI)

- High-Performance Computing is all about leveraging multiple processing units, be they cores, CPUs, or multiple machines. One approach uses seperate processes that communicate over sockets by passing messages.
- This is standardized as MPI (there are a few different implementations).

Next Actions and Reminders

- Read about Qt shared memory