Interprocess Communication

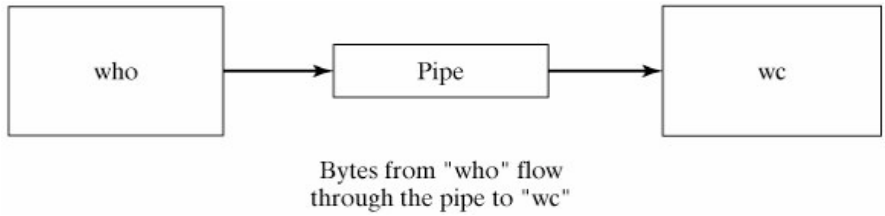
- Based on book chapter 12.6
- How do two processes communicate? We will look at:
  - Pipes
  - Sockets

Interprocess Communication

- Pipes
  - An interprocess communication mechanism allowing two or more processes to send information to each other.
  - They are commonly used from within shells to connect the standard output of one utility to the standard input of another.

Interprocess Communication

- Consider $ who | wc -1
  - option -1 outputs total number of lines in input



Bytes from "who" flow through the pipe to "wc"

  - both processes run concurrently; pipe buffers and protects against overflow; suspends reader until more data becomes available...

Unnamed Pipes

- System Call: int pipe (int fd [2])
  - pipe () creates an unnamed pipe and returns two file descriptors;
  - the descriptor associated with the "read" end of the pipe is stored in fd[0],
  - the descriptor associated with the "write" end of the pipe is stored in fd[1].

Unnamed Pipes

- The following rules apply to **processes that read** from a pipe:
  - If a process reads from a pipe whose write end has been closed, the read () returns a 0, indicating end-of-input.
  - If a process reads from an empty pipe whose write end is still open, it sleeps until some input becomes available.
  - If a process tries to read more bytes from a pipe than are present, all of the current contents are returned and read () returns the number of bytes actually read.

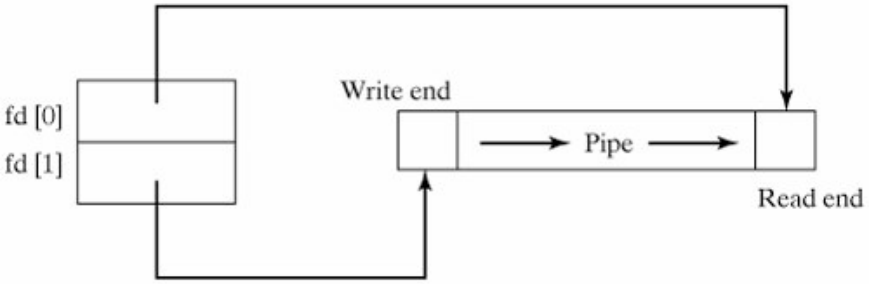
Unnamed Pipes

- The following rules apply to **processes that write** to a pipe:
  - If a process writes to a pipe whose read end has been closed, the write fails and the writer is sent a SIGPIPE signal.
    - The default action of this signal is to terminate the writer.
  - If a process writes fewer bytes to a pipe than the pipe can hold, the write () is guaranteed to be *atomic*; that is, the writer process will complete its system call without being preempted by another process.
  - If a process writes more bytes to a pipe than the pipe can hold, no similar guarantees of atomicity apply.

Unnamed Pipes

- executing the following code will create the data structure shown

```
int fd [2];
pipe (fd);
```



Unnamed Pipes

- Unnamed pipes are usually used for communication between a parent process and its child, with one process writing and the other process reading. The typical sequence of events is as follows:
  - The parent process creates an unnamed pipe using pipe ().
    - The parent process forks.
    - The writer closes its read end of the pipe, and the designated reader closes its write end of the pipe.
    - The processes communicate by using write () and read () calls.
    - Each process closes its active pipe descriptor when finished with it.

Unnamed Pipes

- Example that allows parent to read message from child via a pipe
  - note that child includes NULL terminator as part of the message


```
   $ cat talk.c                          ...list the program.
#include <stdio.h>
#define READ   0       /* The index of the read end of the pipe */
#define WRITE  1       /* The index of the write end of the pipe */
char* phrase = "Stuff this in your pipe and smoke it";
main ()
{
 int fd [2], bytesRead;
 char message [100]; /* Parent process' message buffer */
 pipe (fd); /*Create an unnamed pipe */
 if (fork () == 0) /* Child, writer */
   {
     close(fd[READ]); /* Close unused end */
     write (fd[WRITE],phrase, strlen (phrase) + 1); /* include NULL*/
     close (fd[WRITE]); /* Close used end*/
   }
 else /* Parent, reader*/
   {
     close (fd[WRITE]); /* Close unused end */
     bytesRead = read (fd[READ], message, 100);
     printf ("Read %d bytes: %s\n", bytesRead, message); /* Send */
     close (fd[READ]); /* Close used end */
   }
}
$ ./talk                            ...run the program.
Read 37 bytes: Stuff this in your pipe and smoke it
$ _
```

Unnamed Pipes

- Example of chaining two programs
  - parent creates pipe
  - each end attaches its stin or stout to the pipe (via dup2)
  - both processes exec


```
   $ cat connect.c                        ...list the program.
#include <stdio.h>
#define READ   0
#define WRITE  1
main (argc, argv)
int argc;
char* argv [];
{
 int fd [2];
  pipe (fd); /* Create an unnamed pipe */
  if (fork () != 0) /* Parent, writer */
   {
     close (fd[READ]); /* Close unused end */
     dup2 (fd[WRITE], 1); /* Duplicate used end to stdout */
     close (fd[WRITE]); /* Close original used end */
     execlp (argv[1], argv[1], NULL); /* Execute writer program */
     perror ("connect");  /* Should never execute */
   }
 else /* Child, reader */
   {
     close (fd[WRITE]); /* Close unused end */
     dup2 (fd[READ], 0); /* Duplicate used end to stdin */
     close (fd[READ]); /* Close original used end */
     execlp (argv[2], argv[2], NULL); /* Execute reader program */
     perror ("connect"); /* Should never execute */
   }
}
$ who                          ...execute "who" by itself.
glass    pts/1      Feb 15 18:45   (:0.0)
$ ./connect who wc             ...pipe "who" through "wc".
      1       6      42       ...1 line, 6 words, 42 chars.
$ _
```

Named Pipes

- Named pipes (FIFOs) are less restricted than unnamed pipes, and offer the following advantages:
  - They have a name that exists in the file system.
  - They may be used by unrelated processes.
  - They exist until explicitly deleted.
- All of the pipe rules mentioned for unnamed pipes apply

Named Pipes

- Because named pipes exist as special files in the file system, processes using them to communicate need not have a common ancestry as when using unnamed pipes.
- A named pipe (FIFO) may be created in one of two ways:
  - by using the Linux mkfifo utility or the mkfifo() system call
  - Utility: **mkfifo** *fileName*
    - mkfifo creates a named pipe called fileName.

Named Pipes

- example

```
$ mkfifo myPipe                 ...create pipe.
$ chmod ug+rw myPipe            ...update permissions.
$ ls -l myPipe                  ...examine attributes.
 prw-rw----   1 glass   cs    0 Feb 27 12:38 myPipe
$ _
```

- Note the type of the named pipe is "p" in the *ls* listing.

```
mkfifo ("myPipe", 0660);   /* Create a named pipe */
```


Named Pipes

- Named Pipes operation:
  - a special file is added into the file system
  - once opened by open(),
    - write() puts data into the FIFO queue
    - read() removes data at end of FIFO queue
  - process closes pipe using close()
  - when no longer needed remove pipe from file system using unlink()

Example using a reader and a writer

```
#include <stdio.h>
#include <sys/types.h>
#include <fcntl.h>
/*********************************************************************/
main ()
{
 int fd;
 char str[100];
 mkfifo ("aPipe", 0660); /* Create named pipe */
 fd = open ("aPipe", O_RDONLY); /* Open it for reading */
  while (readLine (fd, str)) /* Display received messages */
   printf ("%s\n", str);
  close (fd); /* Close pipe */
}
/*********************************************************************/
readLine (fd, str)
int fd;
char* str;
/* Read a single NULL-terminated line into str from fd */
/* Return 0 when the end-of-input is reached and 1 otherwise */
{
 int n;
  do /* Read characters until NULL or end-of-input */
   {
     n = read (fd, str, 1); /* Read one character */
   }
 while (n > 0 && *str++ != 0);
 return (n > 0); /* Return false if end-of-input */
}
```


The writer.c program looks like this:

```
#include <stdio.h>
#include <fcntl.h>
/
**********************************************************************
/
main ()
{
 int fd, messageLen, i;
 char message [100];
  /* Prepare message */
 sprintf (message, "Hello from PID %d", getpid ());
 messageLen = strlen (message) + 1;
  do /* Keep trying to open the file until successful */
   {
     fd = open ("aPipe", 0_WRONLY); /*Open named pipe for writing */
     if (fd == -1) sleep (1); /* Try again in 1 second */
   }
 while (fd == -1);
  for (i = 1; i <= 3; i++) /* Send three messages */
   {
     write (fd, message, messageLen); /* Write message down pipe */
     sleep (3); /* Pause a while */
   }
  close (fd); /* Close pipe descriptor */
}
```