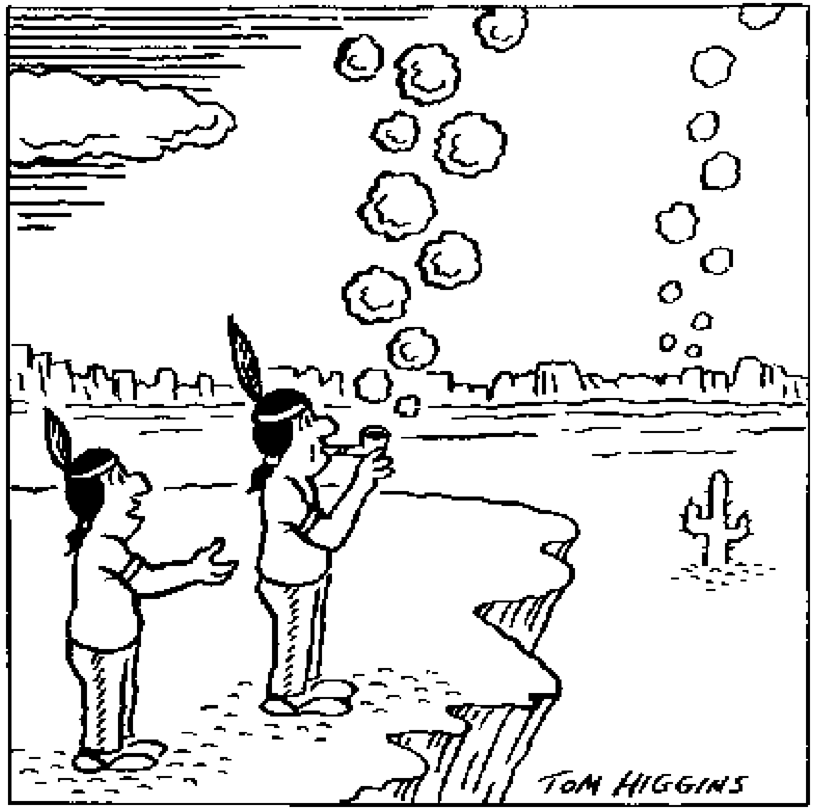
Interprocess communication



Communicating Processes

- Processes can be started using the exec system calls
- Processes can operate in parallel using the fork system call followed by exec
- Processes sometimes wish to cooperate and exchange information during execution

Communicating Processes

- Why multiple processes?
  - Synchronous activities
  - Asynchronous events

- Signals
- Pipes
- Files - select
- Shared memory (tutorial)

File Descriptors

- low level I/O is performed on file descriptors that are small integers indicating an open file
- when process is started file descriptor 0 is standard input, 1 is standard output, 2 is standard error output
- low level system call functions operate on file descriptors

I/O system calls

- low level I/O functions include:
  - creat
  - open, close
  - read, write
  - ioctl
- eg read 100 characters from standard input into array “buffer”

  nread = read(0, buffer, 100)

pipe

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

- filedes is a two element array of integers that is filled in with two file descriptors
- filedes[0] is for reading
- filedes[1] is for writing
- data written into filedes[1] can be subsequently read from filedes[0]
- the pipe function returns 0 on success, -1 on failure

Using pipes

- a parent process can communicate with a child by creating a pipe before the fork
- the parent can then write data to fildes[1] and the child can read filedes[0]
- the system has a small amount of buffering
- if the buffer is filled, the writer is suspended until the reader has read some data

Using files

- Process A talks to Process B via a named file.
- A: Open file, write data, close file
- B: Open file, read data, close file

- How can they synchronise read/write?

Using files

Process A

```
// wait for signal
int fd = open("shared.txt", O_WRONLY);
// write some data
close(fd)
// send signal
```

Using files

Process B

```
while (flag == false)
    check_flag(&flag);  // signal triggered
int fd = open("shared.txt", O_RDONLY);
// read some data
close(fd);
// send signal back
```

Using files

- Requires setup signal
- What is the event?
  - File has been opened/closed
  - File has been read/written

- Use select() !
  - man 2 select

Using files with select()

- select() monitors multiple file descriptors
- The file descriptors are specified by the file descriptor set.
- select() wait for an I/O event for any of the file descriptors in the set
  - There is data available to read from the file
  - There is space available to write to the file

Using files with select()

- Macros are used to define the set of file descriptors
  - FD_ZERO(), FD_SET(), FD_CLR(), FD_ISSET()
- There are three descriptor sets

```
int select(int nfds,
        fd_set *readfds, fd_set *writefds, fd_set *exceptfds,
        struct timeval *timeout);
```

Blocking I/O

Each file descriptor access can cause the processes to block

- pipe/file write will block until space available
- pipe/file read will block until data available

- Processes cannot do other useful work. May miss events, deadlines
  - Realtime systems may not afford to wait for I/O

Blocking I/O

Synchronous sharing of data of

- They each are waiting for signal interrupt, cannot do useful work
- E.g. wait for 100 bytes, but only received 46
- It is possible to open a file in NON BLOCKING MODE

Blocking I/O

- open("bigfile.bin", O_NONBLOCK | O_RDONLY);
- Change mode of existing fd (stdin, stdout, stderr)

Use existing flags

```
fcntl(fd, F_SETFL,
    fcntl(fd, F_GETFL) | O_NONBLOCK);
```

Memory mapping

- Rather than using a real file, signals, or pipes we can map one memory region of one process to another
- Now we are **sharing a range of addressable memory**

```
void *mmap(     void *addr, size_t length,
                int prot, int flags, int fildes, off_t offset);

int munmap(void *addr, size_t len);
```

Summary

- For simple communications between processes a pipe can be used
- For communications where a process needs to be interrupted, signals can be used
- For large amounts of shared data:
  - files are helpful
    - select() and epoll()
    - non-blocking
  - shared memory

- picture acknowledgement:

  http://www.pipes.org/Ephemeris