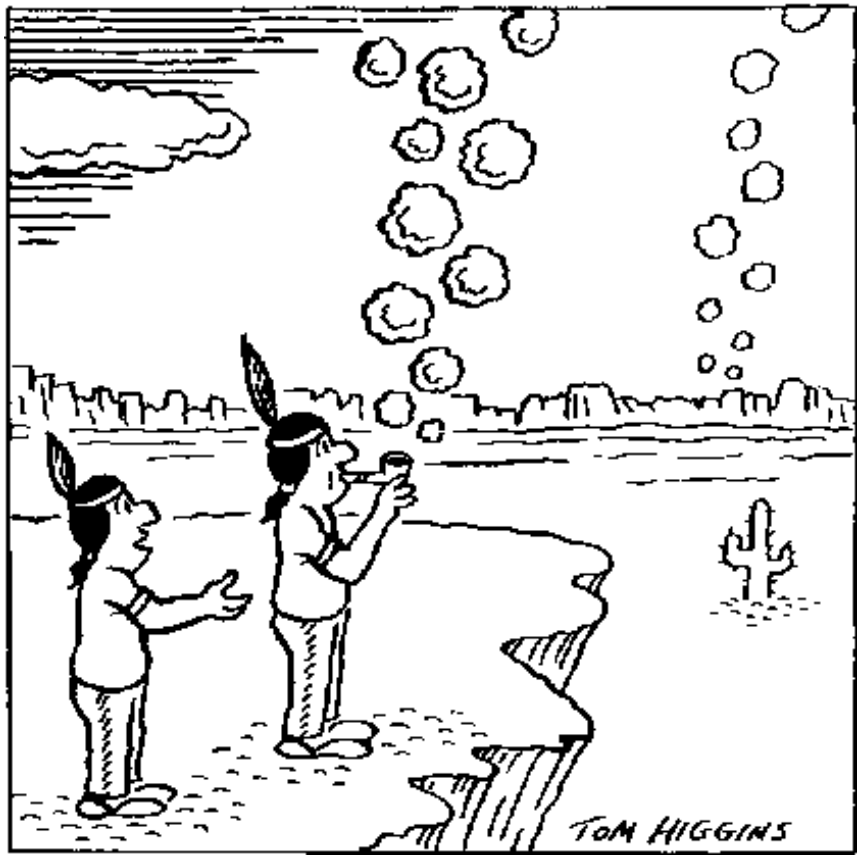
Interprocess communication



"The best way to predict the future is to invent it."

Alan Kay

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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

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Communicating Processes

- Why multiple processes?
  - Synchronous activities
  - Asynchronous events

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

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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

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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”

```
read(0,buffer,100)
```

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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

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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

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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?

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Using files

Process A

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

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Using files

Process B

- Busy loop for flag, triggered by signal
- int fd = open("shared.txt", **O_RDONLY**);
- read some data
- close(fd)
- Send signal back

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Using files

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

- Use select() !
  - man 2 select

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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

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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);
```

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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

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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)

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

Use existing flags

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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