Using Fork and Pipe

Methods & Tools for Software Engineering (MTSE)
Fall 2019

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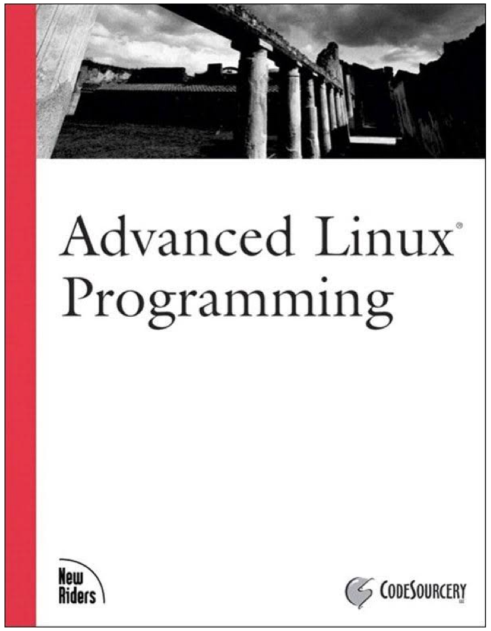
Additional Information

Advanced Linux Programming

- Chapter 2.1 (Interacting with Execution Environment)
- Chapter 3 (Processes)
- Chapter 5.4 (Pipes)

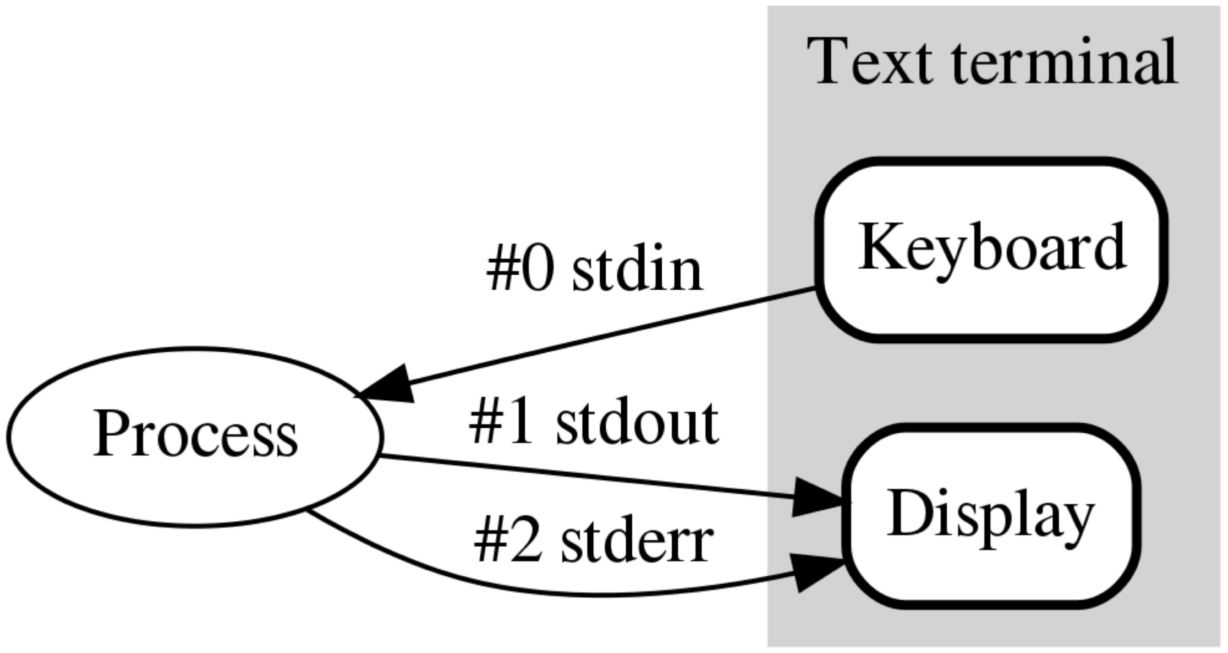


The book is available from the links below

https://github.com/MentorEmbedded/advancedlinuxprogramming/blob/gh-pages/alp-folder/advanced-linux-programming.pdf

https://github.com/MentorEmbedded/advancedlinuxprogramming/tree/gh-pages

Standard input, output, and error



https://en.wikipedia.org/wiki/File:Stdstreams-notitle.svg

- Let’s change stdin, stdout, and stderr

PROCESS

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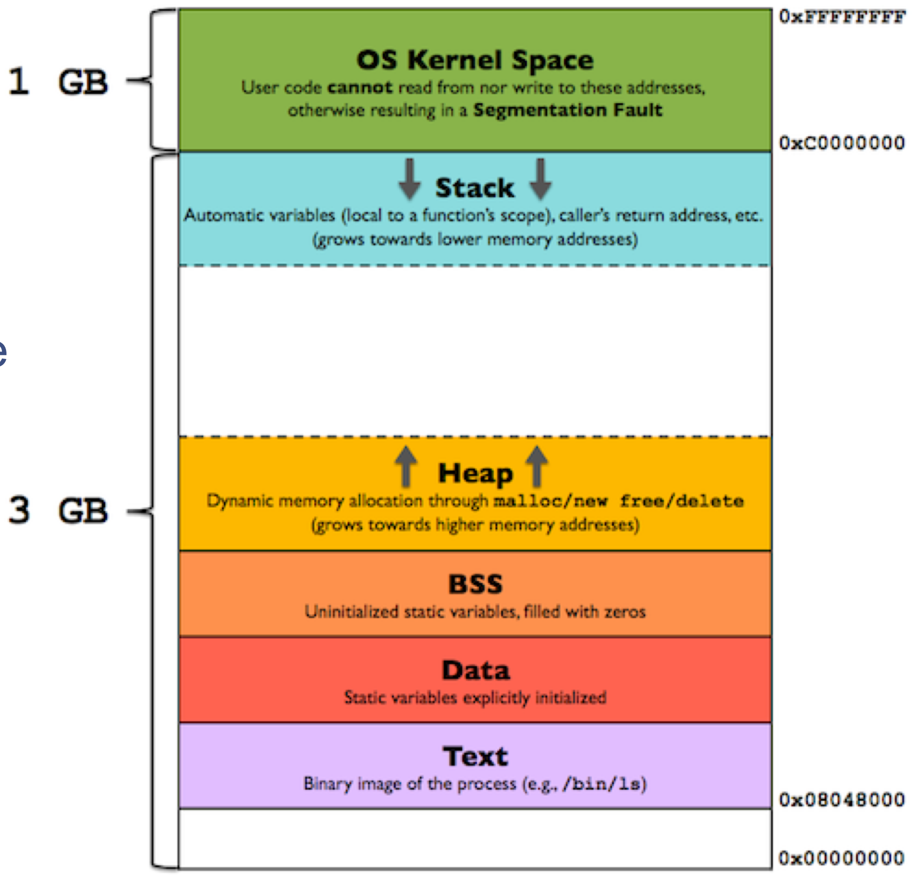
What is a "Process"?

- What is a process:
  - *"A running instance of a program"*
  - *Examples:*
    - *Each of the two instances of Firefox*
    - *The shell and the ls command executed, each is a process*

- Advanced programmers use multiple processes to
  - Do several tasks at once
  - Increase robustness (one process fails, other still running)
  - Make use of already-existing processes

The "Guts" of a Process!

- The main components of a process:
  - An executable piece of code (a program)
  - Data that is input or output by the program
  - Execution context (information about the program needed by OS)


1 GB
3 GB
OS Kernel Space
User code **cannot** read from nor write to these addresses, otherwise resulting in a **Segmentation Fault**
Stack
Automatic variables (local to a function's scope), caller's return address, etc. (grows towards lower memory addresses)
Heap
Dynamic memory allocation through malloc/new free/delete (grows towards higher memory addresses)
BSS
Uninitialized static variables, filled with zeros
Data
Static variables explicitly initialized
Text
Binary image of the process (e.g., /bin/ls)
0xFFFFFFFF
0xC0000000
0x08048000
0x00000000

https://gabrieletolomei.wordpress.com/miscellanea/operating-systems/in-memory-layout/

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Let's Dissect a Process!

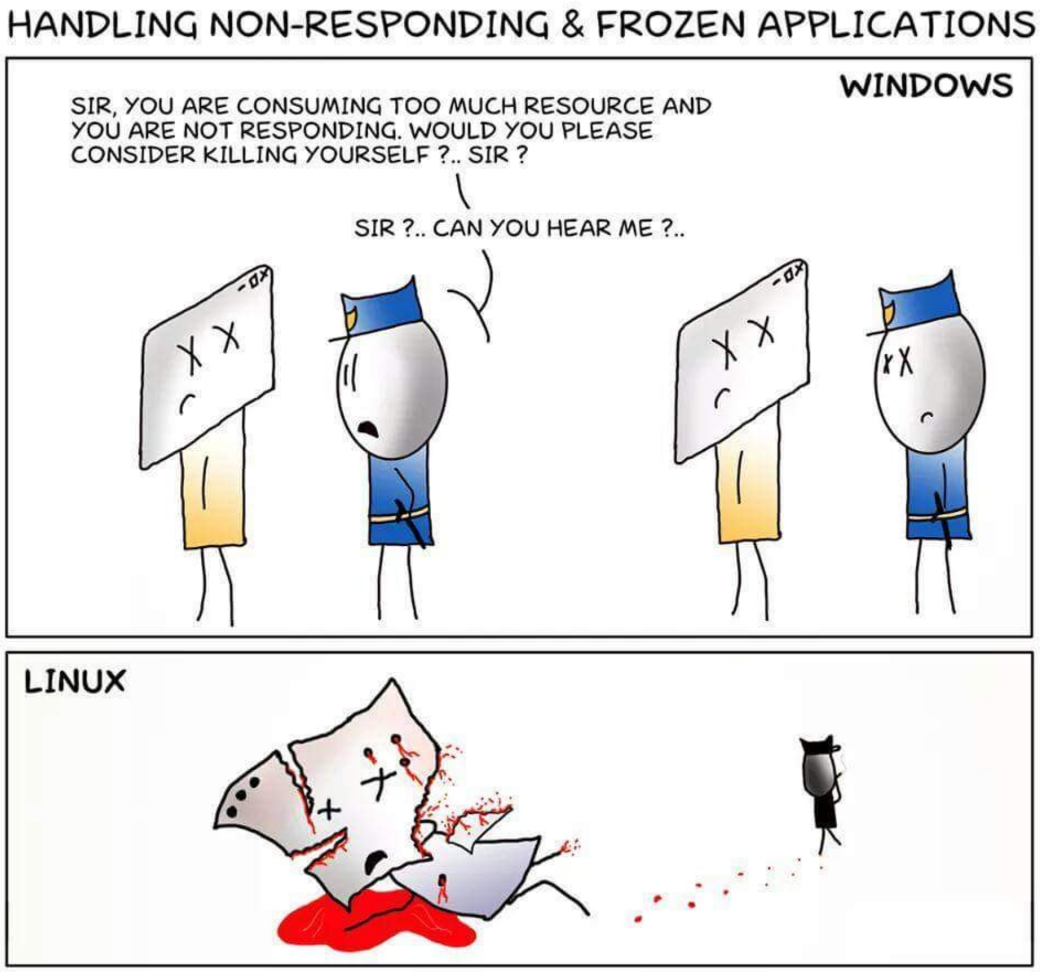
- Windows:
  - Task manager
- Unix-like (Mac and Linux):
  - In the terminal type:
    - `ps` *or* `top`
    - `ps -f` for full details

The Parent of a Process

- Each process (with some exceptions) has a parent process (indicated by ppid)
- Can we get this information within a program?
  - YES!
  - Use `getpid()` and `getppid()` from `unistd.h`

KILLing a Process!

- Run `kill` in the terminal (run kill with -KILL)


HANDLING NON-RESPONDING & FROZEN APPLICATIONS
WINDOWS
SIR, YOU ARE CONSUMING TOO MUCH RESOURCE AND YOU ARE NOT RESPONDING. WOULD YOU PLEASE CONSIDER KILLING YOURSELF ?.. SIR ?
SIR ?.. CAN YOU HEAR ME ?..
LINUX

https://www.reddit.com/r/linuxmasterrace/comments/3y42qz/killing_a_non responding_process/

Creating a Process

- Using a `system`
    - Runs a shell (as a subprocess) to run the given commands

- Why using `system` is not recommended:
    - The call to system relies on the installed shell
    - It brings the shell’s:
        - Features
        - limitations
        - Security flaws

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Creating a Process - fork() system call

Forks an execution of the process

- after a call to fork(), a new process is created (called child)
- the original process (called parent) continues to execute concurrently
- in the parent, fork() returns the process id of the child that was created
- in the child, fork() return 0 to indicate that this is a child process
- The parent and child are independent

Man(ual) Page

- man 2 fork

exec() – executing a program in a process

exec() series of functions are used to start another program in the current process

- after a call to exec() the current process is replaced with the image of the specified program
- different versions allow for different ways to pass command line arguments and environment settings
- `int execv(const char *file, char *const argv[ ])`
  - file is a path to an executable
  - argv is an array of arguments. By convention, argv[0] is the name of the program being executed

Man page

- man 3 exec

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Man page

- man 3 exec

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kill() – sending a signal

A process can send a signal to any other process

- usually the parent process sends signals to its children
- `int kill(pid_t pid, int sig)`
  - send a signal `sig` to a process `pid`
- useful signal: SIGTERM
  - asks a process to terminate

When a parent process exits, the children processes are terminated

It's a good practice to kill and wait for children to terminate before exiting

Man page

- man 2 kill

Signals

- A special message sent to a process
- Signals are asynchronous
- Different types of signals (defined in `signum.h`)
  - SIGTERM: Termination
  - SIGINT: Terminal interrupt (Ctrl+C)
  - SIGKILL: Kill (can't be caught or ignored)
  - SIGBUS: BUS error
  - SIGSEGV: Invalid memory segment access
  - SIGPIPE: Write on a pipe with no reader, Broken pipe
  - SIGSTOP: Stop executing (can't be caught or ignored)
- Handling a signal:
  - Default *disposition*
  - Signal handler procedure
- Sending signal from one process to another process (SIGTERM, SIGKILL)

waitpid() – Waiting for a child

A parent process can wait for a child process to terminate

- `pid_t waitpid(pid_t pid, int *stat_loc, int options)`
  - block until the process with the specified `pid` terminates
  - the return code from the terminating process is placed in `stat_loc`
  - options control whether the function blocks or not
    - 0 is a good choice for options

Man page

- man 2 wait

pipe() and dup2() – Inter-Process Communication

pipe() creates a ONE directional pipe

- two file descriptors: one to write to and one to read from the pipe
- a process can use the pipe by itself, but this is unusual
- typically, a parent process creates a pipe and shares it with a child, or between multiple children
- some processes read from it, and some write to it
  - there can be multiple writers and multiple readers
    - although multiple writers is more common

dup2() duplicates a file descriptor

- used to redirect standard input, standard output, and standard error to a pipe (or another file)
- STDOUT_FILENO is the number of the standard output

Man pages

- man 2 pipe
- man 2 dup2

getopt() – processing CLI options

switch with an argument

positional argument

CLI – comm switch inte

```
$ foo -s -t 10 bar.txt baz.txt
```

At a start of the program, main(argc, argv) is called, where

- argc is the number of CLI arguments
- argv is an array of 0 terminated strings for arguments
  - e.g., argv[0] is “foo”, argv[1] is “-s”, argv[2] is “-t”, argv[2] is “10”, …

getopt() is a library function to parse CLI arguments

- `getopt(argc, argv, “st:”)`
- input: arguments and a string describing desired format
- output: returns the next argument and an option value
- see example in `using_getopt.cpp`

/dev/urandom – Really Random Numbers

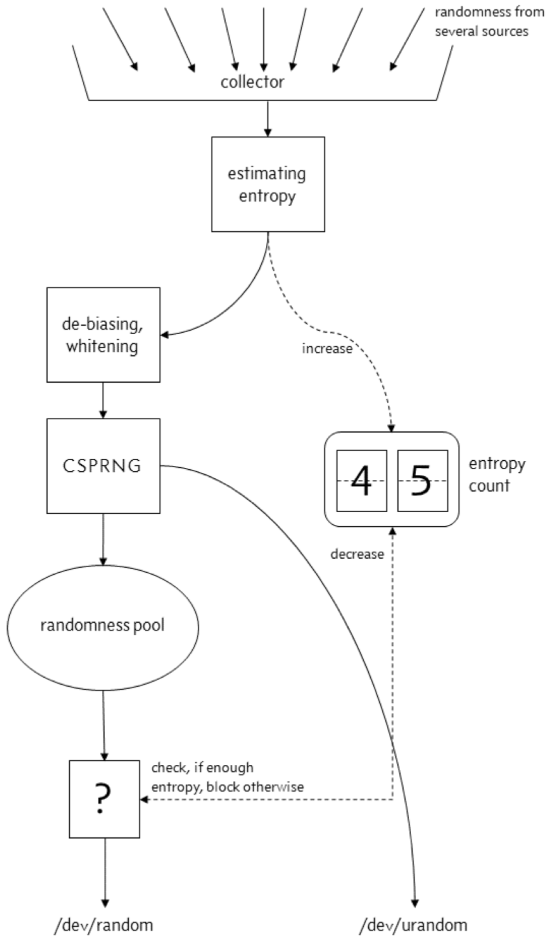
/dev/urandom is a special file (device) that provides supply of “truly” random numbers

”infinite size file” – every read returns a new random value

To get a random value, read a byte/word from the file

see `using_rand.cpp` for an example

Have to use it for Assignment 3!



https://www.2uo.de/myths-about-urandom/