Recitation 1

Welcome back, everybody!

Recitation Logistics

- Turn in your worksheets! This is how we grade recitation participation
    - Due every Thursday at 11:59 pm.

- Finished grading rec00 worksheets this morning
    - Everyone who has turned in a worksheet has either a 9 or a 10
    - Comments are there to give feedback! Please check if you have comments on your submission

Today's Topics

- Processes
- Fork & Exec
- Wait
- Alarm
- Valgrind
- Good Coding Style

Processes

Processes

- Process: One instance of a running (or ready to run) program

- Two ways to visualize processes

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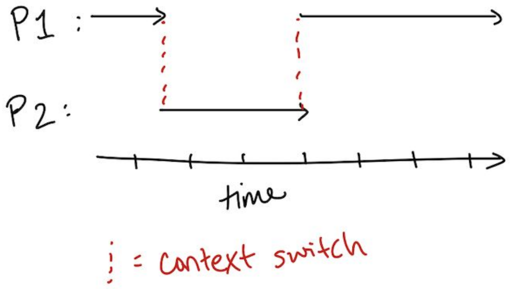

Processes as separate lines of execution

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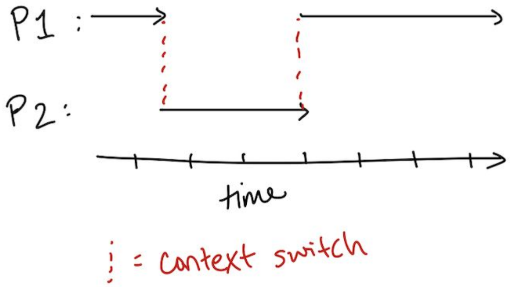
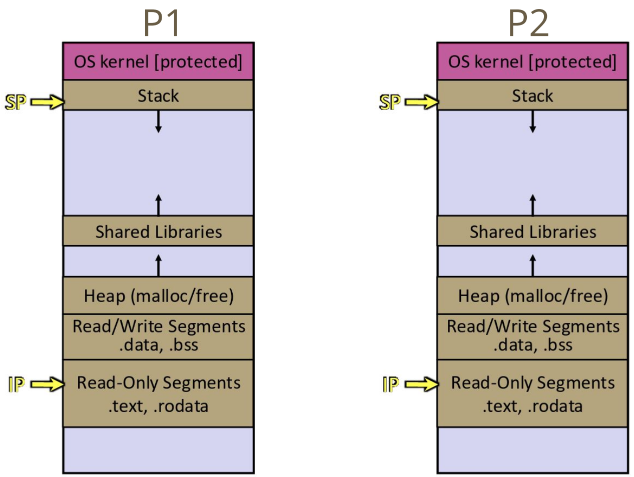
- Two ways to visualize processes



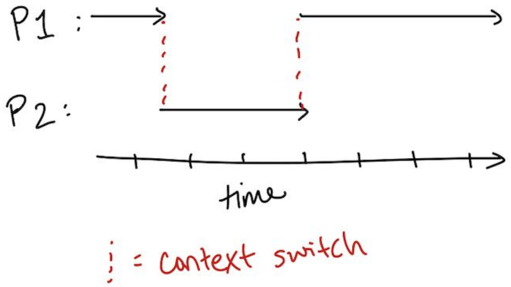


Processes as separate lines of execution OR Processes as separate memory environments

Processes

- Process: One instance of a running (or ready to run) program

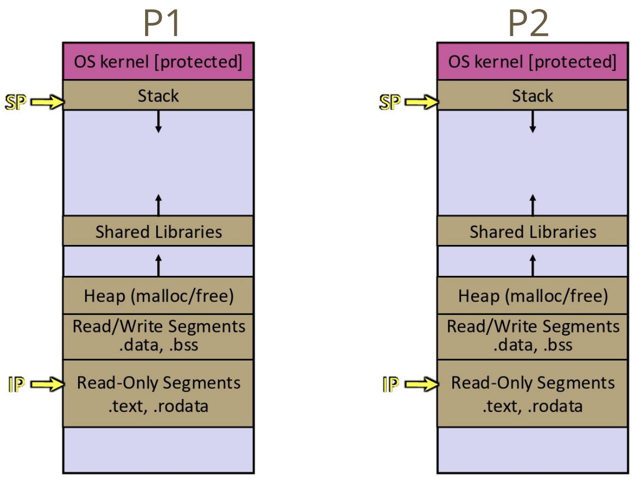
- Two ways to visualize processes



Processes as separate lines of execution

OR

this visual will be more useful later in the semester



Processes as separate memory environments

Fork

Fork

- “The only function that returns twice”

- Generally invoked when we want to run a different program without terminating the current program

- Clones the process that called fork()
  - Memory environment: stack, heap, read-only memory, registers, etc.
  - File descriptor table
  - Signal handlers & mask

- Child starts running the line immediately following fork()

Exec

Exercise 1a: Processes

Which process(es) have access to `file.txt`?

A. Parent
B. Child
C. Both
D. Neither

```c
#include <fcntl.h>
#include <stdlib.h>

int main() {
  pid_t child = fork();
  int fd = open("file.txt", O_WRONLY);
  if (fd == -1) {
    exit(EXIT_FAILURE);
  }
  write(fd, "this is parent or child.", 25);
  close(fd);
  return 0;
}
```

Exercise 1b: Processes

If the parent closes the file, can the child still write to `file.txt`? **Explain you answer.**

```c
#include <fcntl.h>
#include <stdlib.h>

int main() {
  pid_t child = fork();
  int fd = open("file.txt", O_WRONLY);
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  return 0;
}
```

Exec(ve)

- Replaces the current process with another

  ```
  execve(char *pathname, char *argv[], char *envp[]);
  ```

  - `pathname` = string containing path to binary file to be executed
  - `argv` = array of strings containing arguments to run the next program
    - Argv[0] == pathname
  - `envp` = list of environment variables
    - Just set this parameter to `NULL`

- What's replaced?

- What's unchanged?

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- What's unchanged?

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- What's replaced? Memory layout (stack, heap globals, loaded code, registers), **signal handlers**
- What's unchanged? List of open file descriptors, kernel, PID

Wait

Wait

- Parent waits for its child to finish - will block until it receives a signal indicating that the child finished running
    - Can also query how the child finished: was it natural, or was it from a signal?

- A process can only wait on its child (no sibling or grandchild waiting allowed!)

- wait_pid() is more expressive than wait()
    - Waitpid allows you to specify which child you're waiting for
    - Waitpid also allows you to indicate the "type of waiting" you want
        - Block wait
        - Nonblocking wait (with no hang)

Fork, Exec, Wait

- Commonly, the three work together!

- **Fork + Exec** = start a completely new task as a child of current process
  - i.e. if Google Chrome was a running process, then you open a new tab

- **Fork + Exec + Wait** = indicates the current process should not run until newly created task has completed
  - i.e. your shell!

Exercise 2a: The Process “Family Tree”

Here are two diagrams, where each labeled box represents a process. P0 is the “original process” that forks P1. Arrows show the parent-child relationship. The order of processes spawning from first to last is: P0, P1, P2, P3.

Using either C code, psuedocode, or a written description, describe how you would fork 3 processes to achieve diagram 1 and diagram 2.

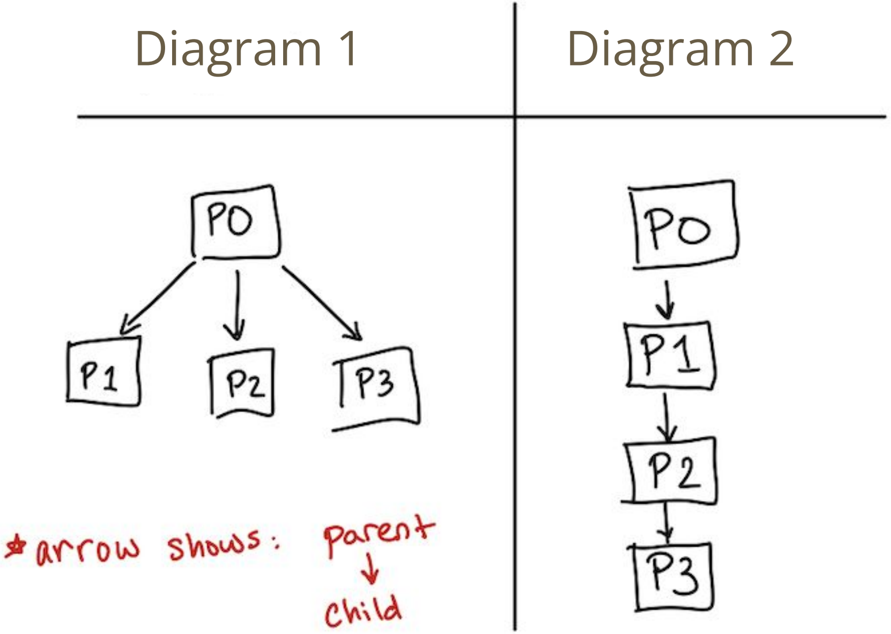


Diagram 1

Diagram 2

* arrow shows: parent ↓ child

Exercise 2b: Choose Your Own Fork

Let’s say I have 3 independent tasks: T1, T2, and T3.

- P1 will exec T1
- P2 will exec T2
- P3 will exec T3

All 3 tasks require I/O calls to be made.

P0 must wait until T1, T2, and T3 have finished.

Which diagram will result in the faster runtime? **Explain your answer.**

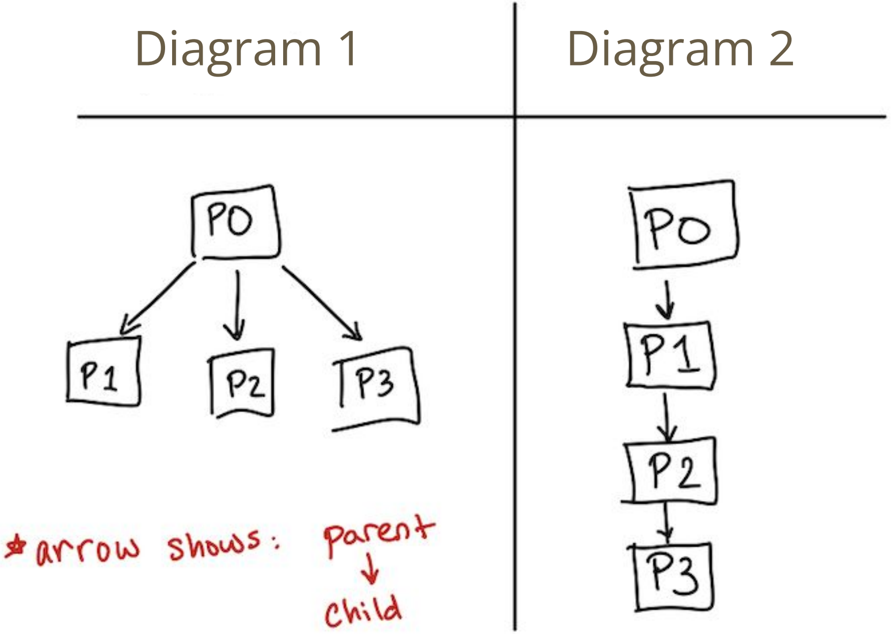


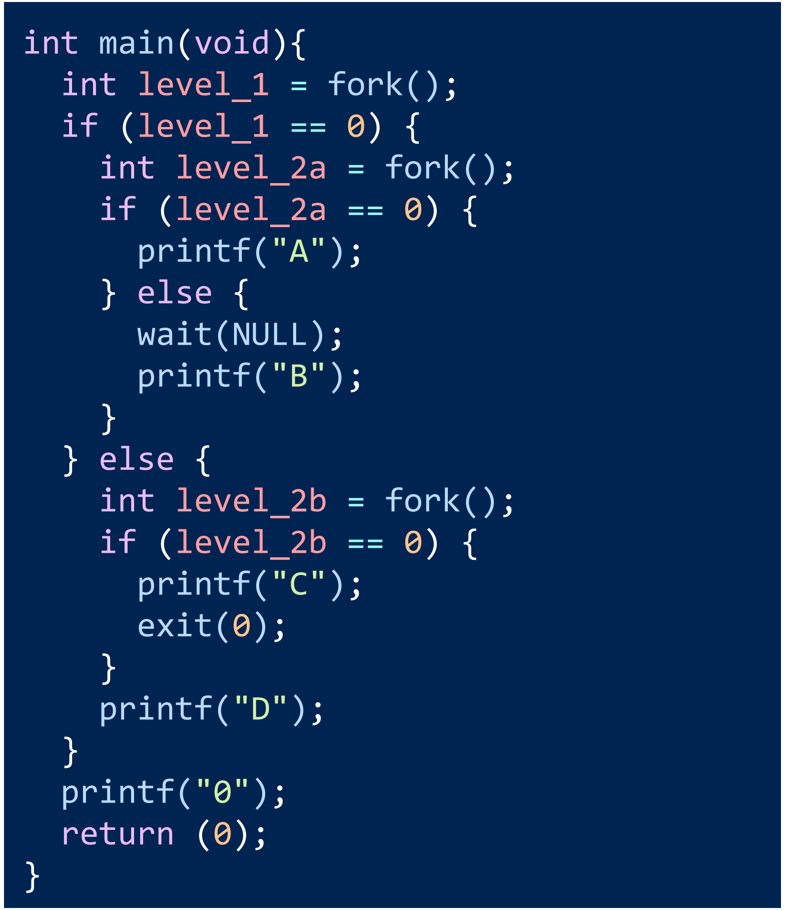
Diagram 1

Diagram 2

Exercise 3: Waiting

1. Draw a diagram of all processes and clearly indicate all parent-child relationships.

2. Which of the following are possible outputs? Select all that apply:
   a. B0AC0D0
   b. D0CA0B0
   c. D0A0B0C
   d. CAD00B0
   e. ABCD000



```
int main(void){
  int level_1 = fork();
  if (level_1 == 0) {
    int level_2a = fork();
    if (level_2a == 0) {
      printf("A");
    } else {
      wait(NULL);
      printf("B");
    }
  } else {
    int level_2b = fork();
    if (level_2b == 0) {
      printf("C");
      exit(0);
    }
    printf("D");
  }
  printf("0");
  return (0);
}
```

Alarm

Alarm

- Will send a SIGALRM signal after a set number of seconds unless cancelled

  Question: Which command will cancel an alarm?

    a. alarm(-1);
    b. alarm(0)

- SIGALRM default disposition: terminate process receiving the signal
  - But can change the default behavior using signal handlers, or block it with a mask

Valgrind

Valgrind

- Your handy debugging tool for memory mismanagement
- It runs your program, and looks for any memory errors during execution
- It will only catch errors it encounters in runtime! Pay attention to **code coverage** - ensure all* lines of code are run in a valgrind session

*or at the very least, the most critical lines

Valgrind Errors

- Memory leaks: memory that hasn’t been freed by the time the program exits
- Invalid read/write: accessing unallocated (or deallocated) memory
- Uninitialized bytes: Using memory that was allocated but never had any values put into them

How to Run Valgrind

- Can run in terminal: **`valgrind ./program <program arguments>`**
- Useful valgrind arguments (put between `valgrind` and `./program`)
  - **`--trace-children=<yes|no>`** (default: no)
  - **`--track-origins=<yes|no>`** (default: no)
  - **`--leak-check=<no|summary|yes|full>`** (default: summary)
    - `full` option gives you the most info

Good Style

Coding with Good Style 😎

Do you want your code to be super easy to read?

Coding with Good Style 😎

Do you want your code to be super easy to read?

And do you want to be an awesome partner during pennshell and pennOS?

Coding with Good Style 😎

Do you want your code to be super easy to read?

And do you want to be an awesome partner during pennshell and pennOS?

Well, look no further!

Coding with Good Style 😎

- Try to keep good style in mind when you're programming!
    - Definitely saves time if you don't have to refactor / polish as many lines due to some forethought

- Maintaining style during the active coding process can also force you to be methodical and plan ahead

Some Questions During the Coding Process

- Modularization
  - “What is the essential role of this helper function?”
  - “Can I break it down further?”
  - “What tasks will I be repeating during a single execution?”
- Design choices: scope, readability
  - “Should I define the variable in the caller or the callee function?”
  - “Should this variable be on the stack or the heap?”
  - “Can I make this a constant or a macro? Should I?”
  - “Have I cleanly defined the cases for my conditionals?”
  - “If my partner had to read this, would they know what this variable is for?”
- Correctness
  - “Am I factoring in all the edge cases?”
  - Memory management, **not ignoring compiler warnings**

Commenting Your Code

- Two ways to approach
  - During the coding process: can save time, slow you down and make you code more intentionally
  - After coding + debugging: doing a final pass-through to get the big picture, can often write better comments after you've finished a function or a C file
- Describe intent, not just is directly happening
- Comments will help out when you do documentation / README
- Where to do:
  - File headers
  - Function headers
  - Beginning of large blocks
  - Explaining complex lines

What to Remove

- Unnecessary comments
    - Commented out code
    - // TODO
    - Redundant comments
- Unnecessary printf statements - when error handling, use `perror()`
- ILLEGAL FUNCTIONS (why are they even there in the first place?)

Reminder

These are not exhaustive directions!!

Most of the ones I talked about were common style pitfalls we docked points for in the spring semester

Please go to the style guide in “Tools and Refs” page of the course website

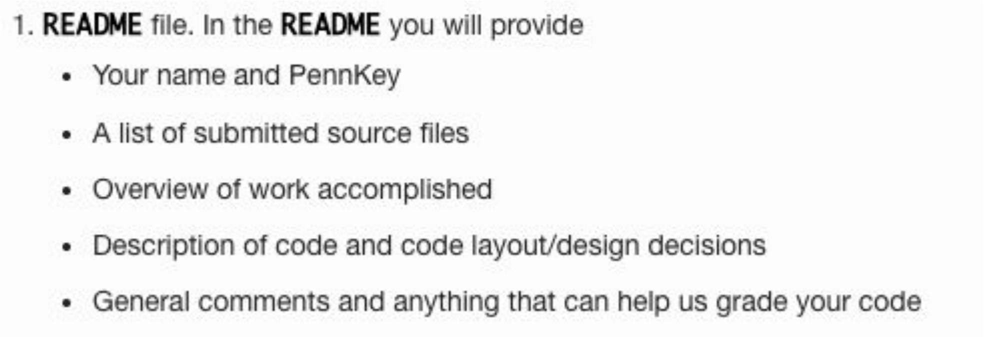
https://www.seas.upenn.edu/~cis5480/25su/documents/style

README Expectations

- Show us that you understand the work you did!

- Implementation details should be more than the penn-shredder spec
  - Go into design decisions ***you*** made, not just what you were instructed to do

- Good formatting also helps (separating the doc into sections, making use of section headers)



1. **README** file. In the **README** you will provide
   - Your name and PennKey
   - A list of submitted source files
   - Overview of work accomplished
   - Description of code and code layout/design decisions
   - General comments and anything that can help us grade your code

Shredder Debugging